STUDY OF LIFE TABLE OF *CERACRIS NIGRICORNIS LAETA* (ORTHOPTERA: ACRIDIDAE) IN LABORATORY CONDITIONS

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Life table of *Ceracris nigricornis laeta* (Bolivar), a pest grasshopper, was constructed and analyzed in laboratory condition. The study indicated the impact of nymph mortality and adult mortality was different on the population. It was also revealed that pre-reproductive mortality in the insect was 46 per cent, while 54 per cent of the individuals survived until the attainment of sexual maturity and took part in reproduction. The data also revealed that adult male metamorphosed from the fifth instars, while the adult females from the sixth instars. Total nymphal mortality was greater than in the eggs and adults. A high mortality rate during the first (14.6 per cent) and fourth (12.9 per cent) instars provide a drastic check on the increase in *C. nigricornis laeta* population and, therefore, may be the best target for the application of control measure.

Key words: *Ceracris nigricornis laeta*, cohort, expectation, grasshopper, life table, mortality, survival rate.

INTRODUCTION

A complete picture of mortality in a population is illustrated systematically by the life table, a statistical device developed by students of human population (Odum & Barret, 2005). Pearl & Parker (1921) first introduced the life table into general biology by applying it to data obtained from laboratory studies of the fruit fly *Drosophila melanogaster*. Deevey (1947) has studied the life table for an Alaskan population of Dall mountain sheep. Work on biology and habits of *Ceracris nigricornis laeta* (Bolivar) still remained unexplored (Bhowmik, 1986). Haojie *et al*. (1998) reported *C. nigricornis laeta* as one of the most important pest of bamboo in Central and Southern China. Both the adults and nymphs feed on bamboo leaves and outbreaks usually causes complete defoliation of bamboo stands. A taxonomic study of Korean Acridinae provided a key, figures of male genitalia and description of little known species *C. nigricornis laeta* (Kim & Kim, 2005). In the present paper life table of pest grasshopper *Ceracris nigricornis laeta* is studied.

MATERIAL AND METHODS

To study the life table and mortality rate in laboratory conditions, adults of *Ceracris nigricornis laeta* were collected from Happy Valley Tea Garden of Darjeeling and were kept in bisexual pairs.

Plastic jars of 5 liter capacity containing 3.0 cm thick sand at the bottom were taken as the rearing cage. The open portion of the cages was covered with nylon net in order to maintain the air supply properly. Conical flask of 50 ml capacity containing food plant was placed in the jar for providing food to the insects. *Hemarthria compressa* (Linnaeus) was considered as food plant due to the preference of this grass by this grasshopper. Rearing was carried out in laboratory conditions, the temperature ranging between 19°C and 34°C and relative humidity ranging between 59% and 75%. After copulation, the female laid eggs in the sand. After approximately 30 days of oviposition the first instars hatched out from the eggs. From a number of selected egg pods which were laid in the sand, some eggs were hatched and some remained un-hatched in the pod. On the basis of the number of hatched first instar nymph on the same day and the number of un-hatched eggs, we got an absolute number of eggs remained within the pod. In such a way 20 pods were studied and a total number of 1000 eggs were taken into account for sample survey.

The first instars and their successive stages including the adult insects were also reared following the same procedure. The laboratory mortality data of *Ceracris nigricornis laeta* were used to construct survivorship curves and life tables.

Explanation of symbols used in the life table (Ricklefs & Miller, 1999; Dash, 2005):

X = age in days;

l_x = Number of individuals out of the cohort, who are expected to complete exactly x days of life;

d_x = Number of individuals out of l_x who die before completing age x+1;

s_x = Survival rate (proportion of individuals of age x surviving to age x+1);

m_x = Mortality rate (proportion of individuals of age x surviving to age x+1);

L_x = Number of individuals alive between ages x and x+1;

T_x = Total number of days lived by the cohort after age x days. In fact, this is the total future life time of the l_x individual (until all of them die off);

q_x = Mortality rate for an age interval;

e_x = Expectation of further life of individuals of age x;

$k_x = -\log_e s_x$, the exponential mortality rate between age x and x+1.

RESULTS

The study was conducted with 1,000 eggs of *Ceracris nigricornis laeta* out of which 890 eggs hatched into first instars nymph, while 110 eggs did not hatched out. So the mortality percentage of eggs was 11 per cent. Out of 890 first instars, 760 were metamorphosed into second instars and the mortality rate was 14.6 per

cent (Table 1). Out of 760 second instars 690 were metamorphosed to third instars and the mortality rate of second instars was 9.2 per cent. Again 620 fourth instar nymph were appeared from third instars and the mortality rate of third instars was 10.1 per cent. Out of 620 fourth instars 540 were metamorphosed into fifth instars and the mortality rate of fourth instar nymph was 12.9 per cent. Out of 540 fifth instars nymph 275 were metamorphosed to adult male insects and rest 265 fifth instars were metamorphosed to sixth instars. Then all 265 sixth instar nymph were metamorphosed into adult female. The mortality rate of fifth and sixth instar nymph were zero.

Table 1

Representation of mortality rate in different instars of *Ceracris nigricornis laeta*

Stage	**l_x**	**d_x**	**d_x as % of lx**
Egg	1000	110	11
I Instar	890	130	14.6
II instar	760	70	9.2
III instar	690	70	10.1
IV intsar	620	80	12.9
V instar	540	0	0
VI instar	265	0	0

Adult Male* 275 (275 male from V instar)
Adult Female* (265 male from VI instar)
* 0 day old

Based on the mortality of 275 male and 265 female, an attempt was made to estimate the number of winged *Ceracris nigricornis laeta* that were capable of reaching the 10, 20, 30, etc. days. The life expectation of the male and the female winged *Ceracris nigricornis laeta* of different ages was calculated. It was evident that the freshly emerged males could be expected to survive up to 11.75 days, while those that attained the age of 10 days were expected to survive for 10.75 days, and in the same way adult males of 150 days old were expected to survive for another 0.75 days. Similarly the expectations for other age groups of adult male were calculated and the results are given in Table 2.

The freshly emerged females of this grasshopper could be expected to survive up to 14.97 days, while those attaining the age of 10 days were expected to survive for 13.97 days, and in the same way females of 150 days old were expected to survive for another 1.61 day. The expectation of other age groups of female adults was calculated and the results are given in Table 3.

Of the 265 adult females emerged at time 0, all of them survived their 10 days. Hence $s_0 = 1.0$, $m_0 = 1–1 = 0$ and $k_0 = 0$. The life table shows a low rate of mortality early days followed by a generally increasing rate of mortality. Less

mortality of early days grasshoppers was reflected in the high expectation for further life of individuals in that age class.

Table 2

Life table of male adult *Ceracris nigricornis laeta*

x (days)	l_x	d_x	s_x	m_x	L_x	T_x	$275q_x$	e_x	k_x
0	275	0	1.0	0	275	3232.5	0	11.75	0
10	275	0	1.0	0	275	2957.5	0	10.75	0
20	275	0	1.0	0	275	2682.5	0	9.75	0
30	275	0	1.0	0	275	2407.5	0	8.75	0
40	275	10	0.96	0.04	270	2132.5	10	7.75	0.040
50	265	10	0.96	0.04	260	1862.5	10.37	7.03	0.040
60	255	14	0.94	0.06	248	1602.5	15.09	6.28	0.061
70	241	13	0.95	0.05	234.5	1354.5	14.83	5.62	0.051
80	228	20	0.91	0.09	218	1120	24.12	4.91	0.094
90	208	15	0.93	0.07	200.5	901.5	19.83	4.33	0.072
100	193	15	0.92	0.08	185.5	701`.5	21.37	3.63	0.083
110	178	15	0.91	0.09	170.5	516	23.17	2.89	0.094
120	163	36	0.78	0.22	145	345.5	60.73	2.12	0.248
130	127	40	0.68	0.32	107	200.5	86.61	1.57	0.385
140	87	47	0.46	0.54	63.5	93.5	148.56	1.07	0.776
150	40	30	0.25	0.75	25	30	206.25	0.75	1.386
160	10	10	0	1.0	5	5	275	0.5	–

Table 3

Life table of female adult *Ceracris nigricornis laeta*

x (days)	l_x	d_x	s_x	m_x	L_x	T_x	$265q_x$	e_x	k_x
0	265	0	1	0	265	3963.5	0	14.95	0
10	265	0	1	0	265	3698.5	0	13.95	0
20	265	0	1	0	265	3433.5	0	12.95	0
30	265	0	1	0	265	3168.5	0	11.95	0
40	265	0	1	0	265	2903.5	0	10.96	0
50	265	0	1	0	265	2638.5	0	9.95	0
60	265	0	1	0	265	2373.5	0	8.95	0
70	265	0	1	0	265	2108.5	0	7.95	0
80	265	0	1	0	265	1843.5	0	6.96	0
90	265	10	0.96	0.04	260	1578.5	10	5.95	0.04
100	255	12	0.95	0.05	249	1318.5	12.47	5.17	0.051
110	243	10	0.95	0.05	238	1069.5	10.90	4.40	0.051
120	233	20	0.91	0.09	223	831.5	22.74	3.57	0.094
130	213	23	0.89	0.11	201.5	608.5	28.61	2.85	0.116
140	190	40	0.79	0.21	170	407	55.78	2.14	0.235
150	150	40	0.73	0.27	130	237	70.66	1.58	0.314
160	110	75	0.36	0.64	75	107	180.68	0.97	1.02
170	40	28	0.3	0.7	26	32	185.5	0.8	0.867
180	12	12	0	1	6.0	6.0	265	0.5	–

Similar observation was reflected in case of male grasshopper. In general, the expectation of life declines with age.

The survivorship curve revealed that survival rate of 100 per cent *i.e.* 275 freshly emerged male might be 1, 265 individuals have survival rate 0.96, in that way survival rate of last 10 individuals was 0. The shape of the survivorship curve was almost convex type as is shown in Fig. 1.

The survivorship curve revealed that with a survival rate of 100 per cent freshly hatched female might survive for 90 days and the survival rate was 1, the survival rate of 255 individuals was 0.95, similarly, the last 12 individuals have 0 survival rate. The shape of the survivorship curve was almost convex type as is shown in Fig. 2.

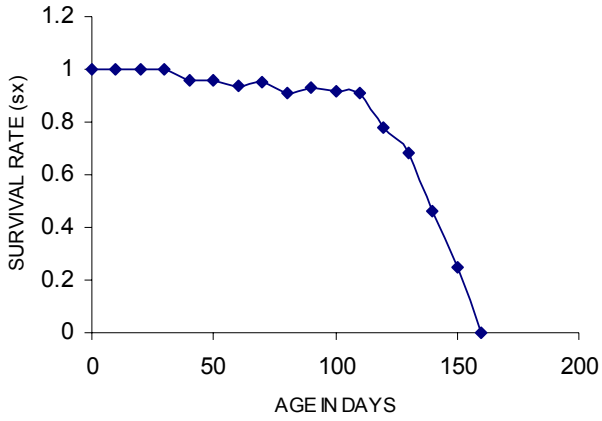

Fig. 1. Survivorship curve of adult male of *Ceracris nigricornis laeta.*

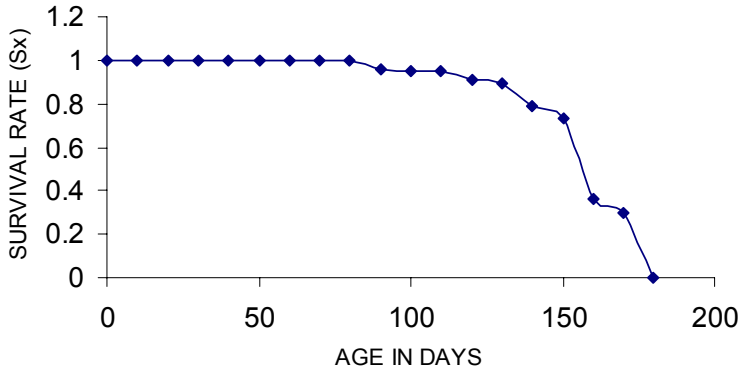

Fig. 2. Survivorship curve of adult female of *Ceracris nigricornis laeta.*

DISCUSSION

The study of the life table in *Ceracris nigricornis laeta* indicated that the impact of nymphal mortality and adult mortality was different on the population. This observation conforms to those recorded in other groups of insects by Togashi (1990). The nymphal mortality is not just a death, but early death, which more or less counterbalances the effect of reproduction in most animal populations. The pre-reproductive or nymphal death rate required to hold a population in check depends, of course, on the reproductive capacity of the species. The present study reveals that pre-reproductive mortality *i.e.* death prior to attainment of sexual maturity (adult), in *Ceracris nigricornis laeta* was 46 per cent, while 54 per cent of the individuals survived until the attainment of sexual maturity and took part in reproduction. The data also revealed that adult male metamorphosed from the fifth instars, where as the adult females from the sixth instars. In many species of grasshopper with notable sexual size dimorphism, the larger females normally have one instar more than male.

The study of survivorship revealed almost a convex curve in which the mortality rate of population is low until near the end of the life span. This result conforms to the observation of Pearl & Parker (1921) in *Drosophila melanogaster i.e.* a higher mortality in old adult than the younger one in both the sexes. It is evident from the above study that a high mortality rate during first and fourth instars provide a drastic check on the increase in *Ceracris nigricornis laeta* population.

The study revealed that so far as the mortality rate is concerned, it was the highest in the first instars (14.6 per cent) followed by fourth instars (12.9 per cent). One of the important observations of the present study was that there was zero per cent mortality rate in fifth and sixth instars. From the present study it is clear that first and fourth instars stage was critical for the application of control measure.

CONCLUSION

Life table of *Ceracris nigricornis laeta* (Bolivar), a pest of bamboo was studied for the first time. So far as the mortality rate is concerned, it was the highest in the first instars followed by the fourth instars and may be considered as critical for the application of control measure. There was zero per cent mortality in fifth and sixth instars.

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