Manipulation of *Praon* populations with synthetic aphid sex pheromones for the control of cereal aphids

R.Lilley, J.Hardie & L.J. Wadhams

**ABSTRACT**

An aphid sex pheromone, (+)-(4aS,7S,7aR)-nepetalactone, acts as a kairomone for aphid parasitoids of the genus *Praon*. The effect of nepetalactone on levels of parasitism by *Praon* spp. was investigated during the summers of 1993 and 1994. Barley seedlings infested with larvae of the English grain aphid, *Sitobion avenae* (F.), were placed in the field with or without an attached pheromone source. The presence of nepetalactone increased the proportion of aphids parasitised compared to aphids on plants where nepetalactone was absent. The application of nepetalactone in aphid control is considered.

**Key words:** Aphid, field, kairomone, parasitoids, *Praon*, semiochemical.

**INTRODUCTION**

The importance of semiochemicals as host location cues for aphid parasitoids is well documented and was reviewed recently by Hägvar & Höfsvang, (1991). Laboratory studies have demonstrated the attraction of aphidiids to honeydew (e.g. Bouchard & Cloutier, 1984; Budenberg, 1990), host-plant volatiles (e.g. Sheehan & Shelton, 1989; Wickremasinghe & van Emden, 1992) and aphid sex pheromone components (Hardie et al., 1994; Lilley et al., 1994a). Field studies with water traps have shown the attraction of aphid parasitoids of the genus *Praon* to the aphid sex pheromone component (+)-(4aS,7S,7aR)-nepetalactone (Hardie et al., 1991; 1994; Lilley et al., 1994b). The pheromone attracted only female *Praon* which responded in the summer and autumn. This study reports on the impact of aphid parasitoids on aphid-infested barley plants in the presence and absence of nepetalactone.
MATERIALS AND METHODS

Insect culture

A clone of *S. avenae* was reared on barley, *Hordium vulgare* (L.) at 15°C in LD 16:8.

Sex pheromone

The aphid sex pheromone component (+)-(4aS,7S,7aR)-nepetalactone, at 98.4% purity, was extracted from cat mint, *Nepeta cataria* L. (Dawson et al., 1989).

Field trials

Twelve pots were prepared weekly, containing 9 ten-day-old barley seedlings infested with 20-70 first and second stadia *S. avenae* larvae. Larvae were produced by inoculating the plants with five adult aphids three days before the trial (adults were removed before plants were used). A Chromacol glass vial (08-CPV), with a 1mm diameter hole drilled in the plastic lid, containing 10mg nepetalactone in 50ml diethyl ether, was placed at the base of the plants. Six pots received vials containing nepetalactone and six, vials without nepetalactone.

Trials were conducted at two sites, approximately 40m apart, in deciduous woodland at Imperial College, Silwood Park. Site A was established at a woodland margin and site B was situated in a clearing. Each site comprised 6 wire-mesh (14cm square), rabbit-exclusion cages (50cm x 75cm) in a 3 x 2 arrangement, 3m apart. Nepetalactone or control pots were assigned to cages at random.

Plants were exposed in the field for four days and then recovered. *S. avenae* found on the plants were counted and reared in the laboratory at 20±2°C until mummies formed. Mummies were isolated in glass vials until parasitoids emerged and adult females were identified after Stary (1976), although males could not be identified to species. Trials were run from the beginning of July for thirteen consecutive weeks in 1993 and 9 weeks in 1994.

RESULTS

1993 - approximately 25% of aphids were retrieved from treated and control plants at both experimental sites. However, the majority (75%) of aphids developing into mummies were from site A. Over 96% of mummies were identified as *Praon* spp., the remainder were *Aphidius* spp. (results were combined for both sites in Table 1 and Figure 1). Overall, more *Praon* mummies formed on nepetalactone treated plants than on control plants (c² - 19.1, df=1, P<0.001; Table 1). Week by week, more *Praon* mummies were found on nepetalactone plants than on controls in eight trials, equal numbers occurred once and controls collected more mummies on two occasions. Most
emerging female parasitoids were identified as *Prion volucr* (Haliday), although some *P. dorsale* (Haliday) were also recorded (Table 2).

![Graph](image)

**Figure 1:** *Prion* mummies recovered from *Sitobion avenae* on barley plants from July to September 1993; dates indicate the last day of each weekly trial. Black bars: with nepetalactone, grey bars: control.

<table>
<thead>
<tr>
<th></th>
<th>Nepetalactone</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Larvae exposed</strong></td>
<td>2409</td>
<td>2683</td>
</tr>
<tr>
<td><strong>Larvae recovered</strong></td>
<td>609</td>
<td>151</td>
</tr>
<tr>
<td><strong>Parasitism</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Prion</em> spp.</td>
<td>355</td>
<td>26</td>
</tr>
<tr>
<td><em>Aphidius</em> spp.</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

**Table 1:** Numbers of *Sitobion avenae* exposed, recovered and parasitised on barley plants associated with (+)-(4aS,7S,7aR)-nepetalactone or control vials.

**1994** - Trials with *S.avenae* in 1994 were less successful as fewer aphids were recovered from plants and parasitism was lower. Although similar numbers of mummies were collected from nepetalactone and control plants, the proportion of recovered aphids which were parasitised was higher on nepetalactone plants ($c^2 - 13.0$, df=1, P<0.001 Tables 1 and 2).
Table 2. Adult *Praon* spp. emerging from parasitised *Sitobion avenae* on plants associated with (+)-(4aS,7S,7aR)-nepetalactone or control vials.

<table>
<thead>
<tr>
<th></th>
<th>Nepetalactone</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. dorsale</em></td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><em>P. volucre</em></td>
<td>69</td>
<td>2</td>
</tr>
<tr>
<td><em>Praon</em></td>
<td>71</td>
<td>2</td>
</tr>
<tr>
<td>Unemerged</td>
<td>211</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>355</td>
<td>26</td>
</tr>
</tbody>
</table>

DISCUSSION

The attraction of aphid parasitoids of the genus *Praon* to the aphid sex pheromone component (+)-(4aS,7S,7aR)-nepetalactone, released from water traps, was first demonstrated by Hardie et al. (1991). In that study and in a subsequent trial (Hardie et al., 1994) three species were collected: *Praon abjectum* (Haliday), *P. dorsale* and *P. volucre*. In both trials, only female parasitoids were collected, although male *Praon* were found in nearby suction traps. Further work demonstrated that female *Praon* responded to the pheromone in the summer as well as the autumn (Lilley et al., 1994b).

Substitution of water traps with barley plants infested with aphids allowed parasitoid behaviour after odour location to be assessed in terms of parasitism levels. The results of trials in 1993 and 1994 are broadly similar to those found for water trap experiments in the that mainly *Praon* parasitoids were collected. Aphids on plants associated with nepetalactone were subject to higher levels of parasitism in both years. This suggested that more *Praon* arrived on nepetalactone plants or, if numbers approaching all plants were similar, that they oviposited more frequently on nepetalactone plants.

*P. dorsale* and *P. volucre* were reared successfully from *S. avenae*, but the majority of females were *P. volucre* (92%). Many mummies were found to be brown, a characteristic often associated with an aestivating or diapause state, rather than white, non-diapausing mummies (Starý, 1976; Polgar et al., 1991). Brown mummies were found to contain dead larvae which could not be identified to species ('unemerged' - Table 2).

The difference between numbers of *P. dorsale* and *P. volucre* emerging from mummies may have resulted from a) fewer *P. dorsale* approaching nepetalactone plants, b) fewer successful ovipositions by *P. dorsale* females or c) many *P. dorsale* failing to develop fully. Collection of identical numbers of *P. dorsale* and *P. volucre* in concurrent water traps trials (Lilley et al., 1994b) indicated that similar numbers of parasitoids of both species would have approached experimental plants. Host preference may provide an explanation as *P. volucre*, but not *P. dorsale*, has been recorded from *S. avenae* (Starý, 1976). Thus the relatively large number of unemerged
parasitoids could have been predominantly those of *P. dorsale* which were unable to develop fully in an unsuitable host.

Few *Aphidius* spp. were recovered in either year, although *Aphidius* spp. were observed on nearby vegetation throughout the study periods (Lilley *pers obs*). Olfactory receptors for nepetalactone have been found in *Aphidius ervi* (Haliday) and *A. matricariae* (Haliday), with the latter responding to the pheromone in olfactometer studies (Hardie *et al.*, 1993). Results from water trap trials and those with aphid-infested plants indicate that *Aphidius* do not respond to the nepetalactone isomer used in the field. In contrast, recent work in which nepetalactone and 

\(-\)-(1R,4aS,7S,7aR)-nepetalactol were released close to plants infested with the pea aphid, *Acyrthosiphon pisum* (Harris), showed an increase in parasitism by *A. ervi* (Pickett *et al.*, 1994).

The present study indicates that initial observations of the attraction of *Praon* spp. females to water traps can translate into an increase in parasitism levels when aphid infested plants are present with the pheromone source. This augers well for the manipulation of these parasitoids to control asexual pest aphid populations. A number of possible applications could be considered:

**Attraction of natural populations** - trials outlined in this paper could be scaled up to assess the impact of parasitoids on populations of aphids infesting cereal crops. On-going studies at IACR-Rothamsted are investigating the exploitation of parasitoids in this way (W. Powell *pers com*). Pheromone composition, presentation method and optimum timing of application will be crucial in such an approach. Powell *et al.* (1993) suggested that the pheromone could be used to attract parasitoids to alternative hosts to build up large overwintering parasitoid populations close to cereal crops.

**Inundative release** - nepetalactone could be used as a pre-release treatment in inundative release programmes to reduce dispersal responses, as other semiochemicals have been effective when used in this way (Gross *et al.*, 1975).

**Monitoring** - assessment of parasitoid population levels using pheromone-releasing water traps could be invaluable in IPM programmes, particularly with respect to the timing of pesticide applications and to avoid antagonism with other control measures which may decrease parasitoid effectiveness e.g. against fungal pathogens (Powell *et al.*, 1986).

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REFERENCES


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**J. Hardie.** Aphid Biology Group. Department of Biology. Imperial College at Silwood Park. Ascot. Berks SL5 7PY. (UK)

**L.J. Wadhams.** IACR-Rothamsted. Harpenden. Herts AL5 2JQ. (UK)