EXCELLENT PUBLISHERS

Original Research Article

The Life History and Population Growth Parameters of Leaf Eating Caterpillar *Cricula trifenestrata* Helfer (Lepidoptera: Saturniidae) Infesting *Manochilus bombycina* King

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A B S T R A C T

The goal of this experiment was to study the life history and population growth parameters of *Cricula trifenestrata* Helfer (Lepidoptera: Saturniidae) reared on *Machilus bombycina* King, the food plant of muga silkworm (*Antheraea assama* Westwood). Biological and life table parameters differed significantly in different generations. The longest and shortest larval period of 43.68±1.34 and 38.67±1.13 days were recorded in January-March and May-October generations respectively. The development time of total pre adult was shortest in March-May (77.12±1.73 and 78.42±1.60 days for male and female) generation. The egg to adult survivorship and fecundity were highest in October-January generation (49.00±1.45% and 122.35±3.02). The sex ratio was male-biased. The highest intrinsic rate of increase (rm), finite rate of increase (λ) and the shortest mean generation (GT) and doubling time (Td) were recorded during January-March. The lowest intrinsic rate of increase (rm), finite rate of increase (λ) and the longest mean generation time (GT) and doubling time (Td) were recorded during May-October. The highest and lowest net reproductive rate (Ro) and potential fecundity occurred in female of October-January and March-May generation respectively. The results revealed that May-October was the most unsuitable month for population growth of *C. trifenestrata*. So, control measure if be taken for the pest during May to October, then the percent of damage caused by the caterpillar can be minimized, that might improve the performance of *Antheraea assama* during commercial rearing seasons in terai region of West Bengal.

Introduction

Machilus bombycina King (Lauraceae: Laurales) is one of the primary host plants of

the muga silkworm *Antheraea assama* Ww. (Saturniidae: Lepidoptera). The plant is evergreen with spreading branches and is very common to Assam, Meghalaya and northern

tract of West Bengal in India (Singh *et al.,* 2000). The northern tract of West Bengal, particularly Cooch Behar, Alipurduar and Jalpaiguri districts, has been explored as new area of muga culture since being contiguous to lower Assam, agro-ecologically, socio-ethno-economically. The successful rearing of this world famous silkworm depends on availability of quality leaves of its food plants apart from other management and climatic factors. The leaf eating caterpillar, *Cricula trifenestrata* Helfer, a saturniid wild silkmoth is the most serious insect-pest of *Machilus bombycina* King. The caterpillar in its last stage eats 69-72% of the total intake and the last three stages are capable of eating more than 95-97% of the total intake (Gharde, 2016). In a severe case, the caterpillars devour the entire leaf blade except the midrib giving a broom like appearance in *Machilus bombycina* King plant and thus hinder successful rearing of muga silkworm during commercial seasons (Ahmed *et al.,* 2012).

As muga silkworm is also a Saturniid insect, so care should be taken in regards to safety of the silkworm while adopting the control measures against *C. trifenestrata*. It is widely distributed in the Indian Sub-continent, thriving on different host plants of economic importance like cashew *Anacardium occidentale* (Mandal, 2000; Rajesh and Zachariah, 2011 and Pal and Medda, 2006), *Cinnamomum zeylanicum* (Ahmad and Ahmad, 1991), Cardamom (Yadav and Kumar, 2003), Som (*Machilus bombycina*) (Tikader, 2011; Ahmed *et al.,* 2012), litchi (*Litchi chinensis* Sonn.), and tea plantations (Arora and Gupta, 1979; Das *et al.,* 1999). The in depth study of the population growth pattern is essential to develop management strategies against polyphagous pest. Since there is no information on life history and the age-stage life table parameters of this pest, the present study was conducted to study the potential of population growth of *C. trifenestra* in terai region of West Bengal,

India. The information provided in this investigation should be essential in understanding the dynamics of *C. trifenestrata* and should contribute to an integrated management action plan that allows for targeted suppression of the pest.

Materials and Methods

The experiment was conducted at the laboratory of the department of Agricultural Entomology and Instructional Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar during 2013 to 2015.

Specimen collection and rearing of insects

Pupae of *Cricula trifenestrata* were collected in nature and brought to the laboratory, Department of Agricultural Entomology. They were kept in rearing cages 2ft (height) x 1.5ft (width) x 2ft (depth) for adult emergence. Upon emergence of the adults, the male and female moths were identified using spots on wings and size, and finally they were placed couple wise in the separate cages containing twigs of *Machilus bombycina* to carry out their normal life. Once laid, batches of eggs were transferred to petridish carefully for hatching. Twigs of *M. bombycina* were provided as food, with their cut ends immersed in water-filled small plastic tubes so that neonates could obtain ready food immediately after hatching. Twigs of leaves were arranged in such a way that enough space in between leaves was present for free movement of the tiny caterpillars. Mass cultures on different hosts were maintained under the laboratory conditions.

Host plant materials

For the experiment, the food plant *Machilus bombycina* King of the family Lauraceae were collected from the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, located under

Terai region of West Bengal, India. The plants selected for the study were of fifteen (15) years old. The experimental domain is situated between $26^0 19' 86''$N latitude and $89^0 23' 53''$E longitude at an elevation of 43.0 m above mean sea level.

Assessment of *C. trifenestrata* development, survivorship and sex ratio on the different host plants

Hundred eggs (collected within 12 h) were collected and the twig with egg was placed in a water filled conical flask lined with wet cotton to prevent desiccation. This was checked twice daily for egg hatch. The development of the insect from egg stage to adult emergence was observed. The sex of the adults was identified after emergence based on the spots present on the fore wings. The following data were collected for each host plant: (1) developmental duration from egg to adult, (2) percentage of insects reaching adult stage, and (3) sex ratio, measured as proportion of females out of the total number of *C. trifenestrata* [♀/ (♀ + ♂)]. The experiment was replicated 5 times.

Reproduction and assessment of demographic parameters

Thirty randomly selected newly emerged adults @ 2:1 (male: female) were used to determine the reproduction and longevity of *C. trifenestrata*. The adults were kept in the cages for mating and after mating the females were transferred individually to cages with twig of host plant species in water filled conical flask (150 ml) and observed daily until they died. The total number of eggs produced by each female was recorded daily. Standard life table parameters including female survivorship (lx; the fraction of females surviving to age x) and age-specific fecundity (mx; mean number of female progeny per female per day) were calculated from daily

records of mortality and fecundity of cohorts on each host plant. Each female was considered a replicate.

Statistical analysis

Adult survivor percentage and sex ratio of *C. trifenestrata* was transformed (angular) before analysis. Data on the developmental time for egg, larva, pupa, total pre-adult, adult longevity, total lifespan, survivorship and sex ratio of *C. trifenestrata* were subjected to one-way analysis of variance (ANOVA) using the PROC GLM in SAS (Ver. 9.2).

Life table for each host plant species was constructed following the method described by Carey (1993) and the intrinsic rate of increase (rm), net reproductive rate (Ro), mean generation time (GT), doubling time (Td) and finite rate of increase (λ)) were estimated using the Jackknife program (Maia *et al.,* 2000). Differences between life table parameters across the different generations completed in a year was estimated by one-way analysis of variance (ANOVA) using GLM procedure (SAS, Ver. 9.2).

Results and Discussion

Development time

The results of the development of immature stages are given in Table 1. Regarding the results, significant difference was observed for egg incubation, larval and pupal period of *C. trifenestrata* in different generations (P<0.05). The longest and shortest values of larval period were 43.68±1.34 and 38.67±1.13 days in May-October and January-March generation. The longest pupal (89.10±3.00 and 92.78±3.41 days for male and female) and development time of total pre-adult (138.26±3.25 and 142.52±3.06 days for male and female) were recorded during May-October. The pupal period was shortest during

January-March (22.40±1.05 and 23.50±1.22 days for male and female) and the total pre-adult days were shortest during March-May (77.12±1.73 and 78.42±1.60 days for male and female).

Longevity, fecundity, life span, survivorship and sex ratio

Adult longevity, fecundity, adult survivor and sex ratio of *C. trifenestrata* adults are given in Table 2. Different rearing months had no significant effect on longevity of adult male. The female longevity and adult survivorship of *C. trifenestrata* was significantly highest in October-January generation (4.13±0.19 days and 49.00±1.45% respectively). The lifespan of *C. trifenestrata* was also varied significantly among different generations and it was longest in May-October (140.95±3.11 and 145.25±3.11 days for male and female) and shortest in March-May (79.85±2.17 and 82.00±1.58 days for male and female). There was a significant difference in the total number of eggs per individual female in different generations (P< 0.05), which was highest in October-January (122.35±3.02/female) and lowest in March-May (72.00±2.08/female). Sex ratio was male biased. It ranged from 0.32±0.02 to 0.34±0.01 in three generations extended from January to October. In October-January generation the female sex ratio was lowest (0.29±0.01) (Table. 2).

Age-specific fecundity and survivorship

The *lx* is the probability that an egg will survive to age *x*. The age-specific survivorship (*l*x) of female curves decreased gradually and asymptotically as *C. trifenestrata* aged (Fig. 1). The female survivor was highest in October-January generation (14%). The entire *Cricula* cohort died on 86 days during March-May and 150 days during May-October generations.

The age-specific fecundity (*mx*) gives the number of offspring produced per day by an individual at age *x*. The curves of age-specific fecundity (*m*x) for *C. trifenestrata* in different generations peaked soon after the onset of reproduction and varied considerably among the different generations (Fig. 1). The insect laid eggs for three days.

More than 60% of eggs were laid on 1st day of oviposition. It was on 70-82 day in March-May generation, 82-84 day in January-March generation, 144-146 day in May-October generation and 109-111 day in October-January generation. The mean number of female progeny (mx) produced in 1st day of oviposition was highest in October-January (21.60♀/♀/day) and lowest in March-May (15.14♀/♀/day). Age-specific maternity (*lxmx*) of *C. trifenestrata* was also highest in October-January and lowest in March-May.

Population growth statistics

There present a profound effect of different generations on all growth parameters [net reproductive rate (*R*o), intrinsic rate of increase (*r*m), population doubling time (*T*d), generation time (*GT*) and infinite rate of increase (λ)] evaluated (Table 3).

The potential fecundity of female was highest in October-January (34.10±1.40/female). It was followed by May-October (27.22±1.59/female) and January-March (26.63±0.96/female) generations. In March-May it was the minimum (24.24±0.77/female). This suggests higher level of population in the field from October to May. The net reproductive rate (*R*o) was found to be significantly different in different generations. The rate was highest (4.79±0.61 ♀/♀/generation) in October-January followed by 3.59±0.35 ♀/♀/generation in May-October and lowest in March-May generation (3.07±0.58 ♀/♀/generation).

Table.1 The mean (±SD) duration of immature stages (days) of *C. trifenestrata* reared on *Machilus bombycina* King

Generations	Incubation (days)	Larval (days)	Pupal (days)		Total pre-adult (days)	
			Male	*Female*	*Male*	*Female*
January-March	14.46±1.02a	43.68±1.34a	22.40±1.05d	23.50±1.22c	80.14±1.99c	81.26±1.26c
March-May	10.12±0.68b	41.85±1.55b	25.30±1.14c	26.75±1.06c	77.12±1.73c	78.42±1.60d
May-October	10.07±0.76b	39.67±1.13c	89.10±3.00a	92.78±3.41a	138.26±3.25a	142.52±3.06a
October-January	10.06±0.80b	40.00±1.00c	55.10±1.89b	59.42±1.46b	104.85±2.40b	109.48±1.50b
F	*33.46*	*11.36*	*1601.15*	*1368.33*	*1229.11*	*1126.43*
P	*<0.0001*	*0.0004*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
LSD	*1.17*	*1.70*	*2.40*	*2.70*	*2.49*	*2.74*

Means with the different letters in the same column are significantly different (P= 0.05, LSD)

Table.2 The mean (±SD) duration of adult life (days), fecundity, total life span (days), adult emergence % and sex ratio of *C. trifenestrata* reared on *Machilus bombycina* King

Generations	Adult (days)		Total Fecundity/♀	Total life span (days)		Adult survivor %	Sex ratio (♀/♂)
	Male	*Female*		*Male*	*Female*		
January-March	3.37±0.37a	3.65±0.30bc	79.02±2.12b	83.46±2.20d	84.68±1.51c	41.26±1.13b	0.32±0.02a
March-May	3.18±0.39a	3.85±0.31b	72.00±2.08c	79.85±2.17c	82.00±1.58c	38.49±1.62c	0.34±0.01a
May-October	3.01±0.23a	3.38±0.22c	80.12±1.60b	140.95±3.11a	145.25±3.11a	38.00±1.66c	0.34±0.02a
October-January	3.45±0.30a	4.13±0.19a	122.35±3.02a	108.00±2.55b	113.02±2.00b	49.00±1.45a	0.29±0.01b
F	*1.66*	*12.74*	*564.52*	*738.40*	*844.69*	*59.54*	*11.36*
P	*0.23*	*0.0005*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*0.0008*
LSD	*0.47*	*0.27*	*2.97*	*3.20*	*3.13*	*2.03*	*0.02*

*Means with the different letters in the same column are significantly different (P= 0.05, LSD)*

Table.3 Life table parameters of *Cricula trifenestrata* reared on *Machilus bombycina* King

Generations	Parameter (Mean±SD)					
	Σmx	*Ro* (Σlxmx)	*rm*	*Td*	λ	*GT*
January-March	26.63±0.96b	3.48±0.51bc	0.015±0.0003a	45.93±1.38c	1.015±0.0003a	82.56±2.12c
March-May	24.24±0.77c	3.07±0.58c	0.014±0.0003b	49.44±1.65b	1.014±0.0004b	79.97±2.54c
May-October	27.22±1.59b	3.59±0.35b	0.009±0.0004b	78.06±2.14a	1.009±0.0004c	144.08±2.20a
October-January	34.10±1.40a	4.79±0.61a	0.014±0.0004c	48.47±1.14b	1.014±0.0004b	109.47±1.88b
F	*269.73*	*29.88*	*268.20*	*386.21*	*76.99*	*1198.46*
P	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
LSD	*0.80*	*0.42*	*0.0004*	*2.37*	*0.001*	*2.66*

Means with the different letters in the same column are significantly different (P= 0.05, LSD)
∑*mx*= potential fecundity (female progeny /female /day),
*R*o = net reproductive rate (female offspring/female/generation),
*r*m = intrinsic rate of increase (female eggs/female/day),
*T*d = doubling time (days) and
λ = finite rate of increase for population (female offspring/female/day),
GT = mean generation time (days).

Fig.1 Age-specific fecundity (*m*x), age-stage specific maternity (*lxm*x), and age-specific survivorship (*l*x) of *Cricula trifenestrata* reared on *Machilus bombycina* King
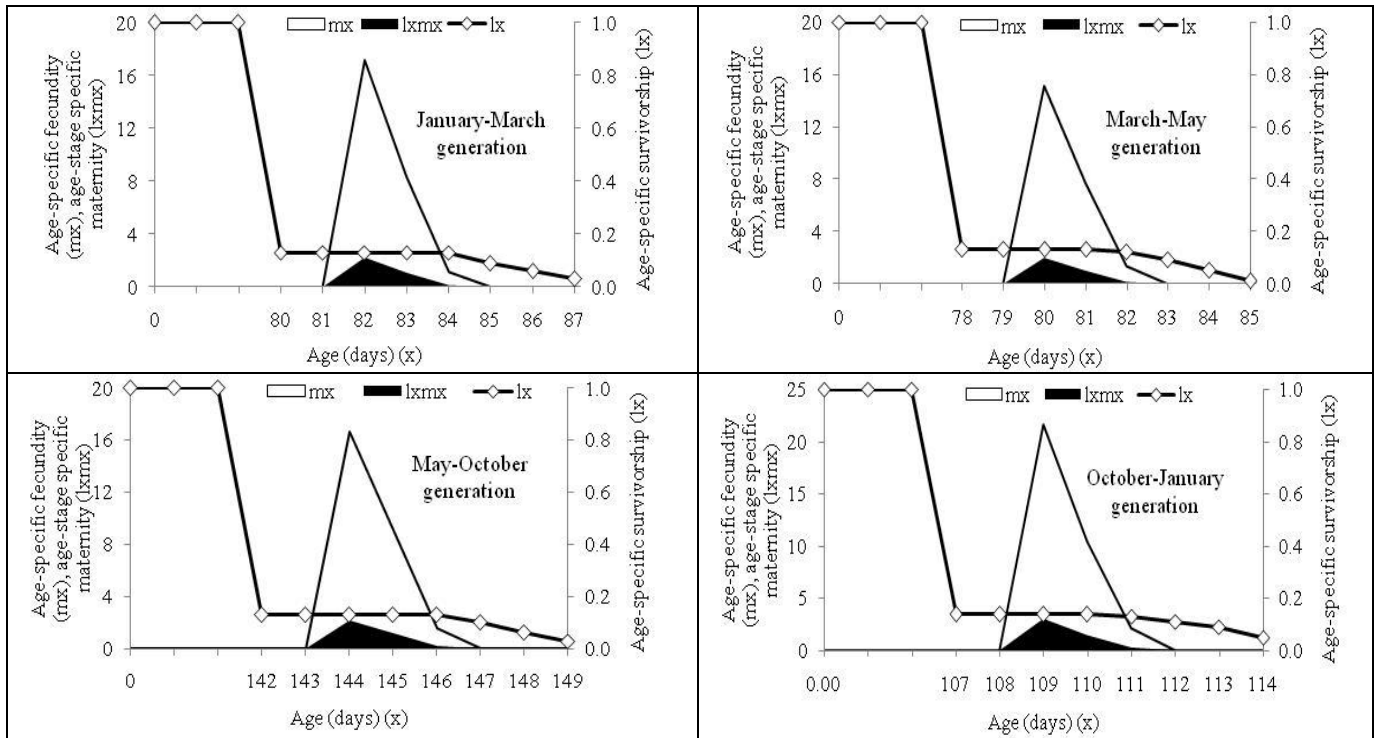
The intrinsic rate of increase (*rm*) was higher (0.015±0.0003 female eggs/female/day) in January-March generation and the population was expected to double in only 45.93 days. The lowest *r*m was recorded in May-October (0.009±0.0004 female eggs/female/day) with a doubling time of 78.06±2.14 days. The finite rate of increase (λ) also showed significant differences and was higher (1.015±0.0003 female offspring/female/day) in January-March generation. It was lowest in May-October generation (Table 2). The lowest generation time of 79.97±2.54 days was recorded in March-May generation and the highest duration (144.08±2.20 days) occurred in May-October generation.

Results of this study showed that the biological and life table parameters of *C. trifenestrata* measured varied significantly across the generations. Previous studies have suggested that *C. trifenestrata* completed four generations in a year (Biswas *et al.,* 2013 and Ghosh *et al.,* 2015). Our results concur with this finding. The duration of development is potentially an important component of fitness, as it will determine how long different developmental stages of the insect will be exposed to predators and parasites. For example, the effectiveness of several natural enemies depends on host growth rates: parasitism increases when host growth is slowed (Benrey and Denno, 1997; Devine *et al.,* 2000). On the other hand, a reduction in developmental duration on an optimal host could represent an advantage to the insect by reducing its vulnerability to parasitism and predation. The development and survival were high in generation completed during October-January. It is probable that some constituent compounds or physiological barriers inherent in this host plant species significantly increases feeding and consequently led to an increment in

development and survival of *C. trifenestrata*. The May-October generation especially warrants careful monitoring for population buildup of this polyphagous insect. The developmental time and survival of cohorts of *C. trifenestrata* was lower in March-May generation. *C. trifenestrata* progeny were male biased. Ghorai and Chaudhuri (2012) also reported male biased progeny of another saturniid *Antheraea assama* Ww.

The life table parameters provide, for the first time, the comprehensive information on the survival, development and reproductive capacity of *C. trifenestrata* infesting *Machilus bombycina*.

The intrinsic rate of natural increase (*r*m) is the most important parameter for describing the growth potential of a population under given climatic and food conditions, as it reflects the overall effect of development, reproduction and survival (Southwood and Handerson 2000). The intrinsic rate of natural increase (*r*m) was higher in January-March and October-January generations, suggest higher damage potential of the pest in these months. So the pest could have a higher potential of threatening to *M. bombycina* during commercial rearing season of *Antheraea assama*.

Overall, the results of this investigation provide strong indication that the population growth parameters, and the timing and extent of damage of *C. trifenestrata* on *M. bombycina* may result in rapid development and greater numbers of the insect surviving to adulthood, and hence more damage on these host plants during October to March; and this observation has significant implications for management of the pest during that period. The lower rate of R_0 in March-May generation suggests declined rate of population build-up after May. The higher rate of R_0 in both the generations extends

from May to January indicates higher level of population build-up from October, the commercial season for *Antheraea assama* rearing (Ghosal *et al.,* 2007).

The longer doubling time and lower R0 suggested decline in population after June. So, control measure if be taken for the pest during May to October, then the percent of damage caused by the caterpillar can be minimized, that might improve the performance of *Antheraea assama* during commercial rearing seasons in terai region of West Bengal.

The life table parameters also provide important new information on the biotic potential of the pest on its host plants that should be useful in developing simulation models that include other factors for field use and management of *C. trifenestrata*. The information provided in this investigation should be essential in understanding the dynamics of *C. trifenestrata* and should contribute to an integrated management action plan that allows for targeted suppression of the pest.

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