The Pharma Innovation Journal 2021; 10(6): 1286-1289

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(6): 1286-1289

www.thepharmajournal.com
Received: 05-04-2021
Accepted: 10-05-2021

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Comparative performance of Diapausing and Non-Diapausing Strains of Silkworm *Bombyx mori* L. under temperate climatic conditions of Kashmir

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Abstract
The results of the present study indicated that significantly higher larval weight (48.77g), cocoon weight (1.903g), shell weight (0.439g), shell ratio (23.06%), filament length (846.25m) and raw silk percentage (12.36%) was registered by NB_4D_2 during spring, however during summer the highest larval weight (37.71g), cocoon weight (1.786g), shell weight (0.326g), shell ratio (18.26%), filament length (772.75m) and raw silk percentage (10.29%) was recorded in SKAU-R-6 breed. Among all the breeds under study pupation rate was observed to be significantly high in SKUAST-28 (92.10%) during spring season, while it was recorded high (94.43%) in case of Nistari during summer.

Keywords: *Bombyx mori* L., cocoon, Shell wt., economic traits, spring.

Introduction
Unemployment and poverty are the major concerns of the developing nations. It has become necessary to generate employment on large scale giving due attention to the needs of the environment and disadvantaged sections of the society for making the developmental processes socially inclusive. Sericulture being an important agro based activity has the potential to act as an effective tool for rural poverty alleviation. An analysis of the trends in the international silk production suggests that sericulture has better prospects for growth in the developing countries rather than in the advanced countries. India is the second largest producer of raw silk after China with 14.57 per cent share in global raw silk production and the biggest consumer of raw silk and silk fabrics in the world (Giridhar *et al.*, 2010) [3].

India holds the second position in the category of sericultural nations and the bulk of its silk comes from multivoltine breeds. Fact of the matter is that Indian silk has yet to find a place in the international market owing to multifarious reasons. Among various sericultural zones in India, Kashmir on account of its congenial climatic conditions, is the only traditional univoltine/bivoltine belt producing quality mulberry silk and as such occupies a place of pride in sericulture. Dr. Tazima (1991), a leading Japanese scientist, upon his visit to India expressed that Kashmir in view of its favourable climatic conditions could be converted into silkworm gene bank for sustaining the sericulture industry of the whole world. Keeping the above factors in mind, the present study was carried out with that aim of judging the performance of multivoltine (non-diapausing) and bivoltine (diapausing) breeds of silkworm *Bombyx mori* L. under Kashmir climatic conditions.

Materials and Methods
Six breeds of the mulberry silkworm, *Bombyx mori* L. comprising of two non-diapausing breeds (Pure Mysore and Nistari) and four diapausing breeds (SKAU-R-6, SKUAST-28, NB_4D_2 and SH_6) were used in the present study. The material was incubated under laboratory conditions at 25 ^oC and relative humidity of 75 per cent and then allowed to hatch. Rearing of all the silkworm breeds was carried out as per the standard package of practices (Raja, 2000) [10]. The experiment was laid out in a completely randomized block design with four replications for each treatment. Each replication comprised of 200 silkworms of uniform age and size retained after third moult. At the end of the experiment the following observations were recorded:

1) **Weight of matured larvae (g larva^{-10}):** Ten mature larvae were selected randomly from each replicate of each treatment and weighed.

2) **Single cocoon weight (g):** Twenty five male and twenty five female cocoons were randomly taken from each replicate of each treatment and weighed to determine the average cocoon weight.
3) **Single shell wt. (g):** The cocoons used for determining average single cocoon weight were cut to obtain the average shell weight.
4) **Shell (%):** It was calculated as per the following formula:

$$\frac{\text{Single shell weight}}{\text{Single cocoon weight}} \times 100$$

5) **Pupation rate (%):**
It was calculated as**:**

$$\frac{\text{Number of live pupae}}{\text{Total number of cocoons harvested from each replicate}} \times 100$$

6) **Filament length (m):** Five randomly selected cocoons from each treatment and replicate were reeled to determine average filament length.
7) **Raw silk (%):** It was calculated by adopting the following formulae :

$$\frac{\text{Weight of reeled silk}}{\text{Cocoon weight}} \times 100$$

Results and Discussion

1) **Larval weight (g):** In the present study, it was found that larval weight was higher in bivoltine breeds as compared to multivoltines. Among them, NB_4D_2 had significantly higher larval weight of 48.77g during spring (Table-1), while it was highest in SKAU-R-6 (37.71g) during summer season (Table-2). Among the multivoltine breeds, Pure Mysore recorded the larval weight of 19.91g and 20.96g whileas Nistari recorded the larval weight of 19.05g and 20.26g during spring and summer respectively. Similar type of results were reported by Kalpana *et al.* (1994) [4]. These observations are in line with the findings of Murugesh *et al.* (2011) [8], who also observed the superiority of bivoltine breeds over multivoltines with respect to larval weight. Ashoka *et al.* (2012) [1] while assessing the performance of multivoltine and bivoltine silkworm breeds for different traits reported that larval weight was significantly higher in bivoltine breed, APS_5 (40.82g), whereas low in multivoltine breed, MY_1 (22.44g). The present findings are also corroborated with the results of these authors. The difference in the larval weight among the genotypes studied could be attributed to the racial character, difference in the degree of assimilation that differ from one breed to another and the quality and quantity of food consumed by the larvae, which has a direct bearing on the performance including growth, development and probably the survival as well.
2) **Cocoon weight (g):** Bivoltine breeds were found to record relatively higher cocoon weight than the multivoltine breeds during both the seasons. These results are in accordance with the findings of Murugesh *et al.* (2011) [8], who reported that cocoon weight of multivoltine breeds ranged from 0.494g to 0.683g, whileas bivoltine breed, CSR_2 recorded the significantly higher cocoon weight of 2.491g. During the course of present investigations, NB_4D_2 and SKAU-R-6 were found to record the highest cocoon weight of 1.903g and 1.786g during spring (Table-1) and summer (Table-2) respectively. The cocoon weight of bivoltine breeds was relatively lower in summer season than spring which could be attributed to the higher temperature and the poor leaf quality available in summer that influences the physiology of the insect. The present results are also in close conformity with those of Singh *et al.* (2010) [11], who reported that temperature and humidity are key environmental factors that influences the physiology of the insects. The present findings also corroborate with the results of Kumar *et al.* (2003) [6] who noticed the deleterious effect of adverse temperature and humidity on economic traits.
3) **Shell weight (g):** Significantly higher shell weight of 0.439 and 0.326g was recorded by NB_4D_2 and SKAU-R-6 breeds during spring (Table-1) and summer seasons (Table-2) respectively. This was followed by SKAU-R-6 (0.410g) in spring and SH_6 (0.310g) during summer season. It was also observed that bivoltine breeds exhibited marked increase in shell weight than the multivoltine breeds during both the seasons. Similar kind of observations were made by Murugesh *et al.* (2011) [8], who reported that bivoltine breed, CSR_2 recorded higher shell weight of 0.556g, while the lowest shell weight was recorded in multivoltine breeds in the range of 0.063 to 0.110g. The present results are also well supported by the findings of Ashoka *et al.* (2012) [1] and Basavaraja (2001) [12]. The variations in the shell weight observed in the present findings might be due to the racial character and difference in the quality of the leaf provided to the silkworms.
4) **Shell (%):** The present study revealed that the bivoltine breeds, NB_4D_2 and SKAU-R-6 recorded the maximum shell ratio of 23.06 and 18.26 per cent during spring (Table-1) and summer (Table-2) respectively. Multivoltine breeds were found to record relatively lower shell ratio than the bivoltine breeds during spring. These results are in line with the findings of Ashoka *et al.* (2012) [1], who observed the low shell ratio of 11.25 per cent in C.Nichi, a multivoltine breed and the highest shell ratio of 21.29 per cent was recorded in CSR_{26}, a bivoltine breed. The present results are also in accordance with those of Basavaraja (2001) [12] and Sudhakararao *et al.* (2001) [12].
5) **Filament length (m):** In the present study, NB_4D_2 and SKAU-R-6 recorded the maximum single filament length of 846.25 m and 772.75m during spring and summer seasons respectively. The single filament length in multivoltine breeds was comparatively lower and it was found to be 360.12m and 453.50m for Pure Mysore and Nistari respectively during spring (Table-1); however during summer it was relatively higher as compared to spring and was recorded to the extent of 391.50m and 478.75m for Pure Mysore and Nistari respectively (Table-2). Similar results were obtained by Narayanswami *et al.* (2000), who observed that NB_4D_2 registered longer filament length (1084.17m) over KA (881.00m). Murugesh *et al.* (2011) [8] also reported that single filament length in multivoltine breeds ranged from 306.58 to 696.73m, while CSR breeds recorded significantly longer filament length. The present findings are also well supported by Ashoka *et al.* (2012) [1], who observed that single filament length in multivoltine

breeds ranged from 363.67 to 660.00m, while in bivoltine breeds it was recorded comparatively higher (580.00 to 840.33m).

6) **Raw silk (%):** Raw silk percentage was observed to be highest in NB_4D_2 (12.36%) during spring (Table-1), however it was recorded maximum in case of and SKAU-R-6 (10.299%) during summer season (Table-2). Relatively higher values of raw silk percentage of all the bivoltine breeds were observed in spring than the summer season, while the trend was found to be reverse in case of multivoltine breeds. The difference in the raw silk percentage among the different silkworm breeds could be attributed to the difference in the utilization of energy resources under nutrition stress conditions. Temperate breeds have been observed to have the ability to utilize the available nitrogen and carbon (energy) resources even under nutrition stress condition towards biomass production (Kamili and Masoodi, 2004) [5].

7) **Pupation rate (%):** Pupation rate is also one of the important components contributing to the survival of races. It was found to be significantly high in SKUAST-28 (92.10 %), followed by Nistari (86.21 %) and Pure Mysore (85.12 %) during spring season (Table-1). During summer, multivoltine breeds were found to record significantly higher pupation rate of 94.43 and 88.11 per cent for Nistari and Pure Mysore respectively (Table-2), however among the bivoltine breeds, SKUAST-28 was found to be the better breed with a pupation rate of 79.44 per cent. These results corroborate with the findings of Suresh Kumar *et al.* (1999) [13], Basavaraju, (2001) [12] and Ashoka *et al.* (2012) [1], who made the similar type of observations. This difference in the pupation rate can be attributed to the environmental conditions, haemolymph content and the quality of food.

Table 1: Performance of different breeds of silkworm, *Bombyx mori* L. during spring seasons (Data pooled over same seasons of 2011 and 2012)

Race	Weight of 10 mature larvae (g)	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)	Filament length (mtrs)	Raw silk (%)	Pupation Rate (%)
Pure Mysore	19.915 ±0.198	1.240 ±0.010	0.212 ±0.007	17.110 ±0.492	360.125 ±7.206	8.410 ±0.179	85.125 ±0.804
Nistari	19.050 ±0.363	1.075 ±0.021	0.181 ±0.003	16.978 ±0.185	453.500 ±8.264	9.893 ±0.039	86.213 ±0.567
NB_4D_2	48.775 ±0.508	1.903 ±0.011	0.439 ±0.006	23.068 ±0.267	846.250 ±8.403	12.368 ±0.196	80.285 ±1.056
SH_6	46.638 ±0.443	1.876 ±0.006	0.403 ±0.013	21.510 ±0.347	796.750 ±2.847	10.605 ±0.352	82.603 ±0.986
SKAU-R-6	46.290 ±0.367	1.853` ±0.011	0.410 ±0.004	22.129 ±0.629	838.750 ±2.056	11.180 ±0.460	83.948 ±0.768
SKUAST-28	45.113 ±0.207	1.809 ±0.014	0.373 ±0.006	20.681 ±0.310	824.500 ±2.979	10.393 ±0.383	92.105 ±0.689
$C.D_{(p\leq0.05)}$	1.095	0.038	0.022	1.198	17.799	0.910	2.481

Each value represents the mean±S.E of four replications

Table 2: Performance of different breeds of silkworm, *Bombyx mori* L. during summer seasons (Data pooled over same seasons of 2011 and 2012)

Race	Weight of 10 mature larvae (g)	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)	Filament length (mtrs)	Raw silk (%)	Pupation Rate (%)
Pure Mysore	20.965 ±0.122	1.285 ±0.018	0.218 ±0.005	16.995 ±0.330	391.500 ±4.198	9.998 ±0.057	88.113 ±0.402
Nistari	20.263 ±0.257	1.161 ±0.021	0.202 ±0.002	17.565 ±0.168	478.750 ±9.453	9.899 ±0.049	94.438 ±0.543
NB_4D_2	36.370 ±0.171	1.725 ±0.004	0.309 ±0.002	17.920 ±0.177	767.625 ±7.116	10.290 ±0.310	73.588 ±0.534
SH_6	36.463 ±0.153	1.729 ±0.008	0.310 ±0.009	17.945 ±0.659	727.375 ±11.757	10.298 ±0.257	76.438 ±0.765
SKAU-R-6	37.713 ±0.155	1.786 ±0.010	0.326 ±0.002	18.261 ±0.187	772.750 ±8.628	10.299 ±0.152	74.243 ±0.522
SKUAST-28	36.151 ±0.209	1.700 ±0.006	0.300 ±0.003	17.653 ±0.241	666.625 ±7.040	10.105 ±0.438	79.440 ±0.468
$C.D_{(p\leq0.05)}$	1.000	0.038	0.014	1.020	25.046	0.898	1.644

Each value represents the mean±S.E of four replications

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