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LIFE TABLES AND POPULATION PARAMETERS OF *HELOPELTIS ANTONII* (HEMIPTERA: MIRIDAE) REARED ON CASHEW (*ANACARDIUM OCCIDENTALE* L.)

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Abstrak: Kadar kemandirian dan fertiliti *Helopeltis antonii* telah dibuat di makmal dan di ladang di Wonogiri, Indonesia. Jadual hidup dan parameter populasi mirid dibuat berdasarkan pada keadaan makanan yang tak terbatas dan bebas dari musuh semula jadi. Mortaliti tertinggi didapati pada peringkat muda, terutama pada peringkat nimfa satu dan dua. Kemandirian dari peringkat telur hingga serangga dewasa ialah 0.92. Nisbah jantina betina kepada jantan ialah 1:0.92. Betina dewasa dapat hidup maksimum selama 24 hari. Corak oviposisi dengan pemuncak didapati pada akhir kehidupan betina. Purata telur yang dihasilkan per betina dewasa ialah 6.8. Kadar pertambahan intrinsik semula jadi (r_m) ialah 0.092 per betina per hari dan kadar pertambahan finit harian (λ) ialah 1.097 betina per betina per hari, dengan purata waktu generasi (T) ialah 27.70 hari. Kadar pembiakan net untuk populasi bersangkutan (R_o) ialah 12.84. Waktu penggandaan populasi (DT) ialah 7.52 hari.

Kata Kunci: *Helopeltis antonii*, Kadar Kemandirian, Gajus

Abstract: Survivorship and fertility of *Helopeltis antonii* were measured under laboratory and field condition in Wonogiri, Indonesia. Life tables and population parameters for the mirid were constructed based on unlimited food condition and a natural enemies-free environment. The highest mortality occurred in the immature stage, especially on first and second instar of nymphal stages. The survival from egg to adult emergence were about 0.92. The proportion of female to male observed was 1:0.92. The females could live for a maximum of 24 days. Oviposition trend with peak at the end of the female life span. The mean number of eggs produced per female was 6.8. The intrinsic rate of increase (r_m) was 0.092 per female per day and daily finite rate of increase (λ) was 1.097 females per female per day, with mean generation time (T) was 27.70 days. The net reproductive rate (R_o) of the population was 12.84. The population double time (DT) was within 7.52 days.

Keywords: *Helopeltis antonii*, Life Table, Cashew

INTRODUCTION

Helopeltis antonii is the most important pest of cashew which causes substantial losses in most cashew growing countries. It is also a major pest of cocoa, tea and neem (Stonedahl 1991; Sundararaju & Babu 1996; Onkarappa & Kumar 1997). The insect feeds by sucking the fluid on young parts of cashew plant such as leaves, shoots, inflorescences and fruits. Attack by this pest causes drying up of the new flushes, giving scorched up appearance to the trees, shriveling and

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falling of the immature nuts of different stages (Singh & Pillai 1984). Crop loss resulting from the mirid mostly was minimized by controlling the pest using synthetic insecticides (Pillai & Abraham 1975; Ambika *et al*. 1983; Pillai 1987). However, insecticide usage in controlling pests would be negative effects to environment. Therefore, implementation of Integrated Pest Management (IPM) program is necessary to avoid or reduce this risk. Research data pertaining to the pest's life table are urgently needed in developing IPM strategies. The objectives of this study are 1) to develop life history information on *H. antonii* fed on cashew for demographic analysis and 2) to determine the population parameters including the survivorship and rate of increase of *H. antonii*.

MATERIALS AND METHODS

The insects used for the experiment were obtained by culturing them in the laboratory following the breeding method by Kilin *et al.* (1998) using cucumber as food source. The experiments were conducted in the laboratory of Estate Service of Wonogiri Regency and in small holders pesticide free cashew plantation in Pondok village, Ngadirojo District, Wonogiri, Central Java, Indonesia from April to July 2004.

The construction of the life tables followed the procedure described by Birch (1948) and Southwood (1978). In order to construct the age-specific life table, 30 females and 24 males were paired in the field into 5 cages (50 cm x 60 cm). Eggs laid during the first 24 hours were marked and observed daily until hatched. First instar nymphs were collected using a fine soft brush and brought to the laboratory. Each nymph was reared individually in a Petri dish (12 cm in diameter and 1.5 cm high) provisioned with a cut of cashew shoot or young leaf as food. The food was changed every day. Observation was carried out daily on the nymphs' development and number of death. The presence of exuviae was used to determine nymph instars of the insect. The study was conducted in the laboratory under the ambient environmental conditions of 23°C–31°C, 60%–86% RH and natural photoperiod, and 19°C–34°C and 60%–96% RH in the field. Hatched adults were paired and caged on a cashew shoot in the field with perforated plastic bag (3-mesh pores) about 20 cm diameter and 30 cm long, they were moved to a new shoot every day. Number of dead adults and eggs laid were recorded daily until all females died. Egg to adult survivorship data, daily fecundity and sex ratio of the reared progenies were used to construct life tables, from which population growth parameters were calculated. Data analysis was carried out following the single sex method (Birch 1948; Southwood 1978).
Life tables were then constructed with the following column of parameters:

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 dying during the age interval x
e_x : the expectation of life remaining for individuals of age x

R_o : net reproductive rate. It was equal to the sum of the l_xm_x products, or $R_o = \sum l_xm_x$

T_c : Cohort generation time (in days), approximated by, $T_c \approx \sum Xl_xm_x / \sum l_xm_x$

r_c : Innate capacity for increase, calculated by, $r_c = \ln R_o / T_c$

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, $\sum e^{-rm.x} l_xm_x = 1$

T : the corrected generation time, $T = \ln R_o / r_m$

Λ : the finite rate of increase, number of female offspring per female per day, calculated by, $\lambda = e^{rm}$

DT : doubling time, the number of days required by a population to double, and is calculated by, $DT = \ln 2 / r_m$

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

d : Intrinsic death rate, $b - r_m$

To estimate the population parameters of *H. antonii*, three sets of data from different cohorts were obtained at different dates (20th April, 22nd April and 22nd June 2004).

RESULTS AND DISCUSSION

Age-specific survival life table

The survivorship (l_x) of *H. antonii* for three different cohorts (Fig. 1) in general shows similar pattern with high mortality occurring during nymphal growth particularly in the early instar which then gradually decreases throughout the life span. The first emerging adults occurred on days 14, 15 and 17, and the maximum life spans (from hatching egg to death of adult) were 32, 28 and 24 days for cohort 1, 2 and 3 respectively. The pattern of survivorship observed indicates that the young immature stage is susceptible to physical disruptions during food changing in their captive or also due to unsuitable food quality. This survivorship curve which indicates a modest rate of mortality during early life stages and comparatively a gradual reduction as it approached adulthood, the population assumed a near type II diagonal survivorship curve following the classification of Pearl (1928 in Schowalter 2006) and Speight *et al*. (1999). Cohort 3 which was carried out in June 2004 (dry season) shows longer egg stage and shorter adult life span compared to cohort 1 and cohort 2 which were carried out in April 2004 (end of rainy season). This difference is possibly attributed to the dry field condition and high daily temperature which may be unfavourable for the population growth. Insect population is highly sensitive to changes in abiotic conditions, such as temperature and water availability. Any changes in these parameters will affect insect growth and survival (Schowalter 2006). Meanwhile, Velasco and Walter (1993) stated that insect survival and growth of nymphs and the reproductive phase are highly influenced by food quality.

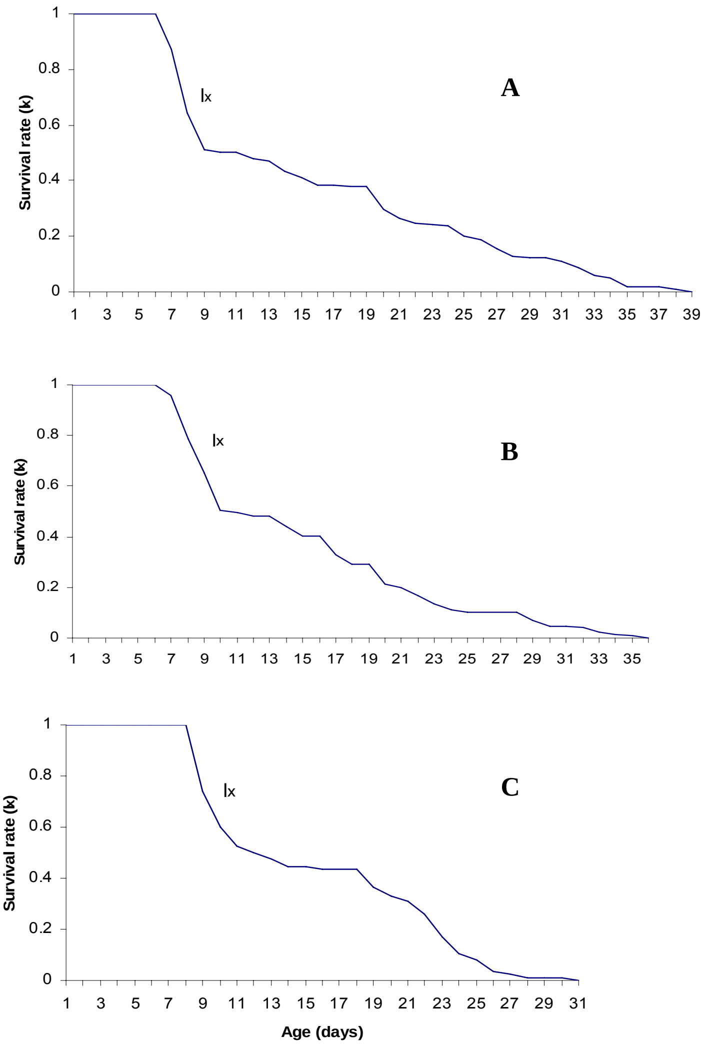

Figure 1: Patterns of survivorship curve (l_x) of *H. antonii* for three (A, B and C) different cohorts.

Table 1 shows the pooled life table concerning the description of one pathway of population change – mortality. All surviving nymphs underwent four moults. The life table indicates that about 39.62% of 424 *H. antonii* eggs successfully emerged as adult and high mortality occurred during early immature stages. This survivorship is commonly found in most insect species (Begon & Mortiner 1981).

Table 1: Pooled life table of *H. antonii* on cashew

x	l_x	L_x	d_x	$100q_x$	S_x	T_x	e_x
Eggs	424	406.5	35	8.25	91.75	1629	3.84
Nymph:							
Instar 1	389	333	112	28.79	71.21	1222.5	3.14
Instar 2	277	241.5	71	25.63	74.37	889.5	3.21
Instar 3	206	200.5	11	5.34	94.66	648	3.15
Instar 4	195	188.5	13	6.67	93.33	447.5	2.29
Instar 5	182	175	14	7.69	92.31	259	1.42
Adult	168	84					

x = developmental stage
l_x = number of entering stage
L_x = number alive between age x and x+1
d_x = number dying in stage x
$100q_x$ = percent apparent mortality
S_x = survival rate within stage
T_x = Total number of age x units beyond the age x
e_x = life expectancy

Age-specific fertility life table

The survivorship and fecundity of *H. antonii* are shown in Figure 2 and the detailed data are shown in Table 2. The first emerging female was on day 15 and the first death was on day 20. The survival of immature stages from egg to adult emergence was about 0.92. The proportion of female to male observed was 1:0.92. The last female died on the 39th day. The females could live for a maximum of 24 days. Females started laying eggs from the 20th day or about 5 days from their first emergence. The numbers of eggs deposited were low in the early period and higher during the final period of their life span. The highest numbers of eggs were laid on the 21st day from their first emergence or 36 days of age with the number of eggs per female was 16.

The population and reproductive parameters of *H. antonii* are summarized in Table 3. The r_m was 0.092 per female per day and λ was 1.097 female offspring per female per day, with T was 27.70 days. The R_o of the population was 12.84. The DT was within 7.52 days. The r_m, T and DT are useful indices of population growth under a given set of growing conditions. It is generally presumed that shorter developmental time and greater reproduction on a host reflect the suitability of the plant tested (Van Lenteren & Noldus).

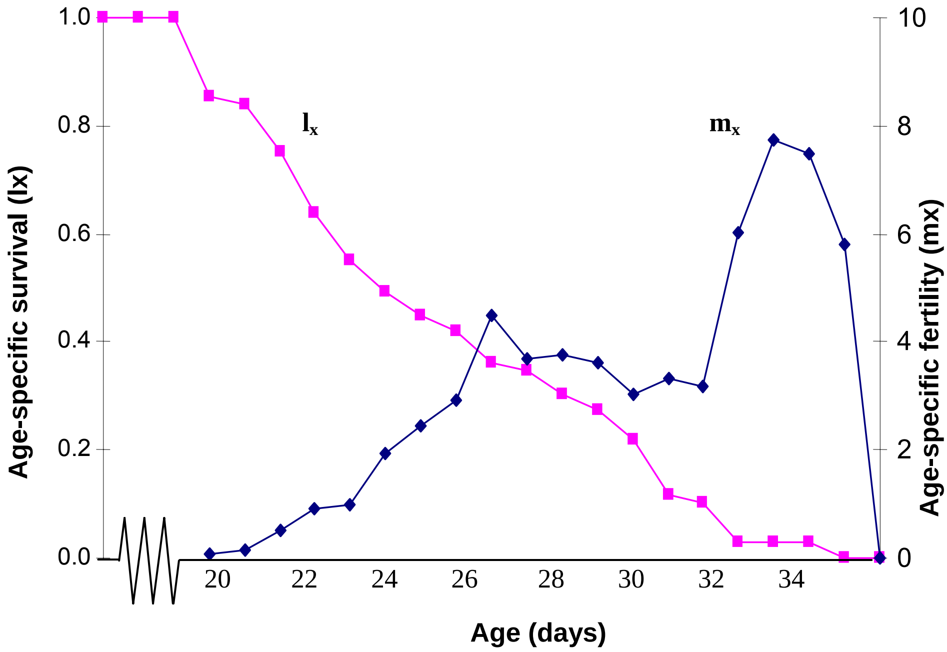

Figure 2: Daily age-specific survival (l_x) and fecundity (m_x) of female *H. antonii* fed shoots of cashew.

Table 2: Life and age-specific fecundity table of *H. antonii* fed shoots of cashew

Age(Days) x	l_x	Eggs/ female	m_x [a]	l_xm_x	xl_xm_x	$e^{-rmx}(l_xm_x)$
0	1.00	-	-	-	-	-
1	1.00	-	-	-	-	-
2	1.00	-	-	-	-	-
3	1.00	-	-	-	-	-
4	1.00	-	-	-	-	-
5	1.00	-	-	-	-	-
6	1.00	-	-	-	-	-
7	1.00	-	-	-	-	-

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Table 2 *(continued)*

Age(Days) x	l_x	Eggs/ female	m_x [a]	l_xm_x	xl_xm_x	$e^{-rmx}(l_xm_x)$
8	1.00	-	-	-	-	-
9	1.00	-	-	-	-	-
10	1.00	-	-	-	-	-
11	1.00	-	-	-	-	-
12	1.00	-	-	-	-	-
13	1.00	-	-	-	-	-
14	1.00	-	-	-	-	-
15	1.00	-	-	-	-	-
16	1.00	-	-	-	-	-
17	1.00	-	-	-	-	-
18	1.00	-	-	-	-	-
19	1.00	-	-	-	-	-
20	0.86	0.15	0.0789	0.0674	1.3487	0.0107
21	0.84	0.33	0.1694	0.1424	2.9896	0.0206
22	0.75	1.06	0.5468	0.4121	9.0662	0.0543
23	0.64	1.86	0.9635	0.6144	14.1313	0.0738
24	0.55	2.03	1.0476	0.5769	13.8466	0.0632
25	0.49	3.97	2.0528	1.0115	25.2881	0.1010
26	0.45	5.06	2.6184	1.1764	30.5854	0.1072
27	0.42	6.03	3.1198	1.3112	35.4033	0.1089
28	0.36	9.28	4.7978	1.7383	48.6729	0.1317
29	0.35	7.67	3.9637	1.3787	39.9813	0.0953
30	0.30	7.76	4.0129	1.2213	36.6396	0.0770

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Table 2 *(continued)*

Age(Days) x	l_x	Eggs/ female	m_x [a]	l_xm_x	xl_xm_x	$e^{-rmx}(l_xm_x)$
31	0.28	7.47	3.8639	1.0640	32.9831	0.0611
32	0.22	6.27	3.2399	0.7043	22.5382	0.0369
33	0.12	6.87	3.5544	0.4121	13.5993	0.0197
34	0.10	6.57	3.3974	0.3447	11.7186	0.0150
35	0.03	12.50	6.4625	0.1873	6.5563	0.0074
36	0.03	16.00	8.2720	0.2398	8.6318	0.0087
37	0.03	15.50	8.0135	0.2323	8.5943	0.0077
38	0.00	12.00	6.2040	0.0090	0.3417	0.0003
39	0.00	0	0.0000	0	0	0.0000
Total			66.3790	12.8441	362.9164	1.000

[a] Sex ratio (F:M) = 1:0.92

Table 3: Population and reproductive parameters of *H. antonii* fed shoots of cashew

No.	Parameters	Formula	Values
1.	T_c, (days)	$\sum l_xm_xx / \sum l_xm_x$	28.26
2.	T, (days)	$\ln R_o / r_m$	27.70
3.	r_c	$\ln R_o / Tc$	0.090
4.	r_m	$\sum e^{-rmx} l_xm_x = 1$	0.092
5.	λ	e^r	1.097
6.	DT, (days)	$\ln 2 / r$	7.52
7.	b	$1 / \sum e^{-rmx} l_x$	1.37
8.	d	$b - r_m$	1.28
9.	Gross reproduction rate	$\sum m_x$	66.38
10.	R_o	$\sum l_xm_x$	12.84

In general, the population parameters (R_o, r_m, λ and adult life span) of *H. antonii* fed shoot of cashew under combined field and laboratory conditions are lower ($R_o = 12.84$; $r_m = 0.092$, λ = 1.097 and adult life span maximum of 24 days) than the population studied by Kilin *et al*. (1998) using cucumber as their food under total laboratory condition ($R_o = 18.95$; $r_m = 0.106$, λ = 1.112 and adult life span about 36 days). It would seem plausible that the field condition had imposed stress in the early development stages and this had influenced the survival and reproductive performance of the adults.

Life tables giving data on the r_m of a particular species provide insight into the characteristic life patterns of different species (Satpute *et al*. 2005). There is a range of innate capacity for individual of a population (Dewitt 1954; Gill *et al*. 1989). Insect's growth, longevity and reproduction could be influenced by their food sources (host plants or host preys). This type of influence can be observed in *Earias vitella* (Lepidoptera: Noctuidae) fed on different host plants (Satpute *et al*. 2005), *Diaphorina citri* fed on four different host plants(Tsai & Liu 2000) and *Orius albidipennis* fed on various arthropod prey (Chyzik *et al*. 1995). The insect growth, longevity and reproduction could also be influenced by environmental conditions such as temperature. Such environmental influence was observed on *Acalymma vittatum* (Coleoptera: Chrysomelidae) in cucurbits (Ellers-Kirk & Fleischer 2006) and *Nasonovia ribisnigri* (Homoptera: Aphididae) in lettuce (Diaz & Fereres 2005).

H. antonii is a polyphagous insect which feeds on various host plants. Cashew is one of the major host plants apart of cocoa, tea and neem. *H. antonii* feeds particularly on the young and succulent parts of this plant. When cashew plants do not have enough reserved food sources for the insects in the area during the dry season, *H. antonii* population would drop and disappear. This situation is caused by lack of food and also influence of dry condition. This is apparent at the study sites as no other alternative host plants were found at the vicinity of the cashew plantation, including cocoa trees.

CONCLUSION

The life table analysis indicated that the survivorship of the *H. antonii* population fed shoots of cashew was a type II with a high hatchability and bulk death occurring during early nymphal stages followed with a relatively lower death throughout the older stages. Oviposition peaking towards the end of the female life span was not an advantage for the population growth because the adult life span was short. The contribution of the female towards female births (m_x) was at a maximum rate on the 16^{th} day of oviposition. The r_m of *H. antonii* fed on cashew reared in field and later in the laboratory (0.092) was lesser than those reared on cucumber in the laboratory (0.106). In this study, the cohort life table was constructed based on unlimited food supply in the environment free from natural enemies. Therefore, predators, parasitoids or pathogens are not included as mortality factors.

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