Eur. J. Entomol. **98**: 283–285, 2001
ISSN 1210-5759

Response of chrysopids (Neuroptera) to larval tracks of aphidophagous coccinellids (Coleoptera)

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Key words. Chrysopidae, Coccinellidae, *Chrysopa oculata, Chrysopa perla*, *Coccinella septempunctata, Cycloneda limbifer, Leis dimidiata, Semiadalia undecimnotata,* predators, aphidophagous insects, larval tracks, oviposition-deterring semiochemicals, allomones, interspecific effects

Abstract. Choice tests showed that tracks left by coccinellid larvae have generally little effect on oviposition site selection by chrysopid females. Fresh tracks of first instar larvae of the coccinellid species *Coccinella septempunctata, Cycloneda limbifer, Leis dimidiata* and *Semiadalia undecimnotata*, did not deter females of the chrysopid *Chrysopa oculata* from laying eggs. Females of *Chrysopa perla* avoided ovipositing only on substrates with tracks of *L. dimidiata* larvae.

INTRODUCTION

Chrysopid and coccinellid larvae touch the surface they are walking on at short intervals with a soft disc on the tip of their abdomen, particularly when walking on smooth substrates or on the lower side of leaves. Sticky secretions from the abdominal disc of chrysopid larvae enable the immediate and effective adhesion of the tip of their abdomen to the surface at these contact sites (Spiegler, 1962). Miniscule amounts of the secretion, which are left behind in the tracks of larvae, deter conspecific females from oviposition. Since the discovery of oviposition-deterring semiochemicals in the tracks of chrysopid larvae in *Chrysopa oculata* (Růžička, 1994), similar spacing cues were found in tracks of the larvae of many other aphidophagous insects (Růžička, 1996, 1997b; Doumbia et al., 1998; Růžička & Havelka, 1998). Although females also respond to physical contacts with larvae (Hemptinne et al., 1992), their encounter with oviposition-deterring tracks is much more frequent. Tracks of larvae prevent egg laying on plants in spite of the presence of aphid prey (Růžička & Havelka, 1998).

Females of four chrysopid species laid more eggs on clean substrates than on substrates with tracks of conspecific or heterospecific chrysopid larvae (Růžička, 1998). Coccinellids also avoided oviposition at sites with conspecific and heterospecific tracks of coccinellid larvae (Růžička, 1997; 2001). Oviposition-deterring responses were frequently found to be stronger to tracks left by conspecific larvae than to tracks of heterospecific larvae. Effects of heterospecific tracks were strong between some allopatric coccinellid species. However, coccinellid females rarely laid fewer eggs on substrates with tracks of chrysopid larvae than on clean ones. The knowledge on semiochemical spacing interactions between different predatory species can help to bring about a better understanding of the occurrence of their eggs and larvae in aphid colonies. Because the larvae of common aphidophagous chrysopids are considered more aggressive and better generalist predators than larvae of aphidophagous coccinellids, the response of chrysopid females to tracks of coccinellids larvae may be expected to be generally low, as indicated by the response of females of the chrysopid *C. oculata* to tracks of *C. septempunctata* larvae (Růžička, 1997). The present study tested this general presumption by examining the response of two species of chrysopids to larval tracks of four coccinellid species.

MATERIAL AND METHODS

Females of chrysopids used in experiments were *Chrysopa oculata* Say (collected in Nova Scotia, Canada) and *Chrysopa perla* (L.) (collected in South Bohemia, Czech Republic). Larvae of coccinellids were *Cycloneda limbifer* Casey (collected in Cuba), *Leis dimidiata* (F.) (collected in south-eastern China), from laboratory cultures maintained for several years, F1-F2 generations of *Coccinella septempunctata* L. (collected in Boršov near České Budějovice, South Bohemia, in April 1999), and F1-F6 generations of *Semiadalia undecimnotata* (Schneider) [=*Ceratomegilla undecimnotata* (Schneider)] (collected in Raná near Louny, Czech Republic, in September 1998).

Contamination of paper substrate by larvae. Strips of white paper were exposed to unfed first-instar larvae of one coccinellid species. Each strip was 20 cm long and 4 cm wide, and was transversely folded every 10 mm to 13 cm. Two strips were exposed to 40 larvae for 4 hours on the bottom of a glass dish, 18 cm in diameter. Fluon on the wall of the glass dish kept the larvae inside.

Choice test with females. Experiments were made in cylindrical cages 10 cm high, 18 cm in diameter. The bottom and the top were covered by glass, the side was tough netting (Růžička, 1997b). Chrysopid females were provided with drinking water, aphids *Acyrthosiphum pisum* Harris in a higher number than the females were able to kill during the test, and a supplementary liquid diet consisting of yeast hydrolysate, sucrose and water. Tests were done at 24 ± 2°C, under light from white-light fluorescent tubes, the photoperiod was 18L : 6D.

One paper strip with larval tracks and one clean paper strip were offered simultaneously to 10 chrysopid females. Both parallel strips were fixed to the lower side of the lid 50 mm apart. Experiments started within 15 minutes after the contamination of paper substrates by the coccinellid larvae. Besides the numbers of eggs laid by females on each paper strip, the numbers of eggs on the semicircular area of the glass around clean strip and on the opposite area around the contaminated strip were recorded. Each choice test lasted 20 hours and had ten replicates. Numbers of eggs laid on contaminated and uncontaminated paper strips were compared with a Wilcoxon paired sample test. The same test was used to analyse the numbers of eggs laid on glass semicircle areas of the lid around each strip.

RESULTS

The females of both chrysopid species mostly laid eggs on the folded paper strips and on the glass lid of the cylindrical cages. In four different choice tests and one blank test*,* *C. oculata* oviposited 856-1320 eggs on paper strips and 501-880 eggs on the glass around strips, *C. perla* laid 303-526 eggs on paper strips and 947-2316 eggs on the glass.

In blank tests, both chrysopid species laid similar numbers of eggs on two clean paper substrates. Females of *C. oculata* laid similar numbers of eggs on clean substrates and on substrates with larval tracks of each of the four coccinellid species tested (Table 1). Females of *C. perla* laid more eggs on the clean substrate only in one case, i. e. when the other substrate was previously exposed to *L. dimidiata* larvae (P < 0.0488). In all choice tests, females of both chrysopid species laid similar numbers of eggs on the semicircular area of the glass lid with contaminated paper strips and on the opposite glass area with clean strips (Table 1).

DISCUSSION

Females of some insects respond to oviposition-deterring heterospecific semiochemicals of species that might compete for food at the larval stage. The interspecific effects were reported less frequently than intraspecific effects in phytophagous species (Birch et al., 1980; Byers & Wood, 1980; Byers et al., 1984), pyralids (Thiery & Gabel, 1992) and in parasitoids (Janssen et al., 1995a,b). For predators, interspecific effects were recently described between chrysopids (Růžička, 1996; 1998) and coccinellids (Růžička, 2001). Females of *Aphidoletes aphidimyza* Rondani laid fewer eggs on aphid infested plants that were previously exposed to first instar larvae of *C. oculata, C. perla* or *C. septempunctata* than on plants with aphids non-exposed to larvae (Růžička & Havelka 1998).

Although strong oviposition-deterring effects were recorded for *C. septempunctata* females on sites with larval tracks of *C. oculata*, females of *C. oculata* laid on sites with tracks of *C. septempunctata* larvae only slightly lower numbers of eggs than on clean sites (Růžička, 1997b). The choice tests of the present study indicate that chrysopid females respond only in exceptional cases to tracks of coccinellid larvae: *C. oculata* laid similar numbers of eggs on clean substrates and on those with tracks of larvae of each of four coccinellid species, and females of *C. perla* decreased oviposition only on substrates previously exposed to *L. dimidiata* larvae.

It has been shown in laboratory experiments that a volatile cue from fresh tracks of *C. oculata* larvae can contaminate clean substrates. When clean papers were enclosed in a Petri dish for four hours near the glass with fresh tracks of starved first instar larvae, they became deterrent to conspecific females, however, clean substrates did not become deterrent when enclosed with glass contaminated in the same way, but then kept for ten days in the open air (Růžička, 1997a). In this study, females of *C. perla* laid similar number of eggs on semicircle area of the clean glass lid around the strip with fresh tracks of *L. dimidiata* larvae and on the opposite half of the lid with the clean strip. This indicates a limited distant deterrent

TABLE 1. Mean number (per replicate; SE in brackets) and mean percentage of eggs laid by females of two chrysopid species (*Chrysopa oculata* and *Chrysopa perla*) on clean substrates (-) and on substrates with tracks (+) of first instar larvae of four coccinellid species (*Cycloneda limbifer*, *Semiadalia undecimnotata*, *Coccinella septempuctata*, *Leis dimidiata*) and on clean glass areas around substrates without (-) and with (+) larval tracks in choice tests. 10 females of each species were tested in ten replicates. Numbers of eggs on substrates and glass areas were compared with Wilcoxon paired sample test, * = P<0.05; ns = not significantly different (P≥0.05).

Females tested	Coccinellid larvae tested												Blank test		
	C. limbifer			***S. undecimnotata***			***C. septempunctata***			***L. dimidiata***					
	-		+	-		+	-		+	-		+	-		-
C. oculata															
eggs on substrate (SE)	61(13)	ns	50(8)	69(7)	ns	63(6)	53(12)	ns	53(4)	59(6)	ns	72(6)	45(7)	ns	41(7)
% eggs on substrate	52		48	52		48	47		53	45		55	53		47
eggs on glass area (SE)	41(6)	ns	47(6)	28(5)	ns	22(5)	33(4)	ns	33(5)	35(6)	ns	33(5)	28(7)	ns	27(5)
% eggs on glass area	47		53	52		48	48		52	50		50	50		50
C. perla															
eggs on substrate (SE)	19(9)	ns	17(9)	25(4)	ns	28(3)	22(4)	ns	18(5)	***30(3)****		22(2)	17(2)	ns	13(1)
% eggs on substrate	51		49	46		54	57		43	***58***		42	55		45
eggs on glass area (SE)	51(1)	ns	44(3)	55(6)	ns	52(7)	64(7)	ns	61(7)	55(6)	ns	49(7)	116(14)	ns	115(10)
% eggs on glass area	52		48	52		48	51		49	54		46	49		51

effect of tracks left by *L. dimidiata* larvae on *C. perla* females.

The comparison of strong and frequent oviposition-deterring interspecific effects between chrysopid species (Růžička, 1996; 1998) with the rare response of coccinellid females to chrysopid larvae (Růžička, 1997b; 2001) and the low occurrence of the oviposition-deterring response of chrysopids to coccinellid larvae in this study may show that coccinellid larvae leave in their tracks additional oviposition-deterring semiochemical cues compared to the larvae of chrysopids. In summary, this study indicates that the deterrent effect of tracks of coccinellid larvae on egg deposition by chrysopid females is low.

ACKNOWLEDGEMENTS. This research was supported by the grant of the Grant Agency of the Czech Republic, No. 206/00/0809, from the Entomology Institute project Z5007907 (Acad. Sci. CR) and the grant project S5007102 (Grant Agency Acad. Sci. CR). I thank M. Červenská and R. Guttwirthová for their assistance with experiments and cultures of insect. I am indebted to V. Semyanov, J. Zelený, O. Nedvěd and D. Růžička for the collection and delivery of predators. I thank to A. Bezděk, R. Zemek and particularly to two anonymous referees, for comments on the manuscript and valuable suggestions.

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Received April 15, 2000; revised March 20, 2001; accepted June 7, 2001