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Egg production by the coccinellid *Hippodamia convergens* fed on two morphs of the green peach aphid, *Myzus persicae*

T. Wipperfürth[1], K. S. Hagen & T. E. Mittler
Department of Entomological Sciences, University of California, Berkeley, CA 94720, USA; [1]Present address: Department of Developmental Biology, University of Tübingen, West Germany

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Abstract

Adults of the lady beetle *Hippodamia convergens* Guérin-Méneville, requiring aphids for egg production, were fed suboptimal amounts of apteriform virginoparous larvae or alatiform gynoparous larvae of the green peach aphid, *Myzus persicae* (Sulz.), and artificial diet *ad lib.* The beetles initiated oviposition sooner and deposited significantly more eggs when supplied with the same weight of apterous virginoparous morph. The possible nutritional, hormonal, and ecological implications of the findings are discussed.

Introduction

Field-collected adult *Hippodamia convergens* from mountain aggregations are sold commercially in California, in an attempt to supplement or introduce populations of this effective biological control agent (Hagen & van den Bosch, 1968; DeBach & Hagen, 1964). Mass rearing of these beetles is presently not practical, partly because they produce few eggs unless they are given an abundant supply of aphids as adults (Hagen & Sluss, 1966; Racioppi *et al.,* 1981; Matsuka & Niijima, 1985). Not all species of aphids fed to one aphidophagous coccinellid species are equally suitable (Hukusima & Kamei, 1970; Hämäläinen & Markkula, 1972; Hodek, 1973; Hagen, 1976; Pasteels, 1978; Ives, 1981). That different morphs of one aphid species may also differ in their ability to induce egg production by these beetles is reported here.

Materials and methods

The coccinellid *H. convergens* was reared from eggs deposited by beetles collected from hibernation sites in the coastal hills near Berkeley, California. Larvae were raised entirely on pea aphids, *Acyrthosiphon pisum* (Harr.). On attaining adulthood, female beetles were set up singly and provided with the test aphids together with an *ad lib.* supply of an artificial diet (Singh, P. & Johnson, J., unpubl) which, by itself, was unable to promote egg production, although the beetles survived well on it. This diet consisted of a mixture of protein [lyophilized potato tuber worm, *Phthorimaea operculella* (Zeller)]:yeast autolysate:honey (85:5:10). On the 4th day of adulthood, they were mated by providing each of them with a male for 24 h.

The aphids *Myzus persicae,* originating from Yakima, Washington State, had been maintained in clonal culture for many generations on radish seedlings under controlled conditions (18 °C, 16 h light per diem). The morphs used in the feeding tests were: apteriform virginoparae, reared under the same conditions as the culture; and alatiform gynoparae, produced under long-night conditions [(18 °C, 9 h light per diem) Matsuka & Mittler, 1979]. When fed to the beetles, the aphids of both morphs were in their last (4th) larval instar. At this stage, the morphs were considered not to differ in their appearance or behavior to the food-seeking beetles.

Feeding experiments. Individual female beetles were maintained in plastic vials (2.5 cm diam., 5 cm height) with a gauze lid. Each beetle was fed 6 mg of live aphids of one morph, on each of the first 27 days of adulthood. The supply of aphids was purposely maintained at a suboptimal level (the beetles could consume 2–3 times that amount), in order to detect whether the two morphs differed in their nutrient value and their ability to promote egg production by the beetles. The experiments were performed at room temperature (20–25 °C), and the eggs produced were counted and removed daily (in order to minimize cannibalistic feeding on the eggs by the beetles).

Results

The beetles ingested all the aphids with which they were provided. Fig. 1 shows that beetles feeding on the apteriform virginoparous aphid larvae deposited eggs 2 days earlier and almost twice as many eggs as beetles feeding on the alatiform gynoparous larvae. Despite the considerable variation in total numbers of eggs produced by the beetles in each treatment (Table 1), the means for all 12 beetles (a–l; m–x) initially set up for each treatment ($\bar{x}_{a-l} = 69.7 \pm$ s.e. 8.9; $\bar{x}_{m-x} = 41.0 \pm$ s.e. 7.2) were significantly different ($t = 2.39$, $P<0.05$). If the calculations excluded data for five beetles (h–l; t–x) in each treatment [on the basis of mortality before the termination of the experiment (beetles: h, k, l; t, u, w); cannibalistic feeding on some of the eggs (by beetle: i); initiation of egg deposition not until 14–24 days into adulthood (beetles: j; v, x) rather than within 5–7 days as appeared typical

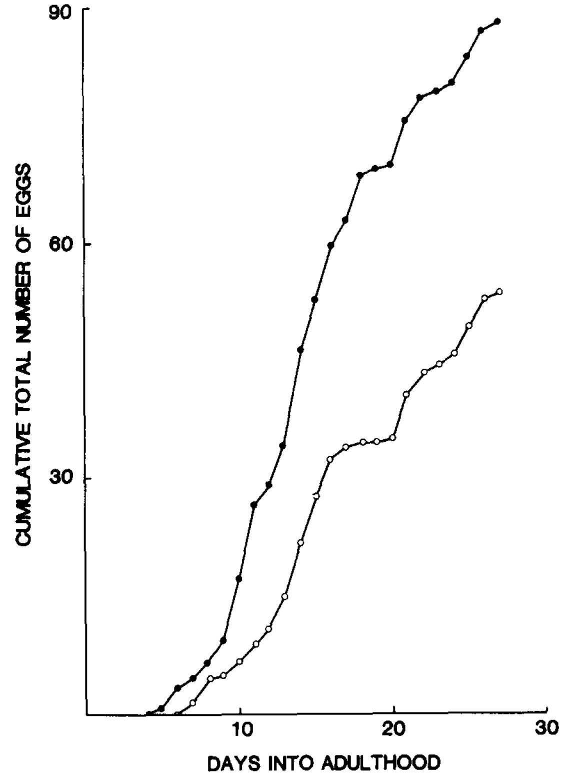

Fig. 1. Cumulative no. of eggs deposited by *H. convergens* fed 6 mg of apteriform virginoparous (●) or alatiform gynoparous (o) larvae of *M. persicae* on each of the first 27 days of adult age. Based on daily averages/seven beetles/treatment.

Table 1. Numbers of eggs deposited by *H. convergens* fed 6 mg apteriform virginoparous larvae or alatiform gynoparous larvae of *M. persicae* daily during the first 27 days of adulthood.

Apt. virg.		Al. gyn.	
a	121	m	84
b	112	n	70
c	88	o	62
d	87	p	55
e	86	q	53
f	72	r	44
g	54	s	12
h	83	t	53
i	50	u	22
j	32	v	22
k	27	w	14
l	24	x	1

for the beetles], the difference in means ($\bar{x}_{a-g}$ = 88.6 ± s.e. 7.9; $\bar{x}_{m-s}$ = 54.3 ± s.e. 7.9) was even greater ($t = 2.83$, $P < 0.02$). The plots in Fig. 1 are based on the first seven beetles in each of the treatments. The irregularities in the curves are due to the fact that the beetles tended to deposit their eggs in batches over periods of 2–3 days. This phenomenon is probably due to endogenous cycles within the beetles.

In a similar experiment in which beetles were provided with up to 10 mg of the apteriform and alatiform aphids per day, 85 and 56 eggs, respectively, were deposited in 16 days. Although these values represent rates of oviposition that are almost twice as high as in the experiment detailed in Table 1, they are still considerably less than the rate of approximately 20 eggs/day which can be achieved by the beetles when they are given an *ad lib.* supply of aphids (Hagen & Sluss, 1966). The amounts of artificial diet consumed by the experimental beetles were not established. However, based on the amounts of aphids consumed in our two experiments, values for the efficiencies of conversion of aphids into beetle egg ranged from 9.1–16% for the alatiform morph to 14.3–22.8% for the apteriform morph. These values are consistent with assimilation estimates by Gutierrez *et al.* (1981).

Discussion

Although the artificial diet (together with free water) was adequate to sustain the entire larval growth and development of the beetles (Singh, P. & Johnson, J., unpublished obs., and confirmed by us) and the adult beetles survived well on it alone, it lacked certain nutrients needed by the beetles for egg development. Clearly, these factors were provided by the aphids, and the apteriform virginoparous morph was able to supply more of these essential factors than the alatiform morph. Several possibilities may be considered to account for the recorded differences.

Apteriform aphids were found to have a higher nitrogen content than alatiforms (Mittler, 1958), and gynoparous *M. persicae* have a higher fat content per unit weight than virginoparae (Mittler, T. E., Chapman, R. & Wilhoit, L., unpublished obs.). These differences are probably related to the fact that 4–5 times as many embryos develop in apteriform virginoparae than in alatiform gynoparae of *M. persicae* (Searle & Mittler, 1982) and may result from higher levels of juvenile hormone (JH) in the virginoparous morph (Mittler *et al.*, 1976). However, the overall levels of JH in aphids are extremely low (Hardie *et al.*, 1985). Whether a dietary intake by the beetles of such low levels of JH could influence their egg production is not known, although topical applications of JH analogues are known to stimulate vitellogenesis in *H. convergens* and other lady beetles (Růzicka *et al.*, 1978; Rankin & Rankin, 1980; Davis & Kirkland, 1982).

Behaviorally, the act of feeding on aphids may also trigger egg development and deposition. The two morphs may provide different levels of stimulation, either by gustation or mechanically because of cuticle-related differences in their textures.

Since a switchover to the production of alatae in a field population of aphids may signal a decline in the number of aphids that would be available to a later generation of beetles, the lower egg production by the beetles feeding on the alatiform morph is probably of ecological significance.

Zusammenfassung

Eiproduktion der Coccinellid Hippodamia convergens *nach Fütterung mit zwei Morphen von der Blattlaus* Myzus persicae

Die Eiproduktion des Marienkäfers *Hippodamia convergens*, welcher hierzu Blattläuse als Nahrung benötigt, wurde bei Fütterung mit zwei verschiedenen Morphen der Blattlaus *Myzus persicae* untersucht. Der Verzehr derselben Menge flügelloser Virginoparen führte im Vergleich zu geflügelten Gynoparen zu früherer und signifikant erhöhter Eiabgabe. Der hormonale und ernährungsphysiologische Hintergrund und die ökologische Bedeutung dieser Ergebnisse werden diskutiert.

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