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APHIDS AS PREY FOR THE COCCINELLID *EXOCHOMUS QUADRIPUSTULATUS*

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Females of *E. quadripustulatus* oviposited when fed on *D. plantaginea* and *A. pisum*. Larvae of *E. quadripustulatus* were able to develop on *D. devecta*, *D. plantaginea*, *A. pisum* and *A. pomi*. *A. fabae*, *M. viciae* were toxic to the larvae, *E. lanigerum* was an alternative food. *E. quadripustulatus* appears to be in an intermediate position between aphido- and coccidophagy.

KEY WORDS: Coccinellidae — *Exochomus quadripustulatus* — Egg laying — Larval development — *Acyrthosiphon pisum* — *Dysaphis devecta* — *Dysaphis plantaginea* — *Aphis pomi* — Essential food — Alternative food.

Coccinellid beetles are food specialists, most species being aphido- or coccidophagous while some genera are phyto- or mycophagous (Hodek, 1973). Some species are both coccido- and aphidophagous, e.g. *Leis conformis* (Boisd.) (Hodek, 1973). Iperti *et al.* (1977), based on morphological and anatomical studies, suggested a transient position between coccido- and aphidophagy for *Exochomus quadripustulatus* (L.). The majority of feeding records or reports of co-occurrence with possible prey organisms shows this species to be coccidophagous (Radovanovic, 1954; Thompson & Simmonds, 1965; Mills, 1981). However, Thompson & Simmonds (1965), Talhouk (1977) and Mailu *et al.* (1980) reported aphid feeding by adults. Kanervo (1940) stated that aphids and psyllids were major food for the larvae, based on observations of co-occurrence in the field and the acceptance of the prey in the laboratory. He mentioned only *Rhopalosiphum padi* (L.) and *Pterocallis alni* (Deg.).

During our studies of apple orchard coccinellids (Radwan & Lövei 1982) we observed *E. quadripustulatus* larvae with different species of aphids, most often *Dysaphis* spp. As records of associations between coccinellids and their possible prey might be misleading in food suitability evaluations (Thompson, 1951; Hodek 1973), we sought direct evidence for aphidophagy in *E. quadripustulatus* and (1) reared adult beetles on aphid food and counted the eggs and (2) reared larvae on different aphid species and weighed them. Here we report that *E. quadripustulatus* was able to complete larval development and to lay eggs when fed some species of aphids.

MATERIAL AND METHODS

We used 3rd instars of 7 aphid species as prey: *Acyrthosiphon pisum* (Harris), *Aphis pomi* Deg., *Dysaphis devecta* (Walk.), *D. plantaginea* (Pass.), *Megoura viciae* Buckt, *A. fabae* Scop. and *Eriosoma lanigerum* (Hausm.). The species *A. fabae*, *M. viciae* and *A. pisum* were reared on broad beans, *Vicia faba* L. at 25° under the photoperiod 16L : 8D. Other aphid species were collected from the field and reared on small apple trees *Malus pumila* cv. "Jonathan" in a glasshouse at 20° and natural spring-summer photoperiod. Overwintered adult *E. quadripustulatus* were collected early in the spring, 1982 from an apple orchard near Budapest.

The beetles were kept in 3 l glass jars (20 beetles/jar) and fed excess aphid food. When the first eggs were found, ♀♀ were separated and kept individually in glass vials with a piece of cardboard, food and water. Food was renewed, the eggs laid counted and removed every day. The eggs were kept at 28°.

The larvae were reared at 23° and under the photoperiod 16L : 8D. Newly hatched larvae were kept individually in gelatine capsules. A

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known number of 3rd instar aphids was provided every day; larvae were checked for ecdysis daily and weighed at 2—3 day intervals.

RESULTS AND DISCUSSION

E. quadripustulatus ♀♀ laid eggs when fed both the rosy apple aphid, *D. plantaginea* and the pea aphid, *A. pisum* (Table I). The former was better food for the egg-laying females as they laid significantly more eggs when kept on this aphid (Student's two-tailed t-test, $t = 10.87$, $p < 0.001$) than on *A. pisum*. The egg laying period also lasted longer. We had a smaller supply of coccids *Parthenolecanium corni* (Bouché) and the 9 *E. quadripustulatus* females that fed on them laid 120 eggs in 9 days. This was many fewer than those laid when feeding on aphids. The eggs hatched in 6 days at 28°.

The larvae successfully developed on *D. plantaginea*, *D. devecta*, *A. pisum* and *A. pomi*. The length of the larval and pupal periods, however, showed differences (Table II). The respective growth curves are shown in Fig. 1.

A. pomi was clearly an inferior prey species except for early development: the adult weight was lower, the mortality nearly double that with other prey, and the peak larval weights were also lower (Fig. 1). During the first 5 days of larval life the weight gain was higher than with other prey (Fig. 1).

The pea aphid, *A. pisum*, allowed the larvae to develop in the shortest period but adults weighed less than those reared on *Dysaphis* spp.

The two *Dysaphis* species gave almost identical effects on the larval development up until the 4th instar but peak weights of 4th instar larvae were lower when the larvae were fed *D. devecta*. The development, however, was accelerated.

The larvae failed to develop on *A. fabae* and *M. viciae* in the laboratory. These aphids were unsuitable and toxic prey since the larvae perished in 2 days after having eaten these aphids.

TABLE I

Fecundity of E. quadripustulatus ♀♀ *fed two species of aphids*

Aphid species	Period of egg laying	Egg numbers/♀ Range	Mean ± S.D.	N	Egg laying rate: eggs/day/♀
A. pisum	21 May—25 June	74—120	91.3 ± 16.0	11	2.6
D. plantaginea	21 May—30 June	141—200	172.8 ± 18.4	10	4.3

The woolly apple aphid, *E. lanigerum*, was also unfavourable food: 50% of the 1st instar larvae moulted to the 2nd instar, only 20% of them reached the prepupal stage and these were unable to pupate. These larvae were very small (5.6 mg) but they lived on this food for a maximum of 20 days (median 12 days).

In our experiments *E. lanigerum*, a com-

TABLE II

Development times in days, adult fresh weights and % mortality of E. quadripustulatus *larvae on different species of aphids at 23%. Data: means ± S.D.*

Duration	Aphid prey species			
	A. pisum	*D. devecta*	*D. plantaginea*	*A. pomi*
Larval stages[1]	18.9 ± 0.3[a] (17)	19.5 ± 0.5[b] (21)	19.8 ± 0.4[bc] (24)	20.1 ± 0.7[c] (16)
Pupal stage	7.9 ± 0.4[a] (17)	8.5 ± 1.1[b] (21)	9.3 ± 1.1[c] (24)	9.5 ± 1.7[bc] (13)
Total development	27.5 ± 0.3[a] (17)	27.7 ± 0.7[a] (21)	29.1 ± 0.9[b] (24)	29.8 ± 2.0[b] (13)
Adult fresh weight, mg	12.1 ± 1.3[a] (17)	13.0 ± 1.0[b] (21)	13.8 ± 1.9[b] (24)	8.4 ± 1.1[c] (13)
Mortality till adult eclosion, %	10.0	6.9	10.7	19.1

[1] Including pre-pupal stage.

Values followed by the same letter in one row are not significantly different at $p = 0.05$ level.

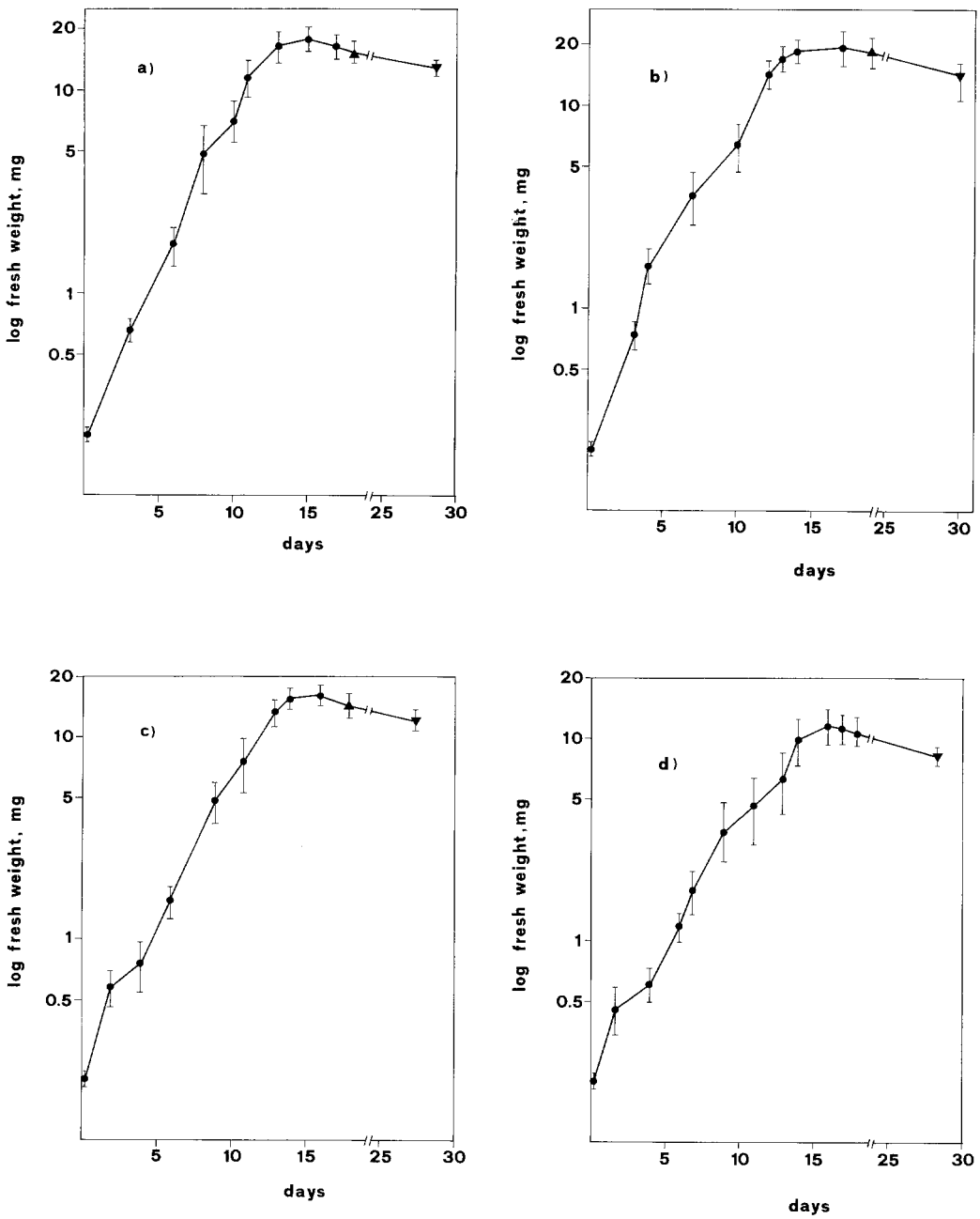

Fig. 1. a—d. Development of *E. quadripustulatus* reflected by mean fresh weight (± S.D.) of larvae, prepupae, and adults fed on four species of aphids at 23°. Preys: a) *D. devecta* (n = 21—23 in individual stages); b) *D. plantaginea* (n = 24—27 but only 8 prepupae weighed); c) *A. pisum* (n = 17—20 but only 6 1st instar larvae weighed); d) *A. pomi* (n = 13—17). ● larval weights; ▲ prepupal weights; ▼ adult weights.

monly mentioned aphid food of the coccinellid, was not suitable. This again emphasizes the need for experimental work in evaluating coccinellid food relationships (Hodek, 1973). However, the rearings reported here were concerned with the tolerance of *E. quadripustulatus* to certain prey rather than with its food preference. These experiments do not prove that *E. quadripustulatus* prefers aphids in the field as our rearings were "forced feeding" experiments and in such situations coccinellids eat many types of food they do not normally consume (Hodek, 1973). We do not have comparable results on the effects of coccid food. The egg laying data showed *P. corni* was suboptimal food for the egg-laying females. This cannot be considered as general for coccids. It is also possible that coccids are favourable food for the larvae only.

We found that *E. quadripustulatus* could develop on aphid food. This puts the species into a transitional position between aphido- and coccidophagy as suggested by Iperti *et al.* (1977) and makes the further study of this "species on an evolutionary crossroad", especially interesting.

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ZUSAMMENFASSUNG

Aphiden als Futter für den Marienkäfer Exochomus quadripustulatus

Weibchen von *E. quadripustulatus* begannen in normaler Weise Eier zu legen, wenn ihnen die Aphiden *D. plantaginea* oder *A. pisum* im Laboratorium als Futter geboten wurden. *D. plantaginea* führte zu stärkerer Eiablage als *A. pisum*; beide Blattläuse waren jedoch der Schildlaus *P. corni* überlegen. *E. quadripustulatus*-Larven konnten sich vollständig entwickeln bei Fütterung mit *D. plantaginea*, *D. devecta*, *A. pisum*, und *A. pomi*. Unterschiede in der Entwicklungszeit und im Adultgewicht werden beschrieben: *A. pomi*-Fütterung führte zur längsten Entwicklungszeit (29,8 Tage) und zum niedrigsten Adultgewicht (8,4 mg). *A. pisum* hatte die kürzeste Entwicklung (27,5 Tage) zur Folge. Das grösste Adultgewicht wurde durch *D. plantaginea* bewirkt (13,8 mg). *A. fabae* und *M. viciae* waren toxisch für die Larven; *E. lanigerum* kann als Alternativfutter aufgefasst werden. Die experimentellen Ergebnisse stützen die Hypothese Iperti's (1977): *E. quadripustulatus* nimmt eine Zwischenstellung ein zwischen Aphidenfressern und Coccidenfressern.

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