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Life and fecundity tables for the longicorn beetle borer, *Olenecamptus bilobus* (Fabricius) (Coleoptera : Cerambycidae)

T N KHAN and P K MAITI
Zoological Survey of India, 34, Chittaranjan Avenue, Calcutta 700 012, India

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Abstract. The present paper deals with the life and fecundity tables for the cerambycid borer, *Olenecamptus bilobus* (Fabricius). Under a given set of conditions and food supply, the population of this species increased with an infinitesimal and a finite rate. The population increased by 20·41 times between two successive generations and 86·42 days were taken to complete one generation. The adults constituted only 1·29% to the population of the stable age, while eggs, larvae, pupae and dormant adults contributed to the extent of 24·95, 68·22, 4·38 and 1·16% respectively.

Keywords. Life and fecundity tables; *Olenecamptus bilobus* (Fabricius); *Artocarpus chaplasha* Roxb.; stable age-distribution.

1. Introduction

The longicorn beetle borer, *Olenecamptus bilobus* (Fabricius), is found predominantly in the Oriental region with an extended distribution up to the Papuan and Malagasy subregions. The species is one of the most common sap-wood borers of a number of dead or dying timber yielding plants. The bionomics and life-history of this species have been dealt with by Khan and Maiti (1980). The observations reported here, are concerned with the life and fecundity tables, including the stable age-distribution of the species. The infinitesimal (r_m) and finite (λ) rates of increase, net reproductive rate (R_0) and the mean generation time were the basic parameters used in the present communication to assess the population growth in the laboratory.

2. Material and methods

The present study was based on the material collected during the period of 1978–80 under a research project on the "Ecological interaction and economic status of the xylophagous insects of the Islands of Andaman and Nicobar", under the guidance of one of us (P K Maiti). During the course of the study, a number of logs of *Artocarpus chaplasha* Roxb., infested with the immature stages of *O. bilobus*, was collected from several field sites of South Andaman and held in galvanized iron cages (70 cm × 37 cm × 37 cm) for the emergence of the adult beetles in the laboratory. The newly emerged beetles were sexed and 50 pairs of males and females were each separately kept in glass breeding-cages (36 cm × 22 cm × 22 cm), containing a layer of moist sandy soil at the bottom. Moist sandy soil was however, kept to minimise the loss of moisture from the breeding-cages. The beetles were provided with fresh green leaves and twigs of *Ficus religiosa* L. for food and freshly cut billets, measuring 25–30 cm in length and 8–12 cm in diameter, of *Artocarpus chaplasha* Roxb. for oviposition, both of which were renewed everyday between 900 and 1000 hr IST. The number of oviposition slits on the billets was counted and the total number of eggs laid thereon was recorded.

Each day, the infested billets from the breeding-cages were assigned a batch-number and placed in a galvanized iron cage (similar to those used for rearing the immature stages collected from the field sites), containing a layer of moist sandy soil at the bottom. In this case, however, the moist sandy soil was used to prevent over desiccation from the infested billets, so that they could retain the moisture content for a longer period for proper development of the progeny. Beginning from the third day following oviposition up to the completion of development of the progeny, three sample billets were taken out and dissected every alternate day between 1200 and 1400 hr IST, to study the development of egg, larva and pupa and other relevant phenomena. The adults, which emerged on a particular day, were transferred to separate cages for oviposition to determine the age-specific fecundity. The average fecundity of the females on subsequent days was recorded until all the females died. Since, the sex-ratio was 2♀ : 1♂ (based on 1600 adults), the number of eggs laid per female was multiplied by 2/3 to get the number of female births (m_x). Life and fecundity tables were constructed according to Birch (1948), elaborated by Howe (1953), Laughlin (1965) and Atwal and Bains (1974). The innate capacity of increase (r_m) and finite rate (λ) were calculated. The values of x (pivotal age in days), l_x (survival of females at different age intervals), and m_x (number of female progeny per female) were worked out. Observations were also made on the stable age-distribution (per cent distribution) of various age groups by calculating the birth-rate and death-rate when reared in a limited space.

During the course of these studies in the laboratory, the maximum and minimum temperatures recorded were 29·7° C and 26·5° C respectively, while the relative humidity prevailed between 67·5% and 93·0%.

3. Results and discussion

The maximum duration of incubation, development of larva, pupa and dormant adult has been observed to be 5, 50, 15 and 7 days respectively. Present observations on the duration of different developmental stages correspond strikingly with those observed by Khan and Maiti (1980). The number of individuals survived between different developmental stages is presented in table 1. From the data presented in the table the developmental survival rate has been estimated at 0·441.

The figures of the mature females emerged from the immature stages have been pooled and a grouping of a day interval of age is employed. The results are

Table 1. Survival of different developmental stages of *Olenecamptus bilobus* (Fabr.) on *Artocarpus chaplasha* Roxb.

Batch No.	No. of eggs	Number survived			
		Egg period (0–5 days)	Larval period (6–55 days)	Pupal period (56–70 days)	Dormant adult period (71–77 days)
1	379	334	235	197	173
2	456	390	274	230	205
3	503	434	303	263	233
4	412	348	244	201	175
5	517	429	290	242	204
6	450	396	280	233	206
7	391	341	241	200	178
8	342	286	203	169	149
9	401	341	238	199	176
10	279	237	171	143	131
Total	4148	3536	2479	2077	1830

Table 2. Observed, as well as, smoothed distribution of mortality among the mature females of *Olenecamptus bilobus* (Fabr.).

Age of the mature females in days x	Observed l_x	Smoothed l_x	Observed d_x	Smoothed d_x
1	854	854·00	24	45·68
2	830	808·32	60	70·63
3	770	737·69	100	88·70
4	670	648·99	95	98·55
5	575	550·44	94	100·44
6	481	450·00	101	95·21
7	380	354·79	89	85·17
8	291	269·62	78	72·05
9	213	197·57	60	58·25
10	153	139·32	50	44·32
11	103	95·00	36	32·63
12	67	62·37	20	22·90
13	47	39·47	17	15·39
14	30	24·08	16	9·92
15	14	14·46	14	14·46
			854	854·00

$X^2 = 15{\cdot}86$; $n = 12$; $P = \langle 0{\cdot}20 \rangle, 0{\cdot}10$; $l_x = 869{\cdot}77e^{-0{\cdot}01830012x^2}$.

presented in table 2, where the customary symbols have been used, i.e., l_x being the number of individuals which survive to the age x and d_x the number dying between the ages x and $x + 1$, so that in the present table,

$$d_x = l_x - l_{x+1}.$$

The raw data have then been smoothed. For smoothening of the raw data, there are many a satisfactory method of which the following one seems to be most convenient :
Defining μ_x as the force of mortality at the age x ;

$$-\frac{1}{l}\frac{dl_x}{dX} = \mu_x.$$

Now, if the force of mortality is assumed to be directly proportional to the age and $\mu_x = 2h^2 X$, where $2h^2$ is a constant, then by integration we get

$$l_x = l_0 e^{-h^2x^2}. \quad (1)$$

Putting $l_x/l_0 = P_x$, and $Q_x = 1 - P_x$,

$$Q_x = 1 - e^{-h^2x^2},$$

and, by differentiation we have,

$$dQ_x = 2h^2 X e^{-h^2x^2} dX ;$$

the probability of dying between the ages X and $X + dX$ being given by the right-hand member of the last equation. Then if M be the mean age at death,

$$M = 2h^2 \int_0^{\infty} X^2 e^{-h^2x^2} dX,$$

from which, by integration we get,

$$M = \frac{\sqrt{\pi}}{2h}.$$

The observed and the smoothed values of l_x have been presented in table 2, and in testing the agreement between the smoothed and observed l_x, Chi-Square test is employed. It has been observed that $X^2 = 15 \cdot 86$ and for $n = 12$, $P = \langle 0 \cdot 20 \rangle$, $0 \cdot 10$, which shows that the fit is satisfactory. As a matter of interest, it might be worth mentioning that the same type of equation has been found to give an excellent fit in the case of 524 female vestigial *Drosophila* (data from Pearl and Parker 1924) and in case of 119 voles (*Microtus agrestis*) (Leslie and Ranson 1940).

The life and fecundity tables for *O. bilobus* on *Artocarpus chaplasha* Roxb. based on the smoothed l_x values, is given in table 3, which has been calculated from the following equation;

$$l_x = 1 \cdot 00 e^{-0 \cdot 0183001x^2}, \quad (2)$$

considering the 83rd, 84th, 85th,. . ., 98th day of the pivotal age as the 0th, 1st, 2nd, . . ., 15th day of the age of mature females (*vide* table 2). In the present table, the l_x column presents the adult survival rate only, while m_x gives the number

Table 3. Life table and fecundity schedule for *Olenecamptus bilobus* (Fabr.) on *Artocarpus chaplasha* Roxb.

Pivotal age in days (x)	Survival of females at different age intervals (l_x)	Age specific fecundity (♀ births) (m_x)	($Dl_x.m_x$)	Actual ♀ births per time unit (k_x)	($x.k_x$)
0–77	**		Immature Stages		
78	1·000	*	0·441	0·441	34·398
79	1·000	*	0·441	0·441	34·839
80	1·000	*	0·441	0·441	35·280
81	1·000	*	0·441	0·441	35·721
82	1·000	*	0·441	0·441	36·162
83	1·000	2·52	1·111	1·111	92·213
84	0·982	4·31	1·901	1·867	156·828
85	0·929	5·98	2·637	2·450	208·250
86	0·848	7·05	3·109	2·636	226·696
87	0·746	7·67	3·382	2·523	219·501
88	0·633	8·73	3·691	2·336	205·568
89	0·517	7·49	3·303	1·708	152·012
90	0·408	7·06	3·113	1·270	114·300
91	0·310	6·19	2·730	0·846	76·986
92	0·227	5·68	2·505	0·569	52·348
93	0·160	5·68	2·505	0·401	37·293
94	0·109	4·59	2·024	0·221	20·774
95	0·072	4·34	1·914	0·138	13·110
96	0·045	4·07	1·795	0·081	7·776
97	0·028	3·34	1·473	0·041	3·977
98	0·016	1·08	0·476	0·008	0·784
99	0·000	0·00	0·000	0·000	0·000

Net reproductive rate = $R_0 = \sum k_x = 20{\cdot}411$; $\sum x \cdot k_x = 1746{\cdot}816$.

* Pre-oviposition period. ** Developmental survival rate = 0·441.

of female eggs laid by the average female per day. For presenting the results in a more convenient way, an additional column ($Dl_x \cdot m_x$) has been proposed, which gives the product of the number of female eggs laid by the average female per day and the developmental survival rate. Another column gives the product of $Dl_x \cdot m_x$ and the adult survival rate (l_x in the present table), whose product is designated by k_x in the present communication.

The total number of female eggs laid per female of the original cohort (R_0) has been estimated at 20·411, which indicates that 20·411 females are produced per female per generation. The maximum pre-oviposition period has been observed to be 5 days, i.e., from the 78th to 82nd day of the pivotal age, and oviposition continues almost throughout the life span of the females. Maximum contribution (m_x = 8·37) in the life-cycle is observed to be made by the females of the 88th day of the pivotal age (*vide* table 3). The first female mortality within the cohort occurs on the 7th day ($l_x = 0·982$) after the emergence of the adult female and mortality increases gradually thereafter, as shown in figure 1.

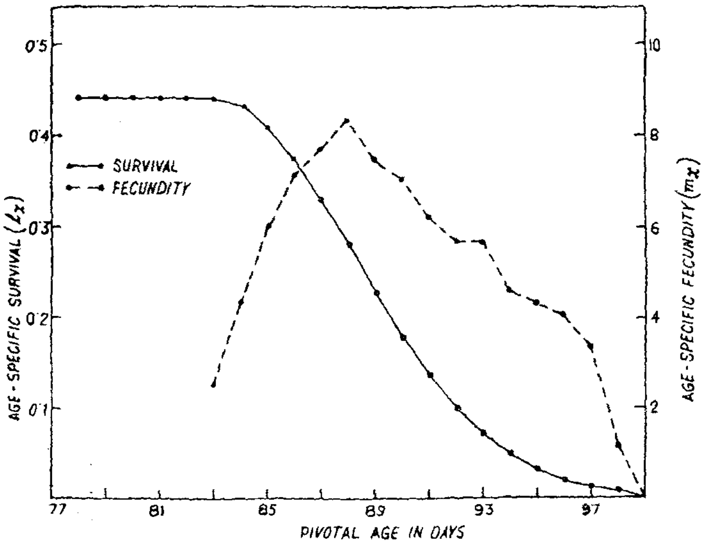

Figure 1. Age-specific survival and fecundity of *Olenecamptus bilobus* (Fabr.) on *Artocarpus chaplasha* Roxb.

Table 4. Mean length of generation, innate capacity for increase in numbers and finite rate of increase in numbers in *Olenecamptus bilobus* (Fabr.) on *Artocarpus chaplasha* Roxb.

Particulars	
1. Cohort generation time (T_c)	
$T_c = \frac{\Sigma x \cdot k_x}{R_0} = \frac{1764·816}{20·411}$	$= 86·464$ days
2. Innate capacity for increase in numbers (r_m)	
$r_m = \frac{\ln R_0}{T_c} = \frac{\log e^{R_0}}{T_c} = \frac{3·0161}{86·464}$	$= 0·0349$
3. Finite rate of increase in numbers	
(λ) = Natural antilog of r_m	
= Natural antilog of 0·0349	$= 1·03552$
4. Corrected generation time (T)	
$T = \frac{\ln R_0}{r_m} = \frac{\log e^{R_0}}{r_m} = \frac{3·0161}{0·0349}$	$= 86·42$ days
5. Weekly multiplication of population	
$= (e^{r_m})^7 = (1·03552)^7$	$= 1·2767$

Table 5. Stable age-distribution of *Olenecamptus bilobus* (Fabr.) on *Artocarpus chaplasha* Roxb.

($r_m = 0 \cdot 0349$)

Pivotal age in days, x	L_x	$e^{-r_m(x+1)}$	$L_x \cdot e^{-r_m(x+1)}$	Percentage age-distribution $100\ \beta L_x \cdot e^{-r_m(x+1)}$	
1	2	3	4	5	
0	1·000	0·9657	0·9657	4·6874	
1	1·000	0·9326	0·9326	4·5268	
2	1·000	0·9006	0·9006	4·3714	Total eggs
3	1·000	0·8697	0·8697	4·2214	24·95%
4	0·930	0·8399	0·7811	3·7914	
5	0·850	0·8111	0·6894	3·3463	
6	0·850	0·7833	0·6658	3·2317	
7	0·840	0·7564	0·6354	3·0842	
8	0·830	0·7304	0·6062	2·9424	
9	0·825	0·7054	0·5820	2·8250	
10	0·820	0·6812	0·5586	2·7114	
11	0·815	0·6578	0·5361	2·6022	
12	0·810	0·6352	0·5145	2·4973	
13	0·805	0·6135	0·4939	2·3974	
14	0·800	0·5924	0·4739	2·3003	
15	0·800	0·5721	0·4577	2·2216	
16	0·800	0·5525	0·4420	2·1454	
17	0·795	0·5336	0·4242	2·0590	
18	0·790	0·5153	0·4071	1·9760	
19	0·785	0·4976	0·3906	1·8959	
20	0·780	0·4805	0·3748	1·8192	
21	0·765	0·4640	0·3550	1·7231	
22	0·750	0·4481	0·3361	1·6314	
23	0·745	0·4327	0·3224	1·5659	
24	0·740	0·4179	0·3092	1·5008	
25	0·735	0·4036	0·2966	1·4397	
26	0·730	0·3897	0·2845	1·3809	
27	0·725	0·3764	0·2729	1·3246	
28	0·720	0·3635	0·2617	1·2703	
29	0·710	0·3510	0·2492	1·2096	
30	0·700	0·3390	0·2373	1·1518	
31	0·695	0·3273	0·2275	1·1043	Total larvae
32	0·690	0·3161	0·2181	1·0586	68·22%
33	0·690	0·3053	0·2107	1·0227	
34	0·690	0·2948	0·2034	0·9873	
35	0·680	0·2847	0·1936	0·9397	
36	0·670	0·2749	0·1842	0·8941	
37	0·665	0·2655	0·1766	0·8572	
38	0·660	0·2564	0·1692	0·8213	
39	0·650	0·2476	0·1609	0·7810	
40	0·640	0·2391	0·1530	0·7426	
41	0·630	0·2309	0·1455	0·7062	
42	0·620	0·2230	0·1383	0·6713	
43	0·615	0·2153	0·1324	0·6427	
44	0·610	0·2079	0·1268	0·6155	
45	0·610	0·2008	0·1225	0·5946	
46	0·610	0·1939	0·1183	0·5742	

1	2	3	4	5	
47	0·610	0·1873	0·1143	0·5548	
48	0·610	0·1808	0·1103	0·5354	
49	0·605	0·1746	0·1056	0·5126	
50	0·600	0·1687	0·1012	0·4912	
51	0·600	0·1629	0·0977	0·4742	
52	0·600	0·1573	0·0944	0·4582	
53	0·600	0·1519	0·0911	0·4422	
54	0·595	0·1469	0·0874	0·4242	
55	0·590	0·1416	0·0835	0·4053	
56	0·585	0·1368	0·0800	0·3883	
57	0·580	0·1321	0·0766	0·3718	
58	0·580	0·1276	0·0740	0·3592	
59	0·580	0·1232	0·0715	0·3471	
60	0·580	0·1190	0·0690	0·3349	
61	0·575	0·1149	0·0661	0·3208	
62	0·570	0·1109	0·0632	0·3068	Total pupae
63	0·565	0·1071	0·0605	0·2937	4·38%
64	0·560	0·1035	0·0580	0·2815	
65	0·545	0·0999	0·0544	0·2641	
66	0·530	0·0965	0·0511	0·2480	
67	0·515	0·0932	0·0480	0·2330	
68	0·500	0·0900	0·0450	0·2184	
69	0·495	0·0869	0·0430	0·2087	
70	0·490	0·0839	0·0411	0·1995	
71	0·480	0·0810	0·0389	0·1888	
72	0·480	0·0781	0·0375	0·1820	
73	0·475	0·0756	0·0359	0·1743	Total
74	0·470	0·0730	0·0343	0·1665	dormant
75	0·455	0·0705	0·0321	0·1558	adults
76	0·441	0·0681	0·0300	0·1456	1·16%
77	0·441	0·0657	0·0290	0·1408	
78	0·441	0·0635	0·0280	0·1359	
79	0·441	0·0613	0·0270	0·1311	
80	0·441	0·0592	0·0261	0·1267	
81	0·441	0·0572	0·0252	0·1223	
82	0·441	0·0552	0·0243	0·1180	
83	0·437	0·0533	0·0233	0·1131	
84	0·422	0·0515	0·0217	0·1053	
85	0·392	0·0497	0·0195	0·0947	
86	0·352	0·0480	0·0169	0·0820	
87	0·304	0·0464	0·0141	0·0684	
88	0·254	0·0448	0·0114	0·0553	
89	0·204	0·0432	0·0088	0·0427	Total adults
90	0·156	0·0418	0·0065	0·0316	1·29%
91	0·119	0·0403	0·0048	0·0233	
92	0·086	0·0389	0·0033	0·0160	
93	0·060	0·0376	0·0023	0·0112	
94	0·040	0·0363	0·0015	0·0073	
95	0·026	0·0351	0·0009	0·0044	
96	0·016	0·0339	0·0005	0·0024	
97	0·010	0·0327	0·0003	0·0015	
98	0·004	0·0316	0·0001	0·0005	
		$1/\beta = 20 \cdot 6019$			

The present investigation suggests that the innate capacity of increase (r_m) is 0·0349 per female per day, while the daily finite rate of increase (λ) is 1·03552 (table 4). The mean time for completing a generation (T) has been calculated at 86·42 days. It appears, therefore, that under a given set of conditions in the laboratory, the daily finite rate of increase ($\lambda = 1 \cdot 03552$) enables the borer insect to multiply by 1·2767 times every week.

From the present observations, the contribution made by the different developmental stages of *O. bilobus* towards the stable age-distribution has also been determined. The results are presented in table 5, in which the life-table age-distribution (L_x) has been worked out with the following formula;

$$L_x = \int_x^{x+1} l_x d_x,$$

which, in practice, is given by

$$L_x = \frac{l_x + (l_{x+1})}{2}. \tag{3}$$

It has been observed that, on reaching the stable age-distribution, the egg, larva, pupa, dormant adult and adult stage of this insect contribute to the extent of 24·95, 68·22, 4·38, 1·16 and 1·29% respectively.

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