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## The influence of cucurbitaceous weeds on the bionomics of the pest species, *Epilachna cucurbitae* Rich. (Col., Coccinellidae)

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### Abstract

The pest species *Epilachna cucurbitae* Richards can survive on a diet of weeds: paddy melon (*Cucumis myriocarpus*) or camel melon (*Citrullus lanatus*). Compared with a diet of crops, fecundity is reduced, and just under half the number of generations are produced in a year. Of the two weeds, *Ct. lanatus* is the preferred food. The development rate on these weeds is the slowest recorded for cucurbitophagous epilachnines. The duration of preoviposition and oviposition periods are double those on crops, the postoviposition only half as long. On *Cu. myriocarpus*, adult male longevity is the longest recorded for an epilachnine, and adult female longevity is the longest for any cucurbitophagous epilachnine. While the total number of eggs laid, number of eggs per batch, and total number of egg batches is similar on weeds and crops, the number of eggs laid per day and the hatch per egg batch on weeds are less than half those on crops. On *Cu. myriocarpus* the number of eggs laid per day is the lowest for cucurbitophagous epilachnines. Far more eggs are destroyed by adults on weeds than on crops, on *Cu. myriocarpus* 28% of the total number laid. On *Ct. lanatus*, *E. cucurbitae* exhibits a temperate reproductive pattern, similar to that on crops, but on *Cu. myriocarpus* it is closer to a tropical pattern.

### 1 Introduction

The Epilachninae are a phytophagous tropical and semitropical subfamily of Coccinellidae which are important pests of agricultural crops. In Australia, they are particularly important in the eastern States (RICHARDS 1983). The bionomics of this subfamily has only recently been studied. ALI (1979) has examined the effect of temperature, photoperiod and food plants on the biology of the alfalfa ladybird *Subcoccinella vigintiquatuorpunctata* (L.) in Europe and the biology of the melon ladybird *E. elaterii* (Rossi) in Egypt (ALI and EL-SAEADY 1981, 1982). NAKAMURA et al. (1984) and ABBAS et al. (1985) have also described development, fecundity and mortality in three unidentified species of *Epilachna* from Sumatra. More recently, KATAKURA et al. (1988) have tentatively identified the Sumatran species, but no type material has been examined. The Egyptian species and two of the Sumatran species feed on Cucurbitaceae, while the other Sumatran species attacks Solanaceae.

Three of the most widespread and important epilachnine pest species, comprising the *Epilachna vigintioctopunctata* complex, all occur in Australia. Two of them, *E. vigintioctopunctata pardalis* (Boisduval) and *E. vigintisepunctata vigintisepunctata* (Boisduval), attack members of the Solanaceae, while *E. cucurbitae* Richards is a pest of the Cucurbitaceae (RICHARDS 1983). The influence of food plants on the development, mortality, fecundity, fertility and longevity of these three species (referred to here as *pardalis*, *26-punctata* and *cucurbitae*) has been studied and compared with the biology of epilachnine species in other parts of the world (RICHARDS and FILEWOOD 1988). The importance of solanaceous weeds as an alternative diet has been demonstrated.

Unlike the two solanivorous species, *cucurbitae* is very widely distributed throughout much of Australia (RICHARDS 1983) and, of the three species, is the most adapted to the Australian environment. Although there are very few endemic Cucurbitaceae, there are

many native and introduced species, particularly in the more arid parts of the continent. Two of these, camel melon (*Citrullus lanatus*) and paddy melon (*Cucumis myriocarpus*), were introduced from South Africa during the last century (JACOBS and PICKARD 1981). Camels had been imported into Australia for transport of men and equipment across arid regions and the two species of weeds were used as camel food. Both plant species are now well established throughout the arid zone in all mainland States. At Fowlers Gap, near Broken Hill in western New South Wales, these weeds and *cucurbitae* occur together. This prompted research into the role of these weeds as an alternative food for *cucurbitae* and their importance for its spread throughout arid areas where cucurbitaceous crops do not occur. This study investigates under laboratory conditions the effect of paddy melon and camel melon on development, mortality, fecundity, fertility and longevity in *cucurbitae*. Comparison is made with results obtained on crops, using similar temperatures, relative humidity and photoperiod (RICHARDS and FILEWOOD 1988).

## 2 Materials and methods

Cultures of *cucurbitae* were established and maintained in the laboratory from adults collected in the field. In the fecundity trials, it was fed on two cucurbitaceous weeds, camel melon (*Citrullus lanatus*) and paddy melon (*Cucumis myriocarpus*) grown under glasshouse conditions. Isolated pairs of adults were used in all fecundity experiments. Each replicate consisted of a pair of teneral adults reared from experiments on the duration of immature development, so that all stages of the life cycle were kept on the same plant species. Each pair of adults was placed in a perspex cage and provided with a regular supply of fresh leaves from the selected plant species. The cages were kept in a cabinet maintained at 25°C, 75% R.H. and a 14:10 L:D photoperiod. Food plants were checked each day for eggs. All egg batches were removed, eggs counted and hatchings recorded. Each experiment was continued until the death of all insects on a particular food plant. To assess development rate and mortality on *Ct. lanatus* and *Cu. myriocarpus*, newly hatched larvae of *cucurbitae* were placed individually in a series of glass phials with cotton wool stoppers. They were inspected each day and fed on a particular food plant until emergence of the adult beetle, when they were sexed.

## 3 Results

### 3.1 Duration of developmental stages

The duration of developmental stages in *cucurbitae* on *Cu. myriocarpus* and *Ct. lanatus* is given in table 1. Variations in total development time on the two food plants were not significant [( $p > 0.05$ ); Hochberg  $GT_2$  test, Spjøtvoll Stoline  $T'$  test and Tukey Kramer test

Table 1. Duration of developmental stages and survivorship in *E. cucurbitae* on different food plants at 25 °C, L:D = 14:10

Food plant	<i>Cucumis myriocarpus</i>			<i>Citrullus lanatus</i>		
	n	Mean (days)	SEM	n	Mean (days)	SEM
Incubation	50	5.56	0.15	40	5.71	0.31
1	46	6.67	0.17	33	6.97	0.37
2 Larval	45	4.91	0.15	28	6.29	0.28
3 Instars	44	5.09	0.13	28	5.43	0.19
4	44	6.48	0.24	28	5.39	0.09
Prepupa	44	2.00	0.07	27	2.67	0.16
Pupa	44	5.20	0.08	27	5.33	0.11
Preoviposition	5	29.40	3.91	5	16.40	1.60
Oviposition	5	113.80	14.50	5	70.20	12.35
Postoviposition	5	15.80	3.99	5	15.20	4.50
Generation $T$		136.73			100.66	

(SOKAL and ROHLF 1969)], and variations in duration of individual larval and pupal instars were significantly different ( $p < 0.01$ ) only in the second larval and prepupal instars. Both total larval and total pupal development were longer on *Ct. lanatus*, but only pupal development was significantly different ( $p < 0.01$ ). Duration of total development on both weeds was significantly longer ( $p < 0.01$ ) than on the crops, pumpkin (*Cucurbita maxima*), marrow (*C. pepo*) and cucumber (*Cucumis sativus*) (RICHARDS and FILEWOOD 1988), averaging 31.3 days on the weeds, 1.4 times that on the crops. Total development was longest on *Ct. lanatus* (32.3 days) and shortest on *C. pepo* (21.4 days). Increases in length of development were more marked in larval than in pupal instars. Total larval development on both weeds was significantly longer ( $p < 0.01$ ) than on the crops, averaging 23.6 days, 1.4 times that on the crops. It was longest on *Cu. lanatus* (24 days) and shortest on *C. pepo* (15.1 days). Duration of the fourth instar on *Ct. lanatus* was significantly longer ( $p < 0.01$ ) than on *C. maxima* and *C. pepo*, while on *Cu. myriocarpus* it was significantly longer than on *C. maxima* ( $p < 0.01$ ) and *C. pepo* ( $p < 0.05$ ). Duration of each of the first three larval instars was significantly longer on weeds ( $p < 0.01$ ) than on crops and was particularly marked in the first instar. Length of pupal development appeared to be affected by larval diet and was significantly longer on weeds ( $p < 0.01$ ), averaging 7.6 days, 1.2 times that on crops. It was longest on *Cu. lanatus* (8 days) and shortest on *C. maxima* (6.1 days). The sex ratio of reared teneral adults on both weeds was about 1:1.

### 3.2 Mortality

Mortality rates per day were calculated using the formula

$$m = 1/T [\log_e(N_1/N_0)].$$

The level of mortality in *cucurbitae* was influenced by the food plant on which the larvae were reared, with high mortality in a particular instar influencing overall results. The daily rate in immatures on *Cu. myriocarpus* (0.014) was almost identical with that on *Ct. lanatus* (0.013). The larval rate in the first instar was higher than in the other three instars combined, being 0.031 on *Ct. lanatus* (3.2 times higher) and 0.014 on *Cu. myriocarpus* (2.8 times higher). The total larval rate of 0.016 on *Ct. lanatus* was 3.5 times that on *Cu. myriocarpus*. It was also 3.5 times the total pupal rate, while on *Cu. myriocarpus* it was 4.4 times higher. Prepupal mortality was equal with pupal mortality on *Cu. myriocarpus*, while pupal mortality was zero on *Ct. lanatus*.

Including mortality results in *cucurbitae* on *C. maxima*, *C. pepo* and *Cu. sativus* (RICHARDS and FILEWOOD 1988), the total daily rate remained highest on *C. pepo* (0.038), being 2.7 times the rate on *Cu. myriocarpus* and 3.0 that on *Ct. lanatus*; the rates on *Cu. sativus*, *Cu. myriocarpus* and *Ct. lanatus* were very similar, ranging from 0.013–0.014. On all five food plants, the larval rate in the first instar was higher than in the other three larval instars combined, with the rate on *Cu. myriocarpus* the lowest of the five. The highest total larval rate of 0.029 on both *C. maxima* and *C. pepo* was 1.8 times that on *Ct. lanatus* and 3.4 times that on *Cu. myriocarpus*. On both weeds, total larval rates compared with total pupal rates were higher than those on the crops. The total larval rate (0.0045) on *Cu. myriocarpus* was approximately 0.5 that on *Cu. sativus*, the previous lowest, with *Ct. lanatus* lying between *C. maxima* and *C. pepo*.

### 3.3 Fecundity

The different plant species on which *cucurbitae* was fed influenced its fecundity [measure of total egg production (SOUTHWOOD 1978)]. On *Ct. lanatus* fecundity was higher than on *Cu. myriocarpus* – the mean total number of eggs laid per female (table 2) being 1.2 times higher; the mean number of eggs laid per day 1.6 times higher and mean total egg hatch 1.4

Table 2. Fecundity in *E. cucurbitae* on two food plants at 25 °C, L:D = 14:10

Food plant	<i>Cucumis myriocarpus</i>		<i>Citrullus lanatus</i>	
	Mean (n = 5)	SEM	Mean (n = 5)	SEM
Eggs laid	708.30	144.33	837.00	261.63
Eggs hatched	267.60	182.72	377.90	158.86
Eggs/day	6.10	1.83	9.78	2.34
Eggs damaged	23.80	11.69	22.40	11.17
Eggs eaten	177.60	35.78	115.50	11.32
Egg hatch/batch	7.78	1.31	8.52	3.07
<i>r</i>		0.04		0.05
<i>R</i> <sub>0</sub>		147.32		171.00

times greater, all differences between the two species being non-significant ( $p > 0.05$ ). On weeds and crops combined (RICHARDS and FILEWOOD 1988), there were no differences ( $p > 0.05$ ) between the total number of eggs laid on each species, number of egg batches, number of eggs per batch, number of eggs which hatched per batch, number of eggs per day or total hatch. The mean total number of eggs laid was highest on *C. pepo* (1145), being 1.4 times that on *Ct. lanatus*, 1.5 times that on *Cu. sativus*, 1.6 that on *Cu. myriocarpus* and twice that on *C. maxima*. The mean number of eggs per batch was also highest on *C. pepo* (31.5), being 1.5 times that on *C. maxima*, *Cu. myriocarpus* and *Ct. lanatus* and 1.2 that on *Cu. sativus*. These results show no preference for crops. However, the mean number of eggs laid per day on *Cu. sativus* (1895) was 3.1 times that on *Cu. myriocarpus* and 1.9 times that on *Ct. lanatus*; mean hatch per egg batch on *C. pepo* (18.88) was 2.4 times that on *Cu. myriocarpus* and 2.2 times that on *Ct. lanatus*; and mean total hatch on *C. pepo* (688) was 2.6 times that on *Cu. myriocarpus* and 1.8 times that on *Ct. lanatus*, these results all favouring crops. On combined crops, the mean hatch per batch was 1.9 times that on combined weeds and significantly different ( $p < 0.01$ , *t* test); the mean number of eggs laid per day was 2.2 times that on weeds and also significantly different ( $p < 0.01$ , *t* test); mean total hatch was 1.5 times that on weeds; mean total number of egg batches and mean number of eggs per batch were both 1.2 times that on weeds; and mean total number of eggs laid 1.0 times that on weeds, all being non-significantly different. The lower hatch on weeds was influenced by females eating their own eggs, something rarely observed in females feeding on crops. On *Ct. lanatus* 115 eggs (13.7%) were eaten, while on *Cu. myriocarpus* this increased to 178 eggs (25.1%).

The number of times a population will multiply per generation is described as the net reproductive rate  $R_0$ , that is the average number of female eggs produced per female beetle. This parameter was calculated using the formula

$$R_0 = 1_x m_x$$

(SOUTHWOOD 1978). Analysis of  $R_0$  based on the survivorship and fertility figures in table 2, and including results on the crops (RICHARDS and FILEWOOD 1988), showed that those beetles fed on *C. pepo* still had the highest reproductive rate, with those on *Ct. lanatus* 0.78 and on *Cu. myriocarpus* 0.67 of that rate, both lying between *Cu. sativus* and *C. maxima*. The mean total number of eggs laid per female (table 2) was 4.9 times the value of  $R_0$  on *Ct. lanatus* and 4.8 times its value on *Cu. myriocarpus*, half-way between that on *C. pepo* and *C. maxima*. Figure 1 shows that the frequency distribution of egg batch size in *cucurbitae* was variable on the weeds, with very little difference in mean egg batch numbers, approximately the same as on *C. pepo*. The distribution of number of egg batches and number of eggs per batch on *Ct. lanatus* and *Cu. myriocarpus* was significantly different ( $p < 0.05$ ; log likelihood ratio test). The distribution on *Ct. lanatus* was

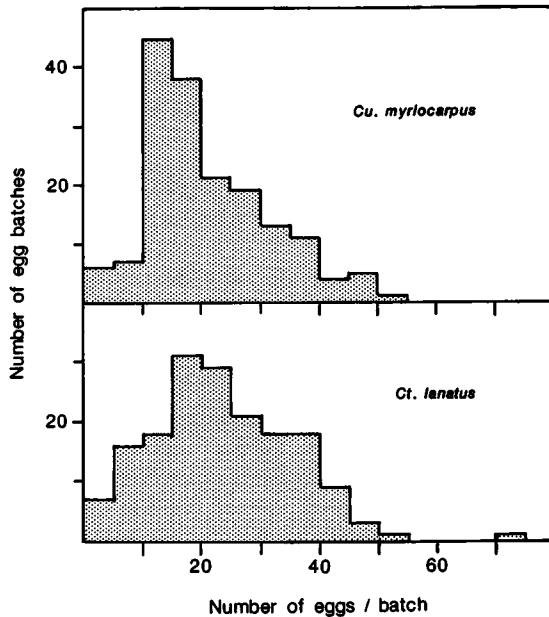


Fig. 1. The frequency distribution of egg batch size in *E. cucurbitae* on different food plants. The number of egg batches is 170 on *Cu. myriocarpus* and 172 on *Ct. lanatus*

significantly different from that on *Cu. sativus* ( $p < 0.01$ ), while on *Cu. myriocarpus* it was significantly different from that on both *C. pepo* and *Cu. sativus* ( $p < 0.01$ ). Similar tests on frequency distribution grouping crops against weeds were not significant ( $p > 0.05$ ).

### 3.4 Survivorship and fertility

Survivorship, the falling of numbers with time ( $l_x$ ) (SOUTHWOOD 1978) in both male and female adults of *cucurbitae* on different food plants is shown in fig. 2. The age-specific fertility, expressed as the change in the number of eggs laid per female per day, is also shown. As a sex ratio of about 1:1 was obtained, the age specific fertility for the two populations equals  $2m_x$  [twice the number of living females born per female per unit time (SOUTHWOOD 1978)].

Table 1 gives the overall mean longevity in *cucurbitae* on *Cu. myriocarpus* and *Ct. lanatus* together with the length of generation time  $T$ . The longevity of males and females was variable on both food plants, and a tendency for males to live longer than females (fig. 2), was not significantly different within or between sexes ( $p > 0.05$ ,  $GT_2$ ,  $T'$  and Tukey Kramer tests). On crops and weeds combined, male longevity was longest on *Cu. myriocarpus* (178 days) and shortest on *Cu. sativus* (92 days), but there was no significant difference. While female longevity on *Ct. lanatus* (104 days) was not significantly different from that on the other four food plants, on *Cu. myriocarpus* (159 days) it was significantly longer than on both *C. maxima* and *Cu. sativus* ( $p < 0.05$ ,  $T'$  and Tukey Kramer tests). With both sexes combined, longevity on *Cu. myriocarpus* averaged 168 days, 1.5 times that on *Ct. lanatus* and *C. pepo*, 1.7 times that on *C. maxima* and twice that on *Cu. sativus*, but was not significantly longer. On combined weeds, longevity was 1.4 times that on combined crops and significantly different ( $p < 0.05$ ,  $t$  test).

The preoviposition period on *Cu. myriocarpus* (29 days) was 1.8 times that on *Ct. lanatus* (table 1), and significantly different ( $p < 0.01$ ,  $t$  test). It was also significantly

longer than on the crops ( $p < 0.05$ , T' and Tukey Kramer tests), being 2.4 times that on *C. maxima*, 3.0 that on *Cu. sativus* and 3.2 that on *C. pepo*. On *Ct. lanatus*, preoviposition was 1.3 times that on *C. maxima*, 1.7 that on *Cu. sativus* and 1.8 that on *C. pepo*, but not significantly longer. On the combined weeds, preoviposition was more than twice that on the combined crops and was significantly different ( $p < 0.01$ , t test).

The oviposition period on *Cu. myriocarpus* (114 days) was 1.6 times that on *Ct. lanatus* (table 1), but not significantly different. It was also much longer than on the crops, being 1.6 times that on *C. pepo*, 2.4 that on *C. maxima* and 2.6 that on *Cu. sativus*, and was significantly different from the periods on both *C. maxima* and *Cu. sativus* ( $p < 0.05$ , T' and Tukey Kramer tests). On *Ct. lanatus* and *C. pepo*, the oviposition periods were similar and approximately 1.5 times those on the other two crops, but not significantly different. On the combined weeds, the oviposition period was 1.8 times longer and significantly different from that on the combined crops ( $p < 0.05$ , t test).

The histograms of age-specific fertility in *cucurbitae* (fig. 2) show that on *Ct. lanatus* the fertility curve was similar to that on crops, reaching a peak fairly early in the oviposition

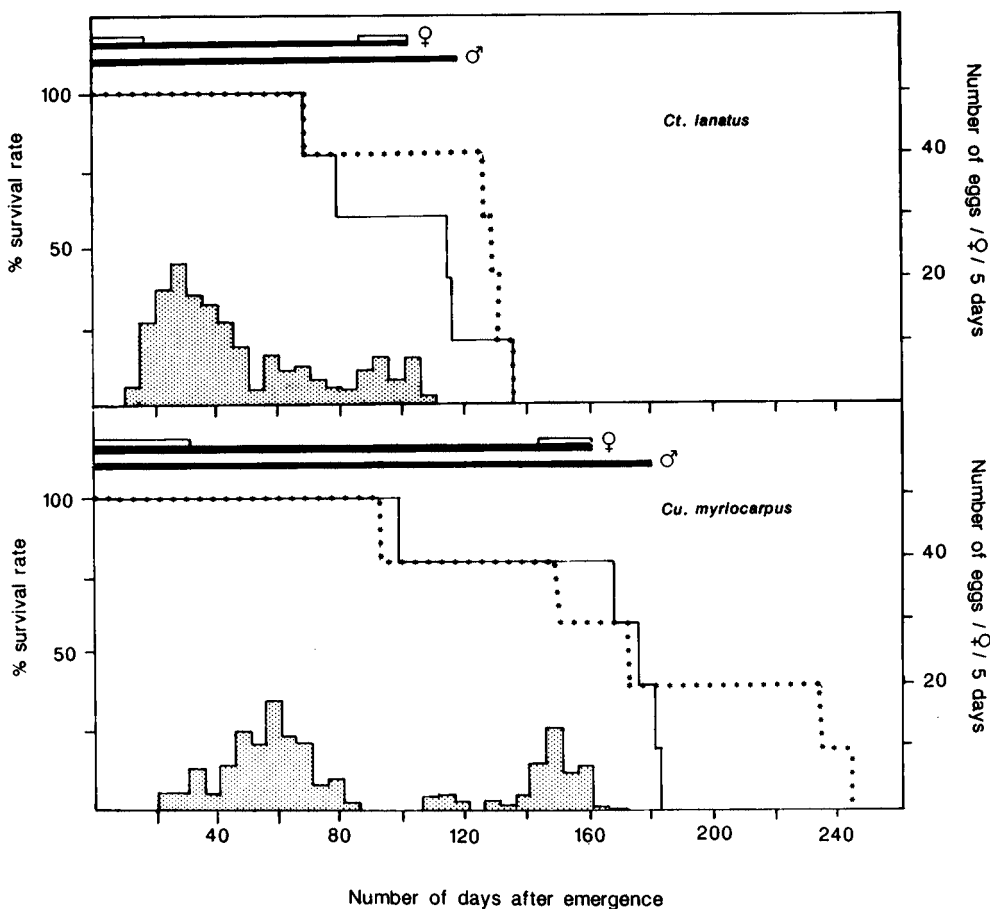


Fig. 2.  $1, m_x$  schedules in *E. cucurbitae* on *Cu. myriocarpus* and *Ct. lanatus*. Solid and starred lines are survivorship curves for females and males respectively. The histogram shows the number of eggs laid per female per 5 days. The horizontal bars depict the mean longevity for both sexes. The boxes above the female bar show the duration of pre- and postoviposition periods

period and then declining over the rest of the period. On *Cu. myriocarpus* it was bimodal and 1.6 times longer than on *Ct. lanatus*. After a slow start, the first peak was reached 32 days after the peak on *Ct. lanatus*, with a second lower peak occurring towards the end of the oviposition period. Because of the variability in length of the preoviposition period, Kendall's rank correlation coefficients were used to test whether the female's age at first oviposition was significantly correlated with her age at final oviposition and her age at death. On neither *Ct. lanatus* nor *Cu. myriocarpus* were differences significant.

The postoviposition periods on *Ct. lanatus* and *Cu. myriocarpus* were similar (table 1) and neither was significantly different ( $p > 0.05$ ,  $GT_2$ ,  $T'$  and Tukey Kramer tests) from those on crops. Combined, their length was approximately 0.5 that on crops and significantly shorter ( $p < 0.05$ ,  $t$  test). Postoviposition on *Cu. myriocarpus* was 0.5 the preoviposition period, while on *Ct. lanatus* the two periods were approximately equal, neither ratio being significantly different (Kruskall-Wallis test). This was reversed on crops, where the combined postoviposition period was 3 times longer than the combined preoviposition period (RICHARDS and FILEWOOD 1988) and significantly different from the ratio on *Cu. myriocarpus* ( $p < 0.01$ ) and on the combined weeds ( $p < 0.01$ ).

The intrinsic rate of natural increase  $r$  describes the growth potential of a population under given climatic and food conditions. Under a stable age distribution with the population still growing in an unlimited environment and using the  $l_x m_x$  values obtained from table 2,  $r$  can be determined using the expression

$$\sum_x e^{-rx} l_x m_x = 1$$

(SOUTHWOOD 1978). For this both immature and adult stages are involved. In *cucurbitae* the  $r$  value per individual per day was 0.08 on crops and 0.045 on weeds (table 2), approximately 0.5 that on crops. It should be stressed that these conditions rarely occur naturally.

Another parameter, generation time  $T$  was obtained using the expression

$$T = \log R_0 / r$$

(SOUTHWOOD 1978). In *cucurbitae* it ranged between 60.8 and 136.7 days on different food plants. A generation on weeds (table 1) took between 1.5 to more than twice that on crops, due to longer preoviposition and oviposition periods.

#### 4 Discussion

The food preference experiments reported here have demonstrated the influences of cucurbitaceous weeds on the development rate, fertility and fecundity of *cucurbitae* under conditions of constant temperature and photoperiod. *E. cucurbitae* has been shown to survive for long periods of time on an alternative diet of weeds, even though this has led to retarded growth and much lower levels of fertility and fecundity than were obtained on crops (RICHARDS and FILEWOOD 1988).

Comparative trials with *cucurbitae* on *Cu. myriocarpus* and *Ct. lanatus* have revealed its preference for *Ct. lanatus*. On *Cu. myriocarpus*, the preoviposition period is almost double that on *Ct. lanatus*, the oviposition period is also considerably longer, with fecundity and egg hatch much lower. The intrinsic rate of natural increase per female per day is lower and is not compensated for by the long oviposition period. The reproductive rate per female is also lower and generation time  $T$  is 1.4 times longer, indicating the potential for fewer generations per year and the production of fewer offspring per female on this food plant. Results on *Ct. lanatus* are closer to those obtained on crops, with the exception of the development rate which exceeds that on *Cu. myriocarpus*.

Results for *cucurbitae* separate the three crops and two weeds into two groups. On

weeds, the development rate is 1.4 times that on crops, total longevity in both males and females is 1.4 times longer, the preoviposition period twice as long and the oviposition period 1.8 times longer. In contrast, the length of the postoviposition period is short, being 0.5 that on crops. The total number of eggs laid, number of eggs per batch and total number of egg batches are similar in both groups; but on crops about 2.1 times more eggs are laid per day, total egg hatch is 1.4 times higher and the hatch rate per egg batch is more than double that on weeds. The preoviposition, oviposition and postoviposition periods, number of eggs laid per day and hatch per egg batch on weeds are all significantly different ( $p < 0.05$  or  $p < 0.01$ ) from those on crops. While the reproductive rate per female is similar in both groups, the intrinsic rate of natural increase per female per day on crops is 1.6 times that on weeds and generation time  $T$  on weeds is 1.8 times longer than on crops. This indicates nearly double the number of generations and greater reproductive capacity in *cucurbitae* when fed on crops.

The duration of developmental stages in epilachnines is influenced by the food plant. Compared with other cucurbitophagous epilachnines under similar environmental conditions, the development rate in *cucurbitae* on *Ct. lanatus* and *Cu. myriocarpus* is by far the longest, being 8–10 days longer than in *elaterii* on *C. pepo*, *Cu. sativus* and *Ct. lanatus* (= *Ct. vulgaris*) (ALI and EL-SAEADY 1981), and about 12 days longer than in the Sumatran species *Epilachna* sp. "C" on bitter melon (*Momordica charantia*) and *Epilachna* sp. "D" on *Cucurbita* sp. (NAKAMURA et al. 1984). It is also about 8–10 days longer than in the Mexican bean beetle (*E. varivestis* Mulsant) on beans [*Phaseolus vulgaris* (Papilionaceae)] (KOGAN 1977). This development rate in *cucurbitae* on weeds is similar to that in the solanivorous species *26-punctata* on nightshade (*Solanum nigrum*) and tomato (*Lycopersicon esculentum*) and *pardalis* also on *S. nigrum* (RICHARDS and FILEWOOD 1988).

Previous results have indicated that the length of the preoviposition period in epilachnines is influenced by the family of plants on which they feed and to a lesser extent by particular plant species within the family. While this is the case in *cucurbitae* on *Ct. lanatus*, results on *Cu. myriocarpus* are much closer to those in *26-punctata* and *pardalis* on Solanaceae. Again, while the oviposition period on *Ct. lanatus* is similar in length to that on *C. pepo*, on *Cu. myriocarpus* it is more than double the average length (50 days) for all other epilachnine species studied, with the exception of *pardalis* on *S. nigrum*, which exceeds it by 14 days (RICHARDS and FILEWOOD 1988). The much longer period cannot be related to higher egg production, as the total number of eggs laid is half-way between the total laid by *Epilachna* sp. "C" on *M. charantia* (NAKAMURA et al. 1984) and the total laid by *cucurbitae* on *Cu. sativus* and *Epilachna* sp. "D" on *Cucurbita* sp. The length of the postoviposition period in epilachnine species is variable, but can be separated into two groups within a species depending on whether it has fed on essential or alternative food. In *cucurbitae*, the period on alternative food is half that on essential food, while in *26-punctata* it is 14 times longer.

In *cucurbitae*, adult longevity on weeds has increased the total life span in this species 1.2 times, or an extra 16 days. Female longevity has increased from 1.5 to 1.7 times that in *Epilachna* spp. "C" and "D" (NAKAMURA et al. 1984) and from 1.5 to 1.6 times that in *varivestis* (BERNHARDT and SHEPARD 1978); while male longevity has increased from 1.5 to 1.7 times that in *Epilachna* sp. "C" and from 1.2 to 1.4 times that in *Epilachna* sp. "D". On *Cu. myriocarpus*, adult longevity in *cucurbitae* is the longest recorded for epilachnines, exceeding *pardalis* on *S. nigrum* by 3 days (RICHARDS and FILEWOOD 1988). Male longevity on *Cu. myriocarpus* is also the longest recorded for an epilachnine, exceeding that in *26-punctata* on common thornapple (*Datura stramonium*) by 4 days. It is 2.5 times that in *Epilachna* sp. "C" and 2.1 times that in *Epilachna* sp. "D". Female longevity is the longest recorded for a cucurbitophagous epilachnine, being 2.5 times that in *Epilachna* spp. "C" and "D". It exceeds *26-punctata* on apple of Peru (*Nicandra physalodes*) by 6 days and is exceeded only by *pardalis* on *S. nigrum*, which lives an extra 35 days.



Unlike Australian solanivorous epilachnines, where much higher egg production occurs on crops than on weeds, such as *D. stramonium* and *N. physalodes*, fecundity in cucurbitophagous epilachnines is fairly stable. However, on weeds the number of eggs laid per day is considerably reduced, resulting in total egg production being spread over a much longer period. On *Cu. myriocarpus*, this daily rate is the lowest recorded on Cucurbitaceae, being approximately 0.3 that laid on crops, while on *Ct. lanatus* it is 0.6 that on crops. The lowest rate per day in epilachnines occurs in *26-punctata* on *N. physalodes* and is 0.6 that on *Cu. myriocarpus*; but here the oviposition period is reduced to 0.6 that on crops. A number of eggs may be damaged during laying and predation by adults and larvae may also occur, further reducing the number of viable eggs. This can be directly related to whether females are feeding on essential or alternative food. In Australian epilachnines, a much higher proportion of eggs are destroyed on weeds than on crops – 2.64 times more in *cucurbitae* and 2.82 times more in *26-punctata*. In *cucurbitae*, damaged eggs on *Cu. myriocarpus* comprise about 28% of the total number laid, the highest number recorded under controlled conditions, and about 1.47 times higher than the previous record in *26-punctata* on *D. stramonium*. In all three Australian species, mean hatch is approximately 0.5 of mean fecundity, similar to that in *elaterii* (ALI and EL-SAEADY 1981), but about 0.67 that in *variovestis* (BERNHARDT and SHEPARD 1978). The very high fecundity in Australian epilachnines is counterbalanced by the low hatch rate.

On *Ct. lanatus*, *cucurbitae* conforms to a typical temperate reproductive pattern (fig. 2). The age specific fertility curve is similar to that on cucurbitaceous crops (RICHARDS and FILEWOOD 1988), with a marked peak near the beginning of the reproductive period. Total egg production is also similar, spread over an equivalent time span, but the value of  $r$  is lower. In contrast, on *Cu. myriocarpus* the fertility curve is bimodal and prolonged (fig. 2), being 1.7 times that on crops and 2.2 times that on *Epilachna* spp. "C" and "D" (NAKAMURA et al. 1984). The first peak comes much later and is lower than in a typical temperate reproductive pattern, with the second smaller peak close to the end of the reproductive period. The value of  $r$  is reduced to 0.5 times that on crops. This is closer to, but not typical of, a tropical reproductive pattern (BIRCH et al. 1963), for instead of reduced total egg production, it is similar to that on crops, but spread over a longer period.

These results have confirmed that the introduction and establishment of the cucurbitaceous weeds *Ct. lanatus* and *Cu. myriocarpus* in arid parts of Australia have assisted in the current distribution of *cucurbitae* (RICHARDS 1983). When fed on *Ct. lanatus*, it is able to maintain the normal reproductive pattern exhibited on cucurbitaceous crops. However, on *Cu. myriocarpus* it suffers a markedly reduced reproductive rate and a very low daily rate of egg production, comparable with rates in solanivorous epilachnines feeding on weeds. Nevertheless, the very long reproductive period, long life span and long generation time  $T$  show that it can survive for extended periods on this alternative food, while awaiting more favourable conditions.

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### Zusammenfassung

#### Der Einfluß von Cucurbitaceen-Kräutern auf die Biologie der Schädlingsart *Epilachna cucurbitae* Rich. (Col., Coccinellidae)

Der Schädling *Epilachna cucurbitae* Rich. kann sich von zwei Kräutern ernähren: der „Paddy Melon“ (*Cucumis myriocarpus*) und der Kamelmelone (*Citrullus lanatus*). Die Fortpflanzungsrate auf diesen Futterpflanzen ist verringert, verglichen mit Getreide: Weniger als die Hälfte an Generationen pro Jahr wird produziert. Von beiden Arten wird *Ct. lanatus* als Futter bevorzugt. Die Entwicklungsdauer der Arten auf diesen Kräutern ist die längste bisher beschriebene für cucurbitophag Epilachninen. Die Dauer der prä-Eiablage und der Eiablagephase ist doppelt so lang, verglichen mit der auf Getreide, die post-Eiablagedauer nur halb so lang. Auf *Cu. myriocarpus* ist die Lebensdauer der Männchen die längste bisher beschriebene für eine Epilachnine, und die Lebenserwartung der Weibchen die längste unter den cucurbitophagen Epilachninen. Während die Gesamtzahl der abgelegten Eier, die Zahl der Eier pro Gelege und die Zahl der Einzelgelege zwischen Getreide und Kräutern vergleichbar groß ist, sind die Zahl der abgelegten Eier pro Tag und die Schlüpftrate pro Gelege weniger als halb so hoch, verglichen mit Getreide. Auf *Cu. myriocarpus* ist die Zahl der abgelegten Eier pro Tag die geringste unter allen cucurbitophagen Epilachninen. Weitaus mehr Eier werden von Adulten auf den Kräuterpflanzen zerstört als auf Getreide, im Falle von *Cu. myriocarpus* bis zu 28 % der Gesamtzahl. Auf *Ct. lanatus* zeigt *E. cucurbitae* ein gemäßigtes Fortpflanzungsmuster, verglichen mit dem auf Getreide, auf *Cu. myriocarpus* kommt es einem tropischen Fortpflanzungsmuster näher.

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