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Survivorship and Fertility Schedules of a Sumatran Epilachnine "Species" Feeding on *Solanum torvum* under Laboratory Conditions (Coleoptera: Coccinellidae)[1, 2, 3]

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A "species" of Sumatran epilachnine beetle, which is similar to *Epilachna* (=*Henosepilachna*) *sparsa* DIEKE feeding on *Solanum torvum*, was reared under laboratory condition to study the survivorship and fertility schedules. The "species A" required 23.4 days for the development of the immature stages. The mean longevity of the males (87.6 days) was longer than that of females (57.7 days). The mean length of the pre-reproductive period (11.0 days) was longer than that of post-reproductive period (2.3 days). The females laid eggs at a nearly constant rate throughout their reproductive period. The reproductive value V_x/V_0 remained at a high level for most of adult life, as a result of the prolonged survivorship and fertility schedules. The total number of eggs produced per female was 770.7. The intrinsic rate of natural increase r was 0.125 per capita per day. The demographic traits of this species are similar to those of the two cucurbitaceae feeding Sumatran epilachnine beetles studied earlier, and are different from those of temperate species.

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INTRODUCTION

In the preceding paper, the survivorship and fertility schedules of two "species" of Sumatran epilachnine beetles under laboratory conditions were reported (NAKAMURA et al., 1984). The two species feeding on cucurbitaceous plants were similar to *Epilachna sparsa* recorded by DIEKE (1947). NAKAMURA et al. (1984) showed that both "species" were characterized by more prolonged longevity and fertility schedules than temperate species, including Japanese epilachnine beetles. This article presents the duration of successive immature stages and the survivorship and fertility schedules of a solanaceae feeding "species," which is closely related to the two cucurbitaceae feeding ones.

MATERIALS AND METHODS

The Indonesian Archipelago is rich, not only in the number of epilachnine species, but also in the intraspecific variability in populations from the same or different localities (DIEKE, 1947). This has caused great confusion of the identification of Indonesian species, because no critical taxonomic studies have been done on these beetles since the work of DIEKE, despite their economical importance (DE GUNST, 1957; KALSHOVEN, 1981).

The solanaceae feeding "species" was closely similar to *Epilachna* (=*Henosepilachna*) *sparsa* recorded by DIEKE (1947). The "species" was referred to as *Henosepilachna sparsa* like "species A" in our tentative list of the Epilachninae of Sumatera Barat (NAKAMURA et al., 1983). The "species" is quite common at altitudes from 0 to 700 m, feeding on solanaceous crops, such as egg plant *Solanum melongena*, and potato *S. tuberosum*, and on *S. torvum*. *S. torvum* is a perennial shrub-like weed, growing on road sides, fields and in gardens. It is known as "rimbang" (Sumatera Barat) and "takokak" (Java) in local languages, and its fruits are used as human food.

The elytra of "sp. A" have 12 "persistent," and from 0 to 8 "non-persistent" spots (cf. DIEKE, 1947), and the spot pattern may be modified by the enlargement and confluence of the spots. "Sp. A" was much more variable in the elytral spot pattern than the two cucurbitaceae feeding "species," which were referred to as "sp. C" and "sp. D" in the tentative list (NAKAMURA et al., 1983).

The methods of rearing were similar to those for "sp. C" and "sp. D" (NAKAMURA et al., 1984). All the experiments were carried out in the Sumatra Nature Study Laboratory, Andalas University in Padang, under room temperatures ranging from 24 to 32°C. The mean monthly temperature of Padang fluctuated only between 26.7 (September to December) and 27.5°C (May) according to the meteorological data from 1897 to 1941 (Rika Nenpyo, 1982).

Experiment 1. Adults of the "sp. A" were collected from *S. torvum* in Padang and reared in the laboratory to obtain eggs for the experiments. Each egg mass was isolated in a plastic cup (13 cm in diameter and 5 cm in depth) with leaves of *S. torvum*, and records were kept of hatching and of larval moults. The number of larvae reared in a cup was restricted to ten from the third instar onwards, to avoid overcrowding. Ten cups were used for these experiments from August to September 1982 (Period I) and from May to June 1983 (Period II), respectively.

Experiment 2. A pair of newly emerged adults were confined in a plastic cup of the same size to study their survivorship and fertility schedules. Ten pairs were reared with daily checking and exchange of *S. torvum* leaves from August to November 1982.

RESULTS

1. *Developmental times of the immature stages*

The duration of successive immature stages (in days) was as follows:

Period	Egg	L1	L2	L3	L4	Pupa	Total
I (Aug.–Sept. 1982)	3.6	3.7	3.1	3.5	4.6	4.6	23.1
II (May–Jun. 1983)	3.3	3.5	3.3	3.7	5.5	4.3	23.6

2. *Sex ratio of newly emerged adults*

Newly emerged adults of "sp. A" showed no significant deviation from the expected 1 : 1 sex ratio (binomial test, 48 ♀♀ : 51 ♂♂ in Period I and 48 ♀♀ : 48 ♂♂ in Period II).

3. *Egg mass size*

Figure 1 shows the frequency distribution of egg mass size, indicating that the mean size of egg masses was 23.0. This value were somewhat smaller than that observed in field populations, possibly because of the limited space in the cups (unpublised data).

4. *Survivorship and fertility schedules*

Figure 2 shows the survivorship (l_x) of female and male adults and the age specific fertility, which is expressed as the change in the number of eggs laid per female per day. Since the sex ratio of the newly emerged adults was 1 : 1, the age-specific fertility in Fig. 2 is equivalent to $m_x \times 2$ (m_x is usually defined as the number of living females born per female per unit time, Southwood, 1978). The shape of histogram giving the age-specific fertility shows that females produced eggs at a nearly constant rate throughout their long reproductive period, although the fertility declined to some extent around day 50 of the female's adult life (Fig. 2). Table 1 also summarizes the longevity, fecundity, intrinsic rate of natural increases (r) and mean length of a generation (T).

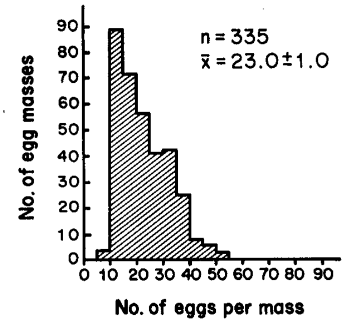

Fig. 1. Frequency distribution in the size of egg masses of *Epilachna* "sp. A." The number of masses examined (n) and values of mean ($\bar{x}$) with 95% confidence limits are given in the figure.

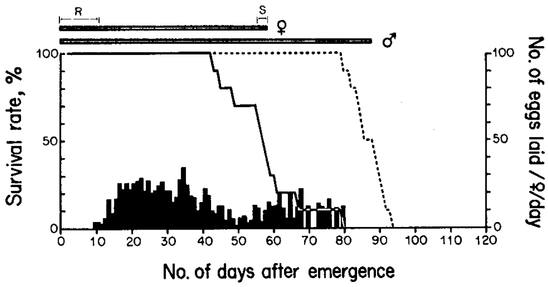

Fig. 2. Survivorship and fertility schedules of *Epilachna* "sp. A" under laboratory condition. Solid and dotted lines refer to survivorship curves for males and females, respectively, and the histogram shows the number of eggs laid per female per day. The horizontal bars above the figure depict the average longevity of both sexes, and R and S the average length of the pre- and post-reproductive period.

Table 1. Survivorship and fertility schedules of *Epilachna* "sp. A" under laboratory condition

Food plant	*Solanum torvum*
No. replication	10
Longevity (in days) of males	87.6±3.3 (80–94)[a]
〃 of females	57.7±8.0 (43–81)
Pre-reproductive period (in days)	11.0±1.5 (8–15)
Post-reproductive period (in days)	2.3±1.3 (1–7)
Fertility (total no. of eggs laid per female)	770.7±108.2 (590–1,115)
Intrinsic rate of natural increase (per capita per day), r	0.125
Mean length of a generation (in days), T	47.6

[a] Average±95% confidence limits (range).

Table 1 also shows that the mean longevity of the males (87.6 days) was significantly longer than that of the females (57.7 days). The mean length of the pre-reproductive period (11.0 days) was much longer than that of the post-reproductive period (2.3 days), and although the duration of the pre-reproductive period of the females varied considerably, i.e. 8–15 days, Kendall's rank test (τ) revealed that the female's age at first oviposition (in days) was not significantly correlated with either age at final oviposition or with age at death.

The intrinsic rate of natural increase r was determined by solving the equation $\sum e^{-rt} l_t m_t = 1$ for r, where t is age in days (Birch, 1948). We need the life table of both the immature and adult stages for the calculation of r, and in practice, we assumed, first, that no death occurred in the immature stages, because the eggs, larvae and pupae rarely died unless we mishandled them, and second, that the length of immature stages were 23.4 days (i.e. the average of Periods I and II, see p. 52).

The net reproductive rate R_0 $(=\sum l_x \cdot m_x)$ is the average number of female eggs produced per female adult. The mean length of generation T was derived from $T = \log R_0 / r$.

The values of r, R and T, thus derived, were 0.125, 385.4 (eggs/♀), and 47.6 (days), respectively (Table 1). The total number of eggs produced per female was 770.7 (range 590–1,115), that is twice the value of R_0.

Fisher's (1930) reproductive value is given by

$$\frac{V_x}{V_0} = \frac{e^{-rx}}{l_x} \sum_{t=x}^{\infty} e^{-rt} l_t m_t \Delta t$$

where Δt is an interval for measuring l_x and m_x ($\Delta t = 1$ in this case). The reproductive value of an individual usually increases until the age of first reproduction and then it decreases with age. However, the reproductive value of "sp. A" had a smooth peak on day 39.4 (i.e. 16 days and 5 days after the start of the female's adult life and of the female's reproductive period, respectively). The reproductive value dropped rapidly during the first 25 days after the peak and then it remained at a relatively constant level until near the end of the female's life span (Fig. 3). Thus, "sp. A" showed a high reproductive value for most of its life span, as a result of its prolonged survivorship and fertility schedules (Fig. 2).

DISCUSSION

Nakamura et al. (1984) presented the survivorship and fertility schedules of two

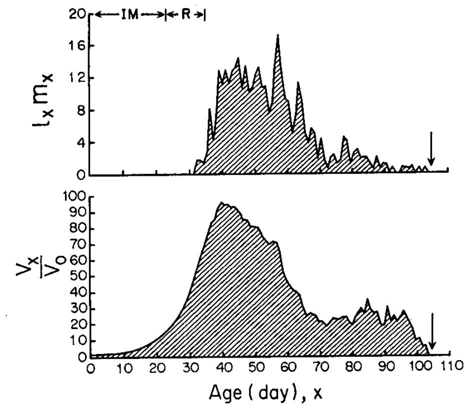

Fig. 3. Reproductive function ($l_x \cdot m_x$, top) and reproductive value (V_x/V_0, bottom) plotted against age for *Epilachna* "sp. A." *IM*: duration of the immature stages. *R*: mean duration of the pre-reproductive period. Vertical arrow shows the death of the females.

Sumatran epilachnine "species" under laboratory conditions. The two, "sp. C" and "sp. D," are also taxonomically similar to *Epilachna sparsa* DIEKE, and the former feeds on bitter cucumber *Momordica charantia* and the latter on many kinds of crop, such as squash *Cucurbita* sp., cucumber *Cucumis sativus* and sponge cucumber *Luffa acutangula*.

This article shows that "sp. A" had similar survivorship and fertility schedules to those of the two cucurbitaceae feeding "species." First, the longevity of males was significantly longer than that of females (i.e. the former was 70.5 days in "sp. C" and 88.6 in "sp. D" and the latter was 63.8 days in "sp. C" and 63.9 in "sp. D," respectively). Secondly, the mean length of the pre-reproductive period (18.9 days in "sp. C" and 15.5 in "sp. D") was much longer than that of post-reproductive period (4.0 days in "sp. C" and 5.2 in "sp. D"). Thirdly, the values of r (0.103 in "sp. C" and 0.124 in "sp. D"), R_0 (332.7 in "sp. C" and 379.2 in "sp. D") and T (58.1 in "sp. C" and 49.5 in "sp. D") are similar in all three "species" (Table 1, NAKAMURA et al., 1984). Finally, the fertility of "sp. C" increased even at the end of the life and "sp. D" produced eggs at a nearly constant rate throughout its reproductive period (Figs. 2–5, NAKAMURA et al., 1984). This was similar to that of "sp. A," and quite different from that of temperate species, which usually have a clear peak in egg production at the beginning of the reproductive period (e.g. PEFEROEN et al., 1981 for the Colorado potato beetle *Leptinotarsa decemlineata*; ZALUCKI, 1981 for several species of butterfly). All three "species" of *Epilachna* were similar in these demographic traits, but "sp. A" was more like "sp. D" than "sp. C" in the above mentioned parameters, and also in the mean egg mass size (23.0 in "sp. A," 28.1 in "sp. D" and 45.6 in "sp. C").

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