Eco. Env. & Cons. 28 (1) : 2022; pp. (330-337)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i01.048

Cocoon Traits and Grainage Behaviour of Modal Ecorace of Tasar Silkworm in three Different Locations of Similipal

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(Received 2 April, 2021; Accepted 3 July, 2021)

ABSTRACT

The wild ecorace of *Antheraea mylitta* "Modal" is bestowed with superior cocoon traits, but it is difficult to rear. The best option is to conserve the ecorace in its natural habitat. To save the population and for its sustainable utilization, conservation works are undertaken every year where wild cocoons are collected, eggs are produced and subsequently released on Sal trees in forest for natural proliferation. There are eight such camps in the peripheral zones of Similipal with varied geographical conditions. To understand the grainage behaviour of Modal silk moths, a study was undertaken in three different locations. The wild Modal cocoons were collected in August and around 20000 cocoons were kept in the pagoda at locations viz. Sarat, Kendujuani and Astabeda of Mayurbhanj district, Odisha. Wide ranges of variation were recorded for cocoon traits with respect to places for almost all traits except shell ratio of male ($P < 0.01$ to 0.001). In case of males, cocoon volume showed significant difference for places. The pupal weight was highest at Kendujuani than Sarat and Astabeda. The cocoon weight and filament length were lowest at Astabeda, whereas at par for Kendujuani and Sarat. But peduncle length was low at Kendujuani where as at par for Sarat and Astabeda. In case of females, cocoon weight and pupal weight values were significantly high at Kendujuani followed by Sarat and low at Astabeda. Shell weight and cocoon volume were significantly high for Kendujuani whereas Sarat and Astabeda were at par. But cocoon breadth and penduncle length were lowest at Astabeda where as Kendujuani and Sarat were at par. The grainage parameters were recorded from 15th August to 25th October. In Kendujuani, Sarat and Astabeda total of 7707,7206 and 7442 female moths were emerged during the entire span respectively. Since, these moths do not mate with the males of the same camp, they are taken to the forest during night for mating with external males. The total number of couplings in these three places were 4385 (56.9%), 3928 (54.5%) and 3219 (43.2%) respectively. From this it is evident that at Astabeda area of Similipal, availability of wild males in the forest is significantly less in comparison to other two areas. The pattern of emergence at one week interval also varied, early mass emergence followed by one more peak in October was recorded in Astabeda. But in other two places, almost uniform emergence with one peak in October was recorded. Thus, more attention is warranted for the proliferation of Modal populations in the Eastern part of Similipal.

Key words: *Antheraea mylitta, Conservation, Grainage, Modal ecorace, tasar silkworm*

Introduction

Tropical tasar silk moth *Antheraea mylitta* is distributed mainly in the dense humid forest over the central and southern plateau covering the state of Jharkhand, Chhattisgarh and Odisha. Odisha is the third largest tasar producing state of India. Sericulture is a labour intensive, export oriented, employment creating and income generating agro-based cottage industry providing quick returns in shorter duration and does not involve utilization of sophisticated machinery in rural areas of our country. India has about 44 ecoraces of *A. mylitta* (Suryanarayan and Srivastava, 2005) out of which only a few are commercially exploited in Odisha. Modal ecorace is unique for its richness in silk and other quantitative traits. Modal is a unique ecorace found in Similipal of Mayurbhanj district of Odisha state between 21°30′ North latitude 86°31′ East latitude. This behaves as univoltine, bivoltine and also multivoltine with overlapping generations depending upon the altitude (Nayak *et al.,* 1992).

Due to large scale exploitation, deforestation and other anthropogenic reasons, Modal ecorace had to face pressure of extinction (Dikshit *et al.,* 2007; Kar *et al.* 2010). An alarming trend of declined of Modal population was observed. The conservation model of this ecorace was developed by Regional Tasar Research Station, Central Silk Board, Baripada based upon project work from 1999-2003. After implementation of conservation process, increasing trend of population was recorded. Government of Odisha is running Modal Ecorace Conservation Programme every year in the peripheral areas of Similipal (Kar *et al.* 2019). Alam *et al.* (2018) emphasized that there is the need to have holistic approach towards the conservation of valuable wild seribiodiversity. The approach must include information on ecology, environmental factors, climatology, flora, fauna and their inter-relationship in the conservation site as a whole, while the life cycle, reproductive biology, voltinism and population dynamics of tasar insect of the ecozone must be taken into account.

Modal cocoons collected from forest are preserved in the conservation camp and eggs are produced, which are clipped on to Sal trees through leaf cups prepared from Siali (*Bauhinia variegata*) leaves in order to allow natural perpetuation (Kar *et al.,* 2019). This has led to sizeable increase in natural Modal populations. In the month of August wild cocoons are collected and processed in conservation camps. Moth mergence and coupling continues during rainy to autumn period. Due to dissimilar topography, Similipal Biosphere Reserve encompasses varied climatic conditions (Nayak *et al.,* 1992). Hence, it is essential to study life history traits of wild tasar at different locations. However, the detail studies on the cocoon traits and its grainage behaviour during conservation process at different locations are not studied so far. Hence the present study was carried out in three locations of Similipal to ascertain quantitative traits of Modal cocoons and grainage or egg production behaviour of Modal silk moths.

Materials and Methods

The cocoons of Modal Ecorace were randomly collected from the tribal people of Similipal Forest Region of Mayurbhanj district of Odisha in 1st fortnight of August. The quantitative traits of cocoons were analysed as per standard procedure adopted by Nayak *et al.* (1997). For studying grainage behaviour of Modal populations, 20000 cocoons were kept respectively in the pagodas at three study sites viz. Sarat, Kendujuani and Astabeda. The grainage parameters included moth emergence behaviour, coupling behaviour, oviposition, clipping of eggs in leave cups and host plants covered for clipping of leaf cups. The data so obtained were statistically analysed for mean, standard deviation, Analysis of Variance (ANOVA) using MS-Excel.

Results

Under conservation programme, two crop system is followed in Similipal forests i.e. Modal and Jhanji. Modal cocoons are collected during the first fortnight of August. Due to varied environmental factors in cropping seasons, the cocoon quantitative traits also vary. The mean quantitative traits of male and female cocoons of Modal ecorace such as cocoon weight, shell weight, pupal weight, shell ratio, cocoon volume, length, breadth, peduncle length and filament length of three study sites are presented in Table 1 and 2 respectively.

In case of males, cocoon weight and filament length showed similar trend for Kendujuani and Sarat, where Kendujuani had the highest values of 16.32 g and 1750 m respectively while Sarat was statistically at par with Kendujuani. Astabeda had the lowest values. The pupal weight was highest at

Table 1. Mean cocoon quantitative traits of male Modal cocoons at three locations

Parameter	Place	Mean	SD	*MS*	*F*	*Pvalue*	*CD at 5%*
Cocoon	Sarat	15.50[b]	0.526	50.012	183.56**	0.001	1.036
Weight(g)	Kendujuani	16.32[b]	0.417				
	Astabeda	14.33[a]	0.605				
Shell	Sarat	3.20[a]	0.411	0.62	8.43**	0.001	0.538
Weight (g)	Kendujuani	3.12[a]	0.151				
	Astabeda	2.98[a]	0.170				
Pupal	Sarat	12.30[a]	0.694	42.792	121.16**	0.001	1.179
Weight (g)	Kendujuani	13.20[b]	0.438				
	Astabeda	11.35[a]	0.622				
Shell	Sarat	20.676[a]	2.806	44.301	12.04**	0.001	3.806
Ratio	Kendujuani	19.128[a]	1.024				
	Astabeda	20.830[a]	1.454				
Cocoon	Sarat	33.50[b]	0.340	247	537**	0.001	0.425
Volume (cc)	Kendujuani	37.22[c]	0.117				
	Astabeda	23.62[a]	0.092				
Cocoon	Sarat	5.160[a]	0.164	0.316	6.99**	0.001	0.422
Length (cm)	Kendujuani	5.022[a]	0.248				
	Astabeda	5.160[a]	0.218				
Cocoon	Sarat	3.33[a]	0.145	0.540	21.91**	0.001	0.311
Breadth (cm)	Kendujuani	3.51[a]	0.112				
	Astabeda	3.33[a]	0.201				
Peduncle	Sarat	6.01[b]	0.078	39.847	185**	0.001	0.291
Length (cm)	Kendujuani	4.55[a]	0.106				
	Astabeda	6.17[b]	0.217				
Filament	Sarat	1702[b]	52.14	1435	565**	0.001	99.968
Length (m)	Kendujuani	1750[b]	36.14				
	Astabeda	1436[a]	59.93				

** P < 0.001 (Difference if highly significant)

Kendujuani (13.2g) and other two places had identical values. The peduncle length was minimum at Kendujuani while the value of that was higher at Sarat and Astabeda. Cocoon volume was had statistically different values for all places where Kendujuani topped the table with value of 37.22cc followed by Sarat (33.5cc) while lowest was at Astabeda (23.62cc). The values of shell weight, shell ratio, cocoon length and breadth were comparable for all places. ANOVA revealed highly significant variation for all the male cocoon quantitative traits (P < 0.001) with F value ranging from 8.43 to 565 (Table 1)

Perusal of data in Table 2 reveals that cocoon weight and pupal weight were significantly highest at Kendujuani with values of 21.31g and 17.72g respectively. This was followed by Sarat and lowest at Astabeda. Shell weight and cocoon volume values were significantly higher for Kendujuani (3.53g and 36.86cc respectively) whereas Sarat and Astabeda were at par for these two parameters. But cocoon breadth and peduncle length were lowest in Astabeda where as Kendujuani and Sarat were at par. In case of female cocoons the shell ratio, cocoon length and filament length were statistically identical in all places as the values were comparable based upon CD. ANOVA revealed highly significant variation for all the female cocoon quantitative traits (P <0.01 to 0.001) with F value ranging from 3.58 to 504.43 (Table 2).

The Grainage performance of Modal cocoons such as emergence of male and female moths, total emergence, number of coupling obtained, total number of eggs produced, leaf cups containing eggs clipped on Sal trees are presented in Table 3. In all three places emergence were recorded from 15th August and continued till 25th October. In Kendujuani, Sarat and Astabeda at total of 7707,7206 and 7442 female moths emerged during the entire span respectively. The total number emergence of moth in these three places were 16580 (82.9%) in Kendujuani,15938 (79.7%) in Sarat and

Table 2. Mean cocoon quantitative traits of female Modal cocoons at three locations

Parameter	Place	Mean	SD	*MS*	*F*	*Pvalue*	*CDat 5%*
Cocoon	Sarat	19.75[b]	0.580	170.922	504.43**	0.001	1.155
Weight (g)	Kendujuani	21.31[c]	0.625				
	Astabeda	17.63[a]	0.538				
Shell	Sarat	3.22[a]	0.180	3.734	119.46**	0.001	0.351
Weight (g)	Kendujuani	3.53[b]	0.207				
	Astabeda	2.98[a]	0.135				
Pupal	Sarat	16.52[b]	0.580	120.469	415.9**	0.001	1.068
Weight (g)	Kendujuani	17.72[c]	0.535				
	Astabeda	14.64[a]	0.497				
Shell	Sarat	16.31[a]	0.958	5.046	6.286*	0.01	1.778
Ratio	Kendujuani	16.62[a]	0.995				
	Astabeda	16.95[a]	0.709				
Cocoon	Sarat	32.25[a]	0.218	1226.892	3.58*	0.01	1.048
Volume (cc)	Kendujuani	36.86[b]	0.685				
	Astabeda	32.29[a]	0.566				
Cocoon	Sarat	5.58[a]	0.109	1.001	29.050**	0.001	0.368
Length (cm)	Kendujuani	5.45[a]	0.131				
	Astabeda	5.31[a]	0.273				
Cocoon	Sarat	3.59[b]	0.107	2.287	175.69**	0.001	0.226
Breadth (cm)	Kendujuani	3.57[b]	0.131				
	Astabeda	3.21[a]	0.102				
Peduncle	Sarat	5.83[b]	0.115	36.315	244.4**	0.001	0.242
Length (cm)	Kendujuani	4.54[b]	0.141				
	Astabeda	4.22[a]	0.107				
Filament	Sarat	1762[a]	45.79	206499	62.6**	0.001	114
Length (cm)	Kendujuani	1798[a]	68.09				
	Astabeda	1673[a]	56.23				

* P < 0.01 ** P < 0.001 (Difference if highly significant)

Table 3. Grainage details of Modal crop in three locations (cocoons =20000 each)

Parameters	Sarat	Kendujuani	Astabeda
Male moths emerged	8732	8873	8418
Female moths emerged	7206	7707	7442
Total emergence	15938	16580	15860
Emergence % with respect to total cocoons	79.7	82.9	79.3
Pairing obtained	3928	4385	3219
Pairing % with respect to female moths	54.5	56.9	43.2
Total eggs obtained	1021280	1315500	817626
Average Fecundity	260	305	254
Leaf cups prepared	51064	65775	40881
Number of trees covered for egg cup clipping	12766	16444	10220

15860 (79.3%) in Astabeda. The coupling percentage with respect to total female moths was 56.9% in Kendujuani 54.5% in Sarat and 43.2% in Astabeda. Fecundity was highest at Kendujuani (305)and lowest at Astabeda (254). Total number of siali leaf cups prepared were 65775, 51064 and 40881 in Kendujuani, Sarat and Astabeda respectively.

The pattern of emergence and couplingby number as well as percentage for Modal grainage recorded in Sarat, Kendujuani and Astabeda at one week interval are presented in Fig. 1, 2, 3, 4, 5 & 6 respectively. The pattern of emergence at one week interval also varied, early mass emergence followed by one more peak in October was recorded in Astabeda. But in other two places, almost uniform emergence with one peak in October was recorded.

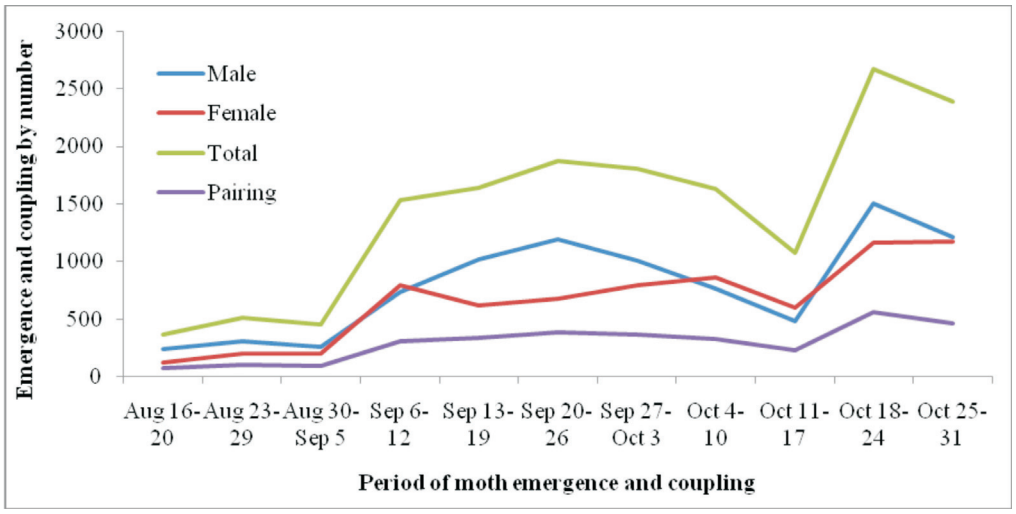

Fig. 1. Emergence and coupling (by number) in Sarat during Modal grainage

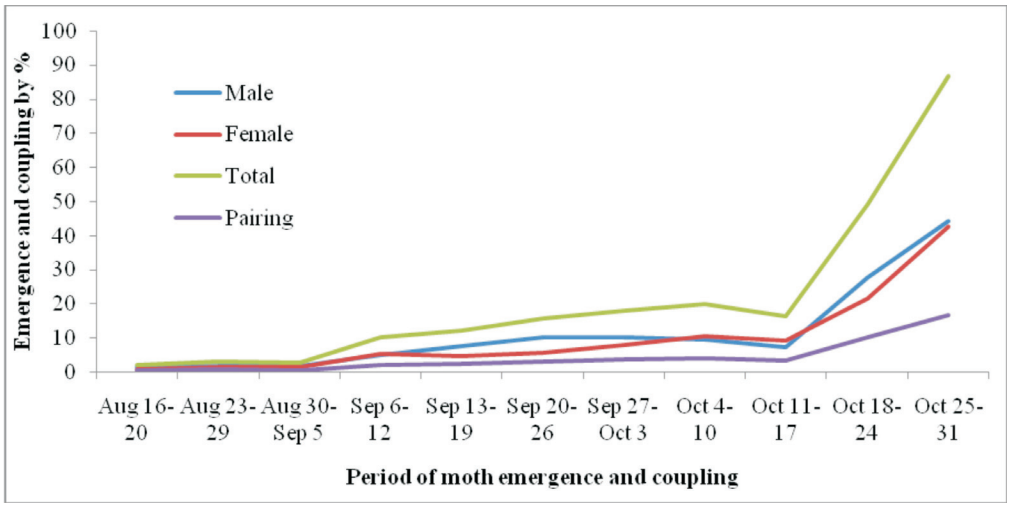

Fig. 2. Emergence and coupling (percentage) in Sarat during Modal grainage

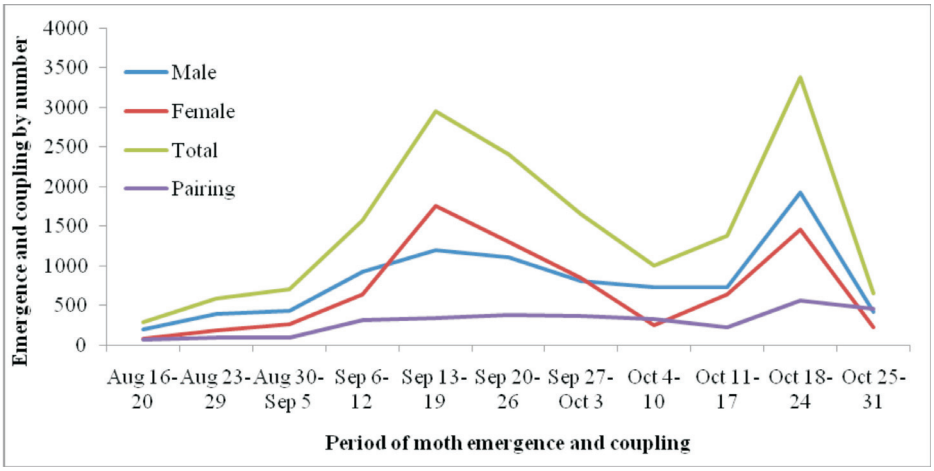

Fig. 3. Emergence and coupling (by number) in Kendujuani during Modal grainage

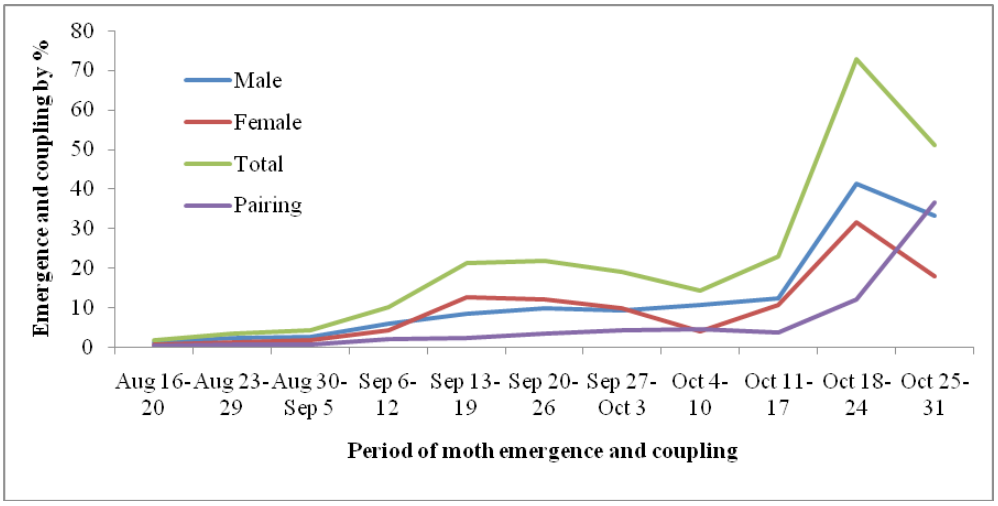

Fig. 4. Emergence and coupling (percentage) in Kendujuani during Modal Grainage

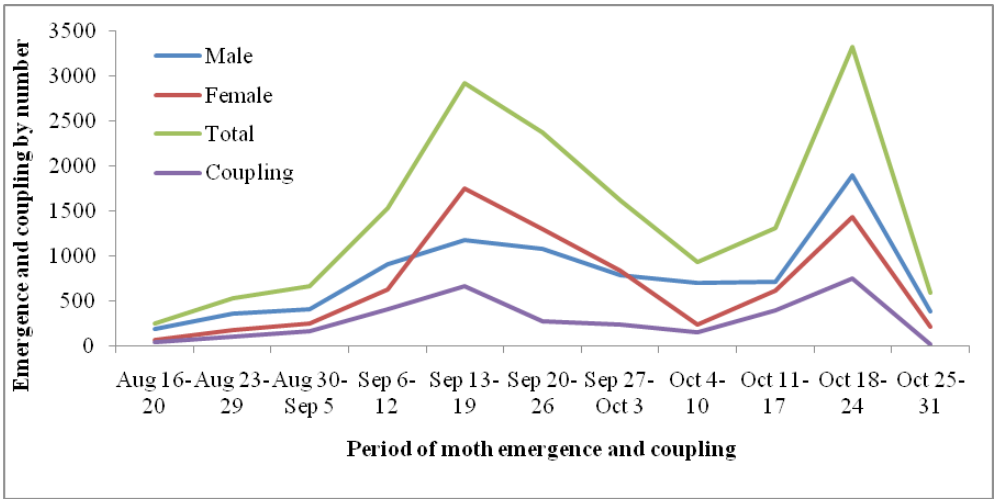

Fig. 5. Emergence and coupling (by number) in Astabeda during Modal grainage

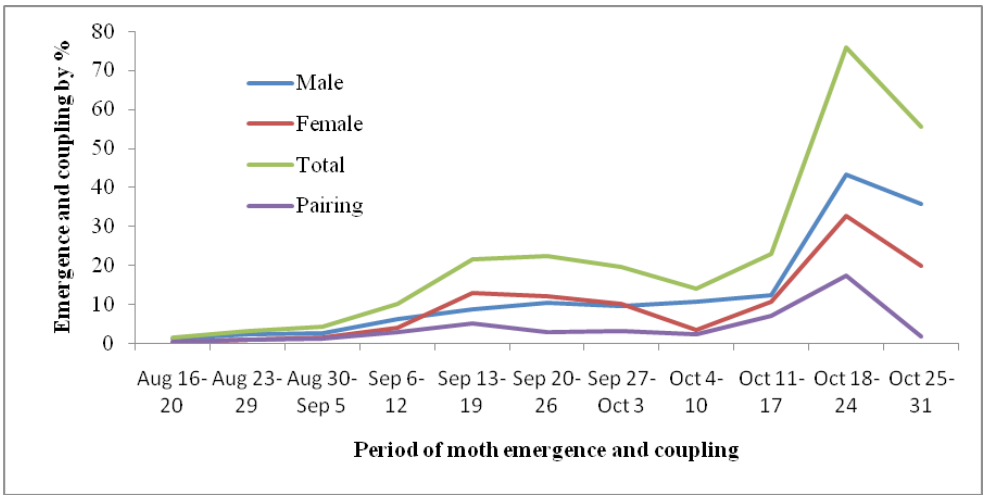

Fig. 6. Emergence and coupling (percentage) in Astabeda during Modal grainage

Discussion

Wild ecoraces of *A. mylitta* are also facing challenges of existence in their natural abodes (Thangavelu, 1992). The alarming decline in natural multiplication of ecoraces is attributed due to the rampant collection, rapid deforestation, and fragmentation oftheir natural habitats (Nayak *et al.,* 2000; Hansda *et al.,* 2008). In Similipal biosphere reserve of Mayurbhanj adequate measures are continuously being taken up for conservationof precious Modal ecorace through establishing camps at eight locations in the peripheral and buffer zones (Kar *et al.,* 2019).

Modal ecorace of *A. mylitta* is the predominant silk moth in the Similipal forest having univoltine, bivoltine and also multivoltine in nature (Nayak *et al.,* 1992). However, the behaviour of this ecorace across different camps is not studied so far. The three places viz. Sarat, Kendujuani and Astabeda although comes under Similipal, the topography varies along with the climatological factors like rainfall, relative humidity and temperature which play vital role for regulating life cycle traits. The abiotic and biotic factors of the environment during different seasons greatly influence the life history features of the *A. mylitta* in the form of larval weight, cocoon weight, pupal weight, shell weight, shell percent, percent emergence, percent coupling, adult longevity, fecundity, hatching percent and silk filament length (Jolly, 1974; Yadav *et al.,* 1992; Nayak *et al.* 1993). In the present study wide range of variation was observed in both male and female cocoon quantitative traits for all the places for Modal. Similar observations were made for Modal (Alam *et al.,* 2000) and other ecoraces of tasar silkworm earlier (Sengupta, 1991; Srivastava *et al.,* 2004).

Normally, for reared variety of tasar silkworm e.g. Daba ecorace, grainage operation begins in the month of June. But in case wild Modal, the emergence starts from the month of August and continues till October. Hence, preservation of wild cocoons and subsequent release of eggs onto the sal trees in the forest become an essential part under Modal Ecorace Conservation Programme (Kar *et al.,* 2019). In the present study, there was significant variation in the grainage behavior in three places. At Astabeda and Kendujuani, the pattern of emergence over period of time was identical whereas in Sarat it was different. This may be due to the prevailing environmental conditions of that period. However, the coupling percentage of Astabeda was very low. It is already mentioned that the female moths mate with the external males from forest i.e. outbreeding. This may be an indirect indication of less availability of wild population in the forest areas of Astabeda. Thus more attention is warranted for the proliferation of Modal population in the Eastern part of Similipal where Astabeda camp is operational. Fecundity or the number of eggs produced by a single female moth has directly proportional to the pupal weight (Kar *et al.,* 1995; Yadav *et al.,* 2001). This also corroborates to the findings of the present study where Kendujuani had highest pupal weight and highest fecundity followed by Sarat and Astabeda. Thus the study has come out with the findings on variability of the cocoon commercial traits at three different places of Similipal as well as the grainage behavior during Modal crop operation. Adequate attention is further required for augmenting conservation efforts in eastern part of Similipal.

Acknowledgement

The authors are thankful to Shri K. B. Mohanta, Shri P. K. Pradhan and Shri S. K. Panigrahi, Secretaries of Sarat, Kendujuani and Shyamsundarpur Tasar Rearers' Cooperative Societies respectively for the cooperation extended during the present work.

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