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SHORT COMMUNICATION

Host adaptation of the fruit piercing moth, *Eudocima fullonia*

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Abstract. The fruit piercing moth, *Eudocima fullonia* (Clerck) (Lepidoptera: Noctuidae), whose larval host plants are vines of the family Menispermaceae in Asia, Africa and Australia, is thought to have adapted to *Erythrina* spp. in the Pacific and Papua New Guinea and has been designated as a separate biotype from the Australasian and African biotype. To test the hypothesis that the Pacific population of *E. fullonia* is a biotype, feeding trials with the host plants *Tinospora homosepala* Diels (Menispermaceae) and *Erythrina variegata* Linn. (Fabaceae) were conducted in Guam. The results indicate that the Guam population of *E. fullonia* is a biotype that has expanded its host range from its normal Menispermaceae plants to *Erythrina* species, possibly due to genetic changes and/or the presence of closely related alkaloids in both the species and paucity of menisperms.

Key words. *Eudocima fullonia*, Fabaceae, fruit piercing moth, host plants, Lepidoptera, Menispermaceae, Noctuidae.

Introduction

A biotype is a population that has some genetic or phenotypic differences from other populations (Drès & Mallet, 2002). It is also believed that biotypes are distinct sibling species (Dethier, 1954). Many biotypes are at various stages of evolutionary divergence and thus provide some of the best opportunities for unravelling the complicated process underlying speciation (Diehl & Bush, 1984). Biotypes have obvious implications for pest management and biological control, as the failure to recognize distinct populations can have costly and frustrating consequences (Rosen, 1978; Gonzales *et al*., 1979). Insect biotypes feeding on different species of host plants are particularly well documented and are also the category most strongly associated with theories of sympatric speciation (Diehl & Bush, 1984; Via, 2001). Such studies are important not only for understanding speciation, but also have many other applications in agriculture and conservation, as suggested by Drès & Mallet (2002).

The fruit piercing moth, *Eudocima fullonia* (Clerck) (Lepidoptera: Noctuidae), is considered one of the top 10 pests in the Pacific region (Waterhouse & Norris, 1987). It is also a serious pest in subtropical and tropical Africa, Asia and Australia (Denton *et al*., 1999). Adult moths pierce ripening fruits with their strongly sclerotized probosces, macerate the pulp and imbibe the liberated juice (Sands & Schotz, 1991). Fruits attacked by these insects become dry and spongy and lose their market value. In addition, the preliminary wound serves as a permanent access point for secondary infection organisms, which can cause further spoilage. In Africa, Asia and Australia the larvae of fruit-piercing moths feed only on the vines of the family Menispermaceae, whereas in the Pacific and Papua New Guinea they feed on plants of the family Menispermaceae and the genus *Erythrina* (Fabaceae).

Unlike the continental land masses, where several genera of Menispermaceae occur, Pacific islands are poorly endowed with menisperm vines (Muniappan *et al*., 1995). *Tinospora homosepala* Diels is the only menisperm present on Guam and it occurs in two small patches in the mid eastern part of the island. However, *Erythrina* spp. introduced as ornamentals occur throughout the island. *Eudocima fullonia* lays eggs on both *T. homosepala* and *Erythrina* spp. Sands & Chan (1996) studied larval feeding with the Australian *E. fullonia* population on *Erythrina variegata* L. (Fabaceae) and *Tinospora smilacina* Benth. (Menispermaceae) and suggested that *E. fullonia* in the

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Pacific is a different biotype from that in Australia. They differentiated the biotype in the Pacific from the Australian one because in the Pacific, female moths of *E. fullonia* oviposited on *Erythrina* spp. and the larvae completed development on these plants, whereas in Australia they oviposited and developed only on menisperms.

Experiments were carried out with a population of *E. fullonia* from Guam to evaluate larval food consumption and larval and pupal development on *T. homosepala* and *E. variegata* to test the hypothesis that *E. variegata* is a host for the Pacific biotype.

Materials and methods

Insect rearing

About 50 larvae of *E. fullonia* were collected from eight of the *E. variegata* trees from the field and reared to adults. Adults were released in a field cage of $2 \times 2 \times 2$ m and three or four oranges were hung from the roof of the cage for food. For oviposition, individual potted *T. homosepala* or *E. variegata* plants were placed inside the cages. Eggs laid on the leaves of *T. homosepala* or *E. variegata* were collected and allowed to hatch. The emerged larvae were used for host suitability studies in the laboratory maintained at 25 ± 2 °C and 70–80% RH.

Feeding studies

For host suitability studies, three fully expanded leaves from *E. variegata* or *T. homosepala* were excised and weighed on an electronic balance (Ohaus, New Jersey). The petioles of all the three leaves were inserted into a one-ounce disposable plastic cup (Comet Products Inc., Chelmsford, Massachusetts) filled with tap water and sealed with parafilm. This allowed leaves to remain fresh until larvae completed feeding on them. Each newly emerged larva of *E. fullonia* was introduced onto the leaves which were placed in a plastic container (12.7×5.0 cm: diameter $\times$ height). Tender leaves were fed to the early instars (first to third) while the later instars were given mature leaves. For aeration, a rectangular opening of 2.5×6.4 cm was cut in the plastic lid of each box and covered with muslin. Each treatment host was replicated 12 times. However, due to larval mortality, not all larvae reached the pupal stage. The larvae were allowed to feed for 4–7 days on the respective host plant leaves before fresh leaves were provided. Larvae, faecal matter, leftover leaves and fresh leaves were weighed whenever fresh leaves were provided. Data on the duration of each larval stadium and pupal stage were also recorded.

All the data were analysed using a factorial ANOVA test, as the plant species of oviposition would be one factor and the species that larvae were fed on would be another factor, in the SPSS 12.0 for Windows statistical package. The significance level was pre-set at $P = 0.05$.

Results and discussion

Larvae from eggs of *E. fullonia* deposited on *T. homosepala* and *E. variegata* consumed the leaves of both the host plants tested in equal amounts ($P < 0.05$). No significant differences were found in the weight of larvae or faecal matter from the feeding on both tested plants irrespective of whether larvae derived from eggs laid on *T. homosepala* or on *E. variegata* (Table 1). The mean developmental periods for larvae derived from the eggs laid on *T. homosepala* or *E. variegata* fed on *T. homosepala* were not significantly different from those fed *E. variegata* in all instars. The only exception involved larvae derived from eggs laid on *T. homosepala*: those fed on *E. variegata* completed development after five stadia (Table 2) whereas those fed on *T. homosepala* developed over six stadia. However, all larvae derived from eggs laid on *E. variegata* fed on *T. homosepala* or *E. variegata* went through six instars (Table 2).

Moths in the genus *Eudocima* are fruit piercers whose larval hosts are mostly the vines in the family Menispermaceae. Some species in this genus have a very narrow host range, e.g. larvae of *Eudocima materna* (Linnaeus) feed only on *Tinospora* spp. (Fay & Halfpapp, 1993; Bhumannavar & Viraktamath, 2001a); larvae of *Eudocima salaminia* (Cramer) feed on the species *Stephania*

Table 1. Attributes (mean ± SD) of immature stages of *Eudocima fullonia* derived from the eggs laid on *Tinospora homosepala* or *Erythrina variegata*, fed on two different host plants (*T. homosepala* and *E. variegata*).

	Eggs laid on *T. homosepala* and reared on		Eggs laid on *E. variegata* and reared on	
Growth parameters	*T. homosepala*	*E. variegata*	*T. homosepala*	*E. variegata*
Leaf consumed (g)	24.6 ± 3.4	23.8 ± 3.9	21.8 ± 4.4	23.0 ± 3.8
Larval weight (g)	6.2 ± 2.1	4.3 ± 0.9	3.9 ± 0.3	4.0 ± 1.1
Fecal matter (g)	6.3 ± 1.6	6.4 ± 2.4	5.6 ± 2.2	5.3 ± 2.2
Larval duration (days)	22.2 ± 0.8	17.5 ± 0.6	21.0 ± 4.8	25.1 ± 8.7
Pupal weight (g)	2.3 ± 0.3	2.4 ± 0.3	2.3 ± 0.3	2.3 ± 0.4

Data for eggs reared on *T. homosepala* were from nine replicates, and for *E. variagata* were from ten replicates.

Table 2. Duration of larval developmental (mean days ± SD) of *Eudocima fullonia* derived from the eggs laid on *Tinospora homosepala* or *Erythrina variegata*, fed on two different host plants (*T. homosepala* and *Erythrina variegata*).

	Eggs laid on *T. homosepala* and reared on		Eggs laid on *E. variegata* and reared on	
Stadium	*T. homosepala*	*E. variegata*	*T. homosepala*	*E. variegata*
First	2.5 ± 0.5	3.0 ± 0.0	3.6 ± 0.5	4.3 ± 0.5
Second	2.5 ± 0.5	2.0 ± 0.0	2.0 ± 0.5	2.6 ± 0.7
Third	1.8 ± 0.6	2.5 ± 0.5	2.3 ± 1.1	2.9 ± 0.8
Fourth	3.3 ± 0.5	3.3 ± 0.9	2.4 ± 0.7	4.7 ± 1.2
Fifth	6.6 ± 1.9	6.7 ± 1.3	5.2 ± 1.0	4.2 ± 1.8
Sixth	5.5 ± 0.7	0.0 ± 0.0	5.5 ± 1.0	6.5 ± 3.7
Total	22.2 ± 0.8	17.5 ± 0.6	21.0 ± 4.8	25.1 ± 8.7

Data for eggs reared on *T. homosepala* were from nine replicates, and for *E. variagata* were from ten replicates.

japonica Miers. (Menispermaceae) and occasionally on *Sarcopetalum harveyanum* F. Muell. (Menispermaceae) in Australia (Sands & Schotz, 1989); and larvae of *Eudocima homaena* (Hübner) feed on the genera *Cocculus*, *Diploclisia*, *Anamirta*, *Cissampelos* and *Tiliacora* in India (Bhumannavar & Viraktamath, 2001b). However, larvae of *E. fullonia* have a very wide host range involving several genera in the family Menispermaceae (Fay, 1994; Muniappan *et al*., 2005).

The centre of origin of *E. fullonia* is the Indomalaysian region (Waterhouse & Norris, 1987) and it has spread to the African and Australian continents from Asia where it uses vines of Menispermaceae as larval hosts. However, the population that migrated and naturalized in the Pacific and Papua New Guinea appears also to have become adapted to feeding on *Erythrina* spp.

Polyphagous herbivores such as *E. fullonia* exhibit monophagy or oligophagy at the population level (Fox & Morrow, 1981; Ueno *et al*., 2001). The difference between the Pacific population and other populations may be due to genetic changes and/or changes in ecological factors such as availability of host plant species (Hare & Kennedy, 1986; Scriber, 1986).

The menisperms and *Erythrina* spp. are known to contain tetracyclic-erythrina type alkaloids (Amar *et al*., 1991), which are likely to serve as oviposition and phagostimulants for the moths and larvae, respectively, although the alkaloids in the menisperms seem to be preferred over those in *Erythrina* (Muniappan *et al*., 1995). Sands & Chan (1996) reported that newly hatched *E. fullonia* larvae from eggs laid on organza by moths collected from menisperms in Australia would not feed on *E. variegata* leaves. However, if allowed to feed initially on *T. smilacina* and transferred in the second stadium, some of the second instars would feed and develop on *E. variegata*. In addition, they found that some newly hatched larvae from eggs laid on *E. variegata* in the laboratory, or eggs laid on organza and treated with an extract of *E. variegata*, would feed and develop on *E. variegata*.

The results presented here show that there were no significant differences in the amounts of food consumed by larvae, or the duration of the stadia of individual larval instars derived from the eggs laid on *E. variegata* or *T. homosepala*. This indicates that the Guam (Pacific) population of *E. fullonia* has adapted to *E. variegata*. The occurrence of biotypes adapted to different food plants has been reported by Bänziger (1982) and Sands & Chan (1996). Although the *E. fullonia* biotype in Guam lays eggs on *E. variegata* and *T. homosepala* and the larvae develop on both, *T. homosepala* (the original host of *E. fullonia*) seems to be the preferred host during larval development. This observation is supported by Corbet (1985), who noted that preference for a secondary host may be acquired during larval developmental stages. The findings of the present studies support the hypothesis of Sands & Chan (1996) regarding the development of host-plant biotypes of *E. fullonia* in the Pacific. It is probable that allopatric speciation is occurring in the geographically isolated populations in Papua New Guinea and the Pacific Islands.

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