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Life Table of the Green Lacewing *Apertochrysa* sp. (Neuroptera: Chrysopidae) Reared on Rice Moth *Corcyra cephalonica* (Lepidoptera: Pyralidae)

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ABSTRACT

The survivorship from egg to adult emergence and fertility of *Apertochrysa* sp. fed on *Corcyra cephalonica* were studied in laboratory and population parameters of *Apertochrysa* sp. were used for construction of life table under ideal condition in laboratory free from natural enemies. The highest mortality occurred in eggs (44.3%) followed by mortality (15.4%) in 2nd instar larva and in pupal stage (11.4%). The sex ratio (proportion of female to male) was 1:1.4. The maximum life span of female was 38 days. The highest number of eggs produced per female was 6.33 at seventh day of oviposition. The gross reproductive rate (GRR) was 19.48 females per female per generation. The net reproductive rate (Ro) was 2.28 females per female per generation. Mean generation time (T) was 40.6 days, while the intrinsic rate of natural increase (r) was 0.02 female per female per day. The finite rate of increase (λ) was 1.02 females per female per day. The population double time (DT) was within 14.8 day. © 2010 Friends Science Publishers

Key Words: Life table; Green lacewing; *Apertochrysa*; Chrysopidae; Predators

INTRODUCTION

The green lacewings (Neuroptera: Chrysopidae) are an important group of insect predators (Dean & Satasook, 1983), that can be mass reared in the laboratory and used against insect pests (Syed *et al.*, 2008). Their ability to adapt to a wide range of ecological factors (Ulhaq *et al.*, 2006) and tolerance insecticides (Bigler, 1984) has made them important in research and field application.

The *Apertochrysa* sp., is one of the important species of Madagascan Chrysopidae that is found wide spread African south of the Saharan and eastward of African continent to the Pacific Region (Ohm & Hölzel, 2002). It is also distributed and well known in India (Bakthavatsalam *et al.*, 1994; Mani & Krishnamoorthy, 1999; Ramani *et al.*, 2002). However this genus is poorly known in South East Asia and is newly record in Malaysia (NHM, 2008). Other species of the family Chrysopidae such as *Chrysopa* sp., *Ankylopteryx trimaculata* Gerst., *Ankylopteryx octopunctata* F., *Nothochrysa evanescens*, Mch. and *Italochrysa aequalis* Walk, have been recorded from Malaysian agro-ecosystem (Yunus & Ho, 1980).

The hosts of *Apertochrysa* sp., include the mealy bug *Maconellicoccus hirsutus* (Green) (Krishnamoorthy & Mani, 1989), the spiralling whitefly, *Aleurodicus dispersus* Russell (Ramani *et al.*, 2002) and the eggs of *Helicoverpa armigera*. This predator can be reared successfully on eggs of *Crocyra cephalonica* in the laboratory (Lee & Shih, 1981; Krishnamoorthy & Mani, 1982; Bakthavatsalam *et al.*, 1994).

Malaysia has a great diversity of biological control agents (Chong, 1986) and many reports are available on the importance of the natural enemies in Malaysia, which suggests that the natural enemies can play a very important role in agriculture and forest ecosystem (Yunus & Ho, 1980; Wong, 1984; Ooi, 1986; Sajap & Kotulai, 1992; Sajap *et al*., 1997). Hussein (1986) released the eggs of *Micromus tasmaniae* Walker to control the population of *Myzus persicae* in potato.

Life table studies on *Apertochrysa* sp., in Malaysia will provide the necessary data for its mass production in a pest management programs. Demographic study was conducted to provide information on the life table of *Apertochrysa* sp., fed *C. cephalonica* eggs; pertinent population growth parameters are hereby furnished.

MATERIALS AND METHODS

Rearing of *C. cephalonica*: Sterilized maize, rice, wheat and semolina (1:1:1:1) were placed in a plastic cage. Eggs of *C. cephalonica* were spread over the diet inside the cage at 22ºC, 55-85% RH and 12L: 12D photoperiod to develop

C. cephalonica to adult stage that was collected for matting in plastic cage. The eggs produced were collected in a glass plate, and placed in the freezer to exhaust egg viability. These eggs were used as food for larvae of *Apertochrysa* sp.

Life table experiments in laboratory: Eggs of *Apertochrysa* sp., were collected from citrus fields at University Putra Malaysia, Serdang, selangor and brought to laboratory. Groups of 148 (cohort1), 123 (cohort2), 106 (cohort3) of freshly laid eggs of *Apertochrysa* sp., were separated individually in a 10 cm Petri dishes to prevent cannibalism. The larvae from these eggs were fed frozen eggs of *C. cephalonica*. Daily records were taken on survival and progress in development was observed until emergence of the adults. These adults were transferred into an oviposition cage measuring 37 x 28cm x 22cm and covered with black organza cloth and provided with a standard diet composing of 3 g sugar, 2.5 g yeast, 2.5 mL honey, 3 g powder milk instead of casein in 10 mL distilled water. The diet was smeared on the wall of the cage with a soft brush daily and kept under constant temperature of 25ºC±1, 55-85% RH and 12L: 12D photoperiod. Fecundity and mortality were recorded daily until the last adult died. Construction of the life tables was done according to the procedures described by Birch (1948) and Southwood (1978).

The life table and fecundity schedule were constructed with the following parameters:

1- Life table

X: the pivotal age for the age class in units of time (days).

l_x: the number of surviving individual at the beginning of age class x.

L_x: the number of individual alive between age x and x+1.

T_x: total number of individual x age units beyond the age x.

d_x: the number of individual dying during the age interval x.

e_x: the expectation of life remaining for individuals of age x.

RM%: percentage of real mortality calculated based on the population density at the beginning of the generation RM = (d_x/lo) 100.

IM%: Indispensable (irreplaceable) mortality, which is the portion of generation mortality that would not occur if the apparent mortality (q_x) of an age interval was removed from the life system. It is assumed that the subsequent mortality factors will destroy the same percentage of the population independent of the change in population density.

2- Fecundity schedule

X: pivotal age for the age class in units of time.

l_x: number of females surviving at the beginning of age class x (given as fraction of 1.0).

m_x: number of female eggs laid by age class x.

l_xm_x: total number of female eggs laid in age class x.

Ro: net reproductive rate. It is equal to the sum of the l_xm_x or $Ro = \sum l_xm_x$.

T: Cohort generation time (in days), approximated by $T = \sum Xl_xm_x / \sum l_xm_x$.

r: Innate capacity for increase, calculated by $r_c = \ln Ro/T_c$.

r_m: the maximum population growth, the intrinsic rate of natural increase or the innate capacity for increase, calculated by iteration of Euler's equation, $\sum e^{-r.x} l_xm_x$.

λ: the finite rate of increase, number of female offspring per female per day, calculated by, $\lambda = e^r$.

DT: doubling time, the number of days required by a population to double, calculated by, DT = ln2/r.

b: Intrinsic birth rate, $1/\sum e^{-r.x} I_x$.

d: Intrinsic death rate, $b - r_m$.

GRR: Gross reproduction rate calculated by $\sum m_x$.

The population parameters of life table and fecundity table were conducted based on 3 data of different cohorots.

RESULTS AND DISCUSSION

Mortality of immature: The results on age specific mortality of immature stages of *Apertochrysa* sp., fed on eggs of *C.cephalonica* are presented in Table I. All surviving larvae underwent three molts. High mortality occurred in eggs (44.3%), then 2nd instar of larvae (15.42%) followed by 11.38% in the pupal stage. The total number of adults obtained was 148 (61 females: 87 males) of 377 *Apertochrysa* sp., eggs. Age-specific survivorship and fecundity of these adults are presented in Table II. Mortality of *Apertochrysa* sp., fed on eggs of *C. cephalonica* was higher compared to other green lacewings such as *Mallada bioninensis* (Okamoto), *M. astur* and *Chrysoperla carnea* cultured on eggs of *C. cephalonica* (Bakthavatsalam *et al.*, 1994; Elsiddig *et al.*, 2006). Similar to the report by Silva *et al.* (2007), this early generation fed on *C. cephalonica* produced very few fertile females. The results of Shivankar and Singh (1998) and Nehrae *et al.* (2004) showed that mortality of different stages of *M. bioninensis* varied on different preys.

The developmental period of from egg to egg was 34 days. This is longer than that of Elsiddig *et al.* (2006) who reported that the immature period (egg to egg) of *M. bionnensis* on *C. cephalonica* eggs was 25.3 days.

Age–specific survival life table: Fig. 1 shows the survivorship (l_x) of *Apertochrysa* sp., for three different cohorts. The figure indicated during the life span of the predator high mortality occurred during eggs, larval (particularly 2nd instar) and pupal stages. The first emerging adult occurred on days 30, 31 and 32 and the maximum life span were 66, 61 and 59 days for cohort 1, 2 and 3, respectively. The 2nd instar was highly susceptible to food quality, most of them failed to remove the cuticle during the molts. The lacewings had been reported to be highly sensitive to changes in temperature and water availability, changes in these parameters affected growth and survival (Schowalter, 2006). The population assumed a near type Π diagonal survivorship curve following the classification of (Pearl, 1928; Speight *et al.*, 1999; Schowalter, 2006).

Table I: Life table of green lacewing (*Apertochrysa* sp.) reared on eggs of *C.cephalonica*

x	I_x	d_x	L_x	T_x	e_x	$100q_x$	RM%	IM%
Eggs	377	167	293.5	1084.5	2.88	44.30	44.30	31.22
1st instar L	210	9	205.5	791	3.77	4.29	2.39	1.76
2nd instar L	201	31	185.5	585.5	2.91	15.42	8.22	7.16
3rd instar L	170	3	168.5	400	2.35	1.76	0.80	0.70
Pupa	167	19	157.5	231.5	1.39	11.38	5.04	5.04
Adults	148		74	74				

Table II: Life and age-specific fecundity table of *Apertochrysa* sp. fed on eggs of *C. cephalonica*

x	survival no	lx	total eggs	eggs/female	Mx	lxmx	xlxmx	$e^{-rm}l_xm_x$
1	377	1						
2	377	1						
3	377	1						
4	377	1						
5	377	1						
6	377	1						
7	266	0.7055						
8	266	0.7055						
9	210	0.5570						
10	208	0.5517						
11	207	0.5490						
12	203	0.5384						
13	200	0.5305						
14	189	0.5013						
15	181	0.4801						
16	177	0.4694						
17	176	0.4668						
18	176	0.4668						
19	170	0.4509						
20	168	0.4456						
21	168	0.4456						
22	168	0.4456						
23	168	0.4456						
24	168	0.4456						
25	168	0.4456						
26	168	0.4456						
27	167	0.4429						
28	167	0.4429						
29	166	0.4403						
30	166	0.4403						
31	164	0.4350						
32	164	0.4350						
33	164	0.4350						
34	37	0.0981	206	5.5675	1.4013	0.1375	4.6761	0.0688
35	43	0.1140	146	3.3953	0.9931	0.1132	3.9648	0.0555
36	47	0.1246	158	3.3617	1.0748	0.1339	4.8239	0.0644
37	52	0.1379	84	1.6153	0.5714	0.0788	2.9162	0.0371
38	52	0.1379	319	6.1346	2.1700	0.2993	11.374	0.1381
39	52	0.1379	103	1.9807	0.7006	0.0966	3.7691	0.0437
40	55	0.1458	348	6.3272	2.3673	0.3453	13.8147	0.1530
41	53	0.1405	187	3.5283	1.2721	0.1788	7.3323	0.0776

Table III: Population and reproductive of *Apertochrysa* sp. fed on eggs of *C. cephalonica*

No.	Parameters	Formula	Values
1	T_C (days)	$\sum xl_xm_x/\sum l_xm_x$	40.61
2	r_c	$\ln Ro/T_C$	0.02
3	r_m	$\sum e^{-rx}l_xm_x=1$	1.00
4	λ	e^r	1.02
5	DT(days)	Ln2/r	14.80
6	b	$1/\sum e^{-rx}l_x$	1.10
7	d	$b-r_m$	0.10
8	Gross reproduction rate(GRR)	$\sum m_x$	19.47
9	Ro	$\sum l_xm_x$	2.29

Fig. 1: Patterns of survivorship curve (l_x) of *Apertochrysa* sp. for (A, B and C) different cohors

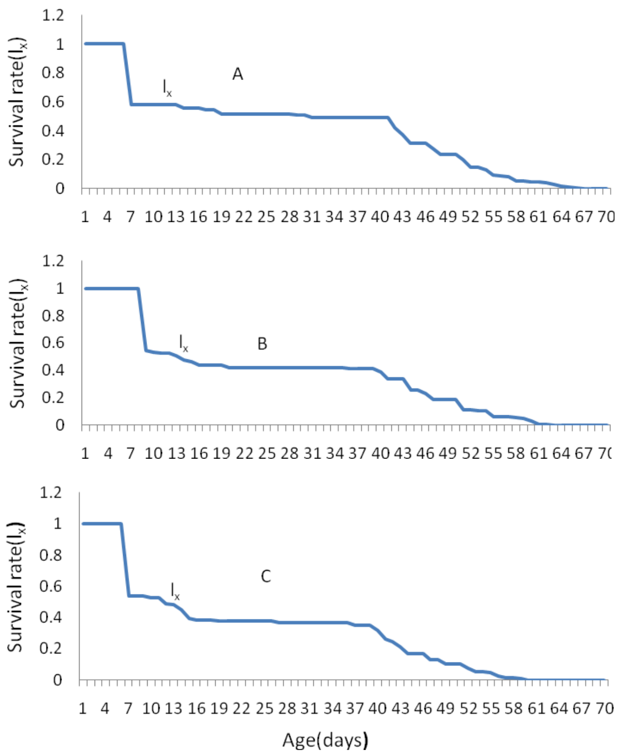
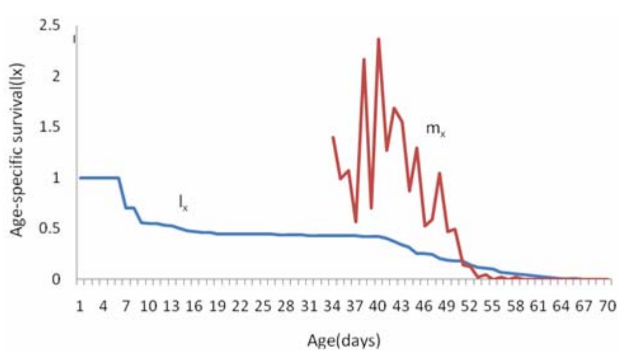


Fig. 2: Daily age–specific survival (l_x) and fecundity (m_x) of female *Apertochrysa* sp. fed on *C. cephalonica*



Age-specific fertility schedule: Fig. 2 shows the survivorship and fecundity of *Apertochrysa* sp., detail of which is shown in Table II. The first female emerged on day 30 and the first death occurred the following day. The last female death was recorded on day 68. The female could live for a maximum of 38 days. Earliest laying of eggs by females was observed on day 34, while the pre-oviposition period was 7.33±4.24 days. The highest number of eggs laid on the day 40 or 10 days following emergence with 6.32 eggs per female.

Table III summarizes the population and reproductive parameters of *Apertochrysa* sp. The r value was 0.02 (female/female/day) with the T being 40.6 days. The Ro of the population was 2.29. The DT was within 14.8 days. The r, T and DT are useful indices of population growth under a given set of growing conditions (Siswanto *et al*., 2008).

In general *Apertochrysa* sp., fed on *C. cephalonica* had extended developmental time but with low reproductive performance. The population parameters (Ro = 2.29, λ = 1.02) of *Apertochrysa* sp. fed on *C. cephalonica* under laboratory conditions were lower than the population studied by Bakthavatsalam *et al*. (1994; Ro = 63.90, λ = 1.558) and similarly, the population parameters (Ro, λ, GRR = 19.47) were also lower than that of *M. boninensis* fed on *C. cephalonica* (Ro = 139.117, λ =1.157, GRR = 225.42) studied by Elsiddig *et al*. (2006).

CONCLUSION

Apertochrysa sp., could be mass successfully cultured in the laboratory under ambient condition (25ºC, 55-85% RH & 12L: 12D photoperiod). Low value of r and high mortality indicated lower suitability of *C. cephalonica* eggs as prey for the predator *Apertochrysa* sp. The first laboratory generation of *Apertochrysa* sp., had very few fertile females. However the oviposition during the medium life span was high advantage for the population growth.

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