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Geranyl hexanoate attracting male click beetles *Agriotes rufipalpis* Brullé and *Agriotes sordidus* Illiger (Col., Elateridae)

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Abstract: In field screening tests in Hungary, traps baited with geranyl hexanoate captured males of the click beetle *Agriotes rufipalpis* Brullé, whereas in Italy males of *Agriotes sordidus* Illiger (Col., Elateridae) were captured. Geranyl hexanoate-baited traps could be very useful in rationalizing the control of these pests. Such traps can give useful information without making expensive and time-consuming samplings of the soil layers in search of larvae. Traps can be effective also in describing swarming patterns and identifying the peak of male activity, thus yielding an estimate of the level of adult populations, making it possible to forecast future outbreaks and to concentrate agronomic and chemical control strategies against the pests most effectively.

1 Introduction

The larvae of click beetles, the wireworms, rank among the most important pests against which soil insecticides are applied in many countries of Europe. By monitoring the occurrence of click beetle adults it may be possible to forecast the occurrence of wireworms and thus to determine the necessity of insecticide applications on a given field, resulting in reduced use of soil insecticide. Pheromone trapping would be an applicable method of monitoring, since females of adult click beetles emit long-range sex pheromones, and for several pest species the chemical identity of the pheromone has been elucidated (Borg-Karlson et al., 1988; Siirde et al., 1993; Yatsynin et al., 1996). Until now field trapping tests with synthetic pheromones have been largely conducted on click beetle populations in the European part of the former Soviet Union (Yatsynin and Lebedeva, 1984; Yatsynin et al., 1986; Kudryavtsev et al., 1993).

In the present study we screened known pheromone components of click beetles in the field to determine whether any of the compounds shows attraction towards click beetle species in European countries more to the west.

2 Materials and methods

2.1 Baits

The synthesis of geranyl esters is exemplified by geranyl butanoate as follows.

Butyryl chloride (6.2 gram, 58 mmol) was added dropwise to a stirred solution of geraniol (7.9 g, 51 mmol) and (7.6 g, 75 mmol) in methylene chloride (60 ml) at 0–5°C. The reaction mixture was stirred at room temperature for 5 h, and then poured onto cold water (50 ml), the phases were separated, the organic phase was washed successively with 1 N HCl solution (30 ml), saturated $NaHCO_3$ solution (30 ml), dried (Na_2SO_4), concentrated and the residue vacuum distilled to give geranyl octanoate (7.8 g, 68%) as a colourless liquid: boiling point: 85–87°C (1.0 mmHg); n_D^{20} : 1.4622; purity ~95%, as judged by thin-layer chromatography (hexane + ethyl acetate = 95 : 5) and 1H-nuclear magnetic resonance.

Geranyl hexanoate was prepared analogously in a 66% yield using hexanoyl chloride as the acylating agent. Boiling point: 103–106°C (1.0 mmHg); n_D^{20} : 1.4611; purity > 95%.

Geranyl octanoate was prepared analogously in a 76% yield using octanoyl chloride as the acylating agent. Boiling point: 123–127°C (1.0 mmHg); n_D^{20} : 1.4602; purity > 95%.

For preparing the baits the following dispenser types were used: (i) rubber: pieces of rubber tubing (Taurus, Budapest, Hungary; No. MSZ 9691/6; extracted three times in boiling ethanol for 10 min, then soaked also three times in methylene chloride overnight, prior to usage); polythene: 1.0 ml polyethylene vials with lid (No. 730; Kartell S.p.A., Milano, Italy).

For making up the baits the required amount of the compound was administered to the surface of (rubber) or into (Kartell) the dispensers in hexane solutions. After having allowed the hexane to evaporate, the lid of the PE Kartell dispensers was closed and the dispensers were wrapped singly in pieces of alufoil. All dispensers were stored at −30°C until use.

2.2 Traps

The funnel traps used were home-made from transparent plastic bottles. The funnel entrance was 8 cm (inside diameter), the hole of the funnel was 2 cm (inside diameter) and the height of the funnel was 10 cm. Beetles falling down

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through the funnel were caught in a plastic jar (capacity 1 litre). A transparent plastic sheet (15 cm × 15 cm) with a central hole (diameter 3 cm) was placed in a vertical position immediately above the opening of the funnel. A bait dispenser was attached to the vertical plastic sheet so that the attractant-containing part was located in the central hole of the sheet.

The sticky traps were of the 'Delta' design normally used in Hungary for trapping moth species (Szőcs, 1993; Tóth and Szőcs, 1993). The trap body consisted of a transparent plastic sheet (23 cm × 36 cm), folded into a triangular prism (length 23 cm, all three sides 12 cm) with the two ends open. The pheromone bait was suspended centrally inside the trap. Insects entering the trap were captured on a replaceable sticky insert (16 cm × 10 cm) that was placed on the floor of the trap body.

2.3 Sites

In Hungary the site for the experiment was an alfalfa field near Debrecen, Hajdú-Bihar county. The traps were inspected three times per week and the baits were replaced at 3-week intervals during the following time periods: 1994: 21 April to 5 August (sticky traps); 1996: 2 May to 14 June (funnel traps). Traps with different baits were set up in a block. The distance between traps within a block was 10–15 m. The distance between blocks ranged between 100 and 1000 m. The traps were moved forward one position within a block on each occasion that they were inspected. At the same time, captured beetles were recorded and, for sticky traps, the sticky inserts were replaced with new ones, if necessary. From each bait combination two traps were set up in parallel on each experimental site.

In Italy, the sites and time periods for the experiments were: 1995: Eraclea, San Donà, Torre di Mosto, Caorle (Venezia province), Torviscosa (Udine province), 1 March to 13 July; 1996: Valle Vecchia (Caorle), 14 May to 14 July; Cà Bianca (Eraclea), 15 May to 15 July; 1997: Caorle: 14 May to 14 June; Eraclea: 16 May to 16 June. The traps were inspected twice weekly and the baits were replaced each second week.

2.4 Statistics

In statistical analyses, capture data were transformed to $(x + 0.5)^{1/2}$ and the differences between means were tested for significance by analysis of variance followed by Duncan's New Multiple Range Test (DNMRT). Statistical analyses were performed using the software packages StatView™ v.4.01 and Superanova™ v1.11 (Abacus Concepts, Inc., Berkeley, CA, USA).

3 Results and discussion

Agriotes rufipalpis Brullé: In the 1994 test in Hungary, large numbers of male *A. rufipalpis* were captured in traps baited with geranyl hexanoate (table 1). No other baits attracted any males of this species. Catches of *A. sputator* were observed in traps with geranyl butyrate, and some catches of *A. lineatus* were recorded in traps with geranyl octanoate; in both cases the compounds being known pheromone components of the respective species (Yatsynin and Lebedeva, 1984; Yatsynin et al., 1986).

Table 1. *Catches of male* Agriotes spp. *in traps baited with different geranyl esters in preliminary screening tests in Hungary and Italy*

	Total number of beetles caught			
	Hungary (1994)			Italy (1995)
Baits (2 mg)	*A. rufipalpis*	*A. sputator*	*A. lineatus*	*A. sordidus*
geranyl butanoate	0	26	0	0
geranyl hexanoate	426	0	3	27
geranyl octanoate	0	0	33	0

Table 2. *Catches of male* A. rufipalpis *(Hungary) and* A. sordidus *(Italy) in traps baited with different amounts of geranyl hexanoate*

Baits		Number of beetles caught			
		A. rufipalpis (Hungary)		*A. sordidus* (Italy)	
Dispenser	Dose (mg)	Mean/trap/inspection[1]	Total	Mean/trap/inspection[1]	Total
1996					
Rubber	0.4	12.0 a	696	0.2 a	6
Rubber	2.0	15.7 abc	910	0.7 a	21
Rubber	10.0	22.3 bc	1295	3.4 b	103
Polythene	0.4	14.5 ab	841	0.3 a	10
Polythene	2.0	23.3 bc	1351	1.0 a	29
Polythene	10.0	31.2 c	1499	6.1 c	183
1997					
Polythene	10	not tested	not tested	2.5 a	60
Polythene	30	not tested	not tested	5.9 a	141
Polythene	100	not tested	not tested	5.7 a	114

[1] Values followed by the same letter are not significantly different according to Duncan's new multiple range test (DNMRT).

In a dosage test (table 2) for baits with both rubber and polythene dispensers, the numerically highest catches of *A. rufipalpis* were recorded with the 10 mg dosage, but these did not differ significantly from catches with the 2 mg dosage. Traps with the lowest dosage, 0.4 mg captured significantly less. There was no significant difference between rubber and polythene dispensers at any of the dose levels tested, although the catches with polythene dispensers were always numerically higher (table 2).

Agriotes sordidus Illiger: In a preliminary test completed in 1995 in Italy, male *A. sordidus* were regularly captured in traps baited with geranyl hexanoate (table 1).

In the dosage tests of 1996 the highest dose tested was significantly more effective than the lower ones, with both types of dispensers (table 2). There was no significant difference between the low captures of smaller dosages. At the 10 mg dose level, traps with polythene dispensers caught significantly more males than those with rubber dispensers (table 2).

In a subsequent test with higher dosages, no significant difference was found between dosages 10–100 mg, although the numerically highest catch was recorded with a dose of 30 mg (table 2).

It remains to be seen whether this compound is also produced by the respective females in the natural sex pheromone. Geranyl hexanoate has been found to be present in the female-produced sex pheromone of several other *Agriotes* spp. (see, e.g. Borg-Karlson et al., 1988; Siirde et al., 1993; Yatsynin et al., 1996). In preliminary studies we were able to show the presence of this compound in pheromone gland extracts of *A. sordidus* (unpublished; detailed analyses will be reported in full elsewhere).

On the basis of the above results, traps baited with geranyl hexanoate can be recommended for use in monitoring tests for both *A. rufipalpis* and *A. sordidus*.

The two species are very similar from a morphological point of view but their biology is unknown at present. Studies on the life cycle of *A. sordidus* are underway in Italy (Furlan, unpublished). *Agriotes rufipalpis* is widespread throughout south-eastern Europe (Greece, Yugoslavia, Hungary, etc.) whereas *A. sordidus* occurs in South-Western Europe (Platia, 1991). The latter is considered to be a serious pest of maize and other crops whereas *A. rufipalpis* is likely to be an important pest in all areas where it is present. Therefore geranyl hexanoate-baited traps could be very useful in rationalizing the control of these pests. Such traps can give useful information without making expensive and time-consuming samplings of the soil layers in search of larvae. Traps can be effective also in describing swarming patterns and identifying the peak of male activity, thus yielding an estimate on the level of adult populations, making it possible to forecast future outbreaks and to concentrate agronomic and chemical control strategies against the pests most effectively.

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