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Host plants of the phytophagous ladybird beetle, *Epilachna vigintioctopunctata* (Coleoptera: Coccinellidae), in Southeast Asia and Japan

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Abstract

The host plants of *Epilachna vigintioctopunctata* in the Southeast Asia region are still not fully known. Larval survival and development of *E. vigintioctopunctata* on solanaceous, cucurbitaceous and leguminous plants were examined for seven local populations from Japan, Thailand, Malaysia and Indonesia. All populations showed the highest emergence rate and largest adult body size when reared on plants of the genus *Solanum* (Solanaceae). On *Cuccinia indica* (Cucurbitaceae), the Malaysian population had an emergence rate of 32% and the Thailand and two Indonesian populations each had an emergence rate of ca. 10%. However, newly emerged adults of these four populations were not able to produce the next generation when reared on *C. indica* because of very low fecundity and hatchability. On *Centrosema pubescens* (Leguminosae), the Malaysian and two Indonesian populations each had an emergence rate of ca. 30%. Newly emerged adults of these three populations showed 62 to 72% hatchability when reared on *Ce. pubescens*. It is concluded that the major host plants of *E. vigintioctopunctata* in Southeast Asia are solanaceous plants and this species is unable to complete its life cycle solely on cucurbitaceous plants.

Key words: Cucurbitaceae, Epilachninae, host plant, Solanaceae, Southeast Asia

INTRODUCTION

The phytophagous ladybird beetle *Epilachna vigintioctopunctata* is widely distributed from tropical to temperate regions throughout Asia and Oceania, and its host plants are Solanaceae only (CAB, 1992). However, Schaefer (1983) listed many cucurbitaceous plants together with Solanaceae as host plants of *E. vigintioctopunctata*. Moreover, *E. vigintioctopunctata* is recorded as a pest insect of cucurbitaceous crops in India (Pareek and Karadia, 1991), Malaysia (Chong et al., 1991) and Thailand (S. Chunram, personal communication). Laboratory evaluation by Nakano and Abbas (1994) indicated that Indonesian *E. vigintioctopunctata* scarcely fed on any cucurbitaceous plants throughout the adult and larval stages. The subfamily Epilachninae contains many species that are morphologically very similar (Dieke, 1947; Li and Cook, 1961), and some species (e.g. *E. pusillanima*), which closely resemble *E. vigintioctopunctata*, are found on cucurbitaceous plants in Southeast Asia (Katakura et al., 1988). These Cucurbitaceae-feeding species may have been confused with *E. vigintioctopunctata*. However, except for a study by Nakano and Abbas (1994), there have been little detailed laboratory investigations on the host plants of *E. vigintioctopunctata* in Southeast Asia.

Recently, Nishida et al. (1997) reported that a population of *E. vigintioctopunctata* was able to complete its life cycle exclusively on the leguminous weed, *Centrosema pubescens* in Padang, Indonesia; a leguminous plant was firstly recorded as the host plant of *E. vigintioctopunctata*. Therefore, the host plants of *E. vigintioctopunctata* in Southeast Asia should be reexamined. In the present study, larval survival on solanaceous, cucurbitaceous and leguminous plants was evaluated for seven local populations of *E. vigintioctopunctata* from Japan, Thailand, Malaysia and Indonesia. Larval survival of Cucurbitaceae-feeding *E. pusillanima* in Thailand was also studied for comparison with that of *E. vigintioctopunctata*.

MATERIALS AND METHODS

Insect collection

E. vigintioctopunctata: For each population, 40 or 50 pairs of adult beetles were collected from the following seven localities; Chiba, Hiroshima, Okinawa (Japan), Bangkok (Thailand), Kuala Lumpur (Malaysia), Padang and Bogor (Indonesia) (Table 1 and Fig. 1). In the field, the Padang population depends on the leguminous weed *Ce. pubescens* and the other six populations depend on plants of the genus *Solanum* (Solanaceae).

E. pusillanima: Forty pairs of adult beetles were collected from *Cuccinia indica* (Cucurbitaceae) in Bangkok City (Table 1). In previous papers, Katakura et al. (1988, 1994) described this species as *E. dodecastigma* (Wiedmann) according to Fürsch (1959) and Kapur (1963, 1967). In the present study, however, we treated this species as *E. pusillanima* because the type-specimen of *E. dodecastigma* is missing (Booth and Pope, 1989).

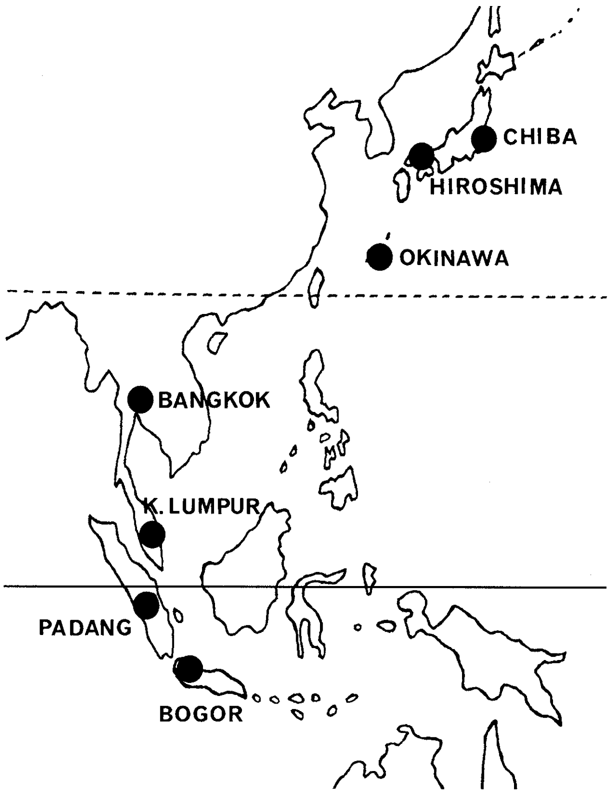

Fig. 1. Collection site of *Epilachna vigintioctopuncta-ta* and *E. pusillanima* examined in the present study.

Larval survival and development

E. vigintioctopunctata: For each population, 25 pairs of adults from the collected beetles were placed in a mesh cage (30 × 35 × 50 cm) with a potted black nightshade, *Solanum nigrum*. For larval experiments, egg-masses laid on *S. nigrum* leaves were taken out daily. Six hatched larvae were transferred to a plastic dish (9 cm diameter, 4.5 cm deep) and reared on leaves of Solanaceae, Cucurbitaceae, or Leguminosae (*Ce. pubescens*). For the Solanaceae, the Chiba population was reared on four species (*S. nigrum, S. tuberosum, S. melongena* and *S. torvum*), while the other six populations were reared on one species only: *S. nigrum, S. torvum* or *S. tuberosum*. For the Cucurbitaceae, the Chiba population was reared on three species (*C. indica, Cucurbita pepo* and *Trichosanthes cucumeroides*) and the other six populations were reared on *C. indica*. A fresh leaf was added to the dish every one or two days until the third instar, and daily during the fourth instar. After emergence, pronotal width measurement was determined for the new

Table 1. Origin of *Epilachna* ladybird beetles examined in the present study

Species	Locality	Host plant in the field	Date of collection	Collector
E. vigintioctopunctata				
	Chiba, Japan	*Solanum melongena* (Solanaceae)	August 15, 1993	Y. Shirai
	Hiroshima, Japan	*S. tuberosum* (Solanaceae)	June 26, 1996	S. Nakano
	Okinawa, Japan	*S. photeinocarpum* (Solanaceae)	May 5, 1997	M. Yafuso
	Bangkok, Thailand	*S. torvum* (Solanaceae)	November 5, 1996	Y. Shirai
	Kuala Lumpur, Malaysia	*S. torvum* (Solanaceae)	November 1, 1996	Y. Shirai
	Padang, Indonesia	*Centrosema pubescens* (Leguminosae)	March 31, 1995	K. Nakamura
	Bogor, Indonesia	*S. torvum* (Solanaceae)	February 14, 1994	T. Nishida
E. pusillanima				
	Bangkok, Thailand	*Cuccinia indica* (Cucurbitaceae)	August 9, 1994	Y. Shirai

adults.

E. pusillanima: Twenty pairs of adults from the collected beetles were placed in a mesh cage ($30 \times 35 \times 50$ cm) with fresh leaves of pumpkin, *C. pepo*, and egg-masses laid on leaves were taken out. Hatched larvae were reared on leaves of the Solanaceae (*S. nigrum, S. melongena* and *S. tuberosum*), Cucurbitaceae (*C. indica, C. pepo* and *T. cucumeroides*), or Leguminosae (*Ce. pubescens*) in the same manner as *E. vigintioctopunctata*. The pronotal width of new adults was measured.

Survival and oviposition of laboratory-reared adults

Host suitability of *C. indica* for *E. vigintioctopunctata*: Adults of the Bangkok, Kuala Lumpur and Padang populations which had been reared on *C. indica* were maintained on *C. indica* leaves to determine female longevity, number of eggs laid and hatchability. Pairs of newly emerged adults were transferred to a plastic dish (9 cm diameter, 4.5 cm deep) and a fresh leaf was added to the dish daily. For the Bogor population, this experiment could not be carried out since the only two females which had been reared on *C. indica* died two days after emergence.

Host suitability of *Ce. pubescens* for *E. vigintioctopunctata*: Adults of the Kuala Lumpur, Bogor and Padang populations which had been reared on *Ce. pubescens* were maintained on *Ce. pubescens* leaves to determine female longevity, number of eggs laid and hatchability, as described above.

All the laboratory experiments were conducted at the National Institute of Agro-Environmental Sciences (NIAES), under 26°C and 14L–10D conditions. All food plants used were grown in the greenhouse of the NIAES.

RESULTS

Larval survival and development of *E. vigintioctopunctata*

Survival rate, developmental period, adult body size and host acceptance of hatched larvae are shown in Table 2. All populations fed well on the leaves of *Solanum* (Solanaceae), with high emergence rates of 79 to 96%, significantly higher than the cucurbitaceous and leguminous plants ($p<0.01$). All populations had the shortest developmental period ($p<0.01$), and tended to have a larger body size, when reared on *Solanum* leaves. When reared on *C. indica* (Cucurbitaceae), the Kuala Lumpur population had an emergence rate of 32% and the Bangkok, Padang and Bogor populations each had an emergence rate of ca. 10%. The developmental periods of these four populations were always longest when they were reared on *C. indica*. For the three Japanese populations, 15 to 28% of hatched larvae fed on cucurbitaceous leaves, but all larvae died by the second instar. When reared on *Ce. pubescens* (Leguminosae), the Kuala Lumpur, Padang and Bogor populations had emergence rates of 30 to 35%. Developmental periods on *Ce. pubescens* were significantly longer than those on *Solanum* leaves ($p<0.01$), and tended to be shorter than those on *C. indica*. Body size was almost identical in beetles reared on *Ce. pubescens* and those reared on *C. indica*. In the Bangkok population, all larvae died by the prepupal stage, although 61% of hatched larvae fed on *Ce. pubescens* leaves. With the three Japanese populations, 26 to 62% of hatched larvae fed on *Ce. pubescens* leaves, but all the larvae died by the second instar.

Larval survival and development in *E. pusillanima*

This species fed well on all cucurbitaceous leaves with high emergence rate of 94 to 99% (Table 3). When reared on three *Solanum* plants, a few hatched larvae nibbled at these plants but all larvae died by the second (on *S. nigrum* and *S. melongena*) or third instar (on *S. tuberosum*). When reared on *Ce. pubescens* leaves, 20% of hatched larvae nibbled at the plant, but none reached the second instar.

Survival and oviposition of *E. vigintioctopunctata* females on *C. indica*

Female longevity, egg production and hatchability of new adults reared and maintained on *C. indica* leaves are shown in Table 4. Females of the three populations (Bangkok, Kuala Lumpur and Padang) lived from 18 to 25 days after emergence. Females of the Kuala Lumpur population did not lay any eggs, while females from Bangkok and Padang laid a few eggs,

Table 2. Larval survival and development of seven *E. vigintioctopunctata* populations

Locality	Food plant	No. replication	Survival rate (%)[a]			Developmental period (days)[b]	Adult body size (mm)[c]		Host acceptance in L-1 larvae (%)[d]
			L-2	L-4	Adult		Female	Male	
Chiba, Japan	Solanaceae								
	Solanum nigrum	12	99.0	96.9	90.0±12.9 a	22.5±0.9 a	3.17±0.11(33)	2.87±0.14(30)	100.0 a
	S. tuberosum	12	97.9	93.8	90.6±10.8 a	21.6±0.6 a	not examined		100.0 a
	S. melongena	12	97.9	94.8	91.7±11.1 a	22.0±0.5 a	not examined		100.0 a
	S. torvum	9	97.2	91.7	79.2±25.0 a	25.7±1.3 b	not examined		100.0 a
	Cucurbitaceae								
	Cuccinia indica	12	13.9	0.0	0.0±0.0 b	—	—	—	23.6 c
	Cucurbita pepo	12	2.8	0.0	0.0±0.0 b	—	—	—	15.3 c
	Trichosanthes cucumeroides	12	0.0	0.0	0.0±0.0 b	—	—	—	25.0 c
	Leguminosae								
	Centrosema pubescens	14	5.6	0.0	0.0±0.0 b	—	—	—	61.9 b
Hiroshima, Japan	*S. tuberosum*	13	100.0	96.2	91.0±14.6 a	21.4±1.0	3.00±0.15(27)	2.84±0.16(36)	100.0 a
	C. indica	12	1.4	0.0	0.0±0.0 b	—	—	—	27.8 c
	Ce. pubescens	13	10.3	0.0	0.0±0.0 b	—	—	—	53.9 b
Okinawa, Japan	*S. nigrum*	12	100.0	98.6	95.9±7.6 a	19.5±0.6	3.06±0.15(39)	2.83±0.15(30)	100.0 a
	C. indica	14	0.0	0.0	0.0±0.0 b	—	—	—	27.4 b
	Ce. pubescens	14	2.4	0.0	0.0±0.0 b	—	—	—	26.2 b
Bangkok, Thailand	*S. nigrum*	12	100.0	100.0	91.7±8.7 a	20.8±1.1 b	3.06±0.19(33) a	2.87±0.17(27) a	100.0 a
	C. indica	14	25.0	11.9	8.3±23.3 b	28.0±6.4 a	2.67±0.18(3) a	2.68±0.09(4) a	39.3 c
	Ce. pubescens	14	20.2	7.1	0.0±0.0 b	—	—	—	60.7 b
Kuala Lumpur, Malaysia	*S. nigrum*	12	100.0	97.2	84.7±11.1 a	22.8±0.5 c	3.06±0.13(30) a	2.83±0.14(19) a	100.0 a
	C. indica	14	85.7	42.9	32.1±24.9 b	33.6±3.4 a	2.99±0.20(13) a	2.65±0.20(12) b	85.7 b
	Ce. pubescens	14	77.4	50.0	29.8±22.8 b	26.7±2.6 b	2.93±0.20(13) a	2.77±0.17(11) ab	78.6 b
Padang, Indonesia	*S. nigrum*	12	100.0	94.4	87.5±12.6 a	22.7±0.7 b	3.18±0.18(27) a	2.89±0.18(22) a	100.0 a
	C. indica	14	29.8	17.9	9.5±20.4 b	29.7±2.5 a	2.97±0.06(3) ab	2.78±0.15(5) ab	46.4 b
	Ce. pubescens	14	85.7	51.2	31.0±29.1 b	24.6±1.1 a	2.81±0.24(8) b	2.66±0.18(18) b	100.0 a
Bogor, Indonesia	*S. torvum*	12	100.0	95.8	94.4±10.9 a	20.5±0.7 b	3.13±0.15(31) a	2.93±0.19(28) a	100.0 a
	C. indica	14	26.2	8.3	7.2±14.2 b	30.1±1.8 a	3.05±0.14(2) a	2.68±0.38(3) ab	40.5 b
	Ce. pubescens	12	88.9	58.3	34.7±39.2 b	24.8±1.9 a	3.03±0.15(6) a	2.74±0.18(19) b	94.4 a

[a] Survival rate, mean±SD.
[b] Developmental period from hatched larva (L-1) to emerged adult, mean±SD.
[c] Pronotal width, mean±SD (no. of beetles measured).
[a–c] Different letters within the same local population indicate significant difference by Kruskal-Wallis test ($p<0.01$).
[d] Proportion of L-1 larvae which fed on food plant. Different letters within the same population indicate significant difference by χ^2-test ($p<0.01$).

none of which hatched. Thus none of the populations was able to produce the next generation.

Survival and oviposition of *E. vigintioctopunctata* females on *Ce. pubescens*

Female longevity, egg production and hatchability of new adults reared and maintained on *Ce. pubescens* leaves are shown in Table 5. Females of three populations (Kuala Lumpur, Padang and Bogor) lived from 28 to 36 days after emergence. Females of all populations laid fertilized eggs (18 to 80), showing 62 to 72% hatchability. Female longevity, egg production and hatchability did not differ significantly among the three populations.

DISCUSSION

There has been confusion about the host plants of *E. vigintioctopunctata* in Southeast

Table 3. Larval survival and development of *E. pusillanima*

Locality	Food plant	No. replication	Survival rate (%)[a]			Developmental period (days)[b]	Adult body size (mm)[c]		Host acceptance in L-1 larvae (%)[d]
			L-2	L-4	Adult		Female	Male	
Bangkok, Thailand	Solanaceae								
	Solanum nigrum	12	0.0	0.0	0.0±0.0 b	—	—	—	1.4 c
	S. melongena	12	0.0	0.0	0.0±0.0 b	—	—	—	1.4 c
	S. tuberosum	12	4.2	0.0	0.0±0.0 b	—	—	—	5.6 c
	Cucurbitaceae								
	Cuccinia indica	12	100.0	100.0	98.6±4.8 a	21.9±0.7 ab	3.35±0.20(29)	3.12±0.20(41)	100.0 a
	Cucurbita pepo	12	100.0	94.4	94.4±8.2 a	21.0±0.5 a	not examined		100.0 a
	Trichosanthes cucumeroides	12	100.0	100.0	98.6±4.8 a	22.6±0.6 b	not examined		100.0 a
	Leguminosae								
	Centrosema pubescens	12	0.0	0.0	0.0±0.0 b	—	—	—	20.8 b

[a] Survival rate, mean±SD.
[b] Developmental period from hatched larva (L-1) to emerged adult, mean±SD.
[c] Pronotal width, mean±SD (no of beetles measured).
[a–c] Different letters indicate significant difference by Kruskal-Wallis test ($p<0.01$).
[d] Proportion of L-1 larvae which fed on food plant. Different letters indicate significant difference by χ^2-test ($p<0.01$).

Table 4. Host suitability of *Cuccinia indica* for *E. vigintioctopunctata* female adults which were reared on *C. indica* leaves

Locality	*n*	Longevity (days)	No. of eggs laid per female	%, Hatchability (no. of egg masses)
Bangkok, Thailand	3	25.3±1.2	35.0±27.8	0.0±0.0 (7)
Kuala Lumpur, Malaysia	12	17.6±5.5	0.0±0.0	— (0)
Padang, Indonesia	3	19.0±3.5	17.0±29.4	0.0±0.0 (2)

Table 5. Host suitability of *Centrosema pubescens* for *E. vigintioctopunctata* female adults which were reared on *Ce. pubescens* leaves

Locality	*n*	Longevity (days)	No. of eggs laid per female	%, Hatchability (no. of egg masses)
Kuala Lumpur, Malaysia	10	33.9±8.9	32.3±31.4	62.0±28.8 (15)
Padang, Indonesia	8	27.8±17.6	18.3±36.7	72.1±41.5 (14)
Bogor, Indonesia	6	36.2±17.9	79.5±87.1	70.8±36.8 (22)

Asia. Of the localities involved in the present study, *E. vigintioctopunctata* has only been recorded as a pest of Solanaceae in Indonesia (Kalshoven, 1981), but of Solanaceae and Cucurbitaceae in Malaysia (Chong et al., 1991). This is because the subfamily Epilachninae contains many species that are morphologically similar, especially in Southeast Asia where *E. pusillanima*, which is morphologically very similar to *E. vigintioctopunctata*, is widely distributed on cucurbitaceous plants (Katakura et al., 1988). In addition, few detailed laboratory studies have been carried out on the host plants or food habits of species of Epilachninae in Southeast Asia, except for that by Nakano and Abbas (1994).

In the present study, all seven local populations of *E. vigintioctopunctata* from Japan, Thailand, Malaysia and Indonesia fed best on *Solanum* (Solanaceae) plants and had the

Table 6. Host suitability of *Solanum* plants for *E. vigintioctopunctata* female adults

Locality	Food plant	No. of females	Longevity (days)	No. of eggs laid per female	Data
Padang, Indonesia	*Solanum torvum*	10	57.7	770.7	Abbas et al., 1985
Bogor, Indonesia	*S. torvum*	8	59.3	426.1	Nakamura et al., 1995
Bangkok, Thailand	*S. nigrum*	30	97.0	429.1	Y. Shirai, unpublished

highest emergence rates, compared with Cucurbitaceae and Leguminosae. Moreover, rearing on *Solanum* plants accelerated larval development and increased body size. Thus *Solanum* plants are a nutritious host plant suitable for larval development of *E. vigintioctopunctata*. While three Japanese populations were unable to emerge when reared on Leguminosae (*Ce. pubescens*) or any Cucurbitaceous plants, the populations in Southeast Asia had emergence rates of 7 to 35% on *C. indica* or *Ce. pubescens* (Table 2). There may be some genetic difference in host plant range between the Japanese and Southeast Asian populations.

Nakano and Abbas (1994) reported that *E. vigintioctopunctata* in Padang (Indonesia) fed well on solanaceous plants (*S. torvum, S. tuberosum, S. melongena* and *Datura metel*) but very little on cucurbitaceous plants (*Benincasa cerifera, Cucumis sativus, Cucurbita moschata*, and *Luffa acutangula*). In the present study, half of the hatched larvae of *E. vigintioctopunctata* from Padang fed on *C. indica* leaves and 10% of them were reared successfully to adulthood (Table 2), which differs from the results reported by Nakano and Abbas (1994). With the Chiba population of *E. vigintioctopunctata*, the greatest number of hatched larvae (14%) were able to reach the second instar when reared on *C. indica* among three Cucurbitaceae plants. This difference may be related to the fact that Nakano and Abbas (1994) did not use *C. indica* as cucurbitaceous plants.

For the index of host plant suitability, it is very important to evaluate not only larval survival but also female fecundity (Hodkinson and Hughes, 1982). From the viewpoint of egg production, *C. indica* is not a principal host plant even for *E. vigintioctopunctata* in Southeast Asia. The number of eggs laid on *C. indica* averaged 35.0 in the Bangkok and 17.0 in the Padang populations; it was zero in the Kuala Lumpur population (Table 4). These figures are much lower than the egg production on *Solanum* plants of the Bangkok, Padang and Bogor populations (426 to 771) (Table 6). Egg-masses laid by the Bangkok and Padang populations did not hatch at all (Table 4). Consequently, no population was able to produce the next generation. It is concluded that *C. indica* is an unsuitable host plant for reproduction and survival of *E. vigintioctopunctata*.

Epilachna pusillanima from Bangkok were able to emerge only on Cucurbitaceae and any hatched larvae were unable to develop to the adult stage on Solanaceae and Leguminosae (Table 3). In Padang, *E. pusillanima* were also able to emerge only on Cucurbitaceae, but neither adults nor larvae fed on any solanaceous plant (Nakano and Abbas, 1994). The food habits of *E. pusillanima* from Bangkok seem to be almost identical to those of *E. pusillanima* from Padang, because the Padang population also scarcely fed on *Ce. pubescens* throughout their adult and larval stages (S. Nakano, personal communication). *Epilachna pusillanima* are therefore easily distinguished from *E. vigintioctopunctata* in the laboratory by host preference between Solanaceae and Cucurbitaceae.

There is also confusion concerning the host plants and identification of species among the Australian Epilachninae, owing to large individual variation in the elytral spots of adult beetles (Richards, 1983; Li, 1993). *Epilachna vigintioctopunctata pardalis*, feeding on Solanaceae only, and *E. cucurbitaceae*, exclusively dependent on Cucurbitaceae, have been treated as the same species, *E. vigintioctopunctata*, for a long time (Richards, 1983). In the case of *E. vigintioctopunctata* and *E. pusillanima* in Southeast Asia, *E. pusillanima* adults are slightly larger (Figs. 2 and 3), and their elytral spot numbers are commonly 12 or 14 (Fig. 3),

Fig. 2. *Epilachna vigintioctopunctata* (above) and *E. pusillanima* (below) collected in Bangkok, Thailand. For each species, female (left) and male (right).

Fig. 3. *E. vigintioctopunctata* (above) and *E. pusillanima* (below) collected in Padang, Indonesia. For each species, female (left) and male (right).

with less individual variation in their elytral spots, whereas *E. vigintioctopunctata* shows large individual variation in the elytral spots (spot numbers range from 12 to 28) (Katakura et al., 1988; Abbas et al., 1988). Moreover, some adults of *E. pusillanima* have elytral spots numbers of more than 14 (Fig. 2). Thus, it is difficult to distinguish these two species by the external morphology of adults.

In the field in Southeast Asia, *E. vigintioctopunctata* probably damages cucurbitaceous crops to some extent, because 7 to 32% of larvae were successfully reared to adulthood on *C. indica* leaves in the laboratory (Table 2). However, it is unlikely that *E. vigintioctopunctata* will become a serious pest of Cucurbitaceae crops, because of the very low suitability of *C. indica* for both egg production and adult survival (Table 4).

Further study will be required to determine the host suitability of the leguminous *Ce. pubescens*. Nishida et al. (1997) reported that there was a significant difference in host plant preference between a population of *E. vigintioctopunctata* on solanaceae plants and one on *Ce. pubescens* in Bogor. Furthermore, at least two local populations of *E. vigintioctopunctata* complete their life cycle solely on this leguminous plant in Padang district (I. Abbas, unpublished data). The present study also indicated that Malaysian and Indonesian populations of *E. vigintioctopunctata* are able to complete their life cycle exclusively on *Ce. pubescens* (Table 5), although the reproductive rate on this plant was somewhat lower than that on *Solanum* plants. *Centrosema pubescens* was introduced from South America to Southeast Asia as green manure and a plantation cover crop in the 19th century (Nishida et al., 1997). The population living on *Ce. pubescens* is therefore important for monitoring any changes in host suitability via a host shift to the new plant (Bush and Smith, 1997).

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REFERENCES

Abbas, I., K. Nakamura and A. Hasyim (1985) Survivorship and fertility schedules of a Sumatran Epilachninae "species" feeding on *Solanum torvum* under laboratory conditions (Coleoptera: Coccinellidae). *Appl. Entomol. Zool.* 20: 50–55.

Abbas, I., K. Nakamura, H. Katakura and H. Sasaji (1988) Geographical variation of elytral spot patterns in the phytophagous ladybird, *Epilachna vigintioctopunctata* (Coleoptera: Coccinellidae) in the province of Sumatera Barat, Indonesia. *Res. Popul. Ecol.* 30: 43–56.

Booth, R. G. and R. D. Pope (1989) A review of the type material of Coccinellidae (Coleoptera) described by F. W. Hope and by E. Mulsant in the Hope Entomological Collections, Oxford. *Ent. Scand.* 23: 343–370.

Bush, G. L. and J. J. Smith (1997) The sympatric origin of phytophagous insects. In *Vertical Food Web Interaction, Evolutionary Patterns and Driving Forces* (G. B. Dettner and W. Volkl eds.). Springer, Berlin, pp. 3–19.

Chong, K. K., P. A. C. Ooi and H. C. Tuck (1991) *Crop Pests and Their Management in Malaysia*. Tropical Press Sdn, K. Lumpur. 242 pp.

Commonwealth Agricultural Bureaux (CAB) (1992) *Distribution Maps of Pests*. No. 532.

Dieke, G. H. (1947) Ladybeetles of the genus *Epilachna* (sens. lat.) in Asia, Europe, and Australia. *Smithonian Miscellaneous Collections, Washington, D.C.* 106: 1–183.

Fürsch, H. (1959) Die palaearktischen und indomalayishen Epilachnini der zoologischen Sammlungen des Bayerischen Staates München (Col. Cocc.). *Opusc. Zool., München* 26: 1–9.

Hodkinson, D. R. and M. K. Hughes (1982) *Insect Herbivory*. Chapman and Hall, New York. 77 pp.

Kalshoven, L. G. E. (1981) *Pests of Crops in Indonesia*. P. T. Ichtiar Baru-Van Hoeve, Jakarta. 701 pp.

Kapur, A. P. (1963) The Coccinellidae of the third Mount Everest expedition, 1924 (Coleoptera). *Bull. Br. Mus. Nat. Hist. (Ent.)* 14: 1–48.

Kapur, A. P. (1967) The Coccinellidae (Coleoptera) of the Andamans. *Proc. Nat. Inst. Sci. India* 32B: 148–189.

Katakura, H., I. Abbas, K. Nakamura and H. Sasaji (1988) Records of Epilachnine crop pests (Coleoptera: Coccinellidae) in Sumatera Barat, Sumatra, Indonesia. *Kontyu, Tokyo* 56: 281–297.

Katakura, H., S. Nakano, T. Hosogai and S. Kahono (1994) Female internal reproductive organs, modes of sperm transfer, and phylogeny of Asian Epilachninae (Coleoptera: Coccinellidae). *J. Nat. History* 28: 577–583.

Li, C. S. (1993) Review of the Australian Epilachninae (Coleoptera: Coccinellidae). *J. Aust. Ent. Soc.* 32: 209–224.

Li, C. S. and E. F. Cook (1961) The Epilachninae of Taiwan

(Col., Coccinellidae). *Pacific Insects* 3: 31–91.

Nakamura, K., L.E. Pudjiastuti and H. Katakura (1995) Survivorship and fertility schedules of three phytophagous ladybird beetle species (Coleoptera: Coccinellidae) under laboratory conditions in Bogor, West Java. *Tropics* 4: 223–231.

Nakano, S. and I. Abbas (1994) Reproductive isolation in four phytophagous lady beetle (Epilachna, Coccinellidae, Coleoptera) in West Sumatra. *Tropics* 3: 121–129.

Nishida, T., L.E. Pudjiastuti, S. Nakano, I. Abbas, S. Kahono, K. Nakamura and H. Katakura (1997) The eggplant beetle on a leguminous weed: Host race formation in progress? *Tropics* 7: 115–121.

Pareek, B.L. and V.S. Karadia (1991) Incidence of *Epilachna* beetle, *Epilachna vigintioctopunctata* Fabr. on different varieties of musk melon, *Cucumis melo* in the field. *Ann. Arid Zone* 30: 163–166.

Richards, A.M. (1983) The *Epilachna vigintioctopunctata* complex (Coleoptera: Coccinellidae). *Int. J. Entomol.* 25: 11–41.

Schaefer, P.W. (1983) Natural enemies and host plants of species in the Epilachninae (Coleoptera: Coccinellidae), a world list. *Agric. Exp. Stn., Univ. Delaware, Bull.* 455: 1–42.