

# A BIBLIOGRAPHY OF RESEARCH WORK IN SILKWORM BREEDING (1960-2011)

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## FOREWORD

Recent approaches in research and development effort to boost sericulture industry has poised for vertical growth in breeding silkworm strains with higher productivity, disease resistance resulting in increased cocoon yield at commercial level. Successful cocoon production depends on the rearing of suitable silkworm breeds/hybrids recommended for a season / region. The contribution of research and development in general, and silkworm breeding in particular has contributed tremendous effort on silk industry. I am happy to place on record that more 500 references with abstracts collected on various aspects of silkworm breeding, evaluation, molecular aspects and vanya silk and documented. This is the first time an attempt is made in this direction to accumulate 50 years of research on silkworm breeding in one volume. The collected references in this volume would go a long way to mitigate the acute need of students and researchers involved in silkworm breeding. This collection will be helpful for the researchers who are involved in silkworm breeding.

I take this opportunity to place on record my sincere thanks to all the scientists associated with this document for their effort in bringing out the publication in time on this Golden Jubilee year.

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# CHAPTER-I

## EVOLUTION OF SILKWORM BREEDS

## EVOLUTION OF SILKWORM BREEDS

01. Rangaswamy, M., 1940.  
(Department of Sericulture, Mysore, India).  
Selective breeding in silkworms.  
In: Second All India Sericulture Conference, Lucknow, 14<sup>th</sup> December, 1940, pp.41-43.
02. Sidhu, N.S., 1967.  
(Central Sericultural Research and Training Institute, Mysore, India)  
A multivoltine breed of silkworm *Bombyx mori* L for tropics in evolution.  
Indian Journal of Sericulture, 1(2):63-66.  
Abstract :Two local races, pure Mysore and Mysore A white were selected for their resistance to hot climates and their ability to survive on poor diets. They were crossed with the Russian bivoltine race, Betakokonnaya, selected for its good yield, cocoon weight, shell weight, filament length and denier.
03. Narayanan, E.S., Tikoo, B.L., 1969.  
(Central Sericultural Research and Training Institute, Nazarbad, Mysore, India).  
Evolution of new races of univoltine silkworm by physiological genetics.  
In: Proceedings of Indian Academy Sciences Section B, 69(6):320-335.  
Abstract :In order to improve pure strains of silkworm *Bombyx mori* Linn. suitable for the univoltine regions of India, 2 breeding plans were drawn up. Out of 80 sublimes isolated, S18, S36, S58 and S79 were selected on the basis of peak performances. Field trails both at Dehra Dun and Kashmir under village conditions gave encouraging results.
04. Narayanan, E.S., Sonwalkar, T.N., Nataraja, N., 1969.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Significant superiority of filament neatness in mysore princese: a newly evolved multivoltine race on mulberry silkworm.  
Indian Journal of Sericulture, 8(1):64-66.
05. Strunnikov, V.A., 1969.  
(V.I. Lenin Tashkent State University, Tashkent, USSR.)  
Obtaining male progeny from silkworms.  
Doklady Akademii Nauk SSSR, 188(5):1155-1158.  
Abstract: Experimental investigation was set up to develop a method of obtaining purely male progeny in the silkworm suitable for industrial use. The problem was solved by using radiation methods to develop a special breeding of silkworm, the males of which when crossed with females of any other breed produce offspring consisting almost solely of males. The eggs of the females sex die at the embryonic stage of development under the effect of recessive sex linked lethals.
06. Kovalev, P.A., 1970.  
Silkworm Breeding Stocks.  
Central Silk Board, Bangalore.pp.209.
07. Nishita, T., 1972.  
On the breeding of a silkworm race N134 x C135.  
Bulletin of Sericulture Experiment Station, Japan, 25(2):61-75.

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Abstract: The silkworm, *Bombyx mori* was bred in the spring rearing season. A Japanese race AN65 and a Chinese strain AC25 was bred and a strain N134 x C135 was created. The AN65 was bred by hybridization between the Japanese race 37-Zai and Japanese race N126. To shorten the feeding period of the silkworm and to achieve greater ability to silk production selection by means of early mounting were carried out during the 1st-5th generation of N126, and then until the 14th generation to improve cocoon qualities and silk qualities strain N134 shows heavy cocoon weight, heavy cocoon shell weight and good neatness. AC25 was bred by hybridization between a Chinese strain RL and a Chinese strain C128. Individual and both selection were applied on AC25 to raise its cocoon quality from 1st-14th generation. The strain obtained i.e C135 is vigorous with high cocoon shell percentage a somewhat higher reliability percentage.

08. Yamamoto, T., Gamo, T., 1976.

(Sericultural Experiment Station, Tokyo, Japan.)

Studies on the breeding in relation to the improvement of food utilization in the silkworm, *Bombyx mori* L. (I). Mutual relations among the amount of food ingested, the amount of food digested, digestibility and several quantitative characters in the silkworm reared on an artificial diet.

Journal of Sericultural Science of Japan, 45(1):81-86.

09. Yamamoto, T., Gamo, T., 1976.

(Sericultural Experiment Station, Tokyo, Japan.)

Studies on the breeding in relation to the improvement of food utilization in the silkworm, *Bombyx mori* L. (II). Heritabilities in amount of food ingested, amount of food digested and digestibility in F2 population.

Journal of Sericultural Science of Japan, 45(2):111-114.

Abstract: Heritabilities of the three characters related to food utilization amount of food ingested amount of food digested and digestibility in the silkworm larvae reared on an artificial diet were studied using two hybrid strains. Heritability was estimated in F2 population by means of the method of parent offspring regression. The heritabilities of amount of food ingested amount of food digested and digestibility in the 5th instar larvae were estimated as 0.53~0.68, 0.42~0.75 and 0.36~0.64 respectively and their values were higher in female larvae than in male ones. Since the heritabilities of these three characters showed relatively high value it is concluded that these characters can be improved by selection.

10. Lee, S.P., Hong, K.W., Kim, K.M., Mah, Y.I., Choi, S.R., 1977.

(Sericultural Experiment Station, Office of Rural Development, Suwon, Korea).

Autumn silkworm variety "Jam 117xJam 118".

Research reports office of rural development veterinary and sericulture, Korea Republic, 19:41-46.

Abstract: For a stable cocoon production during the adverse autumn conditions, breeding of strains which combine high productivity with resistance to unfavourable growth conditions is needed. It was shown that strain Jam 117 x Jam 118 was most satisfactory.

11. Oui, H., 1977.

On the breeding of the silkworm races, J137 x C137.

Bulletin of Sericultural Experiment Station, (Tokyo), 27(1):97-140.

12. Yankov, A., 1977.

Breeding of new silkworm hybrids vratza 5 x vratza 6 and vratza 7 x 157-k.

Animal Science, Bulgaria, 14(4):116-123.

13. Petkov, N., 1978.

(Opitna Stantsiya po Bubarstvo, Vratsa, Bulgaria.)

Inheritance of cocoon silk and selection effectivity in some interlinear *Bombyx mori* L. hybrids.

Genetika Selektsiya, 11(1):63-70.

Abstract: Three interlinear crosses B-1/18xS-2/12, B-1/18xS-2 and B-1/18xB2/21 and their parental lines were studied for 5 generations. The variation of cocoon silk percentage is higher F<sub>2</sub> than in parental lines. In same interlinear crosses ie. B-1/18 x S-2/12 and B-1/18 x B2/21 the range of variation is wider than that of parental lines. These connection are of practical value in the breeding of silkworm lines with high silk content. By selection of the extreme deviations in F<sub>2</sub> and F<sub>3</sub> for silk content, the following high silk content characteristic in the cocoon. A high level inheritance of cocoon silk content was established in the individual generations of the hybrids studied. High values of correlation coefficient for F<sub>2</sub>, F<sub>3</sub>, F<sub>4</sub> and F<sub>5</sub> were observed.

14. Lu, X., 1979.

Technical analysis on breeding of summer-autumn mulberry silkworm race, Zhe Nong-1.

Journal of Sericulture Science, China, 5(4):193-197.

15. Mano, Y., Ohyanagi, M., Nishimura, M., 1979.

On the breeding of the silkworm races, N136 x C131.

Bulletin of Sericulture Experiment Station, 27(6):763-783.

Abstract:(1). The breed, N136 x C131, was authorized as a suitable silkworm race for spring rearing season by the Minister of Agriculture and Forestry under the prescriptions of the third and eighth articles of the sericultural industry law in October, 1972. The Japanese parent race, N136, has been bred in order to make a suitable hybridization with the Chinese parent race, C131, which was authorized in August, 1967. The C131 is a sex-limited silkworm, so the female larva is easily distinguished from the male one by skin marking (marked: female, plain: male) during the fourth and fifth larval instar. (2). The N136, as a superior Japanese parent race for the C131, has been bred from the offspring of hybridization between "Haru" and "Shiga". "Haru" is a Japanese race which has been bred at Syoei Seishi co. Ltd., "Shiga" is one that has been bred at the Sericultural Experiment Station of Nagano prefecture. (3). Characters of N136 are summarised as follows : The percentage of cocoon shell weight and raw silk are high. The cocoon filament is fine and long. The percentage of degumming loss is low. But the duration of larval period is rather long. (4). The N136 x C131 has a pale blue skin and normal larval marking at the stage of larva. The duration of larval period is almost the same as N134 x C135. The cocoons are white slightly constricted bale-shaped, sometimes mixed with oval shaped ones, and they are ordinarily wrinkled. The larvae are healthy. The cocoon yield and the weight of single cocoon and of cocoon shell are high. The raw silk percentage of cocoon shell is high and reelability is good. The cocoon filament is long and neatness is good. The degumming loss and the size of cocoon filament is about 3.0 denier.

16. Yasuhisa, M., Masayuki, O., Nishimura, M., 1979.

On the breeding of the silkworm races, N136xC131.

Bulletin of the Sericultural Experiment Station, 27(6):783.

Abstract: The breed N136 x C131 was authorized as a suitable silkworm race for spring rearing. C131 is a sex limited silkworm (marked plain male) In N136 the cocoon shell weight and raw silk were high the filament is fine and long. The degumming loss percentage is low. But larval duration is long. N136 x C131 has pale blue silkworm normal larval marking. Cocoon white larvae healthy cocoon yield single cocoon and shell weight high. Raw silk percentage of cocoon shell is high, reelability is good. Neatness is good denies is 3.0.

17. Ye, W., 1979.

Discussion on several problems in breeding of summer-autumn silkworm races.  
Journal of Sericulture Science, China, 5(1):9-16.

18. Kitahara, K., Sumida, H., Shikata, E., 1980.

(Kansai Branch Sericultural Experiment Station, Ayabe, Kyoto, Japan).

On the breeding of silkworm race N130, C130 *Bombyx mori*.

Bulletin of Sericultural Experiment Station, 28(1):51-65.

Abstract:(1)The first step of the breeding of the Japanese race N130 was the hybridization between N502 and NL9, both of which were breeding stocks of plain silkworms, in order to breed a good plain silkworm to be used in future as one of the breeding stocks of sex-limited Japanese silkworm race. The breeding of this race was done with laying emphasis on the improvements of reelability and neatness, by the interbatch selection method. (2) Larvae of race N130 was bred from Reigyoku. Reigyoku has been bred by the hybridization between Chinese race and European race by the Shhoei seishi Co Ltd. (3) On the breeding of this race the line separation method was used attaching importance on reelability and neatness. (4) Larvae of the race C130 are robust. The cocoons have good reelability and the amount of cocoon filament reeled from a cocoon is large. (5) The hybrid N130 x C130 was authorized as a commercial race for spring rearing by the Ministry of Agriculture and Forestry in 1966. Larvae of this hybrid are robust and the cocoon crop is high. The cocoons are pure white and elliptical, and its wrinkle is normal. The reelability and the neatness are good, and the faults of exfoliation are little.

19. Mano, Y., 1980.

On the breeding of a silkworm race N129 x C129 with plain pattern.

Bulletin of Sericulture Experiment Station, Japan, 22(3):381-402.

20. Mano, Y., Taniguchi, M., Murakami, A., 1980.

(Sericultural Experiment Station, Yatabe, Ibaraki, Japan)

On the breeding of autosexing silkworm races, N142, N143 [*Bombyx mori*].

Bulletin of Sericultural Experiment Station, 28(2):202-218.

Abstract: (1) The Japanese races N142 and N143 were authorized as the suitable silkworm races for the spring rearing seasons, under the provisions of the third and eight articles of the Sericultural Industry Law by the Minister of Agriculture and Forestry on October 1977. The sex of these races can be easily distinguished by skin patterns (marked: female, plain: male) during the fourth and fifth larval instar. (2) N142 has been bred by the cross breeding method from the offspring of a hybridization between N131 and ANS63 and this race is characterized by good reelability, good neatness and low degumming loss. ANS63 is the basic races of breed which has been bred for the sake of the race of high productivity of silk by mean of early mounting of silkworms in the earlier period of breeding generations. (3) N143 has been bred by the cross breeding method from the offspring of a hybridization between AN56 (after named N136) and N131. The characteristics of N143 are summarized as follows: The percentage of cocoon shell weight and raw silk percentage of cocoon are high, the length of cocoon filament is long and the neatness is good. (4) On the breeding of the race N143, the authors did not used the Japanese races with plain pattern, but directly used the Japanese race with normal pattern, and omitted to breed a good Japanese race with plain pattern. (5) The defect of N142 is egg-laying and one of N143 is reelability. Therefore, the author races as the F1 hybrid for double cross N142 x N143, in order to have these defects compensated. N142 x N143 is characterized by the easy rearing, high productivity of eggs and excellent cocoon qualities. (6) The study to use the F1 hybrid for double cross (N142 x N143) x (C142 x C143) as practical use was taken up by the Third Laboratory of Breeding method in Breeding Department.

21. Tanaka, S., Kinoshita, D., Taniguchi, Y., 1980.  
(Sericultural Experiment Station, Yatabe, Ibaraki, Japan)  
Studies on the breeding of the economical silkworm race, (N142 x N143) x (C142 x C143) *Bombyx mori*.  
Bulletin of Sericultural Experiment Station, 28(2):237-251.  
Abstract: (N142 x N143) x (C142 x C143) was authorized as an economical silkworm race for spring rearing in 1977. (1) The silkworm race, (N142 x N143) x (C142 x C143) is a double cross hybrid, each parent strain of which is sex-limited: the female larva has normal marking ("Kata") on its dorsal skin while the male larva has not the marking. So female larva are easily distinguished from male ones in each parent strain and F1 hybrid for double cross. This sex-limited character contribute to save the labor of egg-production. (2) The economical character of (N142 x N143) x (C142 x C143) are generally well, especially the neatness is excellent is excellent and the boiling off-ratio of cocoon shells is low.
22. Yamashita, A., 1980.  
(Kyushu Branch, Sericultural Experiment Station, Ueki, Kumamoto, Japan).  
On the breeding of the sex-limited silkworm races, C142 and C143 [*Bombyx mori* L].  
Bulletin of Sericultural Experiment Station, 28(2):219-236.  
Abstract: New silkworm races C142, C143 and their F1 hybrid for double cross have been bred at Kyushu Branch Station. N142, N143 and their F1 hybrid for double cross have been bred at Kansai Branch Station. Double cross of above mentioned races has been selected at Breeding Department of the Sericultural Experiment Station. These four silkworm races, F1 hybrid for double cross and double cross hybrid have been authorized by the Minister of Agriculture and Forestry in October 1977, as suitable ones for spring rearing season, based on the provisions of the third and eight articles of the sericultural Industry Law.
23. Saito, S., 1981.  
(Ministry of Agriculture, Forestry and Fisheries, JapanAgriculture, Forestry and Fisheries Research Council Secretariat, Tokyo, Japan).  
Breeding using computer. (VII). Information processing system of silkworm [*Bombyx mori*L] breeding.  
Journal of Agricultural Science, 36(3):112-118.
24. An, H., 1982.  
Breeding for monovoltine race of Chinese tussah silkworm.  
Journal of Sericulture Science of China, 8(2):106-111.
25. Basaen, A.M., Placido, A., Bacuso, P., Ladines, A., Cabrito, F., 1982.  
(Sericulture Research and Training Center, Philippine Textile Research Institute, La Trinidad, Benguet, Philippines)  
Silkworm breeding for the development of Philippine purelines.  
NSTA Technology Journal (Philippines), 7(3):72-85.  
Abstract: A series of periodic silkworm rearings from 1978 to 1981 were conducted to evaluate the performance of silkworm races for selection of breeds for the production of local hybrids that can yield good quality cocoons and silk. The parameters used were larval duration, larval and pupal weight, hatching ratio, fecundity and moth emergence ratio, mortality percentage and cocoon properties. Results of the study indicated the feasibility of silkworm breeding aimed to develop real and original purelines adaptable to Philippine conditions that will produce local hybrids for commercial cocoon production. Data showed that the quality of cocoons produced from the different races reared meets the international standards set in highly advanced silk producing countries such as Japan and Korea.

26. Kim, K.Y., Lea, H.Z., Kang, S.K., 1982.

(Office of Rural Development, Suweon, Korea Republic)

Inheritance of resistance of flacherie virus in the silkworm, *Bombyx mori* L.

The Sericultural Journal of Korea, 24(1):28-31.

Abstract: Flacherie virus (VF) is an important pathogen in the silkworm, which often gives serious damage to farmers for cocoon production. The inbred parents and F1's from an eight-parent diallel were examined to determine the inheritance of resistance to flacherie virus in the silkworm. Three resistant (R), two intermediate (M) and three susceptible (S) inbreds were used in the diallel with no reciprocals. Mean resistance was measured by survival rates of larvae which were fed on mulberry leaves sprayed with diluted midgut homogenate of FV infected larvae. Broadsense heritability was obtained according to inbreds and F1 family performance. Estimation of general (GCA) and specific combining ability (SCA) was made according to Griffing's Model 1, Model 2. Mean FV resistance of F1 family displayed additive effect of the major gene, while heterotic effect was not significant. Considerable variation in FV resistance within F1 group of R\*S and S\*S indicated that action of minor genes for FV resistance may have been involved. FV resistance of inbreds per se and predominant effects of the major gene over minor gene(s) satisfactorily predicted the FV resistance of the hybrids. Broadsense heritability value of FV resistance on the basis of F1 family performance averaged 93, which suggested that environmental effects might have not been important in this experiment. GCA was highly significant for FV resistant among inbreds. GCA effect of 13.1 in Jam 108 was highest and -17.7 in Gyeongchu lowest. Effective selection for high FV resistance would be possible, using inbreds with GCA effect and low GCA variance. SCA was significant among hybrids. High SCA effect in the hybrid of Geumho\*Mudeung (13.7) and Hansaeng #4\*Jam 115(11.6) indicated that the interaction effect of minor genes for resistance to FV in the silkworm could be exploited by standard silkworm breeding procedures.

27. Kremky, J., Szuba, M., 1983.

Effect of biotype breeding on the value of mulberry silkworm hybrids in 1969-1979.

Prace Instytutu Krajowych Wiokien Naturalnych, 28:157-164.

Abstract: The results of rearing polish silkworm biotypes, simple hybrids and polyhybrids in succeeding cycles is presented. To reduce the deviations caused by seasonal influence and to estimate the genetic value of tested silkworms, a comparison of mean values in 5-years overlapping periods has been made. The Japanese hybrid hoshō x shungetsu has been taken as standard. A Stabilisation of hatchability, survival rate, cocoon crop per 1 gram of eggs in polish polyhybrids has been stated on a level approaching the Japanese standard. The cocoon weight and cocoon shell weight, that are factors of individual selection of biotypes, are also stabilized in polyhybrids on a high level in spite of inbreeding depression in biotypes. Silk richness increased along with filament length and silk yield, and caused a decrease of cocoon consumption in silk reeling. A decrease of cocoon crop and cocoon quality in industrial rearings of both polish and Japanese polyhybrids, has been observed as result of a general lowering of rearing culture, caused by a lack of qualified silkworm rearers. It has been decided to elaborate a model family rearing, suitable to actual economic conditions of the country.

28. Datta, R.K., 1984.

(Central Sericultural Research Training Institute, Mysore, India)

Improvement of silkworm races (*Bombyx mori* L.) in India.

Sericologia, 24(3):393-415.

Abstract: Sericulture has been practised in India since time immemorial. Indigenous races of West Bengal, Jammu s also discussed in the paper the perspective breeding programmes apart from the need for international gene bank and biometrical/biochemical genetic researches.

29. Lee, S.P., Hong, K.W., Sohn, K.W., Choi, S.R., Mah, Y.I., Kim, K.Y., 1984.

Breeding of new spring silkworm variety Baegokjam.

Research Report of Office of Rural Development (Suwon, Korea Republic), 26:58-64.

30. Mano, Y., 1984.

(Matsumoto Branch Station, Sericultural Experimental Station, Agata, Matsumoto, Nagano 390, Japan.)

Studies on the breeding of autosexing silkworm races in Japan.

*Sericologia*, 24(3):389-392.

Abstract: This paper deals with the breeding process and features of silkworm races with sex-limited larval marking and those spread in Japan. The most striking characteristic of such sex-limited silkworm races is the easiness of sex discrimination, newly bred sex-limited silkworm races were superior to ordinary silkworm races in raw silk percentage of cocoon and percentage of degumming in raw silk percentage of cocoon and percentage of degumming loss of cocoon shell. In 1983, spread rates of sex-limited silkworm races were approximately 50 percent in spring rearing season and 40 percent in summer and autumn rearing seasons, respectively.

31. Raju, P.J., Krishnamurthy, N.B., 1984.

(Sericulture Research Project, University of Mysore, Mysore, India)

Evolution of high yielding multivoltine races of silkworm *Bombyx mori* by selective hybridization.

*Sericologia*, 24(3):430.

Abstract: In order to evolve disease resistant multivoltine races of silkworm *Bombyx mori* suitable to tropical climates an attempt has been made utilising polyvoltine Pure Mysore race and bivoltine KA and NB18 races by conventional breeding. The progenies obtained after reciprocal matings of these races resulted in varied cocoon colours in the F2 and F3 generations exhibiting the desirable qualities of both the parents. The analysis of the rearing performance of some of these lines following inbreeding revealed a marked improvement in regard to the effective rate of rearing and hatchability over the parents. The possible mechanism of inheritance of the said traits are discussed

32. Sreerama Reddy, C., Ananthanarayana, S.R., 1984.

(Research and Development Programme in Sericulture, World Bank, Bangalore University, Bangalore 560 056, India)

Evolution of new multivoltine strain of silkworm, *Bombyx mori* L. with sex limited larval markings.

*Sericologia*, 24(3):434-435.

Abstract: At present, the females of multivoltine Mysore race are being used as female parent in the cross breeding programme with bivoltine race as male parent for the production of commercial seeds. Sexing the parents at the time of eclosion, involves a time consuming process and reflects on the economy, in the large scale production of hybrids seeds. The present investigation has been taken up to transfer w-chromosome with a translocated piece of 3rd chromosome from the bivoltine race (Zepere) where the female larvae carry Zebra markings, into the chromosomal complement of Mysore race. The hybrids of these parents were inbred upto 9 generations. In every generation, segregation with respect to the colour of the cocoon and hibernation features of the eggs were observed, in addition to the larval markings. The marked larvae were separated and the ones which spins yellow cocoons and moths rears for the next generation. By continuous selection it was possible to fix this trait in one of the sublines with multivoltine features which also shows a marked improvement in the commercial qualities such as cocoon weight, shell weight, shell percentage, denier and renditta, over the traditional pure Mysore race. The advantages of the large scale multiplication of this strain in commercial breeding is discussed.

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33. Hirabayashi, T., Fukazawa, M., Nakagawa, H., Takahashi, T., 1985.  
On the breeding of silkworm races, N146 and C147.  
Bulletin of the Sericulture Experiment Station, 29(6):853-876.  
Abstract: The breeds N146, C147 and N146 x C147 were suitable silkworm races for the spring rearing season. The sex of these races easily distinguished by skin patterns N146 has been bred from the offspring of hybridization between (13). This new race characterised by easy rearing heavy cocoon weight and high reelability, C147 has been bred from the offspring of hybridization between MN201 and MC201. This new race is characterised heavy cocoon and cocoon shell weights. Reelability and neatness good. N146 x C147 has pale blue skin but sometimes mixed with pale, red ones, during larval stage is similar to the N134 x C135. Cocoon are white, oval shaped and ordinarily wrinkled. The cocoon weight and yield cocoon shell weight are heavy cocoon filament weight heavy length of filament length degumming loss is low. The size cocoon filament is about 3.1 denier.
34. Huang, Z., 1985.  
On the breeding of new silkworm races "Zhelei" and "chunxiao" for spring rearing.  
Canye Kexue, 11(1):22.
35. Kamijyo, I., Nakajima, Y., Nakagawa, H., Fukazawa, M., 1985.  
On the breeding of the silkworm races N135 and C136.  
Bulletin of Sericulture Experiment Station, 29(4):499-531.
36. Song, C., 1985.  
The breeding of silkworm races "Qingsong" (Green Pine) and "Haoyue" (Bright Moon) for spring rearing.  
Canye Kexue, 11(4):205.
37. Datta, R.K., 1986.  
(Central Silk Board, Bangalore, India.)  
Mulberry silkworm breeding in India.  
In: Lectures on Sericulture, p.150-156.
38. Hasbullah, H.M., Mohd Yusof, N., 1986.  
(Institut Penyelidikan dan Kemajuan Pertanian Malaysia, Kuala Terengganu. Bahagian Penyelidikan Tanaman Pelbagai).  
Breeding of pure races of silkworm, *Bombyx mori* in Malaysia.  
Teknologi Pelbagai Tanaman, 2:75-79.
39. He, S., 1986.  
The breeding of mulberry silkworm race "532" and its polyway hybrid for summer-autumn rearing.  
Canye Kexue, 12(1):24.
40. Huang, L., 1986.  
Studies on the method of breeding silkworm strains that can resist to the disease of denonucleosis.  
Canye Kexue, 12(1):29.
41. Li, B., Chen, H., Wu, Y., 1987.  
(Institute of Sericulture, Guangdong Provincial Academy of Agricultural Sciences, Guangzhou, China)  
Breeding of 'Xin Nong Guang 3', a hybrid of mulberry feeding silkworm  
Guangdong Agricultural Sciences (China), 2:27-29.
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42. Ni, H., 1987.  
On techniques for breeding new silkworm variety Zhuhua to be reared in summer-autumn season.  
Canye Kexue, 12(4):208.
43. Kanda, T., Tamura, T., Inoue, H., 1988.  
(The Sericultural Experiment Station, Tsukuba, Ibaraki 305, Japan.).  
Feeding response of the silkworm larva to the LP-1 artificial diet designed by a linear programming method and its inheritance.  
Journal of Sericultural Science of Japan, 57(6):489-494.  
Abstract: In order to understand the genes concerning the feeding behaviour and develop the method of breeding the silkworm races that are suitable for the low cost artificial diet, feeding response to the low cost diet LP-1 designed by linear programming method was investigated on the newly hatched larvae of 46 parent strains. The results showed that several Japanese strains, for example, J01, J148, J147 and Sawa J, were able to be grown on the diet. However, no larvae in Chinese strains were found to be grown on the diet, and some larvae used were died rather quickly after food application, Feeding test of F1, F2 and BF1 larvae between the two strains with high and low feeding ability showed that the feeding is controlled by recessive genes. Moreover, the histogram of the larval weight of the F2 and BF1 individuals after food application implied that the feeding ability is determined by a major recessive gene and some modifiers.
44. Hong, K.W., Sohn, K.W., Ryu, K.S., Kim, K.M., Lee, S.P., Choi, S.R., Hwang, S.J., Kim, K.Y., Kwon, Y.H., 1988.  
(Sericultural Experiment Station, RDA, Suweon, Korea Republic)  
Breeding of 'Eunbaekjam', a new high silk-yielding silkworm variety for summer-autumn rearing.  
Research Reports of the Rural Development Administration, Agricultural Engineering and Farm Management, 30(3):119-124.  
Abstract: A new high-yielding variety of silkworm [*Bombyx mori*] is described. The variety resulted from a single cross hybrid between Jam 129 and Jam 130. The general combining ability of the parental lines was high for major characters such as cocoon shell weight and raw silk yield. The survival rate and cocoon yield of the new variety were 3 higher than those of Yangchujam. Also, the silk yield of the new variety was 8 higher than that of Yangchujam.
45. Hong, K.W., Sohn, K.W., Ryu, K.S., Kim, K.M., Choi, S.R., Hwang, S.J., Kim, K.Y., Lee, S.P., Kwon, Y.H., 1988.  
(Sericultural Experiment Station, Suwon, Korea Republic).  
Breeding 'Yonggangjam', a high-yielding silkworm [*Bombyx mori* L] variety for the spring-rearing seasons.  
Research Reports of the Rural Development Administration, Sericulture and Farm Products Utilization and Mycology, 30(2):12-17.
46. Sumida, M., Ishiko, S., Mori, H., Matsubara, F., 1988.  
Breeding of silkworm strains on an artificial diet by aseptic rearing techniques appropriate for production of a silk fiber paper from original silkworm strains which produce a silk fiber.  
Bulletin of the Apparel Science Research Center Kyoto Institute of Technology, 63(7):1-4.  
Abstract: A technique is investigated where silkworm spin on a flat surface to produce a paper of silk fibers. This research is developing a new area of silk fiber utilization, other than fabrics. The applicability of this new technique for producing silk fiber papers for interior decoration is examined. Effects of diet on original silkworm strains and a hybrid strain and their resultant spinning behavior are outlined along with the characteristics of the silk fiber paper.
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47. Hossain, M., 1989.  
(Bangladesh Agriculture University, Mymensingh, Bangladesh.)  
Silkworm breeding and selection of improved hybrid lines.  
In: Proceedings of the workshop on Bangladesh Agriculture University Research Progress, Bangladesh, 29-31 October, 1989, p.60-65.
48. Ishiko, S., Sumida, M., Mori, H., Matsubara, F., 1989.  
(Kyoto Institute of Technology, Japan)  
Breeding of a silkworm strain suitable for silk fiber paper production by mulberry rearing method.  
Kyoto Kogei Sen i' Daigaku Hokoku, 13:1-4.  
Abstract :Breeding a silkworm strain for silk fiber paper was studied using a mulberry leaf rearing method. An optimal number of silkworms were selected to evenly cover the flat surface of the paper. Two lines were selected, maintained, crossed, and reselected to achieve optimal processing.
49. Nacheva, I., 1989.  
(Sericultural Experiment Station, Vratsa 3000, Bulgaria.)  
Possibilities for using partial backcrossing in silkworm breeding.  
Genetikai i Selektsiya, 22(5):441-445(Russian).  
Abstract: In studies in Bulgaria, consecutive simple crosses and backcrosses were made between breeds 157-K and Hessa 2 of the silkworm [*Bombyx mori*L] that were uniform for 2 generations. Tests showed that the mean values for cocoon weight, silk shell weight, silkiness of the raw cocoons and thread length and output increased (with a few exceptions) in F1, were reduced in BC1 and BC2 and increased in BC3 up to the level of or surpassing the level for F1. A similar trend could be observed in the variance of the individual characters suggesting that BC3 is suitable for selection work. A heterosis effect was observed for nearly all characters, usually being greater in F1 and BC3 than in BC1 and BC2. Inheritance of cocoon weight, silk shell weight, silkiness of the raw cocoons and thread length was in nearly all cases superdominant with the better parent contributing more. The method of consecutive backcrosses could be used successfully both in improving old breeds and in developing new breeds and lines.
50. Nacheva, I., 1989.  
(Sericultural Experiment Station, Vratsa 3000, Bulgaria.)  
Correlations following use of partial backcrossing in silkworm breeding.  
Genetika i Selektsiya, 22(6):530-535(Russian).  
Abstract: In work in Bulgaria to improve breed 157-K of the silkworm [*Bombyx mori*] using the Hessa 2 breed as a meliorator, the correlations were studied between cocoon weight and silk shell weight, cocoon weight and fibre length, cocoon weight and laboratory fibre yield, shell weight and fibre length, length and laboratory fibre yield, and shell weight and laboratory fibre yield in the F1 generation and BC1, BC2 and BC3 populations. Phenotypical correlations between all the above pairs of characters were positive except in the case of cocoon weight and laboratory fibre yield, where the correlation was negative. Correlation coefficients between cocoon weight and shell weight were high in all selected populations. The coefficient between shell weight and laboratory fibre yield in BC3 was also high, while all other coefficients were medium to high in degree. Unidirectional trends towards a progressive reduction in coefficients with increasing saturation with Hessa 2 were observed for the relationships between cocoon weight and shell weight, cocoon weight and fibre length, cocoon weight and laboratory fibre yield, shell weight and fibre length, and the length and laboratory yield of cocoon fibre, and likewise towards an increase in the coefficient for the relationship between shell weight and laboratory fibre yield. The changes are probably the result of gene linkage or pleiotropic effects of the controlling genes.

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51. Rao, P.R.M., Vijayaraghavan, K., Singh, R., Premalatha, V., 1989.  
(Multivoltine Breeding Laboratory, Central Sericultural Research and Training Institute, Mysore 570 008, India)  
A note on the oily larval mutant in silkworm, *Bombyx mori* L.  
*Current Science*, 58(20):1155-1157.  
Abstract: In breeding studies on *Bombyx mori* L in June 1988, a spontaneous oily mutant larval form was found in a polyvoltine strain of the silkworm. The mutant was identified as the og mutant, which is situated on chromosome 9 at locus 7.4. Although the mutation has a deleterious effect, the cocoon characters of survivors were better than those of the normal form, and bred true.
52. Tamura, T., Kanda, T., 1989.  
(National Institute of Sericultural and Entomological Science, Tsukuba, Ibaraki 305, Japan.) Breeding of new stocks for low-cost artificial diet by introducing polyphagous genes into the silkworm, *Bombyx mori*.  
In: Proceedings of the 6th International Congress of SABRAO, pp.969-972.
53. Fang, F., Lu, Y., Huang, Z., 1990.  
(South China Agricultural University, Guangzhou, China)  
Study on the breeding of DNV [*Bombyx mori* densovirus] resistant silkworm breed III. Egg production for 'Kang 1 X Kang 2' and a farm survey.  
*Guangdong Sericultural Newsletter*, 1:24-28.
54. He, S., Xia, L., 1990.  
(Institute of Sericulture, Chinese Academy of Agricultural Sciences, Zhenjiang, Jiangsu, China).  
Breeding of the silkworm varieties "57A. 57B, 24.46" and their hybrids for both spring and autumn rearing.  
*Acta Sericologica Sinica*, 16(1):15-20.  
Abstract: Two restriction varieties of Chinese strain 57A, 57B and two varieties of Japanese strain 24, 46 have been respectively bred by means of oriented cultivation and strict offspring selection under different climate circumstances in spring, summer and autumn. Then, the hybrid from four elements, which is 57A.57B \* 24.46, has been selected and bred on the basis of hybrid preponderance. According to appraised results for many times, its output and economic value are 3 to 4 percent higher than those of CK. Furthermore the variety holds the advantages as follows: healthiness, unrestricted demanded to leaf quality, easy egg propagation and top silk quality. So it is a new fine race for both spring and autumn rearing.
55. Noamani, M.K.R., Sengupta, K., Nagaraju, J., Vijayaraghavan, K., Premalatha, V., Ravindra Singh., Rama Mohana Rao, P., 1990.  
(Central Sericultural Research and Training Institute, Srirampura, Mysore - 570 008, India)  
Breeding of multivoltine breeds of the silkworm, *Bombyx mori* L. for high cocoon and shell weight.  
*Indian Journal of Sericulture*, 29(2):227-232.  
Abstract: Six new multivoltine breeds evolved through hybridization and selection have been described. The characteristics of the new breeds are compared with pure Mysore (an indigenous race of Karnataka) as control. All the new breeds are superior to the control in all economic characters viz., cocoon weight, shell weight and cocoon shell ratio. However, no significant difference has been observed in survival rate.
56. Shao, Y., 1990.  
(Institute of Sericulture, Zhejiang Provincial Academy of Agricultural Sciences, Hangzhou, China).
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Breeding of a new silkworm variety "Fangshan x Xing.Ming" for autumn rearing.  
*Acta Sericologica Sinica*, 16(2):74-79.

57. Sohn, K.W., Hong, K.W., Hwang, S.J., Ryu, K.S., Kim, K.M., Choi, S.R., Kim, K.Y., Lee, S.P., 1990.  
(Sericultural Experiment Station, RDA, Suweon, Korea)  
Breeding of Samkwangjam, a F1 hybrid silkworm variety suitable for summer autumn rearing with the high silk yielding ability and a sex-limited parent.

Research Report of Rural Development Administration (Suweon), 32(2):1-6.

Abstract: Samkwangjam, the F1 hybrid silkworm variety between Jam 131, a Chinese parental line was newly bred to improve the resistance to silkworm diseases and the silk yielding ability and to reduce the labour required for the silkworm egg production. The general combining ability (GCA) of Jam 131 was high in the major quantitative characters, such pupation percentage, cocoon and raw silk yields GCA of Jam 132 was high in cocoon filament length and raw silk percentage. The local adaptability test in autumn, 1988 showed that the cocoon and raw silk yields of Samkwangjam were 5 and 6 higher than those of Daesongjam, the check variety. The new variety was less resistant to high temperature and humidity 30°C 85 but was more resistant to flacheric virus, one of the most serious silkworm disease and was adaptable to the silkworm artificial diet. Jam 132, the Chinese parental strain of Samkwangjam is a sex-limited larval marking line, which contribute to the production of quality F1 hybrid silkworm eggs with the less labour.

58. Xu, M., Song, C., 1990.

(Institute of Sericulture, Chinese Academy of Agricultural Sciences, Zhenjiang, Jiangsu, China).

Breeding of the silkworm varieties "Suhua", "Chunhui" and their hybrids for spring rearing.

*Acta Sericologica Sinica*, 16(1):5-13.

59. Aliev, A.G., Musaeva, M.R., 1991.

(Azerbaijan Scientific Research Institute of Silkworm Culture, USSR.)

New methods of increasing resistance of silkworm hybrids to nuclear polyhedrosis.

*Soviet Agricultural Sciences*, 12:34-35.

Abstract: A method was developed using provocation breeding in combination with antiviral treatment of the eggs with sodium bisulfite antiseptic to increase resistance in silkworms [*Bombyx mori*] to nuclear polyhedrosis virus disease.

60. Fan, K.Z., 1991.

(Shandong Provincial Institute of Sericulture, Jinan, China.)

Breeding of a new silkworm variety "Xuan 792".

*Acta Sericologica Sinica* (China), 17(2):106-107(Chinese).

61. Goldsmith, M.R., 1991.

(Department of Zoology, University of Rhode Island, Kingston, USA)

Silkworm breeding for the "90s": new molecular and genetic tools to meet the challenge of the tropics.

*Sericologia*, 31(1):145-155.

62. Haque, T., 1991.

(Bangladesh Sericultural Research and Training Institute, Rajshahi, Bangladesh).

Evolution of superior polyvoltine breeds of mulberry silkworm, *Bombyx mori* L. (II). Breeding of BSRI-88 series.

*Bulletin of Sericulture Research*, 2:26-34.

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Abstract: A Breeding experiment was conducted during 1985-88 with a view to evolve improved polyvoltine breeds of silkworm *Bombyx mori* L. with better economic parameters which can replace low yielding indigenes Nistari. For the above purpose, four inbred lines of multivoltine and one bivoltine (Indian) were utilized under four race breeding plans. In each plan females of multivoltine were crossed with bivoltine males and F1 generation females were backcrossed with the bivoltine male. It was possible to isolate three promising polyvoltine breeds viz. MVRB-1 MVRB-3 and MVRB-4 exhibiting better performance over traditional race in all respects in the 12th generation. The experiments were extended upto F16 generation and fixed for field trial. Depending on the satisfactory performance in the field these improved races were released in the extension for commercial rearing.

63. He, Y., Sima, Y.H., Jiang, D.X., Dai, P., 1991.

(Suzhou Institute of Sericulture, Suzhou, 215151 China)

Breeding of the silkworm varieties for summer and autumn rearing "Xuhua" "Qiuxing" and their hybrids.

Canye Kexue, 17(4):200-207.

Abstract: Adopting hybridization, back cross, line selection, fresh cocoon reeling and directive cultivation of several generations with high temperature and humidity, The Chinese silkworm strain "Xuhua" and the Japanese silkworm strain "Qiuxing" respectively, according to the climate of the Yangtze river valley during summer and autumn was bred. Both of them have the characters of high resistance high yield of silk, excellent quality of cocoon and silk and easy reproduction etc. Through several times identification in laboratory and country side and appraised by the national silkworm variety appraisal committee their F1 hybrids showed as follows: these two new varieties are strong and healthy, unisonant in hatching, molting, euviatiny and maturing. They have high yield of cocoon and silk, 22 percent cocoon shell ratio. 15-16 percent raw silk ratio of fresh cocoons, excellent quality of cocoons and silk. Its reelability percentage is 74 percent and neatness 95 marks, size of filament 2.53 deniers and cocoon filament length more than 1000 meters

64. Kanda, T., Tamura, T., 1991.

(National Institute of Sericultural and Entomological Science, Tsukuba, Ibaraki, Japan).

Breeding of new polyphagous silkworm [*Bombyx mori* L] stocks suitable for low-cost artificial diet.

Bulletin of the National Institute of Sericultural and Entomological Science,3:7-16.

Abstract: In order to breed polyphagous stocks of the silkworm, *Bombyx mori*, we investigated the feeding response of larvae to the LP-1 artificial diet, to which the lowest feeding response was recorded among the diets designed by a linear programming method. Then, we examined the mode of inheritance of the stocks by cross experiments, and attempted to breed new stocks for commercial use.

65. Mano, Y., Ohyanagi, M., Nagayasu, K., Murakami, A., 1991.

(National Institute of Sericultural and Entomological Science, Tsukuba, Ibaraki, Japan).

Breeding of sex-limited larval marking silkworm [*Bombyx mori* L] race, N147 x C145.

Bulletin of the National Institute of Sericultural and Entomological Science,2:1-29.

Abstract: (1) The Japanese parent race, N147, was bred in order to develop a suitable race for hybridization with the Chinese parent race, C145 which was authorized in 1979. The hybrid, N147 x C145, was authorized as a suitable silkworm race for the spring rearing season by the Ministry of Agriculture, Forestry and Fisheries in November, 1984. (2) N147 was obtained by cross-breeding from the offspring of a hybrid between N140 and ANS75. In this race the cocoon weight, cocoon shell weight and raw silk percentage are higher than those of N140. The size of cocoon filament is thick. The sexes of this race can be easily distinguished by body markings (marked: female, plain: male) in the fourth and fifth larval instars. (3) The N147 x C145 larvae have a pale blue skin with normal body markings in the female and plain body markings in the male. The duration of the larval period is almost the same as that

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of N134 x C135. The larvae are healthy. The color of the cocoon is white, the shape is oval though sometimes slightly constricted and bale like shape with ordinary wrinkle. The weight of the cocoon shell and the raw silk percentage of the cocoon shell are high. The cocoon filament is long and the neatness is good. The degumming loss is low and the size of the cocoon filament is about 3.0 denier.

66. Mano, Y., Asaoka, K., Ihara, O., Nakagawa, H., Hirabayashi, T., Murakami, M., Nagayasu, K., 1991.

(National Institute of Sericultural and Entomological Science, Tsukuba, Ibaraki, Japan).

Breeding and evaluation of adaptability of the silkworm, *Bombyx mori*, to the new low-cost artificial diet, LPY lacking mulberry leaf powder.

Bulletin of the National Institute of Sericultural and Entomological Science (Japan),3:31-56.

Abstract: The silkworm, *Bombyx mori* L is known to be a typical monophagous insect which eats only mulberry leaves. Therefore, artificial diets of the silkworm in the market contain a large quantity of mulberry leaf powder which accounts for a considerable part of the cost. Therefore, studies were carried out on the breeding of new commercial silkworm races in which larvae are able to eat a low cost diet, LPY containing feed for domestic animals and lacking mulberry leaf powder. A method was developed to select pure lines with spontaneous mutation genes related to the feeding activity toward the low cost diet, in avoiding to induce artificial mutations by radiation, and so on. We attempted to adapt these lines to the diet.

67. Nagaraju, J.; Noamani, M.K.; Ravindra Singh.; Premalatha, V.; Jolly, M.S.,1991.

(Central Sericultural Research and Training Institute, Mysore, India.)

Isolation of multivoltine strain with sex limited larval marking in silkworm *Bombyx mori* (Lepidoptera: Bombycidae).

In: Proceedings of the International Congress on Tropical Sericulture Practices, Bangalore, India, 18-23 February 1988., Part.4:71-76.

Abstract: A local polyvoltine race of Karnataka, Pure Mysore has been introduced with sex-limited larval markings from an inbred polyvoltine strain maintained in germplasm. F2 generation was backcrossed and subsequently inbred upto F9 generation. The strain was also tested for its hybrid forming ability with bivoltine males of KA, NB7 and NB18. Various economic characters such as differential viability of sexes, larval duration and other cocoon characters of both the inbred line and hybrids were studied. Economic utilization of this strain in sericulture industry is also discussed.

68. Subramanya, G., Sreerama Reddy, G., Krishnamurthy, N.B., 1991.

(Department of Zoology, University of Mysore, Mysore, India)

Utilization of different regional races for breeding superior bivoltine races of silkworm, *Bombyx mori*.

In: Proceedings of the International Congress on Tropical Sericulture Practices, Bangalore, India, 18-23<sup>rd</sup> February 1988, 4:85-92.

Abstract: The genomes of two available bivoltine strains KA and NB4D2 and two exotic races J111 of Japanese origin and E112 of European origin were used in breeding in order to extract the desired genotypes. By following selection pressure at every generation, isolated two sublines MV 281 and MV 287 exhibiting desired combination of genes for productivity and survival at the end of 12th generation. After 26 generations the sublines showed significant improvement of survival over the parents. The importance of inbreeding the hybrids and back crossing are discussed with respect to the evolution of superior races for regional climates.

69. Tazima, Y.,1991.

(Institute of Silkworm Genetics and Breeding, Amimachi, Japan.)

A view on the improvement of Mysore breeds.

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In: Proceedings of the International Congress on Tropical Sericulture Practices, Bangalore, India, 18-23 February 1988, Part.4:1-6.

Abstract: Many attempts have been made for improvement of Mysore breed through selection breeding. The author discusses his own selection procedure for improving Mysore breed through selection of character in direct and reciprocal cross. He also discussed the problem of voltinism and removal of flossyness and also suggests the possible participation of cytoplasm factors in improvement of breed.

70. Yamazaki, D., Kuwabara, N., Fujieda, T., 1991.

(Gunma-ken Sericultural Experiment Station, Maebashi, Japan).

On the breeding and characteristics of a silkworm [*Bombyx mori*] race "Sei.Ki x 2.1" with middle size cocoon filament.

Junma Journal of Agricultural Research Series B. Sericulture (Japan), 8:27-36.

71. Asaoka, K., Mano, Y., 1992.

(National Institute of Sericultural and Entomological Science, Tsukuba, Ibaraki, Japan).

Breeding of polyphagous silkworms [*Bombyx mori* L.] by early selection for feeding ability on LP-1 artificial diet.

Journal of Sericultural Science of Japan, 61(1):1-5.

Abstract: For the purpose of breeding polyphagous silkworm races which can be reared on low cost artificial diets, we selected several strains from breeding stocks using the feeding ability of newly hatched larvae on the LP-1 artificial diet as selection index. We confirmed the suitability of this selection method by investigating the properties of the selected strains in early generations. We observed a high correlation between the feeding ability of the newly hatched larvae and the 4th instar larvae on the LP-1 diet. The strains selected with the LP-1 diet showed an increase in the feeding ability on the semi-synthetic diet. However in some of them, the feeding ability on the LPY-5 diet was low. Feeding ability and effect of selection in most of the Chinese strains using the LP-1 diet were apparently lower and less conspicuous, respectively, compared with the Japanese strains, while the feeding ability of one Chinese strain, MCS26A, was markedly improved by selection with the LP-1 diet not only for the diet but also for the semi synthetic and LPY-5 diets. The feeding ability of the selected strains was mainly controlled by recessive genes and the feeding ability of the F1 hybrids between that of parents. We conclude from these results that the breeding of polyphagous silkworm races is possible by selecting newly hatched larvae with a high feeding ability on the LP-1 diet.

72. Brasla, A., Matei, A., 1992.

(Societatea Comerciala de Sericultura SERICAROM S.A., Bucuresti, Romania)

New silkworm hybrids to be used in spring breeding.

Medicina veterinara si cresterea animalelor (Romania), 11:12-14.

73. Chatterjee, S.N., Rama Mohana Rao, P., Jayaswal, K.P., Ramakrishna, S., Datta, R.K., 1992.

(Central Sericultural Research and Training Institute, Mysore, India.)

New breeding approaches to improve productivity through recombination breeding.

In: National Conference on Mulberry Sericulture Research, CSRTI, Mysore, Dec 10-11, 1992, pp.96.

74. Hong, K.W., Hwang, S.J., Ryu, K.S., Choi, S.R., Kim, K.Y., Lee, S.P., 1992.

(Sericulture Experiment Station, Rural Development Administration, Suwon, Korea Republic)

Breeding of Bunongjam, a high silk yielding silkworm variety for spring rearing season.

Research Reports of the Rural Development Administration, Farm Management, Agricultural Engineering, Sericulture, and Farm Products Utilization, 34(1):30-35.

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Abstract: A new variety of silkworm [*Bombyx mori*], 'Bunongjam', an F1 hybrid between Jam 133 (a Japanese race bred from 7611/J119) and Jam 134 (a Chinese race from M8452/8314), for the spring rearing season is described. The general combining ability (GCA) of Jam 133 is low in the major quantitative characteristics (such as percentage pupation, cocoon and raw silk yields), apart from cocoon filament length, while the GCA of Jam 134 is high in percentage pupation, cocoon and raw silk yields. A local adaptability test in spring 1991 showed that the cocoon and raw silk yields of Bunongjam were 10 and 14 greater than those of Chilbojam, the check variety. Bunongjam was more resistant to high temperature and humidity (30°C, 85 RH), but was less resistant to flacherie virus and was adaptable to artificial silkworm diet.

75. Jayaswal, K.P., Singh, T., Subbarao, G., 1992.

(Central Sericultural Research and Training Institute, Mysore, India)

Evolution of superior multivoltine breeds of silkworm *Bombyx mori* L for tropical regions.

Bulletin of Sericulture Research, 3:1-7.

Abstract: Breeding experiments were conducted to evolve improved multivoltine breeds of silkworm *Bombyx mori* L with better pre and post cocoon parameters which could replace Nistari for its qualitative and quantitative characters. It was possible to isolate two promising multivoltine breeds herein referred to as A-23 and A-25 exhibiting desired combination of genes for optimum productivity and survival ability at the end of 12th generation. These two breeds bred through over 19 generations revealed a significant ( $p < 0.01$ ) improvement over nistari race in regard to various economic parameters like cocoon and shell weight, shell ratio absolute silk content, average filament length, reelability and calculated yield/100 dfls both in favourable and unfavourable rearing seasons. Negative correlation between survival and cocoon character was not observed in A-25 during both the rearing seasons. Negative correlation between survival and cocoon character was not observed in A-25 during both the rearing seasons studied.

76. Liu, J., Cui, Y., Yu, Z., 1992.

(Shandong Provincial Institute of Sericulture, Yantai, China).

Breeding of silkworm variety for sex differentiation by using cocoon fluorescences.

Acta Sericologica Sinica, 18(4):258-259.

77. Midorikawa, E., Aso, T., Shirota, T., Kiyono, C., 1992.

(Institute of Silkworm Genetics and Breeding, Ami, Ibaraki, Japan)

Breeding and characteristics of a hybrid Asa.Hi x To.Kai for spring rearing.

Reports of the Silk Science Research Institute, Japan, 40:7-26.

78. Nagaraju, J., Rama Mohana Rao, P., Datta, R.K., Iyengar, M.N.S., Premalatha, V., 1992..

(Central Sericultural Research and Training Institute, Mysore, India).

Breeding and evaluation of a new polyvoltine breed of the silkworm, *Bombyx mori* L.

National Conference on Mulberry Sericulture Research, CSRTI, Mysore, Dec.10-11, 1992, pp.99.

79. Rajanna, G.S., Sreerama Reddy, G., 1992.

(Department of Zoology, University of Mysore, Mysore).

Breeding of a hardy bivoltine race of silkworm *Bombyx mori* L.

In: Abstracts of 4th All India Conference on Cytology Genetics and Symposium on Cytogenetics of Mulberry and Silkworm, KSSDI, Bangalore, Nov 5-7, pp.121.

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80. Hong, K.W., Ryu, K.S., Hwang, S.J., Kang, P.D., Lee, S.P., Choi, S.R., 1993.  
(Sericultural Experiment Station, RDA, Suwon, Korea Republic).  
Breeding of Tagwangjam, a double cross hybrid and high silk yielding silkworm variety for spring rearing season.  
RDA Journal of Agricultural Science, Farm Management, Agricultural Engineering, Sericulture and Farm Products, 35(1):795-799.  
Abstract: A new high-yielding silkworm [*Bombyx mori* L] variety, Tagwangjam, was bred for the spring rearing season with an improved egg rearing capacity. The variety arose from a double cross between Jam123XJam135 and Jam136XJam138. Tests showed that the cocoon and raw silk yields of Tagwangjam were 8 and 16 greater than those of the control, resp. The new variety, however, was less adaptable to artificial diet compared with the control.
81. Kalpana, G.V., 1993.  
(University of Mysore, Mysore, India).  
Breeding of superior races of silkworm *Bombyx mori* L. for tropical climates.  
PhD Thesis.
82. Liu, Q., Liu, X., Mu, Z., 1993.  
(Shandong Agricultural University, Taiwan, China).  
Breeding of a fluoride-resisting *Bombyx mori* variety--86A. 86B X 54A.  
Acta Sericologica Sinica (China), 19(4):232-234(Chinese).
83. Raju, P.J., Krishnamurthy, N.B., 1993.  
(Department of Studies in Zoology, Sericulture Section, University of Mysore, India).  
Breeding of two bivoltines, MG511 and MG512, of silkworm, *Bombyx mori* L., for higher viability and silk productivity.  
Sericologia, 33(4):577-593.  
Abstract: Breeding experiments were conducted to evolve new hardy bivoltine breeds of silkworm, *B. mori* L. by utilising two existing bivoltine races, NB4D2 and NB4D2 and NB7 and a multivoltine race, Pure Mysore. By inbreeding the hybrids of the above pure races combined with recurrent backcrossing and selection for productivity and viability at each and every generation, two hardy bivoltine breeds, one spinning white oval cocoons and the other white dumbbell cocoons, were isolated. These breeds, herein referred MG511 with Chinese racial features and MG512 with Japanese racial features, have been bred through over 35 generation and revealed significant improvements in regard to viability compared to the existing bivoltines. The overall performance of the evolved breeds with regard to viability and productivity as well as fibre technological characters is discussed emphasising their superiority over the existing bivoltine races in the field.
84. Wu, Y., Tu, Z., Zhang, X., 1993.  
(Department of Sericulture, Zhejiang Agricultural University, Hangzhou, China).  
Breeding of rich egg producing silkworm variety.  
Bulletin of Sericulture, 24(4):8-10.
85. Chen, H., Jin, Y., Huang, Z.X., Ruan, G.H., Yao, L.S., 1994.  
(Institute of Sericulture, Zhejiang Provincial Academy of Agricultural Sciences, Hangzhou, China).  
Breeding of new silkworm variety fanhera, Chunmei for spring rearing.  
Acta Sericologica Sinica, 20(1):26-29.  
Abstract: Chinese race FANHUA with sex-limited marking and Japanese race CHUNMEI. which are all much in weight of cocoon filament and good in quality both of cocoon and silk, have been bred by
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means of cross breeding, pedigree selection and flesh cocoon reeling lasting 10 years. According to the laboratory and countryside valuation in Zhejiang province, the F1 hybrid of these two races shows the characters of healthy and easily rearing, good cocoon and excellent silk, high larva-pupa rate and cocoon crop per 10,000 silkworms which are 5.6 and 13.7 higher than the check variety respectively, filament length which are 90.2m and 7.3m longer than the check variety respectively, and neatness of 93.42 points.

86. He, Y., He, S., 1994.

(Institute of Sericulture, Chinese Academy of Agricultural Sciences, Zhenjiang, Jiangsu, China).

Application of technique for inducing trimolter in breeding of silkworm (*Bombyx mori* L).

*Acta Sericologica Sinica*, 20(1):30-34(Chinese).

Abstract: The physiological active substance was used to induce the trimolter. Following the conventional breeding way, two Chinese and three Japanese cross combinations of *B. mori* were induced respectively by continuous and alternate generation feeding inductions. Without chemicals, F5 could return to 4th moulting after being continuously induced, selected and bred from F1 to F4. The combining ability test has been carried out for F4. The results show the quantitative character and morphological character of the continuous and the alternate generation inductions of F5 are similar to the control. Neither their genotypes nor their combining ability is affected by the feeding induction; the duration of all stars of the induced trimolter is three days shorter than that of the tetramolter as control; the cocoon weight and the cocoon shell weight decrease 30,35 respectively; the cocoon filament length and neatness are similar to those of the tetramolter, but its reelability is higher. Spring season excepted, in all the seasons the physique is stronger than that of the tetramolter; the induction of every race of trimolter shows an extraordinary high rate, it won't be affected by generation and races fed continuously.

87. Strunnikov, V.A., Strunnikova, L.V., Zvyagintseva, T.V., Razumova, O.V., 1994.

(N.K. Koltsov Institute Dev. Biol., Russias. Acad. Sci., Moscow, Russia.)

Breeding high-viable parthenogenetic clones of mulberry silkworms.

*Doklady Akademii Nauk*, 335(2):268-270.

88. Tribhuwan, S., Rao, G.S., 1994.

(Silkworm Seed Technology Laboratory, Carmelram Post, Kodathi, Bangalore, Karnataka 560 035, India)

A-23: new elite multivoltine silkworm genotype.

*Indian Textile Journal*, 104(9):28-30.

Abstract: A new strain of *Bombyx mori* L A-23, was produced from breeding with 3 multivoltine breeds (M2, Nistari and G). The new strain spun golden yellow elongated oval cocoons with good processing qualities.

89. Tsenov, P., 1994.

(Opitna Stantsiya po Bubarstvo, Shumen, Bulgaria.)

Improved technology of Silkworm breeding.

*Animal Breeding*, 48(6):25-26(Bulgarian).

90. Basavaraja, H.K., Nirmal Kumar, S., Suresh Kumar, N., Mal Reddy, N., Kshama Giridhar., Ahsan, M.M., Datta, R.K., 1995.

(Central Sericultural Research and Training Institute, Mysore)

New productive bivoltine hybrids.

*Indian silk*, 34 (2) : 5-9.

91. Eguchi, R., Shimazaki, A., Ichiba, M., Shibukawa, A., 1995.  
(National Institute of Sericultural Entomological Science, Tsukuba, Ibaraki, Japan)  
Breeding of the high yielding silkworm races "Shoho" [N02 x C02] and "Ohwashi" [N150 x C150].  
Bulletin of the National Institute of Sericultural and Entomological Science, (12):47-93.  
Abstract: The studies were focused on the development of basic silkworm races with a high ability for silk production. Two races were bred: N02 times C02, so-called "Shoho" and was N150 times C150, so-called "Ohwashi". The former race was registered by the Ministry of Agriculture, Forestry and Fisheries as a race characterized by a high production of silk in November, 1985, and the latter race was also registered as a race characterized by a high production of cocoon with long filament in February, 1987. The breeding history and their characteristics were as follows: 1. N02 race was selected from the progenies of the hybrid of the stock HN58, in which larvae showed favorable characteristics for rearing and displayed a long cocoon filament, and the stock HN87, which showed a high silk production ability. N02 race was well adapted to artificial diet, the young larval instar was comparatively short and silk production was high. 2. N150 race was selected from the progenies of the hybrid of HN87 race and N138 race, which belonged to the Japanese "Himeko" type and produced a comparatively heavy cocoon shell and a cocoon filament with high neatness. N150 race belongs to the "Himeko" type and shows a high silk production and a particularly high neatness. 3. C02 race was selected from the progenies of the hybrid of Banka, a race with good characteristics for rearing, and MC77, which was a stock characterized by a high production of silk and long cocoon filament with a high reliability. C02 race produced a high percentage of heavy cocoon shell, as well as a long cocoon filament and was suitable for hybridization with silkworm Japanese races. 4. C150 race was further selected from C02 race in order to develop a race with long cocoon filament. 5. In the process of breeding of N02 and N150 races, larvae that showed a high feeding activity like eating a soft mulberry shoot were selected. The N02 and N150 races consumed a large amount of feed, produced a heavy cocoon which the duration of the 5th instar larval period was comparatively short, resulting in superior silk production per day during the 5th instar. 6. The silk production per day of the 5th instar larva which was one of the selection markers, was well correlated with the characters of the cocoon weight, cocoon shell weight and length of cocoon filament, suggesting that this marker was suitable for the selection of races with a high production of silk. On the other hand, this marker was not correlated with the reliability percentage of cocoon and size of cocoon filament. At first, pupal weight was adopted as a selection marker and although it was correlated with silk production per day in the 5th instar larvae, the correlation with the reliability percentage of cocoon was negative. 7. Hybridization tests performed by using the diallel cross method showed that the crossing of N02 race times C02 race and of N150 race times C150 race resulted in optimum combinations in all the crossings.
92. Jayaswal, K.P., Ram Mohan Rao, P., Premalatha, V., Shanthi, R., Ahsan, M.M., Datta, R.K., 1995.  
(Silkworm Seed Project Centre, Mysore, India)  
Breeding of new polyvoltine breeds of the silkworm *Bombyx mori* L for rainfed areas.  
In: Current Technology Seminar on Mulberry and Silkworm Breeding and Genetic, Molecular Biology Agriculture, Sept 20-22, 1995, pp. 4.  
Abstract: A large portion of the sericulture track is characterised by rainfed condition without any assured irrigation facilities. Such conditions restricts the use of high yielding breeds. For such zones efforts should be made to marginally improve upon the yield accompanied with improvement of fibre quality. In order to breed improved polyvoltine strains, a few indigenous and exotic silkworms were hybridised and desired characters were selected in the inbred populations. Two breeds namely BL23 and BL25 were evolved after inbreeding and selection. New breeds are characterised by higher cocoon Wt. (>1.2g) shell Wt. (>20cg) and SR(15). Besides the new breeds showed higher heterotic values for the yield attributes when hybridized with bivoltine male parent NB4D2, than the control hybrid PM x C.nichi.

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New hybrids have recorded an yields of > 17Kg/10,000 larvae, >1.7g cocoon Wt. and > 18 SR compared to control hybrid (PM x C.nichi) performance of which is 11kg yield, 1.2g cocoon Wt. and 13 SR. The prospects of the new breeds and its hybrids in increasing the productivity in rainfed areas are discussed in the paper.

93. Kobayasi, K., Miki, M., Kouno, T., Kagawa, T., Kon, T., Kobayasi, A., Komazawa, A., Watanabe, Y., Nakajima, E., 1995.

(Saitama-ken Sericultural Experiment Station, Kumagaya, Japan).

The breeding and fabric characteristics of a new silkworm [Bombyx mori L] race "Iro x Dori" [Japan].

Bulletin of the Saitama Sericultural Experiment Station (Japan), 67:1-7.

94. Maribashetty, V.G., Sreerama Reddy, G., 1995.

(Department of Sericulture, University of Mysore, Mysore, India).

Breeding of a robust bivoltine line MU720 of silkworm, Bombyx mori L for tropics.

Sericologia, 35(2):203-213.

95. Pan, S.Y., Wang, M.L., He, S.M., 1995.

(Department of Biology, Xuzhou Teachers College, Jiangsu 221009, China).

A study on the breeding tactics and path analysis of yield components of the domestic silkworm [Bombyx mori L] in different seasons.

Hereditas, Beijing, 17(2):23-25.

96. Rama Mohana Rao, P., Premalatha, V., Sudha, V.N., Jayaswal, K.P., Ahsan, M.M., Datta, R.K., 1995.

(Central Sericultural Research and Training Institute, Mysore, India).

Breeding of new polyvoltine breeds of the silkworm Bombyx mori L for irrigated areas.

In: Current Technology Seminar on Mulberry and Silkworm Breeding and Genetic, Molecular Biology Agriculture, Sept 20-22, 1995, pp.3.

Abstract: In India more than 90 of the silk production comes from the hybrids of polyvoltine and bivoltine strains. Pure Mysore females are generally crossed with bivoltine males in the preparation of cross breed in South India. Pure Mysore race is characterised by longer larval duration and poor quantitative traits. To improve upon the productivity in polyvoltines and cross-breeds, indigenous and exotic parents were selected based on the GCA values and hybridised. Selections for desired traits were carried out at different stages of breeding. After few generations of inbreeding coupled with selection, two new productive polyvoltine breeds, BL24 and BL26 were evolved which have higher cocoon Wt. (>1.2g) shell Wt.(>20 cg) and SR(>16) compared to pure Mysore performance of 1g, 14cg and 14 respectively. The new breeds were crossed with bivoltine male parent NB4D2, the resultant F1 hybrids have shown higher yield/10,000 larvae (>18kg), cocoon Wt.(>35 cg) and SR(>1.8g) with less renditta (8.9). In the present paper, the performance of new breeds and its hybrids are compared with control hybrid and discussed. The prospects of the new hybrids in raising productivity in irrigated areas are also discussed.

97. Ratna Sen, Patnaik, A.K., Maheshwari, M., Nataraju, B., Datta, R.K., 1995.

(Central Sericultural Research and Training Institute, Mysore, India.)

An approach towards development of NPV tolerant silkworm breeds.

In: Current Technology Seminar on Mulberry and Silkworm Breeding.

Abstract: Extensive survey studies taken up so far have proven that the prime causes of unstable cocoon crops of majority of our sericultural farmers are poor adoption of disinfection practices for maintenance

of hygienic condition during rearing of silkworm. Development of breeds with resistance to pathogen load prevailing in the field (field resistance) could undoubtedly be a sure way out in context to the backward socio economic condition of Indian Sericultural farmers. Unlike other viral pathogens of silkworm, nuclear polyhedrosis virus (NPV) has so far deluded any concrete clues to its successful tackling by silkworm geneticists and breeders. However, results achieved so far from a fresh approach in this direction reveals some important information for the breeders to work upon. A careful screening of the representatives from a wide germplasm collection not only showed the genetic diversity in tolerance to the pathogen but also hints to a biochemical marker for specific response. Results also show the possibility of obtaining silkworm breeds of higher tolerance to NPV. Estimation of such pathogen loads, selection modalities for parents and progeny during a short term approach of breeding for NPV tolerance and the current status are discussed.

98. Sumalee, T., 1995.

Breeding and selection of polyvoltine silkworm, (BPY1), *Bombyx mori* L.

Silk News, Bangkok, Thailand, 84.

Abstract: Taiwan commercial bivoltine hybrid and the polyvoltine inbred lines were selected as the genetic source of materials for the interbreeding and selection of a new silkworm line with high yellow silk gain and polyvoltine trait. The experiment was carried out for 13 consecutive generations from 1990-1992. The percentage of moth laying non-hibernating eggs was varied from 8.13 to 99.35 percent in the F1 to the F9 generation. Finally this trait was fixed from the F10 generation onwards while that of the yellow cocoon color had been fixed since F6 generation. To reach the desired cocoon shape was exceptionally difficult, the line still retained the variable shape even at the F13 generation. From the F13 generation onwards, the line was referred to as the BPY1 with the 1.09 g of cocoon weight, 0.18 g of shell weight, 16.38 percent of shell percentage, 776.50 m of filament length and 2.03 denier of filament size. Results of combining ability revealed that highly significant difference in the means, the GCA value as well as SCA value of all studied traits. This experiment presented that both additive and non additive genes affected the expressed performance by which non additive gene played the major role and had a maternal effect on ten fullgrown larval weight. Most of the hybrids showed positive heterosis over mid parents. In comparison with the polyvoltine silkworm parents, BPY1 was a good combiner for yield component, as most of its hybrid showed high performance. The vitality of the lune, however was inferior to TH14.

99. Tajima, Y., Ohnuma, A., 1995.

(Institute of Silkworm Genetics and Breeding, Ami, Ibaraki, Japan.)

Preliminary experiments on the breeding procedure for synthesizing a high temperature resistant commercial strain of the silkworm, *Bombyx mori* L.

Reports of the Silk Science Research Institute (Japan), 43:1-16.

100. Yamamoto, T., Mase, K., Enokijima, M., 1995.

(National Institute of Sericultural and Entomological Science, Tsukuba, Ibaraki, Japan).

Breeding of polyphagous silkworm [*Bombyx mori*L] races with a thin cocoon filament.

Bulletin of the National Institute of Sericultural and Entomological Science (Japan), 15:47-62.

Abstract: The project was initiated in order to breed polyphagous silkworm races with a thin cocoon filament. This character was successfully introduced in the polyphagous silkworm race. Further more, attempts were made to carry out a genetical analysis of the feeding response of silkworm larvae to the LPY-141 diet lacking mulberry leaf powder for the 4th instar and also differences in the feeding response of polyphagous larvae to the LPY-141 diet between sexes was studied. Then linkage analysis of the filament size was performed.

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101. Kee, W.H., Kang, S.R., Hwang, S.J., Sohn, B.H., Kang, P.D., Choi, S.R., Seol, K.Y., Lee, S.P., Kim, K.M., 1996.

(National Sericulture and Entomology Research Institute, RDA, Suwon 441 707, Korea).

Breeding of Kumokjam, an artificial diet adaptable silkworm variety, for spring rearing season.

RDA Journal of Agricultural Science, 38(2):801-805.

Abstract: The Kumokjam mulberry variety was evaluated as an adaptable diet for spring rearing silkworms (*Bombyx mori* L.). Kumokjam gave a 4 percent increase in raw silk production compared to other established mulberry varieties.

102. Malinova, K., Nacheva, J., Petkov, N., 1996.

Application of androgenesis in silkworm (*Bombyx mori* L.) breeding.

Agricultural Science, 34(4):34-36.

Abstract: The possibilities for developing bisexual homozygous silkworm lines by use of consecutive backcrosses and adaptation of certain methods of androgenesis are discussed in the article. The conclusion is substantiated that thermic treatment of silkworm eggs at 42°C and exposition 210 min is appropriate for producing androgenic individuals, forefathers of androgenic lines.

103. Ryu, K.S., Lee, S.P., Hong, K.W., Kang, P.D., Sohn, B.H., Choi, S.R., Seol, K.Y., Kang, S.W., 1996.

(Sericultural Experiment Station, RDA, Suwon, South Korea).

Breeding of Sekwangjam, a fine silk yielding silkworm variety for spring rearing season.

RDA Journal of Agricultural Science, Farm Management, Agricultural Engineering, Sericulture, Mycology and Farm Products Utilization, 36(2):716-721.

Abstract: New demands for cocoon filament size were proposed recently in order to develop fashionable silk fabrics, fine and thick cocoon silk are required as new materials. A variety Sekwangjam of [*Bombyx mori*] was bred to produce fine silk for hybrid silk/synthetic fibres. This variety (for the spring season) is an F1 hybrid between the Japanese race Jam301 and the Chinese race Jam302. Local adaptability tests at 9 places in spring 1993 revealed that the filament size and filament length of the new variety were 2.31 d and 1985m, respectively. Sekwangjam was more resistant to unfavourable rearing conditions but less resistant to flacherie virus, and not adaptable to artificial silkworm diet. The robustness of parental lines of Sekwangjam was high and their fecundity was considered to be good.

104. Haque, M.T., 1997.

(Bangladesh Sericultural Research and Training Institute, Rajshahi, Bangladesh).

Breeding of high yielding silkworm races, *Bombyx mori* L.

In: Proceedings of Seminar on Sericultural Development Technology, BSRTI, Rajshahi, 1995, 43-54.

105. Eguchi, R., Hara, W., Shimazaki, A., Hirota, K., Ichiba, M., Ninagi, O., Nagayashu, K., 1998.

(National Institute of Sericultural Science and Entomological Science, Tsukuba, Ibaraki, Japan).

Breeding of the silkworm [*Bombyx mori* L.] race "Taisei" non-susceptible to a densovirus type 1.

Journal of Sericultural Science of Japan, 67(5):361-366.

Abstract: The No.908 strain of the silkworm, *Bombyx mori* L., has a dominant gene, *nid-1*, in homozygous, which controls the non-susceptibility of the silkworm to densovirus type 1 (DENV-1). To establish a silkworm race, non-susceptible to DENV-1, the *Nid-1* gene was introduced to a practical race, N 150: the F1 hybrid of N 150: the F1 hybrid of N 150 x No.908 was recurrently backcrossed with N 150 for several generations and individuals having heterozygous *Nid-1* (*Nid-1/+*) were ascertained in every generation as survivors of the oral inoculation of DENV-1. In the 6th generation of backcrossing, *Nid-1/+* individuals were sib mated to establish a strain having homozygous *Nid-1*. In the subsequent

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generation, the progeny was exposed to DNV-1, and the survivors, whose genotypes was supposed to be Nid-1 or nid-1/+, were further sib mated. Some males which had been used mating were also mated with female of the susceptible race to test whether the genotype of the male is homozygous Nid-1 or not. In the 2nd generation of the sib mating with males which had been ascertained to have homozygous Nid-1, a progeny line produced all of batches containing only non-susceptible larvae was determined to be the strain with homozygous Nid-1. After improvement in economic characters for several generations, the strain with homozygous Nid-1 was established as the practical race, N 203, non-susceptible to DNV-1. The cross, N 203 x C 150, was authorized by the Minister of Agriculture, Forestry and Fisheries in March 1996, as the commercial silkworm race named "Taisei" for spring rearing.

106. He, Y.Y., He, S.M., 1998.

(Sericultural Research Institute, Chinese Academy of Agricultural Sciences, Zhenjiang, China)

Breeding a dominant trimolter 953 with sex limited marking.

*Sericologia*, 38(2):225-236.

107. Kang, P.D., Kim, K.M., Sohn, B.H., Ryu, K.S., Hong, K.W., Woo, S.O., Kim, S.H., 1998.

(National Sericulture and Entomology Research Institute, RDA, Suwon, Korea Republic).

Breeding of "Chungangjam", a high silk yielding new silkworm variety for spring rearing season.

*RDA Journal of Industrial Crop Science (Korea Republic)*, 40(1):75-79.

Abstract: Chungangjam (Jam 303 x Jam 142) was authorized as a new commercial F1 hybrid silkworm (*Bombyx mori*) variety for spring rearing in December 1997. Jam 303, the Japanese parent of the new hybrid variety, showed high GCA in single cocoon weight, cocoon shell weight, cocoon shell percentage, cocoon yield and raw silk yield, and Jam 142, the Chinese parent, showed high GCA in pupation percentage, single cocoon weight, cocoon shell weight, cocoon yield and reliability. In a local adaptability test performed at six areas in spring 1997, Chungangjam recorded 6 percent higher cocoon yield and 5 percent higher raw silk yield than the check variety, Bunongjam. Also in a resistance test to unfavourable rearing conditions, Chungangjam had 10 percent lower pupation than the check variety, but 6 percent higher single cocoon weight.

108. Lea, H.Z., 1998.

(Kangwon National University, Department of Biology, Chunchon, Korea Republic).

Breeding of bivoltine silkworm hybrids DPO308 and DPO314 in Sri Lanka: A simplified but practical approach.

*Korean Journal of Sericultural Science (Korea Republic)*, 40(2):97-104

109. Nacheva, J., Petkov, N., 1998.

Successful breeding and improvement work with silkworm at the experimental station of sericulture, Vratsa.

*Agricultural Science*, 36(1):27-30,

Abstract: A review is made of the successful results and the problems of the breeding and improvement work with silkworm during the 100-year existence of the Experimental station of Sericulture in Vratsa. More than 200 breeds and hybrids have been developed, which made possible six changes of breeds.

110. Sarker, D.D., 1998.

*Silkworm: Biology and Genetics and Breeding*.

Vikas Publishing House, New Delhi, pp.338.

111. Sreerama Reddy, G., 1998.

*Silkworm Breeding*.

Oxford and IBH, New Delhi.

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In: Proceedings of the National Seminar on Silkworm Breeding, March 18-19, 1994, pp.354.

112. Tzenov, P., Nacheva, Y., Petkov, N., 1998.

(Sericultural Experiment Station, Vratza, Bulgaria)

On the problem of cocoon colour segregation in crosses between uni-bivoltine and multivoltine silkworm, *Bombyx mori* L. races.

Bulgarian Journal of Agricultural Science, 4(4):471-479.

Abstract: The F1, F2, F3, RF1 and second RF1 crosses between the uni-bivoltine Bulgarian stocks Super 1 and Hessa 2 having white cocoons and the Tropical multivoltine race Bonde 517 with yellow green coloured have been used in the study. The results obtained manifested that the character coloured cocoons dominated over the character white cocoons in F1. In the F2 the segregation was 3 part coloured and 1 part white cocoons. Cocoons with pure colour without any nuances can be selected for the breeding purposes in F2, F3, RF1, F2 of RF1 and second RF1 without any danger to appear segregation in the following generation.

113. Yamamoto, T., Mase, K., Okada, E., Ishibashi, J., Itsubo, T., Tanaka, Y., Ooi, H., 1998.

(National Institute of Sericultural and Entomological Science, Tsukuba, Ibaraki, Japan).

Breeding of polyphagous silkworm races having high cocoon quality.

Bulletin of the National Institute of Sericultural and Entomological Science, 20:47-58.

Abstract: The project was initiated in order to breed polyphagous silkworm races with a high cocoon quality. A diallel cross among ten strains was carried out. The parents and F1 larvae were reared on the LPY-141 artificial diet (lacking mulberry leaf powder) and the percentages of the larvae normal developed to the second instar were calculated (the percentage is referred to as feeding response in this summary). Selection of a new hybrid was carried out in cooperation with the research team of Institute of silkworm Genetics and Breeding, Dainippon Silk Foundation. Practical traits of two polyphagous hybrids were also investigated for the estimation of their value as commercial races.

114. Li, S., Xu, H., Huang, C., Lu, Z., Zhao, Z., Huang, D., 1999.

(Anhui Sericultural Research Institute, Hefei, China.)

Breeding of wan 5 and Wan 6 silkworm varieties for spring rearing.

Canye Kexue, 25(1):11-15.

115. Li, S., Ling, C., 1999.

(Sericultural Research Institute, Anhui Academy of Agriculture Science, Hefei, China).

Breeding of silkworm new variety Jiu.Hua X Chun.Zao.

Canye Kexue, 25(3):144-148.

116. Mundkur, R., Murthy, M., Nagabhshana Gupta, K.N., Rao, S.K., Raghuraman, R., Dandin, S.B., 1999.

(Karnataka State Sericulture Research and Development Institute, Bangalore, India).

Breeding of sex limited polyvoltine strain, SL-KSPM in silkworm, *Bombyx mori*.

In: Abstracts of the Eighteenth International Sericultural Commission Congress Sessions, Agricultural Research Centre, Ministry of Agriculture, Cairo, Egypt, 1:18

117. Nacheva, Y., Petkov, N., Tzenov, P., Mallinova, K., Chun, G.S., 1999.

(Sericulture Experiment Station, 24, Mito Orozov, Vratza, Bulgaria).

Breeding of bisexual lines of the silkworm *Bombyx mori* L. with androgenic origin.

Bulletin of Indian Academy of Sericulture, 3(1):36-41.

118. Naseema Begum, A., Ahsan, M.M., Datta, R.K., 1999.  
(Central Sericultural Research and Training Institute, Mysore, India).  
Breeding of the two bivoltines, A3 X 935 E and A3 X 916B of silkworm *Bombyx mori* L. for higher survival and moderate silk productivity.  
*Korean Journal of Sericultural Science*, 41(2):94-101.
119. Nirmal Kumar, S., Mal Reddy, N., Basavaraja, H.K., Ramesh Babu, M., Suresh Kumar, N., Ahsan, M.M., Datta, R.K., 1999.  
(Central Sericultural Research and Training Institute, Mysore, 570 008, India.)  
Identification of bivoltine double hybrids for commercial exploitation.  
*Indian Journal of Sericulture*, 38(2):135-139.  
Abstract: Identification of suitable bivoltine double hybrid with productive traits for commercial exploitation was envisaged in view of the advantages of rearing and increased fecundity (13). Based on heterosis for pupation rate and fecundity (egg yield), twenty-one promising foundation crosses involving the productive bivoltine pure breeds have been identified and tested for double cross combinations. A total number of 110 double hybrid combinations were evaluated based on per se performance, cocoon uniformity test, post cocoon parameters, multiple trait evaluation index and heterosis for cocoon yield and cocoon weight. Subsequently, six double hybrid combinations were short listed. Among the six, two double hybrids viz., (CSR6 X CSR26) X (CSR2 X CSR 27) and (CSR6 X CSR20) X (CSR21 X CSR29) were identified for commercial exploitation on the basis of high evaluation indices for economic traits i.e., pupation rate, cocoon yield, silk recovery and filament length.
120. Sen, R., Ahsan, M.M., Datta, R.K., 1999.  
(Central Sericultural Research and Training Institute, Mysore, 570 008, India)  
Induction of resistance to *Bombyx mori* nuclear polyhedrosis virus, into a susceptible bivoltine silkworm breed.  
*Indian Journal of Sericulture*, 38(2):107-112.  
Abstract: In view of the inadequate disinfection and prevalence of unhygienic conditions in the rearing areas, the use of disease resistant silkworm varieties can be a better option. In this direction, an attempt has been made to introduce the resistance to *Bombyx mori* nuclear polyhedrosis virus (BmNPV), into a susceptible bivoltine silkworm breed-KA, by cross breeding with a resistant silkworm breed - g133 and exposing the subsequent progenies to BmNPV, followed by the selection of the individuals from the surviving batches. After nine generations of exposure to BmNPV and selection of survivors, the evolved strain DR-1 exhibited ten times more LC50 for BmNPV as compared to the control, KA. The economic characters of both the breeds almost on par. The resistance ratio of the evolved strain, DR-1 is 5.18. The scope of the disease resistance breeding and the method of breeding process are discussed.
121. Shekarappa, B.M., Radhakrishna, P.G., Keshavareddy, K.S., Dandin, S.B., 1999.  
(Karnataka State Sericultural Research and Development Institute, Thalaghattapura, Bangalore, India).  
Breeding of bivoltine silkworm races with better survival and high shell content for tropics- Karnataka.  
*Sericologia*, 39(2):205-210.
122. Tibiletti, E., 1999.  
Silkworm breeding- a simple but profitable activity.  
*Terra-e-Vita*, Italy, 40(17):87-89 (Italian).
123. Yamamoto, T., Mase, K., Nagasaka, K., Okada, E., Itsubo, T., Miyajima, T., Enokijima, M., Kumai, T., Izumi, S., 1999.  
(National Institute of Sericultural and Entomological Science, Tsukuba, Ibaraki, Japan)

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Breeding of the silkworm [Bombyx mori] race, Hakugin, with super thin cocoon filament.  
Journal of Sericultural Science of Japan, 68(2):125-132(Japanese).

Abstract: The project was executed to breed a silkworm race with super thin cocoon filament. After improvement the size of cocoon filament and the other economical characters for several generations, the two strains were established as the practical race, C514 and C515, having super thin cocoon filament about 1.8 and 1.5 denier in size, respectively. The C514 was bred by cross breeding from the offspring of crossing among TC14, CS31 and C511 strains. This race has polyphagous, and is also characterized by sex-limited larval marking (marked: female, plain: male).

124. Ashwath, S.K., Morrison, M.N., Datta, R.K., 2000.

(Central Sericultural Research and Training Institute, Mysore, India).

Evolution of bivoltine silkworm breeds by amylase isozyme selection and evaluation of hybrids.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, pp.17.

Abstract: Earlier work on biochemical parameters has clearly indicated the prospects of using digestive amylase as a marker in silkworm breeding because of its wide genetic diversity, role in better digestibility and close association with high survival. With the objective of evolving productive bivoltine breeds with higher viability, a breeding scheme was designed using indigenous polyvoltine breeds like Pure Mysore and Nistari with '4/5 band' amylase types as Donor Parents (DPs) and productive bivoltine breeds like NB18, CSR2 and CSR5 having 'Null' type of amylase as Recurrent Parents (RPs). Near Isogenic Lines (NILs) of the RPs were evolved by isozyme selection of the DP type followed by backcrossing in each generation with RPs up to BC10.

125. Das, S.K., Moorthy, S.M., Rao, P.R.T., Sen, S.K., Saratchandra, B., 2000.

(Regional Sericultural Research Station, Kalimpong, Darjeeling, India).

Breeding bivoltine silkworm varieties of Bombyx mori L. for rearing under adverse climatic conditions.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, pp.19.

Abstract: Due to change in socio-economic characteristics caused by rapid industrialization, scarcity of cultivable land, competitive cash crops, labour cost, and production of raw silk has been reduced in many advanced countries. On the other hand, in many Asian countries like India, sericulture is still an attractive viable activity with favourable socio-economic characteristics mainly due to domestic demand and export of finished products.

126. Datta, R.K., 2000.

(Central Sericultural Research and Training Institute, Mysore, India)

Silkworm breeding in India. Present status and new challenges.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Mysore, India, 16-18, November 2000 (Lead papers), 12-20.

127. Datta, R.K., 2000.

(Central Sericultural Research and Training Institute, Mysore, India)

Advances in silkworm breeding and genetics in India.

In: Proceedings of the National Seminar on Tropical Sericulture 1999, University of Agricultural Sciences, Bangalore, India, 28-30 December, 1999, 4:11-23,

128. Datta, R.K., Basavaraja, H.K., Mal Reddy, N., Nirmal Kumar, S., Ahsan, M.M., Suresh Kumar, N., Ramesh Babu, M., 2000.

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(Central Sericultural Research and Training Institute, Mysore, India.)

Evolution of new productive bivoltine hybrids CSR<sub>2</sub> x CSR<sub>4</sub> and CSR<sub>2</sub> x CSR<sub>5</sub>.

Sericologia, 40(1):151-167.

Abstract : With an objective of evolving robust bivoltine breeds/hybrids of silkworm *Bombyx mori* L., for tropical conditions, breeding programme was undertaken by utilizing two Japanese hybrids namely Shunrei x Shogetsu, BN<sub>18</sub> x BCS<sub>25</sub> and an Indian popular bivoltine breed, NB<sub>4</sub>D<sub>2</sub>. The breed CSR<sub>2</sub> spinning white oval and CSR<sub>5</sub> spinning white dumbbell cocoons were isolated from Japanese commercial hybrid Shunrei x Shogetsu through repeated inbreeding coupled with selection, while CSR<sub>4</sub> spinning white dumbbell cocoons was evolved from Japanese hybrid BN<sub>18</sub> x BCS<sub>25</sub> crossed to NB<sub>4</sub>D<sub>2</sub>. After fixation, these breeds along with other newly evolved breeds were subjected for hybrid study using large number of hybrid combinations in the laboratory and evaluated by Evaluation Index method. The hybrids viz., CSR<sub>2</sub> x CSR<sub>4</sub> and CSR<sub>2</sub> x CSR<sub>5</sub> were found promising. The hybrids CSR<sub>2</sub> x CSR<sub>4</sub> and CSR<sub>2</sub> x CSR<sub>5</sub> recorded survival of 96.5 and 97.1% shell weight of 46.5 and 48.7cg, shell ratio of 23.5 and 24.1% raw silk percentage of 20.0 and 20.5% filament length of 1147 and 1278m and renditta of 5.0 and 4.9kg, respectively, whereas the control hybrid (KA x NB<sub>4</sub>D<sub>2</sub>) has recorded survival of 93.8%, shell weight of 40.7cg, shell ratio of 20.5%, raw silk percentage of 17.2%, filament length of 1035m and renditta of 5.8. The new hybrids showed neatness of above 94.4p as against 93.3p in control hybrid. These hybrids were authorized for commercial exploitation during 1997 by Central Silk Board based on the results obtained from 10 test centers located at various regions.

129. Datta, R.K., Basavaraja, H.K., Mal Reddy, N., Nirmal Kumar, S., Ahsan, M.M., Suresh Kumar, N., Ramesh Babu, M., 2000.

(Central Sericultural Research and Training Institute, Mysore, India.)

Evolution of new productive bivoltine hybrids CSR<sub>3</sub> x CSR<sub>6</sub>.

Sericologia, 40(3):407-416.

Abstract : Earlier breeding experiments (1970's) have yielded productive hybrids with a cocoon shell ratio of 18% at commercial level. These hybrids have not made much impact in the field. There is a need to shift production to superior quality and quantity of silk. The experience with bivoltine silk production, on the whole is not very encouraging. Farmers have not realized bivoltine hybrid rearing as very remunerative and rewarding. Keeping this in view, reorientation in breeding approaches has been envisaged. Of late, the adoption of bivoltine sericulture in India gathered momentum being armed with the evolution of a good number of robust and productive bivoltine breeds/hybrids of silkworm, *Bombyx mori* L. for tropical condition. The breeding work was initiated in this Institute by utilizing two Japanese hybrids namely BN<sub>18</sub> x BCS<sub>25</sub> and Shunrei x Shogetsu along with Indian evolved breed, CCI. The breed CSR<sub>3</sub> which is characterized with sex-limited larval marking and white oval cocoons was evolved from the Japanese hybrid BN<sub>18</sub> x BCS<sub>25</sub> by crossing with CCI, while the breed CSR<sub>6</sub> which is characterized with normal marking (marked larvae) and white dumbbell cocoons was extracted from the Japanese commercial hybrid Shunrei x Shogetsu through continuous inbreeding coupled with selection. After fixation, these breeds along with other newly evolved breeds were subjected for hybrid study under optimum environmental conditions in the laboratory for expression of full potential of the genotypes. These hybrids were evaluated by the Evaluation Index Method (Mano et al., 1993). Seven productive hybrids were shortlisted and the hybrid CSR<sub>3</sub> x CSR<sub>6</sub> is one among them. The hybrid CSR<sub>3</sub> x CSR<sub>6</sub> recorded a survival of 94.1%, a shell weight of 50.2cg, a shell ratio of 24.5%, a raw silk percentage of 19.8, a filament length of 1295m and a renditta of 5.1. On the other hand, the control hybrid (KA x NB<sub>4</sub>D<sub>2</sub>) has recorded a survival of 90.6%, a shell weight of 42.1cg, a shell ratio of 20.4%, a raw silk percentage of 15.9, a filament length of 999m and a renditta of 6.3. The hybrid CSR<sub>3</sub> x CSR<sub>6</sub> was authorized by the Central Silk Board in the year 1999 for commercial exploitation during favourable months.

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130. Kalpana, G.V., Kishore Kumar, C.M., Datta, R.K., Ramesh Babu, M., Nirmal Kumar, S., Palit, A.K., 2000.

(Central Sericultural Research and Training Institute, Mysore, India)

Selection of silkworm hybrids in relation to length and size of cocoon filament in *Bombyx mori* L.

In: Proceedings of the National Seminar on Tropical Sericulture 1999, University of Agricultural Sciences, Bangalore, India, 28-30 December, 1999, 2:14-16.

Abstract: An attempt has been made to select suitable silkworm breeds for thin denier and longer filament length to improve the quality aspects of silk. Nine breeds were chosen and subjected to single cocoon cold reeling, followed by directional selection of progenative individuals for the desired denier, (2.2) and longer filament length (1300 m) for over 10-12 generations. Among the nine breeding lines, JPN7, JPN8 and B63 have shown positive selection response for filament length and filament size. Among the fifteen hybrids studied, three hybrids viz., JPN7 x B63 (FL -1433m and D -2.28d), MBC2 x B63 (FL -1399m and D-2.15d) and JPN8 x B63 (FL -1322m and D -2.24d) were adjudicated as the superior hybrids for longer filament and thin denier.

131. Lakshmanan, V., Jayaswal, K.P., Sudhakaran, M., Kamble, C.K., 2000.

(Regional Sericultural Research and Training Institute, Coonoor, Tamil Nadu, India).

Synthesis of breeds with shorter larval duration and productive traits of bivoltine silkworm, *Bombyx mori* L.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, pp.26.

Abstract: In the field, the pathogen-load is usually high because of continuous rearings and improper disinfection particularly in South Indian States. In such cases, the pathogen-load in the rearing houses progresses linearly against the time lag, if silkworm breeds/hybrids have longer larval duration. Besides, such breeds/hybrids demand with shorter larval duration which will minimize problem. In view of the above, a breeding plan was initiated at this centre to develop productive bivoltine breeds/hybrids with shorter larval duration.

132. Mal Reddy, N., Basavaraja, H.K., Kalpana, G.V., Joge, P.G., Suresh Kumar, N., Palit, A.K., Datta, R.K., 2000.

(Central Sericultural Research and Training Institute, Mysore, India).

Breeding of viable sex-limited cocoon colour bivoltine silkworm breed (CSR8) of *Bombyx mori* L.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, pp.15.

Abstract: In India, bulk of the silk is produced from polyvoltine x bivoltine hybrids and about 50 per cent of female bivoltine cocoons are being not utilized during process of hybrid preparation. The bivoltine silkworm breed with sex-limited character for cocoon colour has great significance in sericulture industry for effective utilization of male cocoons for preparation of polyvoltine x bivoltine hybrids and female cocoons for commercial reeling (usually not utilized for egg production). Keeping this in view, a breeding programme was undertaken by utilizing the Japanese bivoltine hybrid (sex-limited cocoon colours) and an Indian popular bivoltine breed NB4D2. A new breed CSR8 spinning dumbbell cocoon for sex-limited cocoon colour, where the yellow cocoons are female and white cocoons are male was evolved.

133. Naseema Begum, A., Basavaraja, H.K., Sudhakar Rao, P., Rekha, M., Ahsan, M.M., 2000.

(Central Sericultural Research and Training Institute, Mysore, India.)

Identification of bivoltine silkworm hybrids suitable for tropical climate.

Indian Journal of Sericulture, 39(1):24-29.

134. Petkov, N., Nacheva, J., Tsenov, P., Shabalina, A., 2000.  
(Optina Stantsiya po Bubarstov, Vratsa, Bulgaria.)  
Possibilities for selecting lines of the silkworm (*Bombyx mori* L.) according to the motional behaviour of the larvae.  
*Selskostopanska Nauka*, 38(5):25-28(Bulgarian).  
Abstract: A study has been carried out on the motional behaviour of the silkworm larvae and on this character in the breeding-and-selection programmes for the purpose of increasing the productivity of cocoons and raw silk. In the course of the study it has been established, that parallelly to the basic characters used in the selection, motional activity of the larvae may also be successfully used in the breeding work applied for developing high-productive lines of silkworms.
135. Petkov, N., Nacheva, J., Tsenov, P., Grekov, D., 2000.  
(Optina Stantsiya po Bubarstvo, Vratsa, Bulgaria).  
Improvement of initial lines of silkworm hybrid Hebar 1/18 x Hebar 2/1, directed for practical use in summer-autumn feeding.I. Average value and variability of quantitative selection traits.  
*Zhivotnov"dni Nauki*, 37(4):89-93.  
Abstract: Study was carried out for determination of average values and variability of the most important quantitative traits of improved lines of directed for practical utilization hybrid Hebar 1/18 x Hebar 2/1 and the reciprocal cross for summer autumn feeding. The new lines featured with higher homogeneity in the basic quantitative traits too. Average values and variation bounds of each trait, differ in the studied breeds and lines were a result of genotype and environment interaction and were different norm of reaction, The obtained information gave us a reason for inclusion of the new lines in the breeding work as to carried out a mass selection in production of super elite and industrial silkworm seeds.
136. Raghavendra Rao, D., Premalatha, V., Rama Mohana Rao, P., Singh, R., Kariappa, B.K., Jayaswal, K.P., Datta, R.K., 2000.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Evolution and evaluation of productive multi X bi hybrids of silkworm *Bombyx mori* L. for irrigated areas of South India.  
In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, P.16 ,  
Abstract: The bulk of silk produced in India from multi X bi hybrids like PM X NB4D2 and Nistari X NB4D2. These hybrids have some inherent defects like poor silk quality, low silk content, less yield, etc. Keeping the above constraints in view attempts were made to evolve productive multivoltine silkworm breeds / hybrids with high silk content, better yield with quality silk.
137. Raju, P.J., Guruswamy, D., Raghuraman, R., 2000.  
(Karnataka State Sericulture Research and Development Institute, Sub-Station, B.R. Hills, Karnataka, India).  
Breeding of promising races of silkworm, *Bombyx mori* L. and identification of suitable hybrids for rainfed area Karnataka.  
In:National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000,pp.16.  
Abstract: In southern parts of India, sericulture is sustained on the firm foundation of polyvoltine Pure Mysore race.This race is being used as female parent in the preparation of hybrids with C. nichii race as male parent in rainfed area though this combination is very inferior in terms of productivity. However, this hybrid combination is very popular among farmers due to its adaptability to local conditions.

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Keeping this in view, the authors have evolved two new polyvoltine breeds C104 and C110 with better productivity and adaptability as possible replacement for *C. nichii*.

138. Siddiqui, A.A., Rajeev Lochan, Chauhan, T.P.S., Singh, B.D., Ahsan, M.M., 2000.

(Regional Sericultural Research Station, Dehradun, India).

On the evolution of new 'DUN' bivoltine breeds and future breeding strategies for sub-tropical area of Uttar Pradesh.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, pp.15.

Abstract: Most of the bivoltine silkworm breeds evolved and reared in field during eighties in India have shell ratio around 19-20 per cent with renditta around ten. Raw silk recovery per unit area of mulberry was as low 35 kg/hectare in comparison to high silk recovery in China (85 kg/hectare) and Japan (100kg/hectare). With this problem in view a breeding project was initiated in 1991 to develop the bivoltine breeds/hybrids with shell ratio above 22.0 per cent and survival rate more than 80 per cent. Fifteen single crosses of selected germplasm races and a few Japanese hybrids received from JICA lab CSRTI, Mysore, were utilized as breeding resource materials to evolve new bivoltine genotypes. As such 15 bivoltine breeds were evolved and named as "DUN" breeds. Hybrids of these lines were evaluated during autumn, 1999 and spring, 2000 and they showed very encouraging results. All the 36 hybrids tested during spring 2000 recorded the shell weight above 42 cg with the highest being in Dun 6 X Dun 22 (55.6 cg SR percent 25.31) followed by Dun 6 X Dun 9 (52.7 cg). Pupation rate was also recorded above 85 per cent with filament length above 1000 m in most of the hybrids. These hybrids will maximise silk production significantly in the field.

139. Subramanya, G., 2000.

(Department of Studies in Sericultural Science, University of Mysore, Mysore, India.)

Studies on the genetics of voltinism in the cross breeding programme.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, pp.16-17.

Abstract: Tropical polyvoltine Pure Mysore race of silkworm *Bombyx mori*, known for its hardness is exclusively used as a female parent in the cross breeding programme in Karnataka. Sericulture in Karnataka is sustained on account of its stability and good combining ability with popular bivoltine races.

140. Wang, Y., He, X., Xu, M., 2000.

(Sericulture Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou, China).

Progress in breeding of silkworm varieties with especially coarse or fine cocoon filament size.

Bulletin of Sericulture, 31(3):9-12.

Abstract: It was necessary to provide the silk with distinctive features in order to meet the varied needs of silk consumers in the International market, therefore, breeding of the silkworm varieties with especially coarse or fine cocoon filament size was very important. Progress in silkworm breeding in this field was summarized in this paper as four aspects, i.e., the factors of influencing the cocoon filament size, the relation between the cocoon filament size and some other characters, the breeding of varieties with especially coarse or fine cocoon filament size, and the opinions concerning the selection and breeding of such type of silkworm varieties for special use in future.

141. Xu, M., Jiang, Y., Chen, Y., Zhu, C., 2000.

(College of Animal Sciences, Zhejiang University, Hangzhou, China)

Breeding of practical varieties Xingmiao x Mingri with super- thick filament size.

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Canye Kexue, 26(4):214-218(Chinese).

Abstract: The new variety Xingmiao x Mingri with the super-thick filament size has bred with the methods of directed hybridization for filament size. Its filament size reached 5.217dtex, non-broken filament length 870m in the laboratory test. The raw silk and its fabric tests have shown a significant increase in bending rigidity and elasticity, tensile strength, elongation and elasticity, which indicates that its raw silk should be a suitable material for the exploration of silk fabrics with the new characteristics of especially thick, anti-wrinkle and better hand-feeling fabrics so as to satisfy the design of new fashion dresses.

142. Yamamoto, T., Mase, K., Nagasaka, K., Okada, E., Miyajima, T., Itsubo, T., Enokijima, M., 2000. (National Institute of Sericultural and Entomological Science, Matsumoto, Nagano, 390-0812, Japan).

Breeding of the polyphagous silkworm race with thin cocoon filament "Honobono".

Journal of Sericultural Science of Japan, 69(1):31-37.

Abstract: The project was executed to breed a polyphagous silkworm races with thin cocoon filament. After improving the feeding ability to the LPY-diet without mulberry leaves, the size of cocoon filament and the other economical characters for several generations, the two strains were established as the practical races, N513 and C514, which have both the special characters of polyphagous and thin cocoon filament about 2.0 and 1.8 denier in size, respectively. The N513 was bred by pure line selection using N511 strain as material. The C514 strain had already been reported as a parent race of Hakugin with superthin cocoon filament. The cross strain of N513 x C514 was authorized by the Minister of Agriculture, Forestry and Fisheries in 1998, as the new commercial race named "Honobono". This hybrid has the special characteristics of polyphagous and thin filament about 2.2 denier in size, and the other quantitative characters are almost same as the previous commercial race which produce the thin filament. The cocoon color is white, and its shape is oval with ordinary wrinkles. We hope this thin cocoon filament will be widely used as a new silk materials.

143. Zhou, J., Shen, K., Dai, J., 2000.

(Agricultural Department of Zhejiang Province, Hangzhou)

The present situation and breeding direction of silkworm races in Zhejiang province.

Bulletin of Sericulture, 31(1):4-6(Chinese).

Abstract: The paper analysed the present situation, main problems existed and future breeding direction of silkworm breeding in Zhejiang province.

144. Aswath, S.K.; Morrison, M.N.; Datta, R.K., 2001.

(Central Sericultural Research and Training Institute, Mysore, India.)

Development of near isogenic lines of productive silkworm breeds by isozyme marker based selection.

In : Proceedings of the National Academy of Sciences India., 71 B(III)

(IV):207-222.

Abstract: Of late, molecular marker facilitated investigations using isozyme/DNA markers is being widely explored in the breeding of crop plants and live stock for the improvement of desirable traits. In India, limited success of conventional breeding and selection strategies adopted so far in silkworm breeding, has warranted testing of the new strategies for maximising yield realisation. In this direction, work carried out earlier on a number of biochemical parameters has shown the prospects of using digestive amylase as a marker in silkworm breeding due to its close association with survival, better digestibility and isozyme polymorphism. A test breeding plan was adopted using the indigenous low yielding polyvoltine breeds namely, Pure Mysore and Nistari having '4 band' and '5 band' cathodic amylase isozyme types respectively as donor parents (DP) and the productive bivoltine breeds like NB18, CSR2 and CSR5 with 'null' type of isozyme as recurrent parent (RP).

145. Chandrashekharaiyah, 2001.

(Andhra Pradesh Sericulture Research and Development Institute, Hindupura, India.)

Need to evolve silkworm breeding strategies.

In: Abstracts of National Seminar on Mulberry Sericulture Research in India, KSSRDI, Thalaghattapura, Bangalore, India, 26-28 November, 2001, pp.13.

Abstract: The efforts made till date in silkworm breeding for the development of silkworm breeds/hybrids suitable for the tropical conditions of India are based on conventional breeding strategies. These efforts usually laid emphasis on single, two or three characters which may be quantitative or a mix of both (such as higher survival rate, pupation rate, yield, shell ratio, silk quality etc.). These approaches are not wholistic to suit field conditions as most of the productivity-linked characters in silkworm are controlled by polygenes. Silk production in India is entirely dependent on productivity achieved through rearing of cross-breed (PM x NB4D2) variety that produces inferior quality of silk. The bivoltine breeds/hybrids synonymous with higher productivity and superior quality silk are reared on a limited scale. The silkworm breeds/hybrids developed, introduced and popularized in India are few.

146. Chattopadhyay, G.K., Sengupta, A.K., Verma, A.K., Sen, S.K., Saratchandra, B.,2001.

(Silkworm Breeding and Molecular Biology Laboratory, Central Sericultural Research and Training Institute, Berhampore, West Bengal, India.)

Transgression of shell weight - A multigenic trait, through development of congenic breed in tropical silkworm, *Bombyx mori* L.

*Sericologia*, 41(1):33-42.

Abstract: Exploitation of heterosis for the improvement of both quantitative and qualitative traits in sericulture is a matter of practice using multivoltine x bivoltine silkworm (*Bombyx mori* L.) strains or vice-versa. The highly heterogenic genepool in tropical silkworm strains produce hybrids with variable performances. Therefore, in the present experiment, a different breeding approach has been adopted for the first time in sericulture by developing successively syngenic line, recurrent backcross line (RBL) and congenic line (Con. L) or near isogenic line (NIL) causing transgression of cocoon shell weight (SCSW), the target character in all the lines in comparison to the original population i.e., CB5 (GP). The target character in congenic or near isogenic line is very close to bivoltine- the donor parent (JPN9LmP). Single cocoon filament length being the most important linked character has also increased substantially keeping larval marking, cocoon colour, cocoon shape and voltinism as that of multivoltine - the receptor parent (CB5Lm-5). Such breeds having higher yield and better silk quality may directly be releases for commercial exploitation bypassing conventional hybridization.

147. Datta, R.K., Basavaraja, H.K., Mal Reddy, N., Nirmal Kumar, S., Suresh kumar, N., Ramesh Babu, M., Ahsan, M.M., Jayaswal, K.P., 2001.

(Central Sericultural Research and Training Institute, Mysore, India)

Breeding of new productive bivoltine hybrid, CSR12 x CSR6 of silkworm *Bombyx mori* L. *International Journal of Industrial Entomology*, 3(2):127-133.

Abstract: With an objective of evolving quantitatively and qualitatively superior bivoltine breeds/hybrids of silkworm *Bombyx mori* L. for tropical conditions, breeding work was initiated in Central Sericultural Research and Training Institute, mysore during 1992 by utilizing two Japanese hybrids namely BN18 x BCS25 and Shunrei x Shogetsu along with Indian evolved breed, KA. The breed CSR12 which is characterized with sex-limited larval marking and white oval cocoons was evolved from the Japanese hybrid BN18 x BCS25 by crossing with KA, while the breed CSR6 which is characterized with normal marking (marked larvae) and white dumbbell cocoons was extracted from the

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Japanese commercial hybrid Shunrei x Shogetsu through continuous inbreeding coupled with selection. After fixation, these breeds along with other newly evolved breeds were subjected to hybrid study under optimum environmental conditions in the laboratory for expression of full potential of the genotypes. These hybrids were evaluated by Multiple Trait Evaluation Index (Mano et al., 1993). The hybrid CSR12 x CSR6 was selected based multiple trait evaluation index value. The hybrid CSR12 x CSR6 recorded survival of 96.0 percent, shell weight of 50.0 cg, shell ratio of 24.3 percent, raw silk percentage of 19.6, filament length of 1,216 m, boil off loss of 22.4 percent and renditta of 5.1. On the other hand, the control hybrid (KA x NB4D2) has recorded survival of 90.6 percent, shell weight of 42.1 cg, shell ratio of 20.4 percent, raw silk percentage of 15.9, filament length of 999 m, boil off loss of 24.8 percent and renditta of 6.3. The hybrid CSR12 x CSR6 was authorized during 1997 by Central Silk Board, Government of India for Commercial exploitation during favourable months based on national level race authorization test.

148. Datta, R.K., Jayaswal, K.P., Raghavendra Rao, D., Premalatha, V., Singh, R., Kariappa, B.K., 2001. (Central Sericultural Research and Training Institute, Mysore, India)

Break through in multivoltine breeding for silk quality improvement.

Indian Silk, 40(3):5-6.

Abstract: Increasing demand in the domestic markets of India for quality silk has necessitated evolution of suitable breeds. Here are new multi x bivoltine hybrids to fit into the situation.

149. Ghosh, B., Sengupta, A.K., Rao, P.R.T., Roy, G.C., Moorthy, S.M., Saratchandra, B., 2001.

Evolution of improved polyvoltine silkworm breeds for Eastern India.

In: Proceedings of Perspectives in Cytology & Genetics, Vol.- 10, pp. 709-716 (Eds. G.K. Manna and S.C. Roy. All India Cong. of Cytology and Genetics. Publ., Kalyani University).

Abstract: The tropical indigeneous silkworm breeds are basically polyvoltines in nature with poor silk quality, which do not allow farmers to reap better return. The present experiment was designed to develop improved polyvoltines breeds with better quantitative and technological traits. A total of 14 improved polyvoltines breeds have been developed through hybridization and selection, which proved much superiority than the traditional breeds and withstand high temperature and high humidity conditions. These breeds were tested for their hybrid performance in the form of multi x multi and multi x bivoltine crosses, the results of which have been presented.

150. Khan, M.Z., Saratchandra, B., 2001.

(Central Sericultural Research and Training Institute, Berhampore, India.)

Relevance of breeding of sex-limited breeds of *Bombyx mori* L. (Lepidoptera : Bombycidae) in sericulture industry.

In: Abstracts of National Seminar on Mulberry Sericulture Research in India, KSSRDI, Thalaghattapura, Bangalore, India, 26-28 November, 2001, pp.166.

Abstract: The hybridisation as well as hybrids are rule and tool in advanced countries for increase in silk production. In *Bombyx mori* L., for the preparation of hybrids 50 percent of the cocoons get wasted, in addition to encountering the problems of selfing. To avoid this wastage and selfing, it is important to know the sex-limited breeds is realized to the extent that at present about 50 percent of the authorised races in Japan are sex-limited in nature. Unfortunately, there are only few parents of the authorised hybrids recommended for various regions and seasons in India, which are sex-limited. Therefore, it is high time that breeding of sex-limited breeds is taken up to boost the sericulture industry. Relevance, review of work done along with methodology have been discussed.

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151. Krishna Rao, S., Sekarappa, B.M., Mundkur, R., Rajanna, G.S., 2001.  
(Karnataka State Sericulture Research and Development Institute, Government Silk Farm, Bidadi, Bangalore, India).  
New silkworm hybrids for tropical conditions.

In: Abstracts of National Seminar on Mulberry Sericulture Research in India, KSSRDI, Thalaghattapura, Bangalore, India, 26-28 November, 2001, pp.143-144.

Abstract: Development of new hybrids to suit different agro-climatic conditions is of utmost importance for increasing raw silk production. Keeping in view the tropical conditions and need for increasing production of quality silk, breeding studies have addressed different target groups. The first approach, NP2 x KSO-1/KSO-1 x NP2 (Rajatha Sampathu) bivoltine hybrids have been identified with hardiness as the primary objective are currently popularized in four southern districts of Karnataka viz. Bangalore (Rural), Bangalore (Urban), Kolar and Tumkur districts yielding higher returns to both farmers and reelers vis-a-vis cross-breed. In the second approach, NTCM x CTM/CTM x NTCM, KSO-1 x NP4, KSO-1 x NP5 and KSO3 x NP2 bivoltine hybrids have been identified which are hardy and with improved productive characters (21 percent SR) targeting farmers with better conditions.

152. Krishna Rao, S., Raghuraman, R., Mundkur, R., Rajanna, G.S., Govindaraju, S.T., Mahadevappa, 2001.  
(Karnataka State Sericulture Research and Training Institute, Government Silk Farm, Bidadi, Bangalore, India).

Evolution of five new robust bivoltine races in the silkworm, *Bombyx mori* L. for tropical conditions.

In: Abstracts of National Seminar on Mulberry Sericulture Research in India, KSSRDI, Thalaghattapura, Bangalore, India, 26-28 November, 2001, pp.168.

Abstract: Keeping the local agro-climatic conditions and requirement of medium farmers in view, breeding experiments were taken up utilizing the promising germplasm races with an objective of evolving superior bivoltine races having better robustness and productivity traits. Hybridization and selection methodology was adopted. The hybrids were inbred and selection pressure was applied in succeeding generations for desirable traits. In 12th/13th generations 5 new promising bivoltine lines were isolated i.e. NP4 (plain larvae dumbbell cocoons), NP5 (plain, dumbbell) KSO-2 (plain, oval), KSO3 (plain, oval), HDO (sex limited larval marking, oval) and HND (sex-limited larval marking, dumbbell). Combining ability studies were carried out and 3 new promising F1 hybrid combinations were identified with better hybrid vigour. The promising hybrids have fecundity above 515, larval duration 24 to 25 days, cocoon yield/10, 000 larvae 16.8 kgs to 17.21 kg, single cocoon weight 1.77 gm to 1.82 gm, shell ratio 20.8 percent to 21.2 percent, pupation rate 95.7 percent to 96.1 percent, filament length 912 meters to 978 meters, denier 2.17 to 2.39, reelability 85 percent to 88.5 percent, renditta 6.4 to 6.8, tenacity 3.60 g/d to 4.0 g/d and elongation 21 percent to 24 percent. Field-testing of the higher returns to the farmers/reelers and in increasing bivoltine raw silk production are discussed.

153. Li, C-K., Muwang, Y-Q., Lin, S., Hou, C., 2001.

(Sericultural Research Institute, Chinese Academy of Agricultural Sciences, Zhenjiang, China).

Breeding of new germplasms of silkworm (*Bombyx mori*) resistant to Zhenjiang (China) strain of densovirus (DNV-Z).

*Sericologia*, 41(1):21-27.

Abstract: A recessive gene, nsd-Z, which confers resistance to densovirus of the Zhenjiang (China) strain (DNV-Z), was transferred to several excellent commercial silkworm races, and was made

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homozygous. Six new germplasms have been bred. They are completely resistant to DNV-Z, and their economic characters are similar to their parents.

154. Li, M.W., Hou, C.X., Yao, Q., Chen, K.P., 2001.

(Sericultural Research Institute, Chinese Academy of Agricultural Sciences, Zhenjiang, Jiangsu, China).

Breeding commercial bivoltine silkworm hybrid resistant to Zhenjiang (China) strain of Densonucleosis virus (DNV-Z).

*Sericologia*, 41(4):581-588.

Abstract: With an objective of evolving bivoltine breeds/hybrids of silkworm (*Bombyx mori* L.) nonsusceptible to Zhenjiang (China) strain of densonucleosis virus (DNV-Z), a breeding program was undertaken with the use of two Chinese bivoltine breeds 8213, 831 and two Japanese bivoltine races 798, 8214. They were all preserved in the Sericultural Research Institute, Chinese Academy of Agricultural Sciences. Some of the individuals were nonsusceptible to DNV-Z. These individuals resistant to DNV-Z were used as breeding materials. Shenlong spinning whits oval cocoons was isolated from 8213 x 831 through repeated inbreeding coupled with selection, while Tengfei spinning white dumbbell cocoons was evolved from 798 x 8214. After fixation, the hybrid Shenlong x Tengfei was identified in laboratory and in rural area and was proved to be similar to the commercial races for autumn rearing and nonsusceptible to DNV-Z.

155. Lin, C.Q., Yao, Q., Fang, Q.Q., Chen, K.P., Hou, C.X., 2001.

(Sericultural Research Institute, Chinese Academy of Agricultural Sciences, Zhejiang, Jiangsu, China.)

Breeding of summer autumn rearing fluoride enduring *Bombyx mori* variety Lu Ping X Qing Guang and improvement of Guang's endurance to fluoride.

*Acta Sericologica Sinica*, 27(1):24-28(Chinese).

Abstract: In developments during 1992-98 in Zhejiang, Jiangsu, China on *B. mori* variety Lu Ping X Qing Guang (LP X QG) and the improvement of Guang's (*B.mori*) endurance to fluoride using the systematic selection method, the first 4 *B. mori* resources preserved by the Sericultural Research Institute, CAAS, by investigating and identifying fluoride endurance (FE), which was then combined to obtain a quaternary cross-combinations T7. 781 X T6, T8 named as LP X QG. Because T6 (Qing) itself carried a dominant FE gene, with an FE threshold of 220 mg/kg, the LP X QG might obtain a high endurance to fluoride if only a dominant FE gene was transferred to T8 (Guang) with good economic characters.

156. Miao, Y.G., 2001.

(Deaprtment of Sericulture and Apiculture, Zhejiang University, Hangzhou, China.)

Study on the selection of suitable mulberry silkworm strains for rearing with artificial diet in young stages.

*Bulletin of Indian Academy of Sericulture*, 5(1):50-53.

Abstract: Feeding habits of silkworms to artificial diet are improved by continuing five generations breeding. The setae dispersion rate, the growth, development and cocoon quality are taken as the selection index. The results suggested that this kind of breeding method is practicable to breed the silkworm strains suitable to artificial diet.

157. Sengupta, A.K., 2001.

(Central Sericultural Research and Training Institute, Berhampore, West Bengal, India.)

Approches of silkworm breeding for Eastern India- A retrospective view.

In: Abstracts of National Seminar on Mulberry Sericulture Research in India, KSSRDI, Thalaghattapura, Bangalore, India, 26-28 November, 2001, pp.204-205.

Abstract: To set a balanced picture of silkworm breeding and the promise it holds, it is appropriate at this juncture to go briefly through the history of the work done and / oo the products produced by this

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institute. The trend shows that with an overlapping period of 10 years between subsequent varieties, cocoons, were produced by rearing varieties in a five step sequential order of breeding strategies.

158. Siddiqui, A.A., Chauhan, T.P.S., Tayal, M.K., Singh, B.D., 2001.

(Regional Sericulture Research Station, Dehradun, India.)

Breeding of thermo-tolerant bivoltine silkworm genotypes for unfavourable seasons.

In: Abstracts of National Seminar on Mulberry Sericulture Research in India, KSSRDI, Thalaghattapura, Bangalore, India, 26-28 November, 2001, pp.144.

Abstract: To meet the huge domestic requirement of raw silk as well as to increase the raw silk production per unit area of mulberry land it is essential to maximise the number of bivoltine crops in a year. In northern states generally one silkworm crop is taken up by sericulturists at commercial level during favourable seasons because most of the races evolved so far are suitable for rearing in congenial climate only. These races/hybrids when reared in hotter months suffer a heavy loss and succumb to different diseases. To overcome this problem, a breeding programme was taken up by at RSRS, Sahaspur to evolve hardy thermo-tolerant breeds. Twenty Bi x Bi crosses have served as breeding resource materials. Breeding methodology advocated by Chinese breeders was adopted to evolve thermo-tolerant bivoltine breeds with high pupation rate and moderate silk recovery, In addition to these Bi x Bi crosses, eight Bi x Multi (white) crosses have also been utilised as breeding material with a strategy to introduce the character of healthiness of multivoltine genotypes in productive bivoltine breeds. As such, three Chinese type (plain, oval) viz., ATR6, ATR16 and ATR28 and three Japanese type (Marked, constricted) namely ATR11, ATR13 and ATR29 have been evolved. In these newly evolved breeds, during unfavourable monsoon season of 2001, pupation rate was recorded to the tune of 80 percent with shell ratio around 20 percent. Hybrids of these thermo-tolerant breeds recorded the pupation rate around 90 percent with shell ratio between 21 to 23 percent in monsoon season of 2001.

159. Singh, R., Raghavendra Rao, D., Kariappa, B.K., Jayaswal, K.P., 2001.

(Central Sericultural Research and Training Institute, Mysore, India.)

Androgenesis in mulberry silkworm *Bombyx mori* L.: A Review.

International Journal of Industrial Entomology, 3(2):109-112.

Abstract: Androgenesis in silkworm acquires a special significance as along with combined applications of other breeding strategies like parthenogenesis and cloning, it may serve as a valuable tool for sex control in sericulture as well selection and production of bisexual homozygous androgenetic lines. Production of hybrid silkworm yielding high proportion of male larvae is of immense use to silk industry (Strunnikov, 1975, 1983). In this review, an attempt has been made to assimilate the works carried out on androgenesis, different techniques of induction towards androgenetic development and its role in silkworm breeding.

160. Basavaraja, H.K., Dandin S.B., 2002.

(Central Sericultural Research and Training Institute, Mysore, India.)

Recent breakthroughs in breeding of silkworm, *Bombyx mori* L. in tropics.

In: Proceedings of the XIXth Congress of the International Sericultural Commission, 21st - 25th September 2002, Queen Sirikit National Convention Centre, Bangkok, Thailand, pp.171-184.

Abstract: The trend of sericultural development in India clearly depicts a quantum jump in mulberry silk production since last two decades. But the bulk of silk produced is from the polyvoltine x bivoltine hybrids and hence the quality of silk is poor when compared to international standards. The domestic consumption is estimated to cross 25,000 MT by the end of five year plan i.e., 2007. In order to meet this demand, the traditional states in South India which are the major silk producers have ambitious plans and aim to fill this demand gap and supply by increasing bivoltine cocoon production. Though, a few

bivoltine breeds/hybrids developed earlier are popular in the field, the cocoon shell ratio remained constant at 20 percent. Owing to poor quality leaf and rearing management, cocoon shell ratio realised in commercial cocoon market is around 18 percent. Besides, the crop stability especially during hotter months is not assured with these bivoltines. This has made bivoltine crops unattractive to the farmers and reelers especially when they get similar shell content for polyvoltine x bivoltine hybrids. Therefore, such a scenario has necessitated the development of better bivoltine hybrids to produce quality silk coupled with high survival rate. Keeping this in view, attempts made at CSRTI, Mysore on these lines have resulted in the development of few productive bivoltine hybrids viz., CSR2 x CSR4, CSR2 x CSR5, CSR3 x CSR6, CSR12 x CSR6 and CSR16 x CSR17 with cocoon shell ratio: 23-25 percent; raw silk recovery 19-20 percent and 2A -4A grade silk. Even though they are known for their productive merit, absence of genetic plasticity to buffer against the tropical environmental stresses acts as a constraint to tap full economic potential of these hybrids. This has led to the development of CSR18 x CSR19 (Pupation rate: 80 percent at  $36\pm 1^\circ\text{C}$ ), a robust bivoltine hybrid for rearing throughout the year. In India, especially in southern states, the bulk of silk produced is from cross breed of multivoltine x bivoltine (PM x NB4D2) hybrids. But the silk produced from PM crosses (PM x C. nichii and PM x NB4D2) is poor in both quality and recovery. This has necessitated the development of more productive and qualitatively superior multivoltine breeds. Concerted efforts of silkworm breeding over the years have resulted in the development of few multivoltine x bivoltine hybrids viz., BL 23 x NB4D2, BL24 x NB4D2 and BL67 x CSR101 (cocoon shell ratio: 19-20 percent) which are superior in most of the productivity traits than the existing local hybrids, besides give higher recovery and A grade silk. Besides, the progress achieved in improved productivity and quality three special programmes namely breeding for high temperature tolerance, breeding for disease tolerance especially, BmNPV, BmDENV-1 and BmIFV, breeding for thin denier races, breeding for sex limited races and to facilitate sustainable seed production programme have also yielded quite encouraging results. Comparative performance of these promising hybrid combinations are discussed in this paper.

161. Chen, Y., Xu, M., 2002.

(Department of Sericulture and Apiculture, Zhejiang University, China.)

A new silkworm hybrids "Xinmiao x Mingri" with superthick filament size.

In: Proceedings of the XIXth Congress of the International Sericultural Commission, 21st - 25th September 2002, Queen Sirikit National Convention Centre, Bangkok, Thailand, pp.165-170.

Abstract: China produced over 70 percent raw silk in the world at present, however the majority is middle or low class products or low additional value, which resulted in slow selling and overstocking of silk products (Li et al., 2000). It might provide technical support to the sustainable development of sericulture in the future by the creation of unusual silkworm varieties with specific cocoon -filament characteristics, so as to provide special raw silk for exploitation of new style of silk products. Therefore, silkworm breeding group in Department of Sericulture and Apiculture, Zhejiang University in China had bred a pair of new varieties "Xinmiao" and "Mingri" with especially thick filament size. This report is to introduce the characters of the hybrids "Xinmiao x Mingri".

162. Joge, P.G., Basavaraja, H.K., Suresh Kumar, N., Mal Reddy, N., Kalpana, G.V., 2002.

(Central Sericultural Research and Training Institute, Mysore, India.)

Breeding approaches followed at CSRTI, Mysore.

In: Proceedings of National Workshop on Sericulture Germplasm Management and Utilisation, Central Sericultural Germplasm Resources Centre, Central Silk Board, Hosur, Tamil Nadu, India, 6-7th February, 2002, pp.97-101.

163. Kang, P.D., Sohn, B.H., Lee, S.U., Hong, S.J., 2002.

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(Department of Sericulture and Entomology, National Institute of Agricultural Science and Technology, RDA, Suwon, Korea)

Breeding of a new non-cocooning silkworm variety, Hachojam, suitable for autumn rearing season.

International Journal of Industrial Entomology, 4(1):77-81.

Abstract: A new non-cocooning silkworm variety, Hachojam, suitable for autumn rearing season is single cross F1 hybrid between Japanese race Jam 307 and Chinese race Jam 126. Jam 307, Japanese parent of the Hachojam, which is a source for non-cocooning process showed a high GCA (generation combining ability) in naked pupation rate and Jam 126, Chinese parent, showed a high GCA in pupation rate and single pupal weight. In the local adaptability test performed at 8 local areas in autumn of 1999 to 2000, the naked pupation rate and thin cocoon rate of Hachojam were 64.7 percent and 35.3 percent, respectively. The pupal weight calculated from 10,000 of the 3rd molted larvae was 24 percent heavier in Hachojam than the cocoon producing, check variety Daesungjam.

164. Maribashetty, V.G., Ahamed, C.A.A., 2002.

(Karnataka State Sericulture Research and Development Institute, Thalaghattapura, Bangalore, India)

Breeding of hardy bivoltine line KSD2 of silkworm, *Bombyx mori* L. for tropical climate, Mysore.

Journal of Agricultural Sciences, 36(2):154-161.

Abstract: The concentrated genotypes of the silkworm *Bombyx mori* L., for high productivity are known to possess a narrow range of adaptability and as such the fluctuating environmental conditions of tropical climate have an impact on their viability. Hence, tropical sericulture necessitates the synthesis of more flexible genotypes for the expression of optimum productivity and viability traits. With an objective of synthesizing silkworm races with suitable genetic constitution, a breeding experiment was initiated to isolate a robust bivoltine line of silkworm *Bombyx mori* L., by utilizing two existing bivoltine races CSR2 and SP2 and multivoltine race, Pure Mysore. By inbreeding the hybrids of the above pure races coupled with recurrent back crossing followed by selection at each and every generation, a hardy bivoltine breed spinning white dumbel cocoons was isolated. This bivoltine line herein referred as KSD 2 with Japanese racial features has been bred through over 15 generations and it revealed significant improvement in regard to viability compared to the control races. The overall performance of the isolated bivoltine with regard to viability and productivity as well as silk technological characters is discussed, emphasizing its superiority over the existing bivoltine races in the field.

165. Mundkur, R., Murthy, M., Nagabhushana Gupta, K.N., Muniraju, E., Raghuraman, R., 2002.

(Karnataka State Sericulture Research Institute and Development, Bangalore, India.)

Breeding of hardy, high shell content bivoltine race, SL-WU8 of silkworm, *Bombyx mori* L.

Journal of Experimental Zoology India, 5(1):131-135.

Abstract: Adopting hybridization selection technique, sex-limited hardy bivoltine race with high shell content SL-WU8 has been isolated using SL-Wu and CH32 as parents. At F13, the isolated race SL-Wu8 has shown significant improvement over the control bivoltine NB4D2. Cross breed produced by using Pure Mysore female and SL-WU8 male, has also shown significant improvement in survival and quantitative traits over Pure Mysore x NB4D2. Hence SL-Wu8 can be used in place of NB4D2 in the commercial production of cross breed layings.

166. Narayanaswamy, T.K., Ananthanarayana, S.R., Govindan, R., Ramesh, S., 2002.

(Department of Sericulture, University of Agricultural Sciences, Bangalore, India.)

Appropriate selection of hybrids of silkworm (*Bombyx mori* L.) through heterosis breeding for rearing traits.

Bulletin of Indian Academy of Sericulture, 6(2):34-38.

Abstract: Search for suitable hybrid combinations of silkworm (*Bombyx mori*) for rearing traits was made among 28 F1 hybrids synthesised from seven multivoltine and four bivoltine silkworm breeds in line X

tester fashion through heterosis breeding. The cross HM X NB18 ranked top for extent of progression to fourth instar and effective rate of rearing by yielding significantly positive heterobeltiosis and standard heterosis for full grown larval weight. The hybrids P2D1 X NB18 recorded highest negative standard heterosis for fifth instar and total larval duration. The rearing traits viz., extent for progression to fourth instar, larval duration up to fourth instar, fifth instar duration, total larval duration full grown larval weight and effective rate of rearing revealed that the hybrids, P2D1 X NB18 and KJ X KA manifested significantly to note that the crosses with P2D1 and NB18 as lines and testers, respectively produced highest standard heterosis for rearing traits in general.

167. Noppaseney, P., 2002.

(Department of Agriculture, Sericultural Research Institute, Sakonkakhon Sericultural Experiment Station, Sakonkakhon-47000, Thailand.)

New-sex-linked multivoltine x bivoltine strains.

In: Proceedings of the XIXth Congress of the International Sericultural Commission, 21st - 25th September 2002, Queen Sirikit National Convention Centre, Bangkok, Thailand, pp.116-121.

Abstract: Breeding for sex-linked multivoltine x bivoltine strains started by silkworm lines collection from various places from which multivoltine and bivoltine lines were bred and conserved. After collection of some promising and important lines, new inbreeds lines were evolved through standard breeding procedure. Two sex-linked multivoltine (SP1 and SP2) and four sex-linked bivoltine (SB2, SB4, SB5, SB7) were evolved. All possible combinations were conducted and tested for combining ability and the selected combinations were subjected to various yield trials. Two promising cross-breeds (SP1xSB2 and SP1xSB7) were selected as compared with the check (Ubonrajbatbani 60-35, UB1xNN). The first one has been approved by Department of Agriculture as till recommended strain in 1999. The other, after testing for grassy disease resistance, and found that it was resistant, now is under process for approval.

168. Raghavendra Rao, D., Premalatha, V., Ravindra Singh., Kariappa, B.K., Jayaswal, K.P., Dandin, S.B., 2002.

(Central Sericultural Research and Training Institute, Mysore, India).

Evolution of a productive multivoltine X bivoltine hybrid, CAUVERY (BL67 X CSR101) of silkworm, *Bombyx mori* L.

International Journal of Industrial Entomology, 4(2):121-126.

Abstract: Breeding programme was initiated during November, 1995 with the main objective to breed productive multivoltine breeds / hybrids with suitable genetic constitution to suit the fluctuating tropical climate prevailed in India. two multivoltine breeds viz., BL-24 and BL-27 were selected as breeding resource materials from the silkworm germplasm maintained by CSRTI, Mysore. By adopting hybridization, backcrossing, inbreeding and selection, a new multivoltine breed namely BL-67. This breed spins light greenish yellow cocoons and cocoon shape is oval with medium to coarse grains. The evolved breed was crossed with five tropical bivoltine breeds viz., NB4D2, CSR2, CSR5, CSR18 and CSR101 to study the combining ability, and identified a superior hybrid, named as CAUVERY. The hybrid is characterized by high pupation rate (>95 percent), high shell weight (>35 cg), high cocoon shell ratio (>20 percent), longer filament length (>900 m) and high neatness (93) with a renditta of 6.5 producing 2A-3A grade silk. The hybrid is selected for race authorization test of Central Silk Board.

169. Sannamvong, K., 2002.

(Udomthanee Sericultural Research Center, Institute of Sericulture, Department of Agriculture, Thailand.)

Improvement of Thai-hybrid silkworm "Udomthanee" variety.

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In: Proceedings of the XIXth Congress of the International Sericultural Commission, 21st - 25th September 2002, Queen Sirikit National Convention Centre, Bangkok, Thailand, pp.110-115.

Abstract: Udonthanee silkworm variety was the single cross of Thai-hybrid silkworm. The Thai-hybrid SKN1 x KSN was cross between SKN1 (Sakolnakorn 1) variety and KSN (Kawe Sakolnakornm) variety. SKN1 was bivoltine race chinese strain plain larva and white cocoon color, KSN was native multivoltine race light green larva and yellow cocoon color. Since 1985, the breeding has been conducted hybrid silkworm. The morphology and agricultural characteristics Udonthanee hybrid silkworm variety egg's color white yellow, larva light yellow plain, oval shape's cocoon, deep yellow cocoon color, yellow filament, Number's eggs (no.) 492, weight of growth larva average 10 larva (gm) 24.90, percentage of survival young larva (percent) 91.18 percentage of sound pupae (percent) 91.12, weight of fresh cocoon one cocoon (gm.) 1.47, weight of shell cocoon one cocoon (cg) 25.14, shell ratio (percent) 17.12, length's filament (m) 677 and percentage of reel ability ( percent) 66. The prominent characteristic of hybrid silkworm variety "Udonthanee" rear easily and can adaptation in the whole year, Both of SKN 1 and KSN was the same duration larva, number's eggs and weight's growth larva more than standard variety "Ubonratchanee 60-35, resistant to Nuclear Polyhedrosis virus (NPV) and the survival of young larva too high.

170. Sudhakara Rao, P., Basavaraja, H.K., Nishitha Naik, V., Pallavi, S.N., 2002.

(Central Sericultural Research and Training Institute, Mysore, India)

Breeding for sex-limited cocoon colour breeds.

Indian Silk, 41(10):9-11.

Abstract: Sex determination has almost become indispensable in silkworm breeding as the rearers culture only hybrids to exploit heterosis for cocoon production for which accurate isolation of male and female is essential.

171. Suresh Kumar, N., Basavaraja, H.K., Kishore Kumar, C.M., Mal Reddy, N., Datta, R.K., 2002.

(Central Sericultural Research and Training Institute, Mysore, India)

On the breeding of "CSR18 X CSR19" - A robust bivoltine hybrid of silkworm, *Bombyx mori* L. for the tropics.

International Journal of Industrial Entomology, 5(2):153-162.

Abstract: Earlier breeding experiments undertaken at CSRTI, Mysore, India since a decade had resulted in the development of many productive and qualitatively superior bivoltine hybrids. However, the hot climatic conditions of tropics prevailing particularly in summer are not conducive to rear these high yielding bivoltine hybrids. This has necessitated breeding of compatible bivoltine hybrids for year round rearing. Accordingly, the Japanese hybrid, B201 X BCS12 which was found to be tolerant to high temperature was used as breeding resource material. Following hybridization and selection rearing of silkworms was taken up in SERICATRON (Environmental Chamber with precise and automatic control facilities for uniform maintenance of temperature and humidity) at high temperature of  $36 \pm 1^\circ\text{C}$  and  $85 \pm 5$  percent RH in fifth instar and the control batches at  $25 \pm 1^\circ\text{C}$  and  $65 \pm 5$  percent RH. Directional selection was resorted to the batches reared at  $36 \pm 1^\circ\text{C}$  till F5 onwards the experiment was modified in such a way as to conduct normal rearing every alternate generation to regain the lost vitality due to continuous exposure to high temperature and high humidity stress. At F2, oval and dumbbell cocoons were separated out and designated as CSR18 and CSR19, respectively. By utilizing these lines at F12, the hybrid CSR18 X CSR19 was prepared and studied for the thermotolerance by subjecting to stress condition at high temperature of  $36 \pm 1^\circ\text{C}$  and  $85 \pm 5$  percent RH in fifth instar and the control batches at  $25 \pm 1^\circ\text{C}$   $65 \pm 5$  percent RH. The better performance of CSR18 X CSR19 (survival > 88 percent) at  $36 \pm 1^\circ\text{C}$  clearly indicates the general superiority of CSR18 X CSR19 with regard to high temperature tolerance over the productive hybrids and CSR18 X CSR19 can perform well in varied agroclimatic conditions of the tropics with optimum qualitative and quantitative characteristics.

172. Wang, Z.E., Wei, Z.J., Qiu, Z.Y., 2002.  
(Sericultural Research Institute, Chinese Academy of Agricultural Sciences, Zhenjiang, Jiangsu, China)  
Breeding of spring-reared silkworm variety Huarui X Chunming.  
*Acta Sericologica Sinica*, 28(2):163.  
Abstract: Huarui X Chunming is a new hybrid with high silk yield and excellent silk quality. It was bred during 1986-2000 from the cross (123 X R) X 628 X 729) in Zhenjiang, Jiangsu, China. Based on laboratory identification, rearing in the countryside, propagation on a silkworm egg production farm, and evaluation by the National Mulberry and Silkworm Examination Committee, its good characteristics were compared with those of control variety Jingsong X Haoyue.
173. Xu, M.K., Chen, Y.Y., Jiang, Y.H., 2002.  
(Department of Sericulture and Apiculture, College of Animal Sciences, Zhejiang University, Hangzhou, P. R. China)  
A brief report on the breeding of special silkworm varieties "Xinmiao" and Mingri".  
*Sericologia*, 42(3):425-429.  
Abstract: A new hybrids "Xinmiao x Mingri" for producing special silk material was bred by the method of hybridization and selection. Its filament size reached 5.217dtex, non-broken filament length 870m in laboratory test rearing. Raw silk and fabric made from this hybrid cocoons showed a significant increase in broken elongation, tensile elasticity, and bending rigidity elasticity, meanwhile a significant decrease in degumming rate if compared with popularized varieties. It indicated that its raw silk should be suitable for designing special silk fabric with thicker style and better anti-wrinkle characters.
174. Yi, H., Yanghu, S., Biping, Z., 2002.  
(Research Institute of Sericulture, Colege of Life Sciences, Soochow University, Suzhou, China)  
Breeding of a new silkworm variety Wuhua X Xuxing for summer autumn rearing.  
*Canye Kexue*, 28(1):56-60.
175. He, S., He, Y., Wu, Y., Qian, H., Zhao, Y., Zhuang, C., Fang, D., Sun, Y., 2003.  
(The sericultural Research Institute, Chinese Academy of Agricultural Sciences, Zhengjiang)  
Breeding of trimoltine race with superfine Silk Size, 853Bai and 543B of *Bombyx mori* L.  
*Acta Sericologica Sinica*, 29(1):38-42.  
Abstract: New practical trimoltine silkworm race 853Bai x 543B characterized with fine economical parameters and stable moltinism has been bred after crossing of pure trimoltine strains characterized by stable moltinism and poor economical parameters with trimoltine strains characterized by good comprehensive economical parameters. The selected hybridized combinations, 853Bai x 543B, showed much advanced characters by combining ability test, such as healthy, stable moltinism (tremolter rate, (98 percent ~ 99 percent), short duration of larval period, superfine silk size(1.87 - 2.2 dtex), 900 - 1 100 m in silk filament, 75 percent ~ 90 percent in reelability, 94~ 96 neatness of raw silk and 3. 7 - 3. 8 g/dtex in strength of raw silk. It is proved for suitable to produce high quality of raw silk cocoons for some special purpose.
176. Kang, P.D., Sohn, B.H., Lee, S.U., Woo, S.O., Hong, S.J., 2003.  
(Department of Sericulture and Entomology, National Institute of Agricultural Science and Technology, RDA, Suwon, Korea)  
Breeding of a new silkworm variety, Chungangjam, with a sex-limited larval marking and high silk yielding, for summer autumn rearing season.  
*International Journal of Industrial Entomology*, 6(1):57-61.

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Abstract: A new silkworm variety, Chungangjam, with a sex-limited larval marking and high silk yielding, for summer autumn rearing season is F1 hybrid between Jam 147, a Japanese race bred from P8503/8453, and Jam 148, a Chinese race from M8306/Jam 130. Jam 147, Japanese parent of the Chungangjam showed a high GCA (general combining ability) in pupation percentage and Jam 148, Chinese parent, showed a high GCA in pupation percentage and single cocoon weight. In the local adaptability test performed at 8 local areas in autumn of 2001, Chungangjam, was 5 percent higher in cocoon yield and 8 percent in raw silk productivity in the 10,000 of the 3rd moulted larvae, respectively, than the check variety Daesungjam.

177. Li, M.W., Xu, A.Y., Hou, C.X., Zhang, Y.H., Huang, J.T., Guo, X.J., 2003.  
(Sericulture Research Institute, Chinese Academy of Agricultural Sciences, Zhenjiang, China)  
Breeding of near isogenic lines of silkworm (*Bombyx mori* L.).

International Journal of Industrial Entomology, 6(2):207-210.

Abstract: Four different backcrossing methods were designed and 23 near isogenic lines (NILs) of 22 linkage groups were obtained using Hb as recurrent parents, the mutant gene lines which held markers as donor parents. Eleven of them had been mated with the recurrent parent for 10 times, and the others for 7~8 times. The NILs of the other 6 linkage groups are under way and had been backcrossed to the recurrent for 3~4 times. These NILs will act important roles in the construction of molecular linkage map and gene location and positional cloning.

178. Mal Reddy, N., Basavaraja, H.K., Suresh Kumar, N., Nirmal Kumar, S., Kalpana, G.V., 2003.  
(Central Sericultural Research and Training Institute, Mysore, India)

Breeding of bivoltine double hybrid (CSR6 X CSR26) X (CSR2 X CSR27) of silkworm *Bombyx mori* L. for commercial exploitation.

In: Abstracts of National Conference on Tropical Sericulture for Global Competitiveness, 5-7th November, 2003, Central Sericultural Research and Training Institute, Mysore, India, pp.18.

179. Mal Reddy, N., Kalpana, G.V., Joge, P.G., 2003.  
(Central Sericultural Research and Training Institute, Mysore, India)

Breeding of economically viable sex-limited silkworm breeds.

In: Concept Papers of Mulberry Silkworm Breeders Summit, 18-19 July 2003, Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India, pp. 60-68.

180. Naseema Begum, A., Rekha, M., Basavaraja, H.K., Ahsan, M.M., 2003.  
(Central Sericultural Research and Training Institute, Mysore, India)

Evolution and identification of thermo tolerant hybrids in the silkworm, *Bombyx mori*, L.

International Journal of Industrial Entomology, 6(2):171-178.

Abstract: Four thermo tolerant lines of silkworm, *Bombyx mori*, L. viz., A HT, B HT (Chinese type) and F HT, G HT (Japanese type) were evolved by utilizing the breeding resource material (identified from initial screening at a temperature of  $31 \pm 1^\circ\text{C}$  and relative humidity  $85 \pm 5$  percent) through conventional breeding. These tolerant lines were crossed with productive breeds and forty four hybrids were evaluated on eight economic traits by the Multiple Trait Evaluation Index Method. Ten hybrids were short listed based on the average evaluation index value larger than 50 for eight economic traits studied. The identified ten hybrids recorded higher index values (>50) for most of the traits studied. Single hybrid G X CSR12 indicated average index value larger than 50 for six traits viz., pupation number (58), cocoon weight (67), shell weight (65), average filament length (74), raw silk percentage (69), reelability percentage (51) except for shell ratio percentage (41). The standard deviation of the cocoons in the above hybrid was 8.41 in the hybrid cocoon length and width measurement. However, two selected hybrids

viz., A X CSR5 and G X CSR13 recorded average index value larger than 50 for all the traits viz., pupation number (57, 60) cocoon weight (50, 54), shell weight (56, 57), shell ratio percentage (59, 53), average filament length (55, 60), raw silk percentage (63, 67) and reelability percentage (53, 53). The standard deviation of the cocoons in the two selected hybrids viz., A X CSR5 and G X CSR13 was 8.41 and 8.06 respectively in the cocoon length and width measurement.

181. Natarajamurthy, N.P., Katti, S.R., Raju, P.J., Raguraman, R., Bongale, U.D., 2003.  
(Germplasm Bank, Karnataka State Sericulture Research and Development Institute, Bangalore, India)  
Bivoltine breeds of silkworm *Bombyx mori* L. for high shell content through line breeding.  
In: Abstracts of National Conference on Tropical Sericulture for Global Competitiveness, 5-7th November, 2003, Central Sericultural Research and Training Institute, Mysore, India, pp.28.

182. Rajanna, G.S., Shivanandaradya, H.S., Mundkur, R., Krishna Rao, S., Raghuraman, R., Bongale, U.D., 2003.  
(Karnataka State Sericulture Research and Development Institute, Bidadi, India.)  
Breeding of a productive polyvoltine line - RPS.  
In: Abstracts of National Conference on Tropical Sericulture for Global Competitiveness, 5-7th November, 2003, Central Sericultural Research and Training Institute, Mysore, India, pp.30.

183. Sen, R., Nataraju, B., Balavenkatasubbaiah, M., Sudhakara Rao, P., Thiagarajan, V., Dandin, S.B., 2003.  
(Central Sericultural Research and Training Institute, Mysore, India)  
Breeding of productive silkworm strains resistant to denonucleosis virus type 1 (BmDENV1).  
In: Abstracts of National Conference on Tropical Sericulture for Global Competitiveness, 5-7th November, 2003, Central Sericultural Research and Training Institute, Mysore, India, pp.28-29.

184. Siddiqui, A.A., Singh, B.D., Chauhan, T.P.S., Tayal, M.K., 2003.  
(Regional Sericultural Research Station, Dehradun, India)  
Breeding of superior bivoltine silkworm genotypes and future breeding strategies.  
In: Abstracts of National Seminar on Sustainable Sericulture India, 1-2 February, 2003, Department of Applied Animal Sciences, Babasaheb Bhimrao Ambedkar University, Lucknow, India, pp.65.  
Abstract: A breeding project was initiated at RSRS, Sahaspur in 1991 to evolve new silkworm bivoltine breeds, the hybrids of which have the shell ratio above 22 percent and pupation rate more than 90 percent. Fifteen single crosses of indigenous bivoltine races along with the six Japanese hybrids received in 1994 from JICA, Lab. CSR and TI, Mysore have served as breeding resource materials to evolve new genotypes. The breeding method advocated by Japanese and Chinese breeds was adopted. As such 15 bivoltine breeds were developed and named as 'Dun' breeds. Thirty six silkworm hybrids of these breeds were tested during spring 2000 to identify the most promising hybrids for exploitation at commercial level. The shell weight in all the hybrids was recorded above 40 cg. with the highest being in Dun6 X Dun22 (55.6 cg) followed by Dun 6 X Dun 9 (52.7 cg.). The shell ratio was ranged from 21.04 percent to 25.31 percent. The pupation rate was recorded to the tune of 90 percent with filament length above 1000 meters in most of the hybrids. Finally, five hybrids were short listed from thirty six hybrids and Dun 6 X Dun22 was selected for testing at all India level under 'Race authorization programme.' In the present paper, breeding methodology adopted for evolution of 'Dun' breeds and future breeding strategies were discussed in detail.

185. Singh, G.P., Xu, M.K., Chen, Y.Y., Datta, R.K., 2003.  
(Central Tasar Research and Training Institute, Ranchi, India.)

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Development of resistance to *Bombyx mori* densovirus into a susceptible silkworm breed.

International Journal of Industrial Entomology, 6(2):145-149.

Abstract: Seeing inadequate disinfection and unhygienic condition in rearing area, use of disease resistant silkworm variety is the best option. In order to this, an attempt has been made to develop the resistance to *Bombyx mori* densovirus (BmDNV-2) into a susceptible silkworm breed Zhenon 1 by cross breeding with a resistant silkworm breed SU12 and exposing the subsequent generations to BmDNV-2 followed by the selection of individuals from the surviving batches. After seven generations the evolved DNV-2 resistant strain showed the significantly higher resistance to BmDNV-2 than control Zhenon 1. The economic characters of both of the breeds were almost on par.

186. Sivaprasad, V., Chandrashekharaiyah., 2003.

(Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India.)

Strategies for breeding disease resistant silkworms.

In: Concept Papers of Mulberry Silkworm Breeders Summit, 18-19 July 2003, Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India., pp.69-76.

187. Suresh Kumar, N., Basavaraja, H.K., Mal Reddy, N., Kariappa, B.K., Dandin, S.B., 2003.

(Central Sericultural Research and Training Institute, Mysore, India.)

Breeding of a new robust bivoltine hybrid (8HT X 5HT) of *Bombyx mori* L. for the tropics.

In: Abstracts of National Conference on Tropical Sericulture for Global Competitiveness, 5-7th November, 2003, Central Sericultural Research and Training Institute, Mysore, India, pp.23-24.

188. Zhu, X., He, K., Huang, J., Xia, J., Liu, X., 2003.

(Sericulture Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou)

Breeding of male silkworm variety Xia. Hua x Ping 8 for spring and autumn rearing.

Acta Sericologica Sinica, 29(1):95-98.

Abstract: With the materials of the sex-linked balanced lethal line S14 introduced from Russia and the silk rich race Chunri for spring rearing, a new sex-linked balanced lethal line Ping8 was bred through hybridization, backcross and combined with test cross and marker gene selection. Xia. Hua x Ping 8 was selected through cross combination with common silkworm race Xia. Hua. The male rate of the variety reached over 99 percent. The results of countryside rearing test showed that it is a strong, healthy and easy to rear variety of male hybrid with uniform development, good cocoon output and economic benefit.

189. Kalpana, G.V., Palit, A.K., Nanje Gowda, B., Basavaraja, H.K., 2004.

(Central Sericultural Research and Training Institute, Mysore, India.)

Breeding strategies for the development of thin denier breeds to meet the Industrial requirement.

In: Abstracts and Souvenir of National Symposium on Recent Trends in Applied Biology, January 28th and 29th, 2004, Department of Life Sciences, Avinashlingam Institute for Home Science and Higher Education for Women- Deemed University, Coimbatore, India, pp.43-44.

Abstract: The success of bivoltine sericulture in India is possible only if quality parameters are maintained during the course of breeding. All these years, lot of importance were given for the development of productive breeds with quality parameters and succeeded in developing CSR2, CSR3, CSR4, CSR5, CSR6, CSR12, CSR16, CSR17, CSR26 and CSR27 by conventional breeding techniques. As a new avenue for breeding, directional selection methods were adopted to develop silkworm breeds for special characters such as fine denier with longer filament to meet the industrial requirement. The Indian sericulture industry utilizes maximum raw silk for the manufacture of silk sarees. The Indian silk (90 percent - cross breed) is utilized only for weft purpose and the strong silk for warp is very less and there

is a lot of demand for bivoltine silk with higher tensile strength with longer filament. This is possible only if silkworm breeds with longer filament (1500m) with higher tensile strength (4g/denier) are developed. Even in advanced countries such as China and Japan lot of efforts have been made to develop silkworm breeds with thick denier and breeds with thin denier (Yamamoto, et.al., 1998) to manufacture warmer coats and under garments respectively. However, in India, more than thick denier breeds, thin denier breeds are most required as their silk can be utilized for warp purpose and also for the preparation of zari (gold coating). Keeping this in view, efforts are being made by silkworm breeders to develop special silkworm breeds namely JPN7, JPN8, B63 and B65 with longer filament with low denier and less variation in the size of the filament from outer layer to inner layer of the cocoons. The strategies followed during the course of development of silkworm breeds for special characters will be discussed.

190. Kang, P.D., Sohn, B.H., Lee, S.U., Kim, M.J., Jung, I.Y., Kim, Y.S., Kim, Y.D., Lee, H.S., 2004. (The National Institute of Agricultural Science and Technology, RDA, Suwon, Republic of Korea.)  
Breeding of "Buhungjam", a sex-limited larval marking and high silk yielding silkworm variety for summer-autumn rearing season.  
Korean Journal of Sericultural Science, 46(2):54-57(Korean).  
Abstract: A new silkworm variety "Buhungjam" for autumn rearing season is F<sub>2</sub> hybrid between Jam149, a Japanese race bred from introduction breeding and Jam150, a Chinese race from introduction breeding. Jam149, Japanese parent of the "Buhungjam" showed high GCA in pupation percentage, cocoon shell percentage and filament length and Jam150, Chinese parent showed high GCA in cocoon shell percentage and cocoon filament length.

191. Mal Reddy, N., Basavaraja, H.K., Joge, P.G., Suresh Kumar, N., Kariappa, B.K., 2004. (Central Sericultural Research and Training Institute, Mysore, India)  
Breeding strategies for the development of bivoltine hybrids of *Bombyx mori* L. for productivity.  
In: Abstracts and Souvenir of National Symposium on Recent Trends in Applied Biology, January 28th and 29th, 2004, Department of Life Sciences, Avinashlingam Institute for Home Science and Higher Education for Women- Deemed University, Coimbatore, India.  
Abstract: The trend of sericultural development in India clearly depicts a quantum jump in mulberry silk production since last four decades. The bulk of this production comes from polyvoltine x bivoltine hybrids and hence, the quality of silk is poor when compared to International standards. A few bivoltine breeds / hybrids were released earlier with the cocoon shell ratio of 20 percent and realization at commercial cocoon market was around 18 percent. This has made bivoltine crops unattractive to the farmers and reelers especially when they recover similar silk content for multivoltine x bivoltine hybrids. Keeping this in view, attempts have made to evolve hybrids with high survival (above 90 percent) and cocoon shell ratio (above 24percent). Japanese F1 hybrids with desired characters were chosen as breeding resource material and crossed them with Indian breeds for the development of productive bivoltine breeds. These breeds were utilized for large number of hybrid combinations (CSR hybrids) and evaluated in the laboratory. These CSR hybrids are more productive and robust, which can be easily reared by the farmers by adopting appropriate rearing technology. However, owing to the existence of negative correlation between high cocoon shell ratio and low pupation rate in pure races, the handling of these pure races need more care and attention. To overcome this, it is highly imperative to develop double hybrids with suitable foundation crosses for easy rearing and production of seed cocoons with high pupation rate. This helps not only in high egg recovery but also in quality seed production. The breeding strategies followed during the course of development of silkworm hybrids (CSR) for productivity will be discussed.

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192. Mal Reddy, N., Basavaraja, H.K., Suresh Kumar, N., Joge, P.G., Kalpana, G.V., Dandin, S.B., Datta, R.K., 2004.

(Central Sericultural Research and Training Institute, Mysore, India)

Breeding of productive bivoltine hybrid, CSR16 x CSR17 of silkworm *Bombyx mori* L.

International Journal of Industrial Entomology, 8(2):129-133.

Abstract: The breeding work was initiated by utilizing two Japanese hybrids namely C135 x N134 and N137 x C146 along with two evolved Indian breeds, J14 and A24. The breed CSR16 which is characterized with marked larvae and white dumb bell cocoons was evolved from the Japanese hybrid C135 x N134 by crossing with J14, while the breed CSR17 which is characterized with plain larvae and white oval cocoons was evolved from the Japanese hybrid N137 x C146 by crossing with A24. The hybrid of these evolved breeds i.e., CSR16 x CSR17 has shown superior over control hybrid KA x NB4D2 and on par with the ruling hybrid of CSR2 x CSR4. The hybrid CSR16 x CSR17 was authorized during 1999 by Central Silk Board, Bangalore, Government of India for commercial exploitation during favourable months based on national level race authorization test.

193. Sudhakara Rao, P., Basavaraja, H.K., Kalpana, G.V., Nishitha Naik, V., Mahalingappa, K.C., Pallavi, S.N., 2004.

(Central Sericultural Research and Training and Institute, Mysore, India)

Evolution of productive bivoltine hybrid of silkworm *Bombyx mori* L. (SD7 X SD12) with shorter larval duration.

International Journal of Industrial Entomology, 8(1):27-32.

Abstract: With an objective of evolving quantitatively and qualitatively superior bivoltine silkworm hybrid of *Bombyx mori* L. for tropics with shorter larval duration without comprising on productivity traits, a breeding programme was initiated at this Institute during 1997 by resource material from the Institutes Germplasm collection. The breed SD7 is characterized with plain larvae spinning white oval cocoons and SD12 is characterized by sex-limited larval markings spinning white dumb-bell cocoons. After fixation, these breeds along with along with other newly evolved breeds were subjected for hybrid evaluation in the laboratory. Based on the hybrid studies, the hybrid SD7 x SD12 was selected and evaluated for one year comprising three major seasons (6 trials) of tropics viz., Pre-monsoon (characterized by high temperature, low humidity and without any rain fall), Monsoon (characterized by moderate temperature, heavy rain fall with high humidity) and post-monsoon season (characterized by low temperature and low humidity with frequent rain fall) to know the fluctuations in the larval duration. The evaluation studies indicated that the hybrid is having shorter larval duration with productive merits. The hybrid SD7 x SD12 recorded survival percent of 92.74, shell weight of 46.7 cg, shell ratio percent of 24.0 and filament length of 1200 meters with a shorter larval duration of 24 hrs; when compared to productive hybrid CSR2 x CSR5 (control). The breeding methodologies and hybrids usefulness for tropics were discussed.

194. Suresh Kumar, N., Mal Reddy, N., Basavaraja, H.K., Kariappa, B.K., Dandin, S.B., 2004.

(Central Sericultural Research and Training Institute, Mysore, India)

Breeding strategies for the development of robust bivoltine hybrids of *Bombyx mori* L. for the tropics.

In: Abstracts and Souvenir of National Symposium on Recent Trends in Applied Biology, January 28th and 29th, 2004, Department of Life Sciences, Avinashlingam Institute for Home Science and Higher Education for Women- Deemed University, Coimbatore, India, pp.44 - 45.

Abstract: One of the main aims of the breeders is to recommend to farmers silkworm breeds that are stable under different environmental conditions and minimise the risk of failing below a certain yield level. Silkworm breeds which are reared over a series of environments exhibiting less variation are considered stable. However, the hot climatic conditions of tropics prevailing particularly in summer are not conducive to rear high yielding (productive) bivoltine hybrids. The low adaptability of these hybrids

to the fluctuating environmental conditions of the tropical climate make them unsuitable for commercial exploitation throughout the year. Even though, they are known for their productive merit, absence of genetic plasticity to buffer against the tropical environmental stresses acts as a constraint to tap full economic potential of these hybrids. Therefore, there is an urgent need for suitable robust bivoltine hybrids which can yield consistently good cocoon crop suiting the macro and micro environmental conditions and inferior management prevailing in the tropical conditions. Among the many factors that are attributed to poor performance of the bivoltine strains under tropical conditions, the most important one is that many quantitative characters such as viability and cocoon traits decline sharply when temperature increases over 28°C (Shibukawa, 1965). Kato et al. (1989) in a series of experiments observed that, high temperature is a heritable character and it may be possible to breed silkworm races relatively tolerant to high temperature. Keeping in view of the above research findings, in a tropical country like India, it is essential to develop bivoltine breeds / hybrids which can withstand the high temperature stress conditions. This has necessitated in the development of compatible hybrids for rearing throughout the year by utilizing Japanese thermo-tolerant hybrids as breeding resource material. This paper delineates the process involved in breeding successfully hybrids, CSR18 x CSR19 and 8HT x 5HT which can withstand the stress like high temperature and high humidity.

195. Zhang, Y.H., Xiao, J.S., Zhou, A.L., 2004.

(The Sericultural Research Institute, Sichuan Academy of Agricultural Sciences, Nanchong 637000, China.)

Breeding of grey-black moth basic silkworm races and the productive performance of hybrid.

Southwest China Journal of Agricultural Sciences , 17(2):244 - 247(Chinese).

Abstract: To distinguish the Chinese race and Japanese race in producing hybrid through moth colour, the melanism gene *mln* (18-35.3) of silkworm race 8216 with poor economic characteristics was transferred into white moth silkworm race 782 and 882 and bred grey-black moth silkworm race 952 and 956, which had good economic characters. The hybridized combination 952.956x781.881 (grey-black moth x white moth) was reared in the laboratory to appraise the productive performance of the hybrid. The results showed that the hybridized combination was strong and healthy, easy to rear, with high cocoon production and excellent silk quality.

196. Das, S.K., Chattopadhyay., Verma, A.K., Sengupta, A.K., Sarkar, A., 2005.

(Silkworm Breeding Genetics and Molecular Biology Section, Central Sericultural Research and Training Institute, Berhampore-742101, West Bengal, India.)

Development of superior silkworm breeds of *Bombyx mori* L. suitable for Eastern India through congenic line breeding approach.

In: Proceedings of 20th Congress of the International Sericultural Commission, Bangalore, India, 15-18 December, 2005, Vol I, pp.268-272.

Abstract: A number of Congenic silkworm breeds, three in multivoltine with high shell weight (M Con.1, M Con.2, M Con. 3) and four in bivoltine (B Con.1, B Con.2, B Con. 3 and B Con. 4) with high survival for adverse climatic condition in Eastern India have been developed by adopting congenic breed developing approach through transferring the genes by repeated back crossing. In multivoltine more than 50 percent improvement in shell weight (0.265 g) over the receptor (0.175g) was observed. Bivoltine congenic breeds recorded more than 60 percent survival in adverse seasons when the receptor (JPN) failed to survive at all. Biochemical studies revealed that two apparent native proteins of 224 kDa and 180 kDa-possessors of 6 Esterase are the marker for high survival and high cocoon shell weight respectively in *Bombyx mori* L. Development of these Congenic breeds opens up the possibility to rear productive multi x bi silkworm hybrids in Eastern India through out the year.

197. Islam, M.I., Ali, I., Haque, T., 2005.  
(Genetics Research Laboratory, Department of Zoology, Rajshahi University, Rajshahi-6205, Bangladesh.)  
Breeding of high yielding multivoltine breeds of silkworm, *Bombyx mori* L.  
*Bioscience Research*, 2(1):9-15.  
Abstract: A breeding experiment was conducted in Rajshahi, Bangladesh, from 1999 to 2002, to evolve improved multivoltine breeds of silkworm, *Bombyx mori*, with high productivity, which can replace the existing low yielding ones. Three multivoltine and three bivoltine inbred races were utilized as breeding resource materials. The multivoltine females were crossed with the bivoltine males and the F1 generation females were again backcrossed with the bivoltine males. Finally, 6 promising lines in the F14 generation were isolated and designated as MRB-1(1)y, 2(5)y, 3(3)y, 5(4)y, 8(2)y and 8(3)y. Analysis of variance and other statistical methods were employed and the performance was observed based on 10 quantitative traits. All the evolved breeds that were found promising showed highly significant values in most of the economic characters. An increase of 32.06-40.89 percent in fecundity, -1.00-0.49 percent in hatching, 84.67-112.49 percent in weight of 10 mature larvae, 31.1050.98 percent in cocoon yield, 32.69-44.33 percent, 113.21-140.56 percent, 66.80-74.96 percent, in cocoon and shell weights and SR respectively, 94.26-112.97 percent, in filament length and 98.41-132.75 percent, in cocoon yield 100 dfls over the control (Nistari race). The evolved breeds have the potential to intensify cocoon production and quality raw silk production in Bangladesh.
198. Khan, M.A., Nisar, M., 2005.  
(Central Sericultural Research and Training Institute, Pampore, Kashmir.)  
Silkworm rearing requirements for temperate areas of India.  
In: Proceedings of 20th Congress of the International Sericultural Commission, Bangalore, India, 15-18 December, 2005, Vol I, pp.274-278.
199. Mirhosseini, S.Z., Ghanipoor, M., Shadparvar, A., 2005.  
(Department of Animal Sciences, Guilan University, Rasht, Iran.)  
Breeding objectives for commercial silkworm lines in Iran.  
In: Proceedings of the British Society of Animal Science Annual Conference 2005, York, UK, 4th-6th April, 2005, p.135.
200. Raghavendra Rao, D., Ravindra Singh, Kariappa, B.K., Basavaraja, H.K., Dandin, S.B., 2005.  
(Central Sericultural Research and Training Institute, Mysore, India)  
Development of a robust polyvoltine x bivoltine hybrid "ND5 x CSR17" of the mulberry silkworm, *Bombyx mori* L.  
*Indian Journal of Sericulture*, 44(2):195 - 201.  
Abstract: Breeding programmes were initiated during 2001 for the development of polyvoltine breeds / hybrids tolerant to high temperature and humidity. Initially, forty-four polyvoltine breeds maintained at Central Sericultural Research and Training Institute, Mysore were evaluated at high temperature and humidity (36±1°C and 85±5% RH) for one year. Eight top ranked polyvoltine breeds for temperature tolerance and seven polyvoltine breeds resistant to BmNPV were utilized and ten breeding plans were initiated. Larvae of breeding lines were exposed to high temperature and humidity for six hours daily from third day of fifth instar onwards till spinning. After F5, the lines were short-listed to five based on pupation rate at high temperature and humidity. Utilizing two polyvoltine breeds viz., BL67 and MAR, the breed ND5 was developed. At F12, ND5 was subjected to hybrid evaluation with six-bivoltine breeds viz., NB4D2, CSR2, CSR4, CSR17, CSr18 and CSR19. The hybrid 'ND5 x CSR17' exhibited its superiority by recording 96.25% survival, 1.965g cocoon weight, 0.413g cocoon shell weight, 21.0 cocoon

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shell percentage, 16.08 raw silk percentage and 928m filament length whereas the control (PM x CSR2) recorded 96.00% survival, 1.921g cocoon weight, 0.352g cocoon shell weight, 18.3 cocoon shell percentage, 14.00 raw silk percentage and 805m filament length. Commercial exploitation of the new polyvoltine x bivoltine hybrid in sericulture industry has been discussed.

201. Siddiqui, A.A., Chakrabarti, S., Lochan, R., Chauhan, J.P.S., Kumar, P., Singh, B.D., 2005.  
(Regional Sericultural Research Station, Sahaspur, Dehradun, 248197, India.)

Breeding of Dun 6 x Dun 22 : A new bivoltine silkworm hybrid.

In: Proceedings of 20th Congress of the International Sericultural Commission, Bangalore, India, 15-18 December, 2005, Vol I, pp.262-267.

Abstract: In 1991, a breeding programme was initiated at Regional Sericultural, Research Station, Dehradun and fifteen single crosses of indigenous races along with six Japanese hybrids were utilized as breeding resource materials to develop new bivoltine genotypes. Breeding procedure advocated by Chinese and Japanese breeders was adopted and consequently, seven bivoltine breeds were developed and thirty six hybrids of new breeds were evaluated during 2000 and 2001 along with control SH6 X NB4D2. All the hybrids recorded the cocoon shell weight above 40 cg, with highest being in Dun 6 X Dun22 (55.6 cg). Finally, five hybrids that were superior in both cocoon and post cocoon traits viz. Dun 6 X Dun22, Dun6 X Dun21, Dun17 X Dun18, Dun 17 X Dun19 and Dun12 X Dun19 were recommended for exploitation at farmers level. In selected five hybrids cocoon yield/10,000 larvae was recorded between 19.87 kg and 21.26 kg against the 17.20 kg in control. The shell ratio in selected Dun hybrids ranged from 23.24 to 25.31 percent and Neatness above 90 points. During field trials an average cocoon yield of 60 kg/100 dfls was recorded in Dun hybrids against 40 kg in control. Dun6 X Dun22 is recently authorized by race authorization committee of Central Silk Board for exploitation in field in northern states of India. In the present paper, breeding procedure adopted and results are discussed in detail.

202. Xiao, J., Zhang, Y., Zhou, A., 2005.

(The Sericultural Research Institute, Sichuan Academy of Agricultural Science, Nanchong 637000, China.)

Breeding of the New Silkworm Variety 923.925 x 928.9314 for Spring Rearing.

Canye Kexue, 31(4):474-477(Chinese).

Abstract: By using hybridization method, the new silkworm variety 923.925 x 928.9214 with characters of high silk yield and excellent silk quality for spring rearing was bred. The results of laboratory identification and countryside productive test in Sichuan province revealed that it is uniform in hatching, molting and maturing strong and healthy, and easy to rear, the size of silkworm body and cocoon is big and uniform. The yields of cocoon crop, cocoon shell weight and silk weight per 10 000 larvae increased by 7.96 percent, 8.36 percent and 7.38 percent, respectively than the contrast breed Jingsong x Haoyue. Cocoon filament length, reelability, neatness, raw silk ratio of fresh cocoon are 1 240 m, 70.94 percent, 95.25 points and 18.90 percent, respectively comprehensive economic characters are good.

203. Ahmad, M.N., Siddiqui, A.A., Raina, S.K., 2006.

Breeding strategies for temperate zone.

In: Theme papers on Mulberry Silkworm Breeders Meet 14th-15th February 2006, Central Sericultural Research and Training Institute, Berhampore, India, pp.49-55.

204. Basavaraja, H.K., Suresh Kumar, N., Dandin, S.B., 2006.

(Central Sericultural Research and Training Institute, Mysore, India.)

Breeding strategies for productivity and quality.

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In: Theme papers on Mulberry Silkworm Breeders Meet 14th-15th February 2006, Central Sericultural Research and Training Institute, Berhampore, India., pp.1-6.

205. Chandrashekharaiah., Sivaprasad, V., 2006.

(Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India.)

Breeding strategies for disease tolerance / resistance in silkworms.

In: Theme papers on Mulberry Silkworm Breeders Meet 14th-15th February 2006, Central Sericultural Research and Training Institute, Berhampore, India, pp.7-12.

206. Chandrashekharaiah, Ramesh Babu, M., Prasad, J., Lakshmi, H., Seetharamulu, J., 2006.

(Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI), Kotipi Road, Hindupur, Andhra Pradesh, India.)

Breeding of new bivoltine silkworm (*Bombyx mori* L.) hybrid, APS45 x APS12 for productivity and quality.

In: Asia Pacific Congress of Sericulture and Insect Biotechnology (APSERI 2006), Sangju, Korea, October 11th-14th 2006, pp.52.

Abstract: Incessant and successful silkworm breeding efforts with an objective to develop productive and qualitatively superior bivoltine breeds/hybrids of silkworm *Bombyx mori* L at Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI), Hindupur (Andhra Pradesh, India) contributed in the development of the new bivoltine hybrid, APS45 x APS12. The inbred lines APS45 and APS12 were evolved utilizing the bivoltine germplasm breeds as initial breeding resource and by following conventional breeding coupled with selection. After fixation, the hybrid performance of the new hybrid was evaluated other newly developed bivoltine hybrids by Multiple Trait Evaluation Index (Mano et al., 1993) method. The hybrid, APS45 x APS12 that ranked first with highest Evaluation Index value is identified as most promising. Further, the new hybrid showed economic merit for the characters fecundity (560 eggs/laying), pupation percentage (95.1 percent), cocoon yield per 10000 larvae by weight (17.6 kg), cocoon weight (1.843 g), cocoon shell weight (0.418 g), cocoon shell ratio (22.7 percent), filament length (1096 m), reelability (87.0 percent) and neatness (93 p) over the control hybrid, CSR2 x CSR4. The hybrid is subjected for large scale field trials with the farmers in Andhra Pradesh. The breeding process of the inbred lines, identification of the hybrid and field performance is discussed in the paper.

207. Dandin, S.B., Basavaraja, H.K., Suresh Kumar, N., Mal Reddy, N., Kalpana G.V., Joge, P.G., 2006.

(Central Sericultural Research and Training Institute, Mysore, India.)

Development of bivoltine silkworm hybrids of *Bombyx mori* L for tropics.

In: Asia Pacific Congress of Sericulture and Insect Biotechnology (APSERI 2006), Sangju, Korea, October 11th-14th 2006, pp.106.

Abstract: The trend of sericultural development in India clearly depicts a quantum jump in mulberry silk production since last four decades. The bulk of this comes from polyvoltine x bivoltine hybrids and hence, the quality of raw silk is poor when compared to international standards. This has necessitated the evolution of better bivoltine hybrids. By utilizing the Japanese commercial hybrids, five highly productive and qualitatively superior hybrids namely, CSR2 x CSR4, CSR2 x CSR5, CSR3 x CSR6, CSR12 x CSR6 and CSR16 x CSR17 were selected as highly productive hybrids. It is a well established fact that under tropical condition, unlike the polyvoltines, the bivoltines are more vulnerable to various stresses. One of the important stresses noticed in tropics is the high temperature environment not congenial for bivoltine rearing. Keeping in view of the above, in a tropical country like India, it is very essential to develop bivoltine breeds/hybrids which can withstand the high temperature stress conditions. This has resulted in the development of CSR18 x CSR19, CSR46 x CSR47 and CSR50 x CSR51. Usually, breeds with high cocoon shell ratio show low viability and produce less number of eggs. However, to increase

the egg number and recovery, the mother moths should have broad genetic base (foundation crosses). Besides, the foundation crosses are easy to rear by the farmers and results in healthy pupae as compared to single parents. The double hybrids have more genetic plasticity to buffer against adverse climatic conditions and thereby resulting in crop stability than single hybrids. In India, for the past three years, concerted efforts were made in developing double hybrids to withstand the fluctuating environmental conditions. This has resulted in the development of the Double hybrid, "(CSR2 x CSR27) x (CSR6 x CSR26)". The new addition to the success story of the Indian sericulture industry is the development of fine denier breed CSR48 and CSR49 with longer filament length (1500m) and denier ranging from 1.9 to 2.0d. The new breeds are gifted with better combining ability when crossed with different silkworm breeds available in the tropical country. Among the two breeds, CSR48 has been identified as the best combiner and its hybrid CSR48 x CSR4 has been selected for commercial multiplication. In India, bulk of the silk is produced from polyvoltine x bivoltine hybrids and about 50 percent of bivoltine cocoons are being not utilised during the process of hybrid preparation. The separation of males and females to prevent the mating between individuals of the same parental race is a very important task in the preparation of quality hybrid eggs and forms a major item of work. Hence, the bivoltine silkworm breed with sex-limited character for cocoon colour (where the female spins yellow Cocoon and male white cocoon) has great significance in sericulture industry for effective utilisation of male cocoon for preparation of cross breed layings and female cocoons for commercial reeling besides ensuring the desired quality cross breed laying preparation. Attempts on these lines have resulted in the development of two cocoon colour sex limited breeds CSR8 (SL) and CSR2 (SL) (Nandi). Considering the experience gained during the last three decades, it is highly imperative that the silkworm breeds must cater to the needs of the farmers, grainuers, reelers, weavers and fabric makers. In this context, it is inevitable that a reorientation in the thinking of silkworm breeders that their efforts should focus on developing silkworm breeds with high egg recovery, genetic plasticity to buffer against the adverse climatic conditions of the tropics to ensure sustainability in cocoon crops, relative tolerance to various diseases and inherent genetic potential to produce good quality raw silk. Further, specific character breeds to meet the rich market demand also needs to be kept in mind while attempting for the development of silkworm races to achieve this goal, the conventional breeding method may have limitations, but a multidisciplinary approach utilizing the recent advances in biotechnology could be a better alternative. Identification of QTLs, marker assisted breeding, transgenic silkworms with incorporation of specific traits/DNA construction needs to be addressed.

208. Das, S.K., Chattopadhyay, G.K., Moorthy, S.M., Veram, A.K., Ghosh, B., Rao, P.R.T., Mukherjee, S., Sengupta, A.K., Sarkar, A., 2006.

(Central Sericultural Research and Training Institute, Berhampore, India.)

Breeding strategies for high humidity and high temperature conditions of North Eastern region.

In: Theme papers on Mulberry Silkworm Breeders Meet 14th-15th February 2006, Central Sericultural Research and Training Institute, Berhampore, India, pp.42-48.

209. Guruswamy, D., 2006.

(Karnataka State Sericulture Research and Development Institute, Bangalore, India.)

Breeding of promising races of silkworm *Bombyx mori* L. and identification of suitable hybrids for rainfed area in Karnataka.

Ph. D. Thesis, University of Mysore, Mysore, India.

210. He, K.R., Zhu, X.R., Liu, X.J., Xia, J.G., Huang, J.H., Yao, L.S., Wang, Y.Q., 2006.

(Sericultural Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China)

The breeding of male silkworm combination Qihua x Ping 30.

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Scientia Agricultura Sinica, 39(6):1272-1276(Chinese).

Abstract: Using the sex-linked balanced lethal line S-14 introduced from Russia as donor and excellent commercial variety Baiyun as receptor, a new sex-linked balanced lethal line Ping30 with fine economical characters was bred by the designed method of sex control gene transferring. The male silkworm rate of the new variety attained 99.8 percent with good viability and fine quality cocoon filament, such as the raw silk percentage of fresh cocoon increased by 26.11 percent and the comprehensive economical benefits increased by 26.63 percent compared with the control.

211. Hu, X.L., Wei, G.Q., Dai, J.J., Chen, C.L., Liu, C.L., Sun, H.Z., Zhang, H., 2006.

(College of Life Science, Anhui Agricultural University, Hefei 230036, China.)

Breeding of a new silkworm variety 951x952 for summer-autumn rearing.

Journal of Economic Animal, 10(1):31-34(Chinese).

Abstract: A new silkworm variety 951x952 for summer-autumn rearing was bred by hybridization and backcrossing. The young silkworms were reared under the high temperature and humidity. The new silkworm variety exhibited excellent characteristics such as strong resistance and quick development. The Anhui Province Sericultural Variety Evaluation Commission passed the variety due to its excellent qualities.

212. Kang, P.D., Lee, S.U., Jung, I.Y., Kim, K.Y., Kim, M.J., Hong, I.P., Kim, Y.D., Lee, H.S., 2006.

(Department of Agricultural Biology, The National Institute of Agricultural Science and Technology, Rural Development Administration, Suwon 441-100, Korea.)

Breeding of "Daepoongjam", a Sex-limited Larval Marking and High Silk Yielding Silkworm Variety for Spring Rearing Season.

In: Asia Pacific Congress of Sericulture and Insect Biotechnology(APSERI 2006), Sangju, Korea, October 11th-14th 2006, pp.101.

Abstract: A new silkworm variety "Daepoongjam" for spring rearing season is FI hybrid between Jam151, a Japanese race bred from introduction breeding and Jam152, a chinese race from introduction breeding. In the local adaptability test performed at 8 local areas in spring of 2005, the heavy cocoon yield of Daepoongjam was recorded 6 percent higher than Kumokjam. The concentration of DNJ was measured 4.22mg in Daepoongjam, similar to Kumokjam( 4.26mg). In the Paecilomyces tenuipes production ability test, the pupal weight of Daepoongjam was 1.61 g/individual, 13 percent heavier than Kumokjam(1.41 g/individual).

213. Mase, K., Iizuka, T., Okada, E., Miyajima, T., Yamamoto, T., 2006.

(National Institute of Agrobiological Sciences (NIAS), Sericultural Science Research Team, 1-10-1 Agata, Matsumoto, Nagano, 3900812, Japan.)

A new silkworm race for sericin production, "Sericin Hope" and its product, "Virgin Sericin".

Journal of Insect Biotechnology and Sericology, 75(2):85-88.

Abstract: Sericin, which is about 25 percent of the total cocoon shell of the silkworm *Bombyx mori*, has a skin moisturizing effect, and an inhibitory effect against lipid peroxidation and tyrosinase activity. According to these properties, it has come into use in the skin care industry. To effectively produce intact sericin protein, a new silkworm race "Sericin Hope" was developed by cross breeding an Nd mutant (naked pupa) and a high cocoon yielding strain KCS83. The new strain spins sericin cocoons at a frequency of 99 percent. The cocoon weight is more than 4 times heavier than that of the Nd mutant. The Sericin Hope cocoon, named "Virgin Sericin", can be gelled in water with less hydrolyzing by autoclaving at 110°C for 10 min. The Virgin Sericin gel can be easily emulsified, firmly creamed or made into foam with 5 percent oil.

214. Mase, K., Miyajima, T., Okada, E., Iizuka, T., Teramoto, H., Nakajima, K., Yamamoto, T., 2006. (Silktechnology Unit, National Institute of Agrobiological Sciences, Agata 1-10-1, Matsumoto, Nagano 390-0812, Japan.)

Silkworm races for sericin production, "SERICIN HOPE" and "SERICIN FLAVO".

In: Asia Pacific Congress of Sericulture and Insect Biotechnology (APSERI 2006), Sangju, Korea, October 11th-14th 2006, pp.91.

Abstract: Sericin accounts for about 25 percent of the total composition of silkworm cocoon shells. It is recently known as a natural attracting material because of skin moisturizing effect, an inhibitory effect against lipid peroxidation and tyrosinase activity, and enhances cell proliferation. We had already developed a sericin iucing race, "SERICIN HOPE" by cross-breeding between Nd mutant (naked pupa) and a high cocoon yielding strain KCS83. As the larvae spin only sericin frequently, it is possible to easily obtain the high contained native sericin without decomposition. Furthermore, in order to improve this race with the flavonol which has clear anti-oxidation and anti-bacterial activities, we bred "SERICIN FLAVO" using SERICIN HOPE and a green-cocoon strain "Daizo". This new race spins a high ratio of green sericin cocoons, each of which contains about 4.1mg of flavonol. As these two characters, secreting sericin and flavonol, are controlled by the respective dominant genes, it is possible to release them as an F1 hybrid race which can be reared easily by ordinary sericultural farmers. Additionally, as with case of SERICIN HOPE, the amount of sericin and flavonol per larva of SERICIN FLAVO was increased by about 15 percent by crossing with a common race. The green sericin cocoon shows higher anti-oxidation and anti-bacterial activity than SERICIN HOPE cocoons. A shielding effect against ultraviolet rays was found not only in UV-B (280-315nm) but also in the UV-A (315~380nm) region. The green sericin cocoons were a little hardly gelled comparing the white sericin cocoon but the flavonol was also active in the gel and emulsion states, and was dually released from the gel into water.

215. Matei, A., Brasla, A., 2006.

(Commercial Society "SERICAROM" - Research Branch, 69, Bucuresti - Ploiesti Road, Sector 1, Bucharest, Romania.)

The silkworm breed "RG 90"

Sericologia, 46(3):285-291.

Abstract: The new silkworm breed "RG 90" is a synthetic one, with yellow colour of the cocoon and striped larvae. The breeding works have extended during 10 generations. The selection and the crossing were the breeding methods. Both methods are efficient for changing the genetical structure of the populations, excluding from reproduction genotypical or phenotypical inadequate individuals and reorganizing the genotypes in the offspring with the increase of heterozygote genotypes ratio. The breed "RG 90" presents the following performances: fresh cocoon weight - 2.133 g; shell weight - 0.436 g; silk ratio - 20.50 percent; dried cocoon weight- 0.945 g; filament length -1194 m; filament weight - 0.365 g; filament size - 2.75 denier; metric number of filament - 3278 m/g; reeling silk -38.64 percent; raw silk - 17.11 percent.

216. Murthy, N., Subramanya, G., 2006.

(Department of Studies in Sericultural Science, University of Mysore, Mysore, India.)

Improvement of viability traits of two popular bivoltine races of silkworm, *Bombyx mori* L utilising a polyvoltine breed npnd.

In: Abstracts of National Conference on "New Strategies in Research and development of Sericulture - Indian Perspective" Department of Sericulture, Jnanabharathi Campus, Bangalore University, Bangalore, India, 9th-10th March, 2006, pp.77-78.

Abstract: A breeding experiment was conducted to improve the viability characters of two bivoltine races of silkworm *Bombyx mori* namely, NB4D2 and Kalimpong - A by utilizing genetically distinct

disease resistant polyvoltine race namely NPND stock (non pigmented but non diapause). By inbreeding the hybrids utilising the bivoltine female parents with those of males of NPND followed by backcrossing and appropriate selection procedures, two improved lines are extracted at 12th generation. At every generation rigid selection was applied to select non diapause eggs, white colour cocoons having uniform built and shape and progenies exhibiting highest effective rate of rearing resembling the male parents. The improved lines derived from hybridization experiments utilizing NB4D2 as one of the parent is denoted as NB4D2-I and the improved lines extracted from the cross where Kalimpong-A is used as one of the parent is denoted as KA-I. The two improved lines were subjected to seasonal studies by rearing them in three different seasons of the year along with the parental races. Appropriate statistical procedure is used to analyse the data. Based on the results it is evident that, the two improved lines exhibited highest effective rate of rearing (ERR) 94 percent and above compared to the two bivoltine parents. The importance of utilization of multivoltine races in improving the viability traits of bivoltine races are discussed.

217. Shen, Z.L., Liao, P.F., Li, R.F., Jing, Y., Xu, M., Dong, X.L., 2006.

(Sericulture and Apiculture Research Institute, Yunnan Academy of Agricultural Sciences, Yunnan, Mengzi 661101, China.)

Selection and breeding of silkworm new variety Yunsong x Yunyue.

Southwest China Journal of Agricultural Sciences, 19(4):737-741(Chinese).

Abstract: Crossing and selection yielded a new silkworm hybrid, i.e. Yunsong x Yunyue. This hybrid performed best in multiple-location tests: cocoon weight per 10000 fourth instar silkworms, 20.71-21.64 kg; cocoon shell weight per 10000 fourth instar silkworms, 5.37-5.52 kg; and length of non-broken cocoon filament, 1090-1119 m. Each economic index reached and exceeded authorized standards.

218. Siddiqui, A.A., Chakarbarti, S., Chauhan, T.P.S., Rajeev Lochan, 2006.

(Regional Sericultural Research station, Sahaspur, Dehradun 248197, India.)

Evolution of bivoltine silkworm hybrid DUN 6 X DUN22.

In: Proceedings of Regional Seminar on "Prospects and Problems of Sericulture an Economic Enterprise in North West India", 11th-12th November 2006, Regional Sericultural Research Station, Dehradun, India, pp.169 -172.

Abstract: Under a breeding project, initiated at RSRS, Sahaspur in 1991, five new bivoltine silkworm hybrids viz. Dun 6 X Dun22, Dun 6 X Dun21, Dun7 X Dun18, Dun 17 X Dun19 and Dun 12 X Dun19 have been developed. Fifteen single crosses of indigenous races along with six Japanese hybrids were utilized to evolve new bivoltine silkworm breeds. Breeding method advocated by Japanese breeders was adopted. Consequently, after F12 generation, seven new bivoltine breeds were developed and named as 'Dun' breeds. These breeds were subjected to hybrid testing and their 36 hybrids were tested in 2000 and 2001 and screened as per Mano's evaluation index. Finally five hybrids as mentioned above were short listed for commercial exploitation. In five selected hybrids cocoon yield / 10000 larvae was recorded between 19.87 kg. and 21.26 kg. Shell ratio in new hybrids was ranged from 23.24 to 25.31 percent. In new hybrids Neatness point was also above 90 points. Dun 6 X Dun22, a most promising hybrid among the five hybrids, was also subjected to testing under Race authorization programme of Central Silk Board during 2002 and 2003 at 23 Test centers. This hybrid was authorized by CSB in November 2005 after thorough analysis of its performance during testing for exploitation at field level in Northwestern states. In the present paper, breeding methodology, characteristics of new hybrid as well as its field performance are discussed in detail.

219. Sudhakara Rao, P., Nataraju, B., Balavenkatasubbaiah M., Dandin, S.B., 2006.

(Central Sericultural Research and Training Institute, Mysore-570008, India.)

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Studies on transfer of disease resistant genes non-susceptible to densovirus type 1 (BmDNV1) into productive silkworm breeds.

Sericologia, 46(4):383-391.

Abstract: Rearing of commercial silkworm hybrids resistant to important silkworm diseases is better option particularly in tropical areas where inadequate disinfection methods are practiced. This necessitated the evolution of productive bivoltine silkworm breeds non-susceptible to BmDNV1. Non-susceptibility BmDNV1 in silkworm is controlled by a single dominant/recessive gene. Seventy silkworm germplasm stocks maintained at Central Sericultural Research and Training Institute, Mysore were screened against BmDNV1 and two silkworm breeds (C. nichii and A) non-susceptible to BmDNV1 identified. Their genetic resistance was established and selected as donor parents. Ten productive, but susceptible bivoltine silkworm breeds are selected as recipient parents and transferred the genes responsible for non-susceptibility to BmDNV1 through cross breeding method. During the course of breeding, individuals having resistance to BmDNV1 is ascertained by per oral inoculation of BmDNV1. Repeated back crossing with their respective recipient parent was carried out to improve the productive traits. After six back crosses, individuals were sib-mated to establish strains having resistant homozygous population with productive merits. Hybrids were made among resistant breeds and identified two most promising hybrids resistant to BmDNV1 (CSR2DR x CSR4DR and CSR21 DR x CSR28DR) for commercial exploitation. The breeding strategies and selection methods adopted were discussed.

220. Sudhakara Rao, P., Datta, R.K., Basavaraja, H.K., 2006.

(Central Sericultural Research and Training Institute, Mysore - 570008, India.)

Evolution of a new thermo-tolerant bivoltine hybrid of the silkworm (*Bombyx mori* L.) for tropical climate.

Indian Journal of Sericulture, 45(1):15-20.

Abstract: With an objective of evolving a robust bivoltine silkworm hybrid of *Bombyx mori* L. suitable for tropical climate, a breeding programme was initiated at Central Sericultural Research and Training Institute, Mysore by utilising indigenous polyvoltine and productive bivoltine breeds. The breeding was carried out under high temperature ( $36 \pm 1^\circ\text{C}$ ) and low humidity ( $50 \pm 5$  percent) conditions in the environmental chamber. By F12, three oval and three dumbbell breeds with higher survival and productive merits were isolated. These hybrids were utilized in the hybrid evaluation along with other popular breeds. Based on combining ability results, the hybrid SR1 x SR4 was selected and evaluated in different seasons. The evaluation studies indicated that the hybrid has higher viability and productive merits and is suitable for rearing throughout the year. The hybrid SR1x SR4 recorded a survival of 92.0 percent, cocoon shell weight of 0.417 g, cocoon shell percentage of 23.0 and filament length of 1042 meters under hot and dry conditions of environmental chamber compared to the control i.e., thermo-tolerant hybrid, CSR18 X CSR19.

221. Suresh Kumar, N., Basavaraja, H.K., Joge, P.G., Mal Reddy, N., Kalpana G.V., Dandin, S.B., 2006.

(Central Sericultural Research and Training Institute, Mysore - 570008, India.)

Development of a new robust bivoltine hybrid (CSR46 x CSR47) of *Bombyx mori* L. for the tropics.

Indian Journal of Sericulture, 45(1):21-29.

Abstract: It is a well established fact that under tropical condition, unlike the polyvoltines, the bivoltines are more able to various stresses. One of the important stresses noticed in tropics is the high temperature environment which is not congenial for bivoltine rearing. Keeping in view of the above, in a tropical country like India, it is very essential to develop bivoltine breeds/hybrids which can withstand the high temperature stress conditions. This has resulted in-the development CSR18 x CSR19, a compatible hybrid for rearing throughout the year by utilising Japanese thermotolerant hybrids as breeding resource material. Though the introduction of CSR18 x CSR19 in the field during summer months had

considerable impact, the productivity level and returns realised did not match to that of other productive CSR hybrids. Therefore, the acceptance level of this hybrid with the farmers was not up to the expected level because of the low productivity traits. This has necessitated in the development of a temperature tolerant hybrid with better productivity traits than CSR18 x CSR19. Considering the gravity of the situation and also to cope up with the challenge, though it was a difficult task to break the negative correlation associated with survival and productivity traits, attempts in this line had resulted in the development of CSR46 x CSR47, a temperature tolerant bivoltine hybrid with better productivity traits than CSR18 x CSR19.

222. Suresh Kumar, N., Basavaraja, H.K., Kalpana, G.V., Mal Reddy, N., Joge, P.G., Palit, A.K., Nanje Gowda, B., Dandin, S.B., 2006.

(Central Sericultural Research and Training Institute, Mysore, India)

Selection strategies for conventional breeding in the mulberry silkworm, *Bombyx mori* L. – An overview.

Indian Journal of Sericulture, 45(2):85-103.

Abstract: In practical silkworm breeding, the ultimate aim is to achieve economic gains by improving the economic traits of silkworm breeds. For any breeding programme, the choice of parents to be utilized as breeding resource material and the strategies to be used for identifying them are of great significance. It is well established that the degree of importance of the contributory traits of economic value are not similar in silkworm. It is also known that, the knowledge on the heritability status of characters under consideration is of utmost importance in any breeding programme. Similarly, it is also of paramount importance the correlation between the different characters and their responses to selection and the influence of environment on the genotypes under selection. Considering all these facts, the main concern of breeders is the use of appropriate selection strategies for the genetic as well all economic improvement of silkworm breeds. In this review, the available information on various selection strategies is compiled for the benefit of silkworm breeders engaged in conventional breeding of the silkworm, *Bombyx mori* L.

223. Verma, A.K., Chattopadhyay, G.K., Das, S.K., Sengupta, A.K., Sarkar, A., 2006.

(Central Sericultural Research and Training Institute, Berhampore, India.)

New multi x bi silkworm hybrids for Eastern region.

In: Proceedings of the Workshop on "Appropriate Technologies for Mulberry Sericulture in Eastern and North Eastern India" held on 17th-18th January, 2006, Central Sericultural Research and Training Institute, Central Silk Board, Berhampore, India., P.97-100.

Abstract: Some multivoltine and bivoltine breeds have been developed with high silk content and with high survival through the application of new breeding technique. Three congenic multi x bi hybrids (MB1, MB2 and MB3) were tested at Mothabari (malda) and Berhampore (Murshidabad) along with ruling hybrids N x YB AND N x NB4D2 during NOV - Dec (Agrahayani), Jan-Feb, (Chaitra), and March-April (Baisakh) commercial crop seasons. The average yield/10000 larvae was observed to be highest in case of MB2 i.e., 14.57kg, 13.95kg and 12.19kg during November-December, January-February and March-April commercial crop season against 11.20 kg, 10.26kg and 10.34kg respectively in N x YB and 12.05 kg, 11.24kg and 9.45kg in N x NB4D2. The filament length and renditta in respect of MB2 during three crop season were 804m, 7.00; 775m, 7.4 and 757m, 7.61 respectively. The corresponding data of N x YB were 668m, 8.83; 594m, 9.53 and 674m, 8.34 and in case of N x NB4D2, 723m, 8.12; 701m, 8.43 and 712m, 8.25 respectively.

224. Yu, Z.C., Yu, N.S., Mu, Z.M., 2006.

(College of Forestry, Shandong Agricultural University, Taian Shandong 271018, China.)

Research progress of fluorescence cocoon color in silkworm, *Bombyx mori* L.

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Canye Kexue, 32(1):84-89(Chinese).

Abstract: Through the breeding of the silkworm fluorescence cocoon color variety, the genetics of the fluorescence cocoon color, fluorochrome research and the relationship between the fluorescence cocoon color and the reelability, quality of cocoon etc, we summarized the research advance of the fluorescence cocoon color and fluorochrome of silkworm, and proposed the practical significance to study them further.

225. Zhao, Y., Chen, K., Yao, Q., Wu, Y., Zhang, J., Guo, X., 2006.

(Institute of Life Sciences, Jiangsu University, Zhenjiang, 212013, Jiangsu Province, China.)

Preliminary report on the breeding of robust and resistant-NPV and high quality silkworm race "Shengming No. 1" for summer-autumn rearing.

International Journal of Industrial Entomology, 13(2):85-95.

Abstract: Several Chinese and Japanese varieties with good characters were used in the breeding. After 5 years (15 generations), a pair of robust and high quality silkworm variety with NPV resistance was bred by means of a combination of crossing and pedigree selection complemented by the selection of NPV resistance. The variety was identified jointly nationwide in 2003 and 2004 and appraised by National Mulberry and Silkworm Appraising Committee. Results are as follows: Its cooning rate is over 93 percent, shell rate 23-25 percent, filament length 1200-1300 meters, reelability 75-88 percent, length of non-broken cocoon filament 900-1100 meters, raw silk rate 17-19 percent, neatness 95-97 points, cocoon crop, cocoon shell weight and raw silk weight per 10 000 larvae is higher than those of the control variety by 7-10 percent, 14-19 percent and 14-18 percent, respectively. The variety is not only robust, resistant to high temperature and NPV, easy to rear, uniform in hatching, molting and maturing, but also lays more eggs, and its fecundity is high. It is suitable to rear in the Yangtze River Basin, the Yellow River basin and the Pearl River basin of China.

226. Dandin, S.B., Singh, R., Raghavendra Rao, D., Basavaraja, H.K., Kariappa, B.K., 2007.

(Central Sericultural Research and Training Institute, Mysore - 570008, India.)

Studies on the isolation of promising polyvoltine breed ND7 and its F1 hybrid performance with productive bivoltine races.

Indian Journal of Sericulture, 46(1):52-58.

Abstract: A breeding programme was initiated during August-September, 2003 utilizing one polyvoltine silkworm breed, BL67, During the maintenance of BL67, some larvae with prominent eye spots on second thoracic segment were observed and separated. By following directional selection for subsequent generations, the line, ND7 was isolated and stabilized. The F1 hybrid performance of ND7 was evaluated at 7th generation by crossing with eleven bivoltine silkworm breeds. One hybrid, ND7 x CSR2 showed its superiority for several economic characters such as fecundity, pupation rate, cocoon yield /10,000 larvae by weight, filament length and raw silk percent. The new hybrid exhibited the highest average evaluation index value and recorded evaluation index value 50 for nine out of ten characters. Ten hybrids revealed higher magnitude of hybrid vigour for cocoon yield /10,000 larvae by weight, cocoon weight, cocoon shell weight and reelability. Advantages of commercial exploitation of ND7 x CSR2 have been discussed.

227. Du, Z.H., Liu, J.F., Zhang, J.F., Xiao, J.S., Zhu, H.S., Zhao, B.M., 2007.

(Sericultural Research Institute, Sichuan Academy of Agricultural Sciences, Nanchong Sichuan 637000, China.)

Breeding of the silkworm variety 1303 x 1302 with double sex-limited markings for summer and autumn rearing.

Canye Kexue, 33(1):121-124(Chinese).

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Abstract: By using the routine method of cross breeding, the silkworm variety 1303 and 1302, both with sex-limited markings and characters of excellent silk quality, for summer and autumn rearing were bred. The new varieties were passed hot temperature and high humidity oriented selection, their combination is therefore of strong resistance and health and easy rearing. The yield of cocoon per 10 000 4th instar larvae of the F1 generation is 18.39 kg, equaling to that of the control Xifang x Qiubai. And the length of filament and non-broken filament reel ability, raw silk ratio of fresh cocoon, neatness are 1 180.5 m, 968.8 m, 82.04 percent, 17.92 percent and 96.0 points respectively.

228. Dzneladze, A., Maisuradze, I., Prangishvili, M., Matiashvili, A., Latsabidze, L., Tskaruashvili, Z., 2007.

(Georgian Agrarian University Scientific Research Institute of Sericulture.)

Highly productive mulberry silkworm breeds and hybrids for industrial feeding.

In: Abstracts of the scientific and technical reports of the International Conference "Sericulture Challenges in the 21st Century" (Serichal 2007) and the 3rd BACSA meeting, 18-21 September 2007, Vratza, Bulgaria, pp.20-21.

Abstract: Selection work has been carried out for the creation of high productive mulberry silkworm breeds and hybrids by the use of analytical and synthetic methods of selection. The main attention had been paid to the increase the viability, at all stages of both embryo and post embryo development. All available methods were used for preliminary prognostics of silkworm viability. These are incubation of grain at the provocative background, worm feeding at the provocative background and others. Selection of cocoon coiling has been introduced which provides isolation of cocoon coiled on the first day and the moths leaving those cocoon on the first day and only grain laid by them on the first day were left for obtaining in generations. Likewise, worms hatched from grain on the first day were left for feeding. In the process of papillonage, after cocoon membrane mass is defined, pupa is placed back in the same cocoon with its head to the non-cut end and the membrane is tightly closed. In such a condition moths of low viability can not manage to leave the cocoon membrane and are mechanically excluded from the selection process. Crossing of individuals selected for breeding is performed by the principle of heterogeneous selection. The above stated method was used for breeding of mulberry silkworm breeds such as : Digomi-1 and Digomi-3, and the hybrids made from those breeds have been zoned by the Ministry of Agriculture of Georgia and are ready for their inculcation and distribution in industry. As a result of purposeful work the mulberry silkworm viability of the above referred breeds and hybrids was increased up to 96-97 percent, silk capacity - up to 25-26 percent, cocoon filament length up to 1400-1500 m. By other biotechnological indices they conform to the fixed normative demands.

229. Giorgadze, A., Dzneladze, A., Kobakhidze, L., Svanidze, M., Revazishvili, T., Chargeishvili, I., 2007.

(Georgian Agrarian University Scientific Research Institute of Sericulture.)

Perspective breeds of mulberry silkworm with the view of cocoon filament length and thinness.

In: Abstracts of the scientific and technical reports of the International Conference "Sericulture Challenges in the 21st Century" (Serichal 2007) and the 3rd BACSA meeting, 18-21 September 2007, Vratza, Bulgaria, pp.21.

Abstract: Lately, while breeding new breeds and hybrids of mulberry silkworm at the Scientific Research Institute of Sericulture of Georgia the great attention has been paid to the problem of increase of cocoon filament/thread length, thinness and homogeneity, alongside with improvement of other technological indices. The breeds of the zoned breeds, such as Mziuri-1 and Mziuri-2 are mostly distinguished by these indices. Cocoon of these breeds gave 1.56 tex linear density raw silk thread. By the length and thinness of cocoon filament they had no analogue in the former Soviet Union and the All Union Ministry of Textile Industry demanded increase of the volume of cocoon of Mziuri breeds at solid extra-price.

Therefore it was planned to obtain breeds possessing better properties at the expense of improvement of these breeds and on the base of analogous selection. This works in this direction are continued till now and annually the pursued results are obtained. In recent years thread length of the breeds reached 2000-2500 m, while in current year cocoon thread length of certain individuals reached 3400 m. The only low index of these breeds was that of viability, which in recent years was increased significantly by the use of modern selection methods. It equals to 96-97.5 percent permanently. Selection works are still continued to obtain more stable indices by preservation of continuous thread length, in order to use these breeds further as starting material for obtaining of new unique breeds.

230. Guo, D.G., Lin, J.R., Huang, P., Lin, Z.F., Zhong, S.Y., Qiu, G.X., Li, L.S., Ni, H.B., Zhang, G.L., Li, H.H., 2007.

(Guangdong Provincial Sericultural Extension Center, Guangzhou 510640, China.)

Breeding of the new silkworm variety Yuefeng No.3 (Wu.Xuan x 28.32).

Canye Kexue, 33(3):466-469(Chinese).

Abstract: By using hybridization and pedigree selection methods etc., and improving main commercial varieties and introduced varieties, a new silkworm variety Yuefeng No.3 (namely Wu.Xuan x28.32) of quaternary F1 hybrid was bred. The results of laboratory identification, countryside rearing and multiplication in silkworm egg farm showed it is a variety of strong anti-adversity and fluoride endurance ability, uniform hatching, molting and maturing. The cocoon shape is large with thick cocoon shell. Compared with the control variety 9·Fu x 7·Xiang, its cocoon crop increases by 9.47 percent. It is of high-grade silk, its cocoon filament length 1 028 m, non-broken filament length 761 m and neatness 92.25 points. Its parent silkworms are easy to rear with high multiplication coefficient of silkworm eggs. The new silkworm variety has been passed the approval of crop of Guangdong Province for its good comprehensive economic character. It is suitable for rearing in the Pearl River valley and other sericulture areas in south China all the year round.

231. He, K.R., Zhu, X.R., Liu, X.J., Wang, Y.Q., 2007.

(Sericultural Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China.)

Preliminary report on breeding of silkworm single-cross combinations.

Canye Kexue, 33(3):462-465(Chinese).

Abstract: To reduce the egg production cost of hybrid and promote the levels of economical characters, single-cross combinations were prepared by hybridizing the female silkworms of ameiotic parthenogenetic clones as female parent with egg color sex-limited varieties as male parent. The practical problems including low hatchability of parthenogenesis and poor economical characters of egg color sex-limited varieties have been resolved during single-cross breeding for 10 years. And the single-cross combination "Wu 11 x Luan 36" has been bred out initially and its major economic characters were superior to the control variety "Qiufeng x Baiyu" under the rearing of laboratory, especially the raw silk rate of fresh cocoon increased by 15.7 percent.

232. Ja, M.Z., Xiang, S.G., Yan, X.P., Liao, M.X., 2007.

(Sericultural Research Institute of Hunan Province, Changsha 410127, China.)

Breeding of silkworm variety Hu . Bin x Ming . Guang for summer and autumn rearing.

Canye Kexue, 33(1):125-128(Chinese).

Abstract: A new silkworm variety Hu· Bin x Ming· Guang for summer and autumn rearing has been bred by the methods of hybridization, back cross and pedigree separation. The laboratory identification in summer and autumn that the larva-pupa rate of the variety was similar to 9· Fu x 7· Xiang, but the major economical characters of the new variety were superior to the control, the cocoon yield per 10 000 four-instar silkworms was 16.37 kg and cocoon shell weight per 10000 larvae was 3.974 kg increased 15.5

percent, 28.4 percent respectively compared with the control. Its cocoon filament length and the length of non-broken cocoon filament were 1 153. 5 m and 932. 5 m: which were 210. 5 m and 166. 5 m longer than the control, respectively. This variety has the advantages of healthiness, high cocoon yield and high silk quality, good adaptability.

233. Lu, R.H., Shi, M.N., Bi, L.H., Gu, J.D., Huang, J.T., 2007.

(General Station of Sericulture Technology Popularization of Guangxi Autonomous Region, Nanning 530007, China.)

A preliminary investigation on the resistance of the silkworm variety resources in Guangxi to BmNPV.

Canye Kexue, 33(1):117-120(Chinese).

Abstract: By peroral inoculation of BmNPV polyhedron suspension to the newly molted second-instar larve the resistance of 84 silkworm varieties preserved in Guangxi region to BmNPV was investigated. The results indicated that there were significant differences among silkworm varieties in their resistance to BmNPV by peroral inoculation, the morbidity of 7532 (B) was the lowest with an average rate of 21. 46 percent, and the average morbidity of Z6, Zhonghuang 4, 9497 etc. reached 100 percent; The mass with on average morbidity less than 55 percent were Japanese variety; There was a defined difference in the resistance to BmNPV peroral infection among difference silkworm strains of the same variety. This result provide the basis for breeding of silkworm strains with high resistance to BmNPV.

234. Moorthy, S.M., Das, S.K., Kar, N.B., Raje Urs, S., 2007.

(Central Sericultural Research and Training Institute, Berhampore-742 101, West Bengal, India )

Breeding of bivoltine breeds of *Bombyx mori* L suitable for variable climatic conditions of the tropics.

International Journal of Industrial Entomology, 14(2):99-105.

Abstract: The success of rearing with presently available conventional bivoltine is unpredictable in some seasons of the tropical regions due to highly fluctuating adverse climatic conditions. Thus, in order to popularize bivoltine breeds in tropical parts of India, it is very much essential to have a bivoltine breed(s), which can give stable cocoon crop under variable environments. With this objective a breeding programme was undertaken to improve the survival trait in bivoltine silkworm by introducing multivoltine genes into bivoltine through back crossing. Resultant bivoltine lines showed significantly higher survival in compared to the receptor bivoltine) parent and control bivoltine breed. Esterase isozyme analysis revealed similar banding pattern the developed bivoltine and in the donor multivoltine, which predicts the introgression of multivoltine character into evolved bivoltine.

235. Moorthy, S.M., Das, S.K., Kar, N.B., Mandal, K and Bajpai, A.K, 2007.

(Central Sericultural Research and Training Institute, Berhampore-742 101, West Bengal, India)

Breeding of bivoltine silkworm breeds suitable for tropics and identification of multi x bi silkworm hybrid for commercial exploitation in Eastern India.

In : Perspectives of Cytology and Genetics. Vol.13, pp. 215-227.

Abstract: Among the different components of sericulture, silkworm breeds / hybrids play an important role in improving the productivity and quality of the silk. Hence silkworm breed development is the most important and continuous process for enhancing cocoon/silk productivity and quality as well. Eastern India experiences wide fluctuation in climatic conditions, which restricted rearing of productive silkworms throughout the year. Especially rearing of parent bivoltine silkworm is major impediment because most of the seed crops are falling under unfavourable season (May-Sep), when temperature and humidity are high. Realizing the environmental constraints, there is a necessity to develop bivoltine breed with high survival with proper balance of other economic characters for rearing during unfavourable season and with productive traits during favourable seasons. In light of this objective, a breeding programme was designed to improve the survival trait in bivoltine silkworm by introgression

of multivoltine genes / characters into bivoltine silkworm through backcrossing. Accordingly a promising bivoltine breed namely SK4C was developed with 56 & 86% survival with shell% of 20 & 21 as compared to 18.58 & 81.7 % survival and shell% of 18.35 & 19.28 in the original bivoltine (recipient) parent SK4 and 11& 77% survival and shell% of 18.42 & 19.8 in control, NB4D2 during unfavourable (Sep-Oct) and favourable seed crop seasons (Dec-Mar) respectively. Esterase isozyme pattern in the newly developed bivoltine breed SK4C revealed the presence of a new band with Rm value of 0.247 (Est-3). Which was absent in recipient bivoltine parent SK4 and available in the donor multivoltine parent, Cambodge. It indicates the introgression of multivoltine genes / character in the developed bivoltine. Further this breed was subjected to hybrid evaluation test along with other bivoltine breeds after crossing with three multivoltine parents and reared during three important commercial seasons of the year (Autumn, Spring and Early summer). Of which, the hybrid M6DP (C) x SK4C adjudged first based on multiple trait evaluation index. It showed the yield of cocoon 10-15 kg/ 10000Lar with shell% of 18.17- 19.49 as compared to 8-14 kg / 10000larv with shell% of 15.8 –18 in control, N x NB4D2. Thus successful directional breeding programme promises immense scope to improve the quantity of cocoon as well as silk and same is discussed in the paper.

236. Pallavi, S.N., Basavaraja, H.K., 2007.

(Central Sericultural Research and Training Institute, Mysore, India)

Selection of suitable foundation crosses for utilization in double hybrid bivoltine silkworm, *Bombyx mori* L.

Indian Journal of Sericulture, 46(2):109 – 116.

Abstract: An attempt has been made to evaluate the performance of foundation crosses over parental breeds and to select suitable foundation crosses for improvement of cocoon yield. Five each of newly evolved, oval type bivoltine breeds (CSR2, CSR17, CSR21, CSR27 and CSR46) and dumbbell type bivoltine breeds (CSR4, CSR6, CSR26, CSR47 and GEN2) were selected as parents for the preparation of foundation crosses (FCs). Utilizing these parental breeds, twenty each of oval type and dumbbell type FCs were prepared and evaluated in the laboratory. Observations were made on fecundity, larval duration, pupation rate, cocoon yield, cocoon weight, shell weight, shell percentage, raw silk percentage, filament length, reelability, filament size and neatness. The results clearly indicated non-significant difference for the traits reelability, denier and neatness, while significant differences ( $p < 0.05$ ) were observed between the parents and foundation crosses with respect to pupation rate (86.8 and 94.2%), cocoon yield (14.0 and 17.2kg), cocoon weight (1.615g and 1.835g), shell weight (0.370 and 0.416g), shell percentage (22.4 and 22.7%), raw silk percentage (17.3 and 18.0%) and filament length (902 and 1002m). It is clear that foundation crosses are more robust than their parents as evidenced by improvement in the aforesaid parameters. Based on pupation and cocoon yield, six each of oval type and dumbbell type FCs viz., CSR2 x CSR21, CSR17 x CSR21, CSR17 x CSR46, CSR27 x CSR46, CSR46 x CSR2 and CSR46 x CSR21 (oval type FCs) and CSR4 x CSR26, CSR6 x GEN2, CSR26 x CSR47, CSR26 x GEN2, CSR47 x CSR26 and GEN2 x CSR26 (dumbbell type FCs) were short listed for preparation of double hybrids and subsequent selection of double hybrids for commercial exploitation.

237. Rama Mohana Rao, P., Ravindra Singh, Premalatha, V., Basavaraja, H.K., 2007.

(Central Sericultural Research and Training Institute, Mysore, India)

Identification of polyvoltine breeds of the silkworm *Bombyx mori* L. through evaluation index method.

Indian Journal of Sericulture, 46(2):163 - 168.

Abstract: In the present study, 22 polyvoltine breeds maintained at Central sericultural Research and Training Institute, Mysore, were evaluated based on quantitative and qualitative traits by utilizing multiple trait evaluation index method. Index values were calculated for rearing and reeling parameters separately. Ten top ranked breeds were identified as potential parents and among that NDV6 ranked the top most both in the reeling and rearing parameters. The other top ranked breeds were BL67, BL68,

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2000H, 2000K, NP1, ND7, 96A, BL62 and BL61. The identified polyvoltine breeds can be utilized in the future breeding programmes as breeding resource materials for the development of superior polyvoltine breeds / hybrids.

238. Sudhakara Rao, P., Narasimha Nayaka, A.R., Mamatha, M., Sowmyashree, T.S., Bashir, I., Ilahi, I., 2007.

(Central Sericultural Research and Training Institute, Mysore - 570 008, India.)

Development of new robust bivoltine silkworm hybrid SR2 x SR5 for rearing throughout the year.

International Journal of Industrial Entomology, 14(2):93-97.

Abstract: A silkworm breeding programme was designed to develop a robust but productive bivoltine silkworm hybrid of *Bombyx mori* L. suitable for rearing throughout the year in tropical climate by utilizing indigenous polyvoltine and productive bivoltine breeds. The breeding was carried out under high temperature ( $36^{\circ}\text{C} \pm 1^{\circ}\text{C}$ ) and low humidity ( $50 \pm 5$  percent) conditions in the environmental chamber. By F12, three oval and three dumbbell breeds were isolated with higher survival and productive merits. These breeds were utilized in the hybrid evaluation along with other popular breeds. Based on combining ability test results, the hybrid SR2 x SR5 was selected for large scale testing and evaluated in different seasons. The evaluation studies indicated that the hybrid has higher viability and productive merits and it is suitable to rear throughout the year. The hybrid SR2 x SR5 recorded a survival of 92.0 percent, cocoon shell weight of 0.417 g, cocoon shell percentage of 23.0 and a filament length of 1042 meters under hot and dry conditions of environmental chamber compared to the control thermo-tolerant hybrid CSR18 x CSRI9.

239. Zhao, Y., Chen, K., He, S., 2007.

Key principles for breeding spring-and-autumn using silkworm varieties: from our experience of breeding 873 x 874.

Caspian Journal of Environmental Sciences, 5(1): 57-61.

Abstract: The successfully breeding of the hybrids 873x874 had settled the problem that the yield was not uniform to the silk quality in silkworm varieties. In this paper, we illuminated the key technology, principle, hints and methods for selection in breeding spring-and-autumn rearing silkworm varieties were analyzed using the procedure of breeding the hybrid of 873x874 as example.

240. Ai, J.W., Yan, X.P., Meng, F.L., Li, Z.B., Tan, S.Y., Yang, Y., 2008.

(The Sericultural Research Institute of Hunan Province, Changsha 410 127, China)

Breeding of a new silkworm variety "Nan . Yue x Xing . Chen" with sex-limited markings for spring and autumn rearing.

Canye Kexue, 34(1):136-139.

241. Ashwath, S.K., Sharmila, K.K., Mahalingappa, K.C., Kamble, C.K., 2008.

(Central Sericultural Research and Training Institute, Mysore, India.)

Evolution of breeding lines of CSR2 and CSR4 introgressing high activity amylase genes from polyvoltines and evaluation of hybrids.

In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10<sup>th</sup> June, 2008, pp.81-84.

242. Basavaraja, H.K., Dandin, S.B., 2008.

(Silkworm Seed Technology Laboratory, Kodathi, Bangalore, India.)

Current experience in bivoltine silkworm breeding and future strategies.

In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10<sup>th</sup> June, 2008, pp.17-19.

243. Chattopadhyay, G.K., Das, G.C., Pal, N.B., Moorthy, S.M., Mondal, K., Das, S.K., Bajpai, A.K., 2008.

(Central Sericultural Research and Training Institute, Berhampore, India)

Congenic breeding approach - A hope for development of sustainable silkworm breeds.

In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10<sup>th</sup> June, 2008, pp. 94-97.

Abstract :In haemolymph, ionic Isozyme pattern based (at pH 7.0 and 8.5) silkworm lines viz., V3CB5-Lm5 and V3M6DPC-Lm were used as receptor having potentiality to withstand adverse climatic situation and JPN-Lm and D6p as donor for high cocoon shell weight for developing multivoltine (V3) congenic breeds with high cocoon shell weight like V3CB5ConOw and V3M6 DPC Con.C. Simultaneously, D6p was used as a receptor and V3M6DPC-Lm as a donor to develop high survival V2D6p Con.Ow. Both multivoltine and bivoltine congenic breeds were developed by adoption of method developed by Chattopadhyay et al., 2001a,b for introgression of a desired trait controlled by multiple genes. Another bivoltine congenic breed V2CB5Con. ow was isolated from developed multivoltine congenic breeds V3CB5Con. Ow those laid hibernating eggs after sib mating maintained separately. Rearing performance of isozyme based developed lines are at par with their parents (GP) whereas the cocoon shell weight of congenic breeds V3CB5Con. Ow and V3M6DPC Con C. was 0.265 g and 0.246g in comparison to their parent 0.172g and 0.202g respectively and almost double over ruling strain Nistari (N+p). Pupation percent of bivoltine Con. B(s) was also equivalent to ruling bivoltine breed NB4D2 (control) during favourable season and was significantly higher over control during unfavourable seasons. Performance of NB4D2 and D6 as bivoltine and V3CB5 and V3M6 DPC as multivoltine developed through general / conventional breeding approach (RIL) showed that all the characters considered for assessment were inferior than the breeds developed through the adoption of congenic breeding approach.

244. Das, S.K., Moorthy, S.M., Chattopadhyay, G.K., Mandal, K., Bajpai, A.K., 2008.

(Central Sericultural Research and Training Institute, Berhampore, India)

Development of silkworm breeds and hybrids for the plains of Eastern India.

In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10<sup>th</sup> June, 2008, pp.6-11.

Abstract: Sericulture plays a unique role in the socio-economic development of the people of Eastern region of India. Eastern India experiences extreme variation in topography, soil, temperature, humidity and rainfall. This region is characterized by luxuriant growth of mulberry due to high temperature, humidity, rainfall and rich soil, but during the period when the leaf production is at the peak, it is not congenial for rearing. The successful rearing of presently available conventional bivoltine and multivoltine breeds is unpredictable in such seasons of this region due to highly fluctuating adverse climate condition. Seed crop failure is frequently experienced. In order to overcome this problem Institute has developed some improved multivoltine breeds viz., M12 (W), M6M81, M6DP(C), MCon 1, MCon 4 with high productivity and quality and bivoltine breeds viz., YB, BCon 1, BCon 4, D6(P)N, SK4C and Foundation cross (SK6 x SK7) with high survival and productivity. Utilizing these breeds season specific productive multi x multi hybrids like, N x M12 (W), M Con1 x M Con 4, and M12 (W) x M6M81 for unfavourable seasons (June-September) and multi x bi hybrids like N x YB, M Con 1 x B Con 4, MCon4 x BCon 4, M6DP (C) x (SK6 x SK7), M6DP (C) x SK4C and M6DP(C) x D6 (P)N for favourable seasons (October - April) were developed with encouraging performance. Breeding methods and performance of the different breeds and hybrids is briefly discussed in this paper.

245. Gangopadhyay, D., Singh, R., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India)  
A new breeding approach to evolve polyvoltine breed (s) of the silkworm, *Bombyx mori* L. using parthenogenetic techniques.  
Indian Journal of Sericulture, 47(1):87-93.  
Abstract: An attempt has been made to develop polyvoltine silkworm breed through application of artificial parthenogenesis utilizing a Japanese type bivoltine breed, NB4D2 and a polyvoltine silkworm breed, Cambodge possessing higher ability towards parthenogenetic development. Artificial parthenogenesis was induced by exposing unfertilized eggs at 46°C for 18 minutes. Backcrossing was adopted twice with a polyvoltine breed and a polyvoltine line, DNP1 was developed, The line was evaluated utilizing four productive bivoltine silkworm breeds. The performances of six short listed polyvoltine x bivoltine hybrids namely, DNP1 x DNB1, DNP1 x CSR2, DNP1 x CSR17, DNP3 X DNB1, DNP3 x CSR2 and DNP3 x CSR17 were compared with that of control, PM x CSR2. Laboratory and field evaluation showed superiority of DNP1 x CSR2, Utilization of artificial parthenogenesis in the development of superior silkworm breed and hybrid has been discussed.
246. Joge, P.G., Kalpana, G.V., Suresh Kumar, N., Kamble, C.K., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Breeding strategies for the development of sex limited cocoon colour breeds for the preparation of foundation cross in silkworm *Bombyx mori* L.  
In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10<sup>th</sup> June, 2008, pp.29-31.
247. Kamble, C.K., Nirmal Kumar, S., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Silkworm breeding - concepts and challenges.  
In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10<sup>th</sup> June, 2008, pp.1-5.
248. Lakshmanan, V., Suresh Kumar, N., Naseema Begum, A., Pandya, R.K., Nirmal Kumar, S., Kamble, C.K., 2008.  
(Satellite Silkworm Breeding Station, Coonoor, India.)  
An attempt on shuttle breeding approach to import genetic plasticity in the bivoltine silkworm, *Bombyx mori* L.  
In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10<sup>th</sup> June, 2008, pp.49-51.
249. Rama Mohana Rao, P., Premalatha, V., Singh, R., Joge, P.G., Nirmal Kumar, S., Kamble, C.K., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Strategies for improving the fibre quality in polyvoltine x bivoltine silkworm hybrids.  
In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10<sup>th</sup> June, 2008, pp.20-24.  
Abstract: In the present study, 22 polyvoltine breeds maintained at Central Sericultural Research and Training Institute, Mysore, were evaluated based on quantitative and qualitative traits by utilizing multiple trait evaluation index method. Filament size variation, has been studied. Data indicated that the size of the filament decreased from the outer to inner layer. The decrease in filament size was sudden in some breeds whereas it was gradual in others. Data indicate that the slope of the denier is gradual in

BL68 (-0.00268) and MY1 (-0.00295). In the case of BL43 (-0.00725) and BL25 (-0.00653), the slope was sudden in nature. In silkworm breeding programmes, breeds with gradual slope has to be selected in order to improve the fibre quality. Boil off loss ratio with reference to cocoon shell was determined. Highly significant correlation was observed between cocoon weight and cocoon shell weight, cocoon shell weight and cocoon shell percentage, cocoon shell weight and filament length and cocoon shell percentage filament length. Among multivoltine silkworm breeds, some breeds such as PV1, BL61, NDV6 and 96A with low boil off loss ratio may be utilized as breeding resource materials in future breeding programme for the development of superior silkworm breeds with quality silk. Filament denier is mainly dependent on the race/hybrid used. Since raw silk is composed of many filaments, variation in thickness of the individual filament influences the size and thickness of the thread. Under these circumstances reeling characters have to be given priority in silkworm breeding. It was observed from the results that significant variation existed among the polyvoltine and MAD can be effectively utilized in the fibre quality improvement breeding programmes. Index values were calculated for rearing and reeling parameters separately. Ten top ranked breeds were identified as potential parents and NDV6 ranked the top most both in the reeling and rearing parameters. The other top ranked breeds were utilized in the breeding programmes as breeding resource materials for the development of superior polyvoltine breeds/hybrids with improved fibre characteristics.

250. Rama Mohana Rao, P., Premalatha, V., Joge, P.G., Nirmal Kumar, S., Kamble, C.K., 2008. (Central Sericultural Research and Training Institute, Srirampura, Mysore, Karnataka, India.) Impact of productive female parent in improving silk productivity in cross-breeds of the silkworm *Bombyx mori* L. In: Souvenir and Abstracts of National Seminar on Scenario of Seribiotechnological Research in India (NSSSRI-2008), Department of Sericulture, Sri Padmavati Mahila Visvavidyalayam, Tirupati, Andhra Pradesh, India, 28<sup>th</sup> – 30<sup>th</sup> August 2008, pp.91.  
Abstract: Silk productivity is expressed in cg of cocoon shell weight/day of 5th instar larval duration and is an important breeding index in silkworm *Bombyx mori* L. In the present investigation, five polyvoltine breeds Pure Mysore (PM), RD1, ND1, NP1 and ND7 which differ in productivity traits and a popular bivoltine breed CSR2 (used in the preparation of commercial silkworm seed) were utilized. All the five polyvoltine breeds were crossed with CSR2 males and F1 seed was prepared. Silk productivity in pure races and their F1 hybrids was calculated. Results indicate significant (P0.01) differences in the silk productivity and also other cocoon traits. For silk productivity the breeds studied were in the order: ND7 (4.6 cg/day) NP1 (3.91 cg/day) ND1 (3.83 cg/day) RD1 (2.73 cg/day) PM (2.2 cg/day). The same trend was also observed in the corresponding F1 hybrids. Highest silk productivity of 7.24 cg/day was recorded in ND7 x CSR2, followed by NP1 x CSR2 (6.28 cg), ND1 x CSR2 (6.13 cg). Least productivity was recorded in PM X CSR2 (5.65 cg/day). Heterosis for silk productivity was also estimated in the hybrids studied. Data on heterosis indicate that for silk productivity only ND7 x CSR2 has recorded positive standard heterosis which is 13.53 percent. While, in all the other crosses negative standard heterosis was recorded. Overall results indicate that to improve productivity traits like silk productivity use of improved polyvoltine as a female component is a must in the cross-breed seed preparation for commercial exploitation. In the present investigation an attempt has been made to study the impact of productive polyvoltine female component in improving the quantitative traits in the preparation of cross-breed seed.

251. Rama Mohana Rao, P., Premalatha, V., Nirmal Kumar, S., Joge, P.G., Kamble, C.K., 2008. (Central Sericultural Research and Training Institute, Mysore, India.) Role of sex in improving the cocoon traits in cross-breeding of the silkworm, *Bombyx mori* L. In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10<sup>th</sup> June, 2008, pp.52-53.

252. Ramesha, C., Seshagiri, S.V., Ibrahim Basha, K., Rao, C.G.P., 2008.  
(Multivoltine Breeding and Molecular Genetics Laboratory, APSSRDI, Kirikera, Hindupur, A.P, India.)  
Synthesis of a superior polyvoltine crossbreeds of silkworm (*Bombyx mori* L.).  
In: Souvenir and Abstracts of National Seminar on Scenario of Seribiotechnological Research in India (NSSSRI-2008), Department of Sericulture, Sri Padmavati Mahila Visvavidyalayam, Tirupati, Andhra Pradesh, India, 28<sup>th</sup> – 30<sup>th</sup> August 2008, pp.81.  
Abstract: In the present study, quantitatively and qualitatively superior polyvoltine crossbreeds have been synthesized through conventional breeding approach. For the development of superior hybrids, the existing polyoltine resource material of the Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI), were screened for the desired qualitative and quantitative traits and four inbred lines were selected. Using the selected parents, twelve foundation crosses were prepared in diallel mode and based on their performance, five promising heterotic lines viz., APMG4, APMG6, APMG8, APMG10 and APM12 were chosen for selection and inbreeding. The breeding lines were also subjected for their thermal tolerance. After fixation of the desired traits, the breeds were subjected for hybrid testing using the five promising bivoltine testers. These new hybrid combinations were assessed in three different seasons for their performance. The data obtained on the traits like fecundity (No of eggs per laying), yield per 10,000 larvae by weight (kg), single cocoon weight (g), shell weight (g), shell ratio (percent), filament length (m) and reelability (percent) was analyzed with the support of statistical tools. Based on two popular evaluation methods such as multiple traits evaluation index and Sub-ordinate function methods, one hybrid combination, APMG12 x APDR105 - that showed superiority among all the hybrids tested was selected for further field trials.
253. Shirota, T., Aso, T., 2008.  
(Institute of Sericulture, Dainippon Silk Foundation, Iikura, Ami, Ibaraki, Japan.)  
Genetic analyses and breeding strategy for silkworm races of different cocoon filament size.  
Journal of Sericultural Science of Japan, 77(2):153-158(Japanese).
254. Singh, R., Gangopadhyay, D., Nirupama, R., Kamble, C.K., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Artificial parthenogenesis and androgenesis as novel breeding strategies in the silkworm, *Bombyx mori* L.  
In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10<sup>th</sup> June, 2008, pp.54-56.
255. Sudhakara Rao, P., Nataraju, B., Balavenkatasubbaiah, M., Sharma, D.D., Chandrasekaran, K., Narasimha Nayaka, A.R., Nisha Gopal., Kamble, C.K., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Breeding strategies for the development of disease resistant silkworm breeds of *Bombyx mori* L. - A Review.  
In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10<sup>th</sup> June, 2008, pp.73-76.  
Abstract: Silkworm crop loss is directly attributed to the occurrence of the disease caused primarily by the pathogens. Mulberry silkworm, *Bombyx mori* L. is affected by a number of diseases caused by viruses, bacteria, fungi and microsporidia silkworm diseases cause mortality and there by affect the cocoon production. Efforts must be made to decrease the pathogen load in rearing environment and to strengthen the diseases resistance ability of the silkworms to obtain high and stable cocoon yield minimizing the crop loss. Although the disinfection of silkworm rearing environment carried out by spraying different disinfection is expected to maintain the pathogen load to the significant tolerable level. It is not always necessarily adequate to prevent the occurrence of silkworm diseases. Rearing of

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disease resistant / tolerant silkworm breeds/ hybrids is always better option with the strategies that the breeder can use skilfully for breeding disease resistant silkworm breeds and the problems and prospects involved in it. This way of managing silkworm disease is most economical and effective to produce high level of quality cocoon yield thereby enhancing overall productivity.

256. Wang, Y.Q., Yao, L.S., Cao, J.R., Ye, A.H., He, X.L., 2008.

(The Sericultural Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China)

Breeding of a new silkworm variety "Ming . Feng x Chun . Yu" for spring and autumn rearing.

Canye Kexue, 34(1):132-135.

257. Wu, Y.C., Qian, P., 2008.

(The Key Laboratory of Silkworm Biotechnology, Ministry of Agriculture, Sericultural Research Institute, Chinese Academy of Agricultural Sciences, Zhenjiang Jiangsu 212018, China)

Selection of trimolter silkworm breeding material suitable for subtropical sericultural area.

Canye Kexue, 34(4):752-755.

Abstract: The aim of this paper is to breed silkworm variety with high quality of raw silk suitable for the subtropical sericultural area. Based on the genetic mechanism of silkworm molting, the technology of cross breeding and dominant homozygous of trimolter silkworm was used. Firstly, the trimolter silkworm variety witt-' superfine silk size was hybridized with silkworm variety for autumn and summer rearing, trimolter silkworm material with thin size silk (Z3 etc) were bred. Secondly, Z3 was hybridized with hypersilkgeneous silkworm variety for spring rearing, and the trimolter silkworm materials of middle size silk (Z3 . C3 etc) were bred primarily. These materials have characteristics of the silk size of 2. 44 dtex, short duration of feeding period, healthy, and high quality of raw silk. Rearing result of the hybridized combination of Z3 x 84Y2 in the lab, which was selected for combination of the trimolter silkworm material, indicated that duration of all instars is 21 d, larva-pupa rate is 98.55 percent, cocoon weight is 1.75 g, cocoon shell rate is 22.47 percent, length of cocoon filament is 1 354 m, reelability is 88.15 percent, neatness of raw silk is 95. 3, and silk size is 2.6 dtex.

258. Xiao, J.S., Zhang, Y.H., Zhou, A.L., Xiao, L.R., 2008.

(The Sericultural Research Institute, Sichuan Academy of Agricultural Sciences, Nanchong Sichuan, China)

Breeding of a new silkworm variety "Chun . Lan x Yu . Bo" for spring rearing.

Canye Kexue, 34(3):439-446.

Abstract: By using the method of cross breeding, a new silkworm variety, "Chun . Lan x Yu . Bo", was bred for spring rearing, with characters of high silk yield and excellent silk quality. The results of laboratory identification and countryside productive test in Sichuan province showed that it is uniform in development. Silkworm of the new variety is strong and healthy, and easy to rear. The size of silkworm body and cocoon is big and uniform. The cocoon crop, cocoon shell weight and silk weight per 10 000 larvae are increased by 1.02 percent, 3.65 percent and 4.00 percent of those of the control, "Jingsong x Haoyue" , and are increased by 2.65 percent, 6.32 percent and 2.45 percent of those of another control, "871 x872", respectively. Cocoon filament length, reelability, neatness, raw silk ratio of fresh cocoon are 1 256 m, 90. 77 percent, 97. 60 points and 19. 90 percent, respectively. The above results suggested that the comprehensive economic characters of the new one is excellent. It is suitable to rear, Western Sericulture Area, such as Sichuan, and Chongqing etc.

259. Xiao, J.S., Zhang, Y.H., Zhou, A.L., Xiao, L.R., 2008.

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(The Sericultural Research Institute, Sichuan Academy of Agricultural Sciences, Nanchong Sichuan 637000, China)

Breeding of a silkworm variety "Shu . Huang x Chuan . Bai" with sex-limited yellow cocoon.

Canye Kexue, 34(4):745-751.

Abstract: Silkworm variety with sex-limited yellow cocoon can improve the efficiency of sex identification in the process of producing eggs. Color of silk from female presents natural gold yellow, and quality of silk from male is superior. In this paper, we report the breeding of silkworm variety with sex-limited yellow cocoon. Shu. Huang . Chuan and Bai were bred by cross breeding combined with disease-resistance selection, and a multi-way hybridized combination, Shu . Huang x Chuan . Bai, was selected. The rearing results from laboratory and countryside showed that resistance and cocoon crop of the hybridized combination were close to that of the control, Jingsong x Haoyue. The reeling results showed that color of silk from female presents natural gold yellow, and its cocoon filament length was shorter with thicker filament size. Silk quality from male is better than that of the control. Its cocoon filament length reached to 1 397 m, length of non-broken filament was 1 244 m and neatness was 98.00 points. Its raw silk rate of fresh cocoons was 21.78 percent, which increased 2.23 percent than that of control.

260. Yu, X.H., Jia, Z.W., Yin, S.Q., Tang, Y.C., Ge, J., 2008.

(School of Life Sciences, Soochow University, Suzhou Jiangsu 215123, China)

Breeding of a new silkworm variety "Su . Xiong x Yinxiao" with sex-identified fluorescent cocoon colour.

Canye Kexue, 34(1):140-143.

261. Zhu, X.R., He, K.R., Liu, X.J., Meng, Z.Q., 2008.

(The Sericultural Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou, China)

Breeding of male silkworm variety "Qiufeng x Ping 28".

Canye Kexue, 34(1):45-49.

262. Cao, J.R., Ye, A.H., Wang, Y.Q., Yao, L.S., Zhou, W.L., 2009.

(Sericulture Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China)

Breeding of a new silkworm variety "Chunhua x Qiushi" for spring and autumn rearing.

Canye Kexue, 35(1):160-164.

Abstract: A new silkworm variety "Chunhua x Qiushi" for spring and autumn rearing with moderate silk yield was bred with traditional hybridization method using parental strains which are good in silk quality and resistant to fluoride. The results of two year laboratory identification and two year rural productive test in Zhejiang Province showed that it was uniform in hatching, molting, mounting and easily rearing, and the size of cocoon was big and cocoon yield was high. The quality of cocoon filament was excellent. The results of spring rearing showed that the cocoon shell rate was 23.46 percent, raw silk rate of fresh cocoon was 17.54 percent, cocoon filament length was 1 263 m, reelability was 83.52 percent, filament size was 2.773 dtex, and the neatness was 94.50 points. Its comprehensive economical characters were fine. Cocoon yield per 10000 larvae increased by 7.0 percent than the control (Jingsong x Haoyue), and cocoon yield per 10 000 larvae, cocoon shell yield per 10 000 larvae, cocoon filament length, length of non-broken cocoon filament, raw silk rate of fresh cocoon increased by 1.7 percent, 8.9 percent, 9.0 percent, 6.6 percent and 8.1 percent respectively than the control (Qiufeng x Baiyu). This variety has passed the evaluation by Zhejiang Agricultural Crops Committee and is suitable for rearing in Zhejiang Province and in the Middle and Lower Reaches of Changjiang River.

263. Cao, J.R., Ye, A.H., Zhou, W.L., Wang, Y.Q., Yao, L.S., 2009.

(Sericulture Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China.)

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Breeding of a new silkworm variety " Qiantang x Xinchao" for summer-autumn rearing.

Canye Kexue, 35(2):394-397(Chinese).

Abstract: Aiming at the silkworm breeding objective of strong vitality and stable yield, a new silkworm variety named "Oiantang x Xinchao" for summer-autumn rearing was bred with the method of hybridization followed by directive breeding and strict selection in specific high temperature and humid environment. The results of laboratory identification in Zhejiang Province showed that it was stable in yield and easy to rear, and the quality of cocoon filament was excellent. The larva-pupa rate of fourth instar increased by 2, 84 percent than the control (Oiufeng x Baiyu), The cocoon shell weight per 10 000 four -instar larvae and cocoon filament length increased by 3, 14 percent and 4, 18 percent respectively than the control. The cocoon output per 10000 four-instar larvae was slightly higher than the control, The results of rural productive test in Zhejiang Province showed that its complex economical characters were better than the control (Oiufeng x Baiyu), It was able to achieve high and stable output in mid-autumn rearing season during which high temperature was often recorded, This new silkworm variety has been approved by the Agricultural Crop Variety Evaluation Committee of Zhejiang Province for rearing in the middle and lower reaches of the Yangtze River.

264. Gangopadhyay, D., Singh, R., Kamble, C.K., 2009.

(National Institute of Science Technology and Development Studies, New Delhi-110012, India)

Evolution of a bivoltine breed "DNB1" of the silkworm, *Bombyx mori* L. through ameiotic parthenogenesis.

Indian Journal of Sericulture, 48(1):41-48

Abstract: An attempt was made to evolve a bivoltine silkworm breed through application of artificial parthenogenesis. Two Chinese bivoltine breeds viz., SR18 and CSR12 possessing higher ability towards parthenogenetic development were utilized as breeding source materials. Artificial parthenogenesis was followed to improve the selection efficiency. Eggs were extracted from virgin female moths. Induction of mitotic parthenogenesis was carried out by treating the excised unfertilised eggs with 46°C hot water for 18 min. Crosses were adopted twice with CSR2 to improve the quantitative characters of the parthenoclones. One line, DNB1 with larval sex-limited character and white oval cocoons was evolved. The line was evaluated utilizing four productive bivoltine silkworm breeds. Laboratory evaluation showed superiority of the hybrid DNB1 x CSR4 exhibiting higher fecundity (586), pupation rate (96.67 percent), cocoon shell weight (0.387 g), cocoon shell percentage 1.50 percent), filament length (1050 m) and neatness (92 P). The possibility of application of artificial parthenogenesis in the evolution of superior silkworm breeds and hybrids has been discussed.

265. Singh, R., Nirupama, R., Gangopadhyay, D., Kamble, C.K., 2009.

(Central Sericultural Research and Training Institute, Mysore, India)

Development of polyvoltine breeds of the mulberry silkworm, *Bombyx mori* L. with androgenic origin.

Sericologia, 49(1):21-28.

Abstract: This study was carried out to develop bisexual polyvoltine breeds of the silkworm, *Bombyx mori* L. with androgenic origin. The breeds were developed by crossing F2 males derived from a polyvoltine hybrid BL68 x BL69 with a polyvoltine race 'Nistari' and the eggs were exposed at 38°C for 200 minutes. The larvae hatched out from these eggs expressed paternal characters. Five polyvoltine breeding lines were developed by repeated backcrosses with androgenic males for several generations. Two polyvoltine x bivoltine hybrids AGL3 x CSR2z and AGL5 x CSR2 were found promising. This method will be useful to shorten the breeding cycle and to produce homozygous ft ~reeds which are of utmost importance in silkworm breeding.

266. Singh, H., Suresh Kumar, N., 2009.

(Central Sericultural Research and Training Institute, Mysore, India.)

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Development of oval bivoltine silkworm breeds of *Bombyx mori* L. tolerant to high temperature and high humidity conditions of the tropics.

Green Farming, 2(12):861-864.

Abstract: The bivoltine rearing in harsh tropical climate of our country is not giving fruitful results as the bivoltine are gifted with high productivity and less tolerance to high temperature and high humidity. In order to have continuous supply of quality bivoltine cocoons to produce quality raw silk, the silkworm breeds which can withstand high temperature and high humidity is the need of the our. Hence, in the present study, by utilizing temperature tolerant breeds six breeding lines were made and at every generation the 5th instar larvae were exposed to high temperature and high humidity and the survived ones were back crossed with the breeds moderately tolerant to diseases were made to improve the quantitative traits. From F6 generations, alternate rearing in normal temperature and high temperature were conducted. At the end of F12 generation, it was possible to isolate three oval breeds viz., HH1, HH3 and HH6 with improvement in quantitative traits. The methodologies followed for the development are discussed.

267. Sun, Y., Fang, D.W., Zhu, Q.G., Guan, R.Y., Liu, G.J., Chen, S., He, K.R., 2009.

(Shandong Guangtong Silkworm Eggs Group Co. Ltd., Qingzhou Shandong 262500, China.)

Breeding of a male silkworm variety "Lujing x Huayang" for spring rearing.

Canye Kexue, 35(1):165-169(Chinese).

Abstract: In this breeding practice, a sex linked balanced lethal line named Huayang with good economic characters were prepared through hybridization, self-fertilization and backcross with the balanced lethal line ping76 and the common silkworm race Haoyue which has good silk quality. Besides, a streak sex-limited silkworm strain Lujing was prepared from female parent silkworm race 857 with sex-limited streaks and male parent Qingsong which has good silk quality, high cocoon shell rate and excellent combining ability. The obtained hybrid combination, Lujing x Huayang, has a high male rate over 98 percent, and the yields of cocoon shell rate, cocoon shell weight and silk weight per 10 000 larvae were increased by 3.42 percent, 0.46 kg and 3.52 percent respectively compared to Jingsong x Haoyue. The results showed that it is a male silkworm variety with good economic characters for spring rearing.

268. Zhu, R., Meng, X.R., Chen, S., Liu, X.J., 2009.

(Sericultural Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China.)

A cross breeding method for sex-linked balanced lethal line of silkworm.

Canye Kexue, 35(3):558-561.

Abstract: Sex-linked balanced lethal lines of the silkworm *Bombyx mori* are key parental materials for "maleonly silkworm raising" practice. In order to improve these materials' practical economic traits more extensively, we developed a cross breeding method for improving the traits of sex-linked balanced lethal lines of silkworm. In this method, first, successive back crosses were conducted between males of conventional variety and females of sex-linked balanced lethal line to obtain a intermediate material with a translocated gene + h /1 on sex chromosome W. Second, a cross was conducted between females of the intermediate material and males of the balanced lethal line. And thirdly, continuous self-crosses were conducted to the above crossed material. Meanwhile, selection was carried out based on phenotype difference of the lethal line. Finally, a new sex linked balanced lethal variety named Ping 60 was obtained. The F1 hybrid of Ping 60 and conventional variety Huajing had an over 99 percent male larval rate. Its cocoon filament quality and larval vitality reached the levels of male populations from current commercial varieties.

269. Guo, D.G., Huang, P., Lin, Z.F., Zhang, G.L., Qiu, G.X., Wang, X.Y., Huang, X.G., Hu, Z.M., Li, L.S., 2010.

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(Guangdong Provincial Sericultural Technology Extension Center, Guangzhou 510640, China.)  
Innovation of trimolter silkworm germplasm materials with strong vitality and selective breeding of trimolter hybrid combination.

Canye Kexue, 36(1): 71-78.

Abstract: Trimolter silkworms can be used to produce raw silk with superfine size for special purposes. Novel trimolter silkworm germplasms, namely San and Long of Chinese strain and Hui, Quan, Yuan and Jing of Japanese strain were prepared by using a trimolter silkworm variety with stable moltinism and a current commercial tetramolter silkworm variety with good comprehensive economic characters as parental strains. The obtained trimolter germplasms had good comprehensive economic characters, stable moltinism and strong vitality. Based on combining ability test and combination selection, a four-way hybrid combination San· Long x Hui · Yuan had been obtained. It has much advanced characters as strong vitality, stable moltinism, fine filament and high silk quality. Its rate of trimolter was over 98 percent. Duration of all instars was 1 -2 d shorter than the tetramolter parent. Filament size was 1.75 - 2.22 dtex. One cocoon filament length was 1 000 - 1 200 m. Reelability was 70 percent - 85 percent and neatness was 93 - 95 points. The four way hybrid combination San.Long x Hui· Yuan also showed the characters of stable moltinism and strong vitality in farmers' rearing houses, being suitable for popularization in the sericultural areas of south China.

270. Liu, J.F., Zhang, J.F., Liu, B.B., Cheng, Y.A., Wu, J.M., Zhu, H.S., Du, Z.H., 2010.

(Sericultural Research Institute, Sichuan Academy of Agricultural Sciences, Nanchong Sichuan 637000, China)

Breeding of a silkworm variety" Xiayue x Qiuyu" with double sexlimited markings for summer and autumn rearing.

Canye Kexue, 36(3), 519 -523.

Abstract: By using the method of cross breeding and pedigree selection, a silkworm variety named Xiayue x Qiuyu which has double sex-limited markings and characters of excellent silk quality and suits for summer and autumn rearing was obtained. The results of laboratory identification and rearing by farmers indicated that the new variety not only had the advantages of strong vitality, easy handling, uniform development, and easy judgment of sex by larval body color and marking, but also had high cocoon yield and excellent silk quality. The main economic features of the new variety were better than the control variety. Cocoon weight per 10 000 larvae of the new variety was 19.66 kg, single cocoon filament length 1 241. 29 m, length of none-broken cocoon filament 941. 99 m, reelability 75. 87percent , raw silk rate of fresh cocoon 17. 07percent , and the neatness 94. 03 points, respectively. This new variety had passed the evaluation organized by Sichuan Silkworm Variety Evaluation Committee and is suitable for rearing in areas of Sichuan, Chongqing and other Yangtze River valleys.

271. Ravindra Singh, Nirupama, R., Gangopadhyay, D., Qadri, S.M.H., 2010.

(Regional Sericultural Research Station, Jorhat , Assam)

Androgenesis - A new approach in silkworm breeding

Indian Silk, 1(2): 10-11.

Abstract: Development of high yielding silkworm breeds is an herculean task that demands both time and patience. The authors make a brief presentation of their attempt at CSRTI, Mysore to develop homozygous bisexual multivoltine hybrids using new approach of androgenetic techniques

272. Sharmila, K.K., Kalpana, G.V., 2010.

(Central Sericultural Research and Training Institute, Mysore-570 008, India.)

Improvement of fecundity in popular silkworm breeds of *Bombyx mori* L. through directional selection.

Uttar Pradesh Journal of Zoology,30(1):27-33.

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Abstract: Factors contributing for the total yield are to be given prime importance by the silkworm breeders during the course of breeding. Among many yield contributors fecundity plays a pivotal role. Higher the fecundity more will be the number of larvae resulting in higher cocoon yield. Improvement in one character automatically enhances the total outcome. Hence, the need for the improvement in fecundity in popular silkworm breeds was realized and the present study on the the directional selection for higher pupal weight in females of CSR2, CSR2 (SL), CSR4 and crossing with high cocoon shell percentage males for four generations continuously resulted in the maximum improvement in fecundity in the 3rd generation of CSR2 (SL) and CSR4 and in the 2nd generation of CSR2. The selected breeds excelled in fecundity when compared to the control and all the other metric traits were at par with the control. The method followed for the improvement of fecundity in popular breeds is discussed.

273. Suresh Kumar, N., Basavaraja, H.K., Kalpana, G.V., Joge, P.G., Mal Reddy, N., Nanjegowda, B., Dandin, S.B., 2010.

(Central Sericultural Research and Training Institute, Mysore- 570 008, India )

Development of sustainable bivoltine double hybrid of the silkworm, *Bombyx mori* L. for tropics.

Indian Journal of Sericulture, 49(1):76-80.

Abstract: In India, the traditional breeding methods employed during the last few decades have resulted in the development of a number of productive silkworm breeds which have contributed significantly in increasing the silk production. Although, efforts of several years of breeding and selection work for many economic traits and concomitant improvement in rearing enhanced the silk productivity, the full genetic potential of the hybrids for various yield attributes has not been realised in the field. As a result, there is a wide gap between the yield potential recorded in the laboratory, and the yield realised in the field (Dandin et al., 2003). Efforts made in this direction during the '90s have led to the evolution of highly productive CSR bivoltine breeds which have the potential to produce international grade silk (Basavaraja et al., 1995, Datta et al., 2000a,b Datta et al., 2001, Mal Reddy et al., 2003,2004). However, these new breeds are being popularized on a limited scale with progressive farmers who can provide the high input and managerial skills. Even though they are known for their productive merit, absence of genetic plasticity to buffer against the tropical environmental stresses acts as a constraint to tap the full economic potential of these hybrids. The bivoltine breeds continue to suffer badly in adverse conditions of high temperature, humidity, germ-load, poor leaf quality and low management prevalent with the small and marginal farmers and hence they can rear only cross breeds which cannot produce high quality raw silk. Efforts made for the development of temperature tolerant bivoltine breeds have led to the development of robust bivoltine hybrid CSR18 x CSR19 for rearing in high temperature conditions of summer (Suresh Kumar et. al., 2002). However, the low productivity realised in the field of this hybrid, during summer months resulted in its nonacceptance by the farmers. Tropical sericulture beset with wide fluctuating environmental conditions and poor leaf quality, urgently needs the development of broad based silkworm breeds with genetic plasticity to buffer these adverse situations. Keeping this in view, attempts were made to develop bivoltine silkworm double hybrid relatively tolerant to silkworm diseases and high temperature environment.

274. Wang, Y.Q., Yao, L.S., Cao, J.R., Ye, A.H., He, X.L., Meng, Z.Q., 2010.

(Sericultural Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China)

Breeding of a new silkworm variety "Heng- Feng x Fuyu" for spring and autumn rearing.

Canye Kexue, 36(3), 524 -528.

Abstract: A new silkworm variety " Heng- Feng x Fuyu" for spring and autumn rearing with excellent comprehensive economic traits was obtained through cross breeding and pedigree selection. The results of laboratory identification and rural productive test in Zhejiang Province showed that it was uniform in hatching, molting and mounting. Compared with those of the control variety Oiufeng x Baiyu, the

cocoon weight per 10 000 larvae, cocoon shell weight per 10 000 larvae, and cocoon shell weight per 10 000 larvae of 1 st day of the 5th instar increased by 2.45percent,4.91 percent and 5.22percent respectively. The length of single cocoon filament and none-broken filament was 1 158 m and 996 m respectively, neatness was 96. 10 points and raw silk rate of fresh cocoon was 16. 12 percent all of which were also superior over the control variety. More over, anti-BmNPV infection ability of the new variety Fuyu was obviously improved over the variety Baiyu. This new silkworm variety had been approved by the Agricultural Crop Variety Evaluation Commission of Zhejiang Province in February of 2010.

275. Xiao, J.S., Zhou, A.L., Zhang, Y.H., Xiao, L.R., Xiao, W.F., Pu, J., 2010.

(The Sericultural Research Institute, Sichuan Academy of Agricultural Sciences, Nanchong Sichuan 637000, China)

Achievements and development orientations on selection and breeding of silkworm variety.

Canye Kexue, 36 (4), 650 –655.

Abstract: In the past 60 years, silkworm variety's selection, breeding and extension in China has experienced a developmental history of replacing the local native varieties and foreign-introduced varieties with high quality hybrid varieties that were bred at home, replacing the colored cocoon varieties with high quality, high yield and hypersilkgeneous white cocoon varieties, replacing the univoltine varieties with bivoltine varieties and varieties with strong vitality that were introduced from polyvoltine pedigree, and replacing polyvoltine varieties with bivoltine hypersilkgeneous varieties in subtropical regions. In the eastern, southern, and southwestern sericultural regions of China, silkworm varieties have undergone four times of renovation. And silkworm selection and breeding activities have been carried out in a much diversified way. In the future, silkworm selection and breeding work should take full advantages of the research progress on silkworm genome and functional genes. Based on traditional breeding technology, molecular marker-assisted selection should be employed to obtain silkworm varieties that adapt to ecological conditions of different sericultural regions, have diversified special characters to satisfy different functions and usages, and have excellent properties on both productivity and quality. The above efforts would lay a solid foundation for renovation of the traditional silk industry and promotion of this industry's benefits.

276. Zhang, Y. H., Xiao, J. S., Zhou, A. L., Xiao, L. R., Xiao, W. F. , 2010.

(The Sericultural Research Institute, Sichuan Academy of Agricultural Science, Nanchong Sichuan 637000, China)

Breeding of a new silkworm variety "Chuanacan 23" for spring and autumn rearing

Canye Kexue, 36(5): 850-854(Chinese).

Abstract: A new silkworm variety "Chuanacan 23" for spring and autumn rearing with characters of excellent quality, easy rearing and high efficiency was bred by means of hybridization and directional selection. The results of laboratory identification and rural production trials in Sichuan Province showed that larvae of the new variety had high vitality, strong endurance to high temperature and humidity, short duration of instars, high forage efficiency, excellent silk quality, and stable cocoon yield. It has passed the evaluation of Sichuan Provincial Silkworm Variety Evaluation Committee. Rural production trials in spring showed that its cocoon production per 100 kg mulberry leaf was 8. 58 percent higher than that of the control variety 871 x 872. The results of laboratory identification in spring showed that its larva-pupa rate was 96. 20 percent, reelability was 79. 86 percent , raw silk rate of fresh cocoon was 17. 72 percent , and neatness was 97. 91 points, being close to those of the control variety Jingsong x Haoyue. Rural production trials in autumn showed that its cocoon production per 100 kg mulberry leaf was 3. 98 percent higher than that of the control variety Dong· Ting x Bi· Bo. The results of laboratory identification in autumn showed that its larva-pupa rate was 93. 05 percent, cocoon weight per 10 000 larvae was 18. 77 kg, single cocoon filament length was 1 150 m, reelability was 81. 04 percent, neatness

was 94.82 points, and raw silk rate of fresh cocoon was 16.90 percent, being 1.74 percentage points, 2.46 percent, 41 m, 83 m, 4.50 percentage points, 3.06 points, and 0.38 percentage points higher than that of the control variety Dong·Ting x Bi·Bo respectively. It is concluded that the new silkworm variety could exhibit favorable production features in silkworm raising areas with relatively poor environmental and climatic conditions.

277. Ashwath, S.K., Sharmila, K.K., Mahalingappa, K.C., Nirmal Kumar, S., Qadri, S.M.H., 2011.

(Central Sericultural Research And Training Institute, Mysore-570 008)

Evolution and evaluation of single and double hybrids developed through Amylase marker assisted selection.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp. 75-76.

Abstract: Previous studies have clearly underscored the utility of digestive amylase as an ideal marker in silkworm breeding which imparts better digestibility and higher survival leading to improvement in robustness of bivoltine breeds. Against this background, six polyvoltine breeds, viz., Pure Mysore, CNichi, Daizo (with 4 band type of amylase), nistari, sarupat and moria (with 5 band type of amylase) carrying high activity digestive amylase genes were used as donor parents (Dp) and two productive bivoltine breeds, namely, CSR2 and CSR4 with 'null' type of amylase were selected as recurrent parents (Rp). Backcross breeding was employed upto BC6 by selecting the progeny with Dp type of amylase at each generation. Six oval near isogenic lines (nils) of *csr2* and five dumb-bell nils of *csr4* were evolved with high activity amylase genes, which showed significantly higher survival than their respective RPs. Using the evolved lines, 36 single hybrids of oval x dumb-bell and 25 double hybrid combinations were raised and evaluated by multiple trait index values. Among the hybrids, the highest e.i. Values were recorded in Gen1 x 4C (54.1) followed by GEN1 x CSR4 (53.0), as against the control hybrid CSR2 x CSR4 (46.9). Among the double hybrids, G3 x G8 was found to be superior in terms of highest e.i. value (56.6), followed by G4 x G9 (56.3) and G2 x G8 (54.5), when compared with the control, FC1 x FC2 (47.3). Based on the results, the single hybrid, GEN1 x 4C and the double hybrid G3 x G8 were short-listed and subjected for in-house testing at TVDC of the institute as well as on station trials at rsrcs units, which showed the superiority of the short-listed hybrids in terms of higher yield and better cocoon traits than the controls.

278. Ibrahim Basha, K., Rao, C.G.P., Sivaprasad, V., Goel, A.K., Raju, P.J., 2011.

(Andhra Pradesh State Sericulture Research And Development Institute, Kirikera-515 211, Hindupur)

Introgression of sex-limited marker trait to the parents of a commercial crossbreed of silkworm (*Bombyx mori* L.), Swarnandhra.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp. 63-64.

Abstract: Breeding methods coupled with the application of basic principles of genetics have enabled the silkworm breeders to develop an array of genotypes with desirable characters. Sex-limited strains assume a special significance in Indian sericulture as the bulk of the silk production is derived from polyvoltine x bivoltine crossbreeds at reduced cost of production and correct preparation. Hence, an attempt has been made to introgress sex-limited trait for larval marking into a commercially exploited crossbreed of silkworm (*Bombyx mori* L.), Swarnandhra, APM1 x APS8 developed by APSSRDI, Hindupur. The recipient parent APM1 (polyvoltine) and APS8 (bivoltine) are devoid of larval marking and characterized by spinning greenish yellow oval cocoons and white dumbbell cocoons respectively. The donor breeds, pmsl (polyvoltine) and 318 sld (bivoltine) characterized by the male larvae which are plain bodied without any larval marking and the females with an eye spot marking on the 2nd thoracic segment and a pair of crescent marking on the dorsal side of the 2nd abdominal segment and a pair of star marks on the dorsal side 5th abdominal segment in addition to the sooty grey random mosaic colour

all over the body. For the introgression of sex-limited trait, pmsl spinning greenish yellow oval cocoons is used as donor to apm1 and the bivoltine sex-limited breed, 318 sld spinning white dumbbell cocoons is used as donor parents to aps8. Introgressive hybridization, recurrent back crossing for 4 to 6 generations, selection of families with nearer to 50: 50 sex ratio and cocoon shell index above 100 followed by sib-mating (6-8 generations) along with selection pressure was employed for development of auto-sexing silkworm strains with desired characteristics of recipient parents. The newly developed strains apm1sl (polyvoltine) and aps8sl (bivoltine) were tested for hybrid performance and found on par when compared with a commercial crossbreed, swarnandhra (APM1 x APS8).

279. Jula, S. Nair., Nirmal Kumar, S., 2011.

(Silkworm Seed Technology Laboratory, Kodathi, Bangalore-560 035)

Development of bivoltine pure strains of silkworm, *Bombyx mori* L. to rear exclusively on artificial diet during young instar.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp. 69.

Abstract: In organized young instar silkworm rearing enterprise, easy and economic technologies hold influential impact. Rearing young silkworm on artificial diet offers clear advantages over the existing practice of raising exclusive mulberry garden and then rearing young silkworm on tender mulberry leaves since artificial diet ensures balanced nutrition irrespective of the seasons and disease free conditions. As component bivoltine pure strains of existing productive hybrids did not accept the artificial diet, the study was taken up to create a pool of such strains which would feed on the artificial diet. Six strains viz., 5ht, gen4, 8ht, b71, csr3 and jpn8 were short-listed based on the results of an initial screening which recorded feeding response percentage of more than 20. These six strains were further subjected to continuous inbreeding and directional selection for 12 generations for improving the feeding response over the generations and stabilizing it at more than 85 percent so that they would form perfect breeding resource materials for preparation of commercial bivoltine hybrids for exclusively rearing on artificial diet during young instar. Care was taken so that all other economic traits were within the stipulated level of breed characters. At the end of ninth generation, the feeding response reached above 78 percent except in b71 and further stabilized at the higher level (88 ~ 90 percent by g12) and thus forming prospective parents for bivoltine hybrid combinations. Data pertaining to g9~g12 were analyzed to check the stability in performance. The traits with particular reference to the diet phase such as feeding response, young instar larval duration and young instar larval weight have reflected non-significant differences in the last four generations clearly indicating the stability in these traits. Other traits such as cocoon weight, cocoon shell weight, shell percentage, survival and cocoon yield also did not vary consistently among the generations. After the strains were stabilized for rearing on artificial diet, they were designated as 5HT(a), GEN4(a), 8HT(a), B71(a), CSR3(a) and JPN8(a) as these strains are different from the normal strains (5HT, GEN4, 8HT, B71, CSR3 and JPN8). The implications of the improved feeding response and stabilized economic traits in the context of this study are discussed.

280. Kishor Kumar, C.M., Basavaraja, H.K., 2011.

(P3, Basic Seed Farm, National Silkworm Seed Organization, Srirampura, Mysore-570 008)

Synthesis of bivoltine silkworm breeds of *Bombyx mori* L. with longer and thin cocoon filament.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp. 66-67.

Abstract: Indian bivoltine sericulture witnessed a tremendous momentum in 1990s when there was re-orientation in breeding strategies for the development of silkworm breeds/hybrids along with suitable rearing technologies to popularize them. Majority of the breeding programmes were concentrated for the evolution of breeds/hybrids for higher silk productivity through high shell content and higher

survival through tolerance studies against high temperature and rh conditions. Later, in order to meet the specific industrial requirement, sex-limited breeds/hybrids for larval marking and cocoon colour for grainuers, polyphagous breeds/hybrids for artificial diet rearing, foundation cross for increased fecundity and easy rearing of parental races, poly-hybrids for higher productivity etc., were developed. Similarly in order to meet the reeling industry requirements, breeding strategies were initiated for improving the reeling characters like filament length, filament size, size deviation, boil-off loss, neatness and reelability in order to compete for quality silk production. In the present investigation, two new bivoltine breeds cr11 (oval) and cr12 (dumbbell) characterized for longer filament and thin denier with less size deviation were synthesized by using f1 crossbreed of csr48 and csr4 (oval x dumbbell) as breeding resource material. Unlike conventional breeding, wherein early generation breeding (f1-f4) is done by mass rearing, on the contrary here, directional selection breeding effected for targeted traits through live cocoon reeling. The oval and dumbbell segregant cocoons from f2 were separated and reeled individually to find the filament length and denier. The progenitive layings were prepared by crossing the males and females showing longer filament length and thin denier. Although cellular rearing was conducted in replicates of three up to f8, only one replication which exhibit longer filament length and thin denier was inbred for fixation of targeted traits. From f9 onwards inter-batch crossing of individuals showing longer filament and less denier was done for stabilization of the traits. The directional selection showed positive selection response for the lines separated and resulted in synthesis of cr11 with oval and cr12 with dumbbell cocoon shape. In every generation careful selection of eggs, survival parameters, cocoon weight, shell weight, shell-ratio, uniformity in cocoon shape and size and filament size deviation was made to maintain the productivity and viability. The newly synthesized oval breed cr11 is characterized with 1600 m filament length with 1.9 denier, while, dumbbell breed cr12 is characterized with 1400 m filament length and 2.1 denier. The mean values of all the economic parameters at f11 and f12 were statistically insignificant (p0.05) indicating the stabilized nature of isolated lines. The superiority of these breeds for the economic traits over their initial parents is discussed.

281. Krishna Rao, S., Mahadevappa, Katti, S.R., Narasimha Rao, C.H., Veeresh. M., 2011.  
(Karnataka State Sericulture Research And Development Institute, Thalaghattapura, Bangalore-62)

New Promising robust bivoltine hybrid, BRO2 X NP4 for summer season.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp. 76.

Abstract: With an object of evolving superior robust bivoltine races for summer season, breeding experiments were taken up at KSSRDI and five robust oval cocoon spinning bivoltine races (BRO2, BRO3, KSO-1, KSO2 and KSO3) and six robust dumbbell cocoon spinning races (BRD12, BRD13, BRD15, NP2, NP4) perform better during high temperature and low humidity conditions of summer season. After preliminary studies, field evaluation of new pure races and hybrids has been taken up from 2006 to 2009 in association with DOS, GOK. The new bivoltine hybrid combinations i.e., BRO2 x NP4, and NP4 x BRO2 have been reared by 69 medium farmers in Bangalore (U), Ramanagaram, Kolar and Maandya districts of Karnataka. A total of 8,575 dfls if new combinations have been reared by 69 farmers during March and June from 2006 to 2009. The average cocoon yield in the new combinations is 58 kg /100 dfls fetching Rs. 138.23 /kg cocoons. The cocoon weight and shell percentage is 1.67 gm and 21 percent respectively. Data on the parallel crops of PM x CSR2 and CSR2 x CSR4 in respective areas have been compiled for reference. Compared to control, the average cocoon yield, rate, returns, yield/unit area etc., are superior in the new hybrids during summer season. Farmers have realized several added advantages in the new hybrids. There is no significant difference in the performance between BRO-2 x NP4 and NP4 x BRO-2. Commercial exploitation of the new bivoltine hybrids during summer season to improve

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bivoltine cocoon and raw silk production is discussed in the light of developing bivoltine hybrids for seasons.

282. Krishna Rao, S., Mahadevappa., Katti, S.R., Narasimharao, C.H., Veeresh., 2011.

(Karnataka State Sericulture Research and Development Institute, Thalaghattapura, Bangalore-62)

New productive bivoltine hybrid NK2 x HND for favourable seasons.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp. 85-86.

Abstract: Silkworm breeding studies were taken up at kssrdi, under seri-2000 programme, to evolve robust and productive bivoltine silkworm races to suit local conditions. two oval cocoon spinning bivoltine races i.e., DD-2 and NK-2 and four dumbbell cocoon spinning races i.e., DD-1, DD-3, NK-1 and nk-3 have been evolved with improved robustness and productivity characters. Based on combining ability studies using these new races and other promising bivoltines two new superior bivoltine hybrid combinations, NK-2 X HND and HND X NK-2 have been identified. NK-2 is white oval cocoon spinning race and hnd is white dumbbell cocoon spinning sex-limited larval marking race. Since hnd has sex-limited larval markings it helps in saving time, money and labour in the production of hybrid layings for commercial production. After elaborate laboratory evaluation and preliminary studies these two new productive bivoltine hybrids, ie., NK-2 X HND and HND X NK-2, have been field tested in Ramanagaram, Bangalore (u), Mandya and Kolar districts of Karnataka from 2006 to 2009 in association with DOS, GOK. A total of 20.025 dfls of new bivoltine hybrids have been reared by 145 medium farmers covering rainy and winter seasons. The average cocoon yield realized is 60kg/100 dfls and the cocoons have fetched rs.153.83/kg. The average cocoon weight and shell percentage is 1.62 gms and 22 percent, respectively. There is no significant different between NK-2 X HND and HND X NK-2 in performance. The farmers have expressed their satisfaction on the performance of the new hybrids with reference to crop stability, lesser leaf wastage, uniform ripening of larvae, easy identification of ripe larvae etc. The new hybrid performance is better compared to the parallel batches of CSR2 X CSR4 and PM X CSR2 in cocoon yield, rate, returns, yield per unit area etc. Performance of new bivoltine hybrids and control is discussed with special reference to their commercial exploitation during favourable seasons to boost quality raw silk production.

283. Lakshmi, H., Chandrashekharaiyah, Ramesh Babu, M., Raju, P.J., Saha, A.K., Bajpai, A.K., 2011.

(Central Sericulture Research and Training Institute, Berhampore, West Bengal)

Development of thermo-tolerant bivoltine silkworm (*Bombyx mori* L.) hybrid, HTO5 x HTP5 suitable for tropical areas

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp. 65.

Abstract: Silkworm breeders across the country contributed significantly to the development of many bivoltine breeds not only with improved economic merit but also suitable for variable climatic conditions so as to make tropical sericulture as a sustainable avocation. However, there is a considerable dearth for season and regional specific breeds suitable for rearing throughout the year. Silkworm breeding is a continuous process aimed at evolving improved superior breeds to satisfy the changing needs of sericulture industry. In this direction, silkworm breeding attempts made at andhra pradesh state sericulture research

284. Mahalingappa, K.C., Ashwath, S.K., Sharmila, K.K., Qadri, S.M.H., 2011.

(Rec, Sub-Unit, Kinakahalli, Kollegal-571 487, Karnataka)

Identification of thermo-tolerant bivoltine hybrids developed through amylase marker assisted selection.

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In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp. 87-88.

Abstract: though a number of thermo-tolerant bivoltine silkworm hybrids have been evolved by conventional methods in the institute, limited success has been achieved in their popularity in the field. There is a need to develop robust and productive bivoltine breeds which can be reared during the high temperature conditions of summer by small and marginal farmers. Previous work in the laboratory have clearly shown the prospects of using molecular markers like digestive amylase in breeding for developing robust breeds, by introgressing high activity amylase genes from the polyvoltines into the genetic background of productive bivoltine breeds. The present study was taken up with the objective to assess the thermo tolerance of the breeds and hybrids developed by amylase selection and identification of thermo-tolerant hybrids for field evaluation. The parental breeding lines developed using amylase selection, single hybrids, foundation crosses and double hybrids were subjected for high temperature ( $36\pm 1^{\circ}\text{C}$ ) and high ( $85\pm 5$  percent R.H.) Humidity conditions from 3<sup>rd</sup> day of 5<sup>th</sup> instar for 6 hours daily till spinning and normal temperature and humidity ( $24^{\circ}\text{C}\pm 1^{\circ}\text{C}$  and  $65\pm 5$  percentrh) during cocooning. The data was collected under three trials. Among the single hybrids, 2C X 4S and 2C X 4C recorded the highest pupation of 59.3 percent, when compared to 35.4 percent in the control, CSR2 X CSR4. Among the oval foundation crosses GEN1 X 2C and GEN1 X 2M showed highest pupation rate of 54 percent and 45.7 percent, when compared to 37.9 percent in the control, FC2. In case of dumbbell FCS, high pupation rate of 58.3 percent and 54.7 percent was observed in 4P X 4D and 4P X CSR4 respectively and in case of the control, FC1, the pupation rate was found to be 40.1 percent. Using the short-listed oval and dumb-bell FCS, 25 double hybrids were raised and exposed to heat stress and highest pupation rate was observed in G11 X G23 (60.3 percent) followed by G11 X G19 (58.3 percent). Based on the results G11 X G19 has been short-listed for large scale in-house testing at the institute as well as on station trials at rsrs farms. The results indicate the prospects of identifying robust hybrids suitable for rearing in high temperature conditions under tropical climate.

285. Moorthy, S.M., Das,S.K., Mandal,K., Pal, N.B., Bajpai,A.K., Rao, P.R.T., Saratchandra, B., 2011. (Central Sericultural Research and Training Institute, Berhampore-742 101, West Bengal, India)

Bivoltine foundation cross, SK6 x SK7: - a breakthrough in bivoltine seed crop stabilization in Eastern and North Eastern India.

In: Golden Jubilee National Conference on "Sericulture Innovations: Before and Beyond" held at CSRTI, Mysore on 28-29<sup>th</sup> January 2011,pp.61.

Abstract: Quality bivoltine seed cocoon is vital for production of quality multi x bi eggs and thereby ensures good commercial cocoon harvest. Unlike other traditional sericultural states of India, Eastern India especially in West Bengal rearing of bivoltine parent during seed crop for preparing multi x bi eggs is very difficult owing to unpredictable, fluctuating and harsh climatic condition prevails in most of the seed crops. As a result bivoltine seed cocoons are to be procured from other parts of the country. To overcome this, after series of study, a suitable bivoltine foundation cross (FC) namely SK6 x SK7 was identified and initially tested at RSRSs level. After encouraging performance at RSRS level, it was tested at four DOS, W.B farms in limited scale during 2004 -2006. Upon success, a large scale trial programme was undertaken from Dec. 2007 – March 2010 and same was evaluated in different seed crop seasons in West Bengal through DOS, W.B and NSSO and also at RSRSs, RECs situated in Assam, Meghalaya, Jharkhand and Orissa states. A total of 31920 dfls of SK6 x SK7 was reared in different seed crop seasons for two years. During favourable seed crop seasons (Dec-Jan & Feb-Mar), SK6 x SK7 yielded an average of 42 kg / 100 dfls as compared to 27 kg in NB4D2 (control). Remarkably in the most unfavourable seed crop season i.e., Sep-Oct, (the target seed crop season), it yielded an average of 34 kg / 100 dfls when other bivoltine rearing is near to fail. Data on the important grainage parameters collected from different grainages indicated on par performance with NB4D2 indicating superiority of SK6 x SK7 in local rearing

conditions. Further multi x bi hybrid combinations prepared with this FC namely, Nistari x (SK6 x SK7) (15.0 lakhs dfls) and M6DP(C) x (SK6 x SK7) (1.0 lakh dfls) were evaluated at farmers level in different commercial seasons at West Bengal for two years shown encouraging performance. Thus with SK6 x SK7 (FC), bivoltine seed crop stabilization - the bottleneck for the development of sericulture industry in Eastern and North Eastern India particularly in West Bengal can be overcome and bivoltine seed cocoons can be raised at Eastern and North Eastern India states itself, hence avoiding transportation of seed cocoons from far flung places to save money and energy.

286. Moorthy, S.M., Das, S.K., Mandal, K., Pal, N.B., Saratchandra, B., Bajpai, A.K., 2011. (Central Sericultural Research and Training Institute, Berhampore-742 101, West Bengal, India) Nistari x (SK6 x SK7): - A new multivoltine x bivoltine hybrid for Eastern India. Indian silk. Vol.2 (50 old), No2. 4-6.

In Eastern India, particularly in West Bengal (the major silk producer in Eastern states), five commercial crops are practiced due to distinct variation in climatic conditions. They are spring (February - March/ Falguni), Early Summer (March-April/ Baisakhi) Dry Summer (June-July/Shravani), Wet summer (August-September/Bhaduri & Aswina) and Autumn (November-December/ Agrahayani). During favourable seasons (Spring and autumn) multi x bi hybrid and in unfavourable seasons (Dry & wet summer) multi x multi hybrids are reared. During early summer, multi x bi as well as multi x multi hybrids are reared. Though 2 -3 commercial crops are congenial for multi x bi rearing and their seed crops are not congenial for bivoltine parent rearing. Especially in the autumn commercial crop, the major problem is production of bivoltine seed cocoons for preparation of multi x bi layings, since seed crop of this commercial crop falls during the months of Sept-Oct, when bivoltine parent rearing is difficult due to prevalence of high temperature associated with high humidity (above 90%) which are extremely disadvantageous for the growth and survival of silkworm. As a result bivoltine (male) seed cocoons are brought from other parts of the country for preparing multi x bi hybrids. In view of the above, it is essential to develop a multi x bi hybrid which gives crop stability and its bivoltine parent could sustain the fluctuating climate during seed crops. Accordingly a three way cross (multi x bi) hybrid namely, N x (SK6 x SK7) was developed.

287. Naseema Begum, A., Qadri, S. M. H., Mal Reddy, N., Nirmal Kumar, S., 2011. (Central Sericultural Research And Training Institute, Mysore-570 008)

Breeding for the development of sericin rich bivoltine silkworm breed/ hybrid.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp. 78.

Abstract: Sericin was hitherto considered as an undesirable waste product in India in the textile industry, of late, it is emerging as a viable product of commercial value. In view of its impotence the present work was undertaken to develop a sericin rich breed/hybrid. In the present study a bivoltine breed characterized by naked pupae 'Nd' was selected from the germplasm maintained at Central Sericultural Research and Training Institute, Mysore. The bivoltine breed, CSR2 was utilized for crossing with 'Nd' breed. At every generation sericin rich cocoons are selected. Sib mating was followed in every generation to get homozygosity in the breed. The resultant breed produces cocoons with 98 percent sericin and named as 'N'. Sericin-mutant is controlled by dominant gene 'Nd' located on the 11 chromosome and the F1 hybrids prepared by crossing sericin breed with the normal breed produces only sericin cocoons. Keeping in view of this concept hybrid study was taken up for the development of sericin rich hybrid. thirty eight hybrid combinations including reciprocals were prepared by utilizing the novel breed 'N', along with nine earlier developed bivoltine breeds viz., CSR2, CSR27, CSR50, CSR6, CSR26, CSR51, NB4D2, CSR3, CSR4 and eleven polyvoltine breeds namely C.NICHI, NISTARI, NP1, ND5, NDV6, ND7, PM, PV1, MULTI, MO6, M26. The Hybrids were evaluated based on 14 quantitative

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traits and the hybrid N x CSR26 was selected. The hybrid, N x CSR26 is characterized by survival of 96.4 percent, cocoon weight of 2.073 g, shell weight of 0.0794 g, shell percentage 3.83 and sericin content of 98.5 percent.

288. Nirmal Kumar, S., 2011.

(Central Sericultural Research and Training Institute, Mysore)

Silkworm breeds - progress and Challenges

Indian silk, 1(9):22-27.

Abstract: Improvement is a continuous process. Breeding high productive silkworm breeds, hybrids and double hybrids of today with better cocoon parameters, exploiting positive characters selectively from the days of cocoon yield of 1215 kg with renditta as high as 18, has been a long way indeed. The research undertaken to develop new breeds with unique traits like artificial diet, thin denier, sericin rich, large filament and sex-limited hybrids have great potential of application in newer areas.

289. Rama Mohana Rao, P., Premalatha, V., Ravindra Singh., Joge, P.G., Nirmal Kumar, S., Qadri, S.M.H., 2011.

(Central Sericultural Research and Training Institute, Mysore-570 008)

Development of new polyvoltine x bivoltine hybrids of the silkworm, *Bombyx mori* L. with quality silk.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January, 2011, pp. 62.

Abstract: Indian silk industry is dominated by polyvoltine x bivoltine silk. The indigenous polyvoltine races are known for their elegant and lustrous silk and well suited to fluctuating eco-climatic conditions but poor in silk production and inferior in silk quality. Concerned efforts of research and development contributed to the increased raw silk production but the quality of raw silk is yet to match the international standard. This has necessitated the development of new silkworm hybrids with improved quality fibre characteristics. Twenty-two polyvoltine breeds maintained at central sericultural research and training institute, mysore were evaluated based on quantitative and qualitative traits by utilising multiple trait evaluation index method. Ten top ranked breeds were identified as breeding resource material. By following the directional selection for subsequent generations, based on the fibre characteristics, ten breeding lines were isolated. The breeds namely, l13, l14 and l15, found promising were stabilized. The new breeds were evaluated by crossing with nine bivoltine breeds. Three new hybrids namely l13 x csr2, l14 x csr2 and l15 x csr2 exhibited their superiority over other hybrids for several yarn characteristics and recorded highest average evaluation index values. The improvement recorded in the new hybrids ranged from 2 to 2.3 percent in pupation, 14.3 to 14.8 percent in cocoon yield, 23.1 to 28.9 percent in cocoon shell weight, 10.8 to 15.1 percent in cocoon shell percentage, 25.5 to 27.1 percent in filament length, 18.8 to 22.5 in raw silk percent. Renditta in the new hybrids is reduced by 16.7 to 19.3. The new hybrids were evaluated under large scale at tvdc and the improvement recorded with the new hybrids ranged from 9.5 to 13.8 percent in pupation, 4.6 to 5.0 percent in cocoon yield, 12.3 to 13.6 in cocoon shell weight, 13.7 to 15.7 in cocoon shell percent, compared to pm x csr2. The new hybrids consumed 12 to 16 percent less leaf to produce one kilogram of cocoons. The cocoons of the new hybrids fetched 12-16 percent higher rate than pm x csr2. In addition, positive heterotic values were recorded in these hybrids for various traits. In the present paper, the improvement in the new hybrids as well as the feasibility of their usage for commercial exploitation in the field is discussed.

290. Ramesh, M., Kanika Trivedy., Nirmal Kumar, S., Muniratnam Reddy, M., 2011.

(Central Sericultural Research And Training Institute, Mysore-570 008)

Evolution of new silkworm multivoltine x bivoltine hybrids for rearing on semi-synthetic diet.

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In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup>, January 2011, pp.77.

Abstract: Advent of artificial diet technology has revolutionized sericulture scenario in Japan, China, Korea due to minimum labour involvement and to provide balance nutrition to young instar silkworm. It was thought that popular and productive silkworm hybrids commercially exploited in India and their parental strains would accept the artificial diet for young instar rearing. Upon testing, it was realized that silkworm strains do not accept the diet and feed response is very low. This is mainly because of obligatory and facultative factors beside the genetical factors responsible for feeding behaviour vis-a-vis its nutritional requirement. For improved multivoltine and bivoltine breeds, directional breeding was employed to multivoltine breed 96C and bivoltine CSR2 and CSR18 to improve feed response. For initial generations, coefficient of variance percent was high. By the eighth generation, both bivoltine and multivoltine strains have shown above 90 percent feed response from below 10 percent with simultaneous reduction in cv percent. These parental stocks are being maintained at CSRTI, Mysore and have completed over 50 generations. Hybrids 96C(A) X CSR18(A) and 96C(A) X CSR2(A) were prepared, tested and evaluation index and heterosis were calculated. Hybrid performance as compared to ruling hybrid PM X CSR2 and found that feed response of 96C (A) X CSR2(A) and 96C (A) X CSR18(A) were more than 98 percent whereas, PM X CSR2 more than 90 percent. There were no significant difference in yield and ERR whereas, SR percent of new diet hybrids were 20 percent as compared to PM X CSR2, 17 percent.

291. Ramesha, C., Seshagiri, S.V., Ibrahim Basha, K., Rao, C.G.P., Chandrasekharaiah., Raju, P.J., 2011.

(Andhra Pradesh State Sericulture Research)

Development of productive silkworm breeds/hybrids (*Bombyx mori* L.) with special traits of longer filament length and thin denier.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, pp. 88.

Abstract: In order to meet the domestic and international demand for thin denier silk, experiments were carried out for the development of breeds with special characters such as longer filament length and thin denier. Ten polyvoltine lines were selected from the polyvoltine germplasm and the selected parents were further multiplied and based on their reeling performance, a few polyvoltine lines showing 650 mts of filament length and 2.5 denier were short listed as initial parents for further breeding programme. In each generation, through directional selection, three polyvoltine breeds i.e. APMG2, APMG4 and APMG16 were found breeding true for the desired traits. These polyvoltine lines viz., APMG4, APMG2 and APMG16, were subjected to line x tester analysis by utilizing two bivoltine breeds APS67 and APS20 having longer filament length and thin denier as testers. Based on the performance of the hybrid combinations and multiple trait evaluation index method, three combinations were short listed viz., APMG4 X APS67, APMG2 X APS67 and APMG16 X APS20. Further, Evaluation of selected hybrid combinations was carried out under both laboratory and field conditions and the hybrid combination of APMG16 X APS20 was selected as the most promising hybrid with special traits.

292. Ravindra Singh., Nirupama, R., Qadri, S. M. H., Bajpai, A. K., 2011.

(Central Sericultural Research and Training Institute, Mysore-570 008)

A new breeding approach to evolve polyvoltine breed(s) of the silkworm, *Bombyx mori* L. using androgenetic techniques.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp.79-80.

Abstract: An attempt was made to evolve a polyvoltine silkworm breed "AGL3" through application of androgenesis. The breed was developed by crossing F2 males derived from a polyvoltine hybrid Bl68 x Bl69 with another polyvoltine race "Nistari" and exposing the eggs at 38°C for 200 minutes. Androgenetic larvae were obtained from these eggs which expressed paternal characters. Repeated backcrosses were adopted with androgenetic males for several generations. One line, agl3 with plain larvae and greenish yellow oval cocoons was evolved. The line was evaluated utilizing five productive bivoltine silkworm breeds. Laboratory evaluation showed superiority of the hybrid AGL3 X CSR2 exhibiting Higher Fecundity (493), pupation rate (96.04 percent), yield/10,000 larvae by weight (18.662 kg), cocoon shell weight (0.391 g), cocoon shell percentage (20.40 percent), filament length (1010 m) and neatness (91 p). The new hybrid ranked first exhibiting maximum average evaluation index value and manifested maximum hybrid vigour for several characters. The possibility of application of androgenesis as a breeding tool in silkworm breeding for the evolution of superior silkworm breeds and hybrids has been discussed.

293. Siddiqui, A. A., Chauhan, T.P.S., Pankaj Tewary., Nisar Ahmad, M., Khan, M. A., 2011.

(Central Sericultural Research and Training Institute, Pampore, J&K)

Dun 17 x Dun18 - A new bivoltine silkworm hybrid with high silk content

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January, 2011, pp.62-63.

Abstract: Fifteen single crosses of indigenous bivoltine races and Japanese hybrids were raised and utilized as breeding resource materials to develop new productive bivoltine hybrids with high silk ratio at RSRS, Sahapsur, Dehradun. Pedigree and a line selection method of breeding was adopted and breeding populations from F1 to F3 generations were reared in mass with random mating to obtain the more gene recombinants and to increase the variation in breeding populations. This has facilitated the selection of desirable individuals in later generations of breeding. During mid-generation of breeding cellular rearing was adopted and directional selection was imposed both at batch and individual level with emphasis on cocoon yield, pupation rate, single cocoon weight, single shell weight, shell ratio, filament length, denier and other post cocoon parameters. Breeding lines which have not responded to selection and have not recorded any improvement in metric traits were culled during breeding. Consequently, fifteen new bivoltine genotypes were evolved in the year 2000 and new breeds were subjected to hybrid testing. thirty six new hybrid combinations were evaluated in the year 2000 and were ranked as per Mano's evaluation index method and finally five most promising hybrids were short listed which excelled the others. Among them Dun 17 x Dun18 has recorded the pupation rate of 90.7 percent, cocoon yield/10000 larvae of 19.82 kg, single cocoon weight of 2.037g, shell weight of 48.9cg and shell ratio of 24.12 percent against the values of 91.7 percent, 19.87 kg, 1.962g, 39.7cg and 20.23 percent respectively which were recorded in control hybrids Sh6 x Nb4d2. At farmers level, an average cocoon yield of 55kg/100 dfls was recorded while in control the average yield was only 40 kg. Dun 17 x Dun18 was tested at 23 test centers under race authorization programme of central silk board in the year 2006 and 2007 and authorized for commercial exploitation. In the present paper, an account of method of breeding of new bivoltine silkworm breeds, selection procedures have been discussed in detail.

294. Sivaprasad, V., Ibrahim Basha, K., Vijayalakshmi, L., Raju, P.J., 2011.

(Andhra Pradesh State Sericulture Research)

Breeding of bivoltine silkworm (*Bombyx mori* L.) breeds APDR105 and APDR126 for disease resistance to BMDNV1 and tolerance to BMNPV.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, pp. 88.

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Abstract: Sericulture in andhra pradesh is practiced strategically under different climatic conditions prevailing in the state. The extreme variation in the climate which is causing stress, there by various diseases to silkworms has necessitated the need for development of disease resistant / tolerant breeds to bmdnv1 and bmnvp respectively. Two bivoltine breeds APDR105 and APDR126 were developed through disease resistance breeding by inducing resistance to bmdnv1 and tolerance to bmnvp. Through selection and inbreeding, these two breeds were found to breed true for various other traits such as high cocoon weight, shell weight and cocoon shell percentage including pupation rate. The hybrid of APDR105 and APDR126 has been field tested and also authorized by central silk board for commercial exploitation. Presently this hybrid combination is very popular among the farmers of andhra pradesh especially during the stressful summer and rainy seasons.

295. Suresh Kumar, N., Harjeet Singh., Saha, A. K., Bajpai, A. K., 2011.

(Central Sericultural Research and Training Institute, Berhampore-742 101)

On the breeding of bivoltine double hybrid of the silkworm, *Bombyx mori* L. tolerant to high temperature and high humidity conditions of the tropics

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp. 80.

Abstract: cocoon crop stability with sustainably good performance is a pre-requisite to introduce bivoltine races in a tropical country like india under high temperature and humidity stress. Considering the poor performance of productive bivoltine hybrids during summer season, emphasis was given to evolve bivoltine silkworm breeds suitable to tropical conditions for achieving the primary objective of establishing bivoltine sericulture with quality raw silk among sericulturists. One of the main aims of the breeders is to recommend silkworm breeds/hybrids to farmers that are good performers and simultaneously stable under different environmental conditions and minimize the risk of falling below a certain yield level. Silkworm breeds that are reared over a series of environment exhibiting less variation are considered stable. Therefore, it becomes imperative or essential to develop bivoltine breeds/hybrids which can with stand high temperature and humidity stress. In india, it is not conducive to rear highly productive bivoltine hybrids, especially in summer. Therefore, attempts are being made to develop bivoltine silkworm hybrids tolerant to high temperature situations of the tropics. Attempts made earlier on these lines had resulted in the development of robust bivoltine hybrids Viz., CSR18 X CSR19, CSR46 X CSR47 and CSR50 X CSR51. However, these hybrids could not make any impact in indian sericulture industry except in certain region/seasons. Keeping this in view, attempt is being made to develop productive and stable bivoltine double hybrid tolerant to high temperature and high humidity conditions of the tropics. The breeding process as well as the comparative performance of the new hybrid with the already developed double hybrid is also discussed in detail.

296. Umadevi, K., Raghavendra Rao, D., Nirmal Kumar, S., Qadri, S.M.H., 2011.

(Central Sericultural Research And Training Institute, Mysore-570 008)

Development of a productive multivoltine x bivoltine hybrid Line4 x CSR2 of the mulberry silkworm *Bombyx mori* L. tolerant to high temperature and humidity.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29<sup>th</sup> January 2011, pp. 73.

Abstract: breeding programmes were initiated during 2004 for the development of multivoltine breeds/hybrids tolerant to high temperature and humidity. Initially, forty four multivoltine breeds maintained at Central Sericultural Research and Training Institute, Mysore were evaluated at high temperature and humidity ( $36\pm 1^{\circ}\text{C}$  and  $85\pm 5$  percent rh) for one year. Eight top ranked multivoltine breeds for temperature tolerance and six multivoltine breeds resistant to bmnvp were utilized and ten breeding plans were initiated. Larvae of breeding lines were exposed to high temperature and humidity for six

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hours daily during fifth instar third day onwards till spinning. After F5, the lines were short-listed to five based on pupation rate at high temperature and humidity. Utilizing two multivoltine breeds viz., Bl67 and mar the breed Line4 was developed. Cross breeding and selective sib mating followed by batch selection for targeted traits resulted in the development of Line4. At F12 generation, line4 was subjected to hybrid evaluation with six bivoltine breeds viz., CSR2, CSR3, CSR4, CSR6, CSR16 and CSR17. The hybrid Line4 x CSR2 exhibited its superiority by recording 96.25 percent survival, 1.965 g cocoon weight, 41.3 cg cocoon shell weight, 21.0 percent cocoon shell ratio, 16.08 percent raw silk percentage and 928 m filament length whereas the control (PM x CSR2) recorded 96.00 percent survival, 1.921 g cocoon weight, 35.2cg cocoon shell weight, 18.3 percent cocoon shell ratio, 14.00 percent raw silk percentage and 805 m filament length. Commercial exploitation of the new polyvoltine x bivoltine hybrid in sericulture industry has been discussed.

297. Yamaguchi, A., 2011.

(Ex Silkworm Race maintenance expert, JICA PPPBST in India)

My experiences with Indian sericulture under JICA project.

Indian silk, 1(9):54-55.

Abstract: Breeding silkworm with higher yield has been his main forte. The author explains the major objectives for silkworm breeding and also the race maintenance along with the steps to be taken.

**CHAPTER-II**

**EVALUATION OF  
SILKWORM BREEDS/  
HYBRIDS**

## EVALUATION OF SILKWORM BREEDS / HYBRIDS

298. Giorgi, D., 1957.  
Comparative silkworm breeding various strains derived from crosses of Japanese and native stock in 1955.  
*Bolletino de Zoologia Agraria e di Bachicoltura*, 22:33-64.
299. Bekirov, A.G., 1958.  
Intraspecific cross breeding of the white-cocoon mulberry silkworm.  
*Agrobiologiya*, 6:80-83.
300. Strunnikov, V.A., 1958.  
Experimental breeding of sexmarked strain of the mulberry silkworm, using X-rays.  
*Akademii Nauki SSSR Moscow*, 220-225.
301. Hirobe, T., 1963.  
A silkworm breeding method taking advantage of the difference of radioasensitivity. (II). The comparison of healthiness  
*Japanese Journal of Breeding*, 13(1):55.
302. Jolly, M.S.; Krishnaswamy, S., 1964.  
(Central Sericultural Research Station, Berhampore, West Bengal, India.)  
Sericin content in cocoons of indigenous silkworm races (*Bombyx mori* L).  
*Indian Journal of Sericulture*, 3(1):17-18.
303. Sun, P.T., 1964.  
The critical conclusions on the some methodological problems of silkworm breeding.  
*Journal of Sericultural Science of Japan*, 2(2):95-100.
304. Jolly, M.S.; Subba Rao, S.; Krishnaswami, S.; Kamala, S., 1965.  
(Central Sericultural Research Station, Berhampore, West Bengal, India.)  
Effect of genetic diversity on hybrid performance in multivoltine Indian silkworm.  
*Indian Journal of Sericulture*, 4(1):9-12.
305. Xia, J., 1965.  
Study on the breeding of resistant races of silkworm, *Bombyx mori*.  
*Journal of Sericulture Science, China*, 3(3):180-184.
306. Samokhvalova, G.V., Bylinkina, A.A., Komova, A.D., 1966.  
(Moscow State University, Moscow, USSR)  
Effect of food quality upon viability and productivity of the silkworm *Bombyx mori* in summer.  
*Zoologicheskii zhurnal*, 45(6):875-883.  
Abstract: The effect of food quality upon silkworm larvae in summer was studied. The *Scorzonera*-line reared in the University of Moscow, early maturing race, hybrids between these 2 races the race SANYYSH-III (Central Asian Research Institute of Silkworm Breeding), the hybrid between *Belokokonnaya-2* x *Ukrainskaya-1*, and some others were used. It was found that in summer young leaves of the mulberry tree (apical, from young shoots and sprouts) gave the best results with respect to viability, cocoon weight, length of the silk thread, productivity, and silk yield. When larvae are fed on mature leaves, a thinner thread is formed. Young in summer contain, along with a high amount of nitrogen, a large amount of mineral salts (K and Ca), as well as that of soluble carbohydrates compared to young leaves in spring.

307. Penkov, I., 1968.  
Influence of the mulberry tree leaves on the silkworm in summer silkworm breeding.  
*Zhivotnov'd nauki*, 5(8):99-106.  
Abstract: During 1960-1962, an attempt was made to breed silkworms of the Hybrid M Shalta X B bivoltina types during the summer, feeding them the leaves of low-stemmed plants of the mulberry tree types No.106, No.101 and Diwa. The development of the silkworms, the cocoon output, the technological properties and the yield of cocoons from this summer breeding are dependent upon the quality of the nutrition. The preparation of the mulberry plants has considerable effect upon the physical properties and the nutritive value of the leaves. The treatment of cutting the tips of the shoots brings better results than thinning out the shoots. For normal cocoon output and quality, the No.106 and 101 types of plants are recommended.
308. Sidhu, N.S.; Venugopala Pillai, S.; Kamala, S.; Sreenivasan, R.,1968.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
The performance of an evolved multivoltine silkworm breed.  
*Indian Journal of Sericulture*, 7(1):6-12.
309. Sengupta, K.,1969.  
(Central Silkworm Seed Station, Pampore, Kashmir, India.)  
An analysis of genotype environment interaction in some races of silkworm *Bombyx mori* L.  
*Indian Journal of Sericulture*, 8(1):4-10.
310. Strunnikov, V.A., 1969.  
(V.I. Lenin Tashkent State University, Tashkent, USSR)  
Obtaining male progeny from silkworms.  
*Doklady Akademii Nauk SSSR*, 188(5):1155-1158.  
Abstract: Experimental investigation were set up to develop a method of obtaining purely male progeny in the silkworm suitable for industrial use. The problem was solved by using radiation methods to develop a special breeding of silkworm, the males of which when crossed with females of any other breed produce offspring consisting almost solely of males. The eggs of the females sex die at the embryonic stage of development under the effect of recessive sex-linked lethals.
311. Kovalev, P.A., 1970.  
(Central Silk Board, Bangalore)  
Silkworm Breeding Stocks.
312. Kremky, J., 1970.  
Heterosis in mulberry silkworm, *Bombyx mori*. (II). Hybrids obtained on top crossing and reciprocal mating.  
*Genetica Polonica*, 11(3/4):403-414.  
Abstract :The present study was entended to explore the industrial value of hybrids obtained on top-crossing and reciprocal mating. Individual families of biotypes were appraised from the stand point of general combing ability by top-crossing i.e mating biotype families with the test race. Next followed elimination of families with in biotypes, and of biotypes in which the general combining ability was unsatisfactory. On the basis of results gained and breeding single cross hybrids acquired on reciprocal mating, the value of double-cross hybrids was calculated by Jenkins formula.
313. Sengupta, K.; Datta, R.K.; Biswas, S.N.; Singh, B.D.,1971.  
(Central Sericultural Research Station, Berhampore, West Bengal, India.)

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Studies on the heterosis in multivoltine silkworm, *Bombyx mori* L. (I). Yield performance of F1 hybrids of Nistari and four evolved multivoltine breeds.

Indian Journal of Sericulture, 10(1):6-13.

Abstract :A comparative study of the yield performance of F1 hybrids between four evolved breeds and the local breed Nistari reared in both favourable and unfavourable seasons, has been carried out. In F1 combination hatching percentage has not differed significantly from the best parent namely Nistari. While the combinations Nistari x D3c, Nistari x D14b, D14b x Nistari are found to be better than the other F1 combinations in regard to effective rate of rearing, all Nistari combinations are superior to non-Nistari combinations in respect of cocoon weight. The single shell weight in the combinations D14b x D3c, D3c x Nistari are better than the top parent D14b. It is evident from the F test of absolute silk content in F1 hybrids that D3c x Nistari, D14b x Nistari, MBDIV x Nistari, D14b x D3c are significantly superior to respective top parents and other combinations at 5 percent level. From the results it has been concluded that F1 hybrid combinations specially of Nistari are significantly superior to the pure Nistari race and should be used for commercial rearing.

314. Tikoo, B.L.; Kaplia, M.L.; Krishnaswami, S., 1971.

(Central Sericultural Research Station, Mysore, India.)

Large scale trials on the comparative performance of multivoltine X bivoltine hybrids of mulberry silkworm in Mysore state.

Indian Journal of Sericulture, 10(1):57-65.

Abstract :Despite the fact that new foreign (P3) races have been introduced for exploiting hybrid vigour with pure Mysore as the female parent in Mysore State, the old long acclimatised races are still being continued and in fact by a certain section performed for use in the preparation of crossbreed seed. In order, therefore, to assess the relative merits of different combinations of multivoltine x bivoltine races currently in use in Mysore and to ascertain why the old foreign races like H.S. 6 and C. Nichi are still being continued, a large scale experiment on the performance of twelve different combinations including ten crosses utilizing pure Mysore as the female parent was conducted at the instance of Research coordination committee of the Central Silk Board. The experiments were carried out for eight seasons during 1969 and 1970. The results of the experiment showed that the ten different combinations with pure Mysore as female parent were not significantly different in regard to practically all important characters. This in other words, would mean that the newly introduced P3 races which have been continuously reared in the plains and perhaps without proper attention to maintenance of their economic characters are in no way superior to the existing races like C, Nichi, H.S.6 or newly evolved races like Kolar Gold N.S. 4. This would call for maintenance of the P3 races and implementation of P3 programme envisaged.

315. Astaurov, B.L., 1973.

(Institute of Developmental Biology, Academy of Sciences, USSR, 26 Vavilov Street, Moscow 117334, USSR)

Selection for predisposition toward thermic artificial parthenogenesis in the silkworm abstract genetics breeding. Genetics, 74(2):12.

316. Sengupta, K., Datta, R.K., Biswas, S.N., 1973.

(Central Sericultural Research Station, Berhampore, West Bengal, India)

Effect of multiple crossing on the type of progeny recovered in silkworm, *Bombyx mori* L.

Indian Journal of Sericulture, 12:31-38.

Abstract: Studies on the ratio of the progeny from the females mated to more than one male in the silkworm, *Bombyx mori* L., with D14b as the female and D14b and Nistari as males for different periods indicated a definite predominance of the second male, so much so, that in crosses involving 15 to 30

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minutes of mating by the first male (in breeding) following 2.5 to 2.5 hrs, mating by the second male (cross-breeding) resulted in progeny from the latter generally ranging from 86.5 to 99.4 percent. This observation changed the concept of chancemated females just on emergence as total waste and afforded a scope for commercial utilization of the same through longer mating with the second male ranging from 2.5 to 2/3/4 hrs. with a maximum of about 14 percent as waste. Some dominance of sperm from Nistari male was also observed which might be due to cross-breeding in this case against in-breeding in the combination D14b x D14b, leading to possible higher mortality in the latter.

317. Pedro, J.R., 1974.

Study of methods of silkworm breeding.  
Boletín de industria Animal (Brazil), 31(2):331-335.

318. Giorgi, D., 1975.

Italian mulberry-silkworm breeding has come to a decisive turning- point  
Terra e Vita (Italy), 16(36):18-19.

319. Iyengar, M.N.S.; Ganesh, N.K.; Tikoo, B.L., 1975.

(Central Silkworm Seed Station, Pampore, Jammu and Kashmir, India.)  
Studies on the differential viability of sexes in the sex-limited breeds of silkworm (*Bombyx mori* L.) in use in India.  
Indian Journal of Sericulture, 14(1):6-11.

Abstract: Sex-limited counterparts of three races, C-Nichi-1, H.S. 6 and pure Mysore were studied for the effect of hyperploidy on the possible differences in survival and yield. All the three sex-limited races showed a significant difference in viability due to sexes, females being less viable. But the difference was lowest in C-Nichi-1 and highest in pure Mysore. The data suggest that the deleterious effect of the introduction of the sex limited markings is not severe in these races, and the large advantage compensate for the slight difference in viability.

320. Yamamoto, T., Gamo, T., 1976.

(Sericultural Experiment Station, The Ministry of Agriculture and Forestry, Hono Coity, Tokyo, Japan)  
Studies on the breeding in relation to the improvement of food utilisation in the silkworm, *Bombyx mori* L., I  
Mutual relations among the food ingested, the amount of food digested digestibility and several quantitative characters in the silkworm reared on an artificial diet.  
Journal of sericultural science of Japan, 45(1):81-85.

Abstract: Present investigation was carried out to develop the selection method for the amount of food ingested, the amount of food digested and digestibility of silkworm larvae, by means of chromic oxide method. for measuring food utilisation in the silkworm larvae reared on an artificial diet. Effects of "crowding" upon the feeding behaviour of the 5th instar larvae, mutual relations among these three characters and their correlations with other several quantitative characters were studied, using two hybrid strains. In the rearing of a single larva, the duration of the 5th instar was slightly longer than that in the rearing of crowded ones, while the values were similar between two levels of group size in other several characters. High positive correlations were observed between the amount of food ingested and the amount of food digested and between the amount of food digested and digestibility, whereas the correlation between the amount of food ingested and digestibility was low. These three characters related to food utilization showed relatively high positive correlations with cocoon weight, cocoon shell weight and weight of the 4th molting larvae.

321. Yamamoto, T., Gamo, T., 1976.

(Sericultural Experiment Station, The Ministry of Agriculture and Forestry, Hono Coity, Tokyo, Japan)

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Studies on the breeding in relation to the improvement of food utilisation in the silkworm *Bombyx mori* L. II Heritabilities in a amount of food ingested, amount of food digested and digestibility in F2 population.

Journal of sericultural science of japan, 45(2):111-114.

Abstract: Heritabilities of the three characters related to food utilization, amount of food ingested, amount of food digested and digestibility, in the silkworm larvae reared on an artificial diet were studied, using two hybrid strains. Heritability was estimated in F2 population by means of the method of parent-offspring regression. The heritabilities of amount of food ingested, amount of food digested and digestibility in the 5th instar larvae were estimated as 0.53 ~ 0.68 , 0.42 ~ 0.75 and 0.36 ~ 0.64 respectively, and their values were higher in female larvae than in male ones. Since the heritabilities of these three characters showed relatively high value, it is concluded that these characters can be improved by selection.

322. Paolieri, L., Silveira, F.A.da., 1976.

(Divisao de Zootecnia Diversificada, Instituto de Zootecnia, Nova Odessa, Sao Paulo, Brazil)  
Experimental rearing of silkworm strains, *Bombyx mori* L.

Boletim de Industria Animal (Brazil), 33(2):301-311.

Abstract: During 12 years of breeding, out of 47 strains of silkworm (*Bombyx mori*), the best strains were selected, taking into consideration: the number of eggs/g, the average weight of the silkworm larvae, the number and production of cocoons per g of eggs, the number of cocoons/kg, the average weight of the cocoon, the silk richness, the percentage of normal, imperfect and double cocoons, the thread qualities, the yearly reproduction of strains, largest laying, health, selection of normal motles for reproduction, and the shape, size, and colour of the cocoons according to each strain.

323. Campos, A.R., 1977.

Behaviour of four different silkworm hybrids at sericulture institutes (*Bombyx mori*). Animal genetic breeding.

Revista de Agricultura (Brazil), 52(4):197-202.

324. Elsaadany, G.; AbdelFattah, M.I.; ElGarhy, A., 1978

(Faculty of Agriculture, Ain Shams University, Cairo, Egypt.)

Biological and technological characteristics of the hybrids and strains of the mulberry silk worm, *Bombyx mori* L. in Egypt.

Academy of Scientific Research and Technology and National Research Centre, In: Fourth Conference of Pest Control, Cairo, Egypt, 30 September 1978.

325. Petkov, N., 1978.

(Opitna Stantsiya po Bubarstvo, Vratsa, Bulgaria)

Inheritance of cocoon silk and selection effectivity in some interlinear *Bombyx mori* L. hybrids.

Genetika i Seleksiya, 11(1):63-70.

Abstract: Three interlinear crosses B-1/18xS-2/12, B-1/18xS-2 and B-1/18xB2/21 and their parental lines were studied for 5 generations. The variation of cocoon silk percentage is higher F2 than in parental lines. In same interlinear crosses ie. B-1/18 x S-2/12 and B-1/18 x B2/21 the range of variation is wider than that of parental lines. These connection are of practical value in the breeding of silkworm lines with high silk content. By selection of the extreme deviations in F2 and F3 for silk content, the following high silk content characteristic in the cocoon. A high level inheritance of cocoon silk content was established in the individual generations of the hybrids studied. High values of correlation coefficient for F2, F3, F4 and F5 were observed.

326. Zhou, X., 1980.

Discussion on the breeding method of sex-limited race of egg colour and marking of silkworm, *Bombyx mori*.

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Journal of Sericulture Science, China, 6(2):80-85.

327. Kremsky, J., 1983.

(Silk Research Station, Institute of Native Natural Fibers, Zolwin, Poland)

Effect of heterosis in Polish single- and double-cross silkworm hybrids (*Bombyx mori* L.).

Genetica Polonica, 24(1):73-93.

Abstract: Results of long-term experiments dealing with breeding of mulberry silkworm hybrids and their testing in Poland and abroad are presented in view of manifestation of inbreeding depression in biotypes and effect of heterosis in main quantitative characters in silkworm hybrids. Inbreeding depression gives evidence for an advanced homozygosity of mulberry silkworm biotypes, obtained as a result of a long-term inbreeding. Sometimes the effect of heterosis appears as a result of mating of related subbiotypes within the biotype and a slight effectiveness of selection in biotypes can be seen.

328. Kremky, J., Szuba, M., 1983.

Effect of biotype breeding on the value of mulberry silkworm hybrids in 1969-1979.

Prace Instytutu Krajowych Wiokien Naturalnych, 28:157-164.

Abstract: The results of rearing polish silkworm biotypes, simple hybrids and polyhybrids in succeeding cycles is presented. To reduce the deviations caused by seasonal influence and to estimate the genetic value of tested silkworms, a comparison of mean values in 5-years overlapping periods has been made. The Japanese hybrid hoshō x shungetsu has been taken as standard. A Stabilisation of hatchability, survival rate, cocoon crop per 1 gram of eggs in polish polyhybrids has been stated on a level approaching the Japanese standard. The cocoon weight and cocoon shell weight, that are factors of individual selection of biotypes, are also stabilized in polyhybrids on a high level in spite of inbreeding depression in biotypes. Silk richness increased along with filament length and silk yield, and caused a decrease of cocoon consumption in silk reeling. A decrease of cocoon crop and cocoon quality in industrial rearings of both polish and Japanese polyhybrids, has been observed as result of a general lowering of rearing culture, caused by a lack of qualified silkworm rearers. It has been decided to elaborate a model family rearing, suitable to actual economic conditions of the country.

329. Datta, R.K., 1984.

(Central Sericultural Research Training Institute, Mysore, India)

Improvement of silkworm races (*Bombyx mori* L.) in India.

Sericologia, 24(3): 393-415.

Abstract: Sericulture has been practised in India since time immemorial. Indigenous races of West Bengal, Jammu Kashmir and Karnataka have been reared in the 19th-20th Century. However, poor yield and quality, lack of infrastructural support and appropriate rearing and seed technology came in the way for evolving high yielding multi- and bivoltine races. During the seventies, Central Sericultural Research Training Institutes (CSRTI), Mysore (Karnataka) and Berhampore (West Bengal) evolved number of poly- and bivoltine races suitable to different agroclimatic conditions of tropics. The commercial hybrids of Pure Mysore and bivoltine breeds, which are popular with the farmers, increased the average cocoon production to 35kg/100 dfls from 18-20 kg of traditional cross, Pure Mysore\**C.Nichi* in South India. The *renditta* too has now come down to 10 from 18 in the traditional crosses. This resulted in trebling of raw silk production in a decade's time apart from the spread of sericulture development programme to the non-traditional states in the country. In the eighties, CSRTI, Mysore, started a bimodal approach to silkworm breeding with an aim to further improve polyvoltine as well as bivoltine breeds with specific needs for tropics. Performances of these new multi- and bivoltine breeds which are presently being field tested, are detailed in the paper. In the new bivoltine hybrids the cocoon yield/10,000 larvae and *renditta* have further improved to register a yield of 21kg and 5.1, respectively.

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The author has also discussed in the paper the perspective breeding programmes apart from the need for international gene bank, and biometrical/biochemical genetic researches.

330. Liu, S.X., 1984.

(Sericultural Research Institute, Guangdong Academy of Agricultural Science, China.)

Identification on the resistance of silkworm (*Bombyx mori*) races to six types of silkworm disease [nuclear polyhedrosis virus, cytoplasmic polyhedrosis virus, Densovirus, *Bacillus thuringiensis*, pebrine spores, sodium fluoride].

*Sericologia*, 24(3):377-382.,

Abstract: The resistance of 33 silkworm races to cytoplasmic polyhedrosis virus (CPV), nuclear polyhedrosis virus (NPV), densovirus (DNV), pebrine, *Bacillus thuringiensis* (Bt) and sodium of fluoride (NaF) have been determined in 1978-1981. It has been found that the difference of resistance between the most highly resistant race and the most susceptible race were 2000-fold, 875-fold, 100,000-fold, 1000-fold, 134-fold and 40-fold respectively. This result provides resistant sources for the breeding races which have resistance to silkworm disease, such as resistant races to CPV (Nong42, Nong51, Yongdaizo etc.), resistant races to NPV (Hainan, Guobai, Qinjing ec.), resistant races to DNV (7201, 115nan, Yue5 etc.) and resistant race to pebrine (Baipidan). Some races have resistances to several silkworm diseases, for example, Yue5 has resistances to NPV, CPV, DNV, pebrine and NaF; Baipidan has resistances to CPV, DNV, pebrine, Bt and NaF.

331. Sidhu, N.S., 1984.

(Genetics Division, Indian Veterinary Research Institute, Izatsnagar, India)

Performance of the CSRTI 1 to 8 multivoltine breeds of silkworm *Bombyx mori* L. for tropics [India].

*Sericologia*, 24(3):440.

Abstract: CSRTI- I to VIII, eight breeds of silkworm were fixed which were multivoltine in nature and bred true, under a plan NSPS-plan No 2 (modified) using two exotic breeds Belakokonaya and Tashkashi and local Pure Mysore races. The breeds gave reasonably expected yields, were giving a filament length which was significantly longer than the local multivoltine breed and has certain quantitative characteristics resembling the exotic parental breeds. Production data of the breeds has been described averaging their performance on the whole, under conditions prevailing in Karnataka in 1970. The breeds were evolved for exploitation, commercially.

332. Tayade, D.S., Jawale, M.D., 1984.

(Sericultural Research Unit, Marathwada Agricultural University, India)

Studies on the comparative performance of silkworm races against different varieties of mulberry under Marathwada conditions [*Bombyx mori*; Maharashtra [India]].

*Sericologia*, 24(3):361-364.

Abstract: Comparative merits of 4 varieties of mulberry, viz., K2, S54, Kosen and LM-2 on the cocoon quality of two bivoltine races (NB7 and NB18) and a hybrid race a(PM X NB 18) were tested. S54 showed higher values in different characters; namely larval duration larval weight, single cocoon weight and cocoon yield. the hybrid PM x NB18 proved superior in cocoon yield.

333. Kouno, Y., Ohdachi, Y., 1985.

(Sericultural Experiment Station, Yatabe, Ibaraki, Japan)

Comparison of feeding of artificial diet in the hybrids among the silkworm strains selected by artificial diet and by mulberry leaf.

*Acta Sericologica*, 135:97-109.

334. Kouno, Y., Ohdachi, Y., 1985.

(Sericultural Experiment Station, Yatabe, Ibaraki, Japan)

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An example of comparison of quantitative cocoon characters in the two silkworm strains, selected by the rearing of artificial diet or mulberry leaf.

Acta Sericologica, 134:99-108.

335. Adler, A., Dumitrescu, C., Titescu, E., 1986.

Observations on the behaviour of silkworm hybrids at the experiment base of the Bucharest Nicolae Balcescu Institute of Agriculture, Moara Domneasca farm.

Lucr Stiint Inst Agron "NICOLAE BALCESU" Zootech, 29(0):75-81.

Abstract: The experiment was aimed at testing 16 silkworm hybrids bred at Moara Domneasca in domestic type conditions. Breeding was organised with the same biological material at the Central Station for Sericulture, Baneasa, for comparative purposes. The results show evident superior values for all the indices: the weight of the raw cocoon and that of the dried cocoons, the weight of the silk wall, the percentage of silk and length of the yarn for the hybrids bred in the conditions of Moara Domneasca. The best results were obtained with hybrids Nos. 7 and 15, which justifies their extension for silkworm breeding in domestic type conditions in southern Romania.

336. Nacheva, i., 1986

Some parameters of basic quantitative breeding characters in *Bombyx mori*: Correlation between the basic breeding character.

Genetika i Seleksiya, 19(2):144-150, (Bulgarian)

337. Pershad, G.D.; Datta, R.K.; Bhargava, S.K.; Vijayakumar, H.V.; Jolly, M.S., 1986.

(Central Sericultural Research and Training Institute, Mysore, India)

Combining ability analysis in multivoltine races of *Bombyx mori* L.

Sericologia, 26(3):307-315.

Abstract: The combining ability effects of nine multivoltine races of *Bombyx mori* L. were analysed in a 9 x 9 diallel for cocoon yield, fecundity, shorter larval duration, pupation rate, shell ratio and filament length for three seasons. The quantities for both the general (GCA) and specific (SCA) combining ability were significant for all the traits. However, the ratio of  $2 a_2 g / (2 a_2 g + a_2 s)$  ranged from 0.91 to 0.97 except for fecundity (0.25) indicating that there is sufficient GCA in these races to make successful selection for cocoon yield and higher survival. General combining ability (GCA) quantities exceeded specific combining ability (SCA) for all traits as determined from  $2a_2g / (2a_2g + a_2s)$  ratios. The GCA quantities indicated that Mysore princess followed by Kollegal jawan are good general combiners. Most of the combinations of Hosa Mysore with indigenous and exotic multivoltine races proved good specific combiners. The positive reciprocal effects in Hosa Mysore hybrids indicate the accumulation of cytoplasmic genes. The selective utilization of these races in future breeding programme has been discussed.

338. Pershad, G.D., Datta, R.K., Vijayakumar, H.V., Bhargava, S.K., Jolly, M.S., 1986.

(Central Sericultural Research and Training Institute, Mysore, India)

Performance of some multivoltine races of *Bombyx mori* L.

Sericologia, 26(3):295-301.

Abstract: Nine indigenous, exotic and evolved multivoltine races maintained at this institute were reared during four distinct rearing seasons at Mysore. Their performance for six independent characters, valuable to silkworm breeding, were statistically analysed. Mysore princess was found superior for higher fecundity, cocoon yield, shell ratio and filament length whereas diazo was superior for shorter larval duration and Nistari for pupation rate during all the rearing seasons. Analysis of variance indicated that races and seasons were significant for all characters, while interactions of races x seasons were significant for fecundity and pupation rate during all seasons.

339. Zhang, Z., 1986.  
Studies on the heredity and breeding technique of silkworm's resistance against CPV disease. (I). The genetic trend of silkworm's resistance against CPV disease.  
*Canye Kexue*, 12(4):211.
340. Govindan, S., Magadum, S.B., Satenahalli, S.B., 1987.  
(Department of Sericulture, College of Agriculture, Dharwad-580 006, India)  
Breeding with some polyvoltine and bivoltine strains of the silkworm, *Bombyx mori* L.  
*Sericologia*, 27(4):597-604.  
Abstract: The extent of variability in economic traits viz., larval, silk gland, cocoon and cocoon shell weights was studied in seven pure breeds (two multivoltines and five bivoltines) and their 42 direct and reciprocal Fls. The extent of heterosis exhibited by the F1 hybrids is also presented.
341. Hossain, M., 1987.  
Maintenance of local and exotic strains of mulberry silkworm and their cross breeding to develop improved strains/races.  
Proceedings of the Workshop on Bangladesh Agricultural University Research Progress Mymensingh, Bangladesh Agricultural University, 294-317.  
Abstract: Cross breeding among the local and exotic strains of mulberry silkworm showed positive results toward developing improved strains. Eight hybrid lines appear to show encouraging results with respect to silk filament length and Cocoon-shell ratio. Among these, four hybrid lines may be given selection as improved strains. Performances of 12 local and three chinese strains were observed through 15 generations to select better strains for cross-breeding. Among these, four local and three chinese strains were found suitable for use in the cross breeding experiment for getting improved high-yielding strains/lines.
342. Petkov, N., Nacheva, I., 1987.  
(Opitna Stantsiya po Bubarstvo, 3000 Vratsa, Bulgaria)  
Breeding evaluation of original material for selection of the silkworm (*Bombyx mori* L.). (II). Lines developed from Chinese populations.  
*Genetika i Seleksiya*, 19(6):538-543.  
Abstract :On the basis of studies carried out in Bulgaria, details are given of the biological characters of 13 breeding lines of silkworms, properties of the raw cocoons and fibres, variability of the main breeding characters and reproductive characters of the adults. Breeding-genetic evaluation showed that the breeds Vratsa 18, Super Kom 2, Hebur 2, Belopol 2 and Vratsa 24 could be used as initial forms in industrial hybridization with suitable Japanese breeds, while 157-K and Veslets 2 could be used as suitable donors for improving viability, Belopol 2 and Vratsa 16 for increasing cocoon weight and silk shell, and Ogosta 2 for increasing cocoon fibre length.
343. Petkov, N., Nguyen, V.L., 1987.  
(Opitna Stantsiya po Bubarstvo, 3000 Vratsa, Bulgaria)  
Breeding-genetic studies on some lines of the silkworm (*Bombyx mori* L.) reared at high temperature and air humidity. (II). Inheritance of quantitative characters.  
*Genetika i Seleksiya*, 20(4):348-354.  
Abstract: The coefficients of heritability of the principal quantitative breeding characters in *Bombyx mori* (cocoon weight, silk shell weight, silkiness and length of the fibre) and the gene effects of character inheritance were determined. Five hybrids and their reciprocal crosses were used in the experiments. The quantitative characters were genetically conditioned when the silkworms were reared at high temperature (26.2-29.4°C) and relative humidity (79-88 RH). The dominant gene and epistatic effects had

the relatively highest share in the inheritance of cocoon weight, weight of silk shell and silkiness of the cocoon. Both dominant and additive gene effects and epistasis showed significant participation in the inheritance of cocoon fibre. The degree of genetic difference between the lines in the crosses was small (1-5 genes). A breeding programme based on maximum utilization of dominance and epistasis is recommended for developing silkworm hybrids suitable for rearing at high temperature and humidity.

344. Venugopala Pillai, S.; Krishnaswami, S., 1987.

(Regional Sericultural Research Station, Coonoor - 1, Tamil Nadu, India.)

Adaptability of silkworm *Bombyx mori*(L.) to tropical conditions. (III). Studies on the effect of high temperature during later developmental stages of silkworm.

Indian Journal of Sericulture, 26(2):63-71.

Abstract: Effect of exposure to high temperature (38°C) in two phases of fifth instar, i.e spinning period and pupal stages of eight silkworm breeds were analysed. Exposure to high temperature during the later development stages considerably reduced the survival rate, pupation rate, cocoon quality and fecundity of the breeds and resulted in increased pupal mortality and unfertilized eggs. Among the breeds, Hosa Mysore, kalimpong 'A' and the hybrid HM X KA revealed increased tolerance to high temperature conditions and overall better crop results

345. Zhang, Z., 1987.

Studies on heredity and breeding technique of silkworm resistance against CPV disease. (II). The breeding selection technique of silkworm resistance against CPV disease.

Canye Kexue, 13(2):81.

346. Benchamin, K.V.; Jolly, M.S.; Benjamin, D.A.I., 1988.

(Central Sericultural Research and Training Institute, Mysore-570 008, India.)

Studies on the reciprocal crosses of multivoltine and Bivoltine breeds in silkworm *Bombyx mori* L. with special reference to the use of bivoltine hybrid as a parent.

Indian Journal of Sericulture, 27(1):27-34.

The rearing and reeling tests were conducted with crosses, bivoltine female x multivoltine male, and the results were compared with conventional crosses, multivoltine female x bivoltine male. Three way crosses of (bivoltine x bivoltine) hybrid female x multivoltine male and its reciprocal were also tested to study the possibility of using bivoltine x bivoltine hybrid as one of the parents, instead of pure breeds. Results indicated crosses using bivoltine as female parent are at disadvantage with significant reduction in hatching (by 5.7 to 9.3 percent) survival rate (by 4.6 to 10.1 percent). cocoon yield (by 8.3 to 17.9 percent), cocoon weight (by 4.9 to 7.3 percent), shell weight (by 6.4 to 9.2) and high floss content (by 10.0 to 22.0 percent) and renditta (by 4.5 to 6.4 percent). The clear advantages in such crosses were shorter larval duration (by 8 to 22h) and higher fecundity (by 34 to 74 eggs/laying). Results also indicated that bivoltine x bivoltine hybrid can be used as male parent with multivoltine as female parent, at par with crosses PM x NB18 or PM x NB7.

347. Datta, R.K., Pershad, G.D., 1988.

Combining ability along Multivoltine x Bivoltine silkworm (*Bombyx mori* L.)

Sericologia, 28(1):21-29.

Abstract: Combining ability for cocoon yield and other five basic independent characters among hybrids of five multivoltine and three bivoltine silkworm (*Bombyx mori* L.) breeds were studied in a 8 x 8 partial diallel crosses including reciprocals, to select out the best combiners for utilisation in replacing the existing hybrids as well as in the heterosis breeding programme. Quantities for general combining ability (GCA) for all characters and for specific combining ability (SCA) for cocoon yield and filament length were highly significant. Superiority of  $2_g(2)/(2_g(2) + s(2))$  ranging from 0.83 to 0.98. Parental

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performance as judged by GCA quantities indicating that Hosa Mysore and Mysore Princess multivoltine with NB7 biovoltine were good general combiners. The crosses of Nistari and Daizo multivoltine with NB7 and Hosa Mysore with NB4D2 bivoltine proved better specific combiners for cocoon yield and pupation rate.

348. Iizuka, E., Ogasawara, I., Tamai, O., 1988.

(Faculty of Textile Science, Shinshu University, Ueda, Nagano, Japan)

Effect of breeding improvement on the mechanical properties of the cocoon filament of the silkworm, *Bombyx mori*.

Journal of Sericultural Science of Japan, 57(3):216-222.

Abstract: The elastic modulus(dynamic) and the degree of crystallinity of the cocoon filaments from a large number of strains of *Bombyx mori* belonging to several races were measured. In all the races tested, the elastic modulus showed a negative linear correlation with the size of the filament, suggesting that the fibrous structure of the cocoon filament becomes less development with increasing size of the filament. The magnitude of the coefficient (negative), *b* of the regression line that represents the linear correlation was smaller in the improved race than in the native race when two Japanese white cocoon races were compared. The improved race includes many strain which originated from European races whose cocoon filament is characterized by a low *b* value. The degree of crystallinity also showed a correlation similar to that of the elastic modulus of the filament; and the *b* value for this variable was smaller in the improved race. In the Chinese white-cocoon races, any significant differences in the *b* value for the elastic modulus was not detected between the two races, native and improved, suggesting that the crossing involved mostly strains belonging to the native Chinese races. However, the elastic modulus of the cocoon filament tended to be higher when the race was improved as also observed in the Japanese race.

349. Kanda, T., Tamura, T., Inoue, H., 1988.

(The Sericultural Experiment Station, Tsukuba, Ibaraki 305, Japan)

Feeding response of the silkworm larva to the LP-1 artificial diet designed by a linear programming method and its inheritance.

Journal of Sericultural Science of Japan, 57(6):489-494.

Abstract :In order to understand the genes concerning the feeding behaviour and develop the method of breeding the silkworm races that are suitable for the low cost artificial diet, feeding response to the low cost diet LP-1 designed by linear programming method was investigated on the newly hatched larvae of 46 parent strains. The results showed that several Japanese strains, for example, J01, J148, J147 and Sawa J, were able to be grown on the diet. However, no larvae in Chinese strains were found to be grown on the diet, and some larvae used were died rather quickly after food application. Feeding test of F1, F2 and BF1 larvae between the two strains with high and low feeding ability showed that the feeding is controlled by recessive genes. Moreover, the histogram of the larval weight of the F2 and BF1 individuals after food application implied that the feeding ability is determined by a major recessive gene and some modifiers.

350. Shamachary., 1988.

(Central Sericultural Research and Training Institute, Mysore, India)

Volume of silkworm cocoons as a post cocoon parameter and its applications in breeding, marketing and reeling techniques.

International Congress on Tropical Sericulture Practices, Bangalore, Feb 18-23, 1988, 15-18.

Abstract: Many useful correlations have been established and reported based on weight factor of silkworm cocoons and their products. At present a correlation established between the volume of the cocoon and its shell content and its application in silk industry is reported. First part of the study revealed a correlation between the volume of the cocoon and its shell weight irrespective of bi or

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multivoltine race of silkworm cocoon which can be of some use in silkworm breeding experiments and which can be made use of in fixing the prices of cocoons in the cocoon markets. Second part of the study reveals that cocoons with less volume and with good compactness i.e., better shell density, are more preferable to those with more volume with poor compactness.

351. Sumida, M., Ishiko, S., Mori, H., Matsubara, F., 1988.

Breeding of silkworm strains on an artificial diet by aseptic rearing techniques appropriate for production of a silk fiber paper from original silkworm strains which produce a silk fiber.

Bulletin of the Apparel Science Research Center Kyoto Institute of Technology, 63(7):1-4. Abstract: A technique is investigated where silkworm spin on a flat surface to produce a paper of silk fibers. This research is developing a new area of silk fiber utilization, other than fabrics. The applicability of this new technique for producing silk fiber papers for interior decoration is examined. Effects of diet on original silkworm strains and a hybrid strain and their resultant spinning behavior are outlined along with the characteristics of the silk fiber paper.

352. Petkov, N., Nguyen, V.L., 1988.

(Opitna Stantsiya po Bubarstvo, 3000 Vratsa, Bulgaria)

Breeding-genetic studies of some lines of the silkworm (*Bombyx mori* L.), reared at high temperature and humidity. (III). Heterosis performances of quantitative characters.

Genetika i Seleksiya, 21(4):336-342.

Abstract: A study was carried out aiming to assess the heterosis performances and the inheritance of some of the most important quantitative characters in promising silkworm hybrids, suitable for rearing at high temperature and air humidity typical for the conditions existing in vietnam. Highest heterosis effect was observed for yield and of the silkworm shell. The heterosis effect for yield of raw cocoons was closely related with that for cocoon weight and to a relatively lower extent with silkworm viability.

353. Gupta, S.K., Das, S.K., Nair, B.P., Sengupta, K., 1989.

Use of genetic parameters for effecting breeding plan of silkworm.

News and Views, Quarterly Bulletin of CSRTI, Berhampore, 4(2):8.

354. Hossain, M., 1989.

(Bangladesh Agriculture University, Mymensingh, Bangladesh)

Silkworm breeding and selection of improved hybrid lines (Bangladesh)

Proceedings of the workshop on Bangladesh Agriculture University Research Progress, Bangladesh, 29-31 October, 1989, 60-65.

355. Jung, D.S., Rhe, I.J., Lee, S.M., Kim, S.E., 1989.

(Miryang National Junior College of Agriculture and Sericulture, Miryang, Korea Republic)

Classification and selection of the breeding materials in the silkworm, *Bombyx mori*, by multivariate analysis. (I). Classification of the silkworm genetic stocks by principal component analysis and cluster analysis.

Korean Journal of Sericultural Science, 31(2):102-112.

356. Murakami, A., Ohtsuki, Y., 1989.

(Department of Ontogenetics, National Institute of Genetics, Mishima, Shizuoka, 411 Japan)

Genetic studies on tropical races of silkworm (*Bombyx mori*) with special reference to cross breeding strategy between tropical and temperate races. (I). Genetic nature of the tropical multivoltine strain of Cambodia.

Japan Agricultural Research Quarterly, 23(1):37-45.

Abstract: In connection with the development of improved races of *Bombyx mori* for sericulture, the genetic nature of the tropical multivoltine strain Cambodia (from Cambodia) is described. Some typical

visible phenotypes are characterized in relation to non-diapausing eggs, egg colour in diapausing eggs, and colour and shape of the cocoons. An attempt is described to detect some useful but not yet established quantitative characters in the tropical race.

357. Murakami, A., 1989.

(Department of Ontogenetics, National Institute of Genetics, Mishima, Shizuoka, Japan)

Genetic studies on tropical races of silkworm (*Bombyx mori*) with special reference to cross breeding strategy between tropical and temperate races. (II). Multivoltine silkworm strains in Japan and their origin.

Japan Agricultural Research Quarterly (Japan), 23(2):127-133.

Abstract :In Japan a dozen of multivoltine strains had been maintained even for a short period from the II half of the 19th century. It should be noted here that multivoltine silkworm strains raised in Japan cease embryonic development during the unfavourable season from October to the coming April. This event and others are strongly suggestive that in general the tropical race is able to be cultured without difficulty in the temperate zone. The multivoltinism among the most representative characteristics of the tropical race is easily adaptable to some monovoltinisms, from the multivoltine to the tetra, tri and bivoltines and rarely to univoltine in the temperate zone. In addition this biological event is only concerned in the phenotypic changes of the gene function controlling the multivoltinism, but that is independent from the essential changes of the gene structure.

358. Nacheva, I., 1989.

(Sericultural Experiment Station, Vratsa 3000, Bulgaria)

Phenotypical and genotypical features characterizing the silkworm during the different seasons of larval rearing.

Genetika i Seleksiya, 22(3):242-247.

Abstract: A study was carried out in Bulgaria on outbred Super-1 and 157-K populations of *Bombyx mori* during 3 seasons of feeding (spring, summer and autumn) using individuals of the same families in each season. The data underwent genetic statistical (monofactorial-dispersion) analysis of variance on the basis of inter-class correlation between full sibs. The feeding season had a considerable influence on the phenotypical expression and value for the coefficient of heritability of the main breeding characters (cocoon weight, weight of the silk shell, silkiness of the raw cocoons) and reproductive characters (numbers of eggs per hatch, weight of hatch, weight of normal seed and physiological waste). Breed differences were found for the coefficient of heritability. In Super 1 it was highest during autumn feeding, and in 157-K likewise during spring feeding.

359. Nacheva, I., 1989.

Correlations between silkworm hatch and some breeding characters.

Genetika i Seleksiya, 22(4):339-345(Russian).

Abstract: Correlation analyses were made relating to the egg-mass, cocoon, silk shell and pupal weights and silkiness of the raw cocoon for 2 outbred populations of the silkworm [*Bombyx mori*] (Super I and 157-K) developed in Bulgaria. The genotypical, paratypical and phenotypical correlation coefficients were determined at population level. Phenotypical correlations between egg-mass weight and cocoon, silk shell and pupal weights were positive, while the correlation between egg-mass weight and cocoon silkiness was negative. Genotypical and paratypical correlations were unidirectional relative to the phenotypical correlation except for the genotypical correlation between egg-mass weight and cocoon silkiness. Selection for cocoon weight and silk shell weight would lead to increased egg-mass weight. The positive genotypical correlation between egg-mass weight and cocoon silkiness is proof of the possibility of developing lines combining high silkiness with high female reproductivity.

360. Nacheva, I., 1989.

Correlations between silkworm hatch and some breeding characters.

Genetika i Seleksiya, 22(4):339-345.

Abstract: Correlation analyses were made relating to the egg-mass, cocoon, silk shell and pupal weights and silkiness of the raw cocoon for 2 outbred populations of the silkworm [*Bombyx mori*] (Super I and 157-K) developed in Bulgaria. The genotypical, paratypical and phenotypical correlation coefficients were determined at population level. Phenotypical correlations between egg-mass weight and cocoon, silk shell and pupal weights were positive, while the correlation between egg-mass weight and cocoon silkiness was negative. Genotypical and paratypical correlations were unidirectional relative to the phenotypical correlation except for the genotypical correlation between egg-mass weight and cocoon silkiness. Selection for cocoon weight and silk shell weight would lead to increased egg-mass weight. The positive genotypical correlation between egg-mass weight and cocoon silkiness is proof of the possibility of developing lines combining high silkiness with high female reproductivity.

361. Petkov, N., 1989.

(Sericultural Experiment Station, Vratsa 3000, Bulgaria)

Improving the initial breeds of the regionally distributed hybrid Hessa 1 X Hessa 2 intended for spring industrial silkworm feedings. (I). Correlations between quantitative breeding characters.

Genetika i Seleksiya, 22(3):248-252.

Abstract: Studies were carried out in Bulgaria to establish correlations between the most important quantitative selection characters for spring industrial rearing of improved inbred and outbred lines of the silkworm [*Bombyx mori*] obtained from the initial breeds of the regionally utilized hybrid Hessa 1 X Hessa 2 and its backcross. It was found that the cocoon shell weight in the newly isolated lines was positively correlated with the cocoon weight ( $r = +0.528$  to  $+0.653$ ) and with the silkiness of the cocoons ( $r = +0.479$  to  $+0.712$ ). In selecting for silkiness in silk production, and in particular in the maintenance of lines, both when producing eggs during preliminary reproduction and also at certain stages during production of the super stock, it is recommended to take into account chiefly the shell weight, but without ignoring the cocoon weight and the fibre length as additional selection characters.

362. Rao, P.R.M., Vijayaraghavan, K., Singh, R., Premalatha, V., 1989.

(Multivoltine Breeding Laboratory, Central Sericultural Research and Training Institute, Mysore 570 008, India)

A note on the oily larval mutant in silkworm, *Bombyx mori* L.

Current Science, 58(20):1155-1157.

Abstract :In breeding studies on *Bombyx mori* in June 1988, a spontaneous oily mutant larval form was found in a polyvoltine strain of the silkworm. The mutant was identified as the og mutant, which is situated on chromosome 9 at locus 7.4. Although the mutation has a deleterious effect, the cocoon characters of survivors were better than those of the normal form, and bred true.

363. Satenahalli, S.B., Govindan, R., Goud, J.V., 1989.

Studies on combining ability in silkworm, *Bombyx mori* L.

Mysore Journal of Agricultural Sciences, 23(2):216-219.

Abstract: A 7 X 7 diallel cross analysis involving 7 breeds of *Bombyx mori* and their 42 F1s, including reciprocals, were studied for their combining ability for 6 quantitative traits. The comparison of parents indicated that none of them was good for all the traits. Predominance of additive genetic variance existed for larval weight, cocoon weight and cocoon shell weight, and non-additive genetic variance for larval duration, cocooning and pupation.

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364. Sengupta, K.; Rama Mohana Rao, P.; Vijaya Raghavan, K.; Noamani, M.K.R.; Manjunath, D.; Raju, H.V.; Shekar, M.A.; Biram Saheb.,1989

(Central Sericultural Research and Training Institute, Mysore, India.)

Impact of MY 1 hybrids in South India.

In: Workshop on Sericulture Extension and Management, Central Sericultural Research

Abstract:In India ninety percent of the silk production is of multivoltine variety. In South India, indigenous multivoltine race - Pure Mysore is the only female parent used for the bulk of the silk production. Pure Mysore, though resistant to various stress conditions, its yield attributes are very poor and larval span is around thirty days. The CSRTI has evolved a new multivoltine breed namely, MY1, through cross breeding and selection. In the present paper, the performance of MY1 x Bivoltine hybrids based on 19 trials data is discussed and compared with PM x Bivoltine hybrids

365. Sengupta, K.; Nagraj, C.S.; Ratna Sen.; Sudha.; Biram Saheb.,1989.

(Central Sericultural Research and Training Institute, Mysore, Karnataka, India.)

Performance of PCN bivoltine hybrid combination in rainfed regions of Karnataka.

In: Workshop on Sericulture Extension and Management, Central Sericultural Research

Training Institute, Mysore, 30-31 August, 1989, p.64.

Abstract Sericulture is practised both under irrigated and rainfed conditions in Karnataka. The cocoon productivity and quality is of lower order in the rainfed tracts. The farmers prefer to rear the traditional Pure Mysore x Ci'nichi crosses. During 1983-89, a new hybrid combination viz., PCN x Bivoltine has been introduced successfully in the rainfed tracts of Karanataka. The comparative performances of PCN x Bivoltine hybrids with traditional hybrids are given below and discussed in the paper.

366. Xu, W.; Wu, Y.; Li, S.,1989

(Institute of Sericulture, Chinese Academy of Agricultural Sciences, Zhenjiang, Jiangsu, China) Studies on the heredity and breeding of number of eggs laid in silkworm (*Bombyx mori* L.). (I). Genetic analysis and breeding meaning in number of eggs laid.

Hereditas, China, 11(3):15-18.,

367. Chatterjee, S.N., Aswath, S.K., Chatterjee, G.K., Rao, G.P., Patnaik, A.K., Datta, R.K., 1990.

(Central Sericultural Research and Training Institute, Mysore, India)

Correlation/interaction between biochemical parameters and yield components *Bombyx mori* L. Abstracts of Seventh All India Congress of Cytology and Genetics, Department of Zoology, University of Kalyani, West Bengal, India, December 22-26, 1990, 91-92.

Abstract: Enormous contribution has been made possible in the field of qualitative and quantitative improvement through breeding by way of better understanding of the correlation/interaction between biochemical pathways and the yield components. It is with similar objective, works have been carried out with various genotypes of mulberry silkworm *B. mori* available in India. Analysis involved 4 major yield components i.e. larval weight, cocoon weight and shell weight and survival (ERR percentage). While the biochemical parameters considered were invertase, protease (pH7 and pH10), alkaline phosphatase, amylase and trehalose data supported the positive role of amylase in the survival and following the cue, short breeding experiments were also done to test the prospect of using biochemical markers for silkworm breeding.

368. Chatterjee, S.N., Nagaraj, C.S., Giridhar, K., 1990.

(Central Sericultural Research and Training Institute, Mysore, India)

An approach to silkworm breeding.

Proceeding of Workshop on Biometrical Genetics, September 7-8, 1990.

369. Jeong, W.B., 1990.  
(Onga University, Pusan, Korea Republic)  
Studies on heterosis, selective index, genetic advance and selective efficiency for some characters in silkworm breeding.  
Korean Journal of Sericultural Science, 32(1):8-16.
370. Jung, D.S., Rhe, I.J., Lee, S.M., Kim, S.E., 1990.  
(Milryang National Junior College of Agriculture and Sericulture, Milryang, Korea Republic)  
Classification and selection of the breeding materials in the silkworm, *Bombyx mori*, by multivariate analysis. (II).  
Combining ability and its pre-estimate for the top cross set made from the silkworm parental lines selected by principal component analysis.  
Korean Journal of Sericultural Science, 32(1):17-30.
371. Rayar, S.G., Govindan, R., Ashoka, J., Narasimharaju, R., Narayanaswamy, T.K., 1990.  
Cocoon traits among single and three-way cross hybrids of silkworm *Bombyx mori* L. with Pure Mysore as maternal parent.  
Current Research, University of Agricultural Sciences, Bangalore, 19(8):140-142.  
Abstract :In breeding experiments with *Bombyx mori*, the single cross hybrid NB18 X J gave the best overall performance in terms of weight per 10 cocoons, weight of 10 cocoon shells and cocoon filament length. In general, the single cross hybrids performed better due to the complete homozygosity of the parents.
372. Satyanarayana, R.C.; Chandrashekaraiiah.; Venugopala Pillai, S.,1990.  
(Regional Sericultural Research Station, Coonoor-643 101, India)  
Performance of Bivoltine breeds of silkworm, *Bombyx mori* L. As influenced by mulberry varieties in high altitude.  
Indian Journal of Sericulture, 29(2):162-167.  
Abstract :A study was conducted with 4 popular bivoltine silkworm breeds viz., NB7, NB18, NB4D2, et KA, to evaluate their comparative performance when reared with 3 mulberry varieties in high altitude conditions of Nilgiris (Tamil Nadu). It was observed that breeds NB7 and NB18 performed better than NB4D2 and Ka. The nutritive quality of Kosen variety was found better than that of Kanva-2 and MR2 varieties.
373. Singh, B.D., Baig, M., Balavenkatasubbaiah, M., Sharma, S.D., Sengupta, K., Reddy, N.S., 1990.  
Studies on the relative susceptibility of different breeds of silkworm (*Bombyx mori* L.) to diseases under natural conditions.  
Indian Journal of Sericulture, 29(1):142-144.  
Abstract :Four bivoltine and 3 multivoltine races of *Bombyx mori* were reared following standard methods. The incidence of the diseases grasserie and flacherie was recorded daily and the cocoon yield was assessed. The experiment was conducted in the winter, summer and rainy seasons. Disease incidence was found to be higher in bivoltine than in multivoltine races. PM was the best multivoltine, and NB18 the best bivoltine, race. The possibility of breeding for disease resistance is discussed.
374. Yu, S.J., Chu, H.T., 1990.  
(Taiwan Apicultural and Sericultural Experiment Station, Taiwan, China)  
A review study on breeding of mulberry silkworm, *Bombyx mori* L.  
Chinese Journal of Entomology, 5:29-36.
375. Zakharieva, K.; Shabalina, A.; Abadzhieva, R.,1990  
(Sericultural Experimental and Monitoring Station, Kharmanli, Bulgaria.)

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Viability and productivity of the silkworm (*Bombyx mori* L.) depending on the physiological waste in the hatchings.

Genetika i Seleksiya, 23(3):237-243.

Abstract: Studies in Bulgaria indicated that degrees of physiological egg wastage in hatchings of *Bombyx mori* between 2 and 25 led to more or less progressive and significant deteriorations in basic biological characteristics such as egg hatchability, larval viability, cocoon weight and productivity, silk shell weight and percentages of normal eggs in the hatch. Selection of hatchings with wastes up to 2 is recommended in selection programmes in order to differentiate highly productive lines within one and the same population. In breeding work, both for maintenance of original lines of regionalized hybrids and for preliminary propagation, use should be made of hatchings with up to 2 wastage, and for production of super-elite, elite and hybrid eggs likewise hatchings with up to 3, 4 and 5 wastage, resp. A study was made in Bulgaria of locomotor activity during ontogenesis (using a method developed by Shabalina [see *Compt. Rend. Acad. Bulg. Sci.* (1989), 42, 91]) and silk-production characteristics in 6 breeds and hybrids of *Bombyx mori*. Analysis of the results (t-test and 3-factor dispersion (LS) analysis) showed both breed and sex differences in locomotor behaviour. Larvae from groups moving towards mulberry leaves in the first 30 min developed better and later had statistically better raw cocoon weight and silk shell weight than larvae of groups that remained in a described circle longer than 60 min.

376. Aliev, A.G., Musaeva, M.R., 1991.

(Azerbaijan Scientific Research Institute of Silkworm Culture, USSR)

New methods of increasing resistance of silkworm hybrids to nuclear polyhedrosis.

Soviet Agricultural Sciences, 12:34-35.

Abstract :A method was developed using provocation breeding in combination with antiviral treatment of the eggs with sodium bisulfite antiseptic to increase resistance in silkworms [*Bombyx mori*] to nuclear polyhedrosis virus disease.

377. Bojovic, S., Marovic, R., 1991.

(Institut za Sumarstvo, Beograd, Yugoslavia)

Testing of differences between qualities of a few races of silkworm imported from P.R. of Bulgaria.

Zbornik radova Institut za sumarstvo, 34-35:57-64.

Abstract :In the Institute of Forestry and Wood Industry in Belgrade - Yugoslavia in 1990 year, 19 races of silkworm were reared, which eggs were imported from Bulgaria. The results of statistical analysis of a few qualities of silkworm, as: hatching, production of cocoons, diameter and length of cocoons and silkness have shown the existence of statistically significant differences between races, i.e. their expressed genetical polymorphism. Better results in respect to the remaining races have shown: Hebar 1, Ukrainska 13, Taskenskaja 15, Vraca 1, No 371. However in the process of hybridization and selection breeding the importance of the remaining races is not disparaged, their genetical wealth and variability being the basis of any breeding.

378. Budisantoso, S.H., Kaomini., 1991.

Effect of rearing location of silkworm and cocoon selection on cocoon quality.

Buletin Penelitian Hutan (Indonesia), 541:23-31.

Abstract: Cocoon selection is one of the treatments in post harvest and very important to be done before cocoon will be reeled. Also rearing location, influenced the production of cocoon. Both have impact on cocoon quality. This experiment was aimed to observe the effect of rearing location of silkworm and cocoon selection on cocoon quality. The experiment was conducted from April 1989 to March 1990 at Sericultural Research Project, Bili-Bili using cocoon produced by farmers of Gowa, Soppeng, Malakaji and Sinjai districts. Factorial Randomized Complete Block Design was used in this experiment. Rearing location as A factor and cocoon selection as B factor with 7 replications. The result showed that: different

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rearing location will produce cocoon with different reelability and length of filament. Cocoon selection using cocoon selector gave best result on reelability and raw silk percentage. The feasibility of location to silkworm rearing and good of cocoon selection will increase quality of cocoon.

379. Goldsmith, M.R., 1991.

(Department of Zoology, University of Rhode Island, Kingston, USA)

Silkworm breeding for the "90s": new molecular and genetic tools to meet the challenge of the tropics.

Sericologia, 31(1):145-155.

380. Hossain, M., 1991.

Breeding performances of indigenous and exotic races of mulberry silkworm and rearing of the Indian honeybee, *Apis cerana* (Apidae : Hymenoptera) [in Bangladesh].

Proceedings of the workshop on Bangladesh Agricultural University Research Progress, Mymensingh, Bangladesh, 214-224.

Abstract: Two cross breeding experiments of mulberry silkworm, *Bombyx mori* and one rearing experiment of Indian honeybee, *Apis cerana* were conducted. In the cross breeding experiments five hybrid lines (AUS 401, AUS 405 and AUS 402) were found promising and these hybrid lines have been considered for selection. In the second cross breeding experiment only three generations of inbreeding were completed when most of the parameters in the four hybrid lines indicated promising results. But for selection purpose results for six generations should be observed. The third experiment dealt with rearing and maintenance of honeybee (*Apis cerana*) colonies maintained in wooden rearing boxes. Experiments during ten months indicated the attack of bacteria, wax moth and mite in the bee colonies. Bacterial infestation was found to be most fatal, However, infestation by wax moth and mite can be overcome by efficient management of the honeybee colonies.

381. Ravindra Singh., Nagaraju, J., Premalatha, V., 1991.

(Central Sericultural Research and Training Institute, Mysore, India)

Studies on radiation sensitivity of multivoltine strains of silkworm, *Bombyx mori*.

Proceedings of the International Congress on Tropical Sericulture Practices, Bangalore, India, 18-23 February 1988, 4:47-52.

Abstract :One hundred and forty two hour old eggs of three polyvoltine strains viz., Hosa Mysore, C. nichii and MY1 (sex-limited) were exposed to three doses of  $\gamma$ -radiation. Dose dependent sensitivity was observed in all the three strains. Hosa Mysore was found to be the most sensitive followed by C. nichii and sex limited strain, females were more sensitive to radiation as compared to males. The importance of radiation resistance in silkworm breeding is described.

382. Rheinberg, L., 1991.

The continuous filament natural fiber. Part 1.

Textiles, 20(4):6-10.

Abstract: The production and properties of silk are discussed. Silk production began in China 4, 000 to 5, 000 years ago. The mulberry silkworm, or *Bombyx mori*, is the most commonly used commercial silkworm. The breeding and lifecycle of silkworms are reviewed. Topics considered include sericulture; the raising of silkworms; the reeling of raw silk from cocoons; raw silk testing and grading; the throwing or twisting of silk into yarn; silk fabric construction; the uses of waste silk; degumming or boiling off; and the printing, dyeing, and finishing of silk fabrics.

383. Tsenov, P., Petkov, N., 1991.

(Opitna Stantsiya po Bubarstvo, Vratsa, Bulgaria)

Accommodation of F1 silkworm pupae (*Bombyx mori* L.) to artificial food.

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Genetics and Breeding, 24(3):207-210.

Abstract: The study included the strains Super 1 of Japanese origin, 157-K and Hessa-2 of Chinese origin and reciprocal hybrids Super 1\*157 K and Super 1\*Hessa 2. Both strain and hybrid specificity were found in respect to the accommodation to artificially prepared nutrient feeding mixture in silkworm pupae nutrition. Comparatively higher accommodation was observed in the strains of Japanese origin and in the crosses in which they were used as the female parent. In most cases the inheritance of silkworm pupae accommodation to artificial feeds in F1 hybrids was with partial dominance in the direction toward the parent with higher value for the character. It is recommended feeding silkworm pupae in the first ages with artificial feed to the applied after breeding specialized strains and hybrids of the mulberry silkworm with genetically conditioned high degree of accommodation.

384. Chatterjee, S.N., Datta, R.K., 1992.

(Genetics Laboratory, Central Sericultural Research and Training Institute, Mysore, India)

Hierarchical clustering of 54 races and strains of the mulberry silkworm, *Bombyx mori* L: Significance of biochemical parameters.

Theoretical and Applied Genetics, 85(4):394-402.

Abstract: A detailed analysis was undertaken to test the efficacy of hierarchical agglomerative clustering (UPGMA method) in grouping the races and strains of the mulberry silkworm, *Bombyx mori* L., and to ascertain the importance of biochemical parameters in the clustering process. The analysis was based on data from two rearing seasons with 54 selected races/strains of different geographic origin and varying yield potentials. The results indicate that seven clusters can be realised with yield parameters alone, whereas the inclusion of biochemical parameters in clustering resulted into two broad groups: one having all the breeds with high cocoon weight and shell weight, the other having all the low-yielding silkworm strains both from India and from other countries. Further sub-grouping under these two groups highlights genetical differences associated with the differentiation of various groups of races in temperate and tropical areas as well as their significance for silkworm breeding. Estimates of all ten variables were further subjected to 'quick clustering' and the results showed that cluster 5, constituted by 38 low-yielding strains of India, China and Europe, had the highest values of the final cluster centre for amylase and the effective rate of rearing (ERR), while clusters 1 and 4 had the highest values for invertase and alkaline phosphatase. The evolutionary aspect of the genetic channelisation of silkworm races from various countries is discussed against the background of differences in the biochemical parameters and yield variables.

385. Chatterjee, S.N.; Suresh Kumar, N.; Ratna Sen.; Mallikarjuna.; Nirmal Kumar, S.; Naseema Begum, A.; Datta, R.K., 1992

(Central Sericultural Research and Training Institute, Mysore, India.)

Classification of breeding resources materials maintained at CSRTI, Mysore, India

In: National Conference on Mulberry Sericulture Research CSRTI, Mysore Dec 10-11, 1992, p.102.

386. Chattopadhyay, S., Ghosh, B., Rao, P.R.T., Sudip, S., Gupta, S.K., Roy, G.C., Sen, S.K., Das, S.K., 1992.

(Central Sericultural Research and Training Institute, Berhampore 742101, India)

Analysis of quantitative traits in some evolved multivoltine silkworm breeds of *Bombyx mori* L. under two environments.

Environment and Ecology, 10(4):845-848.

Abstract: Statistical analysis of the performance of 5 strains of *Bombyx mori* showed that the additive gene effect was important in expressing quantitative traits in varied environments. Strain CB-5 showed greater survival and OS-616 showed better cocoon characters, which may be of use in breeding programmes.

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387. Giridhar, K.; Nirmal Kumar, S.; Jula, S.N.; Datta, R.K., 1992.

(Central Sericultural Research and Training Institute, Mysore, India.)

Heritability, Genetic and phenotypic correlation studies for fitness and quantitative traits of bivoltine silkworm, *Bombyx mori* L.

In: Abstracts of 4th All India Conference on Cytology and Genetics and Cytogenetics of Mulberry and Silkworm, KSSDI, Bangalore, Nov 5-7, 1992, p.115.

Abstract: Heritability values of fitness traits (fecundity), viability and developmental rate) and quantitative traits (single cocoon weight, single shell weight, filament length and filament size) were estimated using two bivoltine strains, viz. NB7 and NB4D2 and their crosses. The heritability (in narrow sense) for quantitative traits was found comparatively higher and ranged from 48 to 64 with a little tendency for the standard error to increase with the estimate, while the range of heritability for fitness traits is much lower (18.25). The data support the classical hypothesis that the fitness traits would exhibit lower heritabilities than the traits in other categories. The genetic and phenotypic correlations were also calculated for the characters separately. High positive genetic (0.75) and phenotypic (0.95) correlations were found between cocoon yield and cocoon weight. The same was also true between single weight and filament length (0.66 to 0.70) and single shell weight and denier (0.78 to 0.85). The results indicated a good scope for selection using filament length and denier for the improvement of cocoon yield.

388. Jade, P.S., 1992.

Chinese silk and silk fabrics.

Knitting International, 99(1177):46

Abstract: Silkworm breeding, silk reeling, and silk weaving have been developed in China over the past 3, 000 years. Natural silk can be produced from numerous silkworm found in China; tussah and mulberry silkworms are the most important commercial breeds. Silk consists of a solidified liquid secreted by two glands at either side of silkworm's head. At the end of its life cycle, a silkworm continuously spins silk to produce a cocoon. Silk apparel is warm in the winter and cool in the summer. Silk has good stretch and elasticity, smoothness, softness, high gloss, high moisture absorption capabilities, and permeability to air. Mulberry silk makes high quality fabrics. Fabric from tussah silk is stiffer and coarser, but has greater strength and moisture absorption.

389. Kanda, T., 1992.

(National Institute of Sericultural and Entomological Science, Tsukuba, Ibaraki, Japan)

Genetical study of feeding habits of the silkworm, *Bombyx mori*, to new-low cost diet designed by linear programming method and application to the breeding.

Bulletin of the National Institute of Sericultural and Entomological Science (Japan), 5:1-89.

Abstract: Recently, new low-cost artificial diets for the silkworm, *Bombyx mori*, have been developed using a linear programming method. The main components of the new diets are ingredients of feed for domesticated animals and fowl, and include little or no mulberry plant powder. Depending on known nutritional requirements of growing silkworm larvae and fluctuating market prices, the components of the diets can be chosen from a wide variety of ingredients, such as soybean meal, rice bran, fish meal, gluten meal, yeast etc. to keep the cost at a minimum level. However, the new low-cost diet is not used by actual farmers since the silkworm races distributed commercially do not eat the diet. Thus, from the viewpoint of genetics and breeding, the question arises whether the new low-cost diet can be practically introduced to farmers by changing the feeding habits of commercial silkworm races genetically. As a result of these studies, we showed the following: (1) Convenient and rapid selection of larvae with high feeding ability to the new diets was possible; (2) Genetical control of feeding preference for the low cost diet was mainly governed by a major recessive gene, which was located on the 3rd chromosome, and by its modifier genes; (3) Breeding new commercial races with high feeding ability was shown to be

theoretically possible since application of convenient methods of selection on the descendants from the hybrid between the high feeding strain and commercial races produced larvae which fed upon the artificial diet. These results indicate that the introduction of the new low cost diet to farmers would be possible if this basic knowledge is applied to practical silkworm breeding. In this summary, we describe these experiments and their results in detail. 1. Feeding response of several stock strains and commercial parent races to the LP-1 diet.

390. Li, W., 1992 .

(Shaanxi Sericultural Research Institute, Zhouzhi, China.)

Genetic path network among quantitative characters in *Bombyx mori* L.

*Sericologia* , 32(4):543-550.,

Abstract: A set of 49 hybrids obtained by crossing 7 Chinese races with 7 Japanese races according to partial diallel cross design was reared in a randomized complete block experiment. Genetic correlation coefficients among 22 quantitative characters were investigated and estimated. Based on the genetic correlation, internal relations of the characters in growth and development, and requirement of breeding aims, causal relationships among the characters and their relative importance were analysed with the method of path coefficients. The results were given out in the path network figure.

391. Lim, Z.F.; Zhong, S.Q.; Tang, W., 1992 .

(Department of Sericulture, South China Agricultural University, China.)

Studies on the heredity and breeding of the degumming loss of cocoon shell of *Bombyx mori*. *Journal of South China Agricultural University*, 13(4):154-161.,

392. Matei, A., Coteanu, O., 1992.

(Societatea Comerciala de Sericultura SERICAROM S.A., Bucuresti, Romania)

Determination of the optimum number of series in silkworm breeding species *Bombyx mori* in various zones of the country.

*Medicina veterinara si cresterea animalelor*, 42:11-12.

393. Rao, P.R.T., Ghosh, B., Chattopadhyay, S., Nair, B.P., Das, S.K., Roy, G.C., Sen, S.K., 1992.

(Silkworm Breeding and Genetics Section, Central Sericultural Research and Training Institute, Berhampore 742101, India)

Variation in the performance of some indigenous multivoltine mulberry silkworm breeds of *Bombyx mori* L. in two environments.

*Uttar Pradesh Journal of Zoology*, 12(2):133-139.

Abstract: A total of 8 indigenous multivoltine silkworm breeds have been reared during two favourable and two unfavourable seasons per year from 1988 to 1991 to evaluate the essence of economic traits of different breeds on varied environmental conditions. Statistical analysis of the rearing performance (ANOVA) reveal that the indigenous breeds Nistid possess high survival: Tamilnadu (W) has better ERR.WT., SCW., SSW and SR; Moria has longest Filleng and fine DN.; Sarupat(W) has highest WT. of ML. which clearly indicate that these breeds can be utilised as better breeding materials for further hybridization studies.

394. Bhargava, S.K.; Thiagarajan, V.; Datta, R.K., 1993.

(Regional Sericultural Research Station, P.O. Box No. 21, Coonoor- 643101, Tamil Nadu, India.)

Hybrid vigour in the silkworm, *Bombyx mori* (L).

*Giornale Italiano di Entomologia*, 6(35):449-453.

Abstract: The hybrid vigour of 20 F-1 hybrids raised from 5 silkworm parental races (N4, 14M, SPJ1, JC2P and SH2) was calculated in terms of mid parent heterosis, better parent heterosis and check

heterosis. The observations were made on 6 economically important characters, namely, larval duration, cocoon yield (number and weight), single cocoon weight, single shell weight and shell ratio. Two hybrids, namely, N4 times JC2P (except for the larval duration) and N4 times SH2 (except for the shell ratio) showed best values of better parent heterosis for all the characters. Through the least significant difference value ( $P = 0.05$ ), only two hybrids, namely, SPJ1 times N4 and N4 times SH2 showed maximum check heterosis (17.18 and 15.76 respectively) for the cocoon yield (weight). The results indicate that the hybrid vigour noticed in the silkworm (*Bombyx mori*) is very useful to improve the existing races for commercial purpose, and to develop new races through the hybridization technique.

395. Chatterjee, S.N., 1993.

(Central Sericultural Research and Training Institute, Mysore, India)

Silkworm breeding in India.

*Sericologia*, 33(3):427-459.

396. Chatterjee, S.N.; Rama Mohana Rao, P.; Jayaswal, K.P.; Ravindra Singh.; Datta, R.K.,1993.

(Central Sericultural Research and Training Institute, Srirampura, Mysore - 570 008, India)

Genetic variability in mulberry silkworm, *Bombyx mori* L. breeds with low silk yield.

*Indian Journal of Sericulture*, 32(1):69-86.

Abstract: Variability of 15 characters contributing to yield of characters either related to silk reeling of characterising silk yarn were analysed using 51 low yielding stocks of mulberry silkworm, *Bombyx mori* L. The 51 stocks include 5 indigenous, 38 evolved Indian multivoltines, 7 Chinese stocks (daizo, Dao 9, Rong Dazao, Guangnong-plain, Guangnong-marked, Nong 42 and Nong 51) and Cambodge (originally from Cambodia but collected from Japan). ANOVA indicated very high significance of the variability contributed by different group means suggesting thereby wide genetic variability among the silkworm stocks analysed. ANOVA further showed positive and negative correlations among the different characters, e.g. larval weight, larval duration and weight of cocoon with denier and evenness (the two reeling attributes). Hierarchical algorithm (UPGMA) was applied to cluster 51 silkworm stocks on the basis of different groups of variables. Results indicate the suitability of the system of hierarchical clustering as evident from the classification of regional Indian races, Chinese races.

397. Chatterjee, S.N.; Rao, C.G.P.; Chatterjee, G.K.; Ashwath, S.K.; Patnaik, A.K.,1993.

(Central Sericultural Research and Training Institute, Mysore, India).

Correlation between yield and biochemical parameters in the mulberry silkworm, *Bombyx mori* L.

*Theoretical and Applied Genetics*, 87(3):385-391,

Abstract: A detailed study was carried out on six biochemical parameters and four yield attributes using multiple regression analysis to investigate their relationship in the mulberry silkworm, *Bombyx mori*. The study generated new information on the importance of digestive amylase activity for the survival of the silkworm and revealed the inability of other enzymes to affect this relationship. Data also substantiate the observations made earlier on the genetic variability of amylase in the mulberry silkworm. Analyses extend the positive role of alkaline phosphatase and invertase in the expression of the other yield traits studied and indicate the definite possibility of using biochemical markers for silkworm breeding.

398. Nacheva, J.,Petkov, N., Malinova, K., 1993.

(Experimental Station Sericulture, Vratsa 3000, Bulgaria)

Breeding-genetic evaluation and prediction of the combining ability of Syrian silkworm breeds in crosses with Bulgaria breeds.

*Genetika i Selektsiya*, 26(4):284-290.

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Abstract: Two silkworm breeds of Japanese and Chinese origin introduced from Syria were tested by using two Bulgarian controls for the respective Syrian breeds. Breeding-genetic evaluation of the main biological and technological characters was made. A preliminary mathematical prognosis was also made of the potential hybrid generation abilities of crosses between the Syrian and 8 promising Bulgarian breeds for the most important breeding characters - weight and silkiness of raw cocoons and length of the silk fiber. A method proposed by Isner (1981) was applied for the complex evaluation of the Syrian breeds and for assessment of the bridging indices. It was found that: The two Syrian breeds studied had high silkworm seed hatchability but lower silkworm viability. They were characterized by relatively high values of the basic breeding characters - cocoon weight, silk shell, silkiness and length of the silk fiber. The variability of these characters expressed by the coefficients of variability was low. The combinations of Syrian 1 times Vratsa 35 and Syrian 2 times Meref 2 could be used in the breeding programs, while Syrian 1 times Meref 2, Vratsa 35 times Syrian 2 and their backcrosses could be used for industrial hybridization.

399. Petkov, N., Nacheva, J., Tzenov, P., 1993.

(Oitna Stantsiya po Bubarstvo, Vratsa, Bulgaria)

On the problem concerning the heritability and the correlative dependences in silkworm production traits.

Slskostopanska-Nauka, Bulgaria, 3(3):35-37.

Abstract: we suggested classification scheme of the main production traits according to the values for  $h^2$  may be used both in the development of genetical-and-mathematical models for predicting the selection by a specific traits and in the planning of optimum breeding programme for developing high-productive breeds, lines and hybrids of silkworms.

400. Petkov, N., Shabalina, A., 1993.

(Opitna Stantsiya po Bubarstvo, Vratsa, Bulgaria)

Productivity studies of silkworm (*Bombyx mori* L.) inbred line F-1071.

Genetika i Seleksiya, 26(5-6):403-410.

Abstract: A study was conducted of the inbred line F-1071 compared to the initial parental forms (T-20 and 5.2 SANISH) and hybrids of backcrosses, as well as an anonymous test for productive characters with practically regionally distributed hybrids. It was found that backcrossing of F-1071 with the better strain T-20 produced heterosis effect in most of the characters studied. Highest values (in respect to MP) were observed for silk shell weight (10.79 percent). Compared to semi-sibs, the sibs were characterized with highest values for silkworm viability, cocoon silkiness and cocoon fiber length and output. In the anonymous test the sibs of F-1071 surpassed the practically regionally distributed Bulgarian hybrid in the above-mentioned characters, a fact substantiating the conclusion that this line could be used in breeding programs for development of new silkworm strains and hybrids.

401. Bolchiserini, g., 1994.

Studies about silkworm (*Bombyx mori* L.) during XIX and XX centuries in Lombardia (Northern Italy).

Mem de Soc Entomology Italy, 72(0):507-520, (Italian)

Abstract: Silkworm breeding in Italy, and especially in Lombardia, represented in the centuries such a great wealth to affect the uses and social organization, till when it was progressively dropped after the last world war, such activity, beginning from the end of 1700, spurred scientific research meant to and (*Nosema bombycis*), improvement of silk production, development, embryogenesis and physiology of the insect were discussed. The historical examination underlines the importance of silkworm as productive subject and topic of biological studies.

402. Dinescu, S., 1994.

(Ministerul Agriculturii si Alimentatiei, Bucuresti, Romania)

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Silkworm breeding strategy in Romania during 1994-1996.  
*Medicina veterinara si cresterea animalelor*, 4-5:1-5.

403. Grekov, D., Petkov, N., Malinova, K., 1994.

(Higher Agriculture Institute, Plovdiv, Bulgaria)

Effect of ethyl-methane sulfonate [EMS] on biology of mulberry silkworm [*Bombyx mori* L.].

*Zhivotnov'dni Nauki*, 31(7-8):164-165.

Abstract: A study in silkworm breeding base, Plovdiv on the effect of EMS on biology of mulberry silkworm (*Bombyx mori* L.) have been carried out. Different concentrations and exposures have been tested. Inhibition effect on hatching indices have been observed. Stimulation effect on vitality is highest (3.55 - 5.26) at two breeds studies and 0.25 concentration, exposure 1 h has been red. Highest stimulation effect in term of productivity shows "Plovdiv 14" breed at concentration 0.5 and exposure 1 h and 0.1 for 2 h exposure at "Plovdiv 15" breed have been found. There is a breed peculiarity.

404. He, Y., He, S., 1994.

(Institute of Sericulture, Chinese Academy of Agricultural Sciences, Zhenjiang, Jiangsu, China)

Application of technique for inducing trimolter in breeding of silkworm (*Bombyx mori*).

*Acta Sericologica Sinica*, 20(1):30-34.

Abstract: The physiological active substance was used to induce the trimolter. Following the conventional breeding way, two Chinese and three Japanese cross combinations of *B. mori* were induced respectively by continuous and alternate generation feeding inductions. Without chemicals, F5 could return to 4th moulting after being continuously induced, selected and bred from F1 to F4. The combining ability test has been carried out for F4. The resulted show the quantitative character and morphological character of the continuous and the alternate generation inductions of F5 are similar to the control. Neither their genotypes not their combining ability is affected by the feeding induction; the duration of all stars of the induced trimolter is three days shorter than that of the trtramolter as control; the cocoon weight and the cocoon shell weight decrease 30,35 respectively; the cocoon filament length and neatness are similar to those of the tramolter, but its reelability is higher. Spring season excepted, in all the seasons the physique is stronger than that of the tetramolter; the induction of every race of trimolter shows an extraordinary high rate, it won't be affected by generation and races fed continuously.

405. Jiang, Y., Xu, M., 1994.

(Department of Sericulture, Zhejiang Agricultural University, Hangzhou, China)

Studies on the brief method of individual selection for cocoon filament size in silkworm (*Bombyx mori*) breeding.

*Bulletin of Sericulture*, 25(2):15-17.

406. Kumar, P., 1994.

(Regional Sericultural Research Station, Kalimpong, India)

Bivoltine silkworm breeding training: An experience.

*Indian Silk*, 33(2):35-38.

407. Kuwabara, N., 1994.

(Gunma-ken. Sericultural Experiment Station, Maebashi, Japan)

Line selection of yellow cocoon in the Japanese oak silkworm, *Antheraea yamamai*.

*Bulletin of the Gunma Sericultural Experiment Station (Japan)*, 1:19-22..

408. Mano, Y; Datta,R.K., Mal Reddy,N., Basavaraja, H.K., Nirmal Kumar, S., Suresh Kumar, N., 1994.

(Central Sericultural Research and Training Institute, Mysore)

Potentiality of Indian and Japanese hybrids .

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Indian Silk (June) 5-7.

409. Moon, B.W., Han, K.S., 1994

(Chinju National Polytechnic University, Chinju, Korea Republic)

The test of combining ability and heterosis on the silkworm (*Bombyx mori*) breeding.

Korean Journal of Sericultural Science (Korea Republic), 36(1):8-25.

410. Patnaik, A.K., 1994.

(Central Sericultural Research and Training Institute, Mysore)

Overseas Training in Silkworm Genetics and Breeding.

Central Sericultural Research and Training Institute, Mysore, 34.

411. Petkov, N., Nacheva, J., Mladenov, G., Tsenov, P., Petkov, Z., 1994.

(Opitna Stantsiya po Bubarstvo, Vratsa, Bulgaria)

Ukrainian machine used in silkworm breeding.

Mekhanizatsiya na Zemedeliето (Bulgaria) Mechanization of Agriculture, 2(7):19-20

412. Singh, R., Nagaraju, J., Datta, R.K., 1994.

(Silkworm Mulberry Germplasm Station, Hosur 635 109, India)

Comparative study of various characters between trimoulters and tetramoulters segregated from F-1 hybrids of trimoulters and tetramoulters strains of the silkworm, *Bombyx mori* L.

Indian Journal of Sericulture, 33(2):155-159.

Abstract: An experiment was conducted in order to make comparison between trimoulters and tetramoulters segregated from F-1 hybrids. Appearance of trimoulters in F-1, F-2 and the backcross was recorded which was found to vary depending upon the type of female parent utilized for crossing. The quantitative characters showed distinct differences between trimoulters, tetramoulters and their hybrids. The larval span of trimoulters and their hybrids was two days shorter than that of tetramoulters and their hybrids. The trimoulters showed higher consumption index and growth rate than tetramoulters though the efficiency of food conversion of ingested food to body weight was less in trimoulters. The size of the silk filament was observed to be thinner than that of tetramoulters and the reliability in trimoulters and their hybrids was found to be better. Importance of trimoulters in breeding programme has been discussed.

413. Subramanya, G.; Murakami, A., 1994

(Department of Sericulture, University of Mysore, Mysore 570 006, India.)

Climatic differential phenotypic expression of voltine genes in *Bombyx mori* L.

Indian Journal of Sericulture, 33(2):103-109.,

Abstract: Voltinism was considered to be under the control of autosomes and sex chromosomes in addition to autosomal modifiers. Earlier reports emphasized this phenomenon as maternal traits. A detailed investigation, by one of the authors of this article (Murakami), on the genetic mechanism of voltinism resulted in the identification of "npnd" stock, the genes for which is located on 'X' chromosomes. As a result, now it is understood that voltinism is a maternally inherited biological event under the control of sex linked genes. The importance of photoperiod on this phenomenon is remarkable. The knowledge of voltinism and 'X' chromosomes is very essential in silkworm breeding to study the combining ability or for evolving robust races. Polygenic involvement in silkworm breeding is questionable since it is proved that 'X' chromosomes carry specific genes for various life history characters of *Bombyx mori* L. Based on the contemporary knowledge of voltinism, the authors in the present article viewed that biology of voltinism of tropical races may open up new avenues to study neurobiology, memory, learning, adaptation and evolution.

414. Tribhuwan, S.; Rao, G.S.; Singh, T., 1994  
(Silkworm Seed Technology Laboratory, Kodathi, Carmalaram Post, Bangalore 560 035, India.) Studies on evaluation of hybrids by breeding index in *Bombyx mori* (L).  
*Entomon*, 19(3)  
Abstract: Eight new bivoltine (F1) hybrids of *Bombyx mori* were compared for their relative and heterobeltiotic responses in silk productivity. The hybrid KPG-B\*P5 and its reciprocal produced the greatest amount of silk and had a high degree of relative heterosis and heterobeltiosis.
415. Tsenov, P., 1994.  
(Opitna Stantsiya po Bubarstvo, Shumen, Bulgaria)  
Improved technology of Silkworm breeding.  
*Animal Breeding*, 48(6):25-26.
416. Tzenov, P., Petkov, N., Natcheva, Y., 1994.  
(Sericultural Experiment Station, Vratza, Bulgaria)  
Studies on heterosis expression and degrees of dominance displayed for some quantitative traits characterizing the food utilization in F1 crosses between Japanese and Chinese bivoltine races of the silkworm, *Bombyx mori* L.  
*Sericologia*, 34(3):421-434.  
Abstract: A Japanese and a Chinese race, namely, Super 1 and Hessa 2, and their F1 and F2 crosses were included in the study. A comparatively higher expression of heterosis was manifested in the efficiencies of conversion of the supplied ingested and digested mulberry leaves into body substances, cocoon shell and eggs. However, a very low heterosis expression was detected with respect to traits such as amount of food ingested, amount of food digested, approximate ingestibility and digestibility consumption index and growth rate. The expression of heterosis was markedly higher when both parents and their F1 crosses were fed at excess feeding amount. Positive dominance for the higher parent (HP) was present in the F1 crosses as regard the amounts of food supplied and ingested per larva and ingestibility. Intermediate inheritance and negative dominance for the lower parent (LP) were observed in respect to the amount of food digested and digestibility. Overdominance for HP was present in the F1 crosses as regards the efficiencies of conversion of food into body substances cocoon shell and eggs.
417. Velasco, A.B., Bacuso, P.M., Cabrito, F.P., Fernandez, R.W., Alvarez, V.B., de Guzman, Z.I., Villanueva, E.P., 1994.  
(Department of Science and Technology, Philippine Textile Research Institute, Bicutan, Taguig, Metro Manila, Philippines)  
New breeds of Filipino silkworm varieties commercialized.  
*Philippine Technology Journal* (Philippines), 19(3):1-25  
Abstract: A series of periodic silkworm rearings from 1979-1984 were conducted to evaluate the performance of silkworm races for selection of breeds for the production of local hybrids that can yield good quality cocoons and silk. The parameters used were larval duration, larval and pupal weight, hatching ratio, fecundity, moth emergence ratio, mortality percentage and cocoon filature properties. Purification and characterization of the parent lines were done followed by combining ability test and hybridization for F1 hybrid evolution. Field testing of the F1 hybrids conducted in Benguet and Misamis Oriental [Philippines] led to the identification of promising hybrids suited to specific location capable of producing quality cocoons.
418. Bhargava, S.K., 1995.  
(Central Sericultural Research and Training Institute, Srirampuram, Manandavadi Road, Mysore-570 008, Karnataka, India)

Combining ability analysis of seven silk yield attributes in silkworm, *Bombyx mori* L.  
Journal of Applied Genetics, 36(1):59-67.

Abstract: The combining ability effects of 5 *Bombyx mori* strains and their 20 F1's including reciprocals were analysed in a 5\*5 diallel cross for 7 silk yield attributes, (effective rate of rearing (ERR), a measure of survival, cocoon yield, cocoon weight, shell weight, raw silk percentage, silk filament length/cocoon and silk reliability). Higher values of specific combining ability (SCA) than the corresponding general combining ability (GCA) for all the attributes except ERR and cocoon yield were indicative of non-additive gene action. The parental strain JC2P was the best general combiner for all the attributes, except cocoon yield. The highest general combining ability effect for cocoon yield was shown by N4. The highest desirable or positive SCA effects resulted from N4\*SH2 (all the attributes except shell weight), JC2P\*14M (all the attributes except cocoon weight and shell weight), 14M\*SH2 (all the attributes except ERR), N4\*SPJ1 (all the attributes except shell weight and raw silk percentage). Only one reciprocal, namely SPJ1\*N4, showed positive effects for all the attributes except silk reelability. The improvement of cocoon yield through mass selection followed by intermating and the use of the parental strain JC2P in future cross breeding are discussed.

419. Bhargava, S.K.; Majumdar, M.K.; Choudhuri, C.C.; Ahsan, M.M.; Datta, R.K., 1995 .  
(Central Sericultural Research and Training Institute, Mysore, India.)

Silkworm breeding.

Indian Textile Journal, 106(4):24-29.

Abstract: Combining ability analysis of silkworms is of utmost importance for identifying the superior races and crosses for fruitful breeding by farmers.

420. Grekov, D., 1995.

(Vissh Selskostopanski Institut, Plovdiv, Bulgaria)

Study on the effect of gamma-radiation on the development of silkworm (*Bombyx mori* L.).

Animal Science, 32(1-2):124-126.

Abstract: The investigations on the effect of gamma-rays on the development of the mulberry silkworm are of special interest to breeding practice due to the lack of profound research activity in that area. Our basis purpose is to find out possibilities of using gamma-rays as a mutagenic factor in breeding. The results obtained show that the irradiation of silkworm eggs at b 2 stage of embryo development with 5, GY, stimulate the biological development. The irradiation doses of 10-25 GY inhibit the development the mulberry silkworm. The different races react in a different way. Probably mutation forms are to be sought within 10-25 GY doses.

421. Jayaswal, K.P.; Dash, B.D.; Nair, B.P., 1995 .

(Silkworm Seed Project Centre, Mysore, India.)

Analysis of diallel cross for metric traits in multivoltine and bivoltine breeds of *Bombyx mori* L. In: Current Technology Seminar on Mulberry

Abstract: Three newly evolved multivoltine and three traditional bivoltine breeds were crossed diallely to estimate the relative significance of GCA and SCA and to identify parents for breeding plans and hybrids for commercial exploitation. Anova showed that GCA and SCA effects were high significant (P0.01) for most of traits SCA for fecundity and ERR (No.) indicating the importance of both additive and dominance type gene actions. High GCA effects were largely due to additive gene interactions. No single breed could be treated as a general combiner for all the traits. Of the multivoltines, CS-68 was observed to be significantly better (P0.05) for fecundity, ERR (No.) and ERR (Wt.). Among bivoltines S19 had significant higher values (P0.05) in respect of larval Wt. cocoon Wt., shell Wt ratio and filament length. SCA effects exhibited that OS-68 x P-5 had positive value for ERR (No.) and ERR (Wt.) and significant value (P0.05) for larva Wt., cocoon Wt., shell Wt. shell ratio and filament length followed by

OS-61 x SF19, indicating superiority of multi x bi. combinations. Reciprocal effects displayed presence of significant values (P0.05) for larval Wt. ERR (Wt.), cocoon Wt. shell Wt. Shell ratio and filament length and positive value for ERR (No) and negative value for fecundity in SF 19 x OS-68 suggesting possible cytoplasmic effects on the traits.

422. Kalpana, G.V.; Sudhakar Rao, P.; Giridhar, K.; Ahsan, M.M.; Datta, R.K., 1995.

(Central Sericultural Research and Training Institute, Mysore, India.)

Identification of promising bivoltine hybrids by MST analysis.

In: Current Technology Seminar on Mulberry and Silkworm Breeding

Abstract: The final outcome of breeding is not only the isolation of races but also its ability to combine with other races. The evolved races even though fare well for the maximum expression of economic traits may not exhibit the same at hybrid level. Hence, the success of a race has to be recognised by studying their hybrid performance. A study has been made to adjudicate the best hybrids derived combinations to MST analysis. Based on the analysed data, 10 hybrid combinations viz., 9147A2 x NB4D2, 915A x NB4D2, 912B2A1 x KA, 9168 x KA, 916A1 x KA, 911C x KA, 9148A x KA, 912B2 x KA, 911A2 x NB18 and 916A2 x KA with index value ranging from 4.51 to 7.12 were recognised. The identification of promising hybrids with genetic improvement for multiple traits is discussed.

423. Kumar, P., Bhutia, R., Ahsan, M.M., 1995.

(Regional Sericultural Research Station, Kalimpong, West Bengal, India)

Estimates of genetic variability for commercial quantitative traits and selection indices in bivoltine races of mulberry silkworm [*Bombyx mori* L.].

Indian Journal of Genetics and Plant Breeding, 55(2):109-116.

Abstract: Genetic variability for economically important quantitative traits and selection indices of 46 bivoltine races of mulberry silkworm (*Bombyx mori* L.) were estimated. High values of heritability along with genotypic and phenotypic coefficient of variations for filament length, single-shell weight and single-cocoon weight showed that the above characters are under genetic control. The correlations between single-cocoon weight and single shell weight as well as single-shell weight and shell ratio were highly significant. The selection index programme based on discriminant function analysis resulted into five clusters of 10 genotypes with lower index values for utilization in hybridization and breeding programmes.

424. Lea, H.Z., Dealwis, S.M., 1995.

(Kangwon National University, Chuncheon, Korea Republic)

Genetic structure of the mulberry silkworm population in Sri Lanka. (I). Estimation of combining ability and heritability.

Korean Journal of Sericultural Science (Korea Republic), 37(1):10-15

Abstract: Genetic characterization of Sri Lanka silkworm bivoltine population has not been attempted so far, since its sporadic introduction of bivoltine strains into the island, starting from the 1950's. Genetic structure of Sri Lanka's population of mulberry silkworm *Bombyx mori* was investigated through estimation of general (GCA) and specific combining ability (SCA) and heritability ( $h^2_B$ ), on the economic quantitative characters from leading 8 inbreds and their 28F1's in a half diallel cross, in an attempt to utilize the estimates in determination of future breeding methods and to predict the breeding value over the phenotypic value. It was found that the breeding population of the bivoltine silkworm in Sri Lanka has still maintained considerable amounts of additive gene action as well as nonadditive. For some time in the future, both breeding strategies of "selection without inbreeding" and also inbreeding followed by crossin should therefore be effective in genetic improvement of economic characters investigated. In addition, superior combiners in general and in specific F1's were identified for each of 6 economic characters, to be immediately utilized in selection and also in cross breeding programs in Sri Lanka.

425. Li, B., 1995.  
(Guangdong Academy of Agricultural Sciences, Institute of Sericulture, Guangzhou, China)  
Selected mating and breeding of multiple silkworm hybrids in south China.  
Guangdong Agricultural Sciences (China), 3:32-33.
426. Naseema Begum, A.; Ashan, M.M.; Chatterjee, S.N.; Bhargava, S.K.; Raghavendra Rao, D., 1995.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Line x Tester analysis for certain quantitative traits in the newly evolved hardy bivoltine silkworm *Bombyx mori* L.  
In: Current Technology Seminar on Mulberry  
Abstract: A project was initiated to improve the survival in bivoltine races and 24 lines have been isolated. The hybrids derived from these lines were compared with (PM x NB4D2) for survival and cocoon characteristics better than the cross breed. The data was analysed through (line x tester) mating design. A total of 24 lines used as female parents were crossed with two widely adapted using two tester (KA and NB4D2). Based on general combining ability effects the lines found to be superior for different characters as follows: 934D1, 934B, 931d, 943A2 for survival 931D, 935E, 934D1, 933A for cocoon yield; 931D, 935E for single cocoon weight; 934B, 931D, 933A, 935E for single shell weight; 933A, 934b, 934A2 for shell ratio. On the basis of specific combining ability effects the crosses found to be superior for different characters are as follows: (932D x KA) for survival, single shell weight and shell ratio; (931C x NB4D2) for survival and shell ratio; (930A1 x NB4D2) for survival rate cocoon yield single cocoon weight (931C x Ka) for cocoon yield single cocoon weight, single shell weight; (932A x NB4D2) for cocoon yield, single cocoon weight, single shell weight. The promising lines will be used in improving the cocoon characteristics and the promising hybrids will be supplied to the farmers for better return.
427. Pan, S.Y.; Wang, M.L.; He, S.M., 1995.  
(Department of Biology, Xuzhou Teachers College, Jiangsu 221009, China.)  
A study on the breeding tactics and path analysis of yield components of the domestic silkworm [*Bombyx mori*] in different seasons.  
Hereditas, Beijing, 17(2):23-25.,
428. Papp, Z., 1995.  
The most important questions of reproduction and production of silkworms. (II). Examination of experimental results of silkworm production (*Bombyx mori* L.).  
Allattenyesztes es Takarmanyozas (Hungary), 44(6):511-515  
Abstract: The primary condition of renaturalization of silkworm breeding is acclimatization of import silkworms and examination of their experimental results of production in the interest of establishing home breeding. The authors examined the output of import silkworms cocoons the mass of the cocoons, the mass of the shell of the cocoons and the silk output of the cocoons. The authors found out that the import silk-worms gave the required results of production because of the fodder of mulberry trees grown in the climatic conditions of our country and because of the required breeding technology. That's why the authors think there is a reason for their further breeding.
429. Petkov, N., Nacheva, J., 1995.  
(Opitna Stantsiya po Bubarstvo, Vraysa, Bulgaria)  
Silkworm (*Bombyx mori* L.) breeding activity in Bulgaria.  
Agricultural Science and Production, 33(4-5):34-36.
430. Tajima, Y., Ohnuma, A., 1995.  
(Institute of Silkworm Genetics and Breeding, Ami, Ibaraki, Japan)

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Preliminary experiments on the breeding procedure for synthesizing a high temperature resistant commercial strain of the silkworm, *Bombyx mori*.

Reports of the Silk Science Research Institute (Japan), 43:1-16.

431. Tzenov, P., Natcheva, Y., Petkov, N., 1995.

(Sericultural Experiment Station, Vratza 3000, Bulgaria)

Phenotypic correlations between the traits characterizing the food ingestion, digestion and utilization and the most important quantitative breeding traits in the silkworm (*Bombyx mori* L.).

Genetika i Seleksiya, 27(1-2):50-53.

Abstract: The mutual relationships between 13 traits, characterizing the food ingestion, digestion and the food utilization and 14 very important quantitative productive characters in the silkworm *Bombyx mori* L. were studied. There were highly positive phenotypic correlations between traits such as the amount of food supplied, ingested and digested by a single larva during the fifth instar, approximate digestibility, growth rate and the most important biological, technological and reproductive traits characterizing the productivity of the silkworm. However the coefficients of phenotypic correlation between the mulberry leaves ingestibility, efficiencies of conversion of the food and the other feeding indices, productive and reproductive traits appeared to be highly negative. Because of the highly positive coefficients of correlation, established between the growth rate and the most important productive characters as well as with the feeding indices and the comparatively easier calculation the growth rate could be successfully used in the breeding procedure to improve the amount of food ingested and digested, digestibility and utilization of the food and raising the general productivity finally.

432. Wu, F.Q., Chen, Z.Y., Lu, T.X., Li, B.Y., Liao, Q.X., Lin, J.M., 1995.

(Guangdong Academy of Agricultural Sciences, Institute of Sericulture, Guangzhou, China)

Breeding of induced silkworm strains with exogenous DNA and their mating combination.

Guangdong Agricultural Sciences (China), 3:34-37.

Abstract: DNA of Subai, a Castor silkworm variety [*Samia cynthia ricini*] was introduced into acceptor Suxue 5, a variety of house silkworm [*Bombyx mori*]. Variant strain BT921 and BT923 were bred. Compared with Suxue 5, the vitality of BT921 was reinforced by 13.23 and its cocoon production and cocoon shell weight all increased by 5. Rearing results were best in the spring and cocoon production and cocoon shell weight increased by 23.02 and 19.87 resp. The performance of strain BT923 was better than that of Suxue 5, apart from cocoon shell weight. Test cross results showed that these two variant strains all had greater combining ability and heterosis. Strain BT921 and its two element hybridized combination had greater resistance to fluorine.

433. Zakharov, V.M.; Shchepotkin, D.V.; Strunnikov, V.A., 1995.

(N.K. Koltsov Institute of Developmental Biology, Russian Academy of Sciences, Moscow, Russia.)

The effect of heterozygosity and temperature on the developmental stability of silkworms (*Bombyx mori*).

Doklady Akademii Nauk, 340(3):430-432.

Abstract: The relationship of developmental stability in *Bombyx mori* to heterozygosity and temperature was investigated in 3 lines of the silkworm in which heterozygosity and viability were closely correlated. As a whole the data presented demonstrated that stability depends on both factors, and developmental stability may serve as a parameter characterizing environmental and genetic stresses. Application for insect breeding are discussed with special reference to selecting the species with minimal asymmetry of wing venation.

434. Chattopadhyay, S., Das, S.K., Roy, G.C., Das, N.K., Sen, S.K., Pavan Kumar, T., 1996.

(Central Sericultural Research and Training Institute, Berhampore, India)

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Evaluation and utilization of specific hybrids of the multivoltine silkworm, *Bombyx mori* L., in unfavourable seasons of West Bengal.

*Sericologia*, 36(1):161-166.

435. Malinova, K., Nacheva, J., Petkov, N., 1996.

Application of androgenesis in silkworm (*Bombyx mori* L.) breeding.

*Agricultural Science*, 34(4):34-36

Abstract: The possibilities for developing bisexual homozygous silkworm lines by use of consecutive backcrosses and adaptation of certain methods of androgenesis are discussed in the article. The conclusion is substantiated that thermic treatment of silkworm eggs at 42°C and exposition 210 min is appropriate for producing androgenic individuals, forefathers of androgenic lines.

436. Nacheva, J., Petkov, N., 1996.

Selection and genetic parameters of basic traits of silkworm lines. (II). Heritability. *Animal Science*, 33(6):68-72

437. Nacheva, J., Petkov, N., 1996.

Selection and genetics parameters of some basic traits of silkworm strains. (I). Selection characteristics.

*Animal Science*, 33(4):58-62

438. Nagaraju, J., Raje Urs., Datta, R.K., 1996.

(Seribiotech Research Laboratory, Bangalore, India)

Crossbreeding and heterosis in the silkworm, *Bombyx mori*, a review.

*Sericologia*, 36(1):1-26

439. Necheva, J., Petkov, N., 1996.

(Experiment Station, Silkworm Breeding, Vratsa, Bulgaria)

Use of mathematical prognostication in the choice of initial forms for development of tetrahybrids of the silkworm (*Bombyx mori* L.).

*Zhivotnov"dni Nauki*, 33(3):83-86

Abstract: The study has been carried out at the Experimental Station of Silkworm Breeding in Vratsa with the purpose of establishing the possibilities for the use of mathematical prognostication in the choice of initial forms for developing tetrahybrids of the silkworms. The preliminary prognostication of the potential capacities of the di- and tetrahybrids with respect to three of the most importance traits in the selection - weight and silkiness of the raw cocoons and length of the cocoon thread has been made after the method of regression analysis. For complex evaluation of the studied breeds and dihybrids use has been made of the method for selection indices determination according to the formula of Eisner (1981). With the help of the mathematical prognostication 7 of the possible 32 dihybrids and 8 of the most prospective combinations among the 78 tetrahybrids have been selected and included in the station tests. It is recommended to apply the mathematical model, used in the study, for prognosticating the choice of initial forms of the development of the silkworm tetrahybrids with a view to reducing the costs and increasing the affectivity of the experimental and selection activities.

440. Petkov, N., Nacheva, J., 1996.

Selection of the silkworm (*Bombyx mori* L.) breeding genetically labelled by sex in the egg and larva stages.

*Animal Science*, 33(3):64-69

441. Serini, G.B., 1996.

(University Degl Studo Di Milano, Via, Celoria Milan, Italy)

Studies about Silkworms during XIX and XX centuries in Lombardia.

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Memories De la Societe, Entomologique du Italiana, 72:507-520,

Abstract: Silkworm (*Bombyx Mori*) breeding in Italy, and especially in Lombardia, was economically important in Italy from the end of 1700 until after the 1940s, when it was progressively stopped. Authors who devoted themselves to the study of silkworm are listed. Subjects referring to pathology (especially with the solution of problems caused by *Beauveria bassiana* and *Nosema Bombycis*) improvement of silk production, development, embryogenesis and the physiology of silkworm are discussed. This historical examination of silkworm are discussed. This historical examination of silkworm rearing underlines its importance as a productive subject and topic of biological studies.

442. Tsenov, P., Petkov, N., 1996.

Effect of the feeding dose during the fifth age of the silkworm (*Bombyx mori* L.) larval development on the rates of domination and display of heterosis in F1.

Animal Science, 33(3):80-82

443. Zhu, J., Weir, B.S., 1996.

(Agronomy Department, Zhejiang Agricultural University, Hangzhou, China)

Diallel analysis for sex-linked and maternal effects.

Theoretical and Applied Genetics (Germany), 92(1):1-9.

Abstract: Genetic models including sex-linked and maternal effects as well as autosomal gene effects are described. Monte Carlo simulations were conducted to compare efficiencies of estimation by minimum norm quadratic unbiased estimation (MINQUE) and restricted maximum likelihood (REML) methods. MINQUE(1), which has 1 for all prior values, has a similar efficiency to MINQUE(theta), which requires prior estimates of parameter values. MINQUE(1) has the advantage over REML of unbiased estimation and convenient computation. An adjusted unbiased prediction (AUP) method is developed for predicting random genetic effects. AUP is desirable for its easy computation and unbiasedness of both mean and variance of predictors. The jackknife procedure is appropriate for estimating the sampling variances of estimated variances (or covariances) and of predicted genetic effects. A t-test based on jackknife variances is applicable for detecting significance of variation. Worked examples from mice and silkworm data are given in order to demonstrate variance and covariance estimation and genetic effect prediction.

444. Bhargava, S.K.; Datta, R.K., 1997.

(Central Sericultural Research and Training Institute, Mysore, India.)

Heterosis and combining ability of silk yield contributing characters in the silkworm, *Bombyx mori* Linn.

Genetika (Yugoslavia), 29(1):49-62.

The combining ability effects of five races (KA, CC1, CA2, NB4D2 and NB18) of the silkworm (*Bombyx mori* Linn) and their 20 F1 generations, including reciprocals were analyzed in a 5 x 5 diallel crossing system for eight silk yield contributing characters (pupation rate, cocoon yield, cocoon weight, shell weight, raw silk percentage, silk filament length, silk reelability and silk neatness).

445. Fan, J., Kong, Y., Liu, H., 1997.

(Jiaxing Agricultural School, Zhejiang, China)

Comparison test for fluoride resistance of three spring silkworm races.

Bulletin of Sericulture (China), 28(3):16-17.

446. Nacheva, I., Petkov, N., 1997.

(Experimental Station of Sericulture, Vratsa, Russia)

Selection and genetic parameters of basic traits of silkworm lines. (III). Correlation coefficients.

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Animal Science, 34(1-2):81-85

Abstract: Genetic, environmental and phenotypic correlation relationships between cocoon weight and cocoon shell weight, cocoon weight and shell ratio of raw cocoons, and cocoon shell weight and shell ratio of raw cocoons, were studied in lines of the source breeds of the Vratsa 35 X Merefa silkworm hybrid at a population level. Theoretical and empirical regression lines between the weight of cocoon shell and cocoon weight, and weight of cocoon shell and shell ratio of ratio raw cocoons, are presented graphically. The phenotypic correlation coefficients between cocoon weight and cocoon shell weight, and cocoon shell weight and shell ratio of raw cocoons, were high and positive. However, correlations between weight and shell ratio of raw cocoons were low and negative. The genetic and environmental correlation coefficients between cocoon shell weight and cocoon weight, and cocoon shell weight and shell ratio of raw cocoons were of the same sign as the phenotype, but varied between the weight and shell ratio of raw cocoons. In addition to the viability of silkworms, the weight of the cocoon shell can be used as a basic criterium in the practical selection and initial stages of breeding activity (preliminary reproduction). Cocoon weight can also be used as a secondary selection criterium in the production of extra quality silkworm seed.

447. Naseema Begum, A.; Bhargava, S.K.; Ahsan, M.M.; Datta, R.K.; Rao, D.R.,1997.

(Central Sericultural Research and Training Institute, Mysore, India.)

Line x tester analysis for economic characters in the bivoltine silkworm, *Bombyx mori* L.

Korean Journal of Sericultural Science (Korea Republic), 39(2):205-209,

448. Petkov, N., 1997.

A study of heterosis, depression and the levels of domination in silkworm (*Bombyx mori* L) line crosses. (II). Cocoon productivity.

Animal Science, 34(5-6):123-125

Abstract :It was found that the heterosis, concerning the production of crude cocoons is emphasized in all examined crosses and seasons of silkworm feeding. Higher values as regards the MP and HP are registered during the summer and autumn breeding seasons.

449. Petkov, N., Nacheva, J., 1997.

A mathematical method for prognosis in choosing the initial material for breeding and industrial hybridization of silk worm (*Bombyx mori* L.).

Agricultural Science, 35(1):10-11

Abstract: The theoretical nature is discussed of the problem for elaborating and using a mathematical model in predicting the results from the breeding material and the industrial hybridization of silkworm. A mathematical model for assessing the breeding indices of hybrid progenies was used in the complex evaluation of the initial forms. It was found that the elaborated mathematical model for prognosis of the potential abilities of silkworm hybrid progenies, contributed for selecting the most promising among the great number of possible combinations, both as initial material and for direct use in industrial hybridization.

450. Petkov, N., Nacheva, J., 1997.

Possibilities of creating genetically marked by sexual traits silkworm breeds.

Animal Breeding, 51(4):29-30.

451. Roy, G.C.; Ghosh, B.; Das, S.K.; Nair, B.P.; Rao, P.R.T.; Sen, S.K.; Sengupta, K.; Sinha, S.S.,1997.

(Central Sericultural Research and Training Institute, Berhampore, India.)

Comparative performance of multivoltine x bivoltine and bivoltine x multivoltine hybrids of *Bombyx mori* L. for commercial use in Eastern India.

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Sericologia, 37(1):113-126.

Abstract: The experiment was designed to compare the quantitative traits of multivoltine x bivoltine (multi x bi) and bivoltine x multivoltine (bi x multi) silkworm hybrids. Five multivoltine breeds i.e., Nistri, CB5, Raj G and B and five bivoltine breeds i.e., P5 NB18, JD6 SF19 and KS(O) were selected on the basis of genetic divergence. Thus a total of twenty-five hybrids each of multivoltine x bivoltine and bivoltine x multivoltine were raised during four commercial seasons of West Bengal each of which is distinct from the other in environmental conditions. Most of the quantitative traits in multivoltine x bivoltine were observed to be superior to bivoltine x multivoltine hybrids except fecundity and larval period. In the present paper, the merits and demerits of rearing of both types of hybrids were evaluated on the basis of their performance with respect to ten quantitative traits.

452. Siddiqui, A.A., 1997.

(Central Tasar Research and Training Institute, Ranchi, India)

Studies on heterosis and heterobeltiosis in the tasar silkworm, *Antheraea mylitta* D. [mid-parent, better parent, progeny].

Sericologia, 37(1):59-69

Abstract: Relative heterosis (over mid-parent) and heterobeltiosis (over better parent) for eight components i.e., oviposition, hatching percentage, larval weight, larval duration, effective rate of rearing cocoon weight, cocoon shell weight and absolute silk yield, were estimated in 24 crosses derived by crossing 8 female and 3 male parents of the tropical tasar silkworm, *Antheraea mylitta* D. Thirteen hybrids exhibited heterobeltiosis for absolute silk yield, effective rate of rearing and cocoon weight. In 12 hybrids, heterosis was observed in 10, 9, 8 and 7 hybrids respectively for larval weight, oviposition, larval duration and hatching percentage. Maximum heterosis and heterobeltiosis were observed in the cross S17 x N5 (114.74 and 108.1) for absolute silk yield. Heterobeltiosis can be used as a criterion in future breeding programmes.

453. Brasla, A., Matei, A., 1998.

(S.C. Serocarom S.A. Research Department, Bucharest, Romania)

Result obtained using the back cross method in silkworm breeding (*Bombyx mori* L.)

Zhivotnov"dni Nauki (supp), 70-72

454. Ignatova, L., Nacheva, J., Petkov, N., 1998.

Genotype characteristics of initial populations silkworm moth (*Bombyx mori* L.) for commercial hybridization.

Animal Science, 35(5):83-87

Abstract: Study was carried out with 6 initial forms of outbred populations in connection with their use in different schemes for commercial hybridization. It was found that genetic variation for the studied populations expressed as heritability vary from low to high for the considered traits cocoon weight, cocoon shell weight and raw cocoon shell ratio. Magnitude of calculated heritabilities allowed carrying out of individual selection.

455. Nacheva, J., Petkov, N., 1998.

Successful breeding and improvement work with silkworm at the experimental station of sericulture, Vratsa.

Agricultural Science, 36(1):27-30

Abstract: A review is made of the successful results and the problems of the breeding and improvement work with silkworm during the 100-year existence of the Experimental station of Sericulture in Vratsa. More than 200 breeds and hybrids have been developed, which made possible six changes of breeds.

456. Nacheva, J., Petkov, N., Malinova, K., 1998.

Possibilities for silkworm, *Bombyx mori* L. bisexual androgenetic lines selection.

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Animal Science, 35(1):82-85

Abstract: The possibilities for silkworm bisexual androgenetic lines creation were discussed in the study. 4 bisexual androgenetic lines have been created. Characteristics of two lines: one - Japan type, and another - Chinese type were made in the study. It was recommended the perspective bisexual androgenetic lines utilization for new highproductive hybrids creation for commercial cocoon production.

457. Nakada, T., 1998.

(Faculty of Agriculture, Hokkaido University, Sapporo, Japan)

A statistical analysis on the genetic differentiation of cocoon shape in the silkworm, *Bombyx mori*.

Memoirs of the Graduate School of Agriculture Hokkaido University, Japan, 21(1):101-109

Abstract: The mulberry silkworm, *Bombyx mori*, is characterized by spinning a cocoon before pupation of larvae. There are many local silkworm strains maintained as material for practice breeding and basic studies in biology at experimental station worldwide. Each strain has diversely complicated cocoon shapes, such as spherical, elliptical, spindle, peanut shell and other types. This may reflect the cross section of genetic differentiation and local race formation of silkworms spread around the world. It is difficult to analyze the inheritance of cocoon shape. As a matter of facts, the measurements of cocoon shape is troublesome work and its difficulty has prevented the development of genetic analysis. Recently, the author has developed a new simple image processing system which linked a CCD camera with a personal computer for an accurate and rapid measurement of some morphological traits in the silkworm.

458. Ninagi, O., Mikuni, T., Maruyama, M., Nagayasu, K., 1998.

(National Institute of Sericultural and Entomological Science, Tsukuba, Ibaraki, Japan)

Behavioral characters of the mature silkworm, *Bombyx mori*, and mode of inheritance.

Bulletin of the National Institute of Sericultural and Entomological Science, Japan, 20:25-37

Abstract: Behavior of the mature larvae of the silkworm, *Bombyx mori*, is closely related to the efficiency of the mounting work of cocooning. Geotaxis dispersal and phototaxis were investigated in order to save labor for the mounting work. Then, in some strains which showed special behavioral characteristics, the mode of inheritance was studied by cross breeding experiments. Geotaxis of the mature larvae was essentially negative, because larvae moving downward were hardly recognized in every strain. The level of geotaxis in each strain and race ranged from active to extremely weak. Consequently, the difference among strains were detected.

459. Petkov, N., Nacheva, J., Shabalina, A., 1998.

Characteristics of the selected with respect to the moving behaviour of the larval silkworm, *Bombyx mori* L. breed SV-1071.

Animal Science, 35(1):106-109

Abstract: During the period of 1099-1995 at the ABI- Kostinbrod and the SES - Vratsa selection and breeding work were made to develop the new silkworm breed SV-1071 by using the additional character ravelly moving behaviour of the larval. The combining ability of the lines will be tested and the best ones will be used for commercial hybrid ration.

460. Petkov, N., Nacheva, J., Tsenov, P., 1998.

Genetic studies of silkworm (*Bombyx mori* L.).

Agricultural Science, 36(1):17-22

Abstract :It is pointed out that genetic research development in *Bombyx mori* L. is related with the genetic statistical models for the prognosis of selection effect and with the choice of initial material for

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breeding and commercial hybridization. Due attention is paid to the problem of developing sure methods for genetic-sex-limited strain breeding and for the genetics of combining ability.

461. Petkov, N., Nacheva, Y., Tzenov, P., Braslavskii, M., Stotskii, M., Golovko, V., 1998  
(Sericultural Experiment Station, Vratsa, Bulgaria)  
Study of some promising Ukrainian silkworm (*Bombyx mori* L.) breeds in relation to their use in breeding work.  
*Zhivotnov"dni Nauki (Supp.)*, 120-123
462. Rama Mohana Rao, P., Jayaswal, K.P., Ravinda Singh., Chatterjee, S.N., Datta, R.K., 1998.  
(Silkworm Breeding Laboratory II, Central Sericultural Research and Training Institute, Srirampura, Mysore-570 008, Karnataka, India)  
Evaluation of some Indian and exotic low yielding silkworm (*Bombyx mori*) breed through diallel cross and its significance for sericulture in dry-zones.  
*Journal of Entomological Research*, 22(1):23-33  
Abstract: Nine low yielding *Bombyx mori* genetic stocks (5 Indian, 3 Chinese and one French) were subjected to full diallel mating to estimate their general combining ability (GCA) and specific combining ability (SCA) for identifying genetically distant parents to adopt definite breeding programmes. Also, specific crosses were identified with high SCA to be utilised for exploitation of heterosis. The results indicated the additive, and additive X additive gene action for the important characters like cocoon weight, shell weight, shell ratio, larval span and survival potential. The data emphasized the superiority of the French strain for improving survival potential. The data emphasized the superiority of the French strain for improving survival potential; and G race, Guangnong, and Hua 204 for improving shell weight and shell ratio. The Indian races, C Nichi and Nistari, showed promise for reducing larval span.
463. Rao, P.R.T., Ghosh, B., Moorthy, S.M., Das, S.K., Roy, G.C., Sengupta, A.K. and Sen, S.K. 1998.  
(CSRTI, Berhampore, WestBengal).  
Combining ability, Gene action and Heterosis through introgressive hybridization in *Bombyx mori* L.  
In: *Proceedings of Perspectives in Cytology & Genetics*, Vol.- 9, pp. 461-471
464. Sreerama Reddy, G., 1998.  
Silkworm Breeding.  
*Proceedings of the National Seminar on Silkworm Breeding*, March 18, 19, 1994, 354
465. Tzenov, P., Nacheva, Y., Petkov, N., 1998.  
(Sericultural Experiment Station, Vratza, Bulgaria)  
On the problem of cocoon colour segregation in crosses between uni-bivoltine and multivoltine silkworm, *Bombyx mori* L. races.  
*Bulgarian Journal of Agricultural Science*, 4(4):471-479  
Abstract: The F1, F2, F3, RF1 and second RF1 crosses between the uni-bivoltine Bulgarian stocks Super 1 and Hessa 2 having white cocoons and the Tropical multivoltine race Bonde 517 with yellow green coloured have been used in the study. The results obtained manifested that the character coloured cocoons dominated over the character white cocoons in F1. In the F2 the segregation was 3 part coloured and 1 part white cocoons. Cocoons with pure colour without any nuances can be selected for the breeding purposes in F2, F3, RF1, F2 of RF1 and second RF1 without any danger to appear segregation in the following generation.
466. Tzenov, P., Nacheva, Y., Petkov, N., Tsenov, P., 1998.  
(Sericultural Experiment Station, Vratza, Bulgaria)
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Inheritance of the larval marking character in hybrids between multivoltine and uni-bivoltine silkworm, *Bombyx mori* L. races.

Bulgarian Journal of Agricultural Science, 4(3):373-378

Abstract: The inheritance of the larval marking character in multi x uni-bivoltine silkworms, *Bombyx mori* L. hybrids has been studied. It was found that the larval marking character is controlled by the gene p which is in multiple allelic series condition.

467. Vasileva, J., Tsenov, P., Mladenov, G., 1998.

Present state, development and trends of research work in the field of parteno- and andro-genesis in silkworm (*Bombyx mori* L.) and the possibilities for their genetic and breeding application.

Agricultural Science, 36(1):22-26

Abstract: The conclusion is researched that application of partheno- and andro-genesis is a qualitatively new stage in silkworm breeding, which makes possible in the near future, by way of gene engineering, the development of new highly productive hybrids with highly expressed heterosis effect.

468. Vineet Kumar., Singh, G.P., Bhargava, S.K., 1998.

(Central Sericultural Research and Training Institute, Mysore, India)

Correlation study of pupal size to egg fecundity and silk yield of silkworm (*Bombyx mori* Linn.).

Philippine Journal of Science, 127(1):73-80

Abstract: A comprehensive study on the correlation of pupal size to egg fecundity and silk yield of silkworm, *Bombyx mori* was made. The results revealed that most of the eggs were mature at the time of oviposition. The number of mature eggs was highly correlated with total number of eggs ( $r=0.99$ ). All the pupal dimensions, namely body weight, body length, body width and wing length could be considered equally important parameters for correlation with total number of eggs and number of mature eggs. However, pupal weight was found to be the best one for estimating both number of mature eggs ( $r=0.63$ ) and total number of eggs ( $r=0.62$ ). Correlations of pupal weight were positive with shell weight ( $P$  less than 0.001), cocoon weight ( $P$  less than 0.001), filament length ( $p$  less than 0.05) and total number of eggs during pedigree selection in silkworm breeding programmes

469. Grekov, D., 1999.

(Vissh Selskotopanski Institut, Plovdiv, Bulgaria)

Phenotypic characteristics of new mulberry silkworm [*Bombyx mori* L.] lines.

Journal of Mountain Agriculture on the Balkans, 2(1):28-34

Abstract: Two mulberry silkworm lines Plovdiv 21 and Plovdiv 22, were developed at the Agricultural University in Plovdiv. It was found that both lines possessed high values and consolidated phenotypic traits. Therefore, the lines can be involved in silkworm breeding programmes intended to line improvement and development of new silkworm races.

470. Grekov, D., Arnaudova, K., 1999.

(Vissh Selskostopanski Institut, Plovdiv, Bulgaria)

Testing of new mulberry silkworm [*Bombyx mori* L.] lines for use in breeding programmes.

Journal of Mountain Agriculture on the Balkans, 2(1):35-42

Abstract: Two newly-developed silkworm lines - Plovdiv 18 and Plovdiv 19, were subjected to biological and technological studies. The lines tested were characterised by their moderate persistence in the values of the main biological and technological traits. The lines Plovdiv 18 and Plovdiv 19 can successfully be involved in breeding programmes for inbred line differentiation, as well as for development of new mulberry silkworm races and hybrids.

471. Laude, R.P., Reyes, R.C., Bantoc, C.B., Masesar, E.B., Ocampo, R.V., Barreto, X.P., Torreta, D.M., 1999.

Silkworm breeding: Study 1. National Integrated Sericulture Development Program Project I:

Silkworm Breeding and Egg Production, College, Laguna, Philippines, 59-81

Abstract: The growth performance and productivity of UPLB established strains and acquired hybrids were evaluated from July 1993 to December 1998 as part of its program on selective breeding. The hatchability of eggs, duration of the various stages of the life cycles, mortality and fecundity of the silkworm were monitored through several generations within a five year period. The mean percentage of egg hatch ranged from 52.4-85.6 percent in all the strains studied. Generally the percentage of egg hatch was highly variable. Incubation of silkworm eggs lasted, on the average, 10.4 to 21 days. Both percentage of egg hatch and duration of incubation were significantly influenced by conditions prior to and during incubation.

472. Matei, A., Ana, B., Oprescu, A., Zeneci, N., 1999.

(Research Branch, Commercial Society - SERICAROM, Bucharest, Romania)

Studies on the use of the evidence on computer in selection and the estimation of breeding value by BLUP methodology in silkworm, *Bombyx mori* L.

Abstracts of the Eighteenth International Sericultural Commission Congress Sessions, October, 1999, Agricultural Research Centre, Ministry of Agriculture, Cairo, Egypt, 1:16

473. Mukherjee, S., Mukherjee, P., Sahani, N.K., Sinha, R.K., 1999.

Characterization and Evaluation of Indian Multivoltine Silkworm (*Bombyx-Mori*) Germplasm

Indian Journal of Agricultural Sciences, 69(5):366-370

Abstract: Variability, heritability, genetic gain as per cent of mean and correlations were studied for 9 quantitative characters among 56 multivoltine silkworm (*Bombyx mori* L.) breeds. Wide variability was recorded among the breeds for morphological and quantitative characters. Fecundity, weight of mature larvae, fifth instar larval duration, yield/10 000 larvae by weight, cocoon weight and shell weight showed high genotypic coefficient of variation (gcv), heritability and genetic advance as per cent of mean, indicating possibility of further improvement through selection. The correlation of yield/10 000 larvae by weight with cocoon weight, shell weight and shell ratio was significant and positive, whereas yield/10 000 larvae by number did not show association with any of the characters except yield/10 000 larvae by weight. Similarly, total larval duration was positively correlated with fifth instar larval duration, but both these variables were not associated with any other characters. The study revealed that one set of variables may control the expression of other set of characters. The breeds like 'MHMP (Y)', 'A 13', 'Hosa Mysore', 'AP 12' and 'MW 13' could be identified potential genotypes for the improvement of multivoltine silkworm through appropriate breeding programme.

474. Petkov, N., Nacheva, Y., Tzenov, P., 1999.

(Sericultural Experiment Station, Vratsa, Bulgaria)

Mathematical forecasting of parents for commercial hybridization in the silkworm, *Bombyx mori* L.

Bulletin of Indian Academy of Sericulture, 3(1):76-79

475. Raju, P.J., 1999.

(Karnataka State Sericultural Research and Development Institute, Thalaghattapura, Bangalore, India)

Present and future perspectives in silkworm breeding research.

Indian Silk, 38(2):11-14

476. Tibiletti, E., 1999.

Silkworm breeding - A simple but profitable activity.

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Terra e Vita, 40(17):87-89

477. Torretta, D.M., Herradura, G.J., Dumelod, D.J., Bombase, N.S., 1999.  
(College of Human Ecology, Philippines University, Los Banos, Colege, Laguna, Philippines)  
Filature and silk quality: Study 3.National Integrated Sericulture Development Program Project I:  
Silkworm Breeding and Egg Production (Terminal Report), College, Laguna, Philippines, 30th June,  
1999, 86-153

Abstract: The filature and silk quality of the UPLB establishing strains and aquired hybrids were assessed as part of the silkworm breeding activities under the National Integrated Sericulture Development Program from 1993 through 1998. Cocoon size, shell ratio, reelability, fibre length and weight, fibre recovery, silk percentage and denier were monitored for the period, at most 14 to 11 rearings for the LBS strains and twelve rearings to one for the rest of the twenty two silkworm strains/hybrids.

478. Amaudova, K., 2000.  
(High School "Agricultural College" in High Agricultural Institute, Plovdiv, Bulgaria)  
(Vissh Selskostopanski Institut, Plovdiv, Bulgaria)  
Study on some lines silkworm *Bombyx mori* L. in connection with their use in the breeding.  
*Zhivotnov'dni-Nauki*, 37(1):44-47

Abstract: Breeding assessment of some of the most prospective lines *Bombyx mori* L. created in the High Agricultural Institute, Plovdiv was made in connection with their use in breeding programes. It was found that majority of the lines included in the gene-fond could be used as donors for creation of new initial breeding populations in the future. The lines Plovdiv 14 (with Chinese origin) and Plovdiv 15 and Plovdiv 16 (both with Japanese origin) could be used as components in classic hybridization scheme for creation of new original Industrial hybrids. In the programes for creation of new synthetic breeding populations could be use line Plovdiv 15 as donor for improvement of silkworm viability, cocoon weight and cocoon shell weight and line Plovdiv 14 for improving of silk filament length.

479. Chen, P., Zhu, Y., Lu, C., Xiang, Z., 2000.  
(The Key Sericultural Laboratory, Agriculture Ministry, College of Sericulture and Silk, South West Agriculture University, Chongqing, China)  
The influence of high temperature during embryonic period on growth and development and some economic characters of silkworm, *Bombyx mori* L.  
*Canye Kexue*, 26(2):75-80

Abstract: We have treated more than 20 silkworm races with 34 °C and RH80 percent during the embryo stage of post end reversion. The results of test indicated that the larval period of same race was changed, most of larval weight became lighter, whole cocoon weight, cocoon shell weight and out put clearly decreased. But it had no apparent effect on healthiness, silk quality and ratio of cocoon shell. And the degree of influence on growth and development and economic characters caused by high temperature is different between pure races. Compared with pure race, the influence on hybrid is less. We think that the influence of high temperature on growth and development and economic characters of silkworm is not the restrictive factor for use of sex-linked temperature sensitive gene and male silkworm variety, some ill influence can be resolved through routine breeding.

480. Ignatova, L.; Petkov, N.; Nacheva, J.,2000.  
(Opitna Stantsiya po Bubarstvo, Vratsa, Bulgaria.).  
Influence of hybridization approaches and schemes on heterosis, depression, and levels of dominance in between breed crosses in silk butterfly [*Bombyx mori* L.].  
Length of silk filament.*Zhivotnov"dni Nauki* , 37(2):67-73,(Bulgarian )

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Abstract: In the Experimental Station in Vratsa an experiment was carried out in order to find out the influence of different methods and schemes of commercial hybridization on manifestation of heterosis in F<sub>1</sub>, depression in F<sub>2</sub> and of degree of dominance in F<sub>1</sub> and F<sub>2</sub> for the trait silk filament length. The heterosis for silk filament length was considerably demonstrated in all studied F<sub>1</sub> crosses and in general it was higher compared to MP and HP for spring breeding and for simple hybridization scheme. Degree of dominance in F<sub>1</sub> and F<sub>2</sub> show that the heterosis for silk filament length was due to overdominance. Relative importance of heterosis and epistatic interaction varied with the change in the environment conditions.

481. Kalpana, G.V., Kishore Kumar, C.M., Datta, R.K., Ramesh Babu, M., Nirmal Kumar, S., Palit, A.K., 2000.

(Central Sericultural Research and Training Institute, Mysore, India)

Selection of silkworm hybrids in relation to length and size of cocoon filament in *Bombyx mori* L.

Proceedings of the National Seminar on Tropical Sericulture 1999, University of Agricultural Sciences, Bangalore, India, 28-30 December, 1999, 2:14-16

Abstract: An attempt has been made to select suitable silkworm breeds for thin denier and longer filament length to improve the quality aspects of silk. Nine breeds were chosen and subjected to single cocoon cold reeling, followed by directional selection of progenative individuals for the desired denier, (<2.2) and longer filament length (> 1300 m) for over 10-12 generations. Among the nine breeding lines, JPN7, JPN8 and B63 have shown positive selection response for filament length and filament size. Among the fifteen hybrids studied, three hybrids viz., JPN7 x B63 (F<sub>1</sub> -1433m and D -2.28d), MBC2 x B63 (F<sub>1</sub> -1399m and D-2.15d) and JPN8 x B63 (F<sub>1</sub> -1322m and D -2.24d) were adjudicated as the superior hybrids for longer filament and thin denier.

482. Kishor Kumar, C.M.; Nirmal Kumar, S.; Vedavyasa, K.; Nanjunda Naik, R.; Khaji, M.M.; Datta, R.K., 2000.

(P4 Basic Seed Farm, Hassan, Karnataka, India)

Studies on the performance of CSR pure races by seed rearers in Hassan district (Karnataka).

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, p.67.,

Three new productive bivoltine races namely CSR2, CSR4 and CSR5 extracted by conventional breeding methods were evaluated for their performance along with the traditional bivoltine race NB4D2 in Hassan seed area. A total quantum of 2215 dfls of these new races was distributed to 14 farmers in three seasons between October, 1999 and February, 2000. Eight characters such as fecundity, hatching, larval duration, yield by weight per 100 dfls, cocoon weight, shell weight and shell ratio were analyzed.

483. Kumaresan, P.; Sinha, R.K.; Sahni A.K.; Sekar, S., 2000.

(Silkworm and Mulberry Germplasm Station, Hosur, Tamil Nadu, India.)

Genetic variability and selection indices for economic quantitative traits of multivoltine mulberry silkworm (*Bombyx mori* L.) genotypes. *Sericologia* vol 15,

*Sericologia*, 40(4):595-605, (English)

Abstract: Genetic variability and selection indices for seven economically important quantitative traits of fifty-six-multivoltine mulberry silkworm races were estimated. ANOVA showed a highly significant variability for all the six commercial characters under study. High value of GCV percentage and PCV percentage along with heritability and genetic advancement for filament length, single-shell weight and single cocoon weight showed that the above characters would be highly effective for improvement. The correlation between single-cocoon weight and single-shell weight as well as single ratio were found highly significant. The filament length was shown a highly significant and positive correlation with four economic characters. The selection index programme based on the discriminant function analysis

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resulted into three clusters of ten genotypes with lower index values for utilisation in hybridisation and conventional breeding approaches.

484. Mahadevamurty, T.S., Kumaresan, P., Singh, R.K., 2000.

(Central Sericultural Germplasm Resources, Hosur, Tamil Nadu, India)

Genetic variability and discriminant function analysis for commercial characters of bivoltine silkworm (*Bombyx mori* L.) germplasm.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, 28.

Abstract: Genetic variability and selection indices for five economically important cocoon and yield attributes (single cocoon weight, single-shell weight, shell ratio, cocoon yield /10,000 larvae by weight and pupation rate) of 153 bivoltine (69 exotic 84 indigenous) accessions were estimated. ANOVA indicates highly significant variability for all the four characters except pupation rate under study. High value of GCV and PCV percentage along with heritability and genetic advancement for single shell weight, shell ratio and single cocoon weight showed that the above characters would be highly effective for improvement. The positive correlation between single-cocoon weight and single-shell weight as well as single shell- weight and shell ratio were found to be highly significant ( $P < 1$  per cent). The cocoon-yield/10,000 larvae by weight have shown positive correlation with single cocoon weight and single shell weight though which showed less heritability and genetic advancement. It indicates that the yield attributes could improve while improving the cocoon characters. The pupation rate has shown negative correlation cocoon characters and positive correlation with yield characters. The discriminant function analysis based on the desired target resulted in to two clusters of ten breeds with lower index values for utilization in the conventional breeding programme.

485. Masilamani, S., Reddy, A.R., Sarkar, A., Sreenivas, B.T., Kamble, C.K., 2000.

(Regional Sericultural Research Station, Coonoor).

Heritability and genetic advance of quantitative traits in mulberry (*Morus* spp.).

Indian Journal of Sericulture, 39 (1):16 – 20.

Abstract: Experiments were conducted with 18 mulberry genotypes to determine the heritability and genetic advance of quantitative traits. Under nursery trial, among the seven characters studied, high heritability (>70%) accompanied with high genetic advance recorded in shoot to root ratio by dry weight, volume of roots and number of roots is due to additive gene effects and selection based on these may be effective. Under preliminary yield trial, among the 10 characters studied, leaf area, weight of 100 leaves and weight of shoot showed additive gene effects. High value of heritability with low value of genetic advance recorded for plant height and number of leaves/m length of a branch is due to non-additive gene effects and heterosis breeding might be useful in this regard. Characters viz., moisture (%) and moisture retention capacity of the leaf were influenced by environmental factors as they exhibited low heritability with low value of genetic advance and selection based on these would be ineffective.

486. Mukherjee, S., Mukherjee, P., Beevi, N.D., Sinha, R.K., 2000.

(Silkworm and Mulberry Germplasm Station, Thally Road, Hosur, Tamil Nadu, India)

Genetic variability in cocoon shape, size and weight variables in multivoltine silkworm, *Bombyx mori* L.

Indian Journal of Genetics and Plant Breeding, 60(4):541-546

Abstract: Studies on variability estimates, heritability, correlation and path analysis in 56 multivoltine silkworm breeds (*Bombyx mori* L.) consisting of 46 indigenous and 10 exotics were carried out for cocoon shape, size and weight variables. Wide range of variability for all the characters was observed and the variability was normally distributed except for cocoon volume where it was positively skewed. High heritability coupled with high genetic advance as percentage of mean was observed for cocoon volume and area, rest of the traits exhibited high heritability associated with moderate genetic advance.

All the correlations were in positive direction. Cocoon volume and area were significantly associated with other characters. Cocoon width was significantly correlated with cocoon weight and shell weight. Path analysis studies revealed the importance of selection pressure on cocoon width cocoon volume and shell weight in breeding programme aimed at improving the cocoon weight.

487. Narayanaswamy, T.K., Govindan, R., Ananthanarayana, S.R., Ramesh, S., 2000.

(Department of Sericulture, University of Agricultural Science, GKVK, Bangalore, India)

Combining ability for rearing traits among multivoltine X bivoltine hybrids of silkworm *Bombyx mori* L.

Mysore Journal of Agricultural Sciences, 34(1):32-39

Abstract: Combining ability for rearing traits among the hybrids synthesized from seven multivoltine and four bivoltine silkworm (*Bombyx mori* L.) breeds was studied in a line X tester analysis, to select the best combinations and combiners for replacing the existing hybrids as well as in the utilization in heterosis breeding programme. The variance due to parents and hybrids was significant for all the six quantitative traits studied viz., extent of progression to fourth instar, larval duration up to fourth instar, fifth instar duration, total larval duration, mature larval weight and effective rate of rearing. The parent KG as line was found to be good general combiner for extent of progression to fourth instar, total larval duration, mature larval weight and effective rate of rearing, whereas NB4D2 and NB18 as testers were found to be good general combiners for fifth instar larval duration, total larval duration and extent of progression to fourth instar, mature larval weight and effective rate of rearing, respectively. The data revealed higher magnitude of SCA variance compared to GCA variance for all the traits studied.

488. Naseema Begum, A.; Rekha, M.; Ahsan, M.M.; Sudhakar Rao, P., 2000.

(Central Sericultural Research and Training Institute, Mysore, India)

Evaluation of two promising hybrids Viz., HSP1 (A3X935 E) and HSP2 (A3X916 B) in the silkworm, *Bombyx mori* L.

International Journal of Industrial Entomology, 1(2):103-109,

Abstract: To evolve silkworm hybrids with higher survival and better cocoon characters, evaluation of seven hybrids in the laboratory (short-listed out of 143 hybrids) resulted in the identification of two promising hybrids, A3 X 935 E (HSP1) and A3X916B (HSP2). The hybrids were evaluated at three different Regional Sericultural Research Stations of Central Silk Board during 1997-1998 and also tested with the farmers along with two control hybrids, KAXNB4D2. Evaluation of the hybrids indicated that these hybrids can be reared in all the seasons, especially during summer season. These hybrids show shorter larva duration (22 days 17hrs against 23 days in control KAXNB4D2 and better cocoon characters as compared to the cross breed, PMXNB4D2)

489. Naseema Begum, A.; Ahsan, M.M.; Basavaraja, H.K.; Rekha, M.; Jayaswal, K.P., 2000.

(Central Sericultural Research and Training Institute, Mysore, India.)

Heterosis studies in the newly developed hybrids of silkworm, *Bombyx mori* L.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, P.21-22 ,

Abstract: Silkworm hybrids developed from inbred lines or from different breeds are commercially exploited for production of silk. With the objective of selection of compatible silkworm hybrids to suit the fluctuating climatic conditions of tropics, studies were taken up for optimum expression of productivity and survival. Four bivoltine breeds evolved under high temperature and high humidity ( $31 \pm 1^\circ\text{C}$  and RH  $85 \pm 5$  percent) stress condition viz., A HT, B HT (ovals), F HT, G HT (dumb-bells) showed survival of 85-90 per cent and shell ratio of 20-21 percent. These evolved breeds were crossed with productive breeds having shell ratio of 23-24 percent and evaluated for hybrid vigour on nine economically important traits viz., total larval duration, survival, and yield/10,000 larvae by weight,

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cocoon weight, shell weight, shell ratio, filament length, raw silk recovery and reelability contributing to silk yield.

490. Panalotov, M., 2000.

(Tracian University, Stara Zagora, Bulgaria.)

Effect of low doses gamma ray irradiation during post-embryonic stage of *Bombyx mori* L. on the phenotypic expression of basic quantitative traits.

Zhivotnov"dni-Nauki, 37(1):59-63,

Abstract: Effect of low doses gamma rays (0.1, 0.25, 0.5, 1.0 and 3.0 Gy) on phenotypic expression of traits cocoon weight and cocoon shell weight (g), silk rate, and laboratory raw silk yield (percentage) in *Bombyx mori* L. was studied. Caterpillars of first age were irradiated by gamma rays (<sup>60</sup>Co) right before begin feeding. Six groups were formed each of four replications with 200 individuals of monovoltine breed 24. Experiment was carried out during spring breeding season. Irradiation with doses from 0.1 to 3.0 Gy caused positive effect on the analyzed traits. Sex depending differences were found in stimulation degree of studied traits. Males were hardly influenced in cocoon weight (up to 9.0 percent) and in cocoon shell weight (up to 14.53 percent) and female- in silk rate (up to 10.9 percent) and laboratory raw silk yield (up to 13.49 percent). The most effective doses for irradiation were 0.25 and 0.5 Gy.

491. Petkov, N., Ignatova, L., Nacheva, J., Tsenov, P., 2000.

(Opitna Stantsiya po Bubarstvo, Vratsa, Bulgaria)

Studies on reproductive traits of simple (di-) and complex (three- and tetra-) hybrids of silkworm (*Bombyx mori* L.).

Zhivotnov"dni Nauki, 37(4):84-88

Abstract: Study was carried out on most important reproductive traits (number and weight of normal eggs in one batch, average egg weight and percentage of physiological discarding in the batches) of new high productive simple (di-) and complex (three- and tetra-) hybrids of silkworm tested during the spring and summer seasons of silkworm feeding. It was found that complex (three and tetra) hybrids exceeds simple ones in number and weight of eggs in one batch with 45-65 eggs and 42-63 mg during the spring season and with 33-56 eggs and 28-50 mg during the summer season. With implementation of the complex hybrids in the production the yield of silkworm seeds from 1 kg utilized breeding cocoons increased with 7.26-10.14 percent during the spring and with 5.40-8.83 percent during the summer.

492. Petkov, N.; Nacheva, J.; Tsenov, P., 2000.

(Opitna Stantsiya po Bubarstvo, Vratsa, Bulgaria.)

The problem of selecting breeds genetically labelled by sex in the egg and larva stages of the silkworm [*Bombyx mori* L.].

Selskotopanska-Nauka, 38(4):42-45, (Bulgarian)

Abstract: Results are presented in this paper from the development and use of methods for selection of new high-producing original, genetically labelled by sex, silkworms in their egg and larva stages. The working hypotheses are based on the view-point about the presence of signal genes, localized in sexual chromosomes and the morphological traits in some of the populations used as initial material for breeding. It has been found that ingestive crossing and sexual hybridization may be successfully used for developing new high-producing original breeds of silkworms, genetically labelled by sex both in their egg and larva stages. In the majority of traits studied there is sexual differentiation within the limits of one breed.

493. Petkov, N.; Nacheva, J.; Tsenov, P., 2000.

(Opitna Stantsiya po Bubarstvo, Vratsa, Bulgaria.)

On the problem of transgression in some production traits of silkworms [*Bombyx mori* L.].

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Selskostopanska Nauka , 38(2):51-52,(Bulgarian )

Abstract: Subject of the study is the character of inheritance in F1 and the extent and frequency of transgressions in F2 with respect to some of the most important production traits of the silkworms in connection with the selection of positively transgressive specimens for developing new high-productive breeding population. Established is superdomination in the inheritance of the traits cocoon weight and weight of silk cover, the contribution being of the parent having higher value of the traits. The combination of positive transgression in the traits cocoon weight and weight of the silk cover in the F2 hybrid populations makes possible the selection of specimens of high-production potential.

494. Petkov, N., Nacheva, J., Tsenov, P., Shabalina, A., 2000.

(Optina Stantsiya po Bubarstov, Vratsa, Bulgaria)

Possibilities for selecting lines of the silkworm (*Bombyx mori* L.) according to the motional behaviour of the larvae. Selskostopanska Nauka, 38(5):25-28

Abstract: A study has been carried out on the motional behaviour of the silkworm larvae and on this character in the breeding-and-selection programmes for the purpose of increasing the productivity of cocoons and raw silk. In the course of the study it has been established, that parallelly to the basic characters used in the selection, motional activity of the larvae may also be successfully used in the breeding work applied for developing high-productive lines of silkworms.

495. Premalatha, V.; Raghavendra Rao, D.; Rama Mohan Rao, P.; Singh, R.; Kariappa, B.K.; Jayaswal, K.P.; Datta, R.K., 2000.

(Central Sericultural Research and Training Institute, Mysore, India.)

Evaluation of heterosis through combining ability in polyvoltine strains of silkworm, *Bombyx mori* L.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, P.25 .

Abstract: Heterosis, general and specific combining abilities (GCA, SCA) were estimated for seven economically important traits viz., fecundity, total larval duration, yield per 10,000 larvae by number and weight, cocoon weight, shell weight and shell ratio for 45 polyvoltine silkworm strains viz., PM, C. nichii, RD1, BL23, BL24, BL25, BL26, BL27, BL28, BL30, BL33, BL34, BL35, BL36, BL37, BL43, BL44, BL45, BL51, BL53, BL54, GNP, Moria, Sarupat, Kw2, T. white, GNM, HM, PA12, PMS2, PMX, Nistari, Cambodge, A4e, Daizo, 95A, 95B, 95D, 95D1, 95G, 95K, 95L, 95M and 95O by line x tester analysis. ANOVA estimates showed that highly significant GCA effects for as many as six characters followed by 95A, PA12, A4e and BL23 for five characters indicating the importance of additive gene action for the expression of traits studied.

496. Rao, P.R.T.; Ghosh, B.; Moorthy, S.M.; Sengupta, A.K.; Sen, S.K.; Saratchandra, B., 2000.

(Central Sericultural Research and Training Institute, Berhampore, India.)

Breeding techniques for seed production and its practical utility.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, P. 22..

Abstract: The preparation of multivoltine x bivoltine hybrids for autumn commercial crop is difficult in the eastern and North-Eastern states of India since the parental breeds of such hybrids have to be raised during September, which is unfavourable for any pure bivoltine silkworm rearing. Therefore, a good quantity of bivoltine cocoons is imported either from Karnataka or from Dheradun for the preparation of multivoltine x bivoltine commercial seed. On the other hand, the recently authorized multivoltine x bivoltine hybrids could not be popularized in Bihar, Orissa and West Bengal owing to the failure of their respective seed crop during September. As a solution to this problem, the breeders of this Institute have formulated a breeding plan to use bivoltine x multivoltine hybrids as male parents because the bivoltine hybrid rearing is easier during the adverse period and hence a better survival is assured.

497. Subramanya, G., 2000.  
(Department of Studies in Sericultural Science, University of Mysore, Mysore, India)  
Studies on the genetics of voltinism in the cross breeding programme.  
National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, 16-17  
Abstract: Tropical polyvoltine Pure Mysore race of silkworm *Bombyx mori*, known for its hardness is exclusively used as a female parent in the cross breeding programme in Karnataka. Sericulture in Karnataka is sustained on account of its stability and good combining ability with popular bivoltine races.
498. Suresh Kumar, N.; Basavaraja, H.K.; Mal Reddy, N.; Jayaswal, K.P.; Datta, R.K., 2000.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Estimation of heterosis in newly evolved CSR bivoltine hybrids of silkworm, *Bombyx mori* L. at room and high temperature.  
In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, P.25-26 .  
Abstract: A number of CSR breeds and hybrids were evolved at CSR TI, Mysore, under the guidance of JICA experts in recent years. The superiority of these hybrids with regard to quantitative and qualitative traits is now well established. The commercial exploitation of hybrid vigour in silkworms has already been introduced since the beginning of the century in most of the developed countries. The high yielding and robust CSR bivoltine hybrids along with their parents were chosen as materials in this study for the estimation of heterosis and heterobeltiosis both at  $25 \pm 1^\circ\text{C}$  and  $36 \pm 1^\circ\text{C}$  temperature in three trials. The results obtained were found to be significant when tested by employing t-test.
499. Tsenov, P., Lazarov, Y., Nacheva, J., 2000.  
(Opitna Stantsiya po Bubarstvo, Vratsa, Bulgaria)  
Study on the race susceptibility to unfavourable rearment conditions of silkworm (*Bombyx mori* L.)  
*Zhivotnov"dni Nauki*, 37(5-6):42-45  
Abstract :In the Sericulture Research Station in Vratsa during the period 1997-1999 were studied 15 Japanese and 13 Chinese races at a standard and at a provocative rearment in the fourth and fifth age. The studied races showed clearly expressed genetic detrimination concerning the traits survival rate and cocoon yield per box of seeds at the provocative regime of rearment. The races of Japanese origine (KK, AC and Hesa 1) and of Chinese origin (Veslec 2, Gergana 2 and SV) with marked resistance at provocative regime could be used in the breeding programs as donors of genes for high viability or directly for commercial hybridization.
500. Yamaguchi, A., 2000.  
(Central Sericultural Research and Training Institute, Mysore, India)  
Future directions of bivoltine silkworm breeding in India.  
National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Mysore, India, 16-18, November 2000 (Souvenir), 17-19
501. Zhou, J., Shen, K., Dai, J., 2000.  
(Agricultural Department of Zhejiang Province, Hangzhou)  
The present situation and breeding direction of silkworm races in Zhejiang province.  
*Bulletin of Sericulture*, 31(1):4-6  
Abstract: The paper analysed the present situation, main problems existed and future breeding direction of silkworm breeding in Zhejiang province.

502. Chandrashekharaiyah., 2001.

(Andhra Pradesh Sericulture Research and Development Institute, Hindupura, India)

Need to evolve silkworm breeding strategies.

In: Abstracts of National Seminar on Mulberry Sericulture Research in India, KSSRDI, Thalaghattapura, Bangalore, India, 26-28 November, 2001, 13.

Abstract: The efforts made till date in silkworm breeding for the development of silkworm breeds/hybrids suitable for the tropical conditions of India are based on conventional breeding strategies. These efforts usually laid emphasis on single, two or three characters which may be quantitative or a mix of both (such as higher survival rate, pupation rate, yield, shell ratio, silk quality etc.). These approaches are not wholistic to suit field conditions as most of the productivity-linked characters in silkworm are controlled by polygenes. Silk production in India is entirely dependent on productivity achieved through rearing of cross-breed (PM x NB4D2) variety that produces inferior quality of silk. The bivoltine breeds/hybrids synonymous with higher productivity and superior quality silk are reared on a limited scale. The silkworm breeds/hybrids developed, introduced and popularized in India are few.

503. Chattopadhyay, G.K., Sengupta, A.K., Verma, A.K., Sen, S.K., Saratchandra, B., 2001.

(Silkworm Breeding and Molecular Biology Laboratory, Central Sericultural Research and Training Institute, Berhampore, West Bengal, India)

Transgression of shell weight - A multigenic trait, through development of congenic breed in tropical silkworm, *Bombyx mori* L.

*Sericologia*, 41(1):33-42.

Abstract: Exploitation of heterosis for the improvement of both quantitative and qualitative traits in sericulture is a matter of practice using multivoltine x bivoltine silkworm (*Bombyx mori* L.) strains or vice-versa. The highly heterogenic genepool in tropical silkworm strains produce hybrids with variable performances. Therefore, in the present experiment, a different breeding approach has been adopted for the first time in sericulture by developing successively syngenic line, recurrent backcross line (RBL) and congenic line (Con. L) or near isogenic line (NIL) causing transgression of cocoon shell weight (SCSW), the target character in all the lines in comparison to the original population i.e., CB5 (GP). The target character in congenic or near isogenic line is very close to bivoltine- the donor parent (JPN9LmP). Single cocoon filament length being the most important linked character has also increased substantially keeping larval marking, cocoon colour, cocoon shape and voltinism as that of multivoltine - the receptor parent (CB5Lm-5). Such breeds having higher yield and better silk quality may directly be releases for commercial exploitation bypassing conventional hybridization.

504. Datta, R.K.; Raghavendra Rao, D.; Jayaswal, K.P.; Premalatha, V.; Singh, R.; Kariappa, B.K., 2001.

(Central Sericultural Research and Training Institute, Mysore, India.)

Heterosis in relation to combining ability in multi X bivoltine strains of silkworm, *Bombyx mori* L.

*Indian Journal of Sericulture*, 40(1):1-6,

Abstract: In an experiment involving 45 polyvoltine strains as lines and 3 bivoltine strains as testers, in a line X tester programme, heterosis, general and specific combining abilities (gca and sca) were estimated for seven quantitative traits viz., fecundity, larval period, cocoon yield per 10,000 larvae by number and weight, cocoon weight, shell weight and shell ratio (percentage). ANOVA estimates showed that significant effects were observed for all the characters studied for all the breeds indicating the significance of both additive and non-additive gene action in the expression of the traits. The breeds, 95B and 95G were judged as good general combiners among the 45 breeds, as these breeds showed significant gca effects for as many as six characters indicating the importance of additive genes action for the expression of traits studied. Out of 135 hybrids studied, no single hybrid indicated positive

heterobeltiosis and /or sca effects for all the quantitative traits, however, the hybrids, BL25 X NB4D2 and 95L X CSR5 expressed desirable sca effects and heterobeltiosis for cocoon yield by weight, cocoon weight, shell weight and for cocoon yield/10000 larvae by number and cocoon weight, respectively, and hence deserve commercial exploitation.

505. Li, M., Yao, Q., Hou, C., Lin, C., Chen, K., 2001.

(Sericultural Research Institute, Chinese Academy of Agricultural Sciences, Ahejiang 212018, Jiangsu, china)

Studies on some special characters in the silkworm (*Bombyx mori* L.) germplasms in China.

Sericologia, 41(4):527-535

Abstract: China is the cradleland of sericulture and has plenty of silkworm germplasm resources. In recent years, we have engaged in the studies on some special characters in the stocks of silkworm in Sericultural Research Institute, Chinese Academy of Agricultural Sciences (SRI-CASS). Three hundred and twelve preserved silkworm races were investigated for their fluoride-resistance and the major dominant gene controlling the fluoride-resistance was discovered, it could endure 200 mg/kg of fluoride. Resistability to *B. mori* nuclear polyhedrosis virus (BmNPV) of 346 races was investigated and the genetic model of resistance to BmNPV was analysed. One main gene (which was located on autosome) and several tiny effecting genes (which were located on chromosome Z) controlled the resistability to BmNPV. Eight races and a few individuals of 31 varieties of 206 stocks were nonsusceptible to *B. mori* densovirus of Zhejiang (China) strains (BmDNV-Z). Female moths holding four, five, six, nine or ten ovarian tubes were discovered in 138 races. In 5 races, male cocoons show yellow fluorescence, while female cocoons show purple fluorescence when they were radiated under 356 nm ultraviolet ray. Several cocoon filament properties of silkworm germplasms have been investigated and analysed. These researches will provide new silkworm breeding material.

506. Mahadevamurthy, T.S., Rayaraddar, F.R., Kumaresan, P., Sinha, R.K., Thangavelu, K., 2001.

(Central Sericultural Germplasm Resources Centre, Hosur, India)

Evaluation of multivoltine silkworm (*Bombyx mori* L.) germplasm for post cocoon parameters and its utilisation.

Abstracts of National Seminar on Mulberry Sericulture Research in India, KSSRDI, Thalaghattapura, Bangalore, India, 26-28 November, 2001, 169

Abstract: In order to promote the utilization of silkworm genetic resources, 56 multivoltine silkworm accessions maintained at CSGRC, Hosur, were evaluated for 10 post cocoon parameters, which includes reeling and quality of raw silk. The results revealed highly significant variability among all the races ( $P > 0.01$  percent) for all parameters studied. Based on the evaluation, ranking was also done and observed that the breed CB5 (BMI-0021) performed better for 09 parameters followed by LMO (BMI-0055) and MW13 (BMI-0043) for 08 parameters. Similarly, 'G' (BMI-0016) race, Kollegal Jawan (BMI-0009) and Kolar Gold (BMI-0008) for 07 parameters; 'O' (BMI-0027) race and Moria (BMI-0003) for 06 parameters and Cambodge (BME-0050) and Wai-4 (BMI-0041) for 05 parameters. Further, 10 best accessions have also been identified for all the post cocoon parameters, which could be utilised in breeding programme and also for commercial exploitation.

507. Nacheva, Y., Petkov, N., Tzenov, P., 2001.

(Sericultural Experimental Station, Vratza, Bulgaria)

Mathematical forecast of breeding effect based on cocoon shell weight index of silkworm (*Bombyx mori* L.)

Bulgarian Journal of Agricultural Science, 7(3):345-347

Abstract: An individual selection for the index of *B. mori* cocoon shell weight was carried out among the primary races of silkworm hybrid Vratza 35 X Meref 2, developed for rearing in certain areas of the country. The progeny of the highest parents and primary populations of zero selection intensity was reared. Breeding effect was determined as the difference between the phenotypic index value of the

progeny of selected parents and the average index value for the population of the preceding generation, based on the realized index of inheritance and breeding differential. The forecast value of cocoon shell weight index was calculated by adding breeding effect to the average phenotypic index value of the primary population. It was established that the method of genetics and breeding used for the purpose of forecast enabled the establishment of breeding effect of selection for cocoon shell weight index.

508. Naseema Begum, A., Basavaraja, H.K., Rekha, M., Ahsan, M.M., Datta, R.K., 2001.

(Central Sericultural Research and Training Institute, Mysore, India)

Identification of breeding resource material for the development of thermo-tolerant breeds in the silkworm *Bombyx mori*.

International Journal of Industrial Entomology, 2(2):111-117

Abstract: Screening of fifteen bivoltine silkworm breeds of *Bombyx mori* Linn. at a temperature of  $31 \pm 1^\circ\text{C}$  and relative humidity of  $85 \pm 5\%$  percent resulted in the identification of eight thermo-tolerant breeds. The survival and cocoon shell ratio of the tolerant breeds ranged from 72.7 to 78.7 percent and 20.0 to 20.1 percent respectively. The tolerant breeds comprised of four oval breeds and four dumb-bell breeds. Eight foundation crosses prepared by crossing the oval and dumb-bell parents among themselves were screened at a temperature of  $31 \pm 1^\circ\text{C}$  and relative humidity of  $85 \pm 5\%$  percent. The performance of the foundation crosses on 11 economic characters were analysed by employing Multiple Trait Evaluation Index Method. Four foundation crosses which scored average index value  $> 50$  were selected as breeding parents and breeding initiated for the evolution of thermo-tolerant bivoltine silkworm breeds. The methodology and the results of the foundation crosses reared both at  $31 \pm 1^\circ\text{C}$  and  $25 \pm 1^\circ\text{C}$  temperatures are discussed.

509. Raghavendra Rao, D.; Premalatha, V.; Singh, R.; Kariappa, B.K.; Jayaswal, K.P.; Rama Mohana Rao, P.; Datta, R.K., 2001.

(Central Sericultural Research and Training Institute, Mysore, India.)

Studies on manifestation of hybrid vigour in polyvoltine x bivoltine crosses of silkworm, *Bombyx mori* L.

Journal of Experimental Zoology India, 4(2):219-232.

Abstract: Heterotic effects for seven characters viz. fecundity, total larval period, cocoon yield/10,000 larvae both by number and weight, cocoon weight, cocoon shell weight and shell ratio were studied among F1 hybrids of 45 polyvoltine and 3 bivoltine breeds. Among 135 hybrids, five hybrids viz. Tamil Nadu white x CSR2, PMS2 x NB4D2, Nistari x NB4D2, 95B x CSR5 and 95L x CSR5 showed significant positive effects for all the seven characters studied. Whereas 35 hybrids exhibited significant heterosis for six characters and 52 hybrids for five important quantitative characters. Majority of the hybrids exhibited significant positive heterotic effects for the three important characters such as cocoon yield per 10,000 larvae by weight, cocoon weight and cocoon shell weight. The present study indicated the need for exploitation of hybrid vigour among polyvoltine x bivoltine hybrids to increase silk production in India.

510. Ramesh Babu, M., Chandrashekharaiyah., Lakshmi, H., Prasad, J., 2001.

(Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, Andhra Pradesh, India)

Silkworm (*Bombyx mori* L.) genetic stocks- An evaluatory analysis.

Bulletin of Indian Academy of Sericulture, 5(1):9-17.

Abstract: Forty-seven (22 oval and 25 dumbbell) bivoltine silkworm genetic stocks maintained as germplasm at APPSRDI, Hindupur are evaluated and ranked based on the overall performance by employing Evaluation Index, Subordinate Function and Joint Scoring methods. The applicability of these methods for evaluation of the genetic stocks for precision is confirmed. The first five top ranked breeds viz. APS9, APS5, APS11, APS7 and APS1 among oval and APS6, APS4, APS8, APS2 and APS10 among

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dumbbell can be utilized as initial parents in breeding programmes for the development of productive and qualitatively superior silkworm breeds/hybrids suitable for tropical climate in general and Andhra Pradesh in particular.

511. Sengupta, A.K., 2001.

(Central Sericultural Research and Training Institute, Berhampore, West Bengal, India)

Approaches of silkworm breeding for Eastern India- A retrospective view.

In :Abstracts of National Seminar on Mulberry Sericulture Research in India, KSSRDI, Thalaghattapura, Bangalore, India, 26-28 November, 2001, 204-205

Abstract: To set a balanced picture of silkworm breeding and the promise it holds, it is appropriate at this juncture to go briefly through the history of the work done and / oo the products produced by this institute. The trend shows that with an overlapping period of 10 years between subsequent varieties, cocoons, were produced by rearing varieties in a five step sequential order of breeding strategies.

512. Shaphakzide, E., Sanikidze, T., 2001.

The perspective of the development of silkworm breeding in Georgia with the introduction of the tidy ecological technology.

Tbilisi (Georgia), 252-258

Abstract: The problems of silkworm farm breeding in georgia and its perspectives are discussed. The recommendations of the silkworm breeding development are offered by the ministries of Agriculture and Industry. The silkworm total harvest in georgia will make up about 14420 tons to the year 2002. the manufacture of mulberry leaves wil grow about 35000 tons. The mulberry trees will be planted on 12000-14000 ha land area. It is advisable to feed silkworms in farms. The effect of the silkworm breeding will be expressed by the use of the new technology totalling 7000 tons will be expressed by the use of the new technology totaling 7000 tons output. 8700 tons will be expressed by the dregs with organic manuring and 5800-8700 min.m2 will be expressed by the construction tiles.

513. Singh, R., Raghavendra Rao, D., Kariappa, B.K., Jayaswal, K.P., 2001.

(Central Sericultural Research and Training Institute, Mysore, India)

Androgenesis in mulberry silkworm *Bombyx mori* L.: A Review.

International Journal of Industrial Entomology, 3(2):109-112.

Abstract: Androgenesis in silkworm acquires a special significance as along with combined applications of other breeding strategies like parthenogenesis and cloning, it may serve as a valuable tool for sex control in sericulture as well selection and production of bisexual homozygous androgenetic lines. Production of hybrid silkworm yielding high proportion of male larvae is of immense use to silk industry (Strunnikov, 1975, 1983). In this review, an attempt has been made to assimilate the works carried out on androgenesis, different techniques of induction towards androgenetic development and its role in silkworm breeding.

514. Singh, R.; Goel, R.; Raghavendra Rao, D.; Rekha, M.; Premalatha, V.; Ahsan, M.M.; Datta, R.K., 2001.

(Central Sericultural Research and Training Institute, Mysore, India.)

Evaluation of multivoltine x bivoltine F1 hybrids of the mulberry silkworm, *Bombyx mori* L. in two different seasons.

Sericologia, 41(2):231-238.

Abstract: A study was conducted during July- August and November-December, 1998 to evaluate the heterosis of F1 hybrids between multivoltine and bivoltine strains of the mulberry silkworm, *Bombyx mori* L. The degree of heterosis varied considerably for several quantitative characters of F1 hybrids in two seasons. During July-August, BL43 X NB4D2 exhibited significant positive hetrosis over mid parent

value for fecundity, yield/10,000 larvae by weight and cocoon weight whereas BL24 x Nb4D2 exhibited significant hybrid vigour for yield/10,000 larvae both by number and weight and cocoon shell weight during November-December. Study on cocoon shape measurement revealed that cocoons were comparatively uniform during November-December as compared to July-August. Importance of this study in the production of uniform shaped cocoons with uniform filament size, F1 hybrids with high heterotic effects and quantitative characters have been discussed.

515. Singh, R.; Rao, D.R.; Premlatha.; Kariappa, B.K.; Jayaswal, K.P.; Datta, R.K.,2001.

(Central Sericultural Research and Training Institute, Mysore, India)

Evaluation of combining ability in hybrids between low, medium and high cocoon weight polyvoltine and bivoltine breeds of silkworm *Bombyx mori* L. *Sericologia* vol 15,

*Sericologia*, 41(1):57-64.

Abstract: General and specific combining abilities of low, medium and high cocoon weight polyvoltine and bivoltine breeds of *Bombyx mori* were evaluated by analysing ten quantitative characters. Six polyvoltine and three bivoltine breeds were used as lines and testers respectively. Evaluation of the performance of polyvoltine and bivoltine breeds for ten quantitative characters revealed that among the lines, PM and Nistari, possessing low cocoon weight, were found to be good general combiners for cocoon yield / 10,000 larvae both by number and weight whereas BL24 and BL23, possessing high cocoon weights, were found good general combiners for cocoon shell weight and cocoon shell ratio. Among the testers, CSR2, having a high cocoon weight, was found a general combiner for cocoon weight and cocoon shell weight. The ratio of GCA:SCA in most of the economic characters were found more than 1 demonstrating predominant role of additive gene action. The hybrid BL24 x J2 exhibited significant positive SCA effects for pupal weight, shell weight and floss percentage. Most of the hybrids revealed positive SCA effects for several quantitative characters.

516. Sudhakara Rao, P.; Singh, R.; Kalpana, G.V.; Naik, V.N.; Basavaraja, H.K.; Rama Swamy, G.N.; Datta, R.K.,2001.

(Central Sericultural Research and Training Institute, Mysore, India.)

Evaluation and identification of promising bivoltine hybrids of silkworm, *Bombyx mori* L., for tropics.

*International Journal of Industrial Entomology*, 3(1):31-35.

Abstract: The newly evolved bivoltine hybrids of silkworm (*Bombyx mori* L.) were evaluated with control hybrid KA x NB4D2 during three seasons of a year for their seasonal performance. Analysis of variance and other statistical methods were employed and the performance was observed in respect of 10 quantitative traits. The results showed significant genotype x environment interaction with respect to four quantitative characters viz., fecundity, yield/10,000 larvae, filament length and raw silk (percentage). Environmental effects were significant for nine characters out of ten characters evaluated. A 105 x J2 and B x NB4D2 were considered as highly adaptable hybrids to local conditions with high mean for maximum characters studied and found suitable to rear in all seasons.

517. Sudhakara Rao, P.; Basavaraja, H.K.; Nishitha Naik, V.; Jayaswal, K.P.; Rekha, M.; Datta, R.K.,2001.

(Central Sericultural Research and Training Institute, Mysore, India.)

Evaluation of combining ability in hybrids between polyvoltine and bivoltine sex-limited cocoon colour breeds of silkworm, *Bombyx mori* L.

*Indian Journal of Sericulture*, 40(2):163-167,

Abstract: General and specific combining abilities in polyvoltine x bivoltine hybrids of *Bombyx mori* L. were evaluated by utilizing 5 polyvoltine and 5 bivoltine sex-limited (SL) cocoon colour breeds as lines and testers, respectively. Evaluation of the hybrids for 8 quantitative characters revealed that among the lines, BL-67 was good general combiner exhibiting significant GCA effects for all the economic

characters except for cocoon yield by 10000 larvae, followed by 96 A showing significant GCA effect for 6 quantitative traits out of eight characters evaluated. Among the testers, B72 (SL) was reported as a good general combiner with significant GCA effects for 4 characters viz., cocoon yield/10000 larvae by number and by weight, shell weight and raw silk recovery. The hybrid 96A x CSR5 (SL) exhibited significant positive SCA effects for cocoon yield/10000 larvae both by number and weight, cocoon weight and filament length, followed by Bl-24 x B72 (SL) for cocoon yield/10000 larvae by weight, shell ratio and filament length.

518. Suresh Kumar, N., Yamamoto, T., Basavaraja, H.K., Datta, R.K., 2001.

(Central Sericultural Research and Training Institute, Mysore, India)

Studies on the effect of high temperature on F1 hybrids between polyvoltine and bivoltine silkworm races of *Bombyx mori* L.

International Journal of Industrial Entomology, 2(2):123-127.

Abstract :In order to introduce bivoltine races in a tropical country like India, it is necessary to have stability in cocoon crop under high temperature environments. Unlike any temperate country like Japan, the rearing conditions/environment, climatic conditions, quality of mulberry leaf and incidence of diseases are unpredictable in India. Geneticists and breeders of all the sericultural countries have experienced the influence of environment during the process of breeding. In order to select efficiently the breeds with high temperature tolerance, it is very important to analyse clearly the heritability nature of high temperature tolerance. In light of the above, the present study was undertaken to determine the effect of high temperature treatment of (A)  $35 \pm 1^\circ\text{C}$  and  $85 \pm 5$  percent RH for 24 hours continuously, (B)  $35 \pm 1^\circ\text{C}$  and  $85 \pm 5$  percent RH for 48 hours continuously and (C) the control ( $25 \pm 1^\circ\text{C}$  and  $65 \pm 5$  percent RH) in the normal rearing condition from the 3rd of 5th instar on the pure races such as Moria, N137 and C146 as well as their F1 hybrids are more tolerant than the pure races., It was also observed that the overall performance declined in those batches where 48 hrs treatment was given. The most interesting observation noticed in this study was that there was maternal effect regarding temperature tolerance as evident from the better performance of those hybrids where the female parent used was more tolerant as pure race.

519. Veeraiyah, T.M., 2001.

(Silkworm Seed Technology Laboratory, Kodathi, Bangalore, India)

Role of silkworm seed technology parameters in the development of silkworm breeds.

In :Abstracts of National Seminar on Mulberry Sericulture Research in India, KSSRDI, Thalaghattapura, Bangalore, India, 26-28 November, 2001, 145

Abstract: Some of the new silkworm breeds developed by the research institute have not been thoroughly studied with regard to seed technological aspects. During the course of time, many promising breeds gradually disappeared despite their qualitative and quantitative potentialities. This reflects that while exhibiting the ambition of good breeds, the crucial seed technological aspects are given secondary importance resulting in various problems during large scale seed production. In view of the above, the seed parameters viz., voltinism, rhythm of moth emergence, male moth potency, circadian rhythm of oviposition, fertility, hatching and embryonic development should be evaluated during the course of breeding. The other parameters viz., seed crop rearing, seed cocoon pupal preservation, egg preservation, acid treatment technique and embryological tool for egg handling have to be studied after developing a breed. The importance of seed technology support to silkworm breeding is discussed.

520. Zelic, J., 2001.

(Hrvatske sume", Milke Trnine 2, Pozega, Croatia)

The role of silkworm (*Bombyx mori*) and white mulberry (*Morus alba*) in silkworm breeding and sericulture.

Sumarski List, 125(7/8):413-423.

Abstract: Silk long has been produced in China through the raising of silkworms (*Bombyx mori*) and the cultivation of mulberries (*Morus alba*) for feeding them. Silk fabric from China has been exported to Europe since the sixth century, and silk production first commenced in Europe in the Eastern mediterranean. Dalmatian cities held primacy in this respect through their trade links with southern Italy. Silk production was introduced to Croatia in the 18th century with the planting of mulberry trees (*morus alba*).

521. Basavaraja, H.K., Dandin, S.B., 2002.

(Central Sericultural Research and Training Institute, Mysore, India)

Recent breakthrough in breeding of silkworm *Bombyx mori* L. in tropics.

In: Proceedings of the XIX International Sericulture Congress, Bangkok, Thailand, September 21-25th, 2002, 171-184

522. Benchamin, K.V., 2002.

(National Silkworm Seed Project, Central Silk Board, Bangalore, India.)

Optimization of silkworm egg production through breeding.

Indian Silk, 41(1):5-7,

Abstract: The breeding techniques have a direct impact on the production, productivity and quality of silkworm eggs.

523. Hosseiny Moghadam, S.H.; Gholamy, M.R., 2002.

(Department of Sericulture, University of Guilan, Somae-sara, Iran. )

The Combining Ability Effects and Heterosis in the Silkworm (*Bombyx mori* L.) by Diallel Cross of Eight Inbred Lines.

In: Proceedings of the XIXth Congress of the International Sericultural Commission, 21st - 25th September 2002, Queen Sirikit National Convention Centre, Bangkok, Thailand. , P.104-110,(English)

Abstract: Recently two breeding programs for isolation of new parental inbred lines were carried out in Iran. This study was undertaken in order to estimate the combining ability of these lines. For this purpose an 8x8 diallel crosses analysis including eight inbred lines of silkworm with four lines from each program were studied for their five quantitative traits. Using Griffing diallel analysis the results indicated that: 1) The reciprocal combining ability effects appeared non significant for most of traits. 2) 111 and 113 from first program were best combiner for SW, CW and SP while for PR 107 and III from second program were the best. 3) The parents with high positive GCA effects indicated positive SCA. 4) Hybrids with high heterosis had high SCA too.

524. Kalappa, H.K., 2002.

(National Silkworm Seed Project, Bangalore, India)

Selection of parents for breeding in silkworm, *Bombyx mori* L.

Journal of Sericulture, 8-10(12):28-33

Abstract: With the objective of selecting potential parents for initiating breeding programme, sixteen polyvoltine and nine bivoltine races were drawn from the germplasm resources maintained at Central Sericultural Research and Training Institute, Mysore. All the 25 silkworm races were reared for 10 generations over a period of two years. Multiple trait index was calculated based on 10 important economic traits. On the basis of the indices obtained for nine characters. Kolar Gold and Mysore Princess

were found most potential parents among polyvoltines and NB4D2 among bivoltines for breeding programme.

525. Mahesha, H.B., Honnaiah, S., 2002.

(Department of Studies in Sericultural Science, University of Mysore, Mysore, India)

Effects of ethyl methanesulfonate on meiotic chromosomes of silkworm *Bombyx mori* L.

*Sericologia*, 42(3):343-360.

Abstract: The effects of ethyl methanesulfonate (EMS), on meiotic chromosomes in general and translocations in particular was studied during spermatogenesis in two races of silkworm *Bombyx mori* L. Different concentrations of EMS like 2.5, 5, 10, 20 and 40 mM in 0.75 percent NaCl was employed by 'oral injection'. The results indicated that increase in concentration of EMS would enhance the frequency of aberrations in total as well as individual types. They include loops, partially paired bivalents, fragments, stickiness and, stickiness and clumping. This basic knowledge could be useful in silkworm breeding programme.

526. Mal Reddy, N., H.K.Basavaraja, P.G.Joge, B.Nanje Gowda, B.K.Kariappa and S.B.Dandin, 2002.

(Central Sericultural Research and Training Institute, Mysore).

Studies on the utilization of bivoltine breeds and their hybrids as male components with pure Mysore race.

*Indian Journal of Sericulture*, 41(2): 124 – 129.

Abstract: In order to study the feasibility of utilizing bivoltine breeds and their hybrids as male components with Pure Mysore race as polyvoltine female and ten newly evolved productive and robust bivoltine breeds viz., CSR2, CSR4, CSR5, CSR8, CSR16, CSR17, CSR18, CSR19, CSR27 and CSR48 and 7 authorized bivoltine hybrids i.e., CSR2 x CSR4, CSR2 x CSR5, CSR3 x CSR6, CSR12 x CSR6, CSR16 x CSR17, CSR18 x CSR19 and KA x NB4D2 were assessed by comparing with popular polyvoltine x bivoltine hybrid (PM x NB4D2) and newly evolved hybrid BL67 x CSR101 (Cauvery). Though there was not much difference among the PM combinations for the characters like pupation rate, shell ratio, floss percentage, filament length, denier, reelability and neatness, significant difference was noticed in many hybrids for larval duration, yield / 10,000 larvae by weight, cocoon weight and shell weight. The hybrid Cauvery has performed better than all hybrids for most of the characters studied. Moreover, many new combinations of PM and CSR breeds have performed better than the control hybrid PM x NB4D2. The multiple trait evaluation index indicated the hybrids, BL67 x CSR101, PM x (CSR3 x CSR6), PM x CSR5, PM x CSR2, PM x (CSR2 x CSR4) and PM x CSR48 as superior combinations in order of merit. The present study also revealed that the hybrids of PM with CSR oval type bivoltine breeds recorded more cocoon uniformity than the hybrids with dumbbell type breeds or hybrids.

527. Nagaraju, J., 2002.

(Centre for DNA fingerprinting and Diagnostics, ECIL road, Nacharam, Hyderabad, India)

Application of genetic principles for improving silk production.

*Current Science*, 83(4):409-414

Abstract: During the last three decades, silk production increase benefited, to a great extent, from the application of genetic principles in the silkworm breeding programmes. The conventional breeding method such as progeny testing, exploitation of hybrid vigour, genotype X environment interaction coupled with utilization of silkworm stocks that carry a translocated W chromosome provided continued success. Recent developments in transgenic silkworm technology, application of DNA markers for strain characterization and construction of linkage maps, and understanding the genetics of viral resistance provide requisite tools that can expedite further silkworm improvement.

528. Narayanaswamy, T.K., Ananthanarayana, S.R., Govindan, R., Ramesh, S., 2002.

(Department of Sericulture, University of Agricultural Sciences, Bangalore, India)

Appropriate selection of hybrids of silkworm (*Bombyx mori* L.) through heterosis breeding for rearing traits.

Bulletin of Indian Academy of Sericulture, 6(2):34-38

Abstract: Search for suitable hybrid combinations of silkworm (*Bombyx mori*) for rearing traits was made among 28 F1 hybrids synthesised from seven multivoltine and four bivoltine silkworm breeds in line X tester fashion through heterosis breeding. The cross HM X NB18 ranked top for extent of progression to fourth instar and effective rate of rearing by yielding significantly positive heterobeltiosis and standard heterosis for full grown larval weight. The hybrids P2D1 X NB18 recorded highest negative standard heterosis for fifth instar and total larval duration. The rearing traits viz., extent for progression to fourth instar, larval duration up to fourth instar, fifth instar duration, total larval duration full grown larval weight and effective rate of rearing revealed that the hybrids, P2D1 X NB18 and KJ X KA manifested significantly to note that the crosses with P2D1 and NB18 as lines and testers, respectively produced highest standard heterosis for rearing traits in general.

529. Naseema Begum, A.; Ahsan, M.M.; Basavaraja, H.K.; Rekha, M., 2002.

(Central Sericultural Research and Training Institute, Mysore, India.)

Comparative performance of thermo-tolerant bivoltine hybrids of silkworm *Bombyx mori* L. under different temperatures and humidity conditions.

Sericologia, 42(4):473-483.

Abstract: Ten hybrids of the silkworm *Bombyx mori* L. exposed to three different combinations of temperature and relative humidity i.e.,  $25 \pm 1^\circ\text{C}$  and RH 75  $\pm$  5 percent;  $31 \pm 1^\circ\text{C}$  and RH 85  $\pm$  5 percent and  $36 \pm 1^\circ\text{C}$  and RH 85  $\pm$  5 percent were analysed for 8 economic traits i.e., 5th instar period, yield / 10 000 larvae by number (cocoon survival), cocoon weight, shell weight, shell ratio, average filament length, raw silk percentage and reelability percentage. The performance of the hybrids at  $25 \pm 1^\circ\text{C}$  and at  $31 \pm 1^\circ\text{C}$  was comparable. The effect of temperature was significant for all the traits except for the shell ratio percentage ( $P > 0.05$ ). The interaction effect (temperature X hybrid) was significant for survival ( $P > 0.05$ ). At  $36 \pm 1^\circ\text{C}$  temperature treatment, all the hybrids showed slightly better cocoon survival as compared to the control hybrid, KA X NB4D2. The better performance of these ten hybrids at  $36 \pm 1^\circ\text{C}$  may be due to the maternal effect of thermo-tolerance where the female parent used was more tolerant. But the deleterious effect of high temperature and high humidity was more pronounced in KA X NB4D2, as evident from the low survival of cocoons (2944 at  $36 \pm 1^\circ\text{C}$ ). However, two hybrids i.e., AHT X FHT (8996) and BHT X GHT (9155) recorded higher cocoon survival number when compared to the other hybrids at  $36 \pm 1^\circ\text{C}$  and RH 85  $\pm$  5 percent.

530. Naseema Begum, A.; Yamamoto, T., 2002.

(Central Sericultural Research and Training Institute, Mysore, India.)

Correlation coefficient studies on certain quantitative traits in the silkworm, *Bombyx mori* L.

International Journal of Industrial Entomology, 5(1):45-52.

Abstract: To understand the relationship among different quantitative traits, correlation studies were performed by utilizing eighty-eight inbred strains of silkworm, *Bombyx mori* L. on twelve economic characters. Analysis resulted in correlation of 5th instar period with total larval period ( $r=0.7882$ ), cocoon weight with shell weight ( $r=0.8326$ ), shell weight with shell ratio ( $r=0.5067$ ), shell ratio with raw silk percentage ( $r=0.7570$ ), raw silk percentage with filament length ( $r=0.3490$ ), filament size (denier) with reelability ( $r=0.3193$ ) and boil off loss percentage ( $r=0.2792$ ). Negative correlation was observed among filament length with filament size ( $r=0.7582$ ) and reelability with boil off loss percentage ( $r=-0.3236$ ). Correlations of different quantitative characters for quality silk production is discussed.

531. Seydavi, A.; Gholami, M.; Biabani, M., 2002.

(Research Department, Iran Silkworm Rearing Co., Rasht., I.R. Iran.)

Evaluation of silkworm *Bombyx mori* L., varieties performance during white muscardine disease incidence.

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In: Proceedings of the XIXth Congress of the International Sericultural Commission, 21st - 25th September 2002, Queen Sirikit National Convention Centre, Bangkok, Thailand. , p.85-90.

Abstract: White muscardine is one of the prevalent diseases at the sericulture industry which isn't remediable. Therefore selection of the resistant varieties is the best strategy for decreasing of damages among farmers. Furthermore recognition of resistant varieties is essential for transition of resistance genes in the breeding of silkworm varieties. This experiment was conducted to determine the performance of commercial pure lines of silkworm *Bombyx mori* under stress of white muscardine fungus. In this experiment that accomplished at summer and autumn of year 2000, 9 commercial pure lines by means of a completely randomised design with 5 replications for each treatment were used and the economical traits including number of live larvae and pupae, percentage of vitality of pupae, number of produced cocoons, number and percentage of the best, middle, low and double cocoons, the best cocoons yield, single cocoon weight, cocoon shell weight, percentage of cocoon shell and larval duration were recorded and analysed. From the obtained results, lines of Y-2 and 103 showed the highest vitality of larvae. Furthermore these mentioned lines showed the highest number of produced and the best cocoons. In this manner lines of 109, 107, 31 and 103 showed the highest vitality of pupae (P0.05). Likewise Line of 31 significantly (P0.05) had the superior performance in comparison to other lines from the aspect of single cocoon weight. Also line of 31 significantly (p 0.05) showed the highest cocoon shell weight. Furthermore line of 32 showed the highest percentage of cocoon shell significantly (P0.05). Likewise lines of 103 and 31 had the superior average of the best cocoons yield.

532. Singh, T., Saratchandra, B., Murthy, G.N., 2002.  
(Central Silk Board, Bangalore, India)

An analysis of heterosis in the silkworm, *Bombyx mori* (L.).

International Journal of Industrial Entomology, 5(1):23-32

Abstract: The introduction of hybrid and exploitation of heterosis played a vital role in Indian Sericulture industry, which clearly depicts a quantum jump in silk production during the last four decades. Since, the introduction of heterosis, progress in silkworm breeding has depended on success or failure in identifying better combiners. Systematic procedures developed have enabled the breeders to identify the best combiners by combining ability test, line X tester analysis or D2 analysis for maximum expression of heterosis. The level of heterosis expressed in the crossbreed population is determined by the interaction between genotype and prevailing environmental factors. Except some of the pre and post cocoon parameters, heterosis is invariably higher in single crosses compared to three way and double crosses. However, during hot and humid season, when rearing of F1 bivoltine hybrids is unsuccessful at field level and indigenous races result in very low and poor quality yield, three way and double crosses can play an important role as an intermediate technology.

533. Sudhakara Rao, P., Datta, .K., Ramesh Babu, M., Vijaya Kumari, K.M., 2002.  
(Central Sericultural Research and Training Institute, Mysore, India)

Breeding resource materials of silkworm *Bombyx mori* L., adaptive to tropical climates.

International Journal of Industrial Entomology, 4(2):109-115

Abstract: With the objective of selecting suitable breeding resource material, 10 polyvoltine and 10 bivoltine breeds were drawn from the germplasm collection of Central Sericultural Research and Training Institute, Mysore, and evaluated for 3 seasons comprising one year (6 trials). Data were collected on seven traits of economic importance such as fecundity, pupation rate, cocoon yield, cocoon weight, cocoon shell weight, cocoon shell ratio and filament length, and statistically analysed with two-way classification, joint scoring method and evaluation index.

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534. Tao, M., Qan, S.Y., Li, A.L., Miyashita, T., 2002.  
(Jiangsu Silkworm Egg Corporation, Wuxi, Jiangsu, China)  
Development of a data management system for silkworm breeding.  
*Acta Sericologica Sinica*, 28(4):337-340  
Abstract: A data management system for silkworm breeding was developed using Visual Basic 6.0 for Windows. It can produce breeding plans and queries, control, analyse and compare breeding data to obtain all sorts of report forms. It can also connect a computer with 2 electronic balances. Moreover, it can collect and calculate the data for individual cocoons and cocoon batch weights automatically. It can also discriminate between the sexes and select individuals automatically based on weight data. Hence, its application would enhance breeding efficiency significantly.
535. Thangavelu, K., Sinha, R.K., 2002.  
(Central Sericultural Germplasm Resources Centre, Hosur, India)  
Utilization of genetic resources for silkworm breeding.  
*Indian Silk*, 41(2):21-24  
Abstract: For any breeding programme, selection of proper donors is very important. The selection of donors in turn depends on the understanding of the germplasm and the gene pool. Thus, utilization of genetic resources assumes greater importance in a successful breeding programme.
536. Zhao, Y., 2002.  
(Sericulture Research Institute, Chinese Academy of Agricultural Sciences, Zhejiang, China)  
Progress of silkworm breeding in China.  
*Sericologia*, 42(1):1-11  
Abstract: This paper introduced the progress of silkworm breeding in China since 1950. The status of silkworm hybrids for spring rearing, summer-autumn rearing, spring and autumn rearing and some special characteristic was reviewed. The application of biotechnology in silkworm in China was discussed too.
537. Basavaraja, H.K., Suresh Kumar, N., Kariappa, B.K., Dandin, S.B., 2003.  
(Central Sericultural Research and Training Institute, Mysore, India)  
Constraints, present status and prospects of silkworm breeding.  
In: Concept Papers of Mulberry Silkworm Breeders Summit, 18-19 July 2003, Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India, 24-40.
538. Chandrashekharaiyah., Ramesh Babu, M., 2003.  
(Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India)  
Silkworm breeding in India during the last decades and what next.  
In: Concept Papers of Mulberry Silkworm Breeders Summit, 18-19 July 2003, Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India, 6-13.
539. Chauhan, T.P.S., Sahni, N.K., Siddiqui, A.A., Singh, B.D., 2003.  
(Regional Sericultural Research Station, Dehradun, India)  
Utilization of genetic diversity of silkworm (*Bombyx mori* L.) in silkworm breeding.  
In: Proceedings on National Workshop on Pre-Breeding Strategies for Utilisation of Sericultural Germplasm Resources, Central Sericultural Germplasm Resources Centre, Hosur, India. February, 19-20, 2003, 75-79
540. Chauhan, T.P.S.; Tayal, M.K.; Siddiqui, A.A.; Singh, B.D., 2003.  
(Regional Sericultural Research Station, Dehradun, India.)
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- Studies on the sex specific cocoon colour genotypes of *Bombyx mori* L. evolved through hybrid breeding.  
In: Abstracts of National Conference on Tropical Sericulture for Global Competitiveness, 5-7th November, 2003, Central Sericultural Research and Training Institute, Mysore, India., p.24,(English)
541. Choudhuri, C.C.,2003.  
(Regional Sericultural Research Station, Chamarajanagar, India.)  
Studies on heterosis breeding in mulberry and non mulberry silkworms.  
In: Abstracts of National Conference on Tropical Sericulture for Global Competitiveness, 5-7th November, 2003, Central Sericultural Research and Training Institute, Mysore, India., p.120,(English)
542. Datta, R.K., 2003.  
(#202, Silver Oak, 8th Cross, Srirampura II Stage, Mysore, India)  
Silkworm breeding in India and its future needs.  
In:Souvenir of National Conference on Tropical Sericulture for Global Competitiveness, 5-7th November, 2003, Central Sericultural Research and Training Institute, Mysore, India, 5-18
543. Joge, P.G.; Pallavi, S.N.; Naseema Begum, A.; Mahalingappa, K.C.; Mallikarjuna, M.; Dandin, S.B.,2003.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Evaluation of double hybrid of silkworm, *Bombyx mori* L. in the field.  
In: Abstracts of National Conference on Tropical Sericulture for Global Competitiveness, 5-7th November, 2003, Central Sericultural Research and Training Institute, Mysore, India., p.26-27,(English)
544. Khan, M.A., Ahmad, M.N., 2003.  
(Central Sericultural Research and Training Institute, Pampore, India)  
Silkworm breeding for the temperate conditions of India.  
In:Concept Papers of Mulberry Silkworm Breeders Summit, 18-19 July 2003, Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India, 41-51
545. Krishna Rao, S., Raghuraman, R., Bongale, U.D., 2003.  
(Karnataka State Sericulture Research and Development Institute, Bangalore, India)  
Silkworm breeding for sub-optimal conditions.  
In:Concept Papers of Mulberry Silkworm Breeders Summit, 18-19 July 2003, Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India, 52-59
546. Lakshmanan, V.L., Sen, A.K., 2003.  
(Regional Sericultural Research Station, Coonoor, India)  
Pre-breeding strategies in silkworm breeding - A view and an account.  
In:Proceedings on National Workshop on Pre-Breeding Strategies for Utilisation of Sericultural Germplasm Resources, Central Sericultural Germplasm Resources Centre, Hosur, India. February, 19-20, 2003, 65-69
547. Naseema Begum, A.; Joge, P.G.; Basavaraja, H.K.; Kariappa, B.K.; Nanje Gowda, B.; Dandin, S.B.,2003.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Evaluation of polyvoltine X bivoltine hybrids of silkworm, *Bombyx mori* L.  
In: Abstracts of National Conference on Tropical Sericulture for Global Competitiveness, 5-7th November, 2003, Central Sericultural Research and Training Institute, Mysore, India., p.27-28,(English)

548. Palit, A.K., Suresh Kumar, N., Basavaraja, H.K., Mal Reddy, N., Kalpana, G.V., 2003.  
(Central Sericultural Research and Training Institute, Mysore, India)  
Stability analysis in bivoltine silkworm breeds for robustness at different temperature and humidity condition.  
Indian Journal of Sericulture, 42(1): 46-49  
Abstract: Stability analysis was carried out to select suitable parents of bivoltine silkworm breeds tolerant to high temperature and humidity condition for initiating new breeding programme. Fifty-seven bivoltine silkworm breeds have been evaluated at high temperature ( $36\pm 1^\circ\text{C}$ ) and high humidity ( $85\pm 5$  percent RH) as well as at room temperature conditions. Based on the pupation rate ( $> 60$  percent) at high temperature and high humidity conditions. 17 breeds have been short-listed. Those were further reared in SERICATRON at three different temperature and humidity conditions. The data were analysed by employing Eberhart and Rusel's Model (1966) of Stability Analysis. The breeds which scored regression coefficient (b-value) less than or nearer to one with pupation rate  $> 60$  percent at high temperature and high humidity conditions have been selected. Based on the performance, 11 breeds namely, 5HT, 6HT, 7HT, 8HT, 9HT, 10HT, NK32, A24, CSR18, CSR19 and Daizo have been selected as breeding resource material tolerant to three different temperature and humidity conditions.
549. Pallavi, S.N.;Naseema Begum, A.; Ashwath, S.K.; Mahalingappa, K.C.; Joge, P.G.,2003.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Evaluation of single parents and foundation crosses of bivoltine silkworm, *Bombyx mori* L.  
In: Abstracts of National Conference on Tropical Sericulture for Global Competitiveness, 5-7<sup>th</sup> November, 2003, Central Sericultural Research and Training Institute, Mysore, India., p.27,(English)
550. Pan, S.Y., Li, A.L., Tao, M., Tamio, M., 2003.  
(Department of Biology, Xuzhou Normal University, Xuzhou, China)  
Automatic weighing and selection system of individual cocoon and batch measuring in silkworm breeding.  
Transactions of the Chinese Society of Agricultural Engineering, 19(2):130-132.  
Abstract: An automatic weighing and selection system of individual cocoon and batch measurement in silkworm breeding was developed using Visual Basic 6.0 for Windows to enhance breeding efficiency and meet the needs of breeding experts. In this system, 2 units of electronic balance were controlled through a computer by serial interface and non modem link method. The system achieved the following: 1) automatic collection and calculation of data of individual cocoon and batch measurement by MSComm communication control; (2) automatic discrimination of sex through the Bayesian discrimination function and cluster analysis; (3) availability of many methods of individual selection; (4) convenience of query and management of the measured data.
551. Raina, S.K.; Khan, R.A.; Tewary, P.; Misri, S.S.; Saxena, N.N.,2003.  
(Regional Sericultural Research Station, Jammu, India.)  
Evaluation of some silkworm breeds under Jammu conditions.  
In: Abstracts of National Seminar on Sustainable Sericulture India, 1-2 February, 2003, Department of Applied Animal Sciences, Babasaheb Bhimrao Ambedkar University, Lucknow, India., p.76,(English)  
Abstract:Sericulture is being practiced in Jammu and Kashmir state since times immemorial. During last decade even though some declining trends in cocoon production were observed in the temperate sericulture division of Kashmir, on contrary the production levels in the subtropical belts of Jammu division have gone up considerably. At present, Jammu division contributes more than 2/3 rd of the entire cocoon production of the state. To exploit the full potential of this region, identification of some acclimatized breeds and their hybrids is most important criterion that needs utmost attention of the

breeders. Rearing performance of the Jam breeds prevailing previously in Jammu region and other breeds of northern region has been evaluated and discussed in the paper. Besides performance of newly evolved breeds from Regional Sericultural Research Station, Miransahib, Jammu has also been presented. The evaluation of the breeds will help in chalking out future breeding, seed production and related assessment programmes' strategies for sustainable sericulture in the region.

552. Sahni, N.K., Chauhan, T.P.S., Misra, P.N., Singh. B.D., 2003.

(Regional Sericultural Research Station, Dehradun, India)

General features, maintenance and evaluation of RSRS, Sahaspur's evolved bivoltine silkworm germplasm stock - A report.

In: Abstracts of National Seminar on Sustainable Sericulture India, 1-2 February, 2003, Department of Applied Animal Sciences, Babasaheb Bhimrao Ambedkar University, Lucknow, India, 60-61.

Abstract: *Bombyx mori* L. popularly known as mulberry silkworm, the sole creature being exploited for practising sericulture for thousands of years, is alone represented by approximately 4,000 races all the world over and forms the basis in full filling the above task and continued to be integral part of genetic diversity of species. In India, institutes of Central Silk Board, State Sericulture Departments and some Universities are maintaining a quite good no. of silkworm Germplasm (the sum of total genetic variability within the species and the basis for the crop improvement programme) which are estimated to be about 150 multivoltine and 450 Bivoltine including duplicates and are being maintained under different accession numbers. Regional Sericultural Research Station, C.S.B., Sahaspur, erstwhile univoltine Reserach Sub-Station, located at Majra, Dehradun has evolved 22 bivoltine silkworm genotypes involving the diverse parentage through different breeding approaches, out of 44 existing presently, since the establishment of the station in 1973. Though in recent past some races of Dun series like Dun6, Dun7, Dun17, Dun18, Dun19, Dun21 have also been evolved and their hybrids are yet under authorization for commercial exploitation in field and not included in the present germplasm stock. Those silkworm races evolved earlier are 1 from JD series, 2 each from SH, SM, AF, PY, JP1 series, 3 from YS series, 4 from SF series, others are CP1B, NS6, JJ5 and SY6. Their general features, parentage, mode of maintenance and preliminary evaluation are summarized in the paper. The specific characters of the superior races are highlighted in view of their placement in race evolution scenario.

553. Singh, R.; Raghavendra Rao, D.; Kariappa, B.K.; Premalatha, V.; Dandin, S.B., 2003.

(Central Sericultural Research and Training Institute, Mysore, India.)

Studies on analysis of combining ability in the mulberry silkworm, *Bombyx mori* L.

International Journal of Industrial Entomology, 6(2):107-113, (English)

Abstract: Analysis of combining ability is a widely used biomaterial tool to select promising parents and hybrids, to determine the kinds and relative magnitudes of genetic variability among hybrids as well as to forecast yield attributes in early breeding generations both in plants and animals. Various statistical approaches like Jinks and Hayman (1953), Griffing (1956), Kempthorne (1957) etc. have been extensively applied in plants. These approaches have been also been tried in the mulberry silkworm, *Bombyx mori* L. In the present review, an attempt has been made to collect most of the studies carried out on combining ability in silkworm at one place and make it available to the scientists engaged in sericultural research.

554. Singh, G.P., Xu, M.K., Chen, Y.Y., Datta, R.K., 2003.

(Central Tasar Research and Training Institute, Ranchi, India)

Development of resistance to *Bombyx mori* densovirus into a susceptible silkworm breed.

International Journal of Industrial Entomology, 6(2):145-149

Abstract: Seeing inadequate disinfection and unhygienic condition in rearing area, use of disease resistant silkworm variety is the best option. In order to this, an attempt has been made to develop the resistance to *Bombyx mori* densovirus (BmDNV-2) into a susceptible silkworm breed Zhenon 1 by cross breeding with a resistant silkworm breed SU12 and exposing the subsequent generations to BmDNV-2 followed by the selection of individuals from the surviving batches. After seven generations the evolved DNV-2 resistant strain showed the significantly higher resistance to BmDNV-2 than control Zhenon 1. The economic characters of both of the breeds were almost on par.

555. Sudhakara Rao, P.; Datta, R.K.; Basavaraja, H.K.; Rekha, M.; Vijayakumari, K.M., 2003.  
(Central Sericultural Research and Training Institute, Mysore, India.)

Analysis of heterosis and combining ability of certain quantitative traits in silkworm *Bombyx mori* L. under different temperature and humidity conditions.

Indian Journal of Sericulture, 42(2):152-157.

Abstract: Heterosis, general and specific combining abilities in 5 newly evolved thermo-tolerant breeds viz., SR1, SR2, SR3, SR4 and SR5 of silkworm *Bombyx mori* L. were evaluated under different temperature and humidity conditions by using 3 widely adapted testers i.e., NB4D2, CSR4 and CSR5. Data were collected for seven quantitative traits viz., pupation rate, cocoon yield, cocoon weight, cocoon shell weight, cocoon shell ratio, filament length and raw silk (percentage) under room temperature (T0). The performance at high temperature ( $36 \pm 1$  °C) and high humidity ( $90 \pm 5$  percent (T1) and high temperature ( $36 + 1$  °C) and low humidity ( $50 \pm 5$  percent) (T2) were only taken into consideration for selecting the best lines/hybrids. Among the lines SR3 and SR4 exhibited positive GCA effects for pupation rate, cocoon yield, cocoon weight and cocoon shell weight traits, followed by SR5 for pupation rate, cocoon yield and cocoon weight under T1 and T2 conditions. Among testers, CSR4 exhibited positive GCA effects for four quantitative traits viz., pupation rate, cocoon yield, cocoon weight and cocoon shell weight under both the adverse temperature conditions and reported as a good general combiner. The hybrids, SR3 x CSR4 and SR4 x NB4D2 exhibited significant positive SCA effects for majority of the characters under both the adverse (T1 and T2) conditions of rearing. The better parent value of heterosis (heterobeltiosis) was exhibited by the hybrids SR3 x CSR4, SR1 x CSR5 and SR4 x NB4D2. hybrids viz., SR3 x CSR4 and SR4 x NB4D2 were selected based on the SCA results for recommending to field trials for commercial exploitation in tropical climate.

556. Suresh Kumar, N., Basavaraja, H.K., Kalpana, G.V., Mal Reddy, N., Kariappa, B.K., Dandin, S.B., 2003.

(Central Sericultural Research and Training Institute, Mysore, India.)

Evaluation of bivoltine breeds and hybrids as male components with Pure Mysore under different temperature and humidity conditions.

Indian Journal of Sericulture, 42(1):41-45.

Abstract: At present, more than 90 percent of the silk production in India is from the polyvoltine X bivoltine hybrid, particularly PM X NB4D2. However, because of the inherent low grade silk coupled with moderate productivity associated with these hybrids, much headway could not be achieved in enhancing either the quality or productivity. In the recent past, after reorientation in breeding approaches, many productive bivoltine (CSR) breeds/hybrids have been developed and commercialized. Therefore, in order to study the feasibility of utilizing these productive CSR breeds/hybrids as male component with PM, a systematic study was undertaken to find out the effect of high temperature and high humidity conditions on the rearing performance of hybrids between Pure Mysore and productive bivoltine pure breeds as well as hybrids. The results of the present study indicated that the survival rate which is considered as the main yardstick to measure the effect of high temperature, was more in those hybrids where the robust breeds, CSR18, CSR19 and the hybrid CSR18 X CSR19 were used as male components with PM. This clearly indicates that during hostile environmental

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conditions, especially during summer months, it is advisable to use the robust bivoltine breeds/hybrids as male components rather than using productive bivoltine breeds/hybrids. However, the productive bivoltine races such as CSR2, CSR4 etc., could be exploited only in favourable months.

557. Verma, A.K., Chattopadhyay, G.K., Sengupta, M., Sengupta, A.K., Das, S.K., Raje Urs, S., 2003.

(Central Sericultural Research and Training Institute, Berhampore, India)

Expression of heterotic genetic interaction among multivoltine recurrent backcross/congenic lines for higher shell weight of silkworm, *Bombyx mori* L.

International Journal of Industrial Entomology, 7(1):21-27

Abstract: Manifestation of heterotic genetic interaction was studied in different hybrids made between multivoltine recurrent backcross (RBL) / congenic lines (Con. L) during unfavourable season when temperature and relative humidity are  $>30^{\circ}\text{C}$  and 86 percent, respectively. A few number of silkworm race or strain or breed like Nistari (N+p or Np) can sustain the temperature above  $30^{\circ}\text{C}$  and RH above 86 percent. The present heterosis study screened a hybrid ie., CB5Lm5RBL1 x M6DPCLmE1RBL and its reciprocal provided heterobeltiotic effect on survival by number and pupation rate at a magnitude of 20 percent ( $p<0.01$ ) and yield by weight of 10 percent ( $p<0.01$ ). Beside all the hybrids expressed heterosis over check Nistari (N+p) with better quality silk. Therefore, aforesaid hybrid may be useful for utilization at commercial level during adverse seasons of West Bengal.

558. Balachandran, N., Mahadevamurthy, T.S., Mohan, B., Sinha, R.K., Thangavelu, K., 2004.

(Central Sericultural Germplasm Resources Centre, Thally Road, Hosur, India).

Estimation of evaluation indices for bivoltine Silkworm genetic resources.

In: Abstracts and Souvenir of National Symposium on Recent Trends in Applied Biology, January 28th and 29th, 2004, Department of Life Sciences, Avinashlingam Institute for Home Science and Higher Education for Women- Deemed University, Coimbatore, India, 63.

Abstract: Selection of germplasm for desired traits is important in silkworm breeding programme. Formulating an ideal and statistically significant method of selection indices plays a vital role in arriving at the desired incorporation of genetic characters in the breeding lines. Central Sericultural Germplasm Resources Centre, Hosur using 102 bivoltine silkworm germplasm accessions worked out character-wise and cumulative selection indices using Mano's Evaluation Index method incorporating five rearing traits viz., fecundity, total larval duration, pupation rate, cocoon yield per 100 Dfls and silk ratio and eight reeling parameters viz., total filament length, denier, renditta, raw silk recovery, neatness, boil-off loss, cleanness, evenness. Wide variability was recorded in different characters and cumulative values. The study revealed significantly higher values for traits in some accessions compared to the ruling silkworm races/breed. This paper details the evaluation index values of the accession studied and tabulates those accessions with desired EI values for considering in breeding programme.

559. Mohan, B., Mukherjee, S., Muthulakshmi, M., Balachandran, N., Sinha, R.K., Thangavelu, K., 2004.

(Central Sericultural Germplasm Resources Centre, Thally Road, Hosur, India).

Characterisation of silkworm genetic resources - An overview.

Abstracts and Souvenir of National Symposium on Recent Trends in Applied Biology, January 28th and 29th, 2004, Department of Life Sciences, Avinashlingam Institute for Home Science and Higher Education for Women- Deemed University, Coimbatore, India, 48-49.

Abstract: Characterisation of silkworm (*Bombyx mori* L.) germplasm based on morphological, biochemical and molecular traits is imperative for conservation management, typifying, and ascertaining the characters as per passport data and exploiting the desirable trait(s) for breeding programme. Morphological traits form indirect indices for certain qualitative and quantitative characters for economic importance. Central Sericultural Germplasm Resources Centre, Hosur is the nodal agency in

India with the mandate to collect, characterise and conserve the silkworm genetic resources. CSGRC maintains 394 accessions of silkworm germplasm, which include indigenous and exotic races, representing the native races, obsolete breeds, evolved breeds in current use and mutant genetic stocks. Ingenious sets of descriptors and descriptor-states have been developed by CSGRC for morphological characterisation of *Bombyx mori* silkworm genetic resources. Morphological characterisation details involving a total of 26 descriptors at egg, larva, cocoon, pupa and moth stages along with the frequency distribution of various descriptors for 330 bivoltine and 64 multivoltine silkworm accessions is presented in the paper. The data helps the users to select the desired germplasm accessions and to form core-set germplasm for further evaluation. It also helps in efficient gene bank management and in the process of germplasm registration. The correlation analysis of certain morphological traits vis-à-vis important economic traits are also highlighted.

560. Rao, C.G.P., Chandrashekharaiyah., Ibrahim Basha, K., Seshagiri, S.V., Ramesh, C., Nagaraju, H., 2004.

(Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India).

Identification of superior polyvoltine hybrids (poly X bivoltine) of silkworm *Bombyx mori* L.

International Journal of Industrial Entomology, 8(1):43-49.

Abstract: Ten promising polyvoltine mulberry silkworm strains (SDMG1, SDMG2, SDMG3, SDMG4, SDMW1, SDMW2, RMW1, RMW2, RMW3 and RMW4) that are superior in quantitative and qualitative traits have been synthesized in the polyvoltine breeding laboratory of Andhra Pradesh State Sericulture Research and Development Institute, Hindupur through systematic hybridization and appropriate selection methods. After the genotypes were found homozygous for the desired traits, they have been crossed with 3 bivoltine testers (APS8, APS4 and NB4D2) and thirty new combinations were developed for the assessment of their hybrid performance. Phenotypic expression of economically important quantitative and qualitative traits of first filial generation were measured and subjected for statistical analysis. Evaluation Index and Subordinate Function methods were employed for the assessment of hybrid performance since they are widely used in silkworm hybrid evaluation. Total of seven poly X bivoltine combinations, which ranked high in both the methods, were selected as potential combinations for further field test. These combinations also ranked significantly higher than the control hybrid (APM 1 x APS8).

561. Rao, C.G.P., Chandrashekharaiyah., Ramesh, C., Basha, K.I., Seshagiri, S.V., Nagaraju, H., 2004.

(Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India).

Evaluation of polyvoltine hybrids based on silk productivity in silkworm, *Bombyx mori* L.

International Journal of Industrial Entomology, 8(2):181-187.

Abstract: Polyvoltine silkworm breeds/hybrids play an important role in tropical sericulture. In the process of synthesizing more potential polyvoltine hybrids (polyvoltine X bivoltine) of superior quantity and quality, the Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI) has developed 8 promising polyvoltine breeding lines (SDMG2, APM16, APM15, APM14, APM5, RM2, APM3, APM13). In order to study their hybrid vigour and performance, these breeds were crossed with 4 potential bivoltine testers (SDD1, SDD2, SDD3, APS8), and 32 different hybrid combinations were prepared and evaluated for their mid parent heterosis (MPH) and better parent heterosis (BPH) of silk productivity. Since silk is the ultimate product required for commercial purpose, based on silk productivity and its heterosis, three superior polyvoltine hybrid combinations namely RM2 x APS8 (24.3 percent), APM3 x APS8 (12.4 percent) and APM15 x SDD2 (10.8 percent) were adjudicated as potential heterotic hybrid combinations of superior silk Yield and hence recommended for further large Scale field trails and commercial exploitation.

562. Asma Maqbool, G.N.Malik, H.U.Dar, Afifa, S.Kamili and Gul Zaffar, 2005.

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(Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir, India).

Evaluation of some bivoltine silkworm (*Bombyx mori* L) genotypes under different seasons. Indian Journal of Sericulture, 44(2):147-155.

Abstract: Twenty-four bivoltine silkworm (*Bombyx mori* L) genotypes were tested along with 2 newly authorized breeds, SKAU-R-1 and SKAU-R-6 (as checks) for their performance in respect of 12 important yield attributing traits during spring ( $E_1$ ) and summer ( $E_2$ ). No genotype displayed significantly superior performance vis-à-vis check breeds in all the metric traits under study. However, several genotypes registered higher performance in several sub-sets of traits. The breeds  $C_{122}$ , Yakwei,  $CSR_4$  and Sannish-M appear to hold promise for commercial exploitation during spring rearing season ( $E_1$ ), whereas the breeds KA, SKUAST-7, Sannish-M and SKUAST-23 in summer rearing season ( $E_2$ ). The genotypes SKUAST-7, SKUAST-8, SKUAST-24,  $C_{122}$ , Haulak,  $J_{112}$ , Sannish-M, Yakwei, KA and  $CSR_4$  have shown stable performance in both the seasons,  $E_1$  and  $E_2$ .

563. P.G.Joge and H.K.Basavaraja, 2005.

(Central Sericultural Research and Training Institute, Mysore).

Studies on the evaluation of sex-limited cocoon colour bivoltine breeds of *Bombyx mori* L. Indian Journal of Sericulture, 44(2):202 - 207.

Abstract: Evaluation of  $CSR_2(SL)$  and  $CSR_8(SL)$  breeds with their normal counterparts,  $CSR_2$  and NB4D2 was undertaken. Comparative performance of sex-limited breeds with their control in three seasons of the year revealed significant ( $P < 0.05$ ) variation for all the traits except for cocoon weight, shell weight and shell percentage. Significant differences in cocoon traits and reeling parameters were observed in summer followed by rainy and winter seasons. The traits, shell weight, shell percentage, reelability, filament length and neatness have not shown significant differences for season x breed interaction. The hybrids PM x  $CSR_2(SL)$  and PM x  $CSR_2$  and PM x NB4D2 in majority of the economic traits except for filament length and filament denier. In light of the results on hybrid performance with Pure Mysore, the sex-limited breeds,  $CSR_2(SL)$  and  $CSR_8(SL)$  could be effectively exploited as male component.

564. Kumaresan, P., Sinha, R.K., Thangavelu, K., 2005.

(Central Sericultural Germplasm Resources P. B. No. 44, Thally Road, Hosur - 635 109, India.)

Perspectives in Silkworm (*Bombyx mori* L.) Bio-Diversity Conservation In India.

In: 20th Congress of the International Sericultural Commission, Bangalore, India, 15-18 December, 2005, Vol I, p.279-291, (English)

Abstract: Silkworm (*Bombyx mori* L.) Genetic Resources are important pre-requisite that provides genetic variability as a source for the evolution of new silkworm breeds. These resources are also widely utilized in laboratory experiments dealing with genetics, physiological, biotechnological aspects. The silkworm gene bank conserves the genetic diversity of these resources and protects them from genetic erosion. The genetic diversity once lost is irreplaceable. At present, the silkworm gene bank at Central Sericultural Germplasm Resources Center, Hosur maintains 71 multivoltine, 330 bivoltine races and 20 mutant stocks of different geographical origin. The enormous wealth of genetic variation should be used judiciously in silkworm-breeding programme for sustainable silk production. The present paper deals with various aspects involved in the conservation of silkworm genetic resources, viz., present scenario of assemblage, genetic diversity present resources, morphological and molecular characterization, strategies on conservation, evaluation, strategies for utilization.

565. Mirhosseini, S.Z., Ghanipoor, M., Shadparvar, A., Seidavi, A.R., Mavvajpour, M., 2005.

(Department of Animal Science, Faculty of Agriculture, University of Guilan, P. O. Box 3179, Rasht, Iran.)

Comparison Of Different Selection Indices For Genetic Improvement Of Economic Traits In Silkworm (*Bombyx mori* L.) Lines.

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In: 20<sup>th</sup> Congress of the International Sericultural Commission, Bangalore, India, 15-18 December, 2005, Vol I, P.245-249,(English)

Abstract: Genetic parameters and economic values of some important traits in six commercial silkworm (110, 107,101433, Xinhong1, Koming 1 and Y) were analyzed and selection indices traits were developed. Economic values of traits were estimated by data simulation using a deterministic model. Individual recordings on cocoon weight, shell weight and shell ratio were carried out in six generations. Heritability and correlation coefficients were estimated by REML method. Heritability of cocoon weight and cocoon shell weight were higher than heritability of cocoon shell ratio. In each variety, three selection indexes including conventional index, restricted index and base index were constructed. Restricting the genetic gain of cocoon weight caused economic efficiency to reduce. The negative effect of restricting index in Koming 1 was lower due to lower genetic correlation between weight and shell weight and as a result, less effect on genetic gain of shell weight. Results obtained from this study showed that the separate breeding strategy must be designed in the varieties and different selection index should be constructed.

566. Naseema Begum, A., Basavaraja, H.K., Joge, P.G., Pallavi, S.N., Mahalingappa, K.C., Dandin, S.B.,2005.

(Central Sericultural Research and Training Institute, Mysore, India.)

Evaluation of Chinese bivoltine double hybrids of silkworm, *Bombyx mori* L.

Indian Journal of Sericulture, 44(1):69-74,(English)

Abstract: Four Chinese double hybrids viz., YX1 x YX2, MC18 x HY01, YN2 x YN1 and NF x SX along with the popular Indian double hybrid as control (CSR2xCSR27) x (CSR6 x CSR26) were evaluated for eleven economic traits using analysis of variance (ANOVA). The results showed significantly (p0.01) lower total larval period in all the Chinese double hybrids as compared to the control. However, higher values in respect of the cocoon weight, shell weight and shell ratio were observed in the control as compared to the Chinese double hybrids. Two Chinese foundation crosses namely, YX1 (oval) and YX2 (dumb-bell) along with the control (CSR2 x CSR27 oval FC and CSR6 x CSR26 dumb-bell FC) were also analysed for five economic traits. The total larval period was also marginally lower in Chinese oval foundation cross (YX1) as compared to the control. But higher values with reference to pupation rate, cocoon weight and shell ratio was recorded in both the Indian control foundation crosses as compared to the Chinese foundation crosses.

567. Ramesh Babu, M., Lakshmi, H., Prasad, J., Seetha Ramulu, J., Chandrashekharaiyah., Goel A.K.,2005

(Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India.)

Evaluation and selection of potential bivoltine parents for silkworm, *Bombyx mori* L. breeding.

Indian Journal of Sericulture, 44(1):82-91,(English)

Abstract:With an objective of selecting suitable parents for silkworm breeding programmes, 47 (22 oval and 25 peanut) bivoltine silkworm genetic stocks maintained at Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI), Hindupur were evaluated for three seasons over two years. Data were collected and assessed for eight traits of economic importance viz., fecundity, cocoon yield per 10000 larvae by weight, survival percent, cocoon weight, cocoon shell weight, cocoon shell ratio, filament length and neatness and statistically analyzed with two way classification, evaluation index and joint scoring method. Significant variations among seasons, breeds and breed x season interaction were observed. The breeds viz., APS5, APS9, APS11, APS31, APS33, APS47, and APS7 (oval) and APS8, APS18, APS6, APS64, APS22, APS12, and APS60, (peanut) were identified as potential breeding resource mate for future breeding programmes aimed at developing promising breeds/hybrids for tropical conditions.

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568. Suresh Kumar, N., Harjeet Singh, G.V.Kalpna, H.K.Basavaraja, B.Nanje Gowda, N.Mal Reddy, P.G.Joge and S.B.Dandin, 2005.

(Central Sericultural Research and Training Institute, Mysore).

Evaluation of temperature tolerant and temperature sensitive breeds of bivoltine silkworm, *Bombyx mori* L.

Indian Journal of Sericulture, 44(2):186 - 194.

Abstract: The present investigation was undertaken to assess the effect of high temperature and high humidity on various quantitative and qualitative characters of temperature tolerant and temperature sensitive breeds and their hybrids to generate additional knowledge on the genetics basis of temperature tolerance so that it can be effectively utilized for future breeding programmes. The results of the present study clearly indicate that the productive bivoltine pure breeds are highly sensitive to high temperature and high humidity conditions. In this study, it was observed that the pupation rates of those hybrids are more (93.1 to 97.4%) where the female parents used are more tolerant to high temperature and high humidity conditions. It is also evident that even bivoltine hybrids will exhibit reciprocal effect when the parents involved are temperature tolerant and sensitive breeds. The expression of hybrid vigour is different in hybrids at the two temperature treatments. It is also clear that the level of heterosis present in the hybrids can be influenced by the environment.

569. Ananth, R., Subramanya, G.,2006.

(Department of Studies in Sericultural Science, University of Mysore, Mysore, India.)

Correlation studies between adult life span and commercial characters of silkworm *Bombyx mori*.

In: Abstracts of National Conference on "New Strategies in Research and development of Sericulture – Indian Perspective" Department of Sericulture, Jnanabharathi Campus, Bangalore University, Bangalore, India, 9<sup>th</sup>-10<sup>th</sup> March, 2006, p.68,(English)

Abstract: Correlation studies were made to understand the importance of adult life span in silkworm, *Bombyx mori* in relation to some of the quantitative traits by popular bivoltine races/ breeds and six multivoltine races. The quantitative traits are eggs per laying, larval duration, larval weight and some post cocoon character from the results that highest average life span is observed in CSR2 breed (12.7 days) and lowest in the race C108 (10.5 days). Among multivoltine races the adult longest life span is discussed in Diazo race (11.3 days) and lowest in the race Precaucity (7.6 days). The death of the adult moth was judged when they did not biologically respond to being poked by the point of a pencil. The mean adult life span for each race/ breed and sex were calculated by following the method of Murakami et al.,(1989). The linear regression lines based on the statistical analysis have clearly indicated that, the longest lifespan has correlation with high cocoon yielding. The importance of genetical studies of life span of adult moths are discussed in the light of its importance in silkworm breeding.

570. Chauhan, T.P.S., Sahni, N.K., Dhar, A., Chakrabarti, S.,2006

(Regional Sericultural Research Station, Miransahib, Jammu, India.)

An account of filament denier and boil off loss in silkworm genotypes, *Bombyx mori* L. reared under subtropical conditions of Doon Valley, Uttarakhand, India.

In: Proceedings of Regional Seminar on "Prospects and Problems of Sericulture an Economic Enterprise in North West India", 11th-12th November 2006, Regional Sericultural Research Station, Dehradun, India., p.196-198,(English)

Abstract: The solubility of sericin has an important role in the silk reeling. There are two or more kinds of sericin in cocoon shell. Chemically, the sericin in cocoon shell is divided into a-sericin and B- sericin. The solubility of a- sericin in boiling water is higher than that of B- sericin which contributes significantly towards the silk reeling and unwinding of silk filament from cocoons. Boil off loss or degumming loss is the loss of sericin from the cocoon shells during the process of boiling for silk reeling cocoons. The degumming loss in cocoon shell varies from one genotype to other in different rearing seasons. Further, the Quality of mulberry leaves' fed tends to differ in different seasons thereby

influencing cocoon characters and their quality in silkworm genotypes. Variation in boil off loss in different silkworm genotypes appears probably due to the variation in the quality of leaves in food plant. Silkworm genotypes of different origin under subtropical condition of Doon valley, Uttaranchal have the boil off loss ranging from 22.98 to 30.82 percent in autumn season. The study further revealed that the silkworm genotypes having filament denier ranging between 2.4 to 2.6 have low boil off loss from 24 – 26 percent. This correlation of boil off loss and the denier was more obvious with genotypes having medium wrinkles and grains of cocoons. This correlation can be effectively used for selection of parents in silkworm breeding.

571. Gangopadhyay, D., Ravindra Singh, 2006.

(Central Sericultural Research and Training Institute, Mysore).

Line x Tester analysis in hybrids between polyvoltine and bivoltine breeds of the silkworm, *Bombyx mori* L.

Indian Journal of Sericulture, 45(2):116 - 122.

Abstract: Genetic potentiality of four polyvoltine breeds developed through artificial parthenogenesis was evaluated with four bivoltine breeds in order to identify promising parents and hybrids by using Kempthorne (1957) model. Among the parental lines, DNP<sub>1</sub> was found good general combiner exhibiting significant GCA effects for seven characters. Among polyvoltine x bivoltine hybrids, DNP<sub>4</sub> x CSR<sub>4</sub> was found good specific combiner exhibiting significant SCA effects for six out of 12 characters. Two hybrids namely, DNP<sub>2</sub> x CSR<sub>4</sub> and DNP<sub>4</sub> x CSR<sub>4</sub> manifested significant hybrid vigour over better parent value for seven characters. Majority of the hybrids showed their superiority particularly for characters such as yield / 10,000 larvae by weight, cocoon weight, cocoon shell weight and filament length.

572. Gangopadhyay, D., Ravindra Singh, Ragahavendra Rao, D., 2006.

(Central Sericultural Research and Training Institute, Mysore, India)

Selection of silkworm breeds / hybrids based on multiple traits indices and cocoon size variability.

Indian Journal of Sericulture, 45(2):181 - 184.

573. Gangopadhyay, D., Singh, S., 2006

(Central Sericultural Research and Training Institute, Mysore – 570 008, Karnataka, India.)

An Improved Method of Parthenogenetic Development and Analysis of combining Ability in Bivoltine Breeds of the Silkworm, *Bombyx mori* L.

International Journal of Industrial Entomology, 13(2):63-72,(English)

Abstract: Parthenogenesis, the development of unfertilized 1m opens new perspectives in silkworm breeding in the development of homozygous breeds. In order to improve induction of artificial parthenogenesis in the excised unfertilized eggs of different breeds of the silkworm, *Bombyx mori* L., a new method was devised and the results were compared with the routine method. General and specific combining abilities and hybrid vigour of newly developed bivoltine breeds were analyzed utilizing bivoltine breeds viz., CSR<sub>2</sub>, CSR<sub>4</sub>, CSR<sub>17</sub> and NB4D<sub>2</sub>. Estimation of GCA revealed superiority of the breeds, DNB<sub>1</sub> for eight characters followed by DNB<sub>4</sub> for five characters. Among the testers, CSR<sub>2</sub> was found good general combiner for seven characters followed by CSR<sub>17</sub> for four characters. A great deal of variations was observed among the hybrids studied. Five hybrids namely, DNB<sub>1</sub> x CSR<sub>2</sub>, DNB<sub>4</sub> X NB4D<sub>2</sub>, DNB<sub>6</sub> X CSR<sub>2</sub> and DNB<sub>4</sub> X NB4D<sub>2</sub>, DNB<sub>6</sub> X CSR<sub>2</sub> and DNB<sub>7</sub> x CSR<sub>2</sub> showed significant SCA effects for 5-6 characters. The hybrid, DNB<sub>4</sub> x CSR<sub>4</sub> showed its superiority by expressing significant hybrid vigour over BPV characters. Majority of the hybrids exhibited significant hybrid vigour for survival rate, yield/10,000 larvae by weight, cocoon weight, cocoon shell weight, filament length and denier.

574. Goel, A.K., Chandrashekharaiyah., Sreenivasa Reddy, Y., 2006.

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(Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India.)

Evaluation and characterization of bivoltine sex-limited inbred lines of silkworm *Bombyx mori* L.

Journal of Experimental Zoology India, 9(2):349-358, (English)

Abstract: Three breeding plans were initiated with three bivoltine commercial hybrids from China with no objective to isolate productive larval marking Sex-Limited bivoltine inbred lines. Five larval marking Sex-Limited bivoltine inbred lines including two ovals and three dumbbells were derived from these hybrids. The characterization and evaluation of all these lines have been carried out. All the inbred lines were also screened for their tolerance and / resistance to BmIFV, BmDENV and BmNPV. Out of five, the four lines exhibited resistance to BmDENV, two were found tolerant to BmIFV and one line showed tolerance to BmNPV.

575. Jaiswal, K., Goel, R., 2006.

(Babasaheb Bhimrao Ambedkar University, Lucknow, India.)

Studies on cocoon shapes in most popular mulberry silkworm race of Uttaranchal different seasons of Uttar Pradesh.

In: Abstracts of National Conference on "New Strategies in Research and development of Sericulture – Indian Perspective" Department of Sericulture, Jnanabharathi Campus, Bangalore University, Bangalore, India, 9<sup>th</sup>-10<sup>th</sup> March, 2006, p.57, (English)

Abstract: Data from an experiment involving most popular mulberry silkworm race of Uttaranchal have been analysed to know the cocoon shape variability in three different treatments (One treatment of Control at Lucknow, other of field conditions at Lucknow and Third of field conditions at Gonda) across different seasons of Uttar Pradesh viz., monsoon, autumn and spring seasons. The overall study showed that in second treatment i.e. field conditions at Lucknow more uniformity in cocoon shape has been obtained for all seasons compared to other treatments except spring season. Therefore, if proper rearing packages are followed, silkworm rearing can prove to be a boon for the farmers of Uttar Pradesh because more uniformity in cocoon shape at Lucknow field in almost all seasons is useful to identify the suitable parents / hybrids for breeding and evaluation to produce uniform shape cocoons with uniform filament size as well as to know the variability among silkworm strains and their hybrids and accordingly their recommendation into the field.

576. Moorthy, S.M., Das, S.K., Rao, P.R.T., Debnath, S and Raje Urs, S 2006.

Genetic variability and selection index of some quantitative traits of bivoltine Silkworm, *Bombyx mori* L.

Indian Journal of Genetics and Plant breeding, 66(1):82-84.

Abstract: The extent of variability present in the bivoltine silkworm germplasm was studied in terms of range, mean, phenotypic and genotypic coefficient of variation. The genotypes showed wide range of variability for all the nine traits studied. Genetic advance with 5% selection intensity, expressed as percent of mean varied from 3.5 to 29.5 %. The high values of PCV and GCV for the characters viz., filament length and single shell weight suggest that there is a possibility of improving these traits through directional selection. In addition ranking of genotypes were done for selecting superior genotypes.

577. Nanje Gowda, B., Mal Reddy, N., 2006.

(Central Sericultural Research and Training Institute, Mysore).

Effect of different environmental conditions on popular multivoltine x bivoltine hybrids of silkworm, *Bombyx mori* L. with reference to cocoon parameters and their effect on reeling performance.

Indian Journal of Sericulture, 45(2):134 - 141.

Abstract: Three popular multivoltine x bivoltine silkworm hybrids namely, PM x CSR2, PM x CSR2(SL) and PM x NB4D2 were chosen for the present study. These hybrids were subjected to different temperature and humidity treatments i.e., 25 ± 1°C and relative humidity (RH) (65 ± 5%)(control) 30 ±

1°C with combinations of low ( $65 \pm 5\%$ ) and high RH ( $85 \pm 5\%$ ) at different stages during rearing and spinning of silkworm larvae. The larvae after 3<sup>rd</sup> moult were subjected to different thermal and humidity stress till the assessment of cocoon traits. The comparative rearing and reeling performance clearly indicated that the adverse effect of high temperature and high RH was more pronounced for majority of traits such as cocoon uniformity, cocoon weight, shell weight, shell percentage, reelability, filament length, raw silk percentage, raw silk recovery, denier and waste percentage on silk weight than other temperature and RH treatments and this effect was almost similar for all three silkworm hybrids studied. The present investigation clearly indicates that the deleterious effect of high temperature and high RH was more pronounced on rearing and spinning of larvae than other temperature and RH treatments. The cocoon characters can be improved up to certain extent by providing ideal environmental conditions even during spinning stage of larvae affected with high temperature and low humidity has greater effect on cocoon parameters whereas high temperature and high humidity has greater effect on reeling parameters.

578. Rao, P.R.T., Ghosh, B., Moorthy, S.M., Sengupta, A.K., Roy, G.C., Das, S.K., Sen, S.K and Saratchandra, B 2006.

Utilization of bivoltine female parents for preparations of cross breeds of *Bombyx mori* L for the tropics. U.P.J.Zool 26(2); 185-192.

579. Ravindra Singh, H.K.Basavaraja, B.K.Kariappa, D.Raghavendra Rao, P.Rama Mohana Rao, V.Premalatha and D.Gangopadhyay, 2006.

(Central Sericultural Research and Training Institute, Mysore).

Reciprocal effect in F<sub>1</sub> hybrids between multivoltine and bivoltine breeds of the silkworm *Bombyx mori* L.

Indian Journal of Sericulture, 45(2):176 - 180.

Abstract: Reciprocal effect was studied in F<sub>1</sub> hybrids involving multivoltine and bivoltine silkworm breeds. Superiority of straight crosses between multivoltine and bivoltine breeds has been shown for cocoon yield / 10,000 larvae by weight, cocoon weight, cocoon shell weight, cocoon shell percentage, filament length and raw silk percentage whereas, reciprocal crosses of bivoltine x multivoltine were found superior only in fecundity and shorter larval span. In multivoltine hybrids, characters such as total larval span, yield / 10,000 larvae by weight, filament length, reelability, raw silk percentage, denier and neatness did not show any significant difference. In bivoltine hybrids, none of the characters except filament length and denier showed significant difference. Reasons for significant difference in straight and reciprocal crosses between multivoltine and bivoltine breeds have been discussed.

580. Sinha, R.K., Mohan, B., Thangavelu, K., 2006.

(Central Sericultural Germplasm Resources, Hosur, India.)

Importance of silkworm germplasm and their potential use in silkworm breeding.

In: Theme papers on Mulberry Silkworm Breeders Meet 14th-15th February 2006, Central Sericultural Research and Training Institute, Berhampore, India, pp.56-62.

581. Shivashankar, M., Revanasiddaiah, H.M., 2006.

(Department of Sericulture, Bangalore University, India.)

Evaluation of F<sub>1</sub> hybrids using larval colour and marking varieties of eri silkworm, *Philosamia ricini* Boisid.

In: Abstracts of National Conference on "New Strategies in Research and development of Sericulture - Indian Perspective" Department of Sericulture, Jnanabharathi Campus, Bangalore University, Bangalore, India, 9<sup>th</sup>-10<sup>th</sup> March, 2006, p.134, (English)

Abstract: An attempt has been made to evaluate 13 quantitative characters of White plain (WP), Blue plain (BP), Green plain (GP) larval colours and White semi zebra (WSZ), Green semi zebra (GSZ), White zebra (WZ) and Green zebra (GZ) larval markings of eri silkworm, *Philosamia ricini* with the main

objective of evolving better parental lines to obtain superior F1 hybrids. The analysis of quantitative traits depicts that the White plain (WP) larval colour variety has lower viability and productivity while the White zebra (WZ) larval marking variety has higher viability and productivity, which justifies their use in the breeding programmes. The genetic analysis of the 42 combinations involving all the parental lines revealed that negative cross of White plain male component with White zebra (WZ) female component are the top general combiners to obtain superior F1 hybrids for all the quantitative traits when compared to other crosses. Therefore, this parental combination can be used as superior breeding material to produce substantial improvement in quality and quantity of eri silk.

582. Subramanya, G., Doddaswamy, M.S.,2006.

(Department of Studies in Sericultural Science, University of Mysore, Mysore, India.)

Genetical studies on the biological characters of multi x bi and bi x multi hybrids.

In: Abstracts of National Conference on "New Strategies in Research and development of Sericulture - Indian Perspective" Department of Sericulture, Jnanabharathi Campus, Bangalore University, Bangalore, India, 9th-10th March, 2006, p.54,(English)

Abstract: In order to understand the genetics of cross breeding system between multi X bi and bi X multi hybrids, an hybridization experiment was conducted by crossing females of multivoltine Pure Mysore race with males of bivoltines race C108 and its reciprocal cross. The F1 and F2 progenies of the above crosses were derived in order to study the biological characters and quantitative traits. The results have clearly indicated that the F1 progeny of PM X C108 produced non-diapause eggs exhibiting 23-24 days larval duration and uniform built of cocoons. On the other hand the F1 progeny of females of C108 crossed with males of Pure Mysore produced only diapause type of eggs, uniform built of cocoons and larval duration was shorter by one to one and half days (22 days) compared to regular cross. The analysis of various cocoon characters revealed that the larvae of reciprocal crosses also spin uniform shaped cocoon, size and colour similar to regular crosses. The F2 progenies involving both the crosses produced 3:1 ratio diapause:non-diapause eggs and green:white cocoons indicating typical Mendelian pattern of inheritance for voltinism and cocoon colour. The authors in the present investigation discuss the importance of hemizygous and heterozygous populations of F1 and F2 progeny and its utility in genetics and breeding of silkworm *Bombyx mori*.

583. Sudhakara Rao, P., Nataraju, B., Balavenkatasubbaiah, M., Dandin S.B. ,2006.

(Central Sericultural Research and Training Institute, Mysore – 570008, India.)

Identification of Productive Mulberry Silkworm Hybrids Resistant to Densonucleosis Virus Type 1 (BmDENV1).

International Journal of Industrial Entomology, 13(2):109-112,(English)

Abstract: The use of commercial silkworm hybrids resistant to important silkworm diseases is economical and better option particularly in tropical areas. This necessitated the evolution of productive bivoltine silkworm breed non-susceptible to BmDENV1. Non-susceptibility to BmDENV1 infection was found to be controlled by a single recessive gene, *nsd-1* or a dominant gene, *Nid-1*. A major dominant/recessive gene confers resistance to BmDENV1 from potent donor parents have been transferred to 10 productive but susceptible bivoltine silkworm strains through conventional breeding methods. By utilizing these breeds prepared 25 hybrids (5 x 5) and hybrid evaluation was carried out to identify most promising hybrids resistant to BmDENV1. All these hybrids are inoculated with BmDENV1 inoculum along with productive control hybrid CSR2 x CSR 4 and reared under standard rearing procedure. Based on inoculated rearing and test reeling results, two most promising hybrids (CSR18DR x CSR29DR and CSR21 DR x CSR50DR) were selected for commercial exploitation. The selected hybrids have shown a survival rate of 85 percent with productive traits, where as control hybrid have shown 11.1 percent survival with inferior cocoon traits. The methodologies adopted were discussed.

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584. Suresh Kumar, N., Basavaraja, H.K., Kalpana, G.V., MalReddy, N., Joge, P.G., Palit, A.K., Nanje Gowda B., Dandin, S.B., 2006.

(Central Sericultural Research and Training Institute, Mysore – 570008, India.)

Selection strategies for conventional breeding in the mulberry silkworm, *Bombyx mori* L. – An overview.

Indian Journal of Sericulture, 45(2):85-103, (English)

Abstract: In practical silkworm breeding, the ultimate aim is to achieve economic gains by improving the economic traits of silkworm breeds. For any breeding programme, the choice of parents to be utilized as breeding resource material and the strategies to be used for identifying them are of great significance. It is well established that the degree of importance of the contributory traits of economic value are not similar in silkworm. It is also known that, the knowledge on the heritability status of characters under consideration is of utmost importance in any breeding programme. Similarly, it is also of paramount importance the correlation between the different characters and their response to selection and the influence of environment on the genotypes under selection. Considering all these facts, the main concern of breeders is the use of appropriate selection strategies for the genetic as well all economic improvement of silkworm breeds. In this review, the available information on various selection strategies is compiled for the benefit of silkworm breeders engaged in conventional breeding of the silkworm, *Bombyx mori* L.

585. Choudhary, N., Singh, R., 2007.

(Central Sericultural Research and Training Institute, Mysore, India.)

Importance of combining ability analysis in the silkworm, *Bombyx mori* L. - A Review.

Indian Journal of Sericulture, 46(1):1-6, (English)

Abstract: Various biometrical techniques have facilitated the breeders in identifying promising parents and hybrids both in plants and animals. In the mulberry silkworm, *Bombyx mori* L., analysis of combining ability is one such tool to select good combiners among the parental breeds and their prospective hybrids in order to obtain maximum hybrid vigour. In this review, an attempt has been made to highlight the advantages of combining ability, different biometrical approaches followed for analysis of combining ability in order to identify promising multivoltine and bivoltine silkworm breeds I hybrids and to know the magnitude of hybrid vigour as well as various applications of combining ability in silkworm breeding.

586. Choudhury, N., Singh, R., Basavaraja, H.K., Dandin, S.B., 2007.

(Central Sericultural and Training Institute, Mysore, Karnataka, India).

Studies on combining ability in the silkworm *Bombyx mori* L.

Bulletin of Indian Academy of Sericulture, 11(2):32-38.

Abstract: Various biometrical techniques have been developed which facilitate the breeders to identify promising parents / hybrids by utilizing analysis of combining ability in order to obtain maximum hybrid vigour. In this review, an attempt has been made to discuss briefly the different technique to analyze combining ability, applications of combining ability and some important studies carried out on combining ability in silkworm *Bombyx mori* L.

587. Doddaswamy, M.S., Subramanya, G., 2007.

(Department of Studies in Sericultural Science, University of Mysore, Mysore, India).

Studies on the adult life span of multivoltine and bivoltine races of the silkworm, *Bombyx mori* L.

Indian Journal of Sericulture, 46(2):106-108.

Abstract: The total life span in insect population is a genetically controlled biological phenomenon. In the lepidopteran member silkworm, *Bombyx mori*, the entire span from eggs to adult death varies from one volinistic group to another. In the present investigation, adult lifespan of five multivoltine and five bivoltine races silkworm, *Bombyx mori* available in the Germplasm Bank of the Department was

investigated. The multivoltine races selected were Pure Mysore, npnd (non pigmented and non-diapausing egg), Nistari, C. nichii and pre (precaucity) whereas, the bivoltine races utilised were NB4D2, NB18, NB7, KA and C108. The adult life span was calculated by following the standard procedure. The life span and survival curve proved to be characteristic for each of the races. The mean life span for the females in bivoltine race was 11.07 days and 10.05 days in males. In multivoltine races, the mean life span for female was 11.07 days and in male it was 8.14 days. It is clear from the present findings that there is sexual difference in the *Bombyx mori* for adult life span. The importance of adult life span as an index breeding is discussed and it is proposed that the hemizygous (heterogametic) sex with only a single X chromosome (XY as male) are long lived than the homogametic sex with two X chromosomes (XX as female).

588. Kamble, C.K., Rama Mohana Rao, P., Sudha, V.N., Ravindra Singh, Umadevi, K. and Nirmal Kumar, S., 2007.

(Central Sericultural Research and Training Institute, Mysore, India).

Impact of improved Polyvoltine female parent in improving the cocoon quality and quantity in cross – breed of the silkworm, *Bombyx mori* L.

Indian Journal of Sericulture, 46(2): 177 - 178.

589. Kamble, C.K., Rama Mohana Rao, P., Sudha, V.N., Ravindra Singh, Umadevi, K. and Nirmal Kumar, S., 2007.

(Central Sericultural Research and Training Institute, Mysore, India).

Use of Bivoltine foundation crosses as male parent in the preparation of F1 cross-breed seed. Indian Journal of Sericulture, 46(2): 197 – 198.

590. Kumaresan, P., Koundinya, P.R., Hiremath, S.A., Sinha, R.K., 2007.

(Central Sericultural Germplasm Resources Centre, Hosur – 635 109, Tamil Nadu, India.)

An analysis of Genetic Variation and Divergence on Silk Fibre Characteristics of Multivoltine Silkworm (*Bombyx mori* L.) Genotypes.

International Journal of Industrial Entomology, 14(1):23-32.

Abstract: The nature of genetic variation and diversity among the 65 multivoltine silkworm genotypes was evaluated for 16 post cocoon characters. The components of genetic variation revealed higher PCV (60.487 percent) and GCV (44.56 percent) for evenness (variation 1) followed by cohesion (PCV=55.38 percent, GCV=40.36 percent) and non-broken filament length (PCV=32.05 percent, GCV=31.28 percent). The higher heritability ( $h^2$  in broad sense) was observed for boil-off loss (95.6 percent) followed by non-broken filament length (95.22 percent). The both genotypic and phenotypic correlation indicated significant positive correlation of filament length with non-broken filament length, silk recovery, raw silk, neatness, and low neatness; and negative correlation with denier, renditta and silk waste. The principal component analysis (PCA) revealed 75.381 percent of total variance from the five principal components extracted. On the basis of Mahalanobis'  $D^2$  values (Ward's minimum variance), the sixty-five multivoltine silkworm genotypes were classified into 9 clusters with substantial inter and intra cluster distances. Number of genotypes included in different clusters varied from 3 to 17. The results indicated that the optimum distance obtained in cluster VII (15.059) along with higher cluster mean values especially for filament length, non broken filament length, renditta, silk recovery, silk waste, and raw silk emphasized the utilization of these genotypes in the conventional silkworm breeding programme for improvement of multivoltine silk fibre quality. The possibility of exploiting genetic variation in post cocoon traits for efficient breeding programme is discussed.

591. Lakshmi, H., Chandrashekharaiyah., 2007.

(Andhra Pradesh State Sericulture Research and Development Institute, Kotipi Road, Kirikera – 515 211, Hindupur, India.)

Identification of breeding resource material for the development of thermo-tolerant breeds of silkworm, *Bombyx mori* L.

Journal of Experimental Zoology. India, 10(1):55-63,(English)

Abstract: Screening of twenty bivoltine silkworm breeds of *Bombyx mori* L. at targeted temperature of  $32^{\circ}\text{C} \pm 1^{\circ}\text{C}$  and relative humidity of 50 percent  $\pm$  5 percent conditions resulted in the identification of eight thermo-tolerant (four each of oval and peanut) breeds. The survival percentage of the tolerant breeds ranged from 92.3 percent (APS31) to 89.0 percent (APS19) among oval and 93.0 percent (APS24) to 90.1 percent (APS6) among peanut breeds respectively. The short-listed breeds are crossed in the form of oval x oval and peanut x peanut foundation crosses. The resultant 12 oval and peanut foundation crosses were screened once again at above targeted environmental conditions. The performance of the foundation crosses was analyzed by employing Multiple Trait Evaluation Index method and Sub-ordinate Index methods. Accordingly, five each of oval x oval crosses viz., APS11 x APS31; APS11 x APS19; APS19 x APS11; APS31 x APS19 and APS7 x APS31 and five peanut x peanut crosses viz., APS12 x APS6; APS18 x APS24; APS6 x APS18; APS6 x APS24 and APS6 x APS12 which scored higher average index values were selected as breeding resource parents and initiated breeding for the evolution of thermo-tolerant bivoltine silkworm breeds.

592. Malik, G.N., Malik, M.A., Sofi, A.M., Farooq, M., Raja, T.A., Dar, H.U., 2007.

(Division of Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, India).

Metroglyph analysis of six economic traits in some bivoltine silkworm (*Bombyx mori* L.) genotypes.

Indian Journal of Sericulture, 46(2):126-129.

Abstract: The extent of variability present in a set of twenty bivoltine silkworm (*Bombyx mori* L.) genotypes comprising eighteen breeding lines (SK-2, SK-3, SK-4, SK-5, SK-7, SK-8, SK-9, SK-10, SK-13, SK-14, SK-19, SK-20, SK-21, SK-22, SK-23, SK-24, SK-25 and SK-26) and two authorized breeds (SKAU-R-1 and SKAU-R-6), was assessed through metroglyph and Index score analyses. On the basis of expression of six Economic traits viz., single cocoon weight, shell weight, shell percentage, effective rate of rearing, yield/10,000 larvae by weight and filament length, SK-7 turned out to be the most outstanding genotype with a maximum Index score of 12 followed by SKAU-R-1, SK-5, SKAU-R-6 and SK-25 with a score of 11 each. Scatter diagram obtained on the basis of two most variable traits viz., yield/10,000 larvae by weight and filament length, showed that all the twenty genotypes could be broadly grouped into four clusters. Clusters I and IV were the most divergent. Hybridization between members of these two clusters might yield more heterotic hybrids.

593. Mohan, B., Balachandran, N., Muthulakshmi, M., Hiremath, S.A., Koundinya, P.R., Sinha, R.K., Kamble, C.K., 2007.

(Central Sericultural Germplasm Resources Centre, Hosur, India.)

Potential bivoltine silkworm germplasm for breeding.

Indian Silk, 46(6):10-11,(English)

Abstract: CSGRC, Hosur has identified a series of bivoltine germplasm for important economic characters which would prove handy to the breeders in their work and ensure wider array of collection to drive better results.

594. Moorthy, S.M., Das, S.K., Rao, P.R.T., Raje Urs, S., Sarkar, A., 2007.

(Central Sericultural Research and Training Institute, Berhampore-742 101, West Bengal, India.)

Evaluation and Selection of Potential Parents Based on Selection Indices and Isozyme Variability in Silkworm, *Bombyx mori*, L.

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International Journal of Industrial Entomology, 14(1):1-7,(English)

Abstract: In order to find out the appropriate parents for the breeding programme, twelve bivoltine and three multivoltine silkworm breeds were evaluated on the basis of multivariate selection index and isozyme analysis. Of which, four [CSR2, D6 (P), SK3, SK4] bivoltine and two multivoltine (Nistari, Cambodge) breeds were selected and breeding initiated to develop higher survival bivoltine silkworm breed suitable for tropical conditions. Among two isozyme (Esterase and acid phosphatase) analyzed, only esterase exhibited polymorphism among the bivoltine breeds. No polymorphism was observed among multivoltine in respect of esterase as well as acid phosphatase.

595. Moorthy, S.M., Das, S.K., Mukhopadhyay, S.K Mandal, and Raje Urs, S 2007.

Evaluation of thermo tolerance of 'Nistari' an indigenous strain of multivoltine Silkworm, *Bombyx mori* L.

Int.J.Indust. Entomol., 15 (1): 17-21.

Abstract: An indigenous multivoltine silkworm, Nistari was evaluated for their thermo tolerance by exposing the larvae to various temperature regimes for eight hours. Among different temperature exposed, this strain has significant tolerance at 32°C. Analysis of heat shock protein revealed the expression of 70kDa and 64 kDa polypeptides in fat body and midgut tissues. Interestingly esterase isozyme pattern in midgut showed characteristic expression of Est-1 and Est-3 at different temperature signifying role in heat and cold shock.

596. Murthy, N., Subramanya, G. ,2007.

(Department of Studies in Sericultural Science, University of Mysore, Mysore, India.)

Heritability and genetic variation of a few quantitative traits in the silkworm, *Bombyx mori* L.

Indian Journal of Sericulture, 46(2):103-105,(English)

Abstract: Heritability studies are very important in understanding the nature of inheritance of quantitative and qualitative traits and to predict the genetic variation in silkworm as well to extrapolate the results in breeding programme. In the present study heritability analysis (broad sense) was carried out among four pure races namely Kalimpong-A, NB4D2, Pure Mysore, and npnd (non pigmented and non diapause) by analyzing eight economic traits. The estimates of heritability (broad sense) have clearly revealed both high values of heritability ( 80 percent) and moderate values of heritability " 80 percent) for some traits. The higher values of heritability were recorded for the traits, yield by number, shell weight, and shell percentage among all the four races. The general trends of high heritability for the above traits have clearly indicated the role of low environmental influences and their usefulness in the selection programme based on phenotypic performances. The estimates of genotypic and phenotypic variance for various economic traits and their heritability are discussed with reference to choosing of the best genotypes and designing successful breeding programme.

597. Naseema Begum, A., Basavaraja, H.K., Palit, A.K., Ramaswmy, G.N., 2007.

(Central Sericultural Research and Training Institute, Mysore, India).

Seasonal variation in cocoon filament size deviation in the bivoltine silkworm, *Bombyx mori* L.

Indian Journal of Sericulture, 46(2):153-162.

Abstract: A study on the cocoon filament size deviation during summer, autumn and winter seasons was carried out in twenty-four bivoltine silkworm breeds comprising of twelve oval breeds namely, A1, A3, A104, AHT, BHT, KA, A70, CSR2, CSR3, CSR18, 8HT and JPN8 and twelve dumbbell breeds viz., 916B, 935E, EHT, FHT, GHT, NB4D2, B60, B63, CSR6, CSR16, CSR19 and 5HT. The data of oval and dumbbell breeds were analysed separately using analysis of variance (ANOVA) and the slope of the curve was calculated by regression analysis. The filament size was minimum during summer and rainy in breed JPN8 (1.47 and 1.76) followed by winter in A1 (1.86). Significant ( $p < 0.01$ ) correlations between average filament length vs. slope during rainy ( $r = 0.84^{**}$ ), summer ( $r = 0.59^{**}$ ) and winter ( $r = 0.90^{**}$ ) were observed. Highly significant ( $p < 0.01$ ) correlations between maximum filament size vs. slope and mean

size deviation vs. slope were observed. But the correlations between average filament size vs. slope was non-significant in all the seasons. The filament size was minimum during winter and rainy seasons in the breed 935E (1.58, 1.69) followed by summer in 916B (1.73). Non-significant correlations between average filament length vs. slope and average filament size deviation vs. slope were observed. The correlation between maximum filament size vs. slope was non-significant during rainy and winter seasons but significant ( $p < 0.01$ ) correlation during summer was observed. Based on the results, four breeds viz., JPN8 and A1 (oval) and 935E and 916B (dumbbell) have been identified as resource material for breeding programmes.

598. Nirupama, R., Singh, R., 2007.

(Central Sericultural Research and Training Institute, Mysore-570 008, India.)

Evaluation of polyvoltine breeds of the mulberry silkworm, *Bombyx mori* L.

Journal of Experimental Zoology, 10(2):341-344, (English)

Abstract: Twenty six polyvoltine breeds of the mulberry silkworm, *Bombyx mori* maintained at Central Sericultural Research and Training Institute, Mysore were evaluated for seven characters utilizing multiple traits evaluation index method. Eight breeds viz, DNP5, DNP3, NP1, ND5, BL24, ND7, 96E and BL68 exhibiting average evaluation index values of 59.95, 58.25, 55.52, 54.42, 53.68, 53.52, 53.21 and 52.78 respectively were found promising. Among eight identified breeds, five breeds viz" DNP5, DNP3, BL68, NP1 and ND7 were utilized as breeding resource materials.

599. Rama Mohana Rao, P., Singh, R., Premalatha, V., Basavaraja, H.K., 2007.

(Central Sericultural Research and Training Institute, Mysore, India).

Identification of polyvoltine breeds of the silkworm *Bombyx mori* L. through evaluation index method.

Indian Journal of Sericulture, 46(2):163-168.

Abstract :In the present study, 22 polyvoltine breeds maintained at Central Sericultural Research and Training Institute, Mysore, were evaluated based on quantitative and qualitative traits by utilizing multiple trait evaluation index method. Index values were calculated for rearing and reeling parameters separately. Ten top ranked breeds were identified as potential parents and among that NDV 6 ranked the top most both in the reeling and rearing parameters. The other top ranked breeds were BL67, BL68, 2000H, 2000K, NP1, ND7, 96A, BL62 and BL61. The identified polyvoltine breeds can be utilized in the future breeding programmes as breeding resource materials for the development of superior polyvoltine breeds/hybrids.

600. Rohit L.Shankar, Doddaswamy, N.Murthy and G.Subramanya, 2007.

(Department of Studies in Sericultural Science, University of Mysore, Mysore).

Evaluation and identification of promising new bivoltine silkworm hybrids using combined trait selection index.

Indian Journal of Sericulture, 46(2): 117 - 125.

Abstract :The performance of sixteen new hybrids produced utilizing four new bivoltine breeds viz., MU<sub>51</sub>, MU<sub>52</sub>, MU<sub>53</sub> and MU<sub>54</sub>, evolved at Department of Studies in Sericultural Science, University of Mysore, and four tropical bivoltines viz., KA, MG<sub>408</sub>, NB<sub>18</sub> and NB<sub>4D2</sub> as parents, was assessed through combined trait selection index. Values of >50 were scored by ten hybrids in pre-monsoon and 9 hybrids each in monsoon and post monsoon seasons. The overall mean data of all the seasons based on their index values revealed that the hybrid, MU<sub>51</sub> x NB<sub>18</sub> has scored the value >50 for all the ten traits. The 10 hybrid combinations which have scored >50, with their index values ranging from 56.588 to 50.384 were MU<sub>51</sub> x NB<sub>18</sub>, MU<sub>54</sub> x NB<sub>18</sub>, MU<sub>51</sub> x NB<sub>4D2</sub>, MU<sub>51</sub> x KA, MU<sub>54</sub> x NB<sub>4D2</sub>, MU<sub>52</sub> x NB<sub>18</sub>, MU<sub>53</sub> x NB<sub>4D2</sub>, MU<sub>53</sub> x KA, MU<sub>52</sub> x NB<sub>4D2</sub> and MU<sub>54</sub> x KA in the descending order of merit and were adjudicated as the most promising.

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601. Sudha, V.N., Uma Devi, K., Rama Mohana Rao, P., Ravindra Singh, Raghavendra Rao, D., Basavaraja, H.K., Kariappa, B.K., Premalatha, V., Dandin, S.B. Kamble, C.K., 2007.  
(Central Sericultural Research and Training Institute, Mysore, India).

Evaluation of a new Multivoltine x Bivoltine hybrid, "ND7 x CSR2" (Jayalakshmi) of the silkworm, *Bombyx mori*. L.

Indian Journal of Sericulture, 46(2): 173 - 176.

Abstract :A new multivoltine x bivoltine hybrid, "ND7 x CSR2" (Jayalakshmi) was evaluated in fifteen locations covering the three southern states, Karnataka, Tamil Nadu and Andhra Pradesh during three different seasons. The result showed significant genotype x environment interactions. Higher cocoon yield was recorded during winter (67.42 kg/100dfis) followed by summer (65.99kg/100dfis). Samayanallur and Salem in Tamil Nadu recorded the highest average yield of 80.60 and 79.80kg/100dfis, respectively. Hence the hybrid can be popularized in the areas in large numbers for improving the cocoon yield of the farmers.

602. Wang, Y.Q., Zhu, X.R., Huang Y.F., Zhou, J.Q., Yao, Y.T., He, K.R., Liu, X.J., He, X.L., 2007.

(Sericultural Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China.)

Studies on Combining Ability of Female Silkworm Parthenogenetic Clones Hybridized With Sex-limited Eggs Color Varieties.

Canye Kexue, 33(2):335-339,(Chinese)

Abstract: To inquire into the feasibility of single-cross model on silkworm breeding and eggs production, the female silkworm parthenogenetic clones were hybridized with sex-limited eggs color varieties by the method of incomplete diallel cross. Forty-two pair single-cross combinations were reared under same conditions (Oiu Feng x Baiyu as the control) and their economical characters and combining abilities were investigated. The results indicated that the cocoon weight and cocoon shell weight per 10 000 silkworms of nineteen pairs single-cross combinations were superior to the control and the larva-pupa rate were superior or similar to the control. Therefore, new variety of single-cross combination for production might be bred out through further selecting in the future

603. Basavaraja, H.K., Dandin, S.B., 2008.

(Silkworm Seed Technology Laboratory, Kodathi, Bangalore, India).

Current experience in bivoltine silkworm breeding and future strategies.

Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10th June, 2008, 17-19

604. Doddaswamy, M.S., Subramanya, G., 2008.

(Department of Studies in Sericultural Science, University of Mysore, Mysore).

Estimation of evaluation index for some quantitative traits in some multi x bi and bi x multi hybrids of the silkworm *Bombyx mori*.

Proceedings of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009, 232-236.

Abstract: Several biometrical procedures are commonly utilized in the animal-breeding programme to select the superior parents and hybrids. Multiple trait evaluation index method developed by Mano et al, 1994 is being extensively utilized in the silkworm-breeding programme. The present investigation is an attempt to understand the utility of evaluation index (EI) method for the adjudication of the superior hybrids derived from regular and reciprocal crosses. The F1 hybrids utilizing females of Pure Mysore with males of two bivoltines namely C108, MG408 and the reciprocal crosses involving females of bivoltines with males of multivoltine Pure Mysore were considered for the evaluation index analysis in three different seasons of the year by analyzing thirteen quantitative traits of practical importance. The results have clearly indicated that there is variable percentage of evaluation index values in three

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seasons of the year. The pooled data for all the three seasons revealed that out of 4 hybrid combinations studied, 3 hybrid combinations expressed the index value of >50. Based on the data it is important note that exploitation of bi x multi hybrids may be considered during scarcity of seed cocoons for the commercial cocoon production.

605. Joge, P.G., Kalpana, G.V., Suresh Kumar, N., Kamble, C.K., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India).  
Breeding strategies for the development of sex limited cocoon colour breeds for the preparation of foundation cross in silkworm *Bombyx mori* L.  
Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10th June, 2008, 29-31

606. Kamble, C.K., Nirmal Kumar, S., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India).  
Silkworm breeding - Concepts and challenges.  
Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10th June, 2008, 1-5

607. Lakshmi, H., Chandrashekharaiyah., 2008.  
(Andhra Pradesh State Sericulture Research and Development Institute, Kirikera, Hindupur, India).  
Evaluation and selection of breeding resource material of bivoltine silkworm *Bombyx mori* L. suitable to tropical conditions.  
Indian Journal of Agricultural Research, 42(4):235-243.  
Abstract: Breeding strategies directed towards the development of hardy bivoltine races to improve the quality and unit production of silk, warrant the selection of suitable parental material and their effective utilization. In this direction, forty seven bivoltine breeds maintained as germplasm at Andhra Pradesh State Sericulture Research Institute, Hindupur were reared under summer (high temperature (30 - 36°C) and low humidity (50 - 55 percent) conditions. Nine quantitative and qualitative traits of the breeds are considered for evaluation based on the Joint Scoring index method. Based on the evaluation, twenty bivoltine breeds comprising of ten oval breeds which scored lower values viz., APS5 (2.5764), APS7 (3.3050), APS19 (3.6508), APS11 (4.0610), APS9 (4.1034), APS31 (4.2272), APS27 (4.2939), APS45 (4.2956), APS39 (4.5588) and APS17 (4.7332) (oval) and ten peanut breeds for APS4 (3.1863), APS8 (3.2886), APS32 (3.4138), APS24 (3.5794), APS12 (3.8078), APS16 (3.9715) APS18 (4.1263), APS62 (4.2164), APS6 (4.2656) and APS10 (4.3777) were adjudicated as potential breeding resource material for initiation of breeding programme for the development of bivoltine silkworm hybrids suitable for tropical conditions.

608. Lakshmanan, V., Suresh Kumar, N., Naseema Begum, A., Pandya, R.K., Nirmal Kumar, S., Kamble, C.K., 2008.  
(Satellite Silkworm Breeding Station, Coonoor, India).  
An attempt on shuttle breeding approach to import genetic plasticity in the bivoltine silkworm, *Bombyx mori* L.  
Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10th June, 2008, 49-51

609. Mase, K., Iizuka, T., Okada, E., Nakajima, K., Tamura, Y., Miyazima, T., Yamamoto, T., 2008.  
(National Institute of Agrobiological Sciences (NIAS), Silk Technology Unit).  
Breeding of the Silkworm Race "Sericin Flavo" for Production of Sericin Cocoons Containing Flavonol.  
Journal of Insect Biotechnology and Sericulture, 77(3):171-174.

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Abstract: Sericin accounts for about 25 percent of the total composition of silkworm cocoon shells. It has recently been found to be a natural attracting material on cosmetic fields because of its skin moisturizing effect, and inhibitory effects against lipid peroxidation and tyrosinase activity. The silkworm race "Sericin Hope" possibly provides undestroyed natural sericin, which is easily gelled and emulsified at lower concentrations. In order to improve this race, we developed "Sericin Flavo" by cross-breeding it with the green-cocoon strain "Daizo (Matsumura)". This new race spins a high ratio of green sericin cocoons, each of which contains about 4.1mg of flavonol. These green sericin cocoons show higher antioxidant activity and a wider UV shielding effect.

610. Naseema Begum, A., Basavaraja, H.K., Dandin, S.B., Joge, P.G., Palit, A.K., 2008  
(Central Sericultural Research and Training Institute, Mysore, India.)

Multiple traits evaluation and selection of promising polyvoltine x bivoltine hybrids of silkworm, *Bombyx mori* Linn.

Uttar Pradesh Journal of Zoology, 28(3):269-280,(English)

Development of viable qualitatively and quantitatively superior polyvoltine x bivoltine hybrids of *Bombyx mori*, is essential to meet the silk demand in India as 95 percent of the total silk production is contributed by cross breed cocoons. Keeping this in view, a study was taken under for the evaluation and selection of polyvoltine x bivoltine hybrids suitable for the fluctuating climatic conditions of the tropics. Twenty five polyvoltine x bivoltine crosses comprising of six polyvoltine parents viz. BL67, Kolar Gold, Kollegal Jawan, Mysore Princess, Nistari, Pure Mysore and six bivoltine silkworm breeds viz. CSR2, CSR4, CSR5, CSR8, CSRI9, NB4D2 were evaluated in respect of 13 economic traits using analysis of variance (ANOVA) along with control Pure Mysore x NB4D2. The hybrids were short-listed using Multiple Traits Evaluation Index (E.I.) method. An average index value above 50 was recorded in fourteen hybrids. Ten hybrids recorded higher index value for 9 to 12 traits. In two hybrids viz. BL67 x CSR 19 and BL67 x CSR2 higher index values were observed for 10 to 12 characters, Among all the hybrids, maximum index value was observed in BL67 x CSR19 (65) followed by BL67 x CSR2(62) and in other hybrids it ranged from 50 to 57 as compared to control hybrid (46). The hybrids, BL67 x CSR2 and BL67 x CSR 19 recorded maximum E.I. for yield/10,000 larvae by weight (63), cocoon weight (73, 70), shell weight (79, 77), shell ratio (75, 74), raw silk percentage (63, 68) reelability (72) and cocoon shape uniformity through their lower standard deviation value of 7.47 and 8.21. respectively.

611. Naseema Begum, A., Basavaraja, H.K., Joge, P.G., Palit, A.K., 2008  
(Central Sericultural Research and Training Institute, Mysore, India).

Evaluation and Identification of Promising Bivoltine Breeds in Silkworm *Bombyx mori* L.  
International Journal of Industrial Entomology, 16(1):15-20.

Abstract: Under the all India programme of evaluation of mulberry and silkworm genotypes, twelve bivoltine silkworm breeds obtained from Central Silkworm Germplasm Resource Centre, Hosur (CSGRC) were evaluated at the bivoltine silkworm breeding laboratory, Central Sericultural Research and Training Institute, Mysore (CSR and TI). These breeds were tested during September-October 2003, August-September 2004 and February-March 2005. The average temperature and humidity during September-October 2003 26.5°C and 72.6 percent RH, while during August-September 2004, it was 26.5°C and 75.2 percent RH and during February-March 2005 it was 24°C and 48 percent RH respectively. The performance of the breeds in respect of 21 traits was studied and statistically analyzed using analysis of variance (Singh and Choudhary, 1985). Silkworm breeds were short-listed using Multiple Trait Evaluation Index method as suggested by Mano et al., (1993). Evaluation Index values were calculated for all the traits of economic importance and six breeds were short-listed based on average index value 50 and above 50. Two breed viz., BV 183 (SMGS-1) have recorded average E.I. >50 in 10 traits (except in neatness and ranked first and the breed BV 262 (SMGS-9) with EI value > 50 in nine

traits except in cocoon weight and neatness ranked second, in the order of merit. These two breeds may be selected as resource material for evolving region specific silkworm breeds.

612. Rama Mohana Rao, P., Premalatha, V., Joge, P.G., Nirmal Kumar, S., Kamble, C.K., 2008. (Central Sericultural Research and Training Institute, Srirampura, Mysore, Karnataka, India). Impact of productive female parent in improving silk productivity in cross-breeds of the silkworm *Bombyx mori* L. Souvenir and Abstracts of National Seminar on Scenario of Seribiotechnological Research in India (NSSSRI-2008), Department of Sericulture, Sri Padmavati Mahila Visvavidyalayam, Tirupati, Andhra Pradesh, India, 28th - 30th August 2008, 91.

Abstract: Silk productivity is expressed in cg of cocoon shell weight/day of 5th instar larval duration and is an important breeding index in silkworm *Bombyx mori* L. In the present investigation, five polyvoltine breeds Pure Mysore (PM), RD1, ND1, NP1 and ND7 which differ in productivity traits and a popular bivoltine breed CSR2 (used in the preparation of commercial silkworm seed) were utilized. All the five polyvoltine breeds were crossed with CSR2 males and F1 seed was prepared. Silk productivity in pure races and their F1 hybrids was calculated. Results indicate significant ( $P < 0.01$ ) differences in the silk productivity and also other cocoon traits. For silk productivity the breeds studied were in the order: ND7 (4.6 cg/day) > NP1 (3.91 cg/day) > ND1 (3.83 cg/day) > RD1 (2.73 cg/day) > PM (2.2 cg/day). The same trend was also observed in the corresponding F1 hybrids. Highest silk productivity of 7.24 cg/day was recorded in ND7 x CSR2, followed by NP1 x CSR2 (6.28 cg), ND1 x CSR2 (6.13 cg). Least productivity was recorded in PM X CSR2 (5.65 cg/day). Heterosis for silk productivity was also estimated in the hybrids studied. Data on heterosis indicate that for silk productivity only ND7 x CSR2 has recorded positive standard heterosis which is 13.53 percent. While, in all the other crosses negative standard heterosis was recorded. Overall results indicate that to improve productivity traits like silk productivity use of improved polyvoltine as a female component is a must in the cross-breed seed preparation for commercial exploitation. In the present investigation an attempt has been made to study the impact of productive polyvoltine female component in improving the quantitative traits in the preparation of cross-breed seed.

613. Rama Mohana Rao, P., Premalatha, V., Nirmal Kumar, S., Joge, P.G., Kamble, C.K., 2008. (Central Sericultural Research and Training Institute, Mysore, India). Role of sex in improving the cocoon traits in cross-breeding of the silkworm, *Bombyx mori* L. Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10th June, 2008, 52-53

614. Rama Mohana Rao, P., Premalatha, V., Singh, R., Joge, P.G., Nirmal Kumar, S., Kamble, C.K., 2008.

(Central Sericultural Research and Training Institute, Mysore, India).

Strategies for improving the fibre quality in polyvoltine x bivoltine silkworm hybrids.

Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10th June, 2008, 20-24.

Abstract: In the present study, 22 polyvoltine breeds maintained at Central Sericultural Research and Training Institute, Mysore, were evaluated based on quantitative and qualitative traits by utilizing multiple trait evaluation index method. Filament size variation, has been studied. Data indicated that the size of the filament decreased from the outer to inner layer. The decrease in filament size was sudden in some breeds whereas it was gradual in others. Data indicate that the slope of the denier is gradual in BL68 (-0.00268) and MY1 (-0.00295). In the case of BL43 (-0.00725) and BL25 (-0.00653), the slope was sudden in nature. In silkworm breeding programmes, breeds with gradual slope has to be selected in order to improve the fibre quality. Boil off loss ratio with reference to cocoon shell was determined. Highly significant correlation was observed between cocoon weight and cocoon shell weight, cocoon

shell weight and cocoon shell percentage, cocoon shell weight and filament length and cocoon shell percentage filament length. Among multivoltine silkworm breeds, some breeds such as PV1, BL61, NDV6 and 96A with low boil off loss ratio may be utilized as breeding resource materials in future breeding programme for the development of superior silkworm breeds with quality silk. Filament denier is mainly dependent on the race/hybrid used. Since raw silk is composed of many filaments, variation in thickness of the individual filament influences the size and thickness of the thread. Under these circumstances reeling characters have to be given priority in silkworm breeding. It was observed from the results that significant variation existed among the polyvoltine and MAD can be effectively utilized in the fibre quality improvement breeding programmes. Index values were calculated for rearing and reeling parameters separately. Ten top ranked breeds were identified as potential parents and NDV6 ranked the top most both in the reeling and rearing parameters. The other top ranked breeds were utilized in the breeding programmes as breeding resource materials for the development of superior polyvoltine breeds/hybrids with improved fibre characteristics.

615. Rama Mohana Rao, P., Singh, R., Sangappa, S., Premalatha, V., Basavaraja, H.K., Palit, A.K., 2008.

(Central Sericultural Research and Training Institute, Mysore, India).

Filament size variation in polyvoltine breeds of the silkworm, *Bombyx mori* L.

Indian Journal of Sericulture, 47(1):34-39.

Abstract: The size of the bave varies greatly with breeds of the silkworm. Even the size of the fibre of same cocoon varies at different parts. In the present study, filament size variation in 22 polyvoltine breeds of the silkworm *Bombyx mori* L. was studied. Data indicated that the size of the filament decreased from the outer to the inner layer. The decrease in filament size was sudden in some breeds whereas it was gradual in others. The slope of the denier was gradual in BL68 (-0.00268) and MY1 (-0.00295). In the case of BL43 (-0.00725) and BL24 (-0.00653), the slope was sudden in nature. In silkworm breeding programmes, breeds with gradual slope have to be selected in order to improve the fibre quality.

616. Rao, P.R.T, Das, S.K, Gupta, S.K, Pattanaik, Roy, G.C, Moorthy, S.M, Das, N.K., Sengupta, A.K., Sen, S.K and Saratchandra, B. 2008.

Induction of thermal stress on mulberry silkworm, *Bombyx mori* L for synthesizing new lines. U.P.J.Zool. 27 (3): 381-389.

Abstract: In West Bengal the rearing of high yielding bivoltine silkworm varieties is problem owing to the prevalence of high temperature and high humidity. Multivoltine breeds though better in survival yet poor economic traits and are unable to fetch better returns. As such a scheme has been framed to evolve temperature tolerance bivoltine lines with moderate technological traits suitable for plains of West Bengal. Therefore, six genetically divergent bivoltine silkworm breeds viz., P5, JD6, YS3, SF-19, NB18 and KPG-B reared alternatively under thermal stress followed by normal rearing in 18 generation. They were then screened under high temperature and high humidity. Three new temperature tolerant lines viz., BHR1, BHR2 and BHR3 with moderate economic traits could be evolved out of the study.

617. Sarkar, B.N., Sarmah, M.C., Chakravorty, R., 2008.

(Central Muga Eri Research and Training Institute, Assam, India).

Trimoulting behaviour in eri silkworm *Samia ricini*.

Indian Silk, 47(5):21-22.

Abstract: Eri silkworm moults three times in its larval period. The authors have reported trimoulting behaviour in *Samia ricini*, which can be utilized in breeding programme of eri silkworm.

618. Shirota, T., Aso, T., 2008.

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(Institute of Sericulture, Dainippon Silk Foundation, Iikura, Ami, Ibaraki, Japan).  
Genetic analyses and breeding strategy for silkworm races of different cocoon filament size.  
Journal of Sericultural Science of Japan, 77(2):153-158

619. Singh, R., Gangopadhyay, D., Nirupama, R., Kamble, C.K., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India).  
Artificial parthenogenesis and androgenesis as novel breeding strategies in the silkworm, *Bombyx mori* L.  
Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training  
Institute, Mysore, India, 10th June, 2008, 54-56

620. Singh, H., Suresh Kumar, N., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Selection of breeding resource material of bivoltine silkworm, *Bombyx mori* L. for breeding for high temperature tolerance.  
Indian Journal of Sericulture, 47(1):20-28,(English)  
Abstract: Evaluation of the working germplasm maintained at Central Sericultural Research and Training Institute, Mysore was carried out at high temperature ( $40 \pm 1$  0c) and high and low humidity conditions ( $85 \pm 5$  percent and  $50 \pm 5$  percent RH) to select breeding resource materials for the breeding for high temperature tolerance. After evaluation, breeds recording pupation rate 60 percent at high temperature conditions, with least b-values, with highest index scores and highest evaluation indices were selected as breeding resource materials. Accordingly, the breeds, CSR18, CSR19, CSR46, CSR47, CSR50 and CSR51 were selected as breeding resource materials for initiating the breeding programme for the development of breeds for high temperature tolerance.

621. Sowmyashree, T.S., Nataraju, B., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India.)  
Comparative studies on the susceptibility of identified BmNPV resistant silkworm breeds to induction of nuclear polyhedrosis.  
Indian Journal of Sericulture, 47(1):45-48,(English)  
Abstract: Five multivoltine and five bivoltine silkworm breeds, comparatively the most resistant to BmNPV PIB per os inoculation were screened for their resistance to BmNPV under inoculated condition as well as inoculation followed by exposure to low temperature condition. The LC50 values for all the breeds under both conditions were determined. Multivoltine and bivoltine silkworm breeds most resistant to BmNPV, under inoculated condition were over 1000 times more susceptible to BmNPV under inoculation and low temperature exposure conditions. It was also observed the bivoltines were the most susceptible to BmNPV when stressed than the multivoltine breeds. The higher susceptibility of silkworm to BmNPV is attributed to polygenic inheritance. It underlines the need to consider the impact of environmental factors on susceptibility while breeding silkworm for resistance to various viral diseases particularly the nuclear polyhedrosis.

622. Sudhakara Rao, P., Nataraju, B., Balavenkatasubbaiah, M., Sharma, D.D., Chandrasekaran, K., Narasimha Nayaka, A.R., Nisha Gopal., Kamble, C.K., 2008.  
(Central Sericultural Research and Training Institute, Mysore, India).  
Breeding strategies for the development of disease resistant silkworm breeds of *Bombyx mori* L. - A Review.  
Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training  
Institute, Mysore, India, 10th June, 2008, 73-76.  
Abstract: Silkworm crop loss is directly attributed to the occurrence of the disease caused primarily by the pathogens. Mulberry silkworm, *Bombyx mori* L. is affected by a number of diseases caused by viruses, bacteria, fungi and microsporidia silkworm diseases cause mortality and there by affect the

cocoon production. Efforts must be made to decrease the pathogen load in rearing environment and to strengthen the diseases resistance ability of the silkworms to obtain high and stable cocoon yield minimizing the crop loss. Although the disinfection of silkworm rearing environment carried out by spraying different disinfection is expected to maintain the pathogen load to the significant tolerable level. It is not always necessarily adequate to prevent the occurrence of silkworm diseases. Rearing of disease resistant / tolerant silkworm breeds/ hybrids is always better option with the strategies that the breeder can use skilfully for breeding disease resistant silkworm breeds and the problems and prospects involved in it. This way of managing silkworm disease is most economical and effective to produce high level of quality cocoon yield thereby enhancing overall productivity.

623. Farooq, M., Khan M.A., Ahmad, M.N., 2009.

(Central Sericultural Research and Training Institute, Central Silk Board, Pampore, Jammu and Kashmir).

Genetic divergence among bivoltine genotypes of silkworm, *Bombyx mori* L.

Proceedings of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009, 94-98.

Abstract: The discovery of heterosis has been one of the major landmarks in the annals of plant and animal breeding (Malik et al., 2003). Heterosis breeding in silkworm, *Bombyx mori* L. has substantially contributed to the increase in cocoon production and in improving the quality of raw silk (Govindan et al., 1996). To realize maximum heterosis, it is essential to have sufficient variability among the silkworm genotypes because variability is the basic requirement for the genetic improvement of a breed (Siddiqui et al., 1992). Crosses involving genetically distant parents are likely to produce more heterotic effect, and also more variability could be attained in the segregating generations of such crosses. Therefore, assessment of genetic divergence is very important to estimate the magnitude of variation and to design appropriate crossbreeding strategies. Estimation of genetic divergence helps to generate crosses which can yield more heterosis and which segregate in later generations into genotypes transgressing the performance of the better parent. To estimate the magnitude of genetic divergence and to identify the most divergent parents in silkworm, various workers have applied Mahalanobis D2 statistical tool over the years (Jolly et al., 1989, Subba Rao et al., 1989 and 1991, Govindan et al., 1996, Farooq et al., 2002 and Malik et al., 2003). The present study was undertaken to assess the magnitude of genetic divergence among forty-seven silkworm genotypes and to identify silkworm genotypes for cross breeding programmes. These forty-seven silkworm (*Bombyx mori* L.) genotypes were of varied geographic origin and were studied for their genetic diversity using Mahalanobis D2 statistic. Based on the D2 values for twelve important quantitative traits, these silkworm genotypes were grouped into twelve clusters using Tocher's method. The clustering pattern revealed that geographic diversity had no association with genetic diversity. The average inters cluster distances ranged from 3.07 to 99.78. Genetically the most divergent genotype, included in cluster 10 and cluster 12. Cocoon shell weight, renditta and single cocoon weight contributed maximum towards the total genetic diversity. The studies revealed that genetic distances should be taken into consideration to select parents for hybridisation. Crosses between genotypes from genetically diverse clusters may yield substantial heterosis.

624. Goel, A.K., Umameheshwar Rao, Y., Lakshmi, H., Ibrahim Basha, K., Sivaprasad, V., Chandrashekharaiyah., 2009.

(Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, Andhra Pradesh, India).

Conservation and utilization of sex limited bivoltine silkworm genetic resources.

Proceedings of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009, 112-117.

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Abstract: Wide range of genetic diversity is present among silkworm germplasm available in India. Like all plants and animals, silkworm genetic resources are the most valuable and essential basic raw material required to meet the current and future needs of silkworm crop improvement programmes. Therefore, collection, evaluation, documentation, utilization and conservation of silkworm genetic resources are of tremendous value to fulfil the requirement of basic genetic materials for silkworm improvement programmes for sustainable development of sericulture. The conventional breeding coupled with utilization of silkworm stocks with a translocated W chromosome has provided continued success in Japan. When the sericulture was in its glory, sex-limited breeds contributed more than 60 of their total silk production. Twenty, five bivoltine sex-limited lines have been derived and maintained at Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI), out of which few potential strains are being effectively utilised for production of commercial bivoltine and crossbreed hybrids.

625. Subramanya, G., Stephen Bishop., 2009.

(Department of Postgraduate Studies and Research in Sericulture Science, University of Mysore, Manasagangothri, Mysore, India).

A novel procedure for estimating inbreeding coefficient (F) in the inbred populations of mulberry silkworm *Bombyx mori* L.

Proceedings of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009, 144-146.

Abstract: During race maintenance the homozygous silkworm stocks are inbred in breeding centers and inbreeding depression for quantitative traits are expected. In order to understand the effect of inbreeding in the inbred population a pedigree data from a breeding experiment for twelve generations are studied by analyzing six important quantitative traits (variates) in four breeds of silkworm. Two Statistical models are developed for estimating the coefficient of inbreeding (F) through REML method based on the equation described by Falconer (1989). The results of the present findings have helped us to understand the relationship between generatios as well races and variates for inbreeding depression. The importance of the two models in silkworm breeding is discussed.

626. Mundkur, R., Mallesha Murthy., Latha, R., Krishna Rao, S., Sekharappa, B.M. ,2009.

(Karnataka State Sericulture Research and Development Institute, Bangalore, India.)

Classical linkage map based genetic stocks of silkworm, *Bombyx mori* maintained at KSSRDI, Bangalore.

In: Proceedings of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009., p.193-196,(English)

Abstract: The Karnataka State Sericulture Research and Development Institute (KSSRDI), Bangalore is maintaining working germplasm at Silkworm Breeding unit located at Bidadi and in two substations located at at Ooty and B.R. Hills. It is maintaining 142 bivoltine accessions and 37 multivoltine accessions spread in all the sub-stations. It is quite essential for a silkworm breeder to know the qualitative and quantitative traits of the working germplasm accessions and the genes related to them. Classical linkage maps list out the genes and their loci for most of the qualitative traits. It is unfortunate that linkage maps do not indicate genes of quantitative traits. Nowadays Molecular linkage maps are being drawn. BGI gene finders have predicted 21302 genes based on DNA marker technology. Attempts are also being made to integrate Classical Linkage Map with the Molecular Linkage maps. With this background an attempt is made to document the traits available in the silkworm germplasm bank of KSSRDI as against the genes marked in the classical linkage map.

627. Bindroo, B.B., Khan, M.A.,2009.

(Regional Sericultural Research Station, Miransahib, Jammu.)

Retrospection of the productive bivoltine silkworm breeds in Jammu and Kashmir.

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In: Proceedings of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009., p.197-201.

Abstract: Historical evidences have, revealed that in Kashmir indigenous silkworm races existed up to the year 1837 which were univoltine and brood white and yellow cocoons. There are also reports that indigenous silkworm races in Kashmir occur in 7th decade of 19th century AD called as Kashmir race or Kashmir cocoon with yellow, elongated and oval cocoons, the race is believed to have gone extinct during 1860's when it got wiped out due to pebrine. However, modern phase of silk industry in Kashmir virtually commenced from the year 1889 onwards when the industry got organized in the state as a Government monopoly. The Sericultural department initially depended on the imported seed especially from France and Italy which yielded good results. However, in the year 1907 a grainage was established in Kashmir where reproduction of seed was taken up on scientific lines but no indigenous race of silkworms was evolved. As a result, the rearing of silkworms in J to B-40 from Japan and the races Russian White, Azad and Azerbaijan from USSR. Although a huge variability was available in the form of more than 150 races, the actual breeding work for synthesis of improved materials began in the year 1959 and it was only during this period up to 1970 that the development of some productive bivoltine lines namely PLF, SS-41, SS-15A, SS-17, SS, BL1, KY1 and KY2 were undertaken. Subsequently during eighties isolation and fixation of lines from imported hybrid materials consisting of Kinshu-Showa continued and lines namely IB2, IB3, IB9 and IB11 were developed along with AT-9A, AT-4 and SKUAST-1 to SKUAST-10. However, all these lines remained unexploited for commercial hybrid utilization due to lack of authorizing agency. Following mass and directional selection procedures from 1985 to 1990, 13 lines named PAM-101 to PAM-113 were developed. Later two hybrids emerging from it namely PAM-101 X NB4D2 and PAM-111 x SF19 were authorized by Race Residual Committee of CSB for commercial use during autumn season in Northern Zone of country. In the year 1996, by using PAM-109 and PAM-111 in single, double and 3-way crosses, four lines namely RSJ1,h RSJ2, RSJ3 and RSJ4 were isolated and fixed. The hybrid RSJ3 x RSJ1 was authorized in the year 2007 by PRAC (Provincial Race Authorization Committee)for commercialization alongwith CS6 x PAM-101. The paper discusses in detail the status and potential of the bivoltine silkworm genetic stocks of J

628. Moorthy, S.M., Mandal, K., Das, N.K., Bhutia, R., Das, S.K., Bajpai, A.K.,2009.

(Central Sericultural Research and Training Institute, Berhampore, West Bengal.)

Genotype x environment interaction and stability analysis in bivoltine silkworm genotypes of *Bombyx mori* L.

In: Abstracts of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009., p.99.

Abstract: Forty-six bivoltine (germplasm / elite lines) silkworm genotypes were evaluated for stability parameters in three environments. Seven quantitative traits namely fecundity, cocoon yield / 10000 Larvae by number and weight, single cocoon weight, shell weight, shell percent and filament length were studied. Pooled analysis of variance showed highly significant differences among the genotypes and environments. Most of the traits indicated the presence of genetic variability among the genotypes and differential response to the environments studied. It was found that the tested genotypes did not show uniformity in stability and responsiveness for all these traits. Stable genotypes were selected based on mean yield, regression co-efficient (bi) and deviation from regression (S2di) for further utilization in breeding programme and also ultimately help to contribute towards easy conservation of biodiversity.

629. Rajanna, G.S., Govindaraju, S.T., 2009.

(Silkworm Breeding Unit, KSSRDI, Govt. Silk Farm, BIDADI- 562109. Ramnagaram District, Karnataka).

Genetic recombination - Repair process and 'stability' in tropical native silkworm races.

Proceedings of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009, 190-192.

Abstract: The ruling tropical polyvoltine silkworm races like Pure Mysore, Nistari and *C. nichii* exhibit consistent stability for higher fitness and lower productivity traits, despite inbreeding for over a thousand generations and rearing under vagaries of tropical environment. In the light of the available literature, it is speculated that these native races have attained stability in expression of fixed economic traits owing to genetic recombination, inheritance with great accuracy as well as efficient DNA repair mechanism, may be operative in them. In addition to harboring antagonistic relation between Productivity and Resistance traits, it is further attributed that while undergoing meiosis these genotypes are enjoying higher 'selection advantage' by incurring higher 'energy costs' for repair of DNA, masking of mutations and transmission of genome to the next generation. The possibilities of exploring the genetic organization- mechanism( s) /enzyme system (s) in place, in these genetic models and their application infuture breeding and maintenance programs to attain the stability, specially in the expression of resistance traits, leading to bio-diversity are discussed.

630. Bindroo, B.B., Khan, M.A., 2009.

(Regional Sericultural Research Station, Miransahib, Jammu).

Retrospection of the productive bivoltine silkworm breeds in Jammu and Kashmir.

Proceedings of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009, 197-201.

Abstract: Historical evidences have, revealed that in Kashmir indigenous silkworm races existed up to the year 1837 which were univoltine and brood white and yellow cocoons. There are also reports that indigenous silkworm races in Kashmir occur in 7th decade of 19th century AD called as Kashmir race or Kashmir cocoon with yellow, elongated and oval cocoons, the race is believed to have gone extinct during 1860's when it got wiped out due to pebrine. However, modern phase of silk industry in Kashmir virtually commenced from the year 1889 onwards when the industry got organized in the state as a Government monopoly. The Sericultural department initially depended on the imported seed especially from France and Italy which yielded good results. However, in the year 1907 a grainage was established in Kashmir where reproduction of seed was taken up on scientific lines but no indigenous race of silkworms was evolved. As a result, the rearing of silkworms in JK state depended exclusively on the imported seeds from France, Italy, Japan and China till 1984 when finally the importation of foreign seed was stopped completely. The imported silkworm races popular in Kashmir during yester years upto 1950 included Italian white and French Yellow from Europe; Bihianchi, White Bagdad, White European, Brussia, Adrionopoli, Italian Yellow, Golden-97, G3-86, G3-96 from Italy; Yellow Cevennes from France and race Bagdad from Padova. The other imported silkworm races which are reared in Kashmir from 1950-1960 included Yakwei, Haulak, Huachi, Chang Naung, King Haung, C-108, C-110, C-122 from China; J-112, J-122, B-23, B-24, B-25, B-26, B-27, B-28, B-29, B-30, B-33 to B-40 from Japan and the races Russian White, Azad and Azerbaijan from USSR. Although a huge variability was available in the form of more than 150 races, the actual breeding work for synthesis of improved materials began in the year 1959 and it was only during this period up to 1970 that the development of some productive bivoltine lines namely PLF, SS-41, SS-15A, SS-17, SS, BL1, KY1 and KY2 were undertaken. Subsequently during eighties isolation and fixation of lines from imported hybrid materials consisting of Kinshu-Showa continued and lines namely IB2, IB3, IB9 and IB11 were developed along with AT-9A, AT-4 and SKUAST-1 to SKUAST-10. However, all these lines remained unexploited for commercial hybrid utilization due to lack of authorizing agency. Following mass and directional selection procedures from 1985 to 1990, 13 lines named PAM-101 to PAM-113 were developed. Later two hybrids emerging from it namely PAM-101 X NB4D2 and PAM-111 x SF19 were authorized by Race Residual Committee of CSB for commercial use during autumn season in Northern Zone of country. In the year 1996, by using PAM-109 and PAM-111 in single, double and 3-way crosses, four lines namely RSJ1,h RSJ2, RSJ3 and RSJ4 were isolated and fixed. The hybrid RSJ3 x RSJ1 was authorized in the year 2007 by PRAC (Provincial Race Authorization Committee)for commercialization alongwith CS6 x PAM-101. The paper discusses in

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detail the status and potential of the bivoltine silkworm genetic stocks of JK state and highlight the economic trait performance of these materials.

631. He, K.R., Zhu, X.R., Meng, Z.Q., Chen, S., Liu, X.J., 2009.

(Sericultural Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China)

A Cross Breeding Method for Sex-linked Balanced lethal Line of Silkworm.

Canye Kexue, 35(3):558-561.

Abstract: Sex-linked balanced lethal lines of the silkworm *Bombyx mori* are key parental materials for "maleonly silkworm raising" practice. In order to improve these materials' practical economic traits more extensively, we developed a cross breeding method for improving the traits of sex-linked balanced lethal lines of silkworm. In this method, first, successive back crosses were conducted between males of conventional variety and females of sex-linked balanced lethal line to obtain an intermediate material with a translocated gene + h /1 on sex chromosome W. Second, a cross was conducted between females of the intermediate material and males of the balanced lethal line. And thirdly, continuous self-crosses were conducted to the above crossed material. Meanwhile, selection was carried out based on phenotype difference of the lethal line. Finally, a new sex linked balanced lethal variety named Ping 60 was obtained. The F1 hybrid of Ping 60 and conventional variety Huajing had an over 99 percent male larval rate. Its cocoon filament quality and larval vitality reached the levels of male populations from current commercial varieties.

632. Mandal, K., Moorthy, S.M., N.K.Das, S.K.Das, A.K.Bajpai and C.Sahu 2009.

An Analysis of Genetic Diversity in Bivoltine Silkworm, *Bombyx mori* L.

In: National conference on "Vanya silk" held at CMERTI, Jorhat on 2-3<sup>rd</sup> Feb 2009, pp.150.

633. Mandal, K., Moorthy, S.M., Das, N.K., Bhutia, R., Das, S.K., Bajpai, A.K and Sahu, C.R 2009.

Genetic variation and trait relationship in some bivoltine silkworm genotypes of *Bombyx mori* L. In: National symposium on " Agriculture in the Paradigm of Intergenerational Equity" held at BCKV, Kalyani, Kolkata on 22-23<sup>rd</sup> May 2009, pp.15.

Abstract: The extent of variability present in the bivoltine silkworm germplasm was studied in terms of range, mean, phenotypic and genotypic coefficient of variation using nine economic traits. Traits association was also studied with correlation analysis. The genotypes showed wide range of variability for all the nine traits studied. Genetic advance with 5% selection intensity, expressed as percent of mean varied from 3.5 to 29.5 %. High heritability (broad sense) was observed in cocoon shell percent (0.712) followed by single shell weight (0.649) and least was observed in yield / 10000 Larv.(No) ( 0.161 ). The high values of PCV and GCV for the characters viz., single shell weight and single cocoon weight suggests that there is a possibility of improving these traits through directional selection. High positive phenotypic as well as genotypic correlation was observed between single cocoon weight and single shell weight, between single shell weight and cocoon shell percent. Negative phenotypic as well as genotypic correlation was observed between yield / 10000 Larvae.(No) and single shell weight and cocoon shell percent.

634. Moorthy, S.M., Mandal, K., Das, N.K., Bhutia, R., Das, S.K., Bajpai, A.K., 2009.

(Central Sericultural Research and Training Institute, Berhampore, West Bengal).

Genotype x environment interaction and stability analysis in bivoltine silkworm genotypes of *Bombyx mori* L.

Abstracts of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009, 99.

Abstract: Forty-six bivoltine (germplasm / elite lines) silkworm genotypes were evaluated for stability parameters in three environments. Seven quantitative traits namely fecundity, cocoon yield / 10000 Larvae by number and weight, single cocoon weight, shell weight, shell percent and filament length

were studied. Pooled analysis of variance showed highly significant differences among the genotypes and environments. Most of the traits indicated the presence of genetic variability among the genotypes and differential response to the environments studied. It was found that the tested genotypes did not show uniformity in stability and responsiveness for all these traits. Stable genotypes were selected based on mean yield, regression co-efficient (bi) and deviation from regression (S2di) for further utilization in breeding programme and also ultimately help to contribute towards easy conservation of biodiversity

635. Moorthy, S.M., Das, N.K., Kar, N.B, Mandal, K and Bajpai, A.K 2009.

Heterosis analysis in some multi x bi three way crosses in silkworm *Bombyx mori* L.

In: National symposium on "Agriculture in the Paradigm of Intergenerational Equity" held at BCKV, Kalyani, Kolkata on 22-23<sup>rd</sup> May 2009, pp.16.

636. Mohan, B., Balachandran, N., Muthulakshmi, M., Hiremath, S.A., Srinivasa Babu, G.K.S., Kamble, C.K. ,2009.

(Central Sericultural Germplasm Resources Centre, Hosur-635 109)

Cocoon size variables vis-a-vis reeling traits of silkworm (*Bombyx mori* L.) germplasm.

Madras Agricultural Journal, 96 (7-12): 411-415.

Abstract: A study on the cocoon size variables and reeling traits was carried out with 101 bivoltine silkworm germ plasm based on single cocoon reeling data with the objectives (i) to analyze the degree of correlation of cocoon length, width and L I W ratio on total filament length, nonbroken filament length, (ii) to understand whether the shape of cocoons influences the reeling process, (iii) to find the cocoon shape uniformity among the accessions and (iv) to group the best accessions based on cocoon shape uniformity and longest filament length with less breakage during reeling cycle. The results revealed that 13 accessions (BBE-175, BBE-178, BBE-179, BBE-180, BBE-181, BBE-182, BBE-185, BBE-186, BBE-187, BBE-192, BBE-197, BBI205 and BBE-270) showed more uniformity for cocoon shape, as its standard deviation and coefficient of variation for cocoon length, width and LIW ratio were less than the overall mean values 1.886, 1.90 and 21.727, and 5.620, 9.990 and 12.360 respectively. These accessions also showed an average total filament length more than 1000 meters and less breakage during reeling cycles, indicating the superiority in filament strength. Correlation analysis showed that cocoon length, width and LIW ratio do not have statistically significant positive or negative correlation with total filament length or non-broken filament length. These 13 silkworm germ plasm have elongated and oval cocoon shape and this study suggests that cocoon shape (especially oval or elongated) should be given more importance in breeding plan than considering the cocoon size (i.e., cocoon length, width).

637. Muthulakshmi, M., Balachandran, N., Mohan, B., Babu, G.K.S., Koundinya, P.R., Hiremath, S.A., Kamble, C.K. ,2009.

(Central Sericultural Germplasm Resources Centre P.O. Box-44, Thally Road, Hosur-635 109, Tamil Nadu).

Performance of Elite Bivoltine Silkworm Germplasm Stocks in India.

Madras Agricultural Journal, 96 (7-12): 416-419.

Abstract: Bivoltine silkworm genetic resources conserved at Central Sericultural Germplasm Resources Centre, Hosur is the largest collection of its kind maintained in India at one place. All the collections were made over a period of 10 years from 1995 and include 180 exotic (13 countries', and 157 indigenous accessions. These collections are well characterized considering different morphological descriptor states and evaluated for various economically important parameters including standard rearing and reeling traits. Breeders require such well characterized and evaluated materials for identification of races suitable for their breeding programme. Witt" this intention the data were evaluated using the cumulative evaluation index and potentia accessions with multiple traits were identified among the germ plasm stocks conservec Accession number BBI-0255 was identified for six specialized characters and Accessio~

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number BBE-0224 and BBE-0268 were identified for five specialized characters. Seven accessions were found to possess four specialized traits and remaining accessions were found to be superior in few or more characters in comparison with ruling bivoltine breeds India (CSR-2 and CSR-4) at present.

638. Ramesh, C.K., Subramanya, G., 2009.

(Post Graduate Department of Biotechnology, Sahyadri Science College, Shimoga, Karnataka).

Selection of promising bivoltine hybrids by MST Analysis.

Asian Journal of Experimental Sciences, 23(1):115-122.

Abstract: The objectives of the silkworm breeding is realized when the best hybrids for commercial exploitation are identified. The ultimate results in silkworm breeding are judged by the superiority of commercial characters of the parental strains that appear in the F1 hybrids. In the present experiment an attempt has been made to select superior Bivoltine hybrids utilizing the four newly evolved bivoltine races, viz., MG405, MG406, MG408, and MG414 and crossing them with newly evolved bivoltine races viz., KA, NB4D2, NB7 and NB18 to evaluate the rearing performance of different hybrid combinations. The mean values of the hybrids were subjected to MST analysis, and relevant selection index programme to identify the promising hybrids. The identified hybrids were short listed. The use of selection index and recommendation of hybrids for commercial exploitation is discussed.

639. Singh, R., Nirupama, R., Gangopadhyay, D., Kamble, C.K., 2009.

(Central Sericultural Research and Training Institute, Mysore - 570 008, India).

An improved method of androgenetic development in the silkworm, *Bombyx mori* L.

Sericologia, 49(2):255-258.

Abstract: Androgenesis provides an opportunity in silkworm breeding for the development of homozygous bisexual silkworm breeds. In the present study, an attempt was made to modify the method of Astaurov (1957) in order to improve the induction of androgenetic development in the oviposited eggs of the mulberry silkworm, *Bombyx mori* L. A higher trend towards androgenetic development and hatching were observed in the improved method.

640. Xu, L., Meng, X.M., Qi, L., Liu, F.Y., Su, G.M., Jiao, Y., 2009.

(The Sericultural Research Institute of Liaoning Province, Fengcheng Liaoning 118100, China.)

Analysis on the Combining Ability of Three Important Economic Traits in *Antheraea pernyi*.

Canye Kexue, 35(3):618-622, (Chinese)

Abstract: Determination of combining ability was one effective way to select excellent parents and make excellent cross combinations in breeding of *Antheraea pernyi*. This study selected 6 tussah varieties including 8821, 8822, 9906, Kangda, Heichi and 582 as parental strains, and analyzed the combining ability of three traits, namely amount of cocoon crop, thousand-cocoon weight and cocooning rate to newly hatched larvae, by Griffing's diallel cross method. The result showed that the variance of special combining ability (SCA) was significantly better than that of the general combining ability (GCA) in amount of cocoon crop and cocooning rate to newly hatched larvae, meaning that non-additive effect of these two characters was dominant in cross combinations, but additive effect of thousand-cocoon weight was dominant. The GCA and SCA between various parents and cross combinations were significantly different. The GCA effect value of 582 was the highest in these three traits. The sum of breeding value and SCA of cross combination 582 x Kangda was significantly superior to other combinations in amount of cocoon crop and cocooning rate to newly hatched larvae. The best cross combination of breeding value and SCA was 582 x 9906 in thousand-cocoon weight.

641. Zhang, S.M., Mao, X.B., Huang, W., Xu, H.D., 2009.

(Rural Development and Information Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China)

Quantitative Assessment on Research Investment Return of Silkworm Breeding in Zhejiang Province.

Canye Kexue, 35(2):445-450.

Abstract: The present work has attempted to assess the impact of research investment in silkworm breeding in Zhejiang Province within the years of 1981 to 2005 using DREAM model. The results revealed that the total economic benefits is 41. 648 million Yuan and the internal rate of return (IRR) is 35. 09 percent which is much higher than the average return rate (8 percent) from social gross investment. But after the year of 2000, the benefit has sharply dropped from 1. 970 2 million Yuan to 0. 6483 million Yuan because very few new varieties had been obtained and distributed. Based on these results, it is suggested that measures and policies should be employed to increase amount of research investment, to speed up innovations in breeding materials and technology, to reform the research system for silkworm breeding and to inspire initiatives of the breeders.

642. Hiremath, S. A., Koundlnya, P. R., Qadri, S. M. H., Kamble, C. K.,2010.

(Central Silk Technological Research Institute, Bangalore 560 068, Kamataka, India)

Cocoon filament size deviation in multivoltine breeds of silkworm, *Bombyx mori* L.

Sericologia, 50(2), 273-280.

Abstract: Parental multivoltine breeds were studied for their size deviation within the cocoon. Single filament was reeled with eppovette in 100 m sects from the beginning to the end. Every 100 m IS weighed and the size deviation along the length of filament was calculated for each breed. Results indicate that the filament size showed decrease from outermost layer to the innermost. The regression analysis (Least square method) was used for calculation of the slope of size on curve and relationship between filament length vs. slope, average filament size vs. slope maximum filament size vs. slope. The analysis indicates that a highly significant positive correlation exists between slope vs. average filament size ( $r = 0.984$ ) and slope vs. maximum filament  $=0.622$ ) for breeds. The accessions BMf-0063 ( $d=1.67, b=-0.00137$ ) and BMf-0013 5,  $b= -0.00113$ ) recorded lower slope values with fine denier. Similarly, accessions BMf-0068 6,  $b=0.00192$ ) and BMf-0038 ( $d=2.52, b=0.00126$ ) recorded lower slope values with coarse These potentiality are to be used in the breeding programme for evolving superior quality multivoltine and also to be used as potential parents to gain heterosis in cross breed development for better post cocoon traits.

643. Kishor Kumar., Basavaraja, H.K.,2010.

(P3, Basic Seed Farm, National Silkworm Seed Organisation, JLB Road, Vidyananyapuram, Mysore-570 008, India).

Studies on the evaluation and identification of silkworm breeds of *Bombyx mori* l. With reference to cocoon filament traits.

Utar Pradesh Journal of Zoology, 30(3): 313-323.

Abstract: The process of silkworm breeding starts with examination of genetic resources and selection of breeding materials. In the present study, 8 dumbbell breeds were evaluated to know their genetic variability with regard to the yield characters giving thrust on post cocoon traits. The statistical results revealed that all the experimental breeds viz., CSR4, CSR5, CSR6, CSRI7, CSRI9, 5HT, NB4D2 and NB 18 performed significantly different indicating the presence of inherent variations. Multiple trait evaluation index study on the overall performance revealed that, CSR4, CSR5 and CSRI9 with 659.7, 596.8, 595.7 cumulative indices respectively were ranked as top 3 breeds. Since the raw silk is composed of many filaments, variations in thickness of the individual filaments influence the raw silk deviation and thereby silk quality. Denier variation studies revealed that, the cocoon filament size showed marked variations with respect to cocoon layers. The denier curve reduces linearly in breeds CSR 19, CSR5 and CSR4 by recording higher regression co-efficient (slope-b) values of -0.00127, -0.00129 and -0.00136 respectively. Significant correlations were observed for size variation versus average filament size ( $r = 0.6908^*$ ), maximum filament size ( $r = -0.8724^{**}$ ) and size differential ( $r = -0.9574^{***}$ ). Based on these results CSR4,

CSR5 and CSR 19 have been identified as future breeding resource materials for development of breeds that can produce high quality silk of international standard.

644. Mandal, K., Moorthy, S.M., Sudip Sen, Das, N.K., Sahu, C.R., 2010.

An Analysis of Genetic Variation and Diversity in Bivoltine Silkworm (*Bombyx mori* L) Genotypes.

In. National symposium on "Deccan Biodiversity Co-existence of funal species in changing landscapes" held at Osmania University, Hyderabad on 2-3 Dec., 2010. pp.38.

Abstract: The bivoltine silkworm, *Bombyx mori* L., shows substantial variation in their qualitative and quantitative traits. In this study the genetic variation and diversity was estimated among fifty-six bivoltine silkworm genotypes by using four morphological and nine economic traits. Among the four morphological characters studied, cocoon shape shown higher variability with six different types followed by larval body colour which shown five different types. The genotypes were grouped into 8 clusters based on nine quantitative traits using Mahalanobis's  $D^2$  - statistics and Canonical root method. The  $D^2$  (Mahalanobis' distance) statistic revealed 8 clusters with substantial inter cluster distances. The genotypes included in different clusters varied from 1 to 49. Cluster III showed maximum intra cluster divergence while inter cluster divergence was maximum between clusters VII and VIII. The cluster III contained forty nine genotype and other clusters contained single genotype. The characters viz., single shell weight, shell%, single cocoon weight and yield / 10000Larv.(wt) showed maximum contribution towards total divergence among the genotypes. The possibility of exploiting genetic variation in these traits for efficient breeding programme is discussed.

645. Moorthy, S.M., Mandal, K., Das, N.K., Kar, N.B., Das, S.K., 2010.

Genotypic variability and Genotype  $\times$  Environment Interactions in Bivoltine silkworm genotypes of *Bombyx mori* L.

In. "National symposium on Deccan Biodiversity Co-existence of funal species in changing landscapes" held at Osmania University, Hyderabad on 2-3 Dec., 2010. pp.10.

Abstract: Sericulture is supported by the silkworm gene resource diversity and its advancement is largely based on the silkworm variety improvement, and breeding of new silkworm varieties which depend on the available silkworm germplasm resources. The extent of variability present in the forty six bivoltine silkworm genotypes was studied in terms of range, mean, heritability, phenotypic and genotypic coefficient of variation to understand nature and magnitude of gene action. The genotypes showed wide range of variability for all the nine traits studied. Genetic advance with 5% selection intensity, expressed as percent of mean varied from 3.5 to 29.5 %. The high values of PCV and GCV for the characters viz., filament length and shell weight suggest that there is a possibility of improving these traits through directional selection. Further, these genotypes were evaluated in three environments to assess the genotype environment interactions (GEI) and determine stable genotypes using stability parameters. Pooled analysis of variance showed highly significant differences among the genotypes and environments. Most of the traits reminded the presence of genetic variability among the genotypes and genotypes responded with the environments. The tested genotypes did not show uniformity in stability and responsiveness for all these traits. Stable genotypes were selected based on mean, regression coefficient (bi) and deviation from regression ( $S^2_{di}$ ) for further utilization in breeding programme and also ultimately help to contribute towards easy conservation of biodiversity.

646. Naseema Begum, A., Moorthy, S.M., Nirmal Kumar, S., 2010.

Boil off loss in cocoons and filament neatness of selected breeds of silkworm, *Bombyx mori* Linn. reared in different seasons.

Entomon 35 (1): 43-46.

Abstract: The boil-off loss percentage and filament neatness in the cocoons of 24 bivoltine silkworm breeds comprising 12 Chinese type oval breeds and 12 Japanese type dumb-bell breeds were assessed in

the laboratory. JPN8 among the oval breeds and EHT among the dumbbell breeds were identified for low boil-off loss and CSR3 among the oval breeds and 5HT among the dumbbell breeds showed higher filament neatness. The above breeds were identified as potential resource material for future breeding programmes

647. Nirmal Kumar, S., Prakash Murthy, Moorthy, S.M., 2010.

Heterosis studies in selected quantitative traits in silkworm, *Bombyx mori* L.

African Journal of Basic & Applied Sciences 2 (5-6): 135-143.

Abstract: The extent of heterosis in certain important characters was studied in silkworm, *Bombyx mori* L in a set of 30 hybrids produced from a two different voltine groups (Three multivoltine breeds and five bivoltine breeds). Appreciable and variable amount of relative heterosis was noticed for all the traits studied indicating genetic diversity among parents used. Irrespective of crosses, negative heterobeltiosis was observed for all the traits except pupation rate. The relative heterosis (%) varied from 8.95 to 37.14 in regular crosses and 8.97 to 36.6 in reciprocal crosses for different characters. In heterobeltiosis, the heterosis (%) ranged from -10.57 to 4.17 in regular crosses and -11.06 to 5.68 in reciprocal crosses for different characters. As far as traits are concerned, maximum relative heterosis was observed in filament length both in regular (37.14%) and in reciprocal crosses (36.6%), whereas pupation rate has shown maximum heterobeltiosis in regular (4.17%) as well as in reciprocal crosses (5.68%). The crosses with CSR17, CSR18 and KA (bivoltine) as one of the parents have shown higher relative heterosis and heterobeltiosis. This result was further confirmed through evaluation index (EI) calculated over heterosis. Five top heterotic crosses were identified based on mid and better parent heterosis and evaluation index calculated over both heterosis for each trait.

648. Nirmal Kumar, S., Prakash Murthy, D.P and Moorthy, S.M 2010.

Analysis of heterosis over environments in silkworm, *Bombyx mori* L.

ARPN Journal of Agricultural and Biological Sciences, 6(3):1-9.

Abstract: The magnitude of heterosis over mid-parent and better parent were calculated in fifty bivoltine hybrids derived from five oval type and five dumbbell type bivoltine genotypes of silkworm, *Bombyx mori* L for eight important traits under varying environmental conditions. The expression of both relative heterosis and heterobeltiosis was higher in summer (8.97 & 6.71%), followed by rainy (5.87 & 3.42%) and winter (2.13 & 0.03%). In summer, pupation rate, cocoon weight, shell weight and filament length exhibited higher heterosis for both relative heterosis and heterobeltiosis and total larval period in winter. Negative heterosis was observed for neatness. Among the characters pupation% exhibited higher heterosis (14.56%), followed by shell weight (11.74%), filament length (8.91%) and cocoon weight (6.49). Many hybrids displayed conspicuous heterosis for most of the characters. There was differential behaviour of various hybrids in different environments for the expression of heterosis. Estimates of heterosis computed revealed significant reciprocal effect for most of the traits but no consistent pattern was found across hybrids. All straight and reciprocal crosses exhibited significant positive heterosis and heterobeltiosis for pupation rate in all three environments. Other characters did not show such uniform trend. The crosses which involved CSR4, CSR17, CSR18, CSR19, KA and NB4D2 as one of the parents exhibited favourable heterosis and crosses (Straight & reciprocals) viz., CSR17 x CSR4, CSR18 x CSR19, CSR4 x KA and CSR17 x 19 showed desirable heterosis for most of the characters. The study showed the potential of commercial exploitation of heterosis as well as the potential of isolating pure lines among the progenies of heterotic  $F_1$ s for improvement of yield potential in silkworm.

649. Sharmila, K.K., Ashwath, S.K., Mahalingappa, K.C., Sabita, N., Qadri, S.M.H., 2010.

(Central Sericultural Research and Training Institute, Mysore-570 008, India)

Field evaluation of new bivoltine hybrid GEN3 X GEN2 developed by amylase marker based selection.

Indian Journal of Sericulture, 49(1):58-63

Abstract: The productive breeds and hybrids with high silk content and raw silk recovery developed recently by adopting conventional method of breeding fares well only during favourable seasons of the year. Hence, attempts were made to evolve robust breeds by adopting marker assisted selection utilizing digestive amylase as marker as it is associated with better digestibility resulting in higher survival. High activity amylase genes from the polyvoltine breeds, viz., Pure Mysore and Nistari were introgressed into the genetic background of productive bivoltine breeds, namely, CSR2 and CSR5 respectively through the strategy of amylase marker based selection in each generation followed by recurrent backcross breeding. Evaluation of the evolved lines and their hybrids indicated the superiority of GEN3 x GEN2 hybrid which performed better both as pure lines as well as hybrid. In order to evaluate the performance of this hybrid in the field, parents were reared and 71,020 GEN3 x GEN2 hybrid layings were prepared during 2001-06 and tested in different agroclimatic conditions of Karnataka, Tamil Nadu and Andhra Pradesh. Evaluation studies indicated a consistent yield of 62 kg/100 dfls in favourable and adverse seasons. Frequency distribution of yield range has shown that 66 percent of the total farmers have achieved cocoon yields of over 60 kg/100 dfls. The results indicated the suitability of this hybrid for rearing throughout the year even with marginal farmers under sub-optimal conditions of leaf quality and rearing management.

650. Ajay Kumar Goel., Uma Maheshwar Rao, Y. , Chandrashekharaiiah., Raju, P.J. ,2011.

(Andhra Pradesh State Sericulture Research )

Selection Of Potential Parents For Hybridization: Screening For Good Combiners

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, p 89,(English)

Abstract: The success of any hybridization programme mainly depends upon the selection of parental breeds. The evaluation index (ei) which is being commonly used by the silkworm breeders for evaluation and selection of parents for hybridization programme does not provide any information about combining ability of breeds under consideration. The experiment initiated with such parental stock may not yield desired success. Initially a broad selection can be made on the basis of personal experience, breeding objective, weak and strong points of the breeds. However, it would be better approach to make the final decision on selection of parents for hybridization programme on the basis of some information about their combining ability with respect to selective important parameters. The present study explains a simple method to screen the inbred lines for their contribution to combining ability and selection of breeding resource material on the basis of information on combining ability and performance of the screened lines.

651. Balachandran. N., Srinivasa Babu, G.K. , Kamble, C.K., 2011.

(Central Sericultural Germplasm Resources Centre, Central Silk Board, Thally Road, Hosur)

Bio.Evaluation And Identification Of Potential Multivoltine Silkworm Genetic Resources For Silkworm Crop Improvement

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, p 82,(English)

Abstract: Genetic resources contribute as raw materials for crop improvement. The success of any breeding depends on the initial selection of parents, their effective utilization in desirable combinations. It also depends on the ability of breeds to assemble and recombine the genetic variability, to get the potential gene combinations from the gene pool based on phenotypic expression leading to genetic fixation of the traits over generation. It is important that the genetic difference between parents should be wide to get heterosis. Varied silkworm germplasm stocks contribute immensely to the development of viable and hardy silkworm breeds for commercial exploitation. The very purpose of the existence of a conservation centre is to collect, characterize, evaluate and conserve the germplasm material and also to prevent these valuable genetic material evolved very long period from extinction. Hence, in the present

study an attempt has been made to identify potential and promising multivoltine silkworm genetic resources conserved at csgrc hosur from among a collection of 73 multivoltine silkworm genetic resources (exotic-10 and indigenous-63) for 28 important economic parameters on rearing as well as post cocoon traits. Many potential and multivoltine accessions also have been identified which are performing better for multiple traits to meet the present demand for utilizing them in various silkworm-breeding programmes. The fact that these silkworm genetic resources have completed more than 70 generations and stabilized to the tropical conditions is an added advantage. Such well-characterized and evaluated silkworm germplasm are very handy tools. Breeders want such proven and thoroughly evaluated silkworm genetic resources for inclusion in the breeding programmes in addition to develop region and season specific breeds for varied agro climatic conditions in such contexts this study would be of much value.

652. Jagadeesh, N., Raju, H.V., Manjula, A.,2011.

(P1 Grainage, National Silkworm Seed Project, Chikkamalavadi)

Studies On Maintenance Of Racial Characters By Adopting Systematic Breeding Programme In Multivoltine Pure Mysore Silkworm *Bombyx mori* L.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, p 67-68,(English)

Abstract: Sericulturists of south India at commercial level are predominantly rearing crossbreed dfls (cb) for their livelihood and to generate cocoons for reeling purpose. The female parent of cb dfls - multivoltine breed pure mysore (pm) is being maintained / reared by p1 seed farmers from time immemorial in multivoltine seed area of kunigal. The sustenance of pure mysore breed is vital and needs to be maintained by systematic programme for its racial characters and at p1 grainage, nssso, chikkamalavadi the said programme is being carried out by one way system of multiplication to produce pm dfls at p3 / p2 / p1 levels. The studies indicated that, the breed characters ie., egg / dfls, larval and cocoon characters can be maintained in different seasons and discussed in the paper.

653. Mandal, K., Moorthy, S.M., Bhutia, R., Das, N.K, Bajpai, A.K., Sahu, C.R.,2011.

Evaluation and identification of suitable bivoltine silkworm hybrids for hilly regions of Eastern India.

In: Golden Jubilee National Conference on "Sericulture Innovations : Before and Beyond" held at CSRTI, Mysore on 28-29 January 2011.pp.70.

Abstract: A total of forty two bivoltine silkworm hybrids prepared from the six oval bivoltine breeds (SK3, O2, O3, O4, MC3, KA) and seven dumbbell bivoltine breeds [SK4, SK6, D4, D6(P), D7, BHR2, MJ1] were evaluated in three seasons viz., autumn, spring and summer in the Darjeeling hills of West Bengal. Analysis of variance (ANOVA) indicated significant differences ( $p < 0.01$ ) for all the characters among hybrids and seasons with significant hybrid x season interactions. Out of forty two hybrids, nineteen hybrids scored evaluation index values (EI) of above 50 in autumn, twenty-three in spring and twenty-nine in summer seasons. Based on the overall mean data and evaluation index values, the hybrids viz., O3 x D6(P) and SK3 x D6(P) are adjudicated as most promising for commercial exploitation in the hilly regions of West Bengal / Eastern India.

654. Moorthy, S.M, Mandal, K., Kar, N.B., Das, S.K., 2011.

(Central Sericultural Research and Training Institute, Berhampore-742 101, West Bengal, India)

Identification of suitable bivoltine foundation cross for sustainable bivoltine silkworm seed crop in tropics

The Bioscan 6(4) : 697-700.

Abstract: The success of rearing with presently available conventional bivoltine breeds are unpredictable in some of the seed crop seasons in West Bengal and similar regions of India because of prevailing of highly fluctuating adverse climatic conditions. Thus, it is very much essential to have a bivoltine breed, which can give stable cocoon crop under variable environments. As single bivoltine parent shown poor

cocoon yield in those seasons, as an alternative, foundation crosses (FC) were tried. Out of nine FCs evaluated, D6 (P) N x SK4C shown higher cocoon yield of 12.8kg/10000 larvae with 91% pupation (average of three seasons) compared to 9.8kg cocoon yield/10000 larvae with 67% pupation in control, NB18 x P5. Thus the identified FC can be utilized as a male parent for preparation of three way cross, multi x bi hybrid for utilization in commercial crop.

655. Moorthy, S.M., Mandal K., Bhutia, R and Das, N.K (2011).

(Central Sericultural Research and Training Institute, Berhampore-742 101, West Bengal.)

Stability of bivoltine silkworm genotypes of *Bombyx mori* L for a few economic traits.

Journal of Sericulture and Technology, 2 (1), 46-50.

Abstract: Forty-six bivoltine genotypes of silkworm were evaluated for stability parameters in three environments. Seven quantitative traits namely fecundity, cocoon yield / 10000Larvae by number and weight, cocoon weight, shell weight, shell per cent and filament length were studied. Pooled analysis of variance showed highly significant differences among the genotypes and environments. Most of the traits indicated the presence of genetic variability among the genotypes and differential response to the environments studied. The tested genotypes did not show uniformity in stability and responsiveness for all these traits. Stable genotypes were selected based on mean yield, regression co-efficient (bi) and deviation from regression ( $S^2_{di}$ ) for further utilization in breeding programme.

656. Murthy, N. , Subramanya, G. ,2011

(University Of Mysore, Mysore, 570 006)

Genotypic And Phenotypic Co-Efficient Variation For The Six Quantitative Traits Of The Silkworm *Bombyx mori*  
In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, p 76-77,(English)

Abstract: Understanding the nature of inheritance of qualitative and quantitative characters and prediction of genotypic and phenotypic variations are very important in any breeding programme. In the present study, heritability analysis (broad sense) was carried out for multivoltine race npnd (non pigmented non diapause), and two evolved bivoltine breeds namely mg406 and kalimpong-a-i by analyzing six economic traits namely larval weight, cocoon weight, shell weight, shell percentage pupation rate and filament length. The estimation of broad sense heritability have clearly indicated high values of heritability (70 percent) for shell weight, shell ratio, larval weight and pupation rate, whereas heritability values of 70 percent was observed for the traits of cocoon weight and filament length. The general trend of high heritability for the above traits have clearly indicated the role of low environmental influences and their usefulness in the selection programme based on phenotypic performances. The estimation of genotypic and phenotypic variance for various economic traits are clearly demonstrated highest pcv and gcv values in ka-i breed than mg406 breed and npnd race. The importance of heritability estimations are discussed with references to choosing of the best genotypes and designing successful for hybridization programme.

657. Naseema Begum, A. , Mal Reddy, N. , Nirmal Kumar, S. , Moorthy, S. M. , Qadri, S. M. H. ,2011

(Central Sericultural Research And Training Institute, Mysore 570008)

Performance Of Newly Evolved Bivoltine Double Hybrid, (Csr50 X Csr52) X (Csr51 X Csr53) Of Silkworm, *Bombyx mori* L. With Reference To Egg Yield Parameters

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, p 64,(English)

Abstract: Silkworm eggs are the vital inputs for the production of cocoons in the silk industry. Egg yield is an important parameter for the egg producers in terms of cost of production of quality seed. The present study was undertaken to assess the performance of newly evolved bivoltine double hybrid, (CSR50 X CSR52) x (CSR51 X CSR53) with reference to egg yield parameters. By using two parental

breeds viz., CSR2 (oval type) and csr4 (dumbbell type) and four foundation crosses (Fcs) viz., CSR2 X CSR27, CSR50 X CSR52 (oval x oval) and CSR6 X CSR26, CSR51X CSR53 (dumbbell x dumbbell), popular single hybrids viz., CSR2 X CSR4 / CSR4 X CSR2 and popular double hybrids (CSR6 X CSR26) X (CSR2XCSR27) / (CSR2XCSR27) X (CSR6XCSR26) and new double hybrids, (CSR50XCSR52) X (CSR51 X CSR53) / (CSR51 X CSR53) X (CSR50 X CSR52) were prepared and studied. Statistical analysis indicated that the fcs have shown significant (p0.05) improvement over parental breeds in respect of pupation (5.15 percent), cocoon yield (14.78 percent), cocoon weight (7.79 percent), shell weight (8.09 percent) with less melting percentage. The double hybrids are significantly superior over single hybrids in respect of egg yield (34.23 percent), layings recovery percent (18.46 percent), eggs / dfl (20.11 percent), less unfertilized and non-diapause eggs. However, the results clearly indicated non-significant difference between single and double hybrids in terms of cocoon yield.

658. Naseema Begum, A. Mal Reddy, N. , Nirmal Kumar, S. , Saikat Babrjee., Moorthy, S.M. , Qadri, S. M. H. ,2011.

(Central Sericultural Research And Training Institute, Mysore 570 008. )

Changes in qualitative and quantitative traits in parents, foundation crosses and double hybrids of bivoltine silkworm of *Bombyx mori* L., due to seasonal variation

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, p 81-82,(English)

Abstract: Seasonal performance of silkworm plays an important role in understanding combined action of environment and genetic potentiality of the genotype. The present study was undertaken to assess the effect of seasonal variation on bivoltine silkworm. Eight newly evolved productive bivoltine breeds and selected oval and dumbbell foundation crosses and double hybrids were used in present experiment. The parental breeds and their foundation crosses and double hybrids were reared in three seasons i.e., pre-monsoon, monsoon and post-monsoon. The observation were made on various yield and silk contributing parameters namely, fecundity, larval duration, survival, cocoon yield, cocoon weight, shell weight, shell percentage, reelability percent, filament length, raw silk percentage, filament size and neatness. In all the breeds / foundation crosses/hybrids highly significant seasonal variation were found for majority of traits evaluated. The double hybrids show less seasonal variation for majority of traits compared to their parental breeds and foundation crosses. The study clearly revealed the maximum expression of economic traits during favourable seasons like monsoon and post monsoon when compared to unfavorable pre- monsoon. The results of the present study clearly showed that the season performance trends reveal that double hybrids have shown less variation in majority of traits due to seasonal variation. The parental breeds have shown more alteration for majority of traits compared to their foundation crosses and double hybrids.

659. Pal N.B., Moorthy, S.M., Khan, M.Z, Das, N.K, Mandal, K., 2011.

Analysis of genetic diversity in some multivoltine silkworm genotypes of *Bombyx mori* L.

In: Golden Jubilee National Conference on “Sericulture Innovations: Before and Beyond” held at CSRTI, Mysore on 28-29 January 2011.pp.68.

Abstract: Genetic divergence is one of the useful tools for selection and efficient use of parents for hybridization to develop potential breeds as well as hybrids. The nature and the magnitude of genetic divergence was estimated in twenty one multivoltine silkworm genotypes using Mahalonobis's  $D^2$  – statistic. The genotypes were grouped onto seven clusters showing fair degree of genetic divergence. The cluster III contained the maximum number of genotype and the cluster II and VII contained the single genotype. The highest inter-cluster distance between cluster I and cluster VII followed by between cluster II and cluster VII showing wide diversity among the groups. The inter cluster distance in most of the cases were higher than the intra-cluster distance indicating wider genetic diversity among the genotypes of different groups. The character wise shell%, fecundity, shell weight and cocoon weight

showed maximum contribution towards total divergence among the genotypes. Thus based on inter-cluster distances, diverse lines from different clusters (I, II, III, VI and VII) should be chosen for hybridization programme for yield improvement in multivoltine silkworm.

660. Pal, N.B. Moorthy, S.M., 2011.

(Central Sericultural Research and Training Institute, Berhampore-742 101, West Bengal, India)

Assessment of variability in larval and cocoon traits in some genotypes of bivoltine silkworm, *Bombyx mori* L.

International Journal of Research in Biological Sciences, 1 (4): 59-65.

Abstract: Variability in larval and cocoon traits was studied in 19 genotypes of bivoltine silkworm, *Bombyx mori* L. A great deal of variability was observed between the genotypes for the characters studied. Characters viz., larval weight, silk gland weight, cocoon weight, shell weight and shell%, have shown higher variability than other characters. Significant and high positive correlation was observed between larval weight and silk gland weight and cocoon weight. Both larval body length and cocoon length has positive correlation with shell weight. Silk gland weight also has positive correlation with larval weight, cocoon weight and shell weight. The dendrogram constructed using Euclidian distance revealed 19 breeds separated in to three distinct clusters and cluster I and III having 7 breeds each and cluster II with 5 breeds. The distinct clustering reflects differences of the origin and traits associated with them.

661. Rama Mohana Rao, P. Premalatha, V. Joge, P.G. Dayananda. Nirmal Kumar, S. Renukeshwarappa., 2011.

(Central Sericultural Research And Training Institute, Mysore-570 008)

Silk Productivity In Different Breeds And Hybrids Of The Silkworm *Bombyx mori* L

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, p 84, (English)

Abstract: Silk productivity expressed in cg. Of shell weight/day of 5th instar larval duration is an important breeding index. In the present study silk productivity in some breeds and hybrids of the silkworm *Bombyx mori* L. were estimated in three different seasons. In the silkworm, *Bombyx mori* L., larval duration is mostly determined by the fifth instar larval period which lasts for about 6 to 8 depending on the silkworm breeds and seasons. In sericulture, shorter fifth instar period is preferred to save mulberry leaves, labour and also to avoid occurrence of diseases. It is necessary to develop silkworm breeds/hybrids with shorter larval duration and higher silk productivity/day. Results indicated significant ( $p < 0.01$ ) variation between breeds and also between hybrids. Silk productivity ranged from 2.41 to 4.813 cg in polyvoltines, 5.333 to 6.9 cg in bivoltines, 4.843 to 7.3 cg in polyvoltine x bivoltine hybrids and 7.426 to 6.744 cg in bivoltine hybrids. Results also indicate significant variation between seasons. Heterosis studies indicated standard positive heterosis in majority of breeds/hybrids in summer. Silk productivity is an important parameter, hence it is essential that this breeding index should be included as one of the characters for evaluation of silkworm hybrids and also as parameter during selection process in the breeding. The present investigation is aimed at assessing the silk productivity in different breeds and hybrids and also in different seasons. Use of this parameter as selection criteria in breeding process is discussed.

662. Rama Mohana Rao, P. Premalatha, V. Shivakumar, K.P. Joge, P.G. Nirmal Kumar, S., 2011.

(Central Sericultural Research And Training Institute, Mysore-570 008.)

Studies on fibre characteristics of polyvoltine breeds and polyvoltine x bivoltine hybrids of the silkworm *Bombyx mori* L.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, p 138-139, (English)

Abstract: Of late, in silkworm breeding programmes, more emphasis is being given to the fibre quality improvement. The main quality parameters for high grade silk are size deviation, evenness, cleanness, neatness, tenacity, elongation and cohesion and winding breaks. Among these, some are breed / hybrid specific. Size deviation of the yarn mainly depends on the individual silk filament size variation from outer to the inner layer and filament size. In the present investigation, some of the new improved polyvoltine breeds and polyvoltine x bivoltine hybrids have been studied and assessed for their fibre characteristics. Present study aimed at investigating the importance of fibre characteristics in silkworm breeding programmes. Special emphasis was given to study the impact of early generation selection in respect of cocoon Size Variation, Neatness And Filament Length In Fibre Quality Improvement Programmes.

663. Veeranna Gowda. Ashwath, S.K. Kalpana, G.V., 2011.

(Central Sericultural Research and Training Institute, Srirampura, Mysore - 570 008 (Karnataka))

Studies on the evaluation of hybrid vigour in different crosses of bivoltine F1 hybrids of silkworm, Bombyx mori L. in varied environmental conditions

Green Farming , 2 (2) : 236-238,(English)

Abstract: Heterotic effects for quantitative traits were studied in varied environmental conditions to evaluate the hybrid vigour in the 28 newly identified bivoltine F1 hybrid combinations. The degree of heterosis and overdominance varied considerably among the quantitative trait. Among the hybrids studied, significant hybrid vigour was found in CSR12xD13, CSR12xCSR26, CSR12xCSR16 and CSR17xCSR26 for all the traits and the same has been identified for commercial exploitation.

# CHAPTER-III

## MOLECULAR ASPECTS OF SILKWORM BREEDING

664. Fujimaki, T., 1976.  
(Sericultural Experiment Station, Tokyo, Japan)  
On the linkage analysis of a new mutant, Eguchi's crayfish pupae, in the silkworm, *Bombyx mori* L.  
*Journal of Sericultural Science of Japan*, 45(6):507-510.  
Abstract: Malformation of silkworm, pupal wing similar to the crayfish (cf) mutant was discovered from a breeding strain and shown to be controlled by a recessive gene which was independent of the cf gene. The gene, named as cf-e (Rguchi's crayfish pupa) was linked with the multilunar marking (L) on the 4th chromosome with the cross over value of 14.92
665. Gamo, T., 1983.  
(Silkworm Breeding Division, Sericultural Experiment Station, Yatabe, Ibaraki, Japan)  
Biochemical genetics and its application to the breeding of the silkworm.  
*Japan Agricultural Research Quarterly (Japan)*, 16(4):264-272.  
Abstract: This paper critically reviews available information on biochemical genetics of the silkworm (*Bombyx mori*) and its application. Biosynthesis of fibroin and sericin in the silk D gland has been studied widely. The DNA encoding both proteins was cloned using gene manipulation techniques. Some base sequences in their nucleotides were analysed. The genetic engineering technique is also applicable to silkworm breeding. Recombination of foreign genes encoding enzymes into silkworms will improve the efficiencies in feeding on mulberry leaves and in protein synthesis of silkworm larvae. Additional studies required are discussed.
666. Hitoshi, U., Shigeki, M., Kensuke, S., 1985.  
(Laboratory of Biochemistry, Department of Agricultural Chemistry, Tohoku University 1-1 Tsutsumidori-Amamiyamachi, Sendai 980, Japan.)  
Sequence polymorphisms around the 5'-end of the silkworm fibroin H-chain gene suggesting the occurrence of crossing-over between heteromorphic alleles.  
*Gene*, 34:351-355  
Abstract: Nucleotide sequences around the 5'-ends of the silkworm fibroin H-chain genes of the three strains, Nd(2), J-139, and F1(Gunka x Hoshun) of *Bombyx mori* were determined. Comparison of the sequences among these strains and the sequences reported previously for the two other strains, F1 (Gunpo x Shugyoku) and Daizo, indicates that polymorphisms are present in the 5'-flanking and intron regions and that each region has at least two sequence variants independent of each other. These results suggest that crossing over between the heteromorphic H-chain alleles has occurred during the breeding of these strains.
667. Tikhomirova, T.P., Timofeeva, M.Y., Kupriyanova, N.S., Rodina, E.Y., Sevastyanova, G.A., Filippovich, Y.B., 1988.  
Polymorphism of ribosomal genes for insertion content in the genomes and breeds and heterotic hybrids of silkworm.  
*Doklady, Biological Sciences*, 303(1-6):685-688.  
Abstract: The organization is compared of the ribosomal genes in DNA of 2 breeds (Skorospelaya-2 and Pyatigorskaya-5) of *Bombyx mori* and their heterotic hybrids. The data presented on the structure of the ribosomal genes can be a convenient molecular-genetic marker for detecting interbreed polymorphism, and can be used for breeding.
668. Asakawa, H., Hamano, K., 1989  
(Kyohoku Senior High School, Nagasaka Yamanashi, Japan)  
Polymorphism of digestive amylase isozyme in the silkworm, *Bombyx mori*.  
*Journal of Sericultural Science of Japan*, 58(4):322-326.,

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Abstract: Amylase isozyme patterns of digestive juice were investigated using 103 silkworm strains. Three types of isozyme patterns were detected; that is, those possessing 4 or 5 cathodal bands (type-4 or type-5), or without any cathodal band (type-0). 59 of 103 strains were grouped into type-0, then 29 and 12 of them were grouped into type-4 and type-5 respectively. The highest amylase activity was shown in type-5 strains followed by type-4, whereas amylase activity was weak in most of the type-0 strains. In the breeding strains, type-5 strains were small in number than type-0 strains. Isoelectric points of four isozymes found commonly in type-4 and type-5 strains were pI 8.95, 9.15, 9.35, and 9.50.

669. Chinya, P.K., Das, P.K., Subba Rao, G., 1990.

(Central Sericultural Research and Training Institute, Berhampore, West Bengal, India)

Gel electrophoresis characterization of haemolymph proteins in some mulberry silkworm genetic stocks evolved by mutation breeding.

In: Seventh All India Congress of Cytology and Genetics, Department of Zoology, University of Kalyani, West Bengal, December 22-26, 1990.

Abstract: Genetic variability of haemolymph proteins of eight genetic stocks of mulberry silkworm was studied by polyacrylamide gel electrophoresis technique. Except one the stocks were evolved by mutation breeding. Haemolymph was collected from early 5th instar larvae for the study. Electrophoresis was carried out in tube gels containing 7 percent polyacrylamide. For the characterization of protein bands, the gels were stained with Coomassie brilliant blue. Polymorphic variations were observed. A comparison of the number, density and migration velocity of larval haemolymph protein bands of the electrophorogram revealed differences.

670. Das, S.K., Chinya, P.K., Patnaik, S., Subba Rao, G., 1990.

(Central Sericultural Research and Training Institute, Berhampore, West Bengal, India)

Studies on the genetic variability of haemolymph esterases in some genetic stocks of mulberry silkworm *Bombyx mori*.

In: Seventh All India Congress of Cytology and Genetics, Department of Zoology, University of Kalyani, West Bengal, December 22-26, 1990.

Abstract: With a view to study the genetic variability of esterase isozyme, polyacrylamide gel electrophoresis of haemolymph of eight genetic stocks of mulberry silkworm, *Bombyx mori* was performed. The stocks were evolved by mutation breeding except one. In silkworm esterase isozyme is known to be related with various metabolic processes like regulation of diapause etc. Esterase of silkworm is known to have properties of both cholinesterases and aliesterases being controlled codominantly by Bes-alleles. Four blood esterase isozymes have been identified viz. A, B, C, and O (Null) are known. In our experiment esterase isozymes have been identified by using naphthyl acetate as substrate and Fast Blue RR as coupler. Analysis of the zymograms reveals the presence of maximum 4 esterase bands. In some genetic stocks one band is lacking. A comparative analysis of isozyme bands in both sexes of eight silkworm genetic stocks has been done in respect of number, migration velocity, thickness and density of bands.

671. Marcato, S., Trevisan, M., Cappellozza, L., Bisol, P.M., 1990.

Variability in the gene-enzyme systems in races of *Bombyx mori* (Lepidoptera, Bombycidae) used for silk production.

Redia, 73(2):595-608.,

Abstract: Microelectrophoresis was used to estimate the level of protein variability in different races of the silkworm *Bombyx mori*. Nine isoenzymes (11 loci) were analysed. There was only a low level of genetic variability since most loci exhibited homozygous genotypes. The only exception was the polymorphic loci of phosphoglucoseisomerase (Pgi) and mannosephosphateisomerase (Mpi) which showed heterozygous genotypes. It is suggested that these results are largely due to the rearing conditions and the breeding of closely related individuals in order to maintain stocks. The relationships

between genetic structure, darwinian fitness and the level of silk production were studied by cross-breeding experiments between individuals with distinctive Pgi genotypes. The results suggested that in *B. mori*, as in other organisms, the Pgi locus may play an adaptive role and the heterozygotes possess superior fitness.

672. He, J., 1991.

(Institute of Sericulture, Chinese Academy of Agricultural Sciences, Zhenjiang, Jiangsu, China) .

Studies on the inheritance of a deletion type of the blood esterase isoenzymes in the silkworm.

*Acta Sericologica Sinica*, 17(2):95-100.

Abstract: The silkworm variety Dong 34, which is a deletion type of the blood esterase isoenzymes on A region of the electrophotogram of the silkworm blood esterase, is a homozygote of the codominant multiple allele Bes Ao of the blood esterase unexpression of A region. The genotype symbol of Dong 34 is Bes Ao/Ao. The silkworm variety Dong 34 was bred from the cross breeding progeny of its parents by segregation, selection and solidification. The esterase on A region belongs to the cholinesterase.

673. Chatterjee, S.N., Rao, C.G.P., Chatterjee, G.K., Ashwath, S.K., Patnaik, A.K., 1993.  
(Central Sericultural Research and Training Institute, Mysore, India)

Correlation between yield and biochemical parameters in the mulberry silkworm, *Bombyx mori* L.

*Theoretical and Applied Genetics*, 87(3):385-391.

Abstract: A detailed study was carried out on six biochemical parameters and four yield attributes using multiple regression analysis to investigate their relationship in the mulberry silkworm, *Bombyx mori*. The study generated new information on the importance of digestive amylase activity for the survival of the silkworm and revealed the inability of other enzymes to affect this relationship. Data also substantiate the observations made earlier on the genetic variability of amylase in the mulberry silkworm. Analyses extend the positive role of alkaline phosphatase and invertase in the expression of the other yield traits studied and indicate the definite possibility of using biochemical markers for silkworm breeding.

674. Promboon, A., Engkakul, A., Gnernsiri, L., Saksoong, P., 1993.

(Department of Biochemistry, Kasetsart University, Bangkok, Thailand)

Amylases of the polyvoltine silkworm (*Bombyx mori*): variation of activity in the Thai local race.

*Sericologia*, 33(4):603-613.

Abstract: This report presents the pattern of the total amylase activities during larval development and some properties of the enzymes in some polyvoltine stocks of Thailand. Among 24 strains studied, variations in the activity of the total enzymes were noted at the peak feeding day of the fifth instar. Eight overlapping groups were differentiated in order to select the high amylase activity strains to be used as raw materials for the future breeding work for the areas under water constraints.

675. Goldsmith, M.R., Shi, J., 1994.

(University of Rhode Isl, Department of Zoology, Kingston, Ri, 02881)

Molecular Map for the Silkworm - Constructing New Links Between Basic and Applied-Research.

In: American Chemical Society Symposium Series, Silk Polymers Materials Science and Biotechnology, 544:45-58.

Abstract: The domesticated silkworm, *Bombyx mori*, has > 200 mapped mutations, and hundreds of inbred races which differ in economically important characters. To enable genetic mapping of such quantitative trait loci, facilitate breeding of silkworm strains for current sericultural growth areas in the tropics, and provide a physical framework for direct gene isolation, we are constructing linkage maps based on physical DNA markers. Preliminary maps using F2 crosses comprise 60 restriction fragment length polymorphisms (RFLPs) which cover 16 linkage groups and 8 unlinked markers, potentially representing 24 of 28 chromosomes. These molecular markers include 10 cloned genes correlated with

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conventional genetic maps, 9 retrotransposons, and 41 anonymous RFLPs isolated from a silkworm follicle cDNA library.

676. Nagaraju, J., Abraham, E.G., Nagaraja, G.M., Sethuraman, B.N., 1995.

(Seribiotech Research Laboratory, Bangalore, India)

Molecular breeding-an unified approach to silkworm improvement.

In: Current Technology Semimar on Mulberry Silkworm Breeding Genetics, Molecular Biology Agriculture, September 20-22, 8.

Abstract: DNA based diagnostics is considered as unigene technique and advantageous in silkworm breeding programme as it involves multigenes or quantitative traits which are difficult to deal with when relying in phenotypic assay alone molecular marker systems are potentially used in crop and animal improvement considering the same techniques with silkworm which offers an ideal genetic background associated with genetic difference for various economically important quantitative and qualitative trait, the application of molecular breeding for silkworm in discussed in this paper.

677. Nagaraju, J., Sharma, A., Sethuraman, B.N., Rao, G.V., Singh, L., 1995.

(Seribiotech Research Laboratory, II Stage Mahalakshmpuram Post, No. 8, West of Chord Road, Bangalore 560 086, India)

DNA fingerprinting in silkworm *Bombyx mori* using banded krait minor satellite DNA-derived probe.

Electrophoresis, 16(9):1639-1642.

Abstract: The genomic DNA from thirteen different ecotypes and inbred lines of silkworm, *Bombyx mori*, were analyzed by digesting with BstNI and HinfI restriction enzymes followed by hybridization with banded krait minor satellite DNA (Bkm)-2(8) minisatellite probe. The DNA fingerprinting revealed 9-31 discrete intense bands, some of which were ecotype/inbred line-specific. Individual specific DNA fingerprints in two representative genotypes and their F-1 hybrid offspring were also obtained. Individuals of a given parental line showed very similar profiles and the hybrid offspring showed the combined profile of both parents. The presence of bands specific to diapausing and nondiapausing strains and to particular genotypes indicate their potential use for marker-assisted breeding and varietal identification.

678. Ohnuma, A., Tazima, Y., 1996.

(Institute of Silkworm Genetics and Breeding, Ami, Ibaraki, Japan)

Sek, a new polyphagous gene discovered in a Japanese indigenous race of the silkworm.

Reports of the Silk Science Research Institute (Japan), 44:1-13.

Abstract :A new polyphagous gene sek was discovered in a Japanese race-sekai-ichi by raising newly hatched larvae on a synthetic diet that is deficient in mulberry leaf components. Breeding experiments with a known polyphagous strain were conducted and the results are discussed.

679. Wu, X.F., Lou, C.F., Xu, J.L., Miao, Y.G., Cui, W.Z., 1996 .

(Zhejiang Agricultural University, Hangzou, China.)

Studies on the catalase activity in the haemolymph of the silkworm, *Bombyx mori* L.

Sericologia, 36(4):681-689,

Abstract: The catalase activity in the haemolymph of the silkworm was analyzed at different developmental stages and it was found that there was a dynamic change. The catalase activity of the male was much higher than that of the female. Diet also affected the activity of the catalase. There was a great variation of the catalase activity among silkworm races. The results showed that the catalase activity was closely related to the larval health. The catalase activity in the larva poisoned by fluoride raise while the degree of rise varied with silkworm races. The change of catalase activity was suggested to be taken as one of the physiological indices for anti-fluoride race breeding.

680. Hwang, J.S., Kang, H.A., Lee, J.S., Lee, S.M., Sohn, H.R., 1997.  
(National Sericulture and Entomology Research Institute, RDA, Suwon, Korea Republic) Genetic relationships among the parental *Bombyx mori* strains of the current F1 hybrid silkworm based on RAPD. Korean Journal of Applied Entomology (Korea Republic), 36(3):206-214.  
Abstract: The genetic relationships among the twenty parental silkworm, *Bombyx mori*, strains authorized in Korea were evaluated using RAPDs-PCR. Twenty-six different 10-mer oligonucleotide primers were used to screen genetic characteristics. Twenty-four primers showed different banding patterns among the strains. Based on these RAPD patterns, the genetic relationship among the silkworm strains were analysed using the unweighted pair-group with arithmetic average method. The phylogenetic relationships in the twenty silkworm strains were classified into two major sub-groups at the genetic similarity coefficient of 0.60. The first sub-group included Jam113, Jam119, Jam120, Jam123, Jam125 and Jam127, and Jam114, Jam121, and Jam122, Jam124, Jam126, Jam128, Jam129, Jam130, Jam131, Jam132, Jam133, Jam134, Jam301 and Jam302 were included in the 2nd group. The genetic distance values among Jam114, Jam120 and Jam127 were lower than those among the other strains, while Jam129 was very closely related to Jam131 with a coefficient value of 1.0.
681. He, Y., He, S., Lu, C., Xiang, Z., 1999.  
(Sericultural Research Institute, Chinese Academy of Agricultural Science, Zhejiang 212 018, China.) Breeding of denonucleosis (DNV) resistance near-isogenic line and RAPD molecular markers. *Canye Kexue*, 25(4):217-220(Chinese).
682. Zhang, Z., Qin, J., 1999.  
(Key Laboratory of Silk Biotechnology, Ministry of Agriculture, Zhejiang, China) Genetic analysis of normal temperature lethal gene (ntl) in the silkworm *Bombyx mori*. *Canye Kexue*, 25(3):141-143.
683. Datta, R.K., Aswath, S.K., 2000.  
(Central Sericultural Research and Training Institute, Mysore, India) Strategies in genetics and molecular biology for strengthening silkworm breeding. *Indian Journal of Sericulture*, 39(1): 1-8.
684. Sree Kumar, S., Sateesh Kumar., Ponnuvel, K.M., Chitra, S., China, P.K., Ashwath, S.K., Rao, C.G.P., Vandana Singh., Chowdary, N.B., Datta, R.K., 2000.  
(Central Sericultural Research and Training Institute, Mysore, India) Identification of DNA markers closely linked to cocoon-shell character in the silkworm, *Bombyx mori* L. through RFLP.  
National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, 18.  
Abstract: Improvement of quantitative traits by conventional breeding has been a time consuming and laborious task for the breeders. In recent years DNA markers especially RFLPs are extensively used for selection and improvement of the target traits during the breeding process. The present study was undertaken to explore the possibility of identifying RFLP markers closely linked to cocoon shell ratio, which primarily determines the silk yield.
685. Xiao, Q., Huang, Y., Cao, Y., Liu, L., Huang, Z., Lu, C., Yu, B., Huang, X., Yu, A., 2000.  
(Department of Sericulture and Fashion, South China Agricultural University, Guanzhou, China) Construction of *Bombyx mori* transposon expression vector pSVHK1.4.  
*Canye Kexue*, 26(4):228-233.  
Abstract :In order to construct *Bombyx mori* transposon expression vector as a tool in research on the transgenic genetics and breeding of silkworm, the hsp70 promoter from *D. melanogaster* genome was

amplified by PCR and cloned into plasmid pcDNA3-GFP containing Green Fluorescent Protein gene (gfp) firstly obtain recombinant plasmid pCGH. Secondly, silkworm K1.4 transposable element (1.35kb fragment) from plasmid pUK1.4 was transferred into eukaryon expression vector pSVL to get recombinant plasmid pSK1.4. Lastly, large fragment containing hsp70 promoter and gfp from plasmid pCGH was transferred into Bgl II site at the K1.4 transposable element of pSK1.4. The silkworm transposon expression vector pSVHK1.4 has been constructed successfully.

686. Aswath, S.K., Morrison, M.N., Datta, R.K., 2001.

(Central Sericultural Research and Training Institute, Mysore, India)

Development of near isogenic lines of productive silkworm breeds by isozyme marker based selection.

Proceedings of the National Academy of Sciences India, 71 B(III).

Abstract :Of late, molecular marker facilitated investigations using isozyme/DNA markers is being widely explored in the breeding of crop plants and live stock for the improvement of desirable traits. In India, limited success of conventional breeding and selection strategies adopted so far in silkworm breeding, has warranted testing of the new strategies for maximising yield realization. In this direction, work carried out earlier on a number of biochemical parameters has shown the prospects of using digestive amylase as a marker in silkworm breeding due to its close association with survival, better digestibility and isozyme polymorphism. A test breeding plan was adopted using the indigenous low yielding polyvoltine breeds namely, Pure Mysore and Nistari having '4 band' and '5 band' cathodic amylase isozyme types respectively as donor parents (DP) and the productive bivoltine breeds like NB18, CSR2 and CSR5 with 'null' type of isozyme as recurrent parent (RP).

687. Li, M.W., 2001.

Breeding of new germplasms of the silkworm (*Bombyx mori* L.) resistant to nuclear polyhedrosis or denonucleosis and identification of RAPD markers to the resistant genes.

Chinese Academy of Agricultural Sciences.

688. Nagaraju, J., 2002.

(Centre for DNA fingerprinting and Diagnostics, ECIL road, Nacharam, Hyderabad, India.)

Application of genetic principles for improving silk production.

Current Science, 83(4):409-414.

Abstract: During the last three decades, silk production increase benefited, to a great extent, from the application of genetic principles in the silkworm breeding programmes. The conventional breeding method such as progeny testing, exploitation of hybrid vigour, genotype X environment interaction coupled with utilization of silkworm stocks that carry a translocated W chromosome provided continued success. Recent developments in transgenic silkworm technology, application of DNA markers for strain characterization and construction of linkage maps, and understanding the genetics of viral resistance provide requisite tools that can expedite further silkworm improvement.

689. Sethuraman, B.N., Mohandas, T.P., Chatterjee, S.N., 2002.

(Seribiotech Laboratory, Central Silk Board, Kodathi, Bangalore, India)

DNA fingerprinting with homologous multilocus probes and search for DNA markers associated with yield attributes in silkworm, *Bombyx mori*.

European Journal of Entomology, 99(3):267-276.

Abstract: RFLP clones harbouring multi-copy DNA sequences were isolated from the Pst I sub-genomic library of the indigenous silkworm race, Nistari, and were used for DNA fingerprinting studies in 13 stocks of silkworm, *Bombyx mori* L. Six multilocus probes produced 180 RFLP markers that showed a high level (98 percent) of polymorphism and are highly useful in molecular mapping, genotype characterization and marker assisted selection (MAS). The dendrogram derived from UPGMA analysis clearly divides the 13 silkworm stocks into two major clusters: high- and low-yield stocks. Furthermore,

adopting multiple regression analyses, the RFLP marker(s) associated with characters of economic importance were identified, a first of its kind for any species of insect of commercial importance. The results obtained create an opportunity of using germplasm stocks directly for isolating specific RFLP band(s) and use it for MAS in breeding programs.

690. Chatterjee, S.N., Mohandas, T.P., 2003.

(Seribiotech Laboratory, Kodathi, Bangalore, India)

Identification of ISSR markers associated with productivity traits in silkworm, *Bombyx mori* L. Genome, 46(3):438-447.

Abstract: *B. mori*, commonly recognized around the world as the mulberry silkworm, is characterized by a wide variability in yield and developmental traits, which have been proven through conventional genetic analysis to be of polygenic nature. A large number morpho-biochemical traits and RFLP and RAPD markers are mapped on different linkage groups, but very little attention has been given to unravelling the genetics of yield traits. To address this issue, polymorphic profiles of 147 markers generated with 12 ISSR primers on the genomic DNA of 20 silkworm stocks of diverse yield status were subjected to multiple regression and discriminant function analyses (DFA). This led to the identification of eight markers generated by six primers, which demonstrated high beta-coefficient indices of -0.451 to -0.940. Furthermore, a significant difference between the yield traits for stocks with and without the specific marker could also be established. The inheritance pattern of one marker, L13 800bp identified at the first step of selection of markers through stepwise regression analyses for five yield parameters is discussed in the context of applying multiple regression analysis for establishing association, if not linkage, between a group of DNA markers and a particular yield trait of polygenic nature and using such markers in molecular marker-assisted breeding programmes.

691. Chatterjee, S.N., Pradeep, A.R., 2003 .

(Seribiotech Laboratory, Central Silk Board, Kodathi Campus, Sarjapur Road, Carmelram, Bangalore 560035, Karnataka, India. )

Molecular markers (RAPD) associated with growth, yield and origin of the silkworm, *Bombyx mori* L. in India. Genetika, 39(12):1612-1624,

Abstract: To identify the molecular markers associated with growth and yield parameters in silkworm, *Bombyx mori*, RAPD profiles generated with seven UBC primers for fourteen silkworm stocks, originated from China, Japan, India and Russia, were statistically analyzed. Stepwise Multiple Regression Analysis establishes significant association of 45 markers with larval span, growth indices and four cocoon yield parameters relevant for silk production and t-test attest significance of the association of 89.5(1500 bp) and 54.13(300 bp), respectively with longer larval duration and high cocoon weight. The validity of this selection of markers was further supported with Discriminant Function Analysis (DFA) done on the basis of Mahalanobis D2 statistics. The two indices of yield/growth were also tested with DFA, which helped in identifying a few markers and thereby opened scope of using such marker (e.g. 91.11(900 bp)) for incorporating molecular markers in the breeding program for crop improvement in silkworm.

692. Rao, C.G.P., Chandrashekharaiyah., 2003.

Molecular marker assisted breeding in silkworm.

In: Concept Papers of Mulberry Silkworm Breeders Summit, 18-19 July 2003, Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India, 80-85.

693. Yao, Q., Li, M.W., Wang, Y., Wang, W.B., Lu, J., Dong, Y., Chen, K.P., 2003.

(Jiangsu University, Institute of Life Sciences, Zhenjiang 212013, Peoples Republic of China)

Screening of molecular markers for NPV resistance in *Bombyx mori* L. (Lep., Bombycidae).

Journal of Applied Entomology, 127(3):134-136.

Abstract: Silkworm (*Bombyx mori* L.) is one of the important economic insects. Silkworm rearing and silk industry plays an important role in china, india and other developing countries. in the long history of sericultural practice, introduction of silkworm strains with high resistance to diseases has greatly improved cocoon and silk quality and productivity. However, current silkworm breeding is mainly based on traditional method that involves high input of time and labour. in order to increase the selection efficiency and accuracy for future silkworm breeding, it is necessary to establish a molecular marker-assisted selection system. in our study, three silkworm near isogenic lines that had different resistance to nuclear polyhedrosis virus (NPV) were established by means of different hybridization methods. a total of 150 random amplified polymorphic dna (rapd) random primers were used to screen molecular markers. among them, two molecular markers opa-18(700) and opy-11(400) were found linked to major genes resistant and susceptible to NPV, respectively. Validity of the molecular markers was proved in F2 populations.

694. Chatterjee, S.N., Tanushree, T.,2004.

(Molecular Genetics, SeriBiotech Laboratory, Central Silk Board, Kodathi Campus, Sarjapur Road, Bangalore-560 035, Karnataka, India.)

Molecular profiling of silkworm biodiversity in India.

Genetika, 40(12):1618-1627.

Abstract: Molecular tools opened a new vista to understand nature's bio-diversity and its relevance and the same approach was availed of to build-up the foundation work on the bio-diversity of silkworm spp in India. It is well established that the heritage of usage of silk for dress materials in India, Russia and China dates back to premedieval period and in spite of industrial development resulting to deforestation, India still can claim as the owner of wide bio-diversity, especially in northern India for silkworm spp. The molecular diversity was assessed among *Antheraea mylitta*, *A. assama*, *A. pernyi*, *A. provlei*, *A. roylei* and *Philcosomia cynthia* with 11 ISSR and 8 non-random primers on agarose gel. Nei's statistics as also Euclidean distance matrix was applied to find the genetic diversity between the six species, wherein the closest relationship between *A. pernyi* and *A. proylei* is established. With the help of POPGEN statistics, the average genetic heterozygosity appeared as 0.271 while Shanon's index is 0.4312 and alleles with segregation ratios of 3:1, 2:1, 1:1, 9:1 (generated with ISSR primers) were identified which can be utilized for future molecular breeding program. Further, an attempt was made to isolate a number of bands generated with 3 ISSR and six non-random primers, specific for different species and 22 such markers have been characterized through sequencing which will be made available through international public domain database.

695. Mohandas, T.P., Vijayan, K., Kar, P.K., Awasthi, A.K., Saratchandra, B., 2004.

(Seri Biotech Research Laboratory, Bangalore, India)

Genetic variability in the natural populations of Daba Ecorace of tasar silkworm (*Antheraea mylitta* Drury), as revealed by ISSR markers.

International Journal of Industrial Entomology, 8(2):211-215.

Abstract: Genetic diversity within the natural populations of Daba ecorace of *Antheraea mylitta* Drury was studied using individual silkworms collected from the South Singhbhum district of Jharkhand state of India with 21 inter simple sequence repeat (ISSR) primers. A total of 148 bands were produced, of which 7 percent was polymorphic. The pair wise genetic distance among the individuals varied from 0.186 to 0.329. The dendrogram grouped the individuals into 3 major clusters. Nei's heterozygosity analysis revealed  $0.265 \pm 0.18$  variability within the population. The high genetic variability present within the natural population of Daba ecorace of *A. mylitta* is indicative of their adaptational strategy in nature and have much importance for in situ conservation as well as utilization in breeding programs.

696. Etebari, K., Mirhoseini, S.Z., Matindoost, L.,2005.

(Department of Sericulture, Faculty of Natural Resources, University of Guilan, Somehe Sara 1144, Iran.)

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A study on intraspecific biodiversity of eight groups of silkworm (*Bombyx mori*) by biochemical markers. *Insect Science*, 12(2):87-94.

Abstract: The recognition of biodiversity in different races and lines of silkworm (*Bombyx mori*) is very useful for breeding programs and production of high efficiency hybrids. In this study eight groups of silkworm were selected including 103, 107, Xihang 1 and 2 of Japanese origin and 104, 110, Koming 1 and 2 of Chinese origin. The activity levels of three enzymes including alkaline phosphatase, alanine amino transferase and aspartate amino transferase in haemolymph of fifth instar larva were measured. Moreover, the quantitative amount of total protein, cholesterol and glucose of haemolymph was evaluated. The data reveal that the activity level of measured macromolecules except for alkaline phosphatase were significantly different in all the groups. Hierarchical agglomerative clustering under UPGMA model separated line 104 from other groups. Two groups of Koming 1 and Xihang 1 had the most intergroup similarities.

697. Kar, P.K., Srivastava, P.P., Thangavelu, K., 2005.

(Central Sericultural Germplasm Resource Centre, Hosur (TN) 635109, India)

Progress and Prospect of Molecular Characterization of Silkworm (*Bombyx mori* L.) Genetic Resources available In India.

In: 20th Congress of the International Sericultural Commission, Bangalore, India, 15-18 December, 2005, Vol III, p.30-31.

Abstract: Central Sericultural Germplasm Resources Centre (CSGRC), Hosur (12044'N and 771152'E) maintains more than 400 silkworm *Bombyx mori* L. genetic resources comprising of multivoitine, bivoitine and mutant stocks. Maintenance of maximum variability is very important for conservation. Of late, several molecular marker systems are being effectively utilized in genetic diversity studies, varietal identification, identification of quantitative trait loci and genetic mapping. The success of genetic resources conservation and breeding programme depends on understanding the extent of genetic diversity, both within and among the accessions. In this paper, we review the progress made so far on molecular characterization of silkworm genetic resources available at CSGRC, Hosur. Initially, RAPD and RFLP techniques were used to study six diapausing and seven non-diapausing silkworms. Subsequently, these genotypes were characterized through SSR-anchored PCR and microsatellites, which revealed more distinct markers than RAPD. During the first phase (1996-2000) of molecular characterization, 56 multivoitine and 80 bivoitine silkworm accessions were studied with two anchored primers 5'GCTAGTGCT (CA)<sub>n</sub>-3' and 5'GCACATGCAR(TG)<sub>n</sub>-3'. During the second phase (2003-2006), genetic diversity among six each of BV, MV and mutants were studied with 21 ISSR, 10 RFLP-STS and 12 RAPD markers. The polymorphic status and genetic diversity were evaluated. A multivoitine specific RAPD marker was identified. Subsequently, sixty multivoitine silkworm accessions were studied with 25 ISSR primers. The study revealed sufficient genetic variability within the multivoitine gene pool (Shanon's information index, 0.501±0.181, Nei's Gene diversity, 0.333±0.145, Overall heterozygosity, 0.333±0.021, Observed number of alleles, 1.994±0.080 and Effective number of alleles, 0.567±0.316). The multivoitine races with bivoltine parentage can be easily discriminated with molecular tools. The importance and utilization of molecular markers for characterisation of silkworm genetic resources are discussed.

698. Pradeep, A.R., Chatterjee, S.N., Nair, C.V., 2005.

(Seribiotech Research Laboratory, Central Silk Board, CSB Campus, Kodathi, Carmelram P.O., India.)

Genetic differentiation induced by selection in an inbred population of the silkworm *Bombyx mori*, revealed by RAPD and ISSR marker systems.

*Journal of Applied Genetics*, 46(3):291-298.

Abstract: Artificial selection has been widely utilized in breeding programmes concerning the commercially important silk producing insect *Bombyx mori*. Selection increase the frequency of homozygotes and makes homozygous effects stronger. Molecular variation induced by selection in the

inbred population of *B. mori* strain Nistari, was assessed in terms of genic differentiation by using polymorphic profile generated by RAPD and ISSR marker systems. Artificial selection for longer larval duration (LLD) for 4 generations, resulted in a significant prolongation of larval duration ( $F=89.28$ ;  $P=5.14 \times 10^{-7}$ ). The lines selected for shorter larval duration (SLD) were not significantly different from the control group. RAPD and ISSR primers generated polymorphic profiles when amplified with genomic DNA of individuals of LLD, and SLD lines. Distinct markers specific to LLD individuals were observed from the 3rd generation and indicated selection of allelic variants for longer larval duration. Both SLD and LLD were characterized by high gene diversity ( $h=0.197$ ) and total heterozygosity ( $Ht=0.26$ ), low homogeneity ( $X^2$  test,  $p=0.005$ ) as well as a large coefficient of gene differentiation ( $Gst=0.42$ ) but low gene flow ( $Nm=0.42$ ). Genetic distance was the highest (0.824) between 3rd generations of SLD and LLD. High heterozygosity and prolonged larval duration substituted for shorter larval duration (the traditional trait of fitness) in the Nistari LLD larvae.

699. Sima, Y.H., Li, B., Xu, H.M., Chen, D.X., Sun, D.B., Zhao, A.C., Lu, C., Xiang, Z.H., 2005.

(The Key Sericultural Laboratory of the Agricultural Ministry, Chongqing 400716, China.)

Study on location of QTLs controlling cocoon traits in silkworm.

Yi Chuan Xue Bao, 32(6):625-632.

Abstract: On the basis of the molecular linkage map, mapmaker software QTLMapper 2.0 was used to analyze the QTLs effect of the whole cocoon weight, cocoon shell weight, ratio of cocoon shell and pupa weight of domestic silkworm. For these four cocoon quantitative traits, 7, 6, 2 and 8 effective QTLs were detected and mapped to 7, 5, 2 and 7 linkage groups, respectively. Complicated epistatic effects were found involved in the genetic variation of the whole cocoon weight and cocoon shell weight. For the whole cocoon weight, there were three pairs of QTLs with significant additive by additive interactions, in which, one pair had significant additive by dominance and dominance by dominance interactions. Whereas significant dominance were detected for three QTLs and significant additive effects one QTL had. For the cocoon shell weight, significant genetic effects, including epistatic effects were found for one pair of QTLs, significant dominance by dominance interaction for another pair of QTLs; one QTL had significant dominance and another QTL had additive by additive interaction. The ratio of cocoon shell and the pupa weight were controlled mainly by additive or dominance effects. No interaction between QTL was found for the ratio of cocoon. Most QTLs, associated with the pupa weight, had negative dominance effects. Only significant additive by additive interaction was found between one pair of QTLs. The 2nd, 3rd, 4th, 11th, 13th, 24th, 34th, 37th, and 40th linkage groups are the common chromosomal regions harboring QTLs of two or more cocoon quantitative traits. There are identical QTL or chromosomal region for the whole cocoon weight and cocoon shell weight, indicating they can be simultaneously improved by utilizing epistatic effects in breeding.

700. Awashi, A.K., Pradeep, A.R., Raje Urs, S., 2006.

(Seribiotech Laboratory, Bangalore, India.)

Bio-technological approaches to silkworm breeding.

In: Theme papers on Mulberry Silkworm Breeders Meet 14th-15th February 2006, Central Sericultural Research and Training Institute, Berhampore, India., P.37-41.

701. Awasthi, A.K., Pradeep, A.R., Raje Urs, S., 2006.

(Seribiotech Research Laboratory, Kodathi, Bangalore, India.)

Biotechnological approaches to silkworm breeding.

In: Souvenir Silver Jubilee Celebration of Department of Sericulture, Jnanabharathi Campus, Bangalore University, Bangalore, India, March 2006., p.10-13.

702. Chandrashekaraiyah., Rao, C.G.P., Nagaraju, J., 2006.

(Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI), Kirikera. Hindupur 515211, A.P., India.)

Synthesis of Polyvoltine Silkworm Hybrid Based on Hybrid Performance and Heterosis and Molecular Marker Heterozygosity.

In: Asia Pacific Congress of Sericulture and Insect Biotechnology (APSERI 2006), Sangju, Korea, October 11th-14th, 2006., p.69.

Abstract: In the present study attempt has been made in silkworms to synthesize hybrids based on hybrid performance, heterosis and molecular marker heterozygosity to select potential hybrid combinations directly from the germplasm stock, which minimizes the time, cost and labour involved in conventional breeding. Six polyvoltine (non diapausing-P) and six bivoltine (diapausing-B) strains of silkworms were chosen as initial parents for this study. The 12 parents were crossed in full diallel combinations to generate 144 hybrids. Eight yield components were measured at F1 generation and analyzed for their performance and heterosis. Group 1 (B x B) intra crosses excelled in performance for most of the traits studied followed by group 2 (B x P) and group 3 (P x B) inter crosses. Group 4 (P x P) hybrids exhibited least performance. In contrary. Group-4 revealed highest heterosis followed by group 2 and 3 (cross breeds) and group-1 (bivoltine crosses). Simultaneously, the parental lines were estimated for molecular marker based homozygosity with in the lines and heterozygosity in between the lines. The ISSR-PCR profiles revealed that the homozygosity with in the lines ranged from 94 percent to 97.5 percent, while heterozygosity between the lines ranged from 45 to 88 percent. Based on hybrid performance and genetic distance, one promising polyvoltine silkworm hybrid (APM3 x APS12) was selected. This hybrid excelled in all the yield components over the control hybrid, PM x CSR2. On an average, this hybrid is yielding 510 fecundity, 93 percent pupation, 66 Kg. yield/100 Dfls, 1.850 cocoon weight 0.364 shell weight and 19.67 percent cocoon shell ratio as against the control hybrid of 455 fecundity, 89 percent pupation, 61Kg. yield/100 Dfls, 1.760 cocoon weight, 0.331 shell weight and 18.80 percent cocoon shell ratio.

703. Li, B., Lu, C., Zhao, A.C., Xiang, Z.H., 2006.

(The Key Sericulture Laboratory, Ministry of Agriculture/College of Sericulture and Biotechnology, Southwest University, Chongqing 400716, China.)

Multiple interval mapping for whole cocoon weight and related economically important traits QTL in silkworm (*Bombyx mori*).

Agricultural Sciences in China, 5(10):798-804.

Abstract: A backcrossed population (BC1) derived from a cross between C100 and Dazao was obtained. The quantitative trait loci (QTLs) of the economically important traits for whole cocoon weight, cocoon shell weight, ratio of cocoon shell and weight of pupae, among others, were analyzed for the first time using the multiple interval mapping software WinQTLCart2.0. In total, 40 QTLs were detected and contributed to 21 groups based on the constructed linkage map. According to the mapping results, 2, 2, 3, and 2 major QTLs explained over 20 percent of total phenotypic variations, whereas four QTLs, namely qCW-19, qSW-2, qCSR-4, and qPW-23, explained more than 30 percent of total phenotypic variations for whole cocoon weight, cocoon shell weight, ratio of cocoon shell and weight of pupae, respectively. Correlated traits QTLs often share the same location. Furthermore, most of the detected QTLs were closed to one-side marker. Using the very close markers, positive QTLs can be aggregated, which can form a basis for molecular marker-assisted selection and breeding

704. Lin, J.R., Mo, L.M., Zhong, Y.S., Zhao, F., Wang, Y.Y., Xu, Q.Y., Huo, Y.K., Kong, Q.M., 2006.

(Department of Silk Science, College of Animal Science, South China Agricultural University, Guangzhou 510642, China.)

Analysis on the Comparison of Total Proteins between Testes and Ovaries in *Bombyx mori* by 2D-PAGE.

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In: Asia Pacific Congress of Sericulture and Insect Biotechnology (APSERI 2006), Sangju, Korea, October 11th-14th, 2006., p.86.

Abstract: Silkworm breeding depends on reproductive system. Study on the physiological metabolism of gonads, especially on the character of proteins in reproductive cells, comparison of the specific in gonads of male and female, and investigation of the differential expression proteins and their function in sex determination, can provide helpful theoretical foundation for elucidating mechanism of genetics and breeding of Silkworm *Bombyx mori*. The comparative analysis of proteins in reproductive cells of the second-day male and female pupae was performed by using two dimensional polyacrylamide gel electrophoresis (2D-P AGE) and image analysis method. There were 435 protein spots found in the electrophoretogram of testes, among which 73 spots were differential proteins, occupying 16.8 percent in total proteins. As for the electrophoretogram ovaries, 417 spots were found and among which 55 spots were differential proteins, occupying 13.2 percent of the total proteins. The matching spots from male and female were 362 pairs, and the matching rate was 85.0 percent.

705. Murthy, B.C.K., Prakash, B.M., Puttaraju, H.P., 2006.

(Laboratory of Seri-Biotechnology, Department of Sericulture, Bangalore University, Bangalore - 560 056, Karnataka, India.)

Fingerprinting of non-diapausing silkworm, *Bombyx mori*, using random arbitrary primers.

*Cytologia*, 71(4):331-335.

Abstract: The Random Amplified Polymorphic DNA (RAPD) technique was used to study DNA profiling of 5 multivoltine silkworm genotypes. The silkworm *Bombyx mori* L, (Lepidoptera; Bombycidae) were analyzed using 30 random primers among which 18 polymorphic primers gave 73 amplified products and of which 38.3 percent were polymorphic. The dendrogram generated using an unweighted pair grouped method with arithmetic averages revealed the pattern of relatedness of 5 genotypes. Genetic similarity co-efficient and cluster analysis were performed by a hierarchical clustering technique. The genetic distances between the clusters and within the clusters estimated 6 percent variability between the 4 races and Nistari. The results of our study indicate that RAPDs are very efficient in the estimation of genetic diversity in populations that are closely related and acclimatized to local environmental conditions. The polymorphic data obtained from the study can be further utilized for MV genome mapping research and finally to assign function to sequences through biometrical tools. Modern breeding tools like molecular markers which show easily detectable differences among different faces of a species offer a wide range of applications for silkworm breeding programs. India is being a country with diverse environmental conditions, the local races are rich reservoirs of many resistant genes, and molecular markers are inevitable tools to study inheritance of such complex genes.

706. Virendra Kumar.; Ashwath, S.K., Dandin, S.B., 2006.

(Molecular Biology Laboratory, Central Sericultural Research and Training Institute, Mysore-570008, India.)

Heamolymph Protein Variability among the Silkworm (*Bombyx mori*) Breeds and Assessment of their Genetic relationship.

In: Asia Pacific Congress of Sericulture and Insect Biotechnology (APSERI 2006), Sangju, Korea, October 11th-14th, 2006., p.54.

Abstract: DNA is being used as a molecular marker for the analysis of polymorphism and their close association with different characters. However, the method is not only time consuming but also costly. The investigations throw light on the efficiency of using the hemolymph based proteins as effective markers for identification of desired races for breeding programme. The method is less time consuming and inexpensive too. In the present study, authors used polyvoltine and bivoltine silkworm breeds which differ in various quantitative and qualitative characters of economic importance through studies on hemolymph proteins. The silkworm hemolymph proteins of larvae have been analysed through gel

electrophoresis. Based on the protein fingerprints, the genetic similarity among various breeds was calculated. The dendrogram constructed using UPGMA resulted in clustering of low yielding and high yielding breeds, geographical distribution and evolved breeds. Our study clearly demonstrated the variability of protein fingerprints among the silkworm breeds which is similar with the DNA analysis through different techniques. The protein profile of different breeds have indicated about the polymorphism and genetic diversity among silkworm breeds which will be useful to select the parents for developing the new breeds and to exploit the heterosis in cross breeding strategies.

707. Guo, Q.H., Zhan, S., Xiang, H., Zhao, Y.P., Li, W.H., Huang, Y.P. ,2007.

(Institute of Plant Physiology and Ecology, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences, Shanghai 200032, China.)

Linkage Analysis of New SSR Markers in Scaffold and DII Gene in Silkworm.

Canye Kexue, 33(2):187-194.

Abstract: The common polymorphic SSR markers are very useful when the integration of linkage maps constructed from two independent parental combinations should be made. However, it is quite difficult to find those SSR markers which are polymorphic in different parental combinations. In order to solve this problem, we search the correspondence scaffold with the existent SSR sequence by blasting the SSR sequence in the genome of *Bombyx mori*. Using SSR Hunter 1.3, the neighbor SSR loci were discovered in addition to the original ones. The repeat numbers of those neighbors SSR loci ranged from 6 to 23 were selected to analyzed. Primers were designed in these new SSR region and their polymorphism was detected between the parents of a (7019) female and F1 (F50B x7019) male of the BC1 generation. The results showed that there are 6 out of 7 primers derived from chromosome 2 showing polymorphism in the BC1 generation and 2 of them were drawn in the linkage map. Their loci were consistent with the original ones. The genetic distance of two neighbours SSR loci (NS02071 and NS02072) of S0207 is 6.9 cM. Employing a BC1 generation derived from a C108 female and F1 (Dazao x C108) male, the two new SSR markers in the same scaffold with DII gene got the consistent result with a genetic distance of 0.0 cM, which indicated they were overlapping in the linkage map. The diverse markers in one scaffold or contig will be helpful to locate valuable economic character's gene and molecular assistant breeding and position cloning of the other functional genes.

708. Pradeep, A.R., Jingade, A.H., Raje Urs, S., 2007.

(Seribiotech Research Laboratory, Kodathi, Bangalore, India)

Molecular Markers for Biomass Traits: Association, Interaction and Genetic Divergence in Silkworm *Bombyx mori*.

Biomarker Insights, 2:197-217.

Abstract :Improvement of high yielding, disease resistant silkworm strains became imminent to increase production of silk, which is a major revenue earner for sericulturists. Since environment interacts with phenotype, conventional breeding did not result in commendable yield improvement in synthetic strains of silkworm, *Bombyx mori*. Identification of DNA markers associated with different economically important biomass traits and its introgression could assist molecular breeding and expression of stabilized high yielding characters, but genetic basis of most quantitative traits in silkworm is poorly understood due to its polygenic control. Correlation analysis ( $R = 0.9$ ) revealed significant interrelation among biomass traits viz., larval duration (TLD), larval weight (LWT), cocoon weight (CWT), shell weight (SWT), shell ratio (SR) and floss content. PCR using inter simple sequence repeat (ISSR) primers revealed 92 percent polymorphism among 14 tropical and temperate strains of *B. mori*, with average diversity index of 0.747. Stepwise multiple regression analysis (MRA) selected 35 ISSR markers positively or negatively correlated with different biomass traits, illustrated polygenic control. ISSR marker 830.81050bp was significantly associated with LWT, CWT, SWT, SR and floss content, indicated its pleiotropic role. Two ISSR markers, 835.51950bp and 825.9710bp showed significant association with floss content and TLD. These markers were segregated in F2 generation and Chi-square test confirmed

( $r^2 = \sim 45$ ;  $P < 0.05$ ) its genetic contribution to the associated biomass traits. Strains, with both positively and negatively correlated markers, had intermediate mean value for biomass traits (eg. SWT =  $0.17 \pm 0.014$  g in GNM and Moria) indicated interaction of loci in natural populations. Low yielding Indian strains grouped together by Hierarchical clustering. Chinese and Japanese strains were distributed in the periphery of ALSCAL matrix indicated convergence of genetic characters in Indian strains. Average genetic distance between Chinese strains and Indian strains (0.193) significantly ( $P < 0.01$ ) varied from that between Chinese and Japanese strains. Interaction of loci and allelic substitutions induced phenotypic plasticity in temperate *B. mori* populations on tropic adaptation in India. These outcomes show possibility to combine favorable alleles at different QTL to increase larval, cocoon and shell weight.

709. Srivastava, P.P., Kar, P.K., Awasthi, A.K., Raje Urs, S., 2007.

(Seribiotech Research Laboratory, Central Silk Board, Carmelram Post, Kodathi, Bangalore 560 035, Karnataka, India.)

Identification and association of ISSR markers for thermal stress in polyvoltine silkworm *Bombyx mori*.

Genetika, 43(8):1038-1045.

Abstract: Evaluation of genetic resources is an essential prerequisite for their effective utilization. In India, the tropical climate prevails in most of the sericultural belts, where temperature goes beyond the ambient during summer, adversely affecting the silkworm rearing. Although polyvoltine silkworms are poor in silk content, they are mostly tolerant to tropical conditions and diseases. With an aim to identify potential silkworm races/breeds specific to thermo-tolerance for their effective utilization in breeding programme, 15 selected polyvoltine silkworm races were studied for their thermo-tolerance behaviour. Their genomic DNA samples were analyzed for ISSR-PCR using 15 selected primers. The UPGMA analysis based on Nei and Li algorithm has clustered the 15 silkworm races into five groups and one isolate. ALSCAL-multidimensional scaling has not only supported the information generated by the dendrogram, but it has made the genetic distance among races more clear and substantiating their status in terms of thermal stress where pupation rate was taken as indicator. Further, discriminant function analysis (DFA) was done with three groups of silkworms classified for thermal stress viz. susceptible, moderately tolerant and tolerant. The canonical correlation value was estimated to be 0.987 (Wilk's lambda = 0.004;  $\chi^2 = 36.044$ ,  $p < 0.05$ ). DFA clearly discriminated the above three groups. Beta statistics with t value and its significance for the markers identified through stepwise multiple regression analysis (MRA) revealed a total of five bands (807(1300), 808(3000), 808(4000), 834(4000), and 834(3000)) showing correlation with pupation rate after thermal treatment. Out of them, marker 8083000 showed maximum and highly significant correlation ( $r$ ).

710. Moorthy, S.M., Das, S.K., Mandal, K and Bajpai, A.K 2008.

Esterase isozyme – a tool for developing high survival bivoltine lines.

In: "6<sup>th</sup> Mulberry Silkworm Breeder's Meet" held at CSR&TI, Mysore on 10<sup>th</sup> June 2008. pp.89-93.

Abstract: The present investigation was conducted to study the use of esterase isozyme as a tool in developing high survival bivoltine lines utilizing polyvoltines as donor. The results from the study suggested that there is significant improvement of survival in new bivoltine lines. Esterase isozyme pattern revealed that presence of band with Rm value of 0.347 in newly developed bivoltine lines, which is available in donor (polyvoltines) parent indicates the introgression of polyvoltines genes / characters into newly developed bivoltine clines / breeds predicting possible increase of survival in bivoltine confirmatory with actual performance .

711. Rao, C.G.P., Ramesh Babu, M., Chandrashekaraiyah., 2008

(Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India.)

Integration of molecular markers in conventional breeding.

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In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10th June, 2008., P.85-88.

712. Sivaprasad, V., Chandrashekharaiyah., 2008.

(Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, India)  
Biotechnological approaches for breeding of silkworm for disease resistance.

In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10th June, 2008, 41-43.

713. Sreekumar, S., Ashwath, S.K., Monika, S., Kamble, C.K., 2008.

(Central Sericultural Research and Training Institute, Srirampura, Manandavadi Road, Mysore).

Analysis of DNA profiles of indigenous and evolved silkworm breeds using RAPD markers.

In: Souvenir and Abstracts of National Seminar on Scenario of Seribiotechnological Research in India (NSSSRI-2008), Department of Sericulture, Sri Padmavati Mahila Visvavidyalayam, Tirupati, Andhra Pradesh, India, 28th - 30th August 2008, 95-96.

Abstract: Sustained breeding efforts by the breeders of the Institute has led to the evolution of a number of productive polyvoltine as well as bivoltine breeds which has played a key role in boosting the quantity and quality of silk in India. There is an urgent need to characterize these breeds at the molecular level for systematic maintenance and also for protection of breeder's rights. In this direction, DNA profiling was taken up using 43 silkworm breeds comprising of six indigenous and thirteen evolved polyvoltine breeds as well as 24 evolved silkworm bivoltine breeds. The genomic DNA from these breeds was extracted, purified and quantified. The template DNA was amplified using 12 RAPD primers belonging to OPA series and PCR was performed as per the standard protocol. The PCR products were analysed using 1.5 percent agarose gel electrophoresis. A total of 127 bands were scored for the 12 primers used which showed a polymorphism of 68.5 percent. Twelve polyvoltine and five bivoltine specific PCR amplicons were detected. Further, 26 breed specific bands were observed for 15 polyvoltine breeds and 29 PCR products were found to be specific to 17 evolved bivoltine breeds, which were absent in other silkworm breeds selected for the study. The results have shown the utility of using RAPD profiling for distinguishing silkworm breeds at the molecular level leading to unambiguous characterization of silkworm genetic resources.

714. Sreekumar, S., Ashwath, S.K., Nirmal Kumar, S., Kamble, C.K., 2008.

(Central Sericultural Research and Training Institute, Mysore, India)

Molecular markers as selection tools or gene tagged breeding in the mulberry silkworm, *Bombyx mori* L.

In: Research Papers of Mulberry Silkworm Breeders' Meet, Central Sericultural Research and Training Institute, Mysore, India, 10th June, 2008, 36-40.

715. Vijaya Kumari, N., Sujathamma, P., Savithri, G., 2008.

(Department of Sericulture, S.P.M. Visvavidyalayam, Tirupati)

Application of biotechnological tools in sericulture.

In: Proceedings of the National Seminar on Scenario of Seribiotechnological Research in India (NSSSRI-2008), Department of Sericulture, Sri Padmavati Mahila Visvavidyalayam, Tirupati, Andhra Pradesh, India, 28th - 30th August 2008, 85-88.

Abstract: To day Biotechnology is referred as gene revolution. Biotech is an industry that manipulates genes and enzymes, cells and tissues for men's needs. Sericulture has been one of the main branches of agriculture in Asistic countries for hundreds of years. The silkworm was long been used as a model lepidopteron for research in physiology, development, endocrinology, biochemistry, genetics and virology providing a rich back ground of information on its basic biology. It was among the first eukaryotic organism to serve as model system for cloning genes and studying the regulation of their expression. To attain' sustainability in Sericulture a highly sophisticated knowledge is required for the

development of silkworm strains which are suitable for producing high quality silk and improved mulberry varieties. Biotechnological tools promises further improvement in in mulberry crop yields and quality. It quickens the pace of conventional breeding methods and improves the ability to diagnose the plant pathogens. Biotech allows the production of environment friendly bio fertilizers and biopesticides. Crop improvement through breeding, biotechnology and molecular genetics largely involves moving genes around. Marker assisted selection is a biotechnology tool that enables faster and more efficient selection of desirable traits even when genes have been introduced by the method of manual cross fertilization. Biotechnology now allows genes to be isolated from one kind of organism and inserted in to another. Many of these approaches are being tried in mulberry and silkworm improvement. By realizing the need of application of biotechnology for sustainable improvement of sericulture number of sophisticated tools are being used. In the present review an attempt was made to give consolidated information on gene revolution that has been carried out in mulberry and silkworm improvement.

716. Yang, H., Fan, W., Wei, H., Zhang, J., Zhou, Z., Li, J., Lin, J., Ding, N., Zhong, B., 2008.

(College of Animal Sciences, Zhejiang University, Hangzhou 310029, China)

Transgenic breeding of anti-Bombyx mori L. nuclear polyhedrosis virus silkworm *Bombyx mori*.

*Acta Biochimica et Biophysica Sinica*, 40(10):873-876.

Abstract: Silkworm strains resistant to *Bombyx mori* L. nuclear polyhedrosis virus were obtained through transgenic experiments. Piggy Bac transposon with an A3 promoter were randomly inserted into the silkworm, driving the enhanced green fluorescent protein (EGFP) reporter gene into the silkworm genome. Polymerase chain reaction results verified the insertion of the extraneous EGFP gene, and fluorescence microscopy showed that the EGFP was expressed in the midgut tissue. The morbidity ratio of the nuclear polyhedrosis decreased from 90 percent in the original silkworm strain to 66.7 percent in the transgenic silkworm strain. Compared with the resistance to the *Bombyx mori* L. nuclear polyhedrosis virus in the Qiufeng strain, which is commonly used in the production, there was an increase of 33 centesimal points in the transgenic silkworms. The antiviral character in the Chunhua x Qiuyue strain, which was bred from a different transgenic family, was about 10 centesimal points higher than that in the Qiufeng x Baiyu, another crossbreed used in production. Our results indicated a good application value of the transposon-inserted mutation in the breeding of anti-BmNPV silkworm strain.

717. Chen, Z.Y., Xu, A.Y., Li, M.W., Zhao, Y.P., Zhou, B., Sun, P.J., Qian, H.Y., Zhang, Y.H., Li, G., Guo, X.J., 2009.

(College of Biological and Environmental Engineering, Jiangsu University of Science and Technology, Zhenjiang Jiangsu 212018, China)

SSH cDNA Library Construction and Corresponding EST Analysis of NILs for Yellow Hemolymph Gene in Silkworm, *Bombyx mori*.

*Canye Kexue*, 35(1):24-29.

Abstract: Near-isogenic lines (NILs) of Yellow Blood (Y) gene in silkworm were constructed using silkworm strains KY (yellow hemolymph) and HB (white hemolymph). An SSH (suppression subtractive hybridization) cDNA library was constructed between yellow and white hemolymph individuals of BC18 progeny using PCR-Select™ cDNA Subtraction Kit. Plasmids were extracted from 46 positive clones randomly selected from the library and then sequenced and assembled using CAP3 software. 4 contigs and 9 unigenes were obtained. EST similarity analysis was finished by comparing sequences with BLASTx searches in NCBI. The results showed that they are proteins involved in biological process such as energy metabolism and RNA molecular level regulation. Some of them are enzymes and structural proteins in the cell. This study provides useful information for future studies on molecular mechanism of filament coloring and for breeding new silkworm variety that spin color cocoons.

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718. Nie, L., Wang, A.J., Lou, Q.N., Zhou, L.X., Zhang, F.L., Wang, N., Yu, Z.C., 2009.

(The Sericultural Research Institute of Shandong Province, Yantai Shandong 264002, China.)

RAPD Analysis to *Bombyx mori* Varieties Conserved in Shandong Province.

Canye Kexue , 35(3):613-617.

Abstract: In this paper, RAPD markers were used to analyze the genetic diversity of 58 silkworm germplasms conserved in Shandong Province. 20 polymorphic primers which yielded good replicative bands were selected and 155 RAPD markers were obtained, with a polymorphic ratio of 93.73 percent. These results indicated that the obtained RAPD markers had a rich polymorphism among different silkworm varieties. According to fingerprints of these 58 silkworm varieties, a phylogenetic tree was obtained by UPGMA cluster analysis. The present research provides useful fundamental information for silkworm breeding.

719. Mundkur, R., Mallesha Murthy., Latha, R., Krishna Rao, S., Sekharappa, B.M., 2009.

(Karnataka State Sericulture Research and Development Institute, Bangalore, India) Classical linkage map based genetic stocks of silkworm, *Bombyx mori* maintained at KSSRDI, Bangalore.

Proceedings of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009, 193-196.

Abstract: The Karnataka State Sericulture Research and Development Institute (KSSRDI), Bangalore is maintaining working germplasm at Silkworm Breeding unit located at Bidadi and in two substations located at Ooty and B.R. Hills. It is maintaining 142 bivoltine accessions and 37 multivoltine accessions spread in all the sub-stations. It is quite essential for a silkworm breeder to know the qualitative and quantitative traits of the working germplasm accessions and the genes related to them. Classical linkage maps list out the genes and their loci for most of the qualitative traits. It is unfortunate that linkage maps do not indicate genes of quantitative traits. Nowadays Molecular linkage maps are being drawn. BGI gene finders have predicted 21302 genes based on DNA marker technology. Attempts are also being made to integrate Classical Linkage Map with the Molecular Linkage maps. With this background an attempt is made to document the traits available in the silkworm germplasm bank of KSSRDI as against the genes marked in the classical linkage map.

720. Tewary, P.K., Singh, M.K., Vijaya Prakash, N.B., 2009.

(Central Tasar Research and Training Institute, Piska Nagari, Ranchi-835303, Jharkhand.)

PCR amplification of genomic DNA of *Terminalia* genotypes.

Status Papers and Abstracts of National Conference on Vanya Silk (NASSI, Bangalore), Central Muga Eri Research and Training Institute, Lahdoigarh, Jorhat, Assam, India, 28th-30th January, 2009, 233.

Abstract: Large number of the *Terminalia* genotypes are extensively and densely distributed in the tropical forest all over India. However due to their complex nature, it is rather difficult to delimit these genotypes. Very little information is available on the genetic diversity of these germplasm and therefore, cataloguing of natural diversity becomes essential for its sustainable germplasm management and also to introduce effective breeding programme to develop superior varieties. DNA based assays such as RAPD AND AFLP is the most widely used tool for assessment of the genetic variation as unlike morphological characterization, this is not influenced by the environmental factors. Genomic DNA of nine genotypes of *Terminalia* have been isolated by using modified CTAB protocol and subjected to PCR amplification, OPAE, OPA primers were exploited to generate distinct profiles in *Terminalia arjuna*, *T. tomentosa*, *T. belerica*, *T. chebula* and five biotypes of *T. arjuna* consisting traits of different fruits wing size and sprout colours. The study provides an indication that RAPD markers can be used as an effective tool to study genetic diversity prevailing at inter and intra specific level of the taxon.

721. Yu, F., Yang, H.J., Li, J.Y., Ding, N., Zhou, Z.H., Ye, J., Zhang, J.W., Duan, J.L., Zhong, B.X., 2009

(College of Animal Sciences, Zhejiang University, Hangzhou 310029, P.R.China.)

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**Analysis of Protein Expression Patterns of Silkworm Jinqiu and Its Cross Parents.**

*Agricultural Sciences in China*, 8(9):1130-1137.

**Abstract:** The differences of protein expression between the improved cross breeding race Jinqiu and its parents were analyzed to discuss the gene construction, and to form a base for illuminating the molecular mechanisms of successful cross breeding in silkworm. Protein samples from silk gland, hemolymph, and midgut were separated by 2-dimensional gel electrophoresis (2-DE). In the three tissues the matched protein spots between Jinqiu and its cross parents were approximately 70 percent with approximately 30 percent specific protein spots. In the matched protein spots, 9-24 percent was differentially expressed representing up- and down-regulated expression. These specific protein spots might be either the newly appeared, which were produced from the genic interaction of cross parents' genes in cross breeding, or posttranscriptionally modified, which were produced from the different modifications on the same original proteins. These results indicate that it is important for a new successful breed, by cross breeding, relying on the actions of some newly produced functional proteins from genic interaction, in addition to marshaling excellent genes of cross parents.

722. Zhan, S., Huang, J., Guo, Q., Zhao, Y., Li, W., Miao, X., Goldsmith, M.R., Li, M., Huang, Y., 2009. (Institute of Plant Physiology and Ecology, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences, Shanghai, 200032, PR China)

**An integrated genetic linkage map for silkworms with three parental combinations and its application to the mapping of single genes and QTL.**

*BMC Genomics*, 10:389.

**Abstract:** *Bombyx mori*, the domesticated silkworm, is a well-studied model insect with great economic and scientific significance. Although more than 400 mutations have been described in silkworms, most have not been identified, especially those affecting economically-important traits. Simple sequence repeats (SSRs) are effective and economical tools for mapping traits and genetic improvement. The current SSR linkage map is of low density and contains few polymorphisms. The purpose of this work was to develop a dense and informative linkage map that would assist in the preliminary mapping and dissection of quantitative trait loci (QTL) in a variety of silkworm strains. Through an analysis of > 50,000 genotypes across new mapping populations, we constructed two new linkage maps covering 27 assigned chromosomes and merged the data with previously reported data sets. The integrated consensus map contains 692 unique SSR sites, improving the density from 6.3 cM in the previous map to 4.8 cM. We also developed 497 confirmed neighboring markers for corresponding low-polymorphism sites, with 244 having polymorphisms. Large-scale statistics on the SSR type were suggestive of highly efficient markers, based upon which we searched 16,462 available genomic scaffolds for SSR loci. With the newly constructed map, we mapped single-gene traits, the QTL of filaments, and a number of ribosomal protein genes. The integrated map produced in this study is a highly efficient genetic tool for the high-throughput mapping of single genes and QTL. Compared to previous maps, the current map offers a greater number of markers and polymorphisms; thus, it may be used as a resource for marker-assisted breeding.

723. Zhang, S.M., Mao, X.B., Huang, W., Xu, H.D., 2009.

(Rural Development and Information Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China.)

**Quantitative Assessment on Research Investment Return of Silkworm Breeding in Zhejiang Province.**

*Canye Kexue*, 35(2):445-450

**Abstract:** The present work has attempted to assess the impact of research investment in silkworm breeding in Zhejiang Province within the years of 1981 to 2005 using DREAM model. The results revealed that the total economic benefits is 41.648 billion Yuan and the internal rate of return (IRR) is 35.09 percent which is much higher than the average return rate (8 percent) from social gross investment. But after the year of 2000, the benefit has sharply dropped from 1.9702 billion Yuan to 0.

6483 million Yuan because very few new varieties had been obtained and distributed. Based on these results, it is suggested that measures and policies should be employed to increase amount of research investment, to speed up innovations in breeding materials and technology, to reform the research system for silkworm breeding and to inspire initiatives of the breeders.

724. Chinnaswamy, R., Sugnana Kumari, S., Anuradha, C. M., Lakshmi, H., Chitta, S. K., 2010. (Silkworm Breeding and Molecular Genetics Laboratory, Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI), Kirikera-515 211, Hindupur, AP, India)  
Nutrigenomic analysis of mulberry silkworm (*Bombyx mori* L.) strains using polymerase chain reaction - simple sequence repeats (PCR-SSR)

International Journal for Biotechnology and Molecular Biology Research , 1(7): 92-100.

Abstract: The DNA marker use in assisting selection are safe method in breeding process and it is an important tool for authentication of new gene cascade in genome. In mulberry silkworm, the major economic and nutrigenomic traits are polygenic in nature. In the present study, we have utilized ten PCR-SSR microsatellite markers to gain better understanding on genotyping of certain nutrigenomic gene loci in nutritionally efficient silkworm breeds / hybrids. Results showed that a single yet varying size amplified band in all four parental silkworm strains (RMG4, RMW2, RBD1 and RBO2) and two clear amplified bands in the hybrids (RMG4 x RBD1 and RMW2 x RBO2) with different molecular weight from three PCR-SSR primers loci viz., F11139, F10429 and F10705. The PCR-SSR results demonstrated that homozygosity in newly evaluated nutritionally efficient parental silkworm strains and heterozygosity in hybrid. These investigations authentically confirmed the previous findings of heterotic nutritionally efficient silkworm hybrids with superior nutrigenomic traits. The developed molecular analysis in silkworm could be utilized for the benefit of the farmers in sericulture industry. In conclusion, these results would be useful in identification of nutrigenomic cascade of genes in silkworm and also emphasize the future prospects of silkworm functional mechanism in nutrigenomic studies.

725. Jiang, Z., Cai, M.W., Xu, S.Q., Fang, L.X., Sima, Y.H., 2010.

(School of Basic Medicine and Biological Sciences, Soochow University, Suzhou Jiangsu 215123, China.)

Analysis on DNA polymorphism and genetic relationship of several commercial silkworm varieties based on RAPD and SSR molecular markers.

Canye Kexue, 36(1):157-164.

Abstract: Molecular marker technique is an important method in studying phylogenetic evolution and genetic relationship of organisms. The DNA polymorphism of 12 commercial silkworm varieties was analyzed based on RAPD and SSR molecular markers. Subsequently, cluster analysis was conducted. By using 21 RAPD primers to amplify the genomic DNAs of 12 silkworm varieties, 196 clearly distinguishable bands were obtained, among which 143 bands showed polymorphism, showing a polymorphism percentage of 72.96 percent and relative genetic distances ranging from 0.157 to 0.352 between different varieties. By using 32 SSR primers to amplify the genomic DNAs of 12 silkworm varieties, 86 distinguishable bands were obtained, among which 80 bands showed polymorphism, showing a polymorphism percentage of 93.02 percent and relative genetic distances ranging from 0.214 to 0.600 between different varieties. Although cluster analysis based on RAPD and SSR molecular markers of the 12 silkworm species yielded different results, both results classified the 12 silkworm varieties into Chinese strain and Japanese strain, among which the genetic relationship between strains 7532 and Xianghui and between strains 871 and 57B were relatively closer. However, Dong 34, a variety that belongs to Chinese strain in the traditional classification, was classified into Japanese strain, though it was independent of other 6 varieties from Japanese strain. The genetic distances and cluster results of the 12 varieties based on RAPD and SSR markers could reflect genetic relationship and origin of different varieties at the molecular level more accurately, being important references for parent selection in silkworm cross breeding.

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726. Song, R.S., Yu, G., Meng, Z.Q., Bai, J., Zhu, X.R., Chen, S., Wang, Z., 2010. (Sericulture Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 31 0021 , China) Working Principle, Basic Structure and Design Ideas of Laser Instrument to Automatically Sort Male and Female Silkworm Eggs.

Canye Kexue, 36(4): 0631 –0638.

Abstract: In order to promote the breeding and commercialization of male silkworm varieties, a laser instrument to automatically sort male and female silkworm eggs has been successfully developed. Based on the different colors possessed by male and female eggs of the particular male silkworm breed, this instrument could direct a laser device to kill female eggs by way of image acquisition, image processing and discerning, and leave the male eggs unharmed. This instrument furnishes a fast and precise method for separating and collecting male silkworm eggs in silkworm breeding and extension, and solves the low efficiency problem of manually sorting the male and female silkworm eggs. This article introduced the working principle and design ideas of the computer imaging processing software, the instrument's basic structure and basic configurations and main work flow, methods for sorting two types of silkworm eggs and primary technological parameters.

727. Wang, Y.Q., Zhu, X.R., He, K.R., Yao, Y.T., Cao, J.R., Zhou, J.Q., Huang, Y.F., Liu, X.J., He, X.L., Meng, Z.Q., 2010.

(Sericultural Research Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China) The Breeding and Application of New Male Silkworm Varieties by Using Female Silkworm Parthenogenetic Clones.

Canye exue, 36(2):0268 – 0273.

Abstract: Realizing the technology of rearing only male silkworm in rural area and rearing more female silkworm in eggs producing station were very important to improve the yield and quality of cocoon silk, and to reduce the productive cost of male silkworm hybrid eggs. Using the method of incomplete diallel crossing, 31 combinations of male silkworm were prepared by crossing the female silkworm parthenogenetic clones with high hatching rate and the balanced lethal male silkworm line. Two new male silkworm varieties named Female 35 x Ping 28 and Female 29 x Ping 28 have been selected out through 5 comparison tests in 3 years. The two new male silkworm varieties have been reared successfully in the main silkworm rearing areas of Zhejiang Province. Compared to the current male silkworm variety, cocoon yield per box of eggs of the new male silkworm varieties increased by 8.53 percent, length of none-broken filament was 45 m longer, and raw silk rate of fresh cocoon increased by 0.7 percent point. The breeding of these new male silkworm varieties makes it expectable to further reduce the production cost of male silkworm hybrid eggs and to accelerate the industrialization process of specially rearing male silkworms.

728. Awasthi, A.K. , Nithya, K. , Pradeep, A.R. , Basavaraja, H. K. , Vijayaprakash, N.B. , Nagaraju, J. , 2011.

(Seribiotech Research Laboratory, Kodathi, Carmelram Post, Bangalore-560 035.)

Molecular markers for nuclear polyhedrosis virus resistance in silkworm, *Bombyx mori* and marker assisted breeding program

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, p 143-144.

Abstract: The mulberry silkworm, *Bombyx mori* has always been a target of persistent infection by nuclear polyhedrosis virus (Bmnpv) that causes up to 30 percent economic loss in sericulture industry. Since beginning this lab was focused on developing elite breed(s) with DNA marker for NPV resistance. During the study, one RAPD based marker was identified which has shown association with NPV resistant phenotype. Segregation of this marker was tested in F2 population raised from a cross of traditionally high (Nistari) and low (nb1) NPV tolerant *B.mori* strain. Many F2 individuals showed resistance to NPV, survived to moth stage, laid eggs and continued next generation and showed the

presence of this marker. This preliminary observation led to studies on molecular divergence among strains of silkworm germplasm with respect to studies of NPV resistance.

729. Sharmila, K.K. , Ashwath, S.K. , Mahalingappa, K.C. , Sudha, V.N. , Thippeswamy, T. , Nirmal Kumar, S. , Qadri, S.M.H. ,2011.

(Central Sericultural Research And Training Institute, Mysore-570 008)

Comparative analysis of amylase activity in the digestive juice of single hybrids evolved by amylase marker assisted selection.

In: Abstracts of golden jubilee national conference on sericulture innovations : before and beyond, CSRTI, Mysore, 28-29, January, 2011, p 77-78.

Abstract: In recent years a few biochemical parameters have been analyzed at CSR&TI, Mysore which has scope for their use as surrogate breeding parameters or markers for specific yield traits leading to silkworm improvement. Among the biochemical markers, amylase has been identified as one of the useful markers as it contributes for better digestibility and associated with the survival. In this direction, studies were made to ascertain the efficacy of using amylase activity as a selection criteria for identifying promising and robust bivoltine hybrids. Accordingly, amylase marker assisted selection was carried out and six oval lines of CSR2, (GEN1, 2N, 2C, 2D, 2S, 2M) and five dumb-bell lines of CSR4 (4P, 4C, 4D, 4S, 4M) were evolved by introgressing amylase genes from the polyvoltine donors. Ten single hybrids were prepared utilizing the oval and dumb-bell lines evolved through marker assisted selection along with the control hybrid, CSR2 x CSR4 which were reared in three seasons, i.e., January-February, March-April and May-June 2009. The digestive juice was collected on the 5th day of v instar from all the hybrids including control and the amylase activity was estimated. All the new hybrid combinations showed higher activity when compared to the control. Among the hybrids, 2Cx4S recorded the highest activity of 240.5 mg/ml followed by 2m x 4s (210.8 mg/ml), which were significantly higher than that of the control hybrid, CSR2 x CSR4, where the activity was found to be 48.1 mg/ml. The survival of these new hybrids were also found to be significantly higher than that of the control. Based on the results, the hybrid 2C X 4S has been short-listed for large scale in-house testing as well as on station trials at RSRS units. The results indicate the prospects of using amylase activity as an additional parameter for selection of hybrids in the breeding programmes which can assure higher survival and yield under sub-optimal conditions.

730. Moorthy, S.M., S.K.Mukhopadhyay, K.Mandal and A.K.Bajpai 2011.

(Central Sericultural Research and Training Institute, Berhampore-742 101, West Bengal, India)

Esterase – a potential biochemical marker for thermo tolerance in silkworm, *Bombyx mori* L.

Indian silk, Vol.2(50 old) 5, 8 – 9.

731. Moorthy, S.M, Mandal, K, Nirmal Kumar S and Qadri, S.M.H. 2011.

(Central Sericultural Research and Training Institute, Berhampore-742 101, West Bengal, India)

Functional classification of esterase and thermo stability variants in silkworm, *Bombyx mori* L.

In: National Conference on Emerging trends in Biological Research” (NCEBR’11) held at Madras University, Chennai from 21<sup>st</sup> & 22<sup>nd</sup> February, 2011.pp.12.

Abstract: The electrophoretic banding pattern of esterase isozymes were examined in haemolymph of six silkworm strains represents three different groups using  $\alpha$ -naphthyl acetate as substrate. A total of five esterase isozymes viz., Est-1(0.425), Est-2 (0.346), Est-3 (0.295), Est-4 (0.247) and Est-5(0.217) were detected in these strains. The distribution of multiple forms of esterases in silkworm was clearly indicates its strain specific. By means of inhibitor studies, two of them were determined to be acetyl choline esterases and two to be cholinesterases as it was inhibited by PMSF and eserine sulfate respectively. Among the five different types of esterase isozymes three are found to be heat liable (0.425, 0.247 and 0.217)two of them heat stable(0.346 and 0.295). This study offers the possibility of identifying

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heat resistant and heat sensitive genetic ecotypes for breeding high-yielding silkworm strains specifically suited to different environmental conditions.

732. Rao, C.G.P. , Vijayaprakash, N.B. ,2011.

(Seribiotech Research Laboratory, Kodathi, Bangalore-560 035)

Bio.development of silkworm hybrids through biotechnology approach.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations : Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, P 156.

Abstract: Productive silkworm hybrids are the need of sericulture industry, because heterozygotes always perform better than the homogygotes and inbred lines. For the past 30 years many number of hybrids have been developed. Some of the hybrids developed based on conventional breeding methods have performed well and many of them failed to express consistent performance in the field, since their performance can be easily influenced by the environment. In classical breeding, selections are made by phenotypic traits (observable traits of an individual) and measureable data ignoring the genotype information. Breeders and scientists were looking for new technologies to make breeding more efficient, less time consuming and cost effective. With the advent of biotechnology, molecular markers were found to be powerful tools for strengthening and fastening the breeding programmes in plants and animals. Selection of suitable parents is one of the most important criteria to develop promising crosses and increase the efficiency of breeding programs. Molecular markers increasingly play an important role in the selection of parents for breeding. The availability and abundance of DNA markers throughout the genome, their polymorphic nature, codominance, and polymerase chain reaction (PCR) based assay make the DNA markers useful in detecting genetic diversity and hybrid development. Through this approach, both the phenotype and the genotype of the parental lines can be analysed by means of performance, heterosis and genetic distance and productive hybrids can be predicted. Molecular information can be integrated in classical breeding to create genotype-to-phenotype trait knowledge of the inbred lines. DNA marker based breeding technology has been successfully used in agriculture and animal husbandry for the improvement of crop plants and cattle in the developed countries. it is a time and cost effective method to be followed in sericulture industry too. It is worth noting the importance of early identification of genotypes to facilitate the selection and recombination process in silkworms with desirable traits and to reduce the time required to conclude a hybrid synthesis programme.

733. Sreekumar, S. , Ashwath, S.K. , Monika, S. , Nirmal Kumar, S. , Qadri, S.M.H.,2011.

(Central Sericultural Research And Training Institute, Mysore-570 008)

Detection of single nucleotide polymorphism (SNP) DNA marker linked to cocoon traits in the mulberry silkworm, *Bombyx mori*.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, P 150-151.

Abstract: cocoon weight and shell weight are the key economic traits which ultimately determine the silk yield. in order to detect main QTL associated with cocoon traits in the mulberry silkworm, *Bombyx mori*, the parents showing large differences for the cocoon weight and shell weight were screened with 240 primer pairs of single nucleotide polymorphic markers (SNPS) representing all the 28 linkage groups in silkworm. Out of the 240 primers, 48 (20 percent) revealed distinct polymorphism between the parents which was confirmed by the co-dominant expression of both the polymorphic PCR products in the F1. The strategy of bulked segregant analysis was adopted by comparing the SNP profiles in the parents, F1 and F2 bulks using the 48 informative SNP primers. The data revealed that out of 48 primers, only one, i.e., no.124 of the 4th linkage group showed clear differences in the amplified products between the bulks corresponding to that of the parents showing contrasting features for cocoon traits suggesting that the DNA regions amplified by this primer are closely linked to the QTLs controlling the cocoon traits. the results were also confirmed by screening the bc progeny. the results of the present study indicate the

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prospects of using SNPS for marker assisted selection (mas) in silkworm breeding programmes for improving cocoon traits.

734. Srivastava, P.P. , Vijayan, K. , Jayarama Raju, P. , Singh, R. N. , Saratchandra, B.,2011.

(Central Silk Board, BTM Layout, Madiwala, Bangalore-560 065)

Genetic variability among polyvoltine silkworm as revealed by molecular markers.

In: Abstracts of Golden Jubilee National Conference on Sericulture Innovations: Before and Beyond, CSRTI, Mysore, 28-29, January, 2011, P 152.

Abstract: Adequate information on the genetic diversity of breeding stock is a prerequisite for planning and execution effective and efficient breeding programs. Although phenotypic variability has been used for selecting parents of desired genetic diversity, expression of most of the economically important traits are polygenic and thus are influenced significantly by extra-genomic factors. Molecular markers on the other hand are least influenced by environmental and developmental factors and also are abundant in number to provide adequate information on the genetic diversity. Owing to these reasons, genetic diversity among thirteen multivoltine silkworm (*Bombyx mori* L.) breeds was estimated with simple sequence repeats (SSRS) and mitochondrial DNA (MTDNA)-single strand conformation polymorphism (SSCP) markers. the seven SSR primers developed a total of 49 alleles, the size of which varied from 70bp in the locus sat3215 to 300bp in the locus sat21. The MTDNA primers developed 2 to 10 haplotypes per primer sets and the size of it also varied 70 bp in 16s2 to 610bp in co2. the heterozygosity generated by the seven pairs of SSR primers varied from 0.098 to 0.396 and that from MTDNA markers varied from 0.016 to 0.302. the dendrogram grouped these silkworms into three groups and three isolates. the information generated by this can be used for harnessing multi x multi hybrids for the adverse climatic conditions in India.

**CHAPTER-IV**

**VANYA SILKWORM**  
**BREEDING**

## VANYA SILKWORM BREEDING

735. Jolly, M.S., 1965.  
(Central Tasar Research Station, Ranchi, Bihar, India)  
Scope of interspecific hybridisation in *Antheraea*.  
*Indian Journal of Sericulture*, 4(1):1-8.
736. Wu, R., 1965.  
The breeding of resistant race of eri silkworm to high temperature (brief report).  
*Journal of Sericulture Science of China*, 3(2):125-126.
737. Bardaiyar, V.N.; Jolly, M.S.; Benchamin, K.V.; Sinha, B.R.R.Pd., 1974.  
(Central Tasar Research Station, Ranchi, India.)  
Heterosis in relation to single, three-way and double crosses in *Antheraea mylitta* D.  
In: Proceedings of the First International Seminar on Non-Mulberry Silks, Central Tasar Research Station, Ranchi, India. 3-4 October, 1974, p.68-74.  
Abstract :The present study is an attempt to examine the expression of heterosis for important economic characters in *Antheraea mylitta* D., in relation to three different mating systems viz., single, three-way and double crosses. Results have indicated maximum heterosis in double cross in respect of most of the characters taken into consideration. It can be advocated that the introduction of polyhybrids for commercial exploitation of this species is highly desirable.
738. Nguyen-Cong-Huan, A., 1974.  
(Vietnam Pasteur Institute, South of Vietnam)  
Wild sericigenous insects and non-mulberry food plants in South of Vietnam.  
In: Proceedings of the First International Seminar on Non-Mulberry Silks, Central Tasar Research Station, Ranchi, India. 3-4 October, 1974, 24-45.  
Abstract :The author has reported nine species of silkworm in the forests and the lowlands of South of Viet-Nam including remote islands. The species are *Cricula Trifenestra*, *Philosamia atlas*, *P. ricini*, *P. cynthia*, *Actias selene*, *Lasiocampa* spp. (big moth), *Lasiocampa* Spp. (small moth) *Attacus atlas*, *Antheraea mylitta*. These insects are polyphagous and feed on young laeaves of naturally grown host plants, namely *Ricinus communis*, *Manihot* sp., *Papaya carica*, *Streblus asper*, *Muntingia calabura*, *Nauclea orientalis*, *Hopea odorata* and *Lagerstroemia speciosa*. Various experiments have shown that breeding of these wild silkworms in the natural conditions, or in the laboratory, give excellent results. The most interesting wild sericigenous insects giving good filament are *Attacus atlas* and *Antheraea mylitta*.
739. Sen, S.K.; Sengupta, A.K.; Das, M.G.; Jolly, M.S., 1974.  
(Central Tasar Research Station, Ranchi, India.)  
Studies on genetic variability and correlations and path co-efficient analysis and discriminant functions in *Antheraea mylitta* Drury.  
In: Proceedings of the First International Seminar on Non-Mulberry Silks, Central Tasar Research Station, Ranchi, India. 3-4 October, 1974, p.86-92.  
Abstract :Estimation of genetic parameters, genotypic and phenotypic correlation co-efficients, path co-efficient analysis and discriminant functions were studied in various regional races of *Antheraea mylitta* D. A wide range of phenotypic variability and highly significant differences between the races have been observed for most of the characters studied. High heritability has been obtained for all characters except hatching percentage. The genotypic correlation co-efficients are higher in magnitude than the phenotypic correlations. Path co-efficients have been calculated with shell weight as the effect, silk ratio

has made a substantial contribution and hence these characters deserve a better attention in breeding programme. Selection indices in relation to shell weight, shell ratio and eggs per laying were considered simultaneously and these characters should get due consideration in selection programme. The scope of mass and recurrent selection has been discussed.

740. Sengupta, K. Singh, K., 1974.

(Central Eri and Muga Research Station, Titabar, India)

Some studies on the inheritance and segregation pattern of extremely variable body colour and body marking in eri silkworm, *Philosamia ricini* Boisd, larva.

In: Proceedings of the First International Seminar on Non-Mulberry Silks, Central Tasar Research Station, Ranchi, India. 3-4 October, 1974, 85-86.

Abstract :Extreme variability is observed in the larval body colour and body markings of eri silkworm, *Philosamia ricini* Boisd. having white, green, greenish blue (deep and light) larval body colour and plain, spotted, spotted with defined black band (zebra) and spotted with undefined black band body markings, with all possible combinations between them. The paper presents a study of the pattern of inheritance and segregation of these characters as has been analyzed from the types of progenies obtained during the process of their breeding, purification and fixation.

741. Smyk, D., 1974.

(Department of Silkworm Breeding, Institute of Zootechnics, Karkow, Poland.)

Breeding oak silkworms *Antheraea pernyi* Guer. and *Antheraea mylitta* Drury on leaves of different tree kinds.

In: Proceedings of the First International Seminar on Non-Mulberry Silks, Central Tasar Research Station, Ranchi, India. 3-4 October, 1974, p.53-55,

742. Bardaiyar, V.N.; Jolly, M.S.; Benchamin, K.V.; Sinha, B.R.R.Pd., 1976 .

(Central Tasar Research Station, Ranchi, Bihar, India.)

Heterosis in relation to single, three-way and double crosses in *Antheraea mylitta* D.

Indian Journal of Sericulture, 15:15-20.

Abstract :The present study is an attempt to examine the expression of heterosis for important economic characters in *Antheraea mylitta* D., in relation to three different mating systems viz., single three-way and double crosses. Results have indicated maximum heterosis in double crosses in respect of most of the characters taken into consideration. Introduction of polyhybrids for commercial exploitation of this species might be desirable.

743. Sen, S.K., Sengupta, A.K., Das, M.G., Jolly, M.S., 1976.

(Central Tasar Research Station, Ranchi, Bihar, India.)

Studies on genetic variability, correlations, path co-efficient analysis and discriminant functions in *Antheraea mylitta* D. Indian

Journal of Sericulture, 15:9-14.

Abstract: Estimation of genetic parameters, genotypic and phenotypic correlation co-efficients, path co-efficient analysis and discriminant function were studied in various regional races of *Antheraea mylitta* D. A wide range of phenotypic variability and highly significant differences between the races have been observed for most of the characters studies. High heritability has been obtained for all characters except hatching percentage. The genotypic correlation co-efficients are higher than the phenotypic correlations. Path co-efficients have been calculated with shell weight as the effect; silk ratio has made a substantial contribution and hence these characters deserve a better attention in breeding programme. Selection indices in relation to shell weight, shell ratio and eggs per laying were considered simultaneously and

these characters should get due consideration in selection programme. The scope of mass and recurrent selections has been discussed.

744. An, H., 1982..

Breeding for monovoltine race of Chinese tussah silkworm.  
Journal of Sericulture Science of China, 8(2):106-111.

745. Jiang, B., 1987.

A study on bundle breeding of young spring tussah silkworm with plastic film tied around the oak.  
Canye Kexue, 13(1):51.

746. Siddiqui, A.A.; Sengupta, A.K.; Dasmohapatra, D.P.; Ajit, K.; Sengupta, K., 1988.

(Breeding and Genetics Laboratory, Central Tasar Research and Training Institute, Ranchi-5, India.)  
Genetic analysis of yield and yield components in *Antheraea mylitta* Drury.  
Indian Journal of Sericulture, 27(2):78-84.

Abstract: The 6 x 6 parent diallel excluding reciprocals and including parents was studied. Both the additive and non-additive gene effects were significant and important for absolute silk yield, fecundity, larval weight, effective rate of rearing, cocoon weight, pupal weight, shell weight and shell ratio. However, for larval weight only additive gene effects were important. The parent RF1 was good combiner for absolute silk yield, shell weight and shell ratio, the parent Daba was a good general combiner for other characters. Similarly a few crosses involving high x high, high x low, high x medium and low x low general combiners and possessing high S.C.A, effects have been sorted out.

747. Rahman, S., Rahman, S.M., 1990.

(Department of Zoology, Rajshahi University, Rajshahi, Bangladesh)  
Estimates of variability and some genetic parameters in eri silkworm Bangladesh  
Journal of Zoology, 18(2):239-244.

Abstract: An investigation of the genetic potential of *Philosamia cynthia ricini* [*Samia cynthia ricini*] was carried out with 36 races in 4 rearing seasons. High genotypic coefficients of variability and high heritability estimates in different genotypes indicated that a wide range of genetic diversity existed which could be used in a breeding programme. It also indicated the importance of additive gene effects in these characters and phenotypic selection of these characters would be effective. A number of characters showed high heritability but low genetic advance due to intra- or inter-allelic interactions.

748. Jin, X., 1991.

Breeding of white cocoon variety baijian 1 of Chinese tussah silkworm.  
Canye Kexue, 17(3):150-154.

Abstract: The whiter cocoon variety of "Baijiann 1" of Chinese tussah silkworm (*Antheraea pernyi*) was firstly selected from the tawny cocoon variety "Qing 6" in 1986 by means of pedigree selection and fluorescence spectrum selection after 9 years i.e., 18 generations. This variety comes from the green silkworm line of bivoltine tussah, and is early mature. The body colour of the grown larva is olive-green, but the moths is mango-brown. The white cocoon exceeds tawny cocoon 35.1 degree in whiteness. The cocoon has better reliability, its consumption of unwinding agent reduced 25-32 percent and the raw silk percentage of its fresh cocoon increased 10-67 percent compared with "Qing 6". Its raw silk exceeds tawny cocoons by 14.3 degree centigrade and is excellent in brightness, feeling intensity, size deviation, tenacity and elongation as well as the dyeing. The variety is good for rearing and has better food preference, high disease-resistance, it also has high and stable yield and is suited for the popularization in bivoltine tussah silkworm raising regions

749. Popescu, M., Ciovica, L., 1992.  
(Cent. Seric. Res. Stat N 69, Bucuresti-ploesti street Bucharest, Sector 1, Romania)  
Comparative research regarding the use of various kinds of castor-oil plants in silkworm breeding  
*Medicina Veterinara si Cresterea Animalelor*, 42(11-12):29-32.
750. Rahman, M.S., Rahman, S.M., 1992.  
(Department of Zoology, Rajshahi University, Rajshahi 6205, Bangladesh)  
Correlations path-coefficients and the application of discriminant function selection in eri silkworm *philosamia ricini* boisd II path-coefficient analysis in *p.ricini*  
*Bulletin of Sericulture Research*, 3:33-39.  
Abstract: Path-coefficient analysis for three groups of larval characters, viz length weight and volume and a group of cocoon characters were estimated with small weight involving 36 races of eri silkworm *philosamia ricini* boisd in Bangalades. Fifth instar larvae and larvae at spinning exhibited a true relationship with respect to both length and volume indicating their significant role towards silk yield larval weight at 1st and 2nd instar, however exhibited positive direct effect and significant correlation with shell weight. Indirect effect of 3rd instar larval volume via male larval volume a spinning seemed to be importunate significant correlation obtained for shell weight with cocoon weight and shell percentage were due to high positive direct effect. Both the characters deserve due consideration during selection in breeding high yielding varieties of *P.ricini*.
751. Siddiqui, A.A.; Chatterjee, S.N.; Goel, A.K.; Sengupta, A.K.,1992.  
(Breeding and Genetics Laboratory, Central Tasar Research and Training Institute, Piska Nagri, India.)  
Genetic divergence in the tasar silkworm, *Antheraea mylitta* D.  
*Sericologia* , 32(3):425-435.  
Abstract: Genetic divergence, as measured by Mahalanobis  $D^2$  statistic, was studied in 26 genotypes of *Antheraea mylitta* D. All the genotypes got grouped into 9 clusters I, IV and V had four genotypes each. The cluster means of the different characters suggest a wide range of variation for fecundity, larval duration, cocoon weight, Shell weight and absolute silk yield. The grouping revealed instability in cluster due to lesser divergence. Further, clusters revealed the absence of a relationship between geographical distribution and genetic divergence. The canonical analysis did not confirm the clusters constellations obtained with  $D^2$  analysis.
752. Sinha, A.K., Sinha, R.K., Goel, A.K., Sinha, B.R.R.Pd., 1992.  
(Central Tasar Research and Training Institue, Ranchi, India)  
A review of the breeding and genetics aspect of tropical tasar silkworm *Antheraea mylitta* D  
In: Abstracts of 4th All India Conference on Cytology Genetics and Symposium on Cytogenetics of Mulberry and Silkworm, KSSDI, Bangalore, Nov 5-7, 108.
753. Yang, H.J., Shen, X.I., Lu, W.X., Liu, Z.M., Yu, J.R., Lou, Q.N., Wang, P.I., Tiang, S.R.,1993.  
(Shandong Provincial Institute of Sericulture, Yantai, China.)  
Breeding of two new variety of *Antheraea pernyi* Yantai No 6 and 789 and selection of its hybrid F1 combination.  
*Acta Sericologica Sinica* , 18(3):177-183,  
Abstract: A new variety of *Antheraea pernyi* Yantai No 6 characterized by early-ripe and strong was bred out by using cross-breeding method among four Chinese tussar varieties, C66,781,446,785 through 20 generations. And by using three varieties; 2H30 (bred through laser induction), Fang-quing, He'nan No.6 three parent strains. The other new variety-789 rich in silk was breed out through 23 generations during 1980-1989. It is found that Yantai No 6X789 exhibited a good specific combining ability. We found that the silk yields of the new vareity is higher than that of the check variety and its silk quality is better than

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that of the check variety. Its cocoon yields per kg eggs is 10.87 higher than that of the check and its income per kg eggs is 15.94 percent more than that of check variety.

754. Wang, Y., Peng, N., Luo, F., 1993.

(Heilongjiang Institute of Sericultural Research, Harbin, China).

Breeding of white cocoon variety "Huabei 1" of Chinese tussah silkworm.

Acta Sericologica Sinica, 19(1):37-43.

755. Sengupta, K.; Singh, K., 1974.

(Central Muga and Eri Research Station, Titabar, India.)

Some studies on the expression of hybrid vigour in muga silkworm, *Antheraea assama* West.

In: Proceedings of the First International Seminar on Non-Mulberry Silks, Central Tasar Research Station, Ranchi, India. 3-4 October, 1974, p.83-84.

Abstract: Little or no study has been made on the expression of hybrid vigour in muga silkworm, *Antheraea assama* West. mainly due to the absence of well established stock lines in this species. In a pioneering attempt, some crosses were made between a yellow mutant muga breed and some normal green lots from Narayanpur and Koranga. Since yellow larval body colour is a rare recessive character and maintenance of its purity meant substantial amount of inbreeding, the same was taken as one of the stock, others selected being normal green lots from Narayanpur and Koranga. In the later combination reciprocal crosses were also made. Observations indicated a clear manifestation of intra-specific hybrid vigour in *Antheraea assama* West. with the lowering of larval period by about 3 days (21 days in hybrids against 24 days in the pure line), higher E.R.R., single cocoon weight, shell weight and shell percentage, thereby suggesting a scope for the utilization of the technique for increased cocoon crop production.

756. Sinha, A.K., Sinha, R.K., Gopal, A.K., Sinha, B.R.R.Pd., Thangavelu, K., 1994.

A review on the breeding genetic aspects of tropical tasar silkworm, *Antheraea mylitta*, D (Saturniidae: Lepidoptera).

Proceedings of the Conference on Cytology and Genetics, 4:7-16.

757. Gershenzon, S.M., 1994.

(Institute of Plant Physiology and Genetics, Ukrain Academy of Science, 252022 Kiev, Ukraine) A melanistic form of the oak silkworm *Antheraea pernyi* (Lepidoptera, Attacidae).

Vestnik Zoologii, 6:46-51

758. Sinha, A.K.; Siddiqui, A.A.; Sengupta, A.K.; Sinha, S.S., 1994.

(Silkworm Breeding and Genetics Laboratory, Central Tasar Research and Training Institute, Ranchi, India)

Selection of best combiner through diallel cross of Indian tropical tasar silkworm *Antheraea mylitta* Drury (Lepidoptera : Saturniidae).

Annals of Entomology, 12(2):9-11.

Abstract: The nature of the combining ability of the silkworm *Antheraea mylitta* was studied in a set of diallel crosses (excluding reciprocals) of genotypes for absolute silk yield and its six contributing characters. Both additive and non-additive gene effects were equally important for all the traits. Only two parents, N1 and N2, appeared to be a good general combiner for all the characters except larval weight for the parents N2. R57 X N2, R57 X N1 and GE2 XN1 crosses appeared to be good for absolute silk yield and most of its components. It was concluded that both additive and non-additive gene effects might be exploited and recurrent selection might be practiced for exploiting this genetic variability.

759. Sengupta, A.K.,1997

(Central Sericultural Research and Training Institute, Berhampore, West Bengal, India)

Effects of gene-environment interaction on silk yield in *Antheraea mylitta* (Saturniidae).

Journal of the Lepidopterists' Society, 51(1):95-97.

Abstract: Laboratory experiments were conducted to measure the interaction between genotype and environment for silk yield in *Antheraea mylitta*, and to screen stable genotypes for use in breeding programmes to enhance silk yields.

760. Siddiqui, A.A.,1997.

(Central Tasar Research and Training Institute, Ranchi, India.)

Studies on heterosis and heterobeltiosis in the tasar silkworm, *Antheraea mylitta* D. [mid-parent, better parent, progeny.

Sericologia, 37(1):59-69,

Abstract: Relative heterosis (over mid-parent) and heterobeltiosis (over better parent) for eight components i.e., oviposition, hatching percentage, larval weight, larval duration, effective rate of rearing cocoon weight, cocoon shell weight and absolute silk yield, were estimated in 24 crosses derived by crossing 8 female and 3 male parents of the tropical tasar silkworm, *Antheraea mylitta* D. Thirteen hybrids exhibited heterobeltiosis for absolute silk yield, effective rate of rearing and cocoon weight. In 12 hybrids, heterosis was observed in 10, 9, 8 and 7 hybrids respectively for larval weight, oviposition, larval duration and hatching percentage. Maximum heterosis and heterobeltiosis were observed in the cross S17 x N5 (114.74 and 108.1) for absolute silk yield. Heterobeltiosis can be used as a criterion in future breeding programmes.

761. Ibohal Singh, N., Ibotombi Singh, N., James Keisa, T., Rajendra Singh, Y., Chaoba Singh, K.,2000.

(Regional Tasar Research Station, Mantripukhri, Imphal, Manipur, India.)

Conservation and utilization of Indian oak fed *Antheraea* fauna.

International Journal of Wild Silkmoth and Silk, 5:330-331,

Abstract: Among the fifteen oak fed species of *Antheraea* known so far, *A. pernyi* (Chinese) and *A. proylei* (Indian) are used for commercial production to tussah silk and conservation and proper utilization of these species are very important for checking the indiscriminate destruction of oak forest ecosystem. *A. frithi* and *A. roylei* are conserved in the germplasm Bank while less attention has been paid for conservation of other species due to their less economic importance. However, it is well known that both mulberry and non-mulberry silkmoths have been important materials of research in insect physiology developmental biology, biotechnology, genetics and breeding. The extent of distribution, conservation and potential for utilization of these Indian oak fed *Antheraea* fauna are discussed in the present paper.

762. Nangia, N., Jagadish, P.S., Nagesh Chandra, B.K.,2000.

(Department of Sericulture, University of Agricultural Sciences, GKVK, Bangalore, India.)

Evaluation of the volumetric attributes of the eri silkworm reared on various host plants.

International Journal of Wild Silkmoth and Silk, 5:36-38.

Abstract: Three prolifically breeding races of eri silkworm namely, Bordeur (Blue Zebra), Titabar local (Yellow spotted) and Dhanubhanga local (Yellow) were reared exclusively on castor (*Ricinus communis*), gulancha (*Plumeria acutifolia*), papaya (*Carica papaya*), tapioca (*Manihot utilissima*) and barkesseru (*Ailanthus excelsa*) hosts and the larval and silk gland volumes and silkgland ratios were assessed in relation to three cocoon characters. Significantly enhanced volumes of attributes were recorded on castor for the three races. The host sequence for volumetric assessment were in the merit order of castor tapioca papaya barkesseru gulancha for Bordeur (Zebra race), whereas it was castor barkesseru

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gulancha tapioca papaya for Titabar local and Dhanubhanga local races, under caged conditions. A positive correlation between volumetric attributes and cocoon characters was registered.

763. Naqvi, A.H., Srivastava, A.K., Sinha, A.K., Ray, S., Roy, G.C., Visvakarma, S.R., Sinha, B.R.R.Pd., Thangavelu, K., 2000.

(Central Tasar Research and Training Institute, Nagri, Ranchi, India)

Diallel analysis for combining ability in tropical tasar silkworm *Antheraea mylitta* Drury.

Current Technology Seminar: Recent Trends in Tasar Culture, 18-19 Oct 2000, CTRTI, Ranchi, India, 9

764. Naqvi, A.H., Srivastava, A.K., Sinha, A.K., Roy, G.C., Sinha, B.R.R.Pd., 2000.

(Central Tasar Research and Training Institute, Ranchi, India)

Conservation of genetic reserves of *Antheraea mylitta* Drury in North-East India.

International Journal of Wild Silkmoth and Silk, 5:332-335.

Abstract: North-East India harbors most of the saturnid wild silkmoths belonging to the genus *Antheraea*. Observations reveal that in North-East India, biodiversity of these silkmoths is being lost as their natural habitats are rapidly eroded due to deforestation. During the present course of investigation, the occurrence of *Antheraea mylitta* Drury in abundance has been established in North-East. The paper deals with intra and inter population variability of the collected bio-material and emphasize the urgent need for its conservation and utilization for future breeding programmes. Study depicts that the variability in economic traits of various population exists between and within the population, which suggests the importance of utilizing these genetic resources of tropical tasar silkworm, *Antheraea mylitta* Drury.

765. Pujar, N.S., Savanurmath, C.J., 2000.

(Post Graduate Department of Sericulture, Karnataka University, Dharwad, Karnataka, India.)

Innovations in indoor maintenance of tasar silk moth, *Antheraea mylitta* Drury.

International Journal of Wild Silkmoth and Silk, 5:61-65,

*Antheraea mylitta* larvae, collected from the wilds of Aravatgi, Dharwad have been successfully domesticated under standardized indoor breeding, grainage and rearing methods.

766. Purushotham Rao, A., 2000.

(Sericulture Unit, Kakatiya University, Warangal, Andhra Pradesh, India.)

Some salient features of Andhra local ecorace, *Antheraea mylitta* Drury in relation to its conservation and multiplication.

International Journal of Wild Silkmoth and Silk, 5:356-358.

Abstract: Outdoor rearing of Andhra local ecorace is found successful in the isolated patches of forest area free from any competition by other ecoraces. Due to genetically weak characters of the ecorace, it is likely to deteriorate further unless detailed and serious studies are made at the molecular level. A methodical breeding activity is require probing into the binding capacity and combining abilities of Andhra local with other ecoraces of *A. mylitta*. Partial and complete indoor rearing of the ecorace, scanning electron microscopic studies of the shell structure and molecular characterization of the ecorace have been studied.

767. Roy, G.C., Thangavelu, K., 2000.

(Central Tasar Research and Training Institute, Ranchi, Bihar, India)

Future research strategy in tasar silkworm breeding - A bimolecular approach.

National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, 91 - 92.

Abstract: No one can do today's work with yesterday's instruments and be in business tomorrow. Therefore, it is essential for the tasar breeders to shift their strategy in the new millennium. But before making the strategy, the breeders must have to keep in their minds two crucial issues, first that the poorest tribal people of the Central Indian Plateau are involved in cocoon production and the second, that this is an age of global competition where industrializations are put on the top priority area particularly in the developing countries like ours.

768. Sengupta, A.K., 2000.

(Central Sericultural Research and Training Institute, Berhampore, India.)

Gene action for yield and yield components in diallel populations of tasar silkworm *Antheraea mylitta* D. International Journal of Wild Silkmoth Silk, 5:249-252.

Abstract: The genetics of yield and yield components was studied in tropical tasar silkworm, *Antheraea mylitta* D. using six parents diallel in F1. The component analysis of yield and four yield contributing traits indicated that the additive component (D) is significant for absolute silk yield and shell weight and non-additive H2 variances are significant for all other characters. Additive components (D) has been found to be always lower than H1 in the present investigation. Positive direction of dominance has also been substantiated by the unity for absolute silk yield, fecundity, ERR, cocoon weight and shell weight indicating over dominant type of gene actions. The ratio (H2/4H1) indicates asymmetrical distribution of positive and negative alleles. The proportion of dominant and recessive genes among parents  $(4DH1)^{1/2} + F / (4DH1)^{1/2} - P$  indicates excess of dominant genes in the parents. Heritability both in broad sense and narrow sense have been computed. On this basis, a selection scheme has been discussed.

769. Srivastava, A.K., Naqvi, A.H., Sinha, A.K., Vishwakarma, S.R., Roy, G.C., Sinha, B.R.R.Pd., 2000. (Central Tasar Research and Training Institute, Ranchi, Bihar, India)

Breeding in tropical tasar silkworm - Future strategies.

National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, 86.

Abstract: Efforts on breeding of tropical tasar silkworm, *Antheraea mylitta* Drury are initiated after establishment of CTRS, Ranchi in the year 1965. Apart from accumulation of gene pool, twenty lines based on morphological characters of larval body colour, cocoon colour, adult female moth wing colour, three lines R57, L8, S17 through selection, another three lines N1, N2, N3 through cross breeding and subsequent selection have been developed in tasar silkworm nevertheless, till today only Daba and Skinda ecoraces are under exploitation.

770. Srivastava, A.K., Naqvi, A.H., Sinha, A.K., Vishwakarma, S.R., Roy, G.C., 2000.

(Central Tasar Research and Training Institute, Ranchi, Bihar, India)

Breeding in tropical tasar silkworm - Future strategies.

In: National Conference on Strategies for Sericulture Research and Development, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, 86.

Abstract: Efforts on breeding of tropical tasar silkworm, *Antheraea mylitta* Drury are initiated after establishment of CTRS, Ranchi in the year 1965. Apart from accumulation of gene pool, twenty lines based on morphological characters of larval body colour, cocoon colour, adult female moth wing colour, three lines R57, L8, S17 through selection, another three lines N1, N2, N3 through cross breeding and subsequent selection have been developed in tasar silkworm nevertheless, till today only Daba and Skinda ecoraces are under exploitation.

771. Lijun, Y., Shuwen, R., Dongfeng, W., Juan, F., Tianmao, W., 2001.

(Sericultural research Institute of Heilongjiang Province, Haerbin, China.)

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Breeding of big cocoon variety 91S20 of Chinese tussah silkworm.  
*Science of Sericulture*, 27(3):240-242,

772. Xianmin, M., Peifeng, L., 2001.  
(Sericultural Research Institute of Liaoning Province, Fengcheng, China.)  
The breeding of new tussah variety Da San Yuan with high diet efficiency.  
*Science of Sericulture*, 27(3):236-239.

773. Debaraj, Y., Datta, R.N., Das, P.K., Benchamin, K.V., 2002.  
(Regional Eri Research Station, Mendipathar, Meghalaya, India)  
Eri silkworm crop improvement- A review.  
*Indian Journal of Sericulture*, 41(2):100-105.  
Abstract: Eri silk, a kind of natural silk, produced by the wild silkworm, *Samia cynthia ricini* (*Philosamia ricini* Hutt), ranks next to mulberry silk produced by *Bombyx mori*. It is an oligophagous and multivoltine insect without diapause, hence it can be reared all through the year. Literature available on crop improvement of eri silkworm with reference to breeding strategies is reviewed.

774. Jayaprakas, P., Sanjeeva Rao, B.V.S., Purushotham Rao, A., Sinha, B.R.R.P., 2002.  
(Regional Tassar Research Station, Warangal, Andhra Pradesh, India.)  
Biology of Andhra local tassar silk moth *Antheraea mylitta* Drury (Lepidoptera: Saturniidae).  
In: Proceedings of the XIXth Congress of the International Sericultural Commission, 21st - 25th September 2002, Queen Sirikit National Convention Centre, Bangkok, Thailand. , p.296-302.  
Abstract: The Telangana region of Andhra Pradesh is a natural abode for Andhra local an ecorace of *Antheraea mylitta* D. The Andhra local is bestowed with superior commercial characters, but suffers with problems of acclimatization at breeding and rearing stages. With a view to understand the problems at rearing stage, an attempt has been made to study the biology of the Andhra local ecorace at its abode.

775. Singh, B.K., Debaraj, Y., Sarmah, M.C., Das, P.K., Suryanarayana, N., 2003.  
(Regional Muga Research Station, Boko, Assam, India)  
Eco-races of eri silkworm.  
*Indian Silk*, 42(1):7-10.  
Abstract: The present day need is for collection, conservation and utilization of existing eri silkworm races / strains as bio-resources in a systematic way. Its best utilization in the future breeding programme yields a positive result.

776. Barah, A., Chakravorty, R., 2004.  
(Central Muga Eri Research and Training Institute, Central Silk Board, Lahdoigarh- 785 700, Assam, India.)  
Seri-biodiversity in North East India with special reference to germplasm of muga silkworm *Antheraea assamensis* Helfer.  
In: Abstracts of International Workshop on Wild Silkmoths and Silks "Current Advances and Development in Wild Silkmoths and Tropical *Bombyx* Silks", Silk Innovation Centre, Mahasarakham University, International Society for Wild Silkmoths, Thailand's Biodiversity Research and Training Programme, Thailand, October 11th - 14 th, 2004., P.60.  
Abstract: The variety and variability of organisms and ecosystems is referred to as biological diversity or biodiversity. The larger the diversity, wider the range of possible responses permitting adaptation to new conditions. North East Region of India is considered as the floral and faunal gate-way for main Asian land to Indian peninsula. The region is having a dense Spectrum of species and considered as a

rich reservoir of natural resources and can very well sustain its populace. Due to the unique climatic condition and varied topography, North East India occupies a distinct and diversified ecosystem and it becomes the natural abode for numbers of sericigenous insects. It harbors about a dozen of wild silk producing insects along with their host plants, forming a separate habitat called "Seri-biodiversity". India's wild silkmoth biodiversity consists of 47 number of species described under 15 genera, three and two sub-families of the family Saturniidae. Of which, muga silkworm, *Antheraea assamensis* Helfer and its related *Antheraea* species are sporadically distributed throughout North East India and the Sub-Himalayan foot hills. Golden silk producer *Antheraea assamensis* Helfer is a typical wild silk moth, native to North East India. It is multivoltine and semi-domesticated in nature. Its wild counterpart is available in different pockets of N.E. India, which shows pupal diapause during winter in its natural abode. Muga silkworm is confined to the Brahmaputra valley of Assam, East Garo Hills, West Garo Hills and West Khasi Hills districts of Meghalaya, Mokokchung, Tuensung, Kohima and Wokha districts of Nagaland, Lohit, Dibang Valley, Changlang and Papumpare districts of Arunachal Pradesh, Tamenglong district of Manipur and Coochbehar district of West Bengal in particular. This endemism or geographical isolation is perhaps because of their distinctive ecological regiments are met with only in this region. Conservation of genetic resources and establishment of a germplasm bank (GPB) is a long felt need in muga silk industry. Monophyletic status of muga silkworm *Antheraea assamensis* is a hindrance in improvement of the species. Sporadic attempts have been made to collect different stocks from different regions in India to utilize in breeding programme, but the efforts were not successful due to discontinuation of generations and other inherent problems. The immediate strategies to be adopted for extensive and intensive exploration, collection and isolation of pure lines of muga silkworm for breeding studies and their ex-situ and in-situ conservation are discussed in the article.

777. Bhattacharya, A., Sahu, A.K., Prasad, B.C., Chakraborty, R., 2005.

(Regional Muga Research Station, Boko, Assam, India.)

Study on some economic characters of different colour polymorphs of muga silkworm, *Antheraea assamensis* Helfer.

*Sericologia*, 45(3):339-341.

Abstract: Muga silkworm *Antheraea assamensis* Helfer shows various larval colour polymorphs, i.e., green, blue, yellow and orange of which occurrence of green colour polymorph is predominant. A study on their economic characters reveals that the yellow colour polymorph has the highest ERR (31.86 percent  $\pm$  0.12), pupal weight (5.78 gm  $\pm$  0.03) and realized a average fecundity (145  $\pm$  0.95) but has the lowest shell weight (0.40g  $\pm$  0.01). The blue colour polymorph though has the lowest ERR (12.50g  $\pm$  0.09) and pupal weight (5.51g  $\pm$  0.01), has the highest shell weight (0.47g  $\pm$  0.01). In the present study, emphasis has been laid on the utilization of the high shell weight of the blue polymorph, which is 17.50 percent more than yellow polymorphism and 9.30 percent more than green polymorph and on the high pupal weight of yellow polymorph, which is 4.90 percent of blue polymorph and 4.14 percent of green polymorph as a genetic resource in muga silkworm for their Exploitation during commercial and seed crops, respectively, through conventional breeding and biotechnological techniques. This will enable the increase of raw silk productivity by utilizing lesser cocoons for getting 1kg of silk and to ensure healthy disease free layings (dfls) for utilization during commercial crops.

778. Kar, P.K., Vijayan, K., Mohandas, T.P., Nair, C.V., Saratchandra, B., Thangavelu, K., 2005.

(Central Sericultural Germplasm Resources Centre, Central Silk Board, Thally Road, P.B. 44635109 Hosur, Tamil Nadu, India.)

Genetic variability and genetic structure of wild and semi-domestic populations of tasar silkworm (*Antheraea mylitta*) ecorace Daba as revealed through ISSR markers.

*Genetica*, 125(2-3):173-183.

Abstract: The genetic diversity in the wild and semi-domestic populations of Daba ecorace of *Antheraea mylitta* was studied to ascertain the distribution of variability within and among populations of semi-domestic bivoltine (DB), trivoltine (DT) and nature grown wild populations (DN) with inter-simple sequence repeat (ISSR) markers. A total of 138 markers were produced among 56 individuals of the three populations, of which 98 percent were polymorphic. For the individual populations, the percentage polymorphism was 58.69, 52.9 and 77.54 for DB, DT and DN, respectively. Average number of observed ( $1.791 \pm 0.408$ ) and effective alleles ( $1.389 \pm 0.348$ ) was also high in the wild populations in comparison to the bivoltine and trivoltine semi-domestic populations. Genetic diversity ( $H(t)$ ) in DB, DT and DN was  $0.180 \pm 0.033$ ,  $0.153 \pm 0.032$  and  $0.235 \pm 0.033$ , respectively and within-population genetic diversity ( $H(s)$ ) ranged from 0.166 to 0.259 with a mean of 0.189. Mean gene differentiation ( $G(ST)$ ) was found to be 0.25. Shannon's diversity index was 0.278, 0.237 and 0.361 for DB, DT and DN and overall it was 0.391. Gene flow ( $N(m)$ ) among the populations was 1.509. The dendrogram produced by UPGMA with Dice's genetic distance matrices resulted in the formation of three major clusters separating the three populations. Considerable intra- and inter-population variability is found in all three populations. The population structure analysis further suggests that the semi-domestic populations of Daba ecorace are at the threshold of differentiating themselves. The high genetic variability present within wild Daba population of *A. mylitta* is of much importance for conservation as well as utilization in systematic breeding program.

779. Vishwakarma, S.R., Rath, S.S., Singh, G.S., Suryanarayana, N., 2005.

(Central Tasar Research and Training Institute, 835 303, Ranchi, India.)

Domestication Of Tasar Silkworm *Antheraea Mylitta* D. - A Brief Review.

In: 20th Congress of the International Sericultural Commission, Bangalore, India, 15-18 December, 2005, Vol II, P.121-125.

Abstract: Tasar silkworm, *Antheraea mylitta* D is an economically important insect but being wild in nature its rearing process is carried out completely in outdoor conditions. About 50-55 percent losses of silkworms make the rearing uneconomical. The major part of the loss is attributed to the natural calamities prevailing during the rearing season. The Indoor rearing technology is evolved to make the tasar silkworm rearing more viable and economical by providing protection to the tiny worms. Gradual development in indoor rearing techniques has paved the path of domestication of the tasar worm. The domestication of tasar silkworms will not only help in systematic production of tasar cocoons in commercial scale but also help in breeding programs and evolution of new hybrids which are very difficult in wild condition. Several successful approach have been made in past at the Central Tasar Research and Training Institute, Ranchi and a suitable indoor rearing technology is developed. All these technologies and future program in this line will gradually help to domesticate the Tasar silkworms.

780. Gogoi, S.N., Ghosh, P.L., Handique, P.K., Chakravorty, R., 2006.

(Central Muga Eri Research and Training Institute, Central Silk Board, Lahdoigarh-785 700, Jorhat, Assam, India.)

Genetic improvement of som, *Persea bombycina* KOST. the principal host plant of muga silkworms (*Antheraea assamensis* HELFER).

In: Proceedings of Regional Seminar on "Prospects and Problems of Sericulture an Economic Enterprise in North West India", 11th-12th November 2006, Regional Sericultural Research Station, Dehradun, India., p.447-454.

Abstract: A total 37 genotypes of som, *Persea bombycina* Kost., a native of northeastern region of India was collected and maintained as genetic resource in field gene bank in CMER and TI, Lahdoigarh, Jorhat, Assam, Among the genotypes, 8 was selected on the basis of morphological variability, 25 was selected as plus trees through Point Grading Method of selection and 4 was evolved as tetraploid

genotypes through polyploidy breeding. Clones of plus tree were collected through air layering technique and revealed wide variation on rooting behaviours (36.50 to 66.67 percent) and survival (12.5 to 100 percent) in ex-situ condition in field gene bank. Among the tetraploids, PB009 tetraploid showed dwarf nature (2.36m in height), PB011 tetraploid showed maximum height ((3.27m) and leaf yield (2.84kg/plant/harvest) over diploid (1.28kg/plant/harvest) and other tetraploids. On the other hand, PB012 tetraploid showed higher ERR (88.33 percent), single cocoon wt.(6.7g) , single cocoon shell wt. (0.617g) besides higher crude protein (12.59 percent), less fibre (18.33 percent) and higher soluble sugar (6.63 percent) and more moisture (64.40 percent) content over other tetraploid and diploids.

781. Mahobia, G.P., Rao, K.V.S., Yadav, G.S., Verma, R.S., Suryanarayana, N.,2006.  
(Regional Tasar Research Station, Jagdalpur-494001, Chhattisgarh, India.)

The rainfall and Raily cocoon production relationship - A case study for wild tasar cocoon production in Bastar (Chhattisgarh).

In: Proceedings of Regional Seminar on "Prospects and Problems of Sericulture an Economic Enterprise in North West India", 11th-12th November 2006, Regional Sericultural Research Station, Dehradun, India., p.406-409.

Abstract: Studies on relationship between annual rainfall and Raily cocoon production in Bastar (Chhattisgarh) revealed they are inversely related to each other. The long term trends of annual rainfall and raily cocoon production indicated increasing trend in cocoon production with the decreasing rainfall. The cocoon production is increasing at the rate of 23 lakhs per year. The excessive rains immensely affects breeding, growth, survival rate etc. in life cycle of raily ecorace. However, it is the monsoonal rainfall which is very much determining period for the nature grown cocoon production of ecorace in Bastar on the basis of developed equations. Therefore, release of live cocoon (at least 10 percent population of each and every season) potential ecopockets for natural regeneration of raily ecorace is strongly recommended. Appropriate technology genera with a clearer understanding of the problems related to multiplication of population in nature is also a need of the hour.

782. Shankar Rao, K.V., Mahobia, G.P., Saxena, N.N., Suryanarayana, N.,2006.  
(Regional Sericultural Research Station, Landiguda, Koraput 764020, Orissa, India.)

Technology for nature grown tasar seed cocoon preservation.

In: Proceedings of Regional Seminar on "Prospects and Problems of Sericulture an Economic Enterprise in North West India", 11th-12th November 2006, Regional Sericultural Research Station, Dehradun, India., p.395-398.

Abstract: Nature grown eco races of *Antheraea mylitta* D contribute considerable share of tropical tasar silk production in India. Over exploration for trade has resulted in the increased effort of collection which always exceeds, the sustainable limits of natural regeneration capacity of the eco races. Hence, there is a need for replenish the seed through various releasing methods. But nature ecoraces impose various problems at their different stages of breeding under captivity. In-order-to evolve an ideal preservation and grainage technique, the behavioral patterns of raily seed cocoons has been studied in detail under conventional and in situ PAGODA device for the first time in tropical Tasar Culture. The conventional grainage house preservation resulted in 69 percent of unseasonal emergence with 18 percent pupal mortality, thereby retaining only 13 percent of seed cocoons for regular emergence against 18 percent of unseasonal emergence, 20 percent of pupal mortality, successfully retained 72 percent of live cocoons for seed preparation under pagoda device. There is no marked difference in regular emergence in either of the conditions. But there is a marked shift in mating behavior. Under pagoda device 50 percent pairings were obtained where as in conventional method only 10 percent of pairings could be obtained. A comparative economics of preservation and seed preparation indicated that 50 dfls were prepared out of 10,000 seed cocoons under conventional method, which gives 200: 1 coc-dfl ratio.

The new pagoda device gave 7:1 coc-dlfs and is thirty three times beneficial in respect of cost of production of seed. The PAGODA technique was validated in eco-race development of modal eco race in Orissa and this breakthrough certainly helps in rejuvenation of nature grown ecoraces of tropical tasar and assists in Seri-biodiversity conservation was analyzed for technology usage at operative level.

783. Sharma, K.K., Srivastava, A.K., Sinha, A.K., Kulshrestha, S.K., Khatri, R.K.,2006.  
(P3 Basic Seed Farm, National Silkworm Seed Organization, Central Silk Board, Majra, Dehradun, India.)

Path co-efficient analysis in yield contributing traits of ecological races of *Antheraea mylitta* (Drury) (Lepidoptera:Saturniidae).

In: Proceedings of Regional Seminar on "Prospects and Problems of Sericulture an Economic Enterprise in North West India", 11th-12th November 2006, Regional Sericultural Research Station, Dehradun, India., p.494-499.

Abstract: Yield is a complex quantitative character that determines the performance of both animals and plants. Information on yield and yield contributing characters, direct and indirect influences of yield components are important for any breeding programme. In the present study, partitioning of correlation co-efficient values into direct and indirect effects in respect component characters viz., fecundity, hatching, larval weight, larval period, effective rate of rearing (E.R.R), cocoon weight, shell weight and silk ratio on absolute silk yield applying path analysis was performed. The results obtained in path co-efficient analysis showed that E.R.R. and fecundity exerted maximum positive direct effect on silk yield with positive and significant correlation at both genotypic and phenotypic levels. Similarly, shell weight and cocoon weight had direct effect on silk yield with positive and significant correlation at both levels. In the present study effective rate of rearing, fecundity, cocoon weight and shell weight were found showing higher absolute silk yield, increasing towards yield. Hence, these characters may be considered as "Selection indices" for future breeding programme to evolve high yielding varieties.

784. Sinha, R.K., Raje Urs, S.,2006.  
(Central Sericultural Germplasm Resources Centre, Central Silk Board, Thally Road, Hosur, Tamil Nadu, India.)

Present status, problems and prospects of vanya silk as an economic enterprise in North West India.

In: Proceedings of Regional Seminar on "Prospects and Problems of Sericulture an Economic Enterprise in North West India", 11th-12th November 2006, Regional Sericultural Research Station, Dehradun, India., P.327-333.

Abstract: Vanya Silk includes silk produced by the wild sericigenous insects. In India more than 40 species of insects are reported to produce silk belonging to two major families Viz., Bombycidae (14 species) and Saturniidae (27 species). However, only four species are being utilized for the production of commercial silk Viz., *Antheraea mylitta* D, *A. proylei* J., *A. assama* Ww. and *Samia ricini*. North Western India is rich in natural sericigenous fauna and their food plants. About 4.55 lakhs hectares of forest are under oak flora consisting of 10 species available at the altitudes from 530 to 6975 mAMSL. About 13 species of muga host plants are reported to be available in 13 districts of Himachal Pradesh and Uttranchal between 681 to 2000 mAMSL, while 6 species of Eri host plants in 8 districts of Himachal Pradesh. So far oak fed silk moth is concern, one species, *A. roylei* is reported from North West. Wild muga silk moth is not reported from these areas; however, wild eri silk moth *S. cynthia* and a few ecoraces of *A. mylitta* have been reported. Beside, 7 species of Bombycides and 7 species of Saturniids are also reported from these areas. No systematic survey, collection, characterization and conservation strategies have been made to know the actual potential of the available wild silk moth and their host plants. However, 11 genetic resources of oak fed silk moths, 05 of muga, 60 of tropical tasar and 10 of eri silk moths are reported to be available in different ex situ (Main and Regional Stations) and in situ

conditions of the country which may be utilized for evolution and identification of high yielding silkworm races or hybrid combinations for commercial exploitations. There are tremendous potentialities of developing Vanya silk through introgression of wild important genes along with conventional breeding programme. Other wild species may also be characterized through molecular means to exploit their secondary characters through biotechnology. This paper deals with the present status, problems and prospects of Vanya silk in North West India besides providing information on utilization of available genetic resources for crop improvement and commercial exploitation.

785. Ibotombi Singh, N., Somen Singh, L., Ibohal Singh, N., Suryanarayana, N., 2008.

(Regional Tasar Research Station, Mantripukhri, Imphal, India)

Evolution of a superior breed of oak tasar silkworm - Blue.

*Sericologia*, 48(3):289-295

Abstract: Evolution of superior breeds of Oak Tasar silkworm is one of the most important areas of breeding research for development of Oak Tasar industry in India. A new breed having Blue colour in the larvae is isolated from the segregating progenies of the backcrosses involving the parents *Antheraea roylei* (n=31) and *Antheraea proylei* (n=49). The new breed has shown improvement in most of the yield contributing characters over that of *A. proylei*. Average fecundity of the new breed ranges from 144 eggs to 158 eggs; cocoon yield ranges from 44 cocoons per disease free layings (df) to 92 cocoons per df; effective rate of rearing (ERR) ranges from 48.85 percent to 80.84 percent; cocoon weight ranges from 6.43 gm to 7.03 gm; cocoon shell weight ranges from 0.65 g to 0.75 g and filament length ranges 157m to 755m. The breed may be exploited for commercial production of Oak tasar raw silk.

786. Manohar Reddy, R., Hansda, G., Ojha, N.G., Vijayaprakash, N.B., 2008.

(P4 Division, Central Tasar Research and Training Institute, Central Silk Board, Piska Nagri, Ranchi)

Selective back crossing and its upshot on larval, pupal and fecundity levels in tropical tasar silkworm *Antheraea mylitta* DRURY.

Proceedings of the National Seminar on Scenario of Seribiotechnological Research in India (NSSSRI-2008), Department of Sericulture, Sri Padmavati Mahila Visvavidyalayam, Tirupati, Andhra Pradesh, India, 28th - 30th August 2008, 276-284

Abstract: Backcross breeding studies with selected parents of Jata and Daba ecotypes of tropical tasar silkworm, *Antheraea mylitta* Drury revealed improvement in larval, pupal and fecundity characters at F1, BC1, BC2 levels. The breeding combination of selective high pupal and high pupal weights of Jata x Daba and Daba parents [PxP] at BC2 level recorded better larval weight (42.65g), pupal weight (9.98g), fecundity (289 eggs) and hatching (78.25 percent) over both the parents and F1/BC1 hybrids. However, the larval span has been reduced at F1, BC1 and BC2 levels in both selective and non-selective breeding combinations over the parents. The improvement of pupal weight has been better in selective breeding over the general combination from F1 to BC2 and it found vice versa in cocoon weight. Though the trend is ascending for fecundity and hatching from F1 to BC2 in general breeding combination, it found less than both the parents at all stages. Where as, the breeding combination with selected parents surpassed both the parents at BC2 stage in fecundity and hatching levels. The increase in larval weight and decrease in larval span has been consistent in selective backcrossing, whilst it is fluctuating in general backcrossing. The selective backcrossing combination has recorded potential introgression of specific character by recipient from the donor parent than the general backcross breeding. This study deduces that the selective backcross breeding is an apt means to optimize the preferred and much wanted trait of quantity and quality in tasar disease free laying. The inference further suggests going in for molecular marker studies to see the variability pattern in their respective components.

787. Neog, K., Chakravorty, R., Deka, G.M., Zamal, T. ,2008.

(Central Muga Eri Research and Training Institute, Lahdoigarh, Jorhat, Assam, India.)

Morphological characterization and rearing performance of muga silkworm, *Antheraea assamensis* helper germplasm accessions.

*Sericologia*, 48(3):301-310.

Abstract: Twelve accessions of Muga silkworm *Antheraea assamensis* Helfer were collected from different prominent muga growing areas of Assam and Meghalaya, viz., Mangaldoi, Tura, Jorhat, Boko, Lakshmipur, Mariani, Titabar, Dhemaaji, Kohar Gaon, Kaliapani, Goalpara etc. and assigned with Accession numbers (Acc. No. Aa-001 to Aa-012). The accessions were morphologically characterized and their rearing performance and reaction towards three major diseases, viz., Grasserie, Flacherie and muscardine under natural conditions were studied during 2005-06. Little morphological differences among different cultivated stocks of Muga silkworm were observed although there is a wide range of variability among these populations in terms of reaction/tolerance to different diseases and rearing performance. Among the accessions, Aa-002 was the best performer in terms of rearing performance and reaction to diseases showing some degree of tolerance. Accession numbers, Aa-005, Aa-009 and Aa-011 which followed Aa-002, also exhibited superiority over others in terms of rearing performance and may be considered for inclusion in future molecular breeding programme for evolution of high yielding races or hybrids.

788. Sarkar, B.N., Sarmah, M.C., Chakravorty, R.,2008.

(Central Muga Eri Research and Training Institute, Assam, india.)

Trimoulting behaviour in eri silkworm *Samia ricini*.

*Indian Silk*, 47(5):21-22

Abstract: Eri silkworm moults three times in its larval period. The authors have reported trimoulting behaviour in *Samia ricini*, which can be utilized in breeding programme of eri silkworm.

789. Tong, Z.X., Wang, F.C., Ji, W.J., Piao, M.L.,2008.

(The Sericultural Research Institute of Liaoning Province, Fengcheng Liaoning 118100, China.)

Study on the Esterase Isozyme of Tussah Silkworm, *Antheraea pernyi*.

*Canye Kexue*, 34(2):345-350.

Abstract: Esterase isozyme of Tussah silkworm was investigated using PAGE method concerning different developing stages, organs and varieties. Activity and the kinds of esterase in the midgut varied among different developing stages, The activity and numbers of esterase loci were both higher in massive ingestion stage than that in other stages, suggested that the expression of esterase isozyme related to the development of Tussah silkworm. The kinds and activity of esterase varied greatly among different organs of Tussah silkworm larva. Esterase in fat body and midgut had higher activity and more kinds than that in other organs, indicated that the activity of esterase isozyme was closely related to the function of specific organ. The esterase isozymes were expressed differently among different varieties, but all the varieties shared a common esterase loci at Rf 0.65. The result of clustering analysis with UPGMA method showed that 33 Tussah varieties were classified into 4 groups most varieties had closer relationship with their female parents, indicated that female parents play an important role in line separation breeding. The result suggested that more attention should be paid on the selection of female parents during the process of hybrid breeding. For some of the varieties bred by system separation method, part of their characters that come from their parent line may tapered gradually during long term intensive selection while some specific characters strengthened, resulted in the far blood relationship with their parents.

790. Xu, L., Meng, X.M., Qi, L., Liu, F.Y., Liu, P.F., Jiang, D.F., 2008.

(The Sericultural Research Institute of Liaoning Province, Fengcheng Liaoning, China.)

Analysis on major gene and polygene mixed inheritance of cocoon weight in the tussah, *Antheraea pernyi*.  
*Canye Kexue*, 34(3):435-438.

Abstract: Character of cocoon weight is one of key indices for breeding of the Tussah, *Antheraea pernyi*. In this paper, we chose 2 tussah strains, 582 and Kuanqing, as parent to investigate inheritance pattern of cocoon weight, which are different significantly in cocoon weight. Combination analysis of 4 generations (P1, P2, F1 and F2) showed that 2 major genes dominate the inheritance of cocoon weight and polygene embellish it. Moreover, the inheritance pattern was different in the different sex. For female, it was fit for two equality-additive major gene plus additive-dominance polygene model. It's major gene heritability was 49.01 percent, and the polygene heritability was 0.53 percent. For male, it was fit for two equality-dominance major gene plus additive dominance polygene model. It's major gene heritability was 24.35 percent, and the polygene heritability was 26.47 percent. The above results indicated that we should apply different schemes for selecting cocoon weight for different sex during the process of tussah breeding. For female, it should be selected at early stage, while it should be selected continuously for several generations for male.

791. Zhu, Y.M., Dong, X.G., Li, Q.F., He, N., Zhao, C.S., Xia, X.H., 2008.

(Sericultural Research Institute of Liaoning Province, Fengcheng Liaoning 118100, China.)

Breeding of A Tussah Variety "Kangda" With Strong Resistance and Selection of Hybridized Combination "Kangda x 8821 . 8822".

*Canye Kexue*, 34(4):756-760.

Abstract: Based on the principle of tussah disease-resistance, the regular heredity pattern of stable yield and the relevance among properties and genetic recombination, we carried out the pure breeding and estimated the hybridized combinations. A new tussah variety "Kangda" and hybridized combination "Kangda x 8821 . 8822" had been bred. The new variety had more strong disease resistance than that of the other tussah varieties. Its resistance to ApNPV was 5.62 times of "Xuanda 1" and 5.58 times of "Dasanyuan" during young larvae stage. Its resistance to tussah streptococcus was 6.67 times of "Xuanda 1" and 4.37 times of "Dasanyuan". The cocoon production per kg eggs of hybrid "Kangda" was 226.9 kg, which increased by 10.9 percent compared with that of "Dasanyuan". New variety had characteristics of strong feeding habit, uniform in the larval development and cocooning, good adaptation to rough feed, and stability of yields. It had been the main tussah variety in the bivoltine tussah areas now.

792. Chakravorty, R., Sahu, A.K., Neog, K., 2009.

(Central Muga Eri Research and Training Institute, Lahdoigarh, Jorhat, Assam)

Muga silkworm germplasm resources and their utilization for sustainable development of muga culture.

Status Papers and Abstracts of National Conference on Vanya Silk (NASSI, Bangalore), Central Muga Eri Research and Training Institute, Lahdoigarh, Jorhat, Assam, India, 28th-30th January, 2009, 1-10.

Abstract: Muga silkworm, *Antheraea assamensis* Helfer (Lepidoptera: Saturniidae), a polyphagous insect, is cultivated in me length and breadth of Assam and few other states of North Eastern Region of India for production of the precious muga silk. Nearly 30,000 families of the region are engaged in production of hundred and seventeen MT muga raw silk annually. Assam and Meghalaya contributes about 98.0 percent of production of the country and remaining 2.0 percent comes from the other states like Arunachal Pradesh, Manipur, Nagaland and West Bengal. Among the different contributing factors for higher productivity of any crop species, high yielding variety or races play a major role. Muga silkworm is a single species and considered as the ancestral species of *Antheraea*, from which, other species might have originated. The species has low genetic base although transposable elements and repetitive sequences are reported from its genome contributing to genetic diversity. The farmers usually cultivate

muga silkworm generation after generation preparing seeds by themselves rotating the place of rearing from the original sources of seed collection. Such stocks are known as 'cultivated stocks'. It loses its vigour in course of time when reared in a particular place for more than 3-5 generations. Muga silkworm stocks collected from forest ecosystem distributed widely in the areas extending from West Garo Hills of Meghalaya, across Cachar Hills of Assam to the north east districts of Nagaland, are known as "wild stocks". Such stocks are superior in qualitative and quantitative traits like fecundity (185-215 nos.), cocoon weight (5.02-8.15 g), shell weight (0.48 - 0.73g), etc. compared to 125-150 nos., 4.53-5.98g and 0.36-0.59 g, respectively of cultivated stocks. Wild muga stocks have higher genetic diversity within and its populations. Maintenance and conservation of the wild silkworm populations al ecology for their utilization through appropriate breeding programmes for development of high yielding muga silkworm races with certain desirable characteristics like disease tolerance will be an advantage for development of muga silk industry in the region.

793. Choudhury, B., Singh, B.K., Bhattacharya, A., Bajpayei, C.M., Das, P.K., 2009.

(Muga Silkworm Seed Organization, Central Silk Board, Guwahati)

Strategies for augmenting the production of muga silk in north eastern region of India.

Status Papers and Abstracts of National Conference on Vanya Silk (NASSI, Bangalore), Central Muga Eri Research and Training Institute, Lahdoigarh, Jorhat, Assam, India, 28th-30th January, 2009, 183.

Abstract: The golden yellow muga silk produced by polyphagous and multivoltine *Antheraea assamensis* Helfer is traditionally and indigenously cultured in north eastern region of India. State wise muga raw silk production profile reveals that over the last 50 years, it fluctuated between 40-100 MT and Assam emerges as its chief contributor by producing 95 percent of the total raw silk. At present, for capacity utilization railable muga plantation, an estimated 150 lakh disease free layings (Dfls) are required. As on date 80 to 100 lakh dfls are being produced, of which, only 20 percent are produced by the organized govt. sector while the major chunk is produced in the unorganized sector - the farmers or local societies, thereby, causing a glut of nearly 50 lakh gm or 33 percent of the total demand of dfls. This gap in demand and supply of dfls is a major impediment for augmenting muga raw silk production, which is attributed primarily to its inherent multivoltine nature and indispensable outdoor mode of rearing. that exposes the worms to multiple vagaries of nature during the vital pre-seed and seed crops. This paper addresses these constraints with a strategy of producing a stock of nucleus seed for multiplication at various parental levels, developing a region and season specific seed crop rearing management technology with crop scheduling reviving Of the infrastructure for seed production available with state government and strengthening of extension mechanism for dissemination of improved technologies and developing a specialized human resource for quality seed production. The importance of developing an improved race of muga silkworm through breeding by participation of government and private agencies in the ongoing conservation and breeding programme of Central Silk Board is also discussed in this paper.

794. Jaya Prakash, P., Jaikishan Singh, R.S., Sanjeeva Rao, B.V., Vijaya Kumar, M., Vijaya Prakash, N.B., 2009.

(Regional Tasar Research Station, Central Silk Board, Warangal, Andhra Pradesh)

Impact assessment of in-situ and ex-situ conservation models on biodiversity of Andhra local eco race, *Antheraea mylitta* D.

Proceedings of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009, 185-189.

Abstract: Strategical programmes with available resources are primary means to achieve the goal of biodiversity conservation of species. Andhra local ecorace of tasar silkworm, *Antheraea mylitta* D. is one among the commercially exploited ecoraces bestowed with superior commercial strengths and inherent

intrinsic weaknesses. The biodiversity of Andhra local ecorace has been decimated and questioned by several threats caused by human-interference. These inherent characters and human activity collectively pushed this ecorace to the verge of extinction. Hence, attempts had been made to prevent this ecorace from becoming dangerously endangered species by adopting in situ and ex situ conservation models. Impact assessment on reproductive parameters revealed that erratic emergence was reduced considerably to 07 percent under in situ conditions whereas in ex situ conditions it was 44.50 percent. Natural pairing was recorded 03 fold increase in in situ (77.50 percent) over ex situ (24.00 percent) conditions. Higher dfl recovery (71.81 percent) recorded in in situ than ex situ (22.30 percent) conditions. Core grainage efficiency measure, the cocoon dfl ratio too recorded 3 to 4 times increase (4.60:1) in in situ than ex situ. Seed production under in situ model fetched Rs. 1.16 per every rupee spent on whereas ex situ conditions incurred losses. Productivity parameters like survival/ERR (27.60 percent), cocoon dfl ratio (22.5:1) and silk ratio (15.29 percent) had shown two fold increase over ex situ conditions. Based on the findings the proven in situ models may be incorporated in conservation and breeding projects aiming at the improvement of Andhra local ecorace.

795. Mahobia, G.P., Yadav, G.S., Rao, K.V.S., Sinha, S., Sinhadeo, S.N., Singh, B.M.K., Vijaya Prakash, N.B., 2009.

(Regional Tasar Research Station, Jagdalpur, Chhattisgarh, India)

Phenotypic variability studies on populations of raily ecorace - A wild tasar silkworm.

Status Papers and Abstracts of National Conference on Vanya Silk (NASSI, Bangalore), Central Muga Eri Research and Training Institute, Lahdoigarh, Jorhat, Assam, India, 28th-30th January, 2009, 244.

Abstract: Studies conducted on phenotypic characters of wild cocoons of Raily ecorace in forests of Bastar (Chhattisgarh) revealed existence of the great degrees of intra and inter population variability. However, average cocoon weight ranges from 10.68 to 16.48 g; pupal weight 8.38-13.47g, shell weight 2.22-3.08g, cocoon length 4.99-5.24 cm, cocoon breadth 3.29-3.46 cm and cocoon volume 23.18-39.43 cc. Studies on the phenotype characters of Raily ecorace revealed high variability in the cocoon weight, pupal weight, shell weight and cocoon volume indicating that these characters are not consistent in different eco-pockets. On contrary, the other characters such as cocoon length and bredth showed low variation indicating their stability within the Raily ecorace in different eco-pockets. However, the CV percent during first season in respect of all these characters were higher in comparison to the second season, which indicates that these characters are more stable during second season (October-December) than the first Season (July- August). The high degree of variability in the natural population of Raily ecorace of *Antheraea mylitta* D could be utilized for exploitation of hybrid vigor for qualitative and quantitative improvement in tasar culture.

796. Manohar Reddy, R., Suryanarayana, N., Sinha, M.K., Gahlot, N.S., Hansda, G., Vijaya Prakash, N.B., 2009.

(Central Tasar Research and Training Institute, Central Silk Board, Govt. of India)

Silk Filament Progression with Backcross Breeding Generations in Tropical Tasar Silkworm, *Antheraea mylitta* D. International Journal of Industrial Entomology, 19(1):187-192.

Abstract: Silk filament progression study applying backcross breeding with recipient parent Jata and donor parent Daba ecoraces of tropical tasar silkworm, *Antheraea mylitta* Drury conducted during 2006 to 2008, revealed introgression of filament denier (10.2 d) superior to both parents at BC4 level. Also, the silk waste (0.35 percent) and filament breaks (2.6 nos) were reduced compared to both parents, while the filament length (973 m) and non break filament (296 m) improved over donor and could attain closer to recipient parent. The best performance of Jata Daba at F1 level, with highest silk filament length (1646 m) of 12.5 d denier, denotes heterosis impact on silk trait with parental heterogeneity, an advantage to exploit silk filament yield. The progression of quality in terms of finer filament denier, less silk waste

and least number of filament breaks over both parents and improvement in filament length and non break filament over donor parent except for a marginal shortage against recipient at BC4 level indicates the prospects of Jata and Daba ecoraces as source of breeding material for qualitative improvement of tasar silk filament. The study suggests that the commercially important finer denier of tasar silk filament can be attained with minor reduction in silk yield of wild Jata ecorace by adopting repeated backcrossing for four generations with semi domesticated Daba ecorace.

797. Nimaichand Singh, K., 2009.

(Department of Sericulture, Govt. of Manipur, Thoubal District, Manipur)

Biodiversity of wild silkmths and their food plants in Manipur - Strategy for conservation. Abstracts of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009, 72.

Abstract: Mother nature has endowed Manipur with a variety of silkworm species under *Bombyx* and *Antheraea* genus along with a variety of their food plants. With regard to Mulberry silk, *Theophila religiosa* is available under wild condition in both valley and adjoining foothills. Among the food plants, *Morus alba*, *M. indica* and *M. laevigata* are available widely in hill and valley area. In respect of oak fed *Antheraea* silkworm races viz. *A. roylei*, *A. frithii*, *A. compta*, *A. helferi* are available in wild condition. Among them *A. frithii* and *A. roylei* are maintained at Regional Tasar Research Station, Imphal for breeding programmes and also for commercialization. Regarding oak varieties *Quercus serrata* (*Q. acutissima*), *Q. dealbata* (*Lithocarpus dealbata*), *Q. grafithi*, *Q. semicarpifolia* and *Q. lemellosa* are reported to grow in different hill districts of Manipur at variable altitudes. Both the silkworm varieties and their food plants have become vulnerable and endangered due to many reasons like change of agro-climatic conditions viz. forest degradation due to deforestation, forest fire and expansion of agricultural land for shifting cultivation, construction of roads, houses and industrial establishments. A long term strategy for conservation of the silkworm species and their food plant varieties in ex-situ and in-situ conditions is highly indispensable since these insect bio-diversity and their food plants play an important role for maintenance of ecological balance in nature. The paper discusses the strategies.

798. Ray, B.C., Chakrvarthy, D., Moorthy, S.M, Das, N.K., Mitra, P and Bajpai , A.K. 2009.

(Central Sericultural Research and Training Institute, Berhampore, W.B)

Evaluation of some eco-races / strains of Eri silkworm (*Samia Cynthia ricini* boisdual) under different seasons in the gangetic plains of West Bengal.

In: National conference on "Vanya silk" held at CMERTI, Jorhat on 2-3<sup>rd</sup> Feb 2009.pp.162.

799. Sahu, A.K., Chakravorty, R., 2009.

(Regional Muga Research Station, Boko, Assam)

Biodiversity of muga silkworm, *Antheraea assamensis* helfer in north-east-their conservation and sustainable utilization.

Abstracts of National Workshop on Seri-biodiversity Conservation, Central Sericultural Germplasm Resources Centre, Hosur, India, 7th-8th March, 2009, 70-71.

Abstract: Biodiversity is the feed stock for the biotechnology industry. The luxuriant forest cover (64.40 percent) of North-Eastern region of India (Longitude: 77°E - 90°E and Latitude 22°N -28.5°N) harbors a wide diversity of flora and fauna including wild silk moths. The region with tropical to temperate type of climate is one of the 25 hot spots declared in the world. Recent survey in North-East recorded ten wild silk moth species namely, *Antheraea assamensis*, *A. mylitta*, *A. frithii*, *A. compta*, *A. roylei*, *Attacus atlas*, *Actias selene*, *Samia cynthia*, *Theophila religiose* and *Cricula trifenestrata* Helfer. It was observed that there is a decline in the total number wild silk moth species in the region as compared to the 1930's when as many as 19 species of wild silk moths were available. Out of these species, the muga silkworm *A.*

assamensis Helfer produces the golden yellow muga silk. The wild forms of this silkworm which were abundantly found in Assam and its bordering areas with the remaining North-Eastern states are becoming scarce with the passing of time. The situation is similar for the rest of sericigenous insects. The Regional Muga Research Station, Boko, Kamrup, Assam is engaged in survey, exploration and collection of wild stocks of muga silkworm from different parts of North East with a view to study their morphological characteristics as also the differences in molecular level. Different wild stocks collected are being maintained under different Accession numbers (RMRS Aa00-1 to RMRS Aa00-10) under ex-situ condition for their evaluation and utilization. DNA fingerprinting of these wild muga stocks being maintained has revealed up to 96 percent polymorphism, contrary to the mono-species status of the silkworm, thereby indicating the scope for production of high yielding breeds / crosses. Utilization of RMRS Aa00-1 to RMRS Aa00-4 accessions under ongoing breeding programme has shown that some of them have better combining ability for different economic traits. In addition, attempts are under way for in-situ conservation of these and other accessions of muga silkworm in the Garo hills of Meghalaya, a very active centre of organic evolution, since it is apprehended that even if endangered species do not become extinct, many of them will lose distinct populations or suffer severe loss of genetic variability through habitat loss or breakdown. The findings of the above studies and the strategies adopted for in-situ conservation of *Antheraea assamensis* Helfer are highlighted in the present paper.

800. Srivastava, A., Gupta, D.K., 2009.

(Department of Biochemistry, University of Allahabad, India.)

Biochemical studies on cold stressed Eri silkworm (*Philosamia ricini* Boisduval) larvae.

Proceedings of the National Academy of Sciences, India., 79(1):38-41.

Abstract: Insects, like other organisms have evolved diverse mechanisms to overcome drastic and adverse changes in environmental conditions. Eri silkworm, *Philosamia ricini* Boisduval, a continuously breeding lepidopteran does not go into diapause. Under conditions of low temperature, the fifth instar larvae do not form cocoons. Various physiological and biochemical studies on *Philosamia ricini* Boisduval were performed. The response to low temperature was studied with respect to the concentrations of carbohydrates, proteins, glycerol, free amino acids, trehalose and alkaline as well as acid phosphatase activities. The work also presents comparative studies on the response of silk gland and hemolymph under cold stress.

801. Tewary, P.K., Singh, M.K., Vijaya Prakash, N.B., 2009.

(Central Tasar Research and Training Institute, Piska Nagari, Ranchi-835303, Jharkhand.)

PCR amplification of genomic DNA of *Terminalia* genotypes.

In: Status Papers and Abstracts of National Conference on Vanya Silk (NASSI, Bangalore), Central Muga Eri Research and Training Institute, Lahdoigarh, Jorhat, Assam, India, 28th-30th January, 2009. , p.233.

Abstract: Large number of the *Terminalia* genotypes are extensively and densely distributed in the tropical forest all over India. However due to their complex nature, it is rather difficult to delimit these genotypes. Very little information is available on the genetic diversity of these germplasm and therefore, cataloguing of natural diversity becomes essential for its sustainable germplasm management and also to introduce effective breeding programme to develop superior varieties. DNA based assays such as RAPD AND AFLP are the most widely used tools for assessment of the genetic variation as unlike morphological characterization, this is not influenced by the environmental factors. Genomic DNA of nine genotypes of *Terminalia* have been isolated by using modified CTAB protocol and subjected to PCR amplification, OPAGE, OPA primers were exploited to generate distinct profiles in *Terminalia arjuna*, *T. tomentosa*, *T. belerica*, *T. chebula* and five biotypes of *T. arjuna* consisting traits of different fruits wing

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size and sprout colours. The study provides an indication that RAPD markers can be used as an effective tool to study genetic diversity prevailing at inter and intra specific level of the taxon.

802. Xu, L., Meng, X.M., Qi, L., Liu, F.Y., Su, G.M., Jiao, Y.,2009.

(The Sericultural Research Institute of Liaoning Province, Fengcheng Liaoning 118100, China.)

Analysis on the Combining Ability of Three Important Economic Traits in *Antheraea pernyi*.

*Canye Kexue* , 35(3):618-622.

Abstract: Determination of combining ability was one effective way to select excellent parents and make excellent cross combinations in breeding of *Antheraea pernyi*. This study selected 6 tussah varieties including 8821 , 8822, 9906, Kangda, Heichi and 582 as parental strains, and analyzed the combining ability of three traits, namely amount of cocoon crop, thousand-cocoon weight and cocooning rate to newly hatched larvae, by Griffing's diallel cross method. The result showed that the variance of special combining ability (SCA) was significantly better than that of the general combining ability (GCA) in amount of cocoon crop and cocooning rate to newly hatched larvae, meaning that non-additive effect of these two characters was dominant in cross combinations, but additive effect of thousand-cocoon weight was dominant. The GCA and SCA between various parents and cross combinations were significantly different. The GCA effect value of 582 was the highest in these three traits. The sum of breeding value and SCA of cross combination 582 x Kangda was significantly superior to other combinations in amount of cocoon crop and cocooning rate to newly hatched larvae. The best cross combination of breeding value and SCA was 582 x9906 in thousand-cocoon weight.

803. Jaya Prakash, P. , Jaikishan Singh, R. S. , Sanjeeva Rao, B.V. , Vija Y Kumar, M.,2010.

(Eri Silkwoon Seed Production Centre, Central Silk Board, Warangal, Andhra Pradesh - 506 001, India.)

Studies on ovipositional behavior and preference of eri silkworm , *Samia Cynthia Ricini* Boiaduv AL under semi arid tropics of India.

*Sericologia*, 50(2) 233-239.

Abstract: Observations on ovipositional behaviour of eri silkworm, *Samia Cynthia ricini* Boisduval. revealed that mated female moth survived for 6.36 days on an average with continuous egg laying upto 5.25 days. Gravid female laid 424.28 (94.00 percent) of eggs during first 05 days of its longevity whereas the commercial realized fecundity of 391.48 (86.73 percent) was obtained during the first 03 days of oviposition. Realized fecundity per moth was recorded as 230.85 (51.14 percent), 128.23 (28.41 percent) and 32.40 (7.18 percent) during first, second and third day of laying period, respectively. The average egg laying coefficient was 86.78 percent during five grainage seasons and ranged from 83.82 to 88.07 percent. Among all the ovipositional devices tested so far, egg laying sheet with cellule device was preferred by moths for securing high realized fecundity (424.40), potential fecundity (455.00) and coefficient of egg laying (93.26 percent) in this tropical region. Other devices like card board box, nylon net bag and earthen cup stood in descending order of preference of egg laying when compared to control traditional device, khorikas. Further, laying sheet with cellule device is more economical for manpower utilization in breeding programme, mother moth examination and reaping rich harvest of realized fecundity on large scale seed production.

804. Tong, Z.X., Wang, F.C., Ji, W.J., Zhang, 2010.

(Sericultural Research Institute of Liaoning Province, Fengcheng Liaoning 118100, China)

Application of Principal Component Analysis on Economic Traits Evaluation of Tussah Silkworm Germplasm Resources.

*Canye Kexue*, 36(3): 0513 -0518.

Abstract: Assessment and classification on traits of tussah silkworm germplasm resources by means of principal component analysis and cluster analysis are beneficial for high efficiency identification on

tussah silkworm germ plasm resources and rational and effective selection of parent variety for breeding. In present study, the principal component analysis was used to evaluate major economic characters of 16 tussah silkworm varieties. Four principal components, namely comprehensive productivity factor, cocoon filament efficiency factor, vitality factor and cocoon filament yield factor, were extracted from the investigated 16 major economic characters. The four principal components represented 83.068 percent of total information from the 16 economic characters, with relatively high percentage of information on cocoon filament traits. According to the result of cluster analysis on four principal components, the 16 tussah silkworm varieties could be divided into 4 groups. The representation of each principal component in the four groups were as follows: G1 G2 G3 G4 for comprehensive productivity factor, G4 G2 G1 = G3 for cocoon filament efficiency factor, G4 G1 G3 G2 for vitality factor, and no obvious tendency for cocoon filament yield factor. An evaluation to 16 tussah silkworm varieties based on these four principal components indicated that Sanlisi and Dingzhou 1 ranked at first places.

805. Hiremath, S.A., Mohan, B. , Qadri, S.M.H. ,2011.

(Central Silk Technological Research Institute, Bangalore 560 068)

Evaluation of elite silkworm (*Bombyx mori* L.) germplasm for post cocoon traits.

In: abstracts of golden jubilee national conference on sericulture innovations : before and beyond, CSRTI, Mysore, 28-29, January, 2011, p 134-135.

Abstract: Twenty elite silkworm germplasm of indigenous and exotics were studied for their post cocoon traits and compared with commercial check (ka and nb4d2). Accession bbe-0262 and bbi-0325 out performed the check accession in all the reeling parameters. The other few silkworm accessions were also performed at par with the checks. Among the selected twenty silkworm accessions used for quality parameters, bbe-0187 and bbi-0294 performed better than check (ka and nb4d2). Other silkworm accessions i.e., bbe-0262 and bbi-0327 are on par with check as far as the quality traits are concerned. Bbe-0262, bbi-0294, bbi-0327 and bbe-0183, bbe-0187 out performed in post cocoon traits and qualified for 14 and 13 reeling and quality traits. Other silkworm accessions i.e., bbi-0325, bbe-0222, bbe-0050, bbi-0326 and bbe-0197, bbi-0291 were also qualified for 11 and 8 post cocoon traits along with checks (ka, nb4d2), which provides scope for selection and further evaluation. The selected silkworm accessions may be included in breeding programme.

806. Srivastava, A. K. , Kar, P. K. , Sinha, M. K. , Prasad, B. C.,2011.

(Central Tasar Research And Training Institute, Piska Nagri, Ranchi-835 303)

Progressive endeavour in tropical tasar silkworm antheraea mylitta drury from bioecology to biotechnology.

In: abstracts of golden jubilee national conference on sericulture innovations : before and beyond, CSRTI, Mysore, 28-29, January, 2011, P 147-148.

Abstract: Among silks, the tropical tasar, an important vanya silk is produced by the silkworm antheraea mylitta drury. tasar silk sector eminently qualifies as one of the most appropriate agro based cottage industry for rural development, environment protection and rejuvenation. this sector is not only important for generating employment and preventing rural labour migration but also for its role in protection and preservation of ecology, heritage and socio-cultural value. Therefore, it is imperative to develop race/breed/cross breed/line with higher fecundity, silk synthesis and sturdiness. Qualitative and quantitative improvement in silk is possible through genetic manipulation or by bringing improvement in reeling technology to exploit the species to its fullest potential. Genetic manipulation can be made either through conventional breeding approach or through the aids of biotechnology. Conventional breeding approach employed so far to enhance quality raw silk production did not yield encouragement results, as actual genetic basis of yield improvement in a. mylitta is little understood. Luxuriant stock of genetic resources is pre-requisite for any improvement. a. mylitta is having 44

ecoraces distributed along the central india (12-31 0n latitude and 72-96 0e longitude) with varied phenotypic, physiological and behavioural characters as genetic resource. Nevertheless, two ecoraces viz. daba and sukinda have attained semi-domestication status through selection and manipulation in life cycle strategies and are commercially exploited throughout the country. Genetic diversity is the prime need for improvement in the race, therefore reliable and robust molecular markers to diagnose the ecorace has been reported in the recent past in tasar silkworm. the paper portrays about the details of the attempt made so far on establishing molecular markers of various types such as rflps (restriction fragment length polymorphism), issrs (inter simple sequence repeat), rapds (random amplified dna), scars (sequence characterized amplified regions), ests (express sequence tagged) data bases, and ssrs (simple sequence repeat) to diagnose the major ecoraces of a. mylitta. The entire marker assisted dna analysis of the populations indicated within and between population diversity nullifying the popular notion that phenotypic characters in the ecoraces are due to environmental influence. Characterization of genetic diversity of the tasar insect through molecular profiling is a stepping stone for molecular breeding. in near future, the role of biotechnology on tasar silkworm is envisaged for selection of superior characters using mas (marker assisted selection) and breeding for introgression of desired character. The other areas like gene identification and expression will facilitate future genetic manipulation in tasar silkworm to enhance tasar production and quality.

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