INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

SCREENING OF SELECTED BIVOLTINE BREEDS OF SILKWORM (*BOMBYX MORI* L.) OF ITS BIONOMICS AND ECONOMIC CHARACTERS IN THE CLIMATE OF JAMMU, INDIA

[*]Murali, S., Tayal, M.K. & Anil Dhar[*]
[*]Regional Sericultural Research Station, Central Silk Board, Miran Sahib, Jammu – 181101
*Corresponding authors email: dr.mmrl@rediffmail.com

ABSTRACT
The selected silkworm PAM breeds *viz*., PAM - 101, PAM - 105, PAM - 108, PAM - 109 and PAM - 111 were utilized for study. Observations on the different phenotypical and economic traits of silkworm, *Bombyx mori* L. were taken at different stages. The data reveals that, fecundity was recorded from 355.33 (PAM - 109) to 399.33 (PAM - 105) and hatching per cent ranged from 94.04 (PAM - 105) to 94.67 (PAM - 108). The larval weight varied in the range of 29.69 g (PAM - 108) to 40.39 g (PAM - 109) whereas, larval duration was observed in the range of 23.07 (PAM - 108) days to 25.01 (PAM - 111) days. The larval length recorded as on 6th day was 7.54 cm (PAM - 105) to 8.12 cm (PAM - 109). The highest single cocoon weight was observed in PAM - 111 (1.73 g), maximum shell weight was recorded in PAM - 111 (0.31 g), Shell percentage was ranged from 17.66 per cent (PAM - 111) to 19.02 per cent (PAM - 108). Maximum yield recorded in PAM - 101 (14.35 Kg), was observed significantly superior compared to others. These findings will help the sericulturists in finding suitable breed for getting more economic returns from silkworm rearing. It is observed that PAM 101 is having highest yield per 10, 000 larvae with shell ratio 18.65 per cent.

KEY WORDS: Fecundity, Larval duration, Larval length, Cocoon yield, Shell ratio, *Bombyx mori* L.

INTRODUCTION

Sericulture is an agro-based rural industry having tremendous employment potential and foreign exchange earnings (Bothikar *et al.,* 2014). It is the rearing of silkworm for the production of raw silk originated in China between 2600 and 2700 BC (Rahmathulla, 2012). Silk is called the queen of textiles due to its glittering luster, softness, elegance and durability. It is a very costly fiber, produced by silk worms (Borisade, 2012). Silkworm is one of the most important domesticated insects where the growth and development is greatly influenced by environmental conditions. Success of silkworm breeds/hybrids largely depends on their adaptability to the environment in which it is destined to be reared. The biological as well as cocoon-related characters are influenced by ambient temperature, rearing seasons, quality mulberry leaf, and genetic constitution of silkworm strains. It is a well established fact that under tropical conditions, unlike polyvoltines, bivoltines are more vulnerable to various stress like hot climatic conditions of tropics, poor leaf quality, and improper management of silkworm crop during summer that is not conducive for bivoltine rearing for technologically and economically poor farmers of India (Suresh *et al.,* 2001; Lakshmi, 2007 and Begum *et al.,* 2008). Silkworm (*Bombyx mori* L.) is essentially monophagous insect feeds solely on mulberry leaves (*Morus* spp.). Its growth and development as well as cocoon and silk production entirely depends upon the quantity and quality of mulberry leaves (Nagaraju, 2002). The success of sericulture industry depends upon several factors of which the impact of the environmental factors such as biotic and abiotic factors is of vital importance. Among the abiotic factors, temperature plays a major role on growth and productivity of silkworm, as it is a poikilothermic (cold blooded) insect (Benchamin and Jolly, 1986).

Evaluation of germplasm is an essential pre-requisite for its effective utilization. As the goals of breeding change rapidly, evaluation needs to be adaptive. The necessity of identification of season specific breeds/ hybrids arises due to variation in quantitative characters during different environmental conditions. Silkworms have been evaluated in many environment and agro-climatic conditions in order to identify the season and region specific breeds for utilization (Venugopal Pillai and Kishnaswamy, 1987). Series of studies were conducted to identify suitable bivoltine silkworm breed for Kashmir valley particularly for spring and autumn seasons (Trag *et al.,* 1992; Malik *et al.,* 2002).

MATERIALS & METHODS

The experiment was carried out on five *B. mori* parental PAM breeds *viz*., PAM - 101, PAM - 105, PAM - 108, PAM - 109 and PAM- 111 maintained at the RSRS, Jammu during spring, 2016 and were incubated for 9-12 days in a neat and clean, disinfected room at 80 - 85 % humidity and 24-25ºC temperature with 18 hrs light till pin head stage, at this stage black -boxing was done to ensure maximum hatching on exposure to bright light. The hatched larvae were reared separately under uniform laboratory conditions as described by Yokoyama (1963) and Krishnaswami (1978). During the entire period of

research, same micro-climate and feeding conditions were ensured as per the larval stage. The experiment analysed for morphological charateristics of egg, larvae and cocoon parameters (Table 1) and biological studies of larvae includes feeding duration (Table 2), hatching percentage, larval weight (Table 5) and total larval duration of different instars were studied, which reflects their variation among the breeds (Table 3) and cocoon characteristics of all breeds were recorded.

All the breeds were reared in three replications by following standard rearing techniques (Krishnaswami, 1978). Three hundred larvae were retained after 2nd moult in each replication. The data pertaining to the morphology/ phenotypic and biological/economic parameters were recorded. During the entire period of research, same micro-climate and feeding conditions were ensured as per the larval stage.

During egg stage parameters were recorded *viz*., egg shape, egg colour, shell color, hatching percentage and average fecundity per female moth were studied. At larval stage observations were taken like larval colour, markings, larval length and mean weight of 10 larvae on each day of V instar were taken and analyzed for different races. During pupal stage weight of pupa were taken and at cocoon stage parameters like cocoon shape, cocoon colour, cocoon grain and economic characters of cocoon were noted.

The statistical analysis was done with the help of software SPSS and weight of larvae was measured with electronic balance.

RESULTS & DISCUSSION

Morphological Qualitative Parameters

Egg: All the PAM breeds which are selected are ellipsoidal in shape, grey in color and shell color was recorded as white (Table 1). Similar results were obtained by Anita *et al.* (2014).

Larvae: Color of newly hatched larvae was recorded as black and haemolymph color was transparent in all the breeds. The pattern of larvae was observed semi plain in PAM - 101, plain in PAM - 105, PAM - 111 and marked in PAM - 108, PAM - 109 was recorded as plain (Table 1). The results were agreement with work done by Anita *et al.* (2014).

Cocoon: All the PAM breeds were distinctly white in color. The shape of cocoon was dumbbell and constricted (DC) in PAM - 101, PAM - 105, PAM - 108 and oval in PAM - 109, PAM - 111 respectively. The build and grain of among all the breeds was recorded hard and medium respectively (Table 1). Similar results were obtained by Anita *et al.* (2014).

TABLE 1. Phenotypic qualitative characteristics of egg, larvae and cocoon parameters of PAM breeds

Breeds	Egg				Larvae		Cocoon			
	Shape	Shell Colour	Egg colour	Colour of Newly Hatched	Haemoly-mph Colour	Larval pattern	Colour	Shape	Build	Grains
PAM -101	E	W	G	B	T	SP	W	DC	H	M
PAM -105	E	W	G	B	T	P	W	DC	H	M
PAM -108	E	W	G	B	T	M	W	DC	H	M
PAM -109	E	W	G	B	T	M	W	O	H	M
PAM -111	E	W	G	B	T	P	W	O	H	M

Note: E - Ellipsoid, W - White, Y - Yellow, G- Grey, SS - Sand Stone, B- Black, T- Transparent, O - Oval, M - Medium, DC - Dumbell Constricted, H - Hard, T- Thin, SP- Semi Plain, P - Plain, M - Marked

TABLE 2. Data showing feeding duration among different stages of PAM breeds during spring rearing (2016)

Race/Breed	Different stages (Days: h)					Total Avg. duration (Days: h)
	1st instar	2nd instar	3rd instar	4th instar	5th instar	
PAM -101	3.05±0.00	2.14±0.00	3.16±0.00	4.00±0.00	6.03±0.00	19.14±0.00
PAM -105	3.05±0.00	2.14±0.00	3.16±0.00	4.08±0.00	6.02±0.02	19.21±0.02
PAM -108	3.05±0.00	2.14±0.00	3.16±0.00	4.05±0.05	5.03±0.03	18.08±0.98
PAM -109	3.05±0.00	2.14±0.00	3.16±0.00	4.07±0.02	7.00±0.00	22.09±0.66
PAM -111	3.05±0.00	2.14±0.00	3.16±0.00	4.05±0.05	7.01±0.02	20.17±0.03

Larval Biological Parameters

Feeding Duration

During first instar of larvae, the active period of feeding among all the breeds was recorded three days five hours (Table 2). Second instar, two days fourteen hours were recorded as most active period of feeding among all the breeds. During third instar, active feeding period was recorded among all breeds was three days sixteen hours, while in fourth instar, feeding period was observed among all breeds varying between 4.00 to 4.08 h in PAM - 101 and PAM - 105 respectively and fifth instar, there is variation among breeds was recorded, seven days one hour more active feeding period was recorded in PAM - 111 and less *i.e.* five days three hours observed in PAM -108 respectively (Table 2).

The total average feeding duration among all the breeds was more recorded in PAM - 109 *i.e.* twenty two days nine hours and less was recorded in PAM - 108 *i.e.* eighteen days eight hours respectively (Table 2).

Larval Duration

The period among all the breeds was recorded as four days five hours during first instar whereas three days fourteen hours were recorded as 2nd stage larval period among all the breeds (Table 3). During third stage larval period among all the breeds ranges between 4.16 - 5.20 h in PAM - 105 and PAM - 108, PAM - 109 and PAM - 111 respectively (Table 3). While in fourth instar, larval period was observed less in five days five hours in PAM - 101 and more was observed in PAM - 108 *i.e.* five days fourteen hours respectively (Table 3). There is variation

among breeds was recorded during fifth instar, more days were recorded in seven days one hour in PAM -111 and less *i.e.* five days three hours observed in PAM - 108 respectively (Table 3).

The total average larval duration among all the breeds was more in PAM - 111 *i.e.* twenty five days one hour and less was recorded in PAM - 108 *i.e.* twenty three days seven hours respectively (Table 5) and larval period was ranged from 23.07 - 25.01 days. The results were agreement with Krishnaswami (1978) reported that the larval duration was longer in race M-5 (24.17), but it was non agreement with results reported by Bothikar *et al.* (2014) the larvae reared on S -1635 recorded 19.66 days. Under ideal conditions it has been reported that the total larval duration is 25-30 days for selected JAM breeds (Raina, 2000). The results were justified with work done by Anita *et al.* (2014) reported similar results on JAM breeds, the larval duration which ranges between 23.22 - 26.16 days.

TABLE 3. Data showing larval duration among different stages of PAM breeds during spring rearing (2016)

Races/breeds	Different instars (Days : h)					Total duration (Days : h)
	1st instar	2nd instar	3rd instar	4th instar	5th instar	
PAM -101	4.05±0.00	3.14±0.00	5.00±0.00	5.05±0.00	6.03±0.00	24.03±0.00
PAM -105	4.05±0.00	3.14±0.00	4.16±0.00	5.13±0.00	6.02±0.02	24.02±0.02
PAM -108	4.05±0.00	3.14±0.00	5.20±0.48	5.14±0.04	5.03±0.03	23.07±0.06
PAM -109	4.05±0.00	3.14±0.00	5.20±0.48	5.10±0.05	7.00±0.00	25.00±0.00
PAM -111	4.05±0.00	3.14±0.00	5.20±0.48	5.10±0.05	7.01±0.02	25.01±0.02

TABLE 4. Showing length of fifth instar larvae of PAM breeds during spring (2016)

Breeds	Days (5th instar)					
	1	2	3	4	5	6
PAM -101	4.20±0.10	4.38±0.13	6.20±0.22	6.60±0.23	7.28±0.15	7.76±0.11
PAM -105	4.24±0.11	4.38±0.19	6.06±0.21	6.46±0.21	6.98±0.16	7.54±0.11
PAM -108	4.26±0.11	4.34±0.11	6.16±0.19	6.56±0.21	7.18±0.19	7.56±0.11
PAM -109	4.28±0.15	5.46±0.17	6.32±0.13	6.98±0.16	7.72±0.08	8.12±0.15
PAM -111	4.24±0.11	4.42±0.08	6.06±0.21	6.40±0.16	7.40±0.16	7.86±0.15
C.D. @ 1%	-	0.19	-	0.26	0.20	0.17
SE. m±	0.05	0.06	0.08	0.08	0.06	0.05
C.V. (%)	2.80	3.10	3.17	2.97	2.10	1.66

Larval Length

The length of 5th instar larvae was recorded from first day to sixth day results revealed that there is significant differences were observed among all the breeds except in first day and third day (Table 4). During first day the larval length ranges from 4.20 (PAM - 101) to 4.28 cm (PAM - 109), 2nd day it was ranges from 4.34 cm (PAM - 108) to 5.46 cm (PAM - 109), 3rd day ranges between 6.06 (PAM – 105, PAM - 111) to 6.32 cm (PAM 109), 4th day recorded as 6.40 cm (PAM - 111) to 6.98 cm (PAM – 109), 5th day it was ranges from 6.98 (PAM - 105) to 7.40 cm (PAM - 111) and 6th day recorded as 7.54 cm (PAM - 105) to 8.12 cm (PAM - 109) (Table 4). Similar results were recorded by 6.71 to 7.25 cm (Prabu *et al.,* 2011) and 6.12 to 7.05 cm (Balasundaram *et al.,* 2013). The data shows that there is increase in larval length from day 1 to day 6 of 5th instar. The length of silk worm depends on amount of food it consumes. Length of larvae increases until larvae reaches it's spinning stage (6th day). When it reaches spinning stage the larvae reduce in size to one third of its normal length, it is the characteristic feature of a silk worm. This reduction in size increases pressure on silk glands to eject silk from the glands. Hence there is a sudden decrease in length on 6th day onwards. This decrease in length continues until pupal stage. The results also agreement with work done by Venugopal Reddy *et al.* (2015) revealed that the larval length varies from 5.00 to 7.43 cm.

Economic Parameters

The data pertaining to nine economic traits *viz*., hatching %, larval duration (h), larval weight (g), cocoon yield per 10,000 larvae by number, cocoon yield per 10,000 larvae by weight, pupation rate, cocoon weight, cocoon shell weight, and cocoon shell ratio of five breeds were presented in Table 5. The perusal of the data reveals that the fecundity was recorded from 355.33 (PAM - 109) to 399.33 (PAM - 105) which shows statistically non significant among all the breeds and hatching per cent ranged from 94.04 (PAM - 105) to 94.67 (PAM - 108) and showing statistically.

non significant among all the breeds where as larval duration shows statistically significant among all the breeds and recorded to a maximum duration of 25.01 days (PAM - 111) and minimum of 23.07 days (PAM - 108) where as larval weight was recorded to a maximum of 40.39 g (PAM - 109) and minimum of 29.69 g (PAM - 108) showing statistically significant among all the breeds. The pupal weight recorded more weight in PAM - 101 and less weight was observed in PAM - 108 having 12.76 g and 10.05 g respectively showing significant among all breeds, whereas pupation rate showing statistically non significant among all the breeds and it was recorded as highest 91.00 per cent (PAM - 101, PAM - 105 and PAM - 108) and less 90.00 per cent (PAM - 111 and PAM - 109).

TABLE 5. Economic parameters of PAM breeds reared during spring (2016)

Breeds	Fecundity by No.	Hatching (%)	Larval duration (Days : h)	Larval weight (g)	Pupal weight (g)	Pupation rate (%)	Yield/ 10000 Larvae		Weight of cocoon (g)	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)
							No.	Wt. Kg)				
PAM 101	393.00 (19.84)	94.49(76.38)	24.03	38.74	12.76	91..00 (72.53)	9420.00 (97.06)	14.35	15.60	1.44	0.27	18.65(25.57)
PAM 105	399.33 (19.98)	94.04(75.90)	24.03	36.74	12.44	91.00 (72.53)	9333.33(96.61)	12.73	14.27	1.65	0.30	18.43(25.41)
PAM 108	385.00 (19.64)	94.67(76.70)	23.07	29.69	10.05	91.00 (72.53)	9293.33(96.40)	11.67	12.03	1.54	0.29	19.02(25.84)
PAM 109	355.33 (18.80)	92.37(73.96)	25.00	40.39	13.61	90.00 (71.55)	9506.67(97.50)	13.39	17.11	1.67	0.30	18.06(25.13)
PAM 111	365.67 (19.14)	94.33(76.24)	25.01	36.76	11.84	90.00 (71.55)	9186.67(95.85)	12.59	14.56	1.73	0.31	17.66(24.83)
C.D. @ 1%	-	-	0.016	1.53	0.72	-	1.06	0.87	1.12	0.05	0.017	-
SE. m±	0.62	0.82	0.02	0.48	0.22	0.56	0.33	0.275	0.35	0.01	0.005	0.22
C.V. (%)	5.58	1.87	0.11	2.28	3.22	1.38	0.59	3.67	4.15	1.96	3.19	1.52

With regard to yield per 10,000 larvae by number was recorded the highest (9506.67) in PAM - 109 and lowest in PAM - 111 (9186.67). Yield per 10,000 larvae by weight (Kg), ranged to the maximum of 14.35 Kg in PAM - 101 and minimum of 11.67 Kg in PAM - 108 showing statistically significant among all the breeds with regard both by number and weight basis. The weight of cocoon found to the highest of 17.11 g in PAM - 109 and lowest of 12.03 g in PAM - 108 shows statistically significant among all the breeds. The cocoon weight ranged from the maximum of 1.73 g (PAM - 111) and minimum of 1.44 g (PAM - 101). The shell weight was maximum (0.31 g) in PAM - 111 and minimum in PAM - 101 (0.27 g) shows statistically significant among all the breeds with respect to both cocoon weight and shell weight. The shell ratio (%) shows statistically non significant among all the breeds and was highest in PAM - 108 (19.02) and lowest in PAM - 111 (17.66) respectively.

The highest average fecundity per moth was 522 in Jam 2 and lowest was 355 in Jam 18 reported by Anita *et al.* (2014) these results were non agreement with our results. The lowest hatching percent (93.79 %) was obtained in Jam 11 race and the highest (94.17 %) was obtained in Jam 27 race, with a mean of 93.92 per cent in all studied races Anita *et al.* (2014). It was justified with our results, 94.04 (PAM 105) to 94.67 (PAM - 108).

The larval weight was agreement with results reported by Bothikar *et al.* (2014) *i.e.* 40.54 g which were reared on S - 1635 and other breeds which on par with silkworm reared on variety M - 5 and breeds having larval weight ranges between 29.69 g (PAM -108) to 40.39 g (PAM - 109). Similar results were recorded by Pakhale *et al.* (2014), the larval weight was ranges from 33.77-40.67 g. The larval duration was non agreement with results reported by Pakhale *et al.* (2014), the larval duration ranges from 21.04 - 22.28 days, our results shows that 23.07-25.01 days among the breeds.

The single cocoon weight was not justified with results reported by Bothikar *et al.* (2014) *i.e.*, 1.86 g which were reared on S - 1635 and Rayer (2006) and Chakravorty (2004) reported the highest single cocoon weight on variety V- 1 and also justified with results reported by Pakhale *et al.* (2014) single cocoon weight ranges from 1.76-1.86 g, our results revealed that it ranges between 1.44-1.73 g.

The single shell weight was non agreement with Bothikar *et al.* (2014) report the silkworms which reared on S-1635 but it was similar results with variety M - 5 reported by Bothikar *et al.* (2014). Rayer (2006) and Chakravorty (2004) reported the highest single shell weight on variety V- 1 and also not justified with results reported by by Pakhale *et al.* (2014) single cocoon weight ranges from 0.32 -0.36 g, our results revealed that it ranges between 0.27 (PAM - 101) - 0.31 g (PAM - 111).

The cocoon shell percentage varies between 17.84 to 19.93 per cent reported by Bothikar *et al.* (2014) and it was agreement with our results the shell percentage varies between 17.66 (PAM - 111) – 19.02 per cent (PAM - 108). Similar results Rayer (2006) and Chakravorty (2004) reported the cocoon shell percentage.

Cocoon yield per 10,000 larvae brushed varied in the range of 18.66 Kg to 16.59 Kg reported by Bothikar *et al.* (2014) and it was non agreement with our results on S - 1635 but similar results which reared on variety M - 5, the yield varies between 9.97- 15.95 Kg. Varietal differences for studied traits in *B. mori* has been reported by Ahsan *et al*., 2000, Li *et al*., 2001; Furdui *et al*., 2010. Similar studies on varietal diversity have also been sustained by the findings of Reza *et al*.,1993, Mistri and Jayaswal, 1992; Ahsan *et al*., 1999; Umashankara and Subramanya, 2002; Nezhad *et al*., 2009; Nguku *et al*., 2007; Nguku *et al*., 2009; Zannata *et al*., 2009; Pal and Moorthy, 2011).

CONCLUSION

The obtained data showed that there are highly significant differences among the breeds for all the studied characters. There is a high positive correlation between economic parameters among all the breeds studied. The differences in obtained results are due to the variability and genotype characters for each individual of every breed.

ACKNOWLEDGEMENTS

The authors wish to thank the authorities of Regional Sericultural Research Station, CSB, Miran Sahib, Jammu - 181101, J & K, India for their encouragement to undertake this work. The authors are also thankful to Dr. Anil Dhar, Scientist-D, for his assistance in conducting effective work and close monitoring during the study. We acknowledge all technical staff who assisted their help in rearing.

REFERENCES

Ahsan, M.K., Rahman, S.M., Ali, I.A. (1999) Inheritance of some quantitative traits in fifteen indigenous varieties of silkworm, *Bombyx mori* L. Univ. J. Zool. Rajshahi Univ. 18: 79-83.

Ahsan, M.K., Rahman, S.M., Ali, I.A. (2000) Variability of some quantitative traits in the hybrids of silkworm, *Bombyx mori* L. Univ. J. Zool. Rajshahi Univ. 19: 20-24.

Anita Tripathi, N.K., Bhatti, A.A., Poonam (2014) Comparative analysis of developmental stages in six different bivoltine races of *Bombyx mori.* Int. J. Recent Sci. Res. 5(11): 1969-1972.

Balasundaram, D., Ganesh Prabu, P., Selvisabhanayakam, Mathivanan, V., Ramesh, V. (2013) Studies on the nutritional supplementation of vitamin C treated MR_2 mulberry leaves fed by V instar larvae of silkworm, *Bombyx mori* (L.) (Lepidoptera: Bombycidae) in relation to feed efficacy and growth rate. Int. J. Res. Biotech. and Biochem. 3(1): 11-18.

Begum, N.A.R., Basavaraja, H.K., Joge, P.G., Palit, A.K. (2008) Evaluation and identification of promising bivoltine breeds in the silkworm, *Bombyx mori* L. Int. J. Ind. Ent. 16: 15-20.

Benchamin, K.V., Jolly, M.S. (1986) Principles of silkworm rearing. Proc. of Sem. On problems and prospects of sericulture. S. Mahalingam (Ed), Vellore, India, pp. 63-106

Borisade, O.M. (2012) Training manual on Sericulture as an avenue for youth empowerment in Ekiti State. Training organized by RMR & DC at Ekiti state sericulture project, Ado Ekiti, Nigeria.

Bothikar, P.A., Jadhav, S.S., Shinde, Y.A. (2014) Growth and Development of Silk Worm (*Bombyx Mori* L.) on Mulberry Leaves. Jr. of Ind. Pollution Contl. 30(2): 239-241.

Chakravorty, N. J. (2004) Studies on different parameters of *B. mori.* Seridoc, 20(2): 21-23.

Furdui, E. M., Marghitas, L. A., Dezmirean, D., Mihai, C. M., Bobis, O., Pasca, I. (2010) Comparative study of biological characters of larvae, crude and dried cocoon in 7 races of Silkworm *Bombyx mori* L. raised in Transylvania area. Scientific Papers: Animal Science and Biotechnologies, 43(1): 490-493.

Krishnaswami, S. (1978) New technology of silkworm rearing. Bulletin of the Central Sericulture Research and Training Institute, Mysore, pp. 1-10.

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

Li, M., Yao, W., Hou, Q., Lin, C. Q., Chen, K. P. (2001) Studies of some special characters in the silkworm (*Bombyx mori* L.) germplasm in China. Sericologia, 41: 527-535.

Malik, G. N., Kamali, A. S., Wani, S. A., Dar, H. U., Raies Ahmed and Sofi, A. M. (2002) Evaluation of some bivoltine silkworm (*Bombyx mori* L.) genotypes. SKUAST J. Res., 4: 83 - 87.

Mistri, P. K. and Jayaswal, K. P. (1992) Studies on phenotypic correlations between some economic traits of silkworm, *Bombyx mori* L. Bull. Seric. Res., 3: 26-29.

Nagaraju, J .(2002) Application of genetic principles in improving silk production. Curr. Sci., **83**(4): 409-415.

Nezhad, M. S., Mirhosseini, S. Z., Gharahveysi, S., Mavvajpour, M., Seidavi, A. R. (2009) Analysis of Genetic Divergence for classification of morphological and larval gain characteristics of peanut cocoon silkworm (*Bombyx mori* L.) Germplasm. American-Eurasian J. Agric. & Environ. Sci., 6(5): 600-608.

Nguku, E.K., Adolkar, V.V., Raina, S. K., Mburugu, K.G., Mugenda, O. M. and Kimbu, D. M. (2009) Performance of six Bivoltine *Bombyx mori* (Lepidoptera: Bombyxidae) silkworm strains in Kenya. The Open Entomology Journal, 3: 1-6.

Nguku, E.K., Muli, E.M. and Raina, S.K. (2007) Larvae, cocoon and post-cocoon Characteristics of *Bombyx mori L.* (Lepidoptera: Bombyxidae) fed on mulberry leaves fortified with Kenyan royal jelly. J. Appl. Sci. Environ. Manage. 11(4): 85-89.

Pakhale, S.G., Bothikar, P.A., Lande, U.L., Shendage, S.A. (2014) Evaluation of Some Mulberry Varieties for Rearing Performance and Economic Traits of Silkworm (*Bombyx Mori* L.). *Journal of Environmental Science, Toxicology and Food Technology* (IOSR-JESTFT) 8: 63-65.

Pal, N.B., Moorthy, S. M. (2011) Assessment of variability in larval and cocoon traits in some genotypes of bivoltine silkworm, *Bombyx mori* L. Intl. J. Res. Bio. Sci. 1(4): 59-65.

Prabu, P.G., Sabhanayakam, S., Mathivanan, V., Balasundaram, D. (2011) Studies on the Growth Rate of Silkworm, *Bombyx mori* (L.) (Lepidoptera: Bombycidae) Fed with Control and Silver Nanoparticles (AgNps) Treated MR2 Mulberry Leaves. Int. J. Indust. Entomol., 22(2): 39-44.

Rahmathulla, V.K. (2012) Management of climatic factors for successful silkworm (*Bombyx mori* L.) crop and higher silk production: A review. Hindaw Publication corporation Psyche. 121234, 12.

Rayer, S.G. (2006) Stability of improved mulberry varities to shootlet feeding and it's impact on cocoon production. J. Maharashtra agric. Univ. 32(3): 367-369.

Reza, A.M.S., Rahman, M. S., Rahman, S.M. (1993) Studies on the variation of some larval traits in different breeds of silkworm, *Bombyx mori* L. Univ. J. Zool. Rajshahi Univ. 12: 21-24.

Suresh Kumar, N., Yamamoto, T., Basavaraja, H.K., Datta, R.K. (2001) Studies on the effect of high temperature on F1 hybrids between polyvoltine and bivoltine silkworm races of *Bombyx mori* L. Int. J. Ind. Ent. 2: 123-127.

Trag, A.R., Kamili, A.S., Malik, G.N., Kukiloo, F.A. (1992) Evaluation of high yielding bivoltine silkworm (*Bombyx mori* L) genotypes. Sericologia, 32(2): 321 - 324.

Umashankara, M.L., Subramanya, G. (2002) Correlation between larval weight and cocoon characters in five breeds of silkworm, *Bombyx mori* L. Geobios, 29: 154-157.

Venugopal Reddy, B., Divya, P., Anitha, M. (2015) Quantitative profile Analysis of Mulberry Silkworm, *Bombyx mori.* L. (CSR2XCSR4). Intl. Let. Nat. Sci. 34: 34-41.

Venugopala Pillai, S., Krishnaswami, S. (1987) Adaptability of Silkworm, *Bombyx mori* L. to tropical conditions III. Studies on the effect of high temperature during later development stages of Silkworm. Indian J. Seric. 26: 63-71.

Zanatta, D.B., Bravo, J.P., Barbosa, J. F., Munhoz, R.E.F., Fernandez, M. A. (2009) Evaluation of economically important traits from sixteen parental strains of the silkworm, *Bombyx mori* L. (Lepidoptera: Bombyxidae). Neotropical Ent. 38(3): 327-331.