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Impact of seasonal adult emergence period on reproductive performance of tasar silkmoth *Antherea mylitta* Drury (Lepidoptera: Saturnidae)

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ABSTRACT: Influence of adult emergence period and prevailing weather parameters on reproductive biology of tasar silkmoth *Antherea mylitta* was studied under grainage (indoor) condition. There was a significant difference of fecundity was observed on different days of adult emergence. Maximum fecundity was observed on 10th day (219 eggs/female) during first grainage (diapause cocoons) while same has been observed on 13th day (224.30 eggs/female) of emergence during second grainage (non-diapause cocoons). With respect to hatching percentage, during first grainage maximum hatching was observed on 1st, 6th, 7th and 12th days of emergence (93.32, 90.14, 90.96 and 90.18 % respectively). In the case of second grainage maximum hatching was on 12th and 2nd day of emergence. Data on per cent egg retention during first grainage ranged between 6.46 to 29.25 % and it was between 6.49 to 14.39 % during second grainage. Retained eggs were unfertile and could observe less than 2 % of hatching across all the days of emergence in first and second grainage together. Despite of significant difference in the reproductive parameters it was not clear about which phase or days of seasonal emergence period yields better layings. Better reproductive performance was scattered randomly across the days of emergence and it also indicates that adult emergence period don't have any influence over reproductive biology of *A. mylitta.* Prevailing temperature and relative humidity during emergence period found to have no major influence over fecundity, hatching percentage and egg retention.

KEYWORDS: Fecundity, hatching, egg retention, relative humidity

INTRODUCTION

Indian tasar silk moth *Antheraea mylitta* Drury (Lepidoptera: Saturnidae), is an economically important wild silk moth species distributed across India. Despite high potential of country's tropical tasar industry scarcity of good quality eggs for commercial rearing is one of the major reasons for the decline in Tasar silk production. In tasar sericulture, pre-seed and seed crops are affected by adverse climatic conditions; diseases and erratic emergence in seed cocoon as a result commercial crops are not getting adequate timely supply of quality seed. The farmers are unable to utilize their full potential of natural plantation for rearing during the favourable commercial crops. Hence, there is a wide gap between the demand and supply of disease free layings (DFLs).

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Most insects survive periods of environmental stress by entering a state of diapause. The Indian tropical tasar silkworm, *A. mylitta* completes two to three generations in a year (Sinha and Chaudhuri, 1992), bivoltine and trivoltine broods undergoes pupal diapause for a period of about six to seven months to overcome unfavourable environmental conditions (Dash and Nayak, 1988, Kapila *et al.,* 1991, Sinha and Chaudhuri, 1992). Pupal diapause in this species normally terminates at the end of May and eclosion begins in June with the advent of rain (Sinha and Chaudhuri 1992). This is known as optimal seasonal emergence. However, in the diapausing brood a portion of the pupae hatch 1-2 months early, emerging in a presumably unfavourable climate before the rainy season (Kapila *et a1.,* 199l). The physiological/hormonal basis of this erratic eclosion remains unclear, although endocrine regulation of pupal diapause in other insects has been well documented (Browning, 1981; Denlinger 1985), Daily patterns of insect behaviour (e,g., locomotion, feeding, emergence, mating, oviposition, and hatching) are governed by daily cycles of temperature, humidity, and light intensity as well as by physiological events (Beck 1983, Ashby and Singh 1990). Considering the fact there is a general recommendation is that during oviposition less than 30°C temperature and 70-80% relative humidity is required to be maintained to prevent egg desiccation and poor hatching (Prasad *et al*., 2000).

Reproductive biology is one of the important factors as per as productive insects are concerned. Generally, it is governed by various factors and they can be broadly categorized into internal (biological) and external (non-biological) factors. The role of temperature and relative humidity on oviposition and incubation of eggs were reported earlier by several workers. However, information on the reproductive performance of *A. mylitta* on different emergence days and influence of prevailing temperature and relative humidity is scanty, with this background during the present study efforts were made to know the impact of adult emergence period over reproductive performance of tasar silkmoth along with influence of temperature and relative humidity prevalent during the adult emergence.

MATERIALS AND METHODS

Study was carried out at Pilot Project Centre, Dept. of Sericulture, Govindpur, Dhanbad, Jharkhand in the month of July and September 2019, covering two grainage periods. Generally in bivoltine tasar silkworm, first grainage (diapause brood) will be performed in June/July months and second grainage (Non diapause brood) will be performed in Aug/ Sept months. During the study, adult emergence was monitored regularly during both grainage periods and when the emergence was started, randomly 15 moths were selected and allowed them for mating, out of them 10 females were used for the study. After the mating period selected moths were decoupled and kept for oviposition for 3 days and it has been continued till the emergence period over. In the course of the experiment various reproductive parameters *viz.,* Fecundity, Hatching percentage, Egg retention and hatching percentage in retained eggs were recorded daily for two grainage periods.

Fecundity: After the oviposition period of 3 days, fecundity was recorded from individual 10 mother moths (Pebrine free) following the method of Sinha (1998).

Hatching percentage: Hatching percentage was calculated by using the formula:

$$\frac{\text{No. of larvae hatched}}{\text{Fecundity}} \times 100$$

Only larvae hatched during first 3 days were considered to calculate hatching %. Similarly hatching % was also calculated for the retained eggs.

Egg retention in moths: To analyse the extent of egg retention after the egg laying period, same 10 coupled mother moths (Pebrine free) were dissected individually and number of eggs retained in ovary were recorded and they have been collected and kept for hatching to know their fertility status. Per cent egg retention was calculate by the following formula

$$\frac{\text{No. of retained eggs}}{\text{Fecundity (No of eggs laid)}} \times 100$$

During the present experiment, possible influence of temperature and relative humidity on reproductive performance of *A. mylitta* was also studied. Daily temperature and relative humidity was recorded for both the grainages and impact of these weather parameters on reproductive performance of *A. mylitta* was studied by correlating fecundity, hatching % and egg retention with daily temperature and relative humidity.

Statistical analysis: Statistical analysis was done using analysis of variance and means were compared by using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Fecundity

There was a significant difference in the fecundity observed across the different days of female emergence during first grainage period. Observed fecundity was ranged from 111 to 219 eggs/moth. Highest fecundity of 219 eggs/female was recorded at 10th day of grainage and it was followed by 13th the (218), 14th day (216) 20th day (207.30) and 11th day (206.80) and fecundity of these days were on par with each other. Similarly next better fecundity was recorded between 3rd to 6th days and 18th to 21st days of emergence. Fecundity recorded during these days was also statistically on par with fecundity recorded during 10th to 15th days of emergence, However marginal difference was observed between these periods. Similarly optimum range of fecundity (152.50 - 173.60 eggs/female) was observed on remaining days except 7th and 8th days of emergence where fecundity was lowest as compared to all other emergence period (Table 1).

Similar observations were made during second grainage as well to understand whether pattern of reproductive performance follows the pattern of first grainage. Results revealed that there was a dissimilar pattern of fecundity was observed across the emergence period. Recorded fecundity among the different days of emergence was statistically significant similar to first grainage. However the pattern of fecundity across different days was differed from the first grainage. Overall fecundity among all the day ranged from 166.90 to 224.30 eggs per female. Highest fecundity was recorded on 13th day of emergence (224.30) and it was significantly differed from remaining days; 16th (221), 11th (216.40), 2nd (216), 17th (210.30), 7th (208.10), 14th (206.80) 1st (196.40) and 8th (194.60). Lowest fecundity was observed at 4th (166.90) whereas on remaining days average fecundity was observed (Table 2).

Overall data of fecundity over different days of female emergence found fluctuating in both the seasons. Fluctuation in the egg laying capacity of tasar silkmoth might be due to various factors like, lack of sufficient nutrients available during rearing period and also unseasonal emergence affects the reproductive performance (Chaudhary, 1996). Sahu (2004) reported that grainage performance during the pre-seed and seed corps suffer due to low humidity and low temperature and high temperature resulting in requirement of more number of cocoons for producing DFLs, poor moth quality and low to very low hatching (<25%) in muga silkworm. Similar results were obtained during second grainage. However these results are not in line with grainage performance of first season. Variations in the finding might be due to the difference in the seasonal difference during the rearing and adult emergence.

Hatching

Hatching varied from 70.79 to 93.31 per cent during first grainage. Highest hatching was recorded on first day (93.31%), followed by 7th (90.95%), 12th (90.18%) and 6th (90.14%) days of emergence and they were statistically on par with each other. Lowest hatching (70.79 %) was recorded on 8th and 13th days of emergence with 70.80 and 71.32 per cent respectively. These were on par with 9th (72.51%), 20th (72.15%), 11th (72.90%), 23rd (74.02%), 16th (74.06%) and 21st (74.46%) day of emergence. While, on remaining days fecundity was 78.72 to 86.68 per cent (Table 1).

During second grainage also, varied hatching was recorded across the days of emergence. Out of 17 days of emergence moths emerged on 12th day

recorded maximum hatching (95.24%) followed by the moths emerged on second day (94.00%) of hatching and were on par with each other. Lowest hatching was recorded from the moths emerged on 6th (85.02%) followed by 5th (85.51%), 16th (86.92%), 14th (87.26%) and 1st day (87.91%). On remaining days hatching ranged from 88. 84 to 91.62 per cent (Table 2).

Generally temperature and relative humidity play major role in the hatching. Usually egg desiccation will occur due to higher temperature. During the present study temperature has shown negative correlation with hatching percentage and wet temperature and relative humidity have shown positive significant relationship with hatching percentage during first grainage. These findings are in line with findings of Kovalev (1970), Ayuzawa et al. (1972), Jolly (1983), Narashimhanna (1988), Biram Saheb and Gowda (1987) and Ming (1994). However in the second grainage wet temperature and relative humidity have shown negative correlation that might be due to seasonal difference.

Egg retention (%)

Results revealed that there was no significant difference across the different emergence days. However data on the unlaid eggs revealed certain marginal difference over emergence period. Among

Table 1. Effect of seasonal adult emergence on reproductive performance of tasar silk moth during first grainage

Days of emergence	Fecundity*	Hatching**	Egg retention**	Hatching % in retained eggs**
1	173.60 (13.19)$^{a-d}$	93.32 (74.99)^{a}	13.95 (21.92) ^{ab}	4.50 (12.24) ^{ab}
2	166.10 (12.91) $^{a-d}$	86.68 (68.57)^{c}	29.25 (32.73) ^{a}	4.91 (12.80) ^{ab}
3	187.90 (13.73) $^{a-d}$	85.66 (67.72)^{cd}	6.80 (15.11) ^{b}	1.75 (7.61) ^{abc}
4	172.90 (13.17) $^{a-d}$	85.97 (67.98)^{cd}	10.55 (18.95) ^{ab}	3.52 (10.82) ^{abc}
5	187.20 (13.70) $^{a-d}$	81.91 (64.80)^{def}	13.52 (21.57) ^{ab}	0.73 (4.89) ^{cd}
6	193.30 (13.92) ^{abc}	90.14 (71.67)^{b}	16.56 (24.00)^{ab}	0.00 (0.00)^{d}
7	111.90 (10.60) ^{e}	90.96 (72.47)^{ab}	14.12 (22.06) ^{ab}	0.00 (0.00)^{d}
8	138.40 (11.79) ^{de}	71.32 (57.60)^{h}	21.53 (27.64) ^{ab}	6.00 (14.47)^{a}
9	169.00 (13.02) $^{a-d}$	72.51 (58.35)^{h}	10.52 (18.91)^{ab}	1.29 (6.52) ^{cbd}
10	219.60 (14.84) $^{a-d}$	85.49 (67.58)^{cd}	10.88 (19.25) ^{ab}	0.00 (0.00) ^{d}
11	206.80 (14.40) ^{abc}	72.90 (58.61)^{h}	6.46 (14.72) ^{b}	0.00 (0.00) ^{d}
12	195.00 (13.98) ^{abc}	90.18 (71.71)^{b}	14.87 (22.67)^{ab}	0.00 (0.0) ^{d}
13	218.70 (14.81)^{a}	70.80 (57.27)^{h}	17.75 (24.91)^{ab}	0.00 (0.00)^{d}
14	216.50 (14.73) ^{ab}	78.73 (62.51)^{fg}	13.29 (21.37) ^{ab}	0.00 (0.00) ^{d}
15	196.70(14.04) ^{abc}	81.82 (64.73)^{def}	14.00 (21.96) ^{ab}	0.00 (0.00)^{d}
16	168.50 (13.00) $^{a-d}$	74.06 (59.36)^{h}	28.35 (32.16)^{a}	0.00 (0.00) ^{d}
17	169.10 (13.02) $^{a-d}$	83.95 (66.36)^{cde}	14.21 (22.13) ^{ab}	4.50 (12.24) ^{ab}
18	185.80 (13.65) $^{a-d}$	81.18 (64.26)^{ef}	11.30 (19.64) ^{ab}	0.00 (0.00)^{d}
19	186.80 (13.69) $^{a-d}$	82.74 (65.42)$^{c-f}$	10.78 (19.16)^{ab}	0.00 (0.00) ^{d}
20	207.30 (14.42) ^{abc}	72.15 (58.13)^{h}	17.13 (24.44) ^{ab}	0.00 (0.00) ^{d}
21	180.70 (13.46) $^{a-d}$	74.46 (59.62)^{gh}	16.20 (23.72) ^{ab}	0.00 (0.00)^{d}
22	161.00 12.71) ^{bcd}	80.54 (63.80)^{ef}	16.63 (24.06) ^{ab}	0.00 (0.00) ^{d}
23	152.50 (12.37) ^{cd}	74.03 (59.34)h	27.00 (31.29)^{a}	0.00 (0.00) ^{d}

Values are means of 10 replications; Means followed by same letter in the column do not differ significantly by DMRT (P=0.01); Figures in parentheses are square root* and arcsine** transformed values

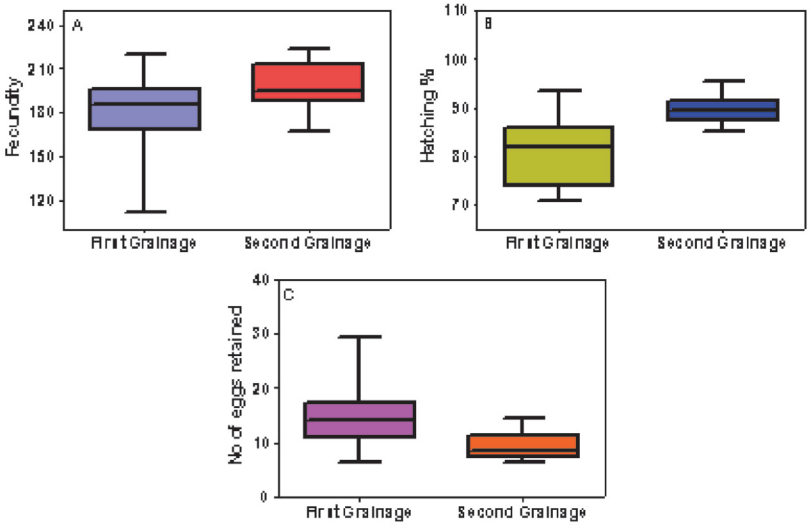

Fig. 1 Variability in the reproductive parameters of *A. mylitta* during first and second grainage periods: A) Fecundity, B) Hatching %, C) Egg retention

the different days of emergence maximum egg retention was recorded on 2nd day (29.25 %), which was statistically on par with 16th (28.35 %) and 23rd day (27.00 %). Whereas, minimum eggs retesion was recorded on 11th day (6.40 %) of emergence followed by 3rd (6.80%) and 9th day (10.52%) of emergence and these were on par with each other. On remaining days of emergence intermediate range (27.64 to 18.91) of egg retention was observed (Table 1).

With respect to number of eggs retained significant difference was observed among the different days of moth emergence during second grainage. Maximum eggs were retained in the moths which are emerged on 17th day (14.39 %) followed by 12th (12.81 %) day of emergence and it was on par with 1st, 3rd 5th 6th 8th 13th and 15th days of emergence (21.70 %). Minimum was noticed during 11th day (6.49 %) and it was on par with remaining days (Table 2).

Whole data of per cent egg retention from both the seasons ranged frm 6.46 to 29.25. Further it was observed that egg retention had a positive correlation with temperature and relative humidity during first grainage. Similar results were obtained by Mathur *et al.* (1995), where they reported that high temperature with high humidity favoured high retention of eggs in the ovary. During the second grainage results were in contrast to first grainage it might be due to seasonal difference in rearing, no diapauses period and adult emergence season.

Hatching in retained eggs

In the study whether retained eggs are fertile or unfertile, results revealed that most of the retained eggs were unfertile with less than 2 per cent of hatching across all the days of emergence. Among the different days of emergence negligible per cent of hatching was observed on 2nd (1.40%), 9th (1.18%), 8th (1.15), 4th (1.09%), 3rd (0.76), 1st (0.72%) and 17th (0.39) day emerged moths. No hatching was observed in remaining days of moth emergence. However, during second grainage hatching per cent in retained eggs was completely nil across all the days of emergence (Table 1).

Poor hatching in the retained eggs (it was almost nil except few days in first grainage) might be due to incomplete development of the ovum, insufficient semen and due to higher temperature. Since higher temperature desiccation of eggs will takes place which ultimately leads to unfertile eggs. Presently there were no studies in same line hence results

Table 2. Effect of seasonal adult emergence on reproductive performance of tasar silk moth during secondgrainage

Days of emergence	Fecundity*	Hatching**	Egg retention**	Hatching % in retained eggs**
1	196.40(14.03)^{abc}	87.91 (69.63)$^{c-f}$	8.38 (16.82)^{ab}	0.00
2	216.00 (14.71)^{ab}	94.00 (75.59)^{ab}	7.09 (15.44)^{b}	0.00
3	184.20 (13.59)^{bc}	90.03 (71.57)^{cde}	11.76 (20.04)^{ab}	0.00
4	166.90 (12.94)^{c}	91.48 (73.01)^{bc}	7.87 (16.28)^{ab}	0.00
5	192.00 13.87)^{abc}	85.50 (67.60)^{ef}	9.59 (18.03)^{ab}	0.00
6	185.40 (13.63)^{bc}	85.01 (67.20)^{f}	9.38 (17.83)^{ab}	0.00
7	208.10 (14.44)^{ab}	88.84 (70.46)^{cde}	7.58 (15.97)^{b}	0.00
8	194.60 13.97)^{abc}	89.76 (71.13)^{cde}	9.41 (17.85)^{ab}	0.00
9	186.30 (13.67)^{bc}	91.04 (72.56)^{cde}	7.02 (15.36)^{b}	0.00
10	189.6 (13.79)^{abc}	89.63 (71.19)$^{c-f}$	8.12 (16.55)^{ab}	0.00
11	216.40 14.73)^{abc}	89.55 (71.11) $^{c-f}$	6.49 (14.57)^{b}	0.00
12	189.00 (13.77)^{a}	95.24 (77.37)^{a}	12.81 (20.97)^{ab}	0.00
13	224.30 (14.99)^{a}	90.99 (72.51)^{bcd}	10.99 (19.35)^{ab}	0.00
14	206.80 (14.40)^{ab}	87.26 (69.06)$^{c-f}$	8.17 (16.06)^{b}	0.00
15	189.40(13.79)^{abc}	91.61 (73.14)^{bc}	11.53(19.84)^{ab}	0.00
16	221.90 (14.91)^{a}	86.92 (68.77)^{def}	7.03 (15.37)^{b}	0.00
17	210.30 (14.52)^{ab}	89.11 (70.71)$^{c-f}$	14.39 (22.29)^{a}	0.00

Values are means of 10 replications; Means followed by same letter in the column do not differ significantly by DMRT (P=0.01); Figures in parentheses are square root* and arcsine** transformed values

Table 3. Influence of weather parameters on reproductive parameters of tasar silkworm

Reproduction parameters	First grainage		Second grainage	
	Temperature	Relative Humidity	Temperature	Relative Humidity
Fecundity (Eggs/female)	-0.289	-0.020	-0.420	-0.174
Hatching (%)	-0.286	0.284	-0.096	-0.170
Egg retention	0.068	0.176	-0.574*	-0.242

*. Correlation is significant

cannot be discussed further. When comparison of fecundity, hatching and egg retention was made between the both grainage periods, it was found that reproductive performance of the moths emerged during second grainaige was superior over first grainage moths (Fig. 1). This variability might be due to the reason that first grainage moths are gone through pupal diapause, since diapause known to adversely affect reproductive physiology in some lepidopterans (Dillon and Hasan, 2018).

Correlation analysis between reproductive parameters and weather parameters during first grainage revealed that none of the reproductive parameter had a significant correlation with any of the three parameters considered (fecundity, hatching % and retained eggs). However there was a non-significant negative correlation was observed between temperature and fecundity (r=-0.289), similarly hatching per cent also showed non-significant negative correlation (=-0.286), whereas

egg retention showed positive and non-significant relationship (r=0.068) with temperature. While, relative humidity found to have non-significant negative correlation with fecundity (r=-0.020) and positive and non-significant relationship with hatching per cent (r=0.284) and egg retention (r=0.176) (Table 3).

Similar analysis was also carried out during second grainage between reproductive parameters and weather parameters all three parameters (Fecundity, Hatching % and Retained eggs) showed negative relationship with temperature and relative humidity. However there was a non-significant negative correlation was observed between temperature and fecundity (r=-0.289), similarly hatching per cent also showed non-significant negative correlation (=-0.286), whereas egg retention showed negative and significant relationship (r=-0.574) with temperature. Similarly relative humidity found to have non-significant negative correlation with fecundity (r=-0.174) hatching per cent (r=-0.170) and egg retention (r=-0.242) (Table 3). These results indicates that prevailing temperature and relative humidity during emergence period do don't have major influence over fecundity, hatching percentage and egg retention, rather temperature and relative humidity during the cocoon storage will impact these reproductive parameters as reported by Mathur *et al.* (1995) and Sahu (2004).

Based on the outcome of the present study it is evident that moths emerging across the different days during grainage period are poses significant difference in their reproductive potential and in reproductive biology. However we cannot consider any particular day or a period during the process of emergence for better reproductive traits, since they were scattered randomly across the seasonal emergence period. Further indicating that adult emergence has nothing to do with reproductive biology of *A. mylitta*. Experimental results of present study also signify that temperature and relative humidity during emergence period are not major influencers on reproductive biology of the tasar silkmoth. Considering these outcomes it seems that weather parameters during rearing period and cocoon storage period along with quality of foliage supplied during the larval stage are major factors influencing the reproductive performance of tasar silkmoth.

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