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IMPACT OF CLIMATIC FACTORS ON LIFE CYCLE OF TROPICAL TASAR SILK INSECT ANTHERAEA MYLITTA DRURY (LEPIDOPTERA: SATURNIIDAE)

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ABSTRACT

The paper describes the impact of climatic factors on the mortality rates, fecundity and longevity of the daba ecorace of tropical tasar silk insect *Antheraea mylitta Drury during* the outdoor and indoor rearing programmes. In the indoor rearing programme of the bivoltine daba ecorace the egg period of activated eggs last for 11-15 days, larval period 24-28 days, the pupal period 28-30 days and the adult 6-10 days. In outdoor rearing conditions bivoltine races produced two generations during the July - September and October - December and pupae undergone through a period of long hibernation till the next rainy season i.e., of 177-210 days. In the indoor rearing programme it was found that a potential female laid 150-285 eggs in rainy, autumn and winter seasons respectively with % hatchability 45-0+2.5, 50.0+13.0 and 80.0+2.0 in 2008-09 while 43.0+2.0, 55.0+3.5 and 99.0 + 4.0 in 2009-10 respectively. It was observed that the egg laying potential varied in different seasons of the year, the incubation period varied from 8-10 days depending upon prevailing climatic conditions. The pupal incubation period in rainy and autumn seasons varied from 28-30 days while the incubation period and pupal stage of commercial crop varied between 177-220 days till the onset of first monsoon rains after which emergence of adults occurred in late June and life cycle again resumed. Thus, out of different climatic regime it was rainfall who exerted a profound impact for controlling the life cycle of this wild variety of daba ecorace of tasar silk insect, *Antheraea mylitta* Drury.

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INTRODUCTION

Climate has been recognized as the greatest physical factors controlling the voltinism, sustainable exploitation as well as differentiation of phenotypic and behavioural traits in tasar silkworms (Kumari and Roy, 2011a, b).Owing to the economic importance of *Antheraea mylitta* Drury in India, information on the productivity and reproductive success of the tasar silk moth are of considerable importance. It is much relevant to know such parameters of the life cycle as mortality rates, fecundity, hatchability and longevity of *Antheraea mylitta* Drury reared on primary plant arjun (*Terminalia arjuna* Bed. Fam-Combretaceae).

Considerable references exist on the characterization of voltinism in *Antheraea mylitta* Drury and to show its relationship with environmental factors (Man Singh and Smallman, 1967; Tanaka, 1950a, 1950b, 1950c; Nayak and Das, 1991). Many previous studies have been made on the occurrence of voltinism and the effect of temperature and photoperiod on different *Antheraea* species (Dawson, 1931; Tanaka, 1956 and Bahl *et al.,* 1987). Many earlier studies on the effect of environmental factors on voltinism indicate that high temperature and high humidity induce higher voltinism and low temperature and humidity induced univoltivism although temperature and relative humidity requirement varies from species to species (Morohoshi, 1957).

The present observation based on the data of life cycle collected from outdoor and indoor rearing of *Antheraea mylitta* Drury in relation to the climatic regime in order to know the most vital and crucial controlling factor for survival, propagation and success of this ecorace in outdoor as well as indoor rearing. Considering such objectives, the present study has been

MATERIALS AND METHODS

Five hundred cocoons of *Antheraea mylitta* were collected at random from host plant lot of the Tasar Basic Seed and Multiplication Centre, Bhagalpur. Each batch of 500 cocoons for observations, the attributes of life cycle such as fecundity, mortality rates, hatchability and longevity were noted. The experiment was repeated in the tasar three rearing seasons in 2008-09 and 2009-10 (i.e. rainy, autumn and winter) for each of the two host plants (Suryanarayana and Srivastava,2005).

Observations were made daily on the moulting of larvae and mortality of eggs, larvae, pupae and imago. For determining the age specific fecundity, the adult emerged on a particular day were transferred to a separate cage. The eggs laid by the female on subsequent days were noted daily till all the females died. The number of eggs laid/female was divided by two (sex ratio) to get the number of female births (m_x). Stable age distribution, percent distribution of various stages were worked out by observing the population schedule of birth rate and death rate (m_x and q_x) when reared in a limited space. The mortality rate, fecundity and longevity of this moth were calculated by the following formulae as per Smith and Smith (1998).

$$\text{Mortality rate (qx)} = \frac{dt}{Nt}$$

where dt = number of mortality during course of time;

Nt = number of survivors during course of time,

$$\text{Fecundity} = \frac{\text{Total number of eggs laid}}{\text{Number of eggs hatched and survive}}$$

Longevity (Survivability) lx = Nt – dt

where

Nt = number of survivors,

dt = number of deaths in unit time

RESULTS

The life cycle attributes of *Antheraea mylitta* Drury has been studied under the outdoor as well as indoor rearing progamme at the temperature range between 25-30°C and relative humidity 70.0-80.0% in rainy season (seed crop), autumn and winter season (commercial crop) during the period 2008-09 and 2009-10 respectively and the data has been depicted in tables– 1.0a to 1.0c in indoor and outdoor rearing programmes. The fecundity of *Antheraea mylitta* Drury on *Terminalia arjuna* in different seasons (2008-10) has been depicted in table 2.0. The life table statistics of *Antheraea mylitta* Drury on *Terminalia arjuna* in rainy season crop (2008-10) in table 3.0, in autumn season crop (2008-10) in table 4.0 and in winter season crop (2008-10) in table 5.0 respectively. The life cycle stages have been depicted in plate–1 and phenogram of daba ecorace of *Antheraea mylitta* Drury in relation to climatic factors have been shown in plate–3 respectively.

In outdoor rearing programme of the bivoltine races, the egg period of activated eggs last for 11-15 days, the larval period 24-25 days, the pupal period 28-30 days and the adult stage 6-10 days. The gross and net fecundity rate in different seasons (2008-10) revealed egg laying potential of @& moths in all seasons. However, the mortality rate (q_x) was higher in rainy crop (57.0%), followed by autumn crop (52.0%), followed by winter season crop (48.0%) indicating least mortality rates (q_x) in winter season. The comparative survivability (l_x) of this ecorace has been calculated and observed that in rainy season l_x was 43.0%, in autumn season l_x was 48.0 % and in winter

Table 1.0a: Life cycle attributes of *Antheraea mylitta* Drury during indoor rearing programme

Year	Crops	Months	Preovip-osition Period(days)	Oviposition Period (days)	Number of Eggs/moth Eggs(days)	Incubation Period of	Hatchability (%)
2008-09	Seed Crop	July -August	3.0 + 0.5	2.0 + 0.25	150.0 +10.5	8.0-10.0+1.5	2.0 + 0.25
	Autumn Crop	September-October	2.5 + 0.40	2.0 +0.30	200.0 +15.0	8.0 +1.5	45.0 +0.30
	Commercial Crop	November-December	2.0 + 0.85	3.0 + 1.4	285.0+ 20.5	8.0 + 1.6	50.0 + 3.0
2009-10	Seed Crop	July-August	3.15 + 0.6	2.50 + 0.30	180.0 +12.5	8.0-10.0+1.6	43.0 + 2.0
	Autumn Crop	September-October	3.0 + 0.50	2.6 + 0.45	255.0 +21.5	8.0 + 2.0	55.0 + 3.5
	Commercial Crop	NovemberDecember	2.5 + 0.90	2.8 + 0.38	283.0 +25.0	8.0 + 1.8	90.0 + 4.0

Table 1.0 b: Life cycle of *Antheraea mylitta* Drury on *Terminalia arjuna* in different seasons (2008-09)

Seasonal crops	Developmental Stages						
	Eggs	Larvae					Pupae
	Duration of Developmental Period (in days)						
	Incubation period	1st instar larvae	2nd instar larvae	3rd instar larvae	4th instar larvae	5thinstar larvae	Pupa
Rainy Crop June-Aug.	9.5	5	4	5	6	.3.7	25
Autumn Crop Sept.-Oct.	11	5.25	4.5	5.7	6.5	4.5	27.5
Winter Crop Nov.-Dec.	12.5	5.5	5	6	6.75	5	177-210
x	11.00	5.250	4.50	5.566	6.416	4.4	28.333
ó	1.224	0.204	0.408	0.418	0.311	0.535	2.574

Table 1.0c: Life cycle of *Antheraea mylitta* Drury on *Terminalia arjuna* in different seasons (2009-10)

Seasonal crops	Developmental Stages						
	Eggs	Larvae					Pupae
	Duration of Developmental Period (in days)						
	Incubation period	1st instar larvae	2nd instar larvae	3rd instar larvae	4th instar larvae	5thinstar larvae	Pupa
Rainy Crop June-Aug.	10	4.75	4	5	5	.4	25
Autumn Crop Sept.-Oct.	10.5	5	4.5	5.6	6	4	27.5
Winter Crop Nov.-Dec.	12	5.5	5	6	6.5	5	32.5
							177 -210
x	10.833	5.083	4.500	5.533	5.833	4.333	28.333
ó	0.849	0.537	0.707	0.711	0.622	0.470	2.574

Table 2.0: Fecundity of *Antheraea mylitta* Drury on *Terminalia arjuna* in different seasons (2008-10)

Rainy Crop Duration	GrossFecundity	NetFecundity	Autumn Crop GrossFecundity	Net Fecundity	Winter crop Gross Fecundity	Net Fecundity
2008-09	286	289	278	261	281	260
2009-10	289	287	283	259	280	254

Table 3.0: Life table statistics of *Antheraea mylitta* on *Terminalia arjuna* in rainy season (2008-10)

Stage of Insect X	Raw Data X^1	Survivorship l_x	Death d_x No. in Cohort	No. in Discrete Series	Mortality Rate q_x % in Cohort	% in Discrete Series
Eggs	286	1.000	0.06	17	0.06	5.944
Larval phase-I-II	269	0.940	0.011	13	0.011	4.832
	256	0.951	0.33	20	0.347	7.812
				Total : 50	Total :18.588	
Larval phase-III-V	236	0.921	0.036	27	0.039	11.440
	209	0.885	0.063	37	0.071	17.703
	172	0.822	0.119	10	0.144	5.813
				Total: 74	Total : 34.599	
Pupa	162	0.941	0.182	39	0.195	24.074
				Over all 163		
Adult	123	0.759	0 (beginning)	0	0	0

Entire Generation : % of Mortality : 56.993; Mortality rate : 56.993; Survivability : 43.007

Table 4.0: Life table statistics of *Antheraea mylitta* on *Terminalia arjuna* in autumn crop (2008-10)

Stages of Insect X	Raw Data X_1	Survivorship l_x	Death d_x No. of Cohort	% in cohort Series	Mortality Rate q_x No. in Discrete	% in Discrete series
Eggs	278	1.000	0.062	17	0.06	0.11
Larval phase – I-II	261	0.938	0.054	15	0.057	5.747
	246	0.884	0.032	9	0.036	3.658
				Total:41	Total : 15.515	
Larval phase – III-V	237	0.852	0.065	18	0.076	7.594
	219	0.782	0.118	33	0.149	15.068
	186	0.669	0.054	15	0.080	8.064
				Total :66	Total : 30.726	
Pupa	171	0.615	0.168	37	0.273	21.637
				Overall 144		
Adult	134	0.783	0	0	0	0

Entire Generation : % of Mortality : 51.798; Mortality rate : 51.798; Survivability: 48.202

Table 5.0: Life table statistics of *Antheraea mylitta* on *Terminalia arjuna* in winter crop (2008-10)

Sages of Insect X	Raw Data X^1	Survivorship Ix	Death d_x No. of Cohort	No. in Discrete Series	Mortality Rate q_x % in cohort	% in Discrete series
Eggs	281	1.000	0.075	21	0.075	7.473
Larval phase – I-II	260	0.925	0.04	09	0.043	3.461
	251	0.965	0.011	06	0.011	2.390
Larval phase – III-V	245	0.976	0.038	15	0.038	6.122
	230	0.938	0.047	25	0.050	10.869
	205	0.891	0.06	10	0.067	4.878
				Total :50	Total :	
Pupa	195	0.951	0.23	49	0.213	25.128
				Overall 135		
Adult	146	0.748	0(At beginning)	0	0	0

Entire Generation : % of Mortality : 48.042; Mortality rate : 48.042; Survivability : 51.958

season l_x was 52.0%. Thus, of all seasons winter season cultivation of *Antheraea mylitta* Drury was most suitable due to least mortality rates and higher survivability. In nature bivoltine races produce two generations during the September and December and pupae goes through a period of long rest or hibernation till the next rainy season i.e. between 177-210 days.

In the indoor rearing programme of *Antheraea mylitta* Drury the oviposition, hatchability, fecundity, larval and pupal performances of daba ecorace of *Antheraea mylitta* Drury was also studied. The tasar silkworms have been cultured by feeding the leaves of arjun (*Terminalia arjuna*) in the laboratory. It was estimated that a potential female of *Antheraea mylitta* Drury laid 150-283 eggs in different seasons under study which were all viable with absolute hatchability i.e. all eggs hatched into 1st instar larvae. It was observed that on hatching the neonate larvae were dull brown, yellow with black head and soon start crawling for finding suitable portion of host plants for feeding. After hatching the colour of 1st instar larvae has been changed to green with brown head. It was perhaps due to impact of environmental factors for initiation of its behavioural traits with regard to host plants. The egg laying potential of @& *Antheraea mylitta* Drury in outdoor rearing programme varied considerably during rainy, autumn and winter seasons. In winter season maximum eggs laying potential was recorded (238/ @&). The incubation period varied from 8-10 days depending upon prevailing environmental conditions. The incubation period of pupae in rainy and autumn seasons varied from 28-30 days while the incubation period of pupae of commercial crop varied between 177-210 days till the onset of first monsoon rains after which emergence of adults occurred in late June. Thus, this ecorace remained in long diapause state after the commercial crop. It was observed that the monsoon rains act as a stimulus for emergence of adults from the cocoons.

DISCUSSION

The present study relates with the attributes of the life cycle stages reared on food plants arjun and in indoor and outdoor rearing programmes to pin point the constrancies of cultures of this wild variety of tasar silkworm. In order to domesticate this commercially important species it is much relevant to know the various attributes of the life cycle of this moth (Rivero *et al.,* 2001).

Plate 1.0: Life cycle of *Antheraea mylitta* Drury

From the data it was observed that monsoon rains were not suitable for the propagation of tasar silkworm culture. A heavy rainfall dislodges the larvae from the branches of host plants causing a great reduction in their population. The mortality rates(q_x) of silkworms were recorded maximum (56%) in rainy season while in winter season the q_x = 48.0% showing least mortality rates indicating suitability for tasar silk production. The present study is in conformity with the work of Suryanarayan and Srivastava (2005) who reported on the seasons and food plants determined differences in productivity and resproductive success of the Indian tasar silkworm, *Antheraea mylitta* Drury(Saturniidae) larvae.

The tasar silkworms are cultured in wild conditions in nature. The extrinsic facors viz. temperature, light, humidity, wind and rain play an important role for their oviposition, development and growth in a particular habitat. These environmental conditions are responsible in determining the different larval activities. Some important investigation in relation to the impact of environmental conditions and their range of tolerance have been carried out by Jolly *et. al.*(1979). It is, stated that the tasar larvae in general can withstand to temperature as high as 34°C and as low as 10°C provided it does not continue for longer duration. Likewise the tasar silkworms can tolerate relative humidity as low as 30-40% and as high as 90-100%. It is further revealed that high temperature (30°-32°C) combined with high humidity (90-95% RH) enhances the rate of mortality due to inducing viral diseases and low temperature (20°-25°C) with low humidity (55-60%RH) accelerates the incidence of bacterial diseases.

As regards to photoperiodic condition, the tasar larvae in general prefer bright sunlight. However, the larvae becomes restless in very strong sunlight and take their shelter in shady places. The newly hatched larvae have been found to be more sensitive to photoperiodic conditions. Apart from this the wind, rain and hailstorm are also the major disturbing factors during the course of tasar culture. It is very interesting to mention that the environmental factors exert profound effect on the physiological activities of tasar silkworms in relation to their various metabolic manifestations. Under the adverse environmental conditions the tasar silkworms follow long pupal diapauses for their survival and existence. Under such unfavourable conditions the tasar silkworms undergo long pupal diapauses for 7-8 months, as such only two crops namely seed crop (July-August) and commercial crop (November-December) are propagated, causing a great loss to the productivity of tasar cocoons.

The excessive heat and cold becomes the vital factors for the long pupal diapauses among tasar producing insects. In order to overcome this problem the regulation of environmental factors appears to be essential factors. Some useful investigations in order to terminate long pupal diapauses among tasar silkworm by regulating the environmental conditions and also under the treatment of phytohormones

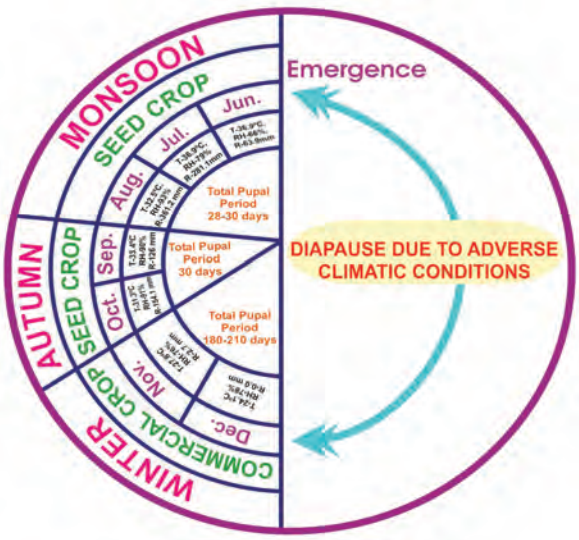

Plate 2.0 : Phenogram of daba ecorace of *Antheraea mylitta* Drury in relation to climatic

have been carried out (Jolly, 1970 and Jolly *et. al.*1979).

The life table statistics such as gross and net fecundity rates (Ro), hatchability, longevity (survivability)(Ix) and mortality rates (q_x) indicate that winter crop (November – December) of tasar culture has least mortality rates, high survivability and has a long pupal period to avoid unfavourable environmental conditions. The long diapauses period of pupae is a device to overcome adverse climatic factors for the survival of this ecorace in this tropical ecozone. The study on the life table statistics provides us correct information on the causes of mortality and chances of survival of this ecorace in indoor rearing programme.

Thus, the life cycle of this tropical tasar silk moth serves as an index of climate change. The delayed arrival of monsoon rains also delayed the emergence of adult mouths from the cocoon and altered the life cycle duration of this moth significantly.

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