J. Appl. Ent. 123, 413–415 (1999)

ISSN 0931-2048

Semiochemicals associated to spacing behaviour of the bird cherry-oat aphid *Rhopalosiphum padi* L. (Hem., Aphididae) do not affect the olfactometric behaviour of the cereal aphid parasitoid *Aphidius rhopalosiphi* De Stephani-Pérez (Hym., Braconidae)

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Abstract: Volatiles produced by the interaction of *Rhopalosiphum padi* and wheat, and semiochemicals which elicit the spacing behaviour of *R. padi* on wheat and oat, were evaluated in an olfactometer against the cereal aphid parasitoid *Aphidius rhopalosiphi*. The parasitoid was attracted by volatiles produced by the *R. padi*-wheat interaction at high density of aphids, but not by the *R. padi*-wheat interaction at low density. Compounds produced by the interaction of wheat or oat that was infested with a high density of aphids (approximately 9 aphids/cm^2), 6-methyl-5-hepten-2-one (MHO), 6-methyl-5-hepten-2-ol (MHOH), 2-tridecanone (2-T), and methyl salicylate (MS), neither attracted nor repelled *A. rhopalosiphi* as pure compounds or in the naturally occurring mixture. The results are discussed in terms of the use of semiochemicals and parasitoids in the integrated management of aphid pests.

1 Introduction

The aphid *Rhopalosiphum padi* (L.), a common pest of cereals around the world, is generally controlled using pesticides. However, the use of semiochemicals, namely chemicals that mediate interactions between organisms, may result in a complementary action or even in a positive synergism with the action of natural enemies within integrated pest management (IPM) strategies on cereal crops (PICKETT et al., 1997).

Semiochemicals from aphids and their host plants are used by parasitoids to locate and accept their hosts. In particular, the parasitoid of cereal aphids *Aphidius rhopalosiphi* De Stephani-Pérez is attracted by wheat and this attraction is stronger in wheat infested by *R. padi* (WICKREMASINGHE and VAN EMDEN, 1992). PETTERSSON et al. (1994) and QUIROZ et al. (1997) reported that the following compounds are produced by *R. padi*–cereal complexes, but only at a high density of *R. padi* (approximately 9 aphids/cm^2): 6-methyl-5-hepten-2-one (MHO), 6-methyl-5-hepten-2-ol (MHOH) and 2-tridecanone (2-T) for aphids on wheat (*Triticum aestivum* L.), and MHO and methyl salicylate (MS) for aphids on oat (*Avena sativa* L). These semiochemicals elicit the spacing behaviour of *R. padi* as pure compounds and in the naturally occurring mixture. Furthermore, MHO is also a putative pheromone of the hyperparasitoid *Alloxysta victrix* (Westwood) (MICHA et al., 1993) and has been shown to repel *Aphidius uzbekistanicus* Luzhetzki, another specialist parasitoid of cereal aphids. Since the above-mentioned compounds have been suggested as promising alternatives for a stimulo-diversionary strategy against cereal aphids, we evaluated the effect of those semiochemicals on the olfactory behaviour of *A. rhopalosiphi*, a widely distributed and specialist biological control agent of cereal aphids.

2 Materials and methods

2.1 Plants and parasitoids

Aphidius rhopalosiphi was reared on *R. padi* on wheat (*T. aestivum* cv. Paleta) at 18–22°C and 18 h light : 6 h dark. Newly emerged females were allowed to mate and to stay on wheat that was infested with *R. padi* for a further 2 h before the olfactometer assays.

2.2 Entrainment of volatiles and sources for pure compounds

Volatiles were entrained from wheat (*T. aestivum* cv. Paleta) seedlings at growth stage 12 (ZADOKS et al., 1974) under the following conditions: (1) without aphids; (2) with a low density of aphids (approximately 1 aphid/cm^2); and (3) with a high density of aphids (approximately 9 aphids/cm^2). Air, dried and purified by passage through activated 5 Å molecular sieves and charcoal, was drawn at 1 l/min for 48 h through two bell jars containing the odour sources (PETTERSSON et al., 1994). The airborne volatiles were absorbed into Porapak Q and desorbed by elution with distilled diethyl ether. The resulting extract was concentrated, dissolved in hexane and stored at 0°C. Pure compounds were obtained from Aldrich Chemical Co. (Milwaukee, Wisconsin, USA) (purity ≥ 99%).

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***Table** Olfactometric responses of females of the parasitoid* Aphidius rhopalosiphi*, to volatiles present in air entrained from wheat seedling with aphids at low and high density, and to pure chemicals and the naturally occurring mixture reported in the literature to elicit the spacing behaviour of* Rhopalosiphum padi

Stimulus[2]	Time spent in each stimulus (min) (mean ± SE)	P[1]
Wheat with low aphid density	4.99 ± 0.13	0.069
Wheat alone	3.25 ± 0.25	
Wheat with high aphid density	5.67 ± 0.38	0.019
Wheat alone	3.86 ± 0.26	
10 ng MHO	5.16 ± 0.34	0.86
Hexane	4.19 ± 0.28	
10 ng MHOH	4.72 ± 0.31	0.69
Hexane	5.32 ± 0.35	
10 ng 2-T	4.25 ± 0.28	0.77
Hexane	3.72 ± 0.25	
10 ng MS	4.48 ± 0.30	0.57
Hexane	3.37 ± 0.23	
20 ng Mixture	3.53 ± 0.24	0.65
Hexane	4.39 ± 0.29	

[1] Wilcoxon matched pairs test; $P < 0.05$ means significant difference.
[2] MHO, 6-methyl-5-hepten-2-one; MHOH, 6-methyl-5-hepten-2-ol; 2-T, 2-tridecanone; MS, methyl salicylate; Mixture, MHO : MHOH : 2-T (8 : 2 : 3). Sample size $n = 15$.

2.3 Olfactometry

Behavioural assays were performed in an olfactometer described by PETTERSSON (1970). One female parasitoid was enclosed in an arena permeated by air coming from each of its four stretched-out arms and drawn out through a hole above the center of the arena. The stimuli were diluted in 10 μl of hexane and applied to filter papers which were placed at the ends of two adjacent arms, and pure hexane was also placed on filter papers in the two remaining control arms. The parasitoid was constantly observed for a period of 15 min. Each experiment was replicated ($n = 15$) and the times spent in the stimulus and control arms were compared using Wilcoxon matched pairs test.

3 Results and discussion

Aphidius rhopalosiphi was attracted by the volatiles emitted by the interaction of wheat with a high density of aphids (approximately 9 aphids/cm^2) in relation to those of wheat alone (table). This effect seemed to decrease, being marginally non-significant at a low density of aphids (approximately 1 aphid/cm^2). These results are in general agreement with previous reports by WICKREMASINGHE and VAN EMDEN (1992), which showed that wheat infested by *R. padi* was more attractive to parasitoids than wheat alone.

Since the attractiveness of the *R. padi*–wheat complex to *A. rhopalosiphi* was related to the increase in density of the aphid population, those semiochemicals associated to the spacing of aphids, that were identified from cereals infested with a high density of aphids but not from cereals alone, may explain the olfactory behaviour of the parasitoid. The olfactometric assays with these compounds in pure form as well as in their mixture in the naturally occurring proportion did not show any significant attraction or repellence toward *A. rhopalosiphi* (table). These results suggest that other compounds may be responsible for the attraction of *A. rhopalosiphi* to wheat that was infested with aphids at high density or that other cues are necessary to complement the effect of these semiochemicals.

HÖLLER et al. (1994) reported that females of *A. uzbekistanicus* were repelled by MHO in flight-tunnel experiments and in Petri dish bioassays. Flight-tunnel results represent the parasitoid responses to long-range semiochemicals, whereas Petri-dish experiments involve short-range contact with the odour source and represent parasitoid responses to within-habitat semiochemicals. Our experiment was conducted in Pettersson's olfactometer, which evaluates parasitoid responses to short-range semiochemicals without allowing direct contact with the odour source. These differences in experimental conditions may explain the absence of repellence of MHO towards *A. rhopalosiphi*, or alternatively the effect of volatile stimuli may be highly species-specific. In an applied context, semiochemicals shown to repel *R. padi* do not show any repellent effect on the olfactory behaviour of *A. rhopalosiphi*. Thus, these semiochemicals and this parasitoid species could be used complementarily in an IPM strategy to control cereal aphids.

Acknowledgements

This work was supported by IPICS (International Program in the Chemical Sciences at Uppsala University) and the Presidential Chair in Sciences awarded to H.M.N. W.L.G. was supported by a LANBIO (Latin American Network for Research on Bioactive Natural Compounds) fellowship during the development of this work.

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