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Exploitation of Fabaceae plants by the Mexican bean beetle *Epilachna varivestis* (Coleoptera: Coccinellidae) in Japan

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Abstract

The host plant preference of the Japanese population of *Epilachna varivestis* Mulsant (Coleoptera: Coccinellidae) as well as the host suitability for the beetle were studied at 25°C, under a 15L : 9D photoregime. Three Fabaceae crops: *Vigna angularis* (L.), *Phaseolus vulgaris* L. and *Vicia faba* L., and two Fabaceae weeds: *Pueraria lobata* (Willd.) and *Lespedeza bicolor* Turcz., were examined. None of the 1st stadium larvae of *E. varivestis* fed on *L. bicolor*. The survivorship of larvae was low on *P. lobata*, but some adults fed on this plant. Thus, *P. lobata* may be used as a temporary resource by *E. varivestis* before this beetle colonizes more suitable plants. Neither adults nor 1st stadium larvae of *E. varivestis* fed on *V. faba*, but almost all the beetles examined completed development and reproduced on *V. angularis* and *P. vulgaris*. Therefore, *E. varivestis* has the potential to become an economic pest of *V. angularis*, although this bean, at present, is not as suitable as *P. vulgaris* for larval development and reproduction.

Key words: *Epilachna varivestis*, host suitability, host preference, Fabaceae

INTRODUCTION

In 1997, the Mexican bean beetle, *Epilachna varivestis* Mulsant, was discovered for the first time in Japan, in Yamanashi Prefecture (Sasaji, 1997) and Nagano Prefecture (Fujiyama and Shirai, 1998), which is contiguous with Yamanashi Prefecture, Central Honshu. Fujiyama et al. (1998) suggested that the geographical range of *E. varivestis* has begun to expand in Japan. This beetle was originally distributed in Mexico and Guatemala, and its range extended north to Canada in the mid 20th century (Auclair, 1959). *E. varivestis* is an economically important pest of *Phaseolus* spp. and soybean *Glycine max* (L.) throughout the United States of America (Fan et al., 1992).

Fujiyama and Shirai (1998) suggested that *E. varivestis* was accidentally introduced from the New World to Japan in recent years. In Japan, they and Funakubo et al. (1998) found this beetle on adzuki bean *Vigna angularis* (L.), kidney bean *Phaseolus vulgaris* L., scarlet runner bean *P. coccineus* L. and *G. max*. In addition to the four Fabaceae crops, two Fabaceae weeds, kudzu *Pueraria lobata* (Willd.) and silk tree *Albizia julibrissin* (Willd.) Durazz., were recorded as host plants of *E. varivestis* in Nagano Prefecture (Toyoshima and Funakubo, 1998). We examined the performance of *E. varivestis* on five Fabaceae plants which are common in Japan: *V. angularis, P. vulgaris*, broad bean *Vicia faba* L., *P. lobata* and bush clover *Lespedeza bicolor* Turcz. *V. angularis* was originally distributed in South China, and is now mainly cultivated in Japan and China (Hotta et al., 1989). The range of *P. vulgaris* was originally limited to Mexico, Guatemala and Honduras, but it is now cultivated all over the world (Hotta et al., 1989); *E. varivestis* prefers this plant (Auclair, 1959). Hotta et al. (1989) inferred that *V. faba* was originally distributed in Central Asia and North Africa, but it is now also cultivated worldwide. Elmore (1949) reported that *E. varivestis* does not feed on this plant. *P. lobata* and *L. bicolor* are weeds

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commonly found around the bean fields where *E. varivestis* occurs in Nagano and Yamanashi Prefectures (Y. Abe, personal observation). *P. lobata* was originally found in Japan, China and Korea, but has become naturalized in North America (Hotta et al., 1989). *L. bicolor* occurs in Japan, Russia, China and Korea (Hotta et al., 1989).

The main purpose of our study was to clarify the suitability of *V. angularis, P. lobata* and *L. bicolor* for *E. varivestis*. These three Fabaceae species have not been reported as host plants of *E. varivestis* (Schaefer, 1983). Their suitability for *E. varivestis* has not been examined. In the present paper, we discuss (1) whether or not *E. varivestis* can be expected to spread by exploiting the Fabaceae weeds commonly found in Japan, and (2) whether or not this beetle has the potential to become an economic pest of *V. angularis*.

MATERIALS AND METHODS

Insects and host plants. About 200 larvae of *E. varivestis* on *P. coccineus* leaves were collected by the first author in Chino City, Nagano Prefecture, on 2 September 1997. The collection data was used as part of the reference data by the Nagano Prefectural Plant Protection Office in designing a protection program against *E. varivestis*. From 3 September 1997, these insects were provided with fresh leaves of *P. vulgaris* and reared at 25°C, under a 15L : 9D photoregime in our laboratory. Within five days after eclosion, males and females were paired and provided with *P. vulgaris*, and each of 40 pairs was reared within a 90-ml plastic cup (55 mm in diameter). Thirty-three of the 40 pairs and their progeny were used in the following experiments, which were conducted at 25°C, under a 15L : 9D photoregime. The plants *V. angularis, P. vulgaris* and *V. faba*, were grown in our greenhouse, and *P. lobata* and *L. bicolor* were collected in a field of Kyoto Prefectural University. Excised fresh leaves of the host plants were used in all experiments.

Experiment 1. Host plant preference of 1st stadium larvae. Four pairs of *E. varivestis* were chosen randomly from the 40 pairs. One egg mass laid by each of the four females was used. Within 24 h after hatching, six larvae were randomly chosen from each egg mass, and each larva was placed on the center of a filter paper (55 mm in diameter) on the bottom of a 90-ml plastic cup. Just before the introduction of the larva, four leaf disks (10 mm in diameter) of *V. angularis, P. vulgaris, P. lobata* and *V. faba* (one each) were placed along the cup wall at equal intervals on the filter paper, and the order of the four plant species was randomized in each cup. Each larva was allowed to feed for 24 h. Host preference was then estimated by the feeding traces.

Experiment 2. Host plant suitability for feeding and oviposition of adults. Twenty-four of the 40 pairs of *E. varivestis* were used in this experiment. Within 24 h after oviposition of the second egg mass, each of the 24 pairs was transferred into a new 90-ml plastic cup. Before the transfer, a sheet of filter paper was placed on the bottom of each new cup, and leaves of one of the four species (*V. angularis, P. vulgaris, P. lobata* or *V. faba*) were placed on the filter paper. The leaves covered the filter paper and were sufficient for feeding and oviposition of the *E. varivestis* adults. Six pairs of adults were examined for each plant species. The beetles were allowed to feed and oviposit for 72 h.

Experiment 3. Host plant suitability for development and reproduction. Five of the 40 pairs of *E. varivestis* were chosen randomly, and one egg mass laid by each of the five females was used. Five or six larvae within 24 h after hatching from each egg mass were randomly divided into five groups. Each group, consisting of five or six *E. varivestis* larvae, was placed in the center of a filter paper on the bottom of a 250-ml plastic cup (70 mm in diameter). Just before the introduction of the *E. varivestis* larvae, leaves of one of the five species (*V. angularis, P. vulgaris, P. lobata, L. bicolor* or *V. faba*) were placed on the filter paper in the cup. During the experiment, sufficient leaves of the same plant species were provided for feeding of the larvae in the same cup. The total numbers of the *E. varivestis* larvae examined were 25 each for *V. angularis, P. vulgaris* and *P. lobata*, 30 for *L. bicolor*, and 28 for *V. faba*. When adult eclosion occurred, adults were provided with the same plant species as the larvae. Virgin

adult females and males which had fed on the same plant species during the larval period were paired within two days after eclosion in a 90-ml plastic cup, but siblings were not paired. The reproductive performance of the paired females was then recorded.

RESULTS

Experiment 1. Host plant preference of 1st stadium larvae

Many of the 1st stadium larvae of *E. varivestis* fed on *P. vulgaris*, but only one larva fed on *P. lobata* (Table 1). One larva, which had not fed on any of the plants during the 24 h-experiment, fed on *P. vulgaris*, when it was placed under the same conditions for a further 24 h.

Table 1. Host plant preference of 1st stadium larvae of *Epilachna varivestis*

Plants	No. of feeding larvae
Phaseolus vulgaris	15
Vigna angularis	5
Phaseolus vulgaris and *Vigna angularis*	2
Pueraria lobata	1
None	1[a]
Total	24

[a] This larva fed on *P. vulgaris* during a further 24 h after the experiment under the same conditions.

Experiment 2. Host plant suitability for feeding and oviposition of adults

As seen in Table 2, all the *E. varivestis* pairs fed on *V. angularis* and *P. vulgaris* leaves, and five of the six pairs fed on *P. lobata* leaves. No pairs fed on *V. faba* leaves. Each female of every pair deposited only one egg mass during the experiment. There was a significant difference in the number of eggs per female among the four plant species (Kruskal-Wallis test, $p<0.01$), but that was not indicated between any two of these species (Mann-Whitney *U*-test with the Bonferroni method, $p>0.05$).

Experiment 3. Host plant suitability for development and reproduction

As seen in Table 3, none of the 1st stadium larvae of *E. varivestis* fed on *L. bicolor* or *V. faba* leaves, and they all died. Also, 20 of the 25 1st stadium larvae failed to feed on *P. lobata* leaves, and died. Four of the five remaining larvae died during the 2nd stadium, but one male became an adult. The larval and pupal periods of this male were 29 and five days, respectively. The larval period of this male was much longer than that of *E. varivestis* feeding on *V. angularis* or *P. vulgaris*, with no obvious difference in the pupal period. The *E. varivestis* larvae feeding on *V. angularis* developed significantly slower than those on *P. vulgaris*, with no significant difference in pupal development. On *V. angularis* and *P. vulgaris*, the survivorship of *E. varivestis* during the larval and pupal periods was high (92 and 96%, respectively), without any significant difference between the two plants.

The reproductive performance of *E. varivestis* females on the two plants was as follows. The pre-oviposition period was significantly longer on *V. angularis* than on *P. vulgaris*, but no significant difference was found in the reproductive period, post-reproductive period and longevity of the female adults. The females on *P. vulgaris* deposited three times as many eggs

Table 2. Host plant suitability for feeding and oviposition of *Epilachna varivestis* adults

Plants	No. of pairs examined	No. of pairs feeding	No. of females ovipositing	No. of eggs per mass (mean±SD)[a]
Vigna angularis	6	6	6	47.5±9.7
Phaseolus vulgaris	6	6	6	62.8±12.1
Pueraria lobata	6	5	6	31.8±23.4
Vicia faba	6	0	3	14.3±20.6

[a] No. of eggs per mass was significantly different among the four plant species (Kruskal-Wallis test, $p<0.01$), but not between any two of these species (Mann-Whitney *U*-test with the Bonferroni method, $p>0.05$).

Table 3. Survivorship, development and reproduction of *Epilachna varivestis* on *Vigna angularis, Phaseolus vulgaris, Pueraria lobata, Lespedeza bicolor* and *Vicia faba*

Plants	*Vigna angularis*	*Phaseolus vulgaris*	*Pueraria lobata*	*Lespedeza bicolor*	*Vicia faba*
No. of individuals examined	25	25	25	30	28
Survivorship from larva to adult (%)[a]	92	96	4	0	0
Larval period (in days)[b]**	17.4±0.6	14.7±1.0	29	—	—
Pupal period (in days)[b]	5.0±0.6	4.8±0.6	5	—	—
No. of pairs examined	11	11	—	—	—
Longevity of female adult (in days)[b]	46.7±15.8	44.5±14.4	—	—	—
Pre-reproductive period (in days)[b]*	11.8±1.2	8.6±0.7	—	—	—
Reproductive period (in days)[b]	29.2±12.2	33.1±14.7	—	—	—
Post-reproductive period (in days)[b]	4.9±5.4	2.7±1.8	—	—	—
Fertility (Total no. of eggs laid per female)[b]*	253.8±153.2	741.5±383.4	—	—	—

[a] There was no significant difference in survivorship between *V. angularis* and *P. vulgaris* (Fisher's exact probability test, $p>0.05$).

[b] Means are provided±one standard deviation. *($p<0.05$) and **($p<0.001$) show significant differences between *V. angularis* and *P. vulgaris* by Mann-Whitney *U*-test. Means with no asterisks show no significant difference between the two plants (Mann-Whitney *U*-test, $p>0.05$). There was no significant difference in larval and pupal periods between the sexes on each host plant (Mann-Whitney *U*-test, $p>0.05$), so the data were pooled.

as those on *V. angularis*.

DISCUSSION

No 1st stadium larvae of *E. varivestis* fed on leaves of *L. bicolor* (Table 3), indicating that this beetle cannot utilize this Fabaceae weed as a host plant. Almost none of the 1st stadium larvae of *E. varivestis* preferred *P. lobata* (Table 1), and only one male completed development on this weed. Fujiyama and Shirai (1998) reported that 47.2% of *E. varivestis* larvae completed development on *P. lobata*, although they did not mention the number of individuals examined. A large difference was thus evident in the survivorship of *E. varivestis* on *P. lobata* between this study and that of Fujiyama and Shirai (1998). *P. lobata* has not been reported as a host plant of *E. varivestis* in the United States of America (Schaefer, 1983). Further study is needed to clarify the suitability of *P. lobata* for *E. varivestis*. Five of the six pairs of *E. varivestis* fed on *P. lobata*, and all the females deposited eggs on this plant during three days after the transfer from *P. vulgaris* to *P. lobata* (Table 2). Thus, *P. lobata* may function as a temporary food plant for *E. varivestis* before it colonizes more suitable host plants (e.g. *P. vulgaris*). Toyoshima and Funakubo (1998) found *E. varivestis* on *P. lobata* in Nagano Prefecture. Consequently, *E. varivestis* should be most carefully monitored on *P. lobata* among the common Fabaceae weeds in Japan.

Since the adults or 1st stadium larvae of *E. varivestis* did not feed on *V. faba* leaves, this bean does not appear to be a host plant for this beetle, as reported by Elmore (1949). Almost all the *E. varivestis* examined completed larval development on *V. angularis* and *P. vulgaris*, but the larvae developed significantly slower on *V. angularis* than on *P. vulgaris* (Table 3). No significant difference was found in adult longevity, reproductive period or post-reproductive period between female adults on *V. angularis* and those on *P. vulgaris* (Table 3). However, female adults of *E. varivestis* on *V. angularis* started oviposition significantly later and deposited significantly fewer eggs than those on *P. vulgaris* (Table 3). The present study verifies that *E. varivestis* can complete development and produce the next generation solely on *V. angularis*. Although *V. angularis* is not as suitable as *P. vulgaris* for larval development and reproduction of *E. varivestis*, this beetle has the potential to become an economic pest of *V. angularis*. In conclusion, *E. varivestis* should be

monitored not only in fields of *Phaseolus* spp. and *G. max*, but also in those of *V. angularis* in Japan.

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