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Published in:
IOBC/WPRS Bulletin

2002

Use of pheromones and other semiochemicals in integrated production
IOBC wprs Bulletin Vol. 25(•) 2002
pp. •-•

On the origin of pine sawflies caught in pheromone traps

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Abstract: This study investigated behaviour of male European pine sawflies, *Neodiprion sertifer* Geoffr. (Hym., Diprionidae), that were released downwind from pheromone traps. Releases were done at three distances; either at 5 m from one trap, or at 50 m or 200 m from five traps, placed in a line perpendicular to the current wind direction. As a control, males were released identically but without any pheromone source present. The behaviour of the males prior to take-off was studied on a release platform. The following different types of behaviour were recorded: grooming, wing fanning, orientating and take-off. The frequency of grooming was significantly higher in the pheromone treatments compared to the control, whereas the frequency of wing fanning and orientating increased, although not significantly. The direction in which the males displayed the various types of behaviour was more concentrated towards the wind when pheromone was present than during the control experiment. By colour marking of Ecology, Lund University, d travel speed could be calculated. The minimum recorded time from take-off to landing was 1 min, 6 min and 45 min for the 5 m, 50 m and 200 m experiments, respectively. The stimulation- and attraction range of the trap was at least 200 m, and the sampling range after 24 hr was calculated to approximately 400 m (c.i. 140–1600 m).

Keywords; Diprionidae, *Neodiprion sertifer*, sampling range, attraction range

Introduction

Traps baited with species-specific pheromones are becoming common tools for monitoring insect pests. However the correspondence between catches and damage is often poor (Trumble, 1996), partly because of an unknown sampling range of the trap. The sampling range is the maximum range from which insects can be shown to reach an attractive (odour) source within a given time period (Wall & Perry, 1987). Another definition is attraction range, the maximum distance over which insects can be shown to direct their movement to a source (Wall & Perry, 1987). Hence, the sampling range will increase with time up to a maximum level where it levels off, whereas the attraction range is constant.

By performing well designed mark-release-recapture experiments one can gain increased knowledge about the function of the monitoring trap: How many insects

are recaptured from different distances within a given time? How fast do the insects reach the trap? When combined with information from a weather station the influence of weather on trap catch can also be determined. Studies of this kind are rare, but are useful when designing a monitoring program for an insect.

The European pine sawfly, *Neodiprion sertifer* Geoffr. (Hymenoptera: Diprionidae), is one of the most harmful insects to forestry in Europe (Day & Leather, 1997). The larvae consume pine needles, and following an outbreak trees loose growth capacity at least for the following ten years (Austarå *et al.*, 1987). The adult *N. sertifer* female contains approximately 10 ng of the sex pheromone precursor (2*S*,3*S*,7*S*)-3,7-dimethyl-2-pentadecanol (diprionol) (Wassgren *et al.*, 1992). Males respond to the female-released pheromone: either acetate or propionate of the alcohol, both in electrophysiological recordings (Hansson *et al.*, 1991) and in field trapping (Anderbrant *et al.*, 1992a).

In the present study we investigated if there exists any pheromone-modulated behaviour in males of *N. sertifer*. By releasing individually marked males we calculated the recapture rates from different distances and the travel speed of males flying upwind towards the pheromone, together with the sampling range.

Material and Methods

Study site and insects. The study was performed in a young, 2 to 3 m tall, birch (*Betula pendula* Roth.) plantation, surrounded by old pine plantations (*Pinus sylvestris* L.). in Aug.-Sept., from 1996 to 1998, 35 km east of Lund, southernmost Sweden. Larvae of *Neodiprion sertifer* were collected in June from various places in Sweden. The larvae were reared outdoors in a protected place. All the males were marked before release; in 1996 and 1997 a colour dot was painted on thorax dorsally with instant markers. In 1998, we released individually marked males. By dividing the thorax into four fields and painting one to three dots of seven different water based and water-resistant colours, there were enough combinations for releasing differently marked males. After marking the males were kept individually in test tubes, and stored at +4 to +8 °C until use.

Experimental setup. Males were either released 50 m or 200 m downwind of five pheromone traps (inter-trap distance 25 m), or downwind of one trap 5 m away (Fig. 1 in Östrand *et al.*, 2000). The traps were of Lund-II type (Anderbrant *et al.*, 1989). The pheromone, 100 µg acetate of the attractive isomer (2*S*,3*S*,7*S*)-3,7-dimethyl-2-pentadecanol, > 99% stereochemically pure, prepared at and obtained from the Mid Sweden University (Högberg *et al.*, 1990; Anderbrant *et al.*, 1992a) was added to a cotton roll, Celluron® No. 2 (Paul Hartmann, S.A., France),. The traps were placed 1.7 m above ground. New baits were used in every pheromone experiment, and each bait released approximately 45 µg of the pheromone during the first day (calculated from Anderbrant *et al.*, 1992b).

The test tubes containing the males were opened and stacked horizontally in a plastic jar. The jar was covered on the outside with black opaque plastic. Five holes were drilled in the lid. After leaving the test tubes, the males moved towards the light coming through the holes in the lid, and on to a white cardboard platform that was attached to the lid. When > 40 males were released two such platforms were used.

Experimental procedure. The prevailing wind direction was determined by aid of a wind vane and the platforms and the traps were re-located every experimental day, so that the males always were released downwind of the trap(s). One or two persons stood behind the platforms and recorded which males that took off using a tape recorder, while a second person patrolled the five traps and recorded incoming males.

The ground speed of male *N. sertifer* flying upwind to the pheromone source(s) could not be determined. Instead, we calculated the time elapsed from take off to landing = travel time. The exact time for landing could not be recorded when patrolling the five traps in the 50 m and 200 m experiments, and instead we present a range. The median of such ranges was used when the 'exact' travel speed was not available.

Results and Discussion

No unique pheromone-stimulated behaviour was recorded in *N. sertifer* males on the release platform. However, significantly more groomings were recorded at the presence of pheromones compared with the control (Fig. 1). The frequency of males displaying wing fanning and orientation on the platform increased compared to when pheromone was absent, but these differences were not significant, presumably due to the frequency of wing fanning shifting with wind speed (Östrand *et al.*, 2000), and too little data on orientation. An increased frequency of wing fanning is often seen in pheromone-stimulated male moths (e.g. Kishaba *et al.*, 1970; Elkinton *et al.*, 1984).

Significantly more males displayed wing fanning against the wind in all three pheromone experiments compared to the control, and more males took off into the wind at all three distances, although at 200 m the difference was not statistically different from the control (Fig. 2). Thus, the attraction range of the traps were at least 200 m. To compare, males of pea moth *Cydia nigricana* (F.) and oriental fruit moth *Grapholita molesta* Busck. were stimulated at 500 m (Wall & Perry, 1987) and 80 m (Baker & Roelofs, 1981) from 100 µg pheromone sources, respectively. Differences between species are partly due to different sensitivity in the insects, but also the release rate of the pheromone is important.

The fastest recorded travel times from the release platform to the trap were approximately 1 min, 5 min and 45 min for males flying from 5 m, 50 m and 200 m, respectively (Fig. 3). If these travel times are re-calculated to travel speeds the fastest ones, 5–10 m/min, were comparable for the different distances. This travel speed is

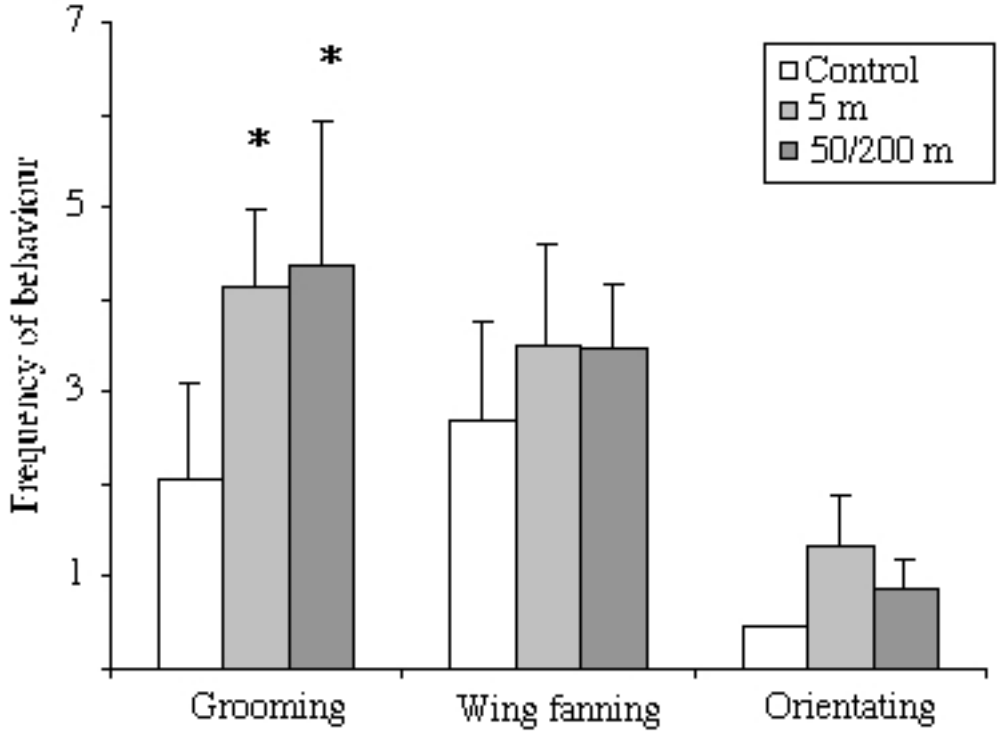

Figure 1. Recorded frequencies of grooming, wing fanning and orientation from pheromone and control experiments. Frequencies are expressed as number of occurrences per hr and number of males present on the platform during the time period, lasting from 30 to 50 min. Data from 50 and 200 m pooled. Values marked with * are significantly different from the control following Students *t*-test. Data from Östrand *et al.*, 2000.

lower than recorded in moths flying upwind to odours, e.g. 50-75 m/min in pea moths (Wall & Perry, 1987) and 20 m/min in cabbage loopers, *Trichoplusia ni* (Hübn.) (Kishaba *et al.*, 1970). The difference is most likely explained by the fact that our experiments were carried out in a young, relatively dense, birch plantation, as compared with the open fields used in the studies on moths, allowing for the pine sawflies to make stops along their way to the pheromone traps.

The recapture rates after 24 hr were on average 3.7 %, 14.0 % and 20.0 % for the 5 m (n=8), 50 m (n=8) and 200 m (n=9), respectively. The recaptures varied with the recorded wind speed (Östrand *et al.*, subm.). At 50 m the recapture was highest at intermediate wind speeds of 1.5-2.0 m/s, whereas it decreased at wind speed > 1.5 m/s at 200 m. Optimal wind speed for capturing insects in odour-baited traps have also been reported in various field experiments on flies (e.g. Nottingham, 1987; Aluja & Prokopy, 1992; Brady *et al.*, 1995).

The sampling range after 1 hr, 2.5 hr and 24 hr were calculated to 190 m (confidence interval following Sokal & Rohlf, 1995: 70–630 m), 290 m (90–1250 m)

and 400 m (140–1600 m) (Data from Östrand *et al.*, subm.) (Fig. 3). In order to achieve homogenous variances and a linear relation recaptures were arc-sin√recapture transformed while distances were log transformed (see Schlyter, 1992). The sampling range was then calculated as the X-intercept of this linear regression. Although these estimate of sampling ranges have wide confidence intervals it is the first estimates of sampling range of a monitoring trap for pine sawflies and it will be helpful when designing monitoring programmes for these insects. Zhang & Schlyter (1996) calculated the sampling range of a trap used for the arctid moth *Hyphantria cunea* (Drury) to 340 m (190–710 m) after 60 hr, using a similar experimental set-up.

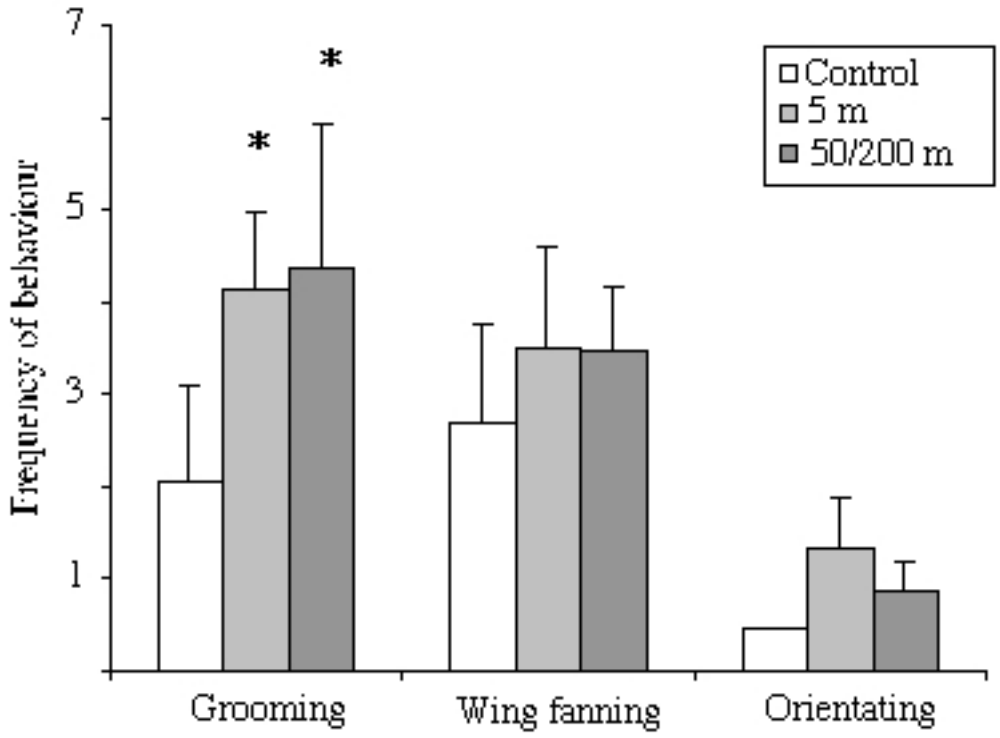

Figure 2. Proportion of upwind-directed wing fanning and take-off in the different pheromone experiments and control. Values having different letters are significantly different from each other following *G*-test.

Acknowledgements

We appreciate assistance in the field from Karin Johnson, Johanna Skobe and Thomas Johansson, for a well running weather station through the aid of Peter Jönsson, Christine Achberger, Marie Ekström and Kristina Blennow. Erik Hedenström and Hans-Erik Högberg kindly provided the pheromone. The experiments were fi-

nanced by grants from the Swedish Council for Forestry and Agricultural Research, Stiftelsen Futura and from the Commission of the European Communities, Agriculture and Fisheries (FAIR) specific RTD programme "Pine sawfly pheromones for sustainable management of European forests (PHERODIP)", CT 95-0339. The study does not necessarily reflect the Commission's views and in no way anticipates its future policy in this area.

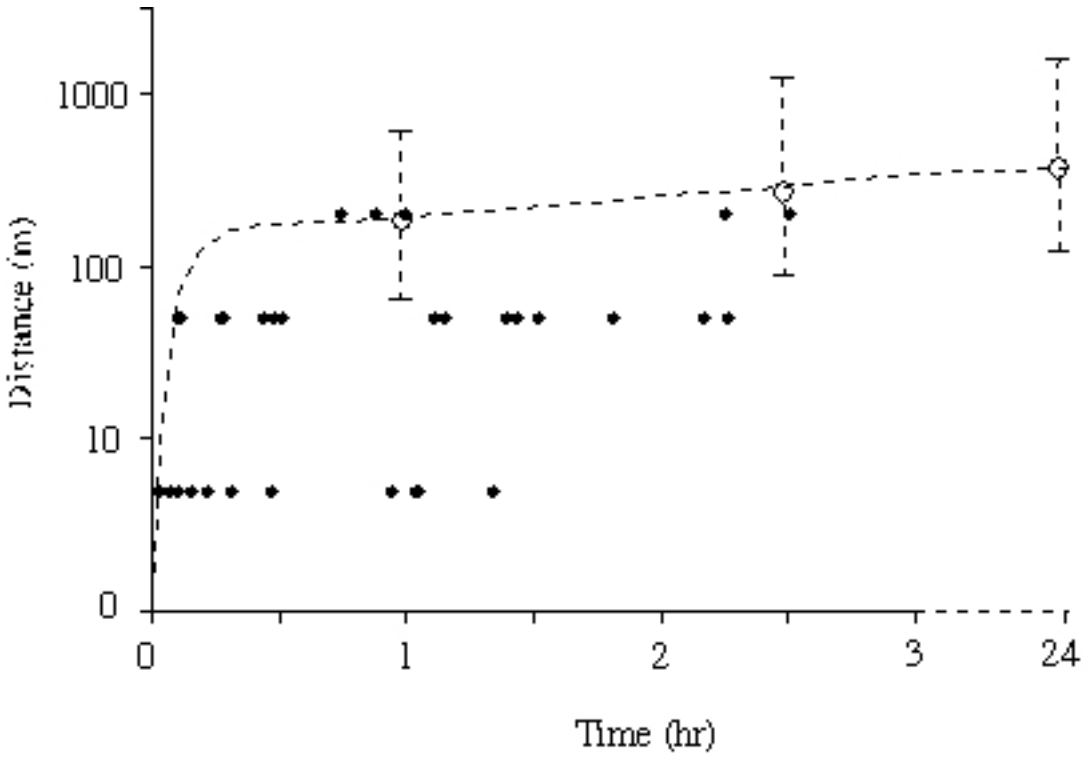

Figure 3. The relationship between distance from pheromone traps and arrival times of caught males during the first 3 hr in the 5 m (n=12), 50 m (n=16) and 200 m (n=5) experiments performed in 1998 (black dots). In many cases the median time of catch has been calculated, as the exact time for take-off and / or landing was not determined. Calculated sampling ranges, with 95% confidence intervals, after 1 hr, 2.5 hr and 24 hr of sampling are shown as unfilled circles. The dashed line illustrates the relationship between time and sampling range.

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