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Development of Polyvoltine breed, APMG249 of Silkworm *Bombyx Mori* L. for Hybrid Preparation Suitable to Tropical Regions of India

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ABSTRACT:

Even after introduction of bivoltine hybrids to the field, the popularity of Poly x Bivoltine hybrids have not come down and 85% of the raw silk produced in our country is from cross breeds**.** Enrichment of silkworm breeds and synthesis of new gene combinations by conventional breeding technique is one of the important tools. The genetic constitution of the selected genotypes and non-genetic variability produced by the environmental factors are the two key factors while development of a breed. Keeping these, five polyvoltine breeds *i.e.* SDMW1CT, ROSY, GD, GP3 and GP2 maintained at Andhra Pradesh State Sericulture Research and Development Institute were selected as initial resource material. By utilizing these, a total of twenty new combinations were prepared and their performance was evaluated. Based on evaluation index and superiority of the new combinations, three new combinations were identified and accordingly three breeding plans were designed. In the present paper out of these breeding plans, the breeding plan which led to the development of polyvoltine breed, APMG249 is discussed. The breeding line was stabilized for their quantitative and qualitative traits by F_{10} generation and the performance was studied up to F_{12} generation. During breeding, inbreeding coupled with appropriate selection procedures were carried out and the resultant was named as ‘APMG249’. The newly developed polyvoltine breed was subjected for hybrid testing and field trials.

Keywords: Silkworm, Polyvoltine, Breeding, Development, Evaluation, Commercial Hybrid

INTRODUCTION:

Sericulture is the science that deals with the production of silk by rearing of silkworm. The silk is preferred over all other types of fibers due to its remarkable properties like water absorbency, heat resistance, dyeing efficiency and luster. The silkworm, *Bombyx mori* L. is a lepidopteran economic insect known for the production of mulberry silk which is aptly named as *"the Queen of Natural Fibers*" and has been successfully retaining its esteemed position even in the face of growing competition from other man-made fibers. The mulberry silkworm is very delicate, highly sensitive to environmental fluctuations and unable to survive extreme natural fluctuation. Thus, the adaptability to environmental conditions in the silkworm is quite different from those of wild silkworm and other insects. Silkworm is one of the most important domesticated insects, which produces luxuriant silk thread in the form of cocoon by consuming mulberry leaves during larval period.

India enjoys the comfortable second position for the production of silk in the world next only to China. Traditionally sericulture in India is practiced in tropical environmental regions such as Karnataka, Tamil Nadu, Andhra Pradesh and West Bengal and to a limited extent in temperate region of Jammu and Kashmir. The existing tropical condition provides scope for exploiting the polyvoltine × bivoltine hybrid at commercial venture as they are very hardy and have tremendous capacity to survive and reproduce under fluctuating environmental climatic conditions. Bulk share of the silk production (85%) is accounting from cross breed hybrids and in southern India, it is being produced from the hybrid 'PM x CSR2'. Though, it is very well adapted and popular its productivity and quality of silk is prominently low with high renditta, low neatness etc. For instance, the continuous exploitation of the indigenous polyvoltine races such as Pure Mysore in South India and Nistari in West Bengal which are strikingly known for their poor productivity has resulted in rather slow growth of the industry. Thus, breeding emphasizes the need for developing promising genotype of known genetic potential to increase the productivity in plants and animals (1). Earlier studies revealed that, silk quality couldn't be improved unless existing breeds are replaced or improved upon its economic characters. So, breed development and their utilization is a continuous process for the development of productive hybrids which in turn ensures the sustainable development of sericulture industry. Though the evolved polyvoltine breeds/hybrids have recorded better economic traits, but could not sustain for a long time in the field due to several inherent problems of the breeds. Keeping this view in India, silkworm breeding efforts for more than 50 years to evolve better breeds than indigenous PM have resulted many new breeds (2, 3, 4, 5, 6) and some of them are evaluated in the field (7, 8).

Though the evolved polyvoltines have recorded better economic traits, no new polyvoltine breed could get established in the field due to lack of bimodal emergence, shows cocoon colour variations, occasional tri-moultars and lower survival under field condition. Thus only PM is still used for production of crossbreed in south. . Hence, silkworm breeds play a vital role in the success of sericulture industry. Thus the breed development and improvement is a continuous process which aims at providing suitable genotypes with desired traits (9). Hence, prominent breeders and geneticists of Japan (10, 11) stressed the importance of polyvoltine breeding in the tropical regions of India. Keeping this in view, the breeding programmes at Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI), Hindupur, Andhra Pradesh, India led to the development of many polyvoltines to replace the existing breeds.

MATERIALS AND METHODS:

Based on the genetic background and performance, five promising polyvoltine breeds such as SDMW1CT, ROSY, GD, GP3 and GP2 were chosen as the parental breeding resource material developed by APSSRDI, Hindupur, Andhra Pradesh, India. Involving these resource material, twenty possible new combinations *viz*., SDMW1CT x ROSY, SDMW1CT x GD, SDMW1CT x GP3, SDMW1CT x GP2, ROSY x SDMW1CT, ROSY x GD, ROSY x GP3, ROSY x GP2, GD x SDMW1CT, GD x ROSY, GD x GP3, GD x GP2, GP3 x SDMW1CT, GP3 x ROSY, GP3 x GD, GP3 x GP2, GP2 x SDMW1CT, GP2 x ROSY, GP2 x GD and GP2 x GP3 were prepared and reared. The data on quantitative traits were collected *Viz*., fecundity, cocoon yield per 10,000 larvae by number, cocoon yield per 10,000 larvae by weight (kg), survival rate (%), cocoon weight (g), cocoon shell weight (g), cocoon shell ratio (%) and filament length (m). The performance of each of the combinations were evaluated by employing evaluation index method (12) and based on the evaluation method and performance of the breeds; three combinations were identified and continued for further breeding as breeding lines. In the present paper, based on the outcome of one of the breeding plan, the development of polyvoltine breed, APMG249 is discussed (Fig.1). A productive new hybrid 'APMG249 x APS14' was isolated by utilizing APMG249 with a productive bivoltines breed 'APS14' and was subjected for limited field trials with the farmers.

RESULTS AND DISCUSSION:

The rearing performance (Table 1) of new combinations was recorded on eight economic parameters *viz*., fecundity, cocoon yield per 10,000 larvae by number, cocoon yield per 10,000 larvae by weight, survival rate, cocoon weight, shell weight, cocoon shell ratio and filament length. The fecundity ranged from 437 (GP2 x GD) to 510 (SDMW1CT x GP3) with an average of 473. With regard to yield per 10,000 larvae by number, the combinations such as GD x ROSY and GP3 x ROSY were recorded the highest (9377) and lowest in GP3 x GD (8784). Yield per 10,000 larvae by weight (kg) ranged to the maximum of 14.752 kg in SDMW1CT x GP2 and minimum of 11.602 kg in GP3 x GD. The survival rate found to the highest of 94.24 % in GP3 x ROSY and lowest of 85.23 % in GP3 x GD. The cocoon weight ranged from the maximum of 1.581 g (SDMW1CT x GP2) and minimum of 1.345 g (GP3 x GD) with an average of 1.455 g. The shell weight was maximum (0.262 g) in GD x SDMW1CT and minimum in ROSY x SDMW1CT (0.197 g) and shell ratio (%) was highest in GD x SDMW1CT (16.82) and lowest in GP3 x GP2 (14.31). The filament length varied between 753 m (SDMW1CT x GP2) to 609 m (GP3 x GP2) with an average of 667 m.

The new combinations performance data was subjected to multiple trait evaluation index method and the combinations *viz*., SDMW1CT x GP2 (62.92), GD x SDMW1CT (61.77), ROSY x GP2 (61.29) were stood top and shown above 60 EI value (Table 2 and Table 3). Based on evaluation index and superiority of the new combinations, higher ranked three new combinations were identified and accordingly three breeding plans were separately designed. In the present paper out of these breeding plans, the breeding plan which led to the development of polyvoltine breed, APMG249 is discussed (Fig.1).

Performance of APMG249:

Expression of various traits during the course of breeding revealed (Table 4) that the fecundity was found to be 520 at F_1 recorded to the maximum of 530 at F_2 and the trait showed the decreasing trend from F_2 to F_4 (488). For the trait cocoon yield per 10,000 larvae by number it was recorded to the maximum of 9401 (F_4) and minimum of 8867 (F_6). It was found between 13.986 kg (F_7) and 11.490 kg (F_6) with an overall average of 12.979 kg for the trait cocoon yield per 10,000 larvae by weight. Further, it revealed that maximum of 13.290 kg at F_1 showed a gradual decrease up to F_3 (13.019 kg) followed by fluctuations up to F_8 (12.985 kg) and in the later generations, the trait showed consistency. With regard to the trait survival rate ranged from the maximum of 93.15 % (F_4) and to the minimum of 87.50 % (F_6). Where as the cocoon weight which was recorded 1.422 g at F_3 showed a decreasing trend up to F_6 (1.327 g) followed by an increase in F_7 (1.525 g) and the decreasing trend up to F_{10} (1.399 g). The line was recorded the overall average cocoon shell weight of 0.238 g over generations which was varied between 0.267 g (F_7) to 0.223 g (F_6) with CV of

5.54 %. The trait, cocoon shell ratio showed wider fluctuations in different generations with 16.60 % at F_1 reached to the maximum of 18.06 % at F_8 and was fixed at 16.96 % by F_{12}. The filament length of 692 m that recorded at F_1 showed fluctuations in various generations and exhibited consistency in later generations.

During breeding of polyvoltine breed 'APMG249', due focus was given on important economic traits. The segregating population was subjected to appropriate selection procedure at different stages of development. Emphasis was laid to select the cocoons of intermediate size and no selection pressure was applied during $F_1 – F_3$ and cellular rearing was carried out from F_4 generation with five replications. At the time of brushing, emphasis was given to high fecundity and good hatching percentage at every generation. The selected cocoons were subjected for sex separation to assess the cocoon, shell weight, cocoon shell ratio and for filament length. This method of individual selection was followed to facilitate the fixation of desired economic traits at a faster rate.

Field trials of the new hybrid combination: The newly developed hybrid combination with the newly evolved breed 'APM249 x APS14' was subjected to field trials and a total of 8750 dfls were tested and an average yield of 62.61kg /100 dfls was recorded.

The polygenic nature of the quantitative traits and role of different intensities of selection in changing the mean expression have been demonstrated in plants and animals (13). Selection cannot create new genes and however, it can increase the frequency of desirable genes existing in the population. Inbreeding of the hybrid combinations followed by selection of desirable combinations from the segregating population until the extraction of the new strains have involved careful study of genetic variability, phenotypic expression, nature and magnitude of heterosis at F_1 with respect to eight quantitative traits such as fecundity, cocoon yield per 10,000 larvae by number, cocoon yield per 10,000 larvae by weight, survival rate (%), cocoon weight (g), cocoon shell weight (g), cocoon shell ratio (%)

and filament length (m). Silkworms breeding which has been in practice since many decades in Japan where in desirable goals were achieved with certain specific objectives (14) and attempts were made in India, to breed superior polyvoltine races which have met with little success (15, 16). The poor adaptability of the bivoltines to the fluctuating environmental conditions of the tropical climate makes them unsuitable for their commercial exploitation throughout the year (17). Though the evolved polyvoltine breeds/hybrids have recorded better economic traits could not sustain for a long time in the field due to several inherent problems of the breeds.

The fecundity, determined on the genotype of maternal parent and environmental conditions prevailing at the time of oviposition and it is one of the fitness components reflecting on the productivity. The trait, yield per 10,000 larvae by number which showed variations between generations during the course of breeding can be partially attributed to the influence of environmental factors and interaction of alleles. The overall improvement of productivity in the isolated strain confirms their superiority over their respective polyvoltine parents. These results are in conformity with the findings of earlier workers (18, 19). Survival rate is an important parameter which reflects the viability of the breed and the fluctuations observed for the trait among the generations during the course of breeding in all the evolved strains could be partially attributed to the influence of environmental conditions and the interaction of alleles responsible for expression of the trait (20). The cocoon weight is considered to reflect the vigor of the silkworm breed and similarly the cocoon shell weight showed wider variations in different generations during the course of breeding.

The cocoon shell weight was observed to be moderately heritable on positive response of the selection as revealed by other scientists (21, 22). In the present investigation, the response to selection for the trait was rather low and variations were observed in the initial generations and showed increase in the subsequent generations with little variations and it may be attributed to the fact that selection of initial parents with higher shell ratio. The cocoon shell ratio indicated the downward and fluctuations during the breeding process and difficult to increase by selection which are corroborating the findings of other workers (21). However, the length of the filament is related to cocoon shell weight in the isolated lines and the results of the study are in agreement with the findings of others (23). Thus, the results of the present study are in agreement with the earlier workers (24, 25) who pointed out selection as the basic tool for generating desired hereditary changes in the improvement of commercial qualities of plants and animals. Selection increases the frequency of desirable genes to a certain extent in each generation and stability in the expression of important economic characters under study at later generations indicates the fixation of desirable traits (26).

REFERENCES:

1. Yokoyama, T. (1979). Silkworm selection and hybridization. In: Genetics in relation to insect management. *Working Papers*. *The Rockfeller Foundation Management*. pp. 71-83.

2. Ragavendra Rao, D.; Ravindra Singh; Kariappa, B.K.; Basavaraja, H.K. and Dandin, S.B. (2005). Development of a robust polyvoltine x Bivoltine hybrid ND5 x CSR17 of mulberry silkworm *Bombyx mori* L. *Indian J. Seric.*, 44 (02):195-201.

3. Dandin, S.B.; Ravindra Singh; Ragavendra Rao, D.; Basavaraja, H.K. and Kariappa, B.K (2007). Studies on the isolation of promising multivoltine breed ND7 and its F1 hybrid performance with productive bivoltine races. *Indian J. Seric.*, 46(1): 52-58.

4. Nirupama, R and Ravindra Singh (2007). Androgenetic development in F1 hybrids of the mulberry silkworm *Bombyx mori* L, *Uttar Pradesh J. Zool.*, 27(2): 247-250.

5. Rama Mohana Rao, P., Qadri, S.M.H., Nirmal Kumar, S., Premalatha, V., Dayananda, Joge, P.G., Radhalakshmi, Y.C and Shivakumar, K.P. (2012). Identification of polyvoltine x bivoltine hybrids of the silkworm Bombyx mori L. with superior fiber quality: A breakthrough in silkworm breeding. Indian J. Seric., 51(2): 128-142.

6. Rajanna, G.S., Latha, R., Venkatesh, H., Promod, K.V., Nagesh, M., Parashivamurthy, H.R., Phaniraj, H.S., Mahadevaiah, B.M., Rajendra Mundkar, Krishna Rao, S., and Patil, C.S. (2013). Post authorization field performance of improved cross breed MH1 x CSR2. *Abstract- National Conference on Recent Advances in Modern Biology and Sericulture for Women Empowerment and Rural Development* (RAMBSWERD), KSSRDI, Bangalore, 24-26 October 2013. P: 85.

7. Umadevi, K.; Sudha, V.N.; Prakashmurthy, D.P.; Ragavendra Rao, D.; Ravindra Singh; Premalatha, V and Kariappa, B.K (2005). Evaluation of new multivoltine x bivoltine hybrid “Cauvery” (Bl67 x CSR101) of the silkworm *Bombyx mori* L. *Indian J. Seric.*,44(01):131-133.

8. Sudha, V.N.; Umadevi, K.; Rama Mohana Rao, P.; Ravindra Singh; Ragavendra Rao, D.; Basavaraja, H.K.; Kariappa, B.K Premalatha, V.; Dandin, S.B. and Kamble, C.K. (2007). Evaluation of new multivoltine x bivoltine hybrid ND7 x CSR2 (Jayalakshmi) of the silkworm Bombyx mori L. Indian J. Seric.,46(2):131-133.

9. Raju, P.J. (1990). Studies on the hybridization and synthesis of new breeds of silkworm, Bombyx mori L. Ph.D. Thesis, University of Mysore, Mysore.

10. Mano, Y.; Nirmal Kumar, S.; Basavaraja, H.K.; Mal Reddy, N. and Datta, R.K. (1993). A new method to select promising silkworm breeds/combinations. Indian Silk 31(10): 53.

11. Tazima, Y. (1958). Report on sericulture industry in India. Central Silk Board,Bombay, India. pp. 1-49.

12. Mahadevappa, R. (2006). Evolution of superior bivoltine races for tropical conditions. Ph. D. Thesis, Bangalore University, Bangalore.

13. Datta, R.K.; Pal, D.C.; Das, S.K. and Sengupta, K. (1981). Evaluation of superior multivoltine breeds through mutation breeding technique Proc. Seric. Symp. Tamilnadu, India, 39 – 50.

14. Harada, C. (1961). On the heterosis of quantitative characters in silkworm. Bull. seric.Expt. stn. 17(1): 50 – 52.

15. Darlington, C.D. (1939). The evaluation of genetic systems. Cambridge Univ. Pr. London.

16. Sengupta, K. (1969). An analysis of genotype environment interaction in some races of silkworm, *Bombyx mori* L. Indian J. Seric. 8(1):4-10.

17. Lakshmi, H. (2008). Studies on development of bivoltine hybrids of silkworm, *Bombyx mori* L. for tropical conditions of Andhra Pradesh. Ph.D. thesis, University of Mysore, Mysore.

18. Gamo, T. (1976). Recent concepts and trend in silkworm breeding. Farming Japan 10: 11-22.

19. Gower, J. C. (1971). A general co-efficient of similarly and some of its properties. Biometrics 27: 857-871.

20. Sudhakara Rao, P.; Datta, R.K. and Basavaraja, H.K. (2006). Evolution of thermo-tolerant bivoltine hybrid of the silkworm (*Bombyx mori* L.) for tropical climate. Indian J. Seric. 45(1): 15-20.

21. Falconer, D.S. (1981). Introduction to quantitative genetics. (Second Ed.) Longmans Press, London.

22. Tsuchiya, S. and Kurashima, H. (1959). Studies on the heritability of the measurable characters in *Bombyx mori*, L- Heritabilities in the reciprocal crossings of two strains from the strain groups. J. Seric. Sci. Jpn. 28: 313.

23. Basavaraja, H.K. (1996). Studies on the synthesis of productive bivoltine strains of *Bombyx mori* L. through hybridization, selection and genetic evaluation. Ph.D. Thesis, University of Mysore, Mysore.

24. Chandrashekharaiah, Sivaprasad, V., Lakshmi, H. and Basha, K. (2000). Development of silkworm breeds suitable for Andhra Pradesh conditions. In: 4th China International Silk Conference, Yinchuan, Ningxia, PRC, 2000, 4th May 2000, 356-361.

25. Seshagiri, S.V., Seetharamulu, J., Lakshmi, H., Sankar Naik, S. and Raju, P.J. (2013). Breeding of new potential crossbreed *(bombyx mori l.),* 'MSO3 x APS45' for Tropical regions, Int.J. Plant, Animal and Environ. Sci., 3(2): 222 – 230,

26. Lakshmi, H. and Chandrashekharaiah, (2007). Identification of breeding resource material for the development of thermo-tolerant breeds of silkworm, *Bombyx mori* L. J. Exp. Zool., India, 10(1): 55 – 63.

Table 1. Performance of new combinations prepared from the selected parents

Sl.No.	New Combinations	Fecundity (No.)	Yield /10,000 Larvae		Survival Rate (%)	Cocoon Weight (g)	Shell Weight (g)	Shell Ratio (%)	Filament Length (m)
			No.	Wt. (kg)					
1	SDMW1CT x ROSY	484	9344	13.319	93.20	1.457	0.240	16.50	739
2	SDMW1CT x GD	472	9014	12.656	90.71	1.399	0.222	15.84	644
3	SDMW1CT x GP3	510	8982	12.299	89.21	1.362	0.217	15.90	640
4	SDMW1CT x GP2	509	9278	14.752	92.87	1.581	0.254	16.09	753
5	ROSY x SDMW1CT	503	8883	12.078	88.39	1.353	0.197	14.54	657
6	ROSY x GD	479	8982	13.159	88.39	1.486	0.238	16.05	673
7	ROSY x GP3	473	8949	12.161	89.71	1.353	0.223	16.44	617
8	ROSY x GP2	503	9245	14.649	91.88	1.580	0.258	16.35	714
9	GD x SDMW1CT	488	9310	14.472	93.37	1.559	0.262	16.82	698
10	GD x ROSY	466	9377	13.378	93.70	1.477	0.238	16.15	692
11	GD x GP3	491	9179	12.787	92.20	1.426	0.236	16.58	705
12	GD x GP2	456	9113	14.585	91.30	1.488	0.222	14.89	624
13	GP3 x SDMW1CT	449	9080	12.943	90.96	1.435	0.229	15.92	671
14	GP3 x ROSY	439	9377	14.072	94.24	1.542	0.254	16.49	691
15	GP3 x GD	471	8784	11.602	85.23	1.345	0.208	15.43	609
16	GP3 x GP2	449	8883	13.448	87.39	1.500	0.215	14.31	613
17	GP2 x SDMW1CT	459	9014	12.324	89.04	1.380	0.218	15.76	629
18	GP2 x ROSY	463	9344	13.179	93.20	1.466	0.234	16.00	701
19	GP2 x GD	437	8949	13.684	89.71	1.478	0.240	16.27	666
20	GP2 x GP3	454	8916	12.783	88.72	1.427	0.218	15.25	610
	Average	**473**	**9100**	**13.216**	**90.67**	**1.455**	**0.231**	**15.88**	**667**
	SD	**23**	**187**	**0.952**	**2.42**	**0.077**	**0.018**	**0.68**	**41**
	CV	**4.90**	**2.05**	**7.20**	**2.67**	**5.30**	**7.81**	**4.31**	**6.20**

Table 2. Evaluation index values of the new combinations

Sl. No.	Combination	Fecundity	Yield /10,000 larvae		Survival rate	Cocoon weight	Shell weight	Shell ratio	Filament length	Average EI value
			No.	Wt.						
1	SDMW1CT x ROSY	54.86	63.04	51.08	60.44	50.31	55.15	59.08	67.24	57.65
2	SDMW1CT x GD	49.68	45.41	44.11	50.16	42.79	44.69	49.36	44.34	46.32
3	SDMW1CT x GP3	66.10	43.67	40.36	43.99	38.02	41.94	50.28	43.35	45.96
4	SDMW1CT x GP2	65.66	59.50	66.13	59.09	66.38	62.85	53.03	70.69	62.92
5	ROSY x SDMW1CT	63.07	38.39	38.04	40.57	36.86	30.93	30.37	47.54	40.72
6	ROSY x GD	52.70	43.67	49.39	40.57	54.01	54.04	52.50	51.48	49.79
7	ROSY x GP3	50.11	41.92	38.91	46.04	36.86	45.24	58.25	37.93	44.41
8	ROSY x GP2	63.07	57.76	65.05	54.97	66.25	65.05	56.85	61.33	61.29
9	GD x SDMW1CT	56.59	61.24	63.19	61.14	63.55	67.25	63.77	57.39	61.77
10	GD x ROSY	47.08	64.78	51.70	62.50	52.85	54.04	53.92	55.91	55.35
11	GD x GP3	57.89	54.22	45.49	56.33	46.27	52.94	60.27	59.11	54.07
12	GD x GP2	42.76	50.69	64.38	52.59	54.26	44.69	35.60	39.41	48.05
13	GP3 x SDMW1CT	39.74	48.94	47.13	51.19	47.43	48.54	50.67	50.99	48.08
14	GP3 x ROSY	35.42	64.78	58.98	64.72	61.35	62.85	58.93	55.66	57.84
15	GP3 x GD	49.24	33.11	33.04	27.53	35.83	36.99	43.49	35.96	36.90
16	GP3 x GP2	39.74	38.39	52.44	36.46	55.81	40.84	27.10	36.95	40.96
17	GP2 x SDMW1CT	44.06	45.41	40.63	43.29	40.34	42.49	48.32	40.64	43.15
18	GP2 x ROSY	45.79	63.04	49.60	60.44	51.43	51.84	51.72	58.13	54.00
19	GP2 x GD	34.55	41.92	54.91	46.04	52.98	55.15	55.72	49.75	48.88
20	GP2 x GP3	41.90	40.13	45.45	41.93	46.40	42.49	40.78	36.21	41.91

Table 3. Ranking of new combinations

Rank	Name of the combination	Avg. EI value
1	SDMW1CT x GP2	62.92
2	GD x SDMW1CT	61.77
3	ROSY x GP2	61.29
4	GP3 x ROSY	57.84
5	SDMW1CT x ROSY	57.65
6	GD x ROSY	55.35
7	GD x GP3	54.07
8	GP2 x ROSY	54.00
9	ROSY x GD	49.79
10	GP2 x GD	48.88
11	GP3 x SDMW1CT	48.08
12	GD x GP2	48.05
13	SDMW1CT x GD	46.32
14	SDMW1CT x GP3	45.96
15	ROSY x GP3	44.41
16	GP2 x SDMW1CT	43.15
17	GP2 x GP3	41.91
18	GP3 x GP2	40.96
19	ROSY x SDMW1CT	40.72
20	GP3 x GD	36.90

Table 4. Generation wise rearing performance of APMG249

Generation	Fecundity (No.)	Yield /10,000 Larvae		Survival Rate (%)	Cocoon Weight (g)	Shell Weight (g)	Shell Ratio (%)	Filament Length (m)
		No.	Wt. (kg)					
F_1	520	9300	13.290	92.50	1.434	0.238	16.60	692
F_2	530	9367	13.199	91.00	1.419	0.234	16.49	687
F_3	502	9267	13.019	92.08	1.422	0.227	15.95	690
F_4	488	9401	13.190	93.15	1.409	0.224	15.90	697
F_5	505	9357	12.997	92.92	1.395	0.232	16.63	693
F_6	456	8867	11.490	87.50	1.327	0.223	16.80	649
F_7	512	9233	13.986	91.97	1.525	0.267	17.50	755
F_8	495	9267	12.985	91.83	1.434	0.259	18.06	747
F_9	487	9300	12.990	92.00	1.406	0.244	17.33	704
F_{10}	486	9217	12.879	91.26	1.399	0.236	16.87	709
F_{11}	490	9200	12.803	91.45	1.414	0.235	16.62	721
F_{12}	485	9267	12.923	91.73	1.412	0.239	16.96	729
Average	**497**	**9254**	**12.979**	**91.62**	**1.416**	**0.238**	**16.81**	**706**
SD	**21**	**136**	**0.561**	**1.44**	**0.044**	**0.013**	**0.61**	**29**
CV (%)	**4.24**	**1.47**	**4.33**	**1.57**	**3.11**	**5.54**	**3.64**	**4.09**

Fig. 1. Breeding plan of APMG249