Acta Phytopathologica et Entomologica Hungarica 38 (3–4), pp. 323–331 (2003)

Field Screening for Attractants of Scarab (Coleoptera: Scarabaeidae) Pests in Hungary

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In field screening tests conducted on selected pest scarabaeids in Hungary, *Epicometis (Tropinota) hirta* (subfamily Cetoniinae) was attracted to traps baited with either cinnamyl alcohol or *trans*-anethol. In some tests attraction was also detected to phenethyl alcohol or cinnamyl acetate. In other tests, adults of *Cetonia aurata aurata* and *Oxythyrea funesta* (subfamily Cetoniinae) also were attracted to *trans*-anethol, while the ternary mixture of phenethyl propionate, eugenol and geraniol attracted *Potosia cuprea* (subfamily Cetoniinae). Some attraction of *Valgus hemipterus* (subfamily Valginae) to cinnamyl alcohol also was observed. All of the above species are pests of more or less economic importance in Hungary. The attractant chemicals discovered in the present study will form a starting point for the development of effective attractants for the respective pest scarab species.

Keywords: attractant, *trans*-anethol, cinnamyl alcohol, *Epicometis (Tropinota) hirta, Oxythyrea funesta, Cetonia aurata, Potosia cuprea, Valgus hemipterus,* Coleoptera, Scarabaeidae, Cetoniinae, Valginae.

Flower-feeding scarabs (Coleoptera, Scarabaeidae, Cetoniinae) are among the most damaging insect pests of agricultural plants. Traps baited with effective scarab lures can have an important role in an environmentally conscious plant protection program. In the present study, our objective was to define lures by field screening of synthetic candidate attractant compounds for scarabs of the Hungarian fauna. A number of chemicals have been shown to be attractive for various scarab adults (Allsopp and Cherry, 1991; Cherry and Klein, 1992; Cherry et al., 1996; Donaldson et al., 1986; 1990; Klein and Edwards, 1989; Ladd et al., 1981; Reed et al., 1991; Williams et al., 2000). In these tests we concentrated on selected compounds described previously as attractants for species of the Cetoniinae and Rutelinae subfamilies. To our knowledge there are no previous reports in the literature on attractants for any of the species reported on in this study.

0238–1249/2003/$ 20.00

Materials and Methods

Baits

Two different types of dispensers (adsorbent disks and polyethylene PE bags) were tested.

For the adsorbent disk dispensers, we used 5 ml of the attractant compound applied to a high void polyethylene disk in a white 3 cm diam. round plastic container as described by Klein and Edwards (1989).

For PE bag bait dispensers a 1 cm piece of dental roll (Celluron®, Paul Hartmann Ag. Heidenheim, Germany) was put into a tight polythene bag made of 0.02 mm linear polyethylene foil. The dispenser was attached to an 8 × 1 cm plastic handle for easy handling when assembling the traps. Each compound (0.1 ml) was administered onto a dental roll and the opening of the polythene bag was heat-sealed. Dispensers were wrapped singly in pieces of aluminum foil and were stored at –30 °C until used.

Synthetic compounds (listed in *Table 2*) were obtained from Sigma – Aldrich Kft. (Budapest, Hungary or St. Louis, MO, USA), with the exception of the phenethyl propionate from BERJI (Bloomfield, NJ, USA). All compounds were >95% pure as stated by the suppliers.

Traps

The traps used were the standard VARb2 funnel traps used by the Budapest laboratory for catching scarabs (Tóth et al., unpublished). The trap consisted of a plastic funnel (top opening outer diameter: 13 cm, funnel hole diameter: 3 cm, height of funnel: 16 cm), under which a transparent plastic round catch container (ca 1 liter capacity) was attached by a rubber band. The top funnel opening was enlarged by attaching a transparent plastic sheet to the trap body, so that the inner diameter of the top trap opening became ca 20 cm. The dispenser was suspended from the plastic sheet so that the bait hung in the middle of the funnel opening, ca 1 cm higher than the level of the upper edge of the original funnel.

Trapping tests

Tests were conducted at several sites in Hungary. Details of the tests are given in *Table 1*. Traps were set up in blocks. Each block consisted of one replication of each treatment (=bait). The distance between traps within a block was 5–10 m. The distance between blocks ranged from 50–100 m. Traps were rerandomized within a block at weekly intervals. When inspecting the traps, captured insects were removed and recorded. Unless otherwise indicated, traps were inspected twice weekly, and old baits were replaced at two to three week intervals with new ones.

Capture data were transformed to $(x+0.5)^{1/2}$ and were analyzed by ANOVA. Treatment means were separated using Duncan's New Multiple Range Test. When only two means were compared, the Student's *t*-test (unpaired) was used. In case one of the treatments was catching no insects, the difference of the catch of other treatments from zero catch was analyzed pair-wise by a one-sample *t*-test. All statistical procedures were conducted using the software packages StatView® v4.01 and SuperANOVA® v1.11 (Abacus Concepts, Inc., Berkeley, USA).

Results and Discussion

Epicometis (Tropinota) hirta Poda (Scarabaeidae, Cetoniinae)

In the first test, traps baited with cinnamyl alcohol alone, or in combination with eugenol, both caught significantly more *E. hirta* than did unbaited traps (*Table 2,* Test 1). There was no difference between catches by the two baits. This suggests that only cinnamyl alcohol was responsible for attractive activity. Beetles were also attracted to traps with cinnamyl acetate and beta-ionone, but these captures were not significantly different from catches in unbaited traps. No other chemicals attracted beetles. In a subsequent smaller experiment, *trans*-anethol attracted significantly more E. hirta than did traps baited with geraniol or the ternary mixture of phenethyl propionate, eugenol and geraniol (*Table 2,* Test 2). Cinnamyl alcohol attracted similar numbers as *trans*-anethol, but the number of beetles captured was not different from the other two baits in this test. In the

Table 1

Methods of single field experiments

Target species	Test site, period and biotop	No. of replicate blocks	Trap placement	Dispenser type
Epicometis hirta	Test 1. Halásztelek, Pest county, Hungary, 1997 May 10–July 17; mixed orchard	2	on branches, at a height of 1.5 m	PE bag
	Test 2: Halásztelek, Pest county, Hungary, 1997 May 17–July 17; mixed orchard	2	on branches, at a height of 1.5 m	adsorbent disk
	Test 3: Halásztelek, Pest county, Hungary, 1998 April 10–July 16; mixed orchard	2	ground level	PE bag
Cetonia a. aurata *Potosia cuprea*	Test 4: Julianna major, Budapest, Hungary, 1998 May 10–October 22; bushy edge of mixed oak forest	2	on branches, at a height of 1.5 m	adsorbent disk
Oxythyrea funesta	Test 5: Agárd, Fejér county, Hungary, 1998 May 7–28; weedy edge of maize field	4	ground level	adsorbent disk
Valgus hemipterus	Test 6: Agárd, Fejér county, Hungary, 1998 May 7–28; weedy edge of sunflower field	9	ground level	PE bag

Table 2

Catches of *E. hirta, C. a. aurata* and *P. cuprea* in field screening tests in Hungary

Bait	Test 1 *E. hirta* (Total caught: 68 beetles)		Test 2 *E. hirta* (Total caught: 50 beetles)	Test 3 *E. hirta* (Total caught: 70 beetles)		Test 4 *C. a. aurata* (Total caught: 68 beetles)		Test 4 *P. cuprea* (Total caught: 38 beetles)	
	mean	P value*	mean	mean	P value*	mean	P value*	mean	P value*
Phenethyl propionate + eugenol + geraniol 3:7:3	0.00	–	0.17a	0.10a	0.1712	0.31a	0.0243	1.13b	0.0033
Cinnamyl acetate	1.00a	0.0873	n.t.	1.30abc	0.0078	n.t.	–	n.t.	–
Cinnamyl alcohol	3.25b	0.0008	4.25ab	2.60c	0.0062	0.19a	0.0411	0.06a	0.1658
Beta-ionone	0.12a	0.1749	n.t.	0.00	–	0.00	–	0.31a	0.1658
Isosafrol	0.00	–	n.t.	0.00	–	n.t.	–	n.t.	–
Eugenol + cinnamyl alcohol 1:1	4.25b	0.0041	n.t.	n.t.	–	n.t.	–	n.t.	–
Valeric acid + hexanoic acid + octyl butyrate 1:1:1	0.00	–	n.t.	0.40ab	0.1006	n.t.	–	n.t.	–
Trans-anethol	n.t.	–	4.83b	0.50ab	0.0450	3.75b	0.0244	0.38a	0.0121
Geraniol	n.t.	–	0.50a	n.t.	–	n.t.	–	n.t.	–
Anisyl acetone	n.t.	–	n.t.	0.10a	0.1712	n.t.	–	n.t.	–
Methyl anthranilate	n.t.	–	n.t.	0.00	–	n.t.	–	n.t.	–
Phenethyl alcohol	n.t.	–	n.t.	2.00bc	0.0223	n.t.	–	n.t.	–
Hexanoic acid	n.t.	–	n.t.	n.t.	–	0.00	–	0.00	–
Eugenol	n.t.	–	n.t.	n.t.	–	0.00	–	0.31a	0.0454
Unbaited	0.00	–	n.t.	0.00	–	0.00	–	0.00	–

Significance: Means with same letter within one column are not significantly different at P=5% by ANOVA followed by Duncan's NMRT. P value*= testing difference from zero catch (one-sample t test); n.t. = not tested in particular test. Anisylacetone = 4-(4-methoxyphenyl)-2-butanone; beta-ionone = 4-(2,6,6-trimethyl-1-cyclohexen-1-yl)-3-buten-2-one; cinnamyl alcohol = 3-phenyl-2-propen-1-ol; eugenol = 2-methoxy-4-propylphenol; geraniol = (E)3,7-dimethyl-2,6-octadien-1-ol; isosafrol = 5-(1-propenyl)-1,3-benzodioxole; *trans*-anethol = 1-methoxy-4-(1-propenyl)benzene.

following year, trap catches with cinnamyl alcohol, phenethyl alcohol, cinnamyl acetate, and *trans*-anethol (*Table 2,* Test 3), significantly exceeded those of unbaited traps, corroborating the previous attractive activity of cinnamyl alcohol and *trans*-anethol.

E. hirta is widespread in much of Eurasia, from the Mediterranean to the Middle East and Central Asia (Hurpin, 1962). The species can cause significant damage by destroying the reproductive parts of flowers of many orchard trees and other agricultural plants (i.e. strawberries and cereals) (Hurpin, 1962; Homonnay and Homonnayné-Csehi, 1990), so an attractive compound used to trap this pest may be of great use to growers. Based on the above results we conclude that cinnamyl alcohol and *trans*-anethol can form a basis for the development of a usable bait for *E. hirta.* Other potential attractive compounds may include cinnamyl acetate and phenethyl alcohol. Results of our efforts to optimize a chemical bait for *E. hirta* will continue and will be published in detail in the future.

Cetonia aurata aurata L. (Scarabaeidae, Cetoniinae)

In a test conducted at the edge of a mixed oak forest, significantly more *C. a. aurata* were caught in traps baited with *trans*-anethol, the ternary mixture of phenethyl propionate, eugenol and geraniol, and with cinnamyl alcohol, than in unbaited traps (*Table 2,* Test 4). The highest numbers of beetles were caught in the *trans*-anethol trap that was significantly greater than were the two other attractive chemicals. *Beta*-ionone, hexanoic acid and eugenol baited traps caught no beetles. The attractive activity of *trans*-anethol was corroborated by a subsequent comparison of unbaited vs. *trans*-anethol-baited traps. Traps with *trans*-anethol caught a mean of 2.91 *C. a. aurata* beetles vs. a mean of 0.03 beetles in unbaited traps ($P=<0.0001$ by Student's *t*-test; Telki, Pest county, Hungary, 2000 June 20–July 29, 4 block replicates; a total of 94 beetles were caught in the test).

C. a. aurata is present in Eurasia, from the Atlantic Ocean in the west to North-Western China and Mongolia on the east, and in the north from St. Petersburg to Lake Baikal. The typical form can be found to the south as far as the Astrakhan and Aral Sea region, while var. *praeclara* Muls. of the species lives in the Middle East including Iran and Syria, and var. *funeraria* Gory is found in North Africa (Hurpin, 1962). The adult beetles can damage flowers of several orchard and ornamental trees and shrubs, preferring especially Rosaceae and Caprifoliaceae (Hurpin, 1962). In Hungary, it is regarded as a secondary pest (Homonnay and Homonnayné-Csehi, 1990). The only method recommended for control is by mass collection of damaging beetles (Homonnay and Homonnayné-Csehi, 1990). A trap with an attractive compound would be ideal for this type of control. The development of an attractant based on the activity of *trans*-anethol, discovered in this study, may be possible, provided that other components increasing the activity of this compound can be discovered.

Potosia cuprea Fabr. (Scarabaeidae, Cetoniinae)

In the same test where *C. a. aurata* was trapped, a closely related beetle, *P. cuprea,* was also caught (*Table 2,* Test 4). The highest numbers of beetles were found in traps with the ternary mixture of phenethyl propionate, eugenol and geraniol, which was significantly greater than all other baits. Traps with *trans*-anethol or eugenol had significantly more beetles than unbaited traps.

P. cuprea is among the most important pest representatives of the genus *Potosia,* and is widespread in all the Palaearctic region (Hurpin, 1962). The adults of this species cause damage similar to that of *C. a. aurata.* In Hungary, the species has secondary importance (Homonnay and Homonnayné-Csehi, 1990). The ternary mixture found to be attractive in this study may serve as a starting point for the development of a more active bait for the species.

Oxythyrea funesta Poda (Scarabaeidae, Cetoniinae)

In a test comparing the activity of *trans*-anethol, cinnamyl alcohol and their mixture, traps with trans anethol alone, and the combination of *trans*-anethol and cinnamyl alcohol caught more *O. funesta* than cinnamyl alcohol alone. Captures with *trans*-anethol alone were significantly greater than cinnamyl alcohol alone, but the combination was not significantly greater than cinnamyl alcohol alone (*Fig. 1,* Test 5). This may be an indication for the attractive activity of *trans*-anethol also for this species. *O. funesta* is present in the western Palaearctic region, in all Europe, and in the Mediterranean from the Atlantic coast of Morocco to well into Russia and Lithuania up to Kaunas, Vitebsk to the north and to Armenia and Azerbaidjan to the south-west (Hurpin, 1962). In Hungary, its pest status is far less significant than that of *E. hirta,* since it causes only occasional damage (Homonnay and Homonnayné-Csehi, 1990). However, to the south, more important damage has been reported on peaches, pears and chestnuts (Hurpin, 1962). The development of a more potent bait combination can be attempted based on the activity of *trans*-anethol discovered in this study.

Valgus hemipterus L. (Scarabaeidae, Valginae)

In a test similar to the previous one with *O. funesta,* another scarab beetle, *V. hemipterus* was caught in traps baited with cinnamyl alcohol, which was significantly different from the catch with *trans*-anethol, which was zero (*Fig. 1,* Test 6). Trap catches with cinnamyl alcohol alone, or the cinnamyl alcohol – *trans*-anethol mixture, were not significantly different. This may be an indication of the attractive activity of cinnamyl alcohol by *V. hemipterus,* too.

The pest status of *V. hemipterus* is not clear. It can be observed causing damage similar to that of *E. hirta* on flowers of orchard trees, but the species is never very numerous, at least in Hungary (Endrödi, 1956). A bait developed on the basis of the activity of cinnamyl alcohol observed in this study may also be helpful in studies on the importance of this species as a pest.

The compounds screened in the present study were chosen because all of them have been reported to be attractive towards one or more scarabs in the literature. These compounds seem to be among the most common, possibly host-plant derived, allelochemicals utilized for chemical communication, especially in the subfamilies Cetoniinae and Rutelinae. Among the compounds evaluated in the present study, *trans*-anethol has

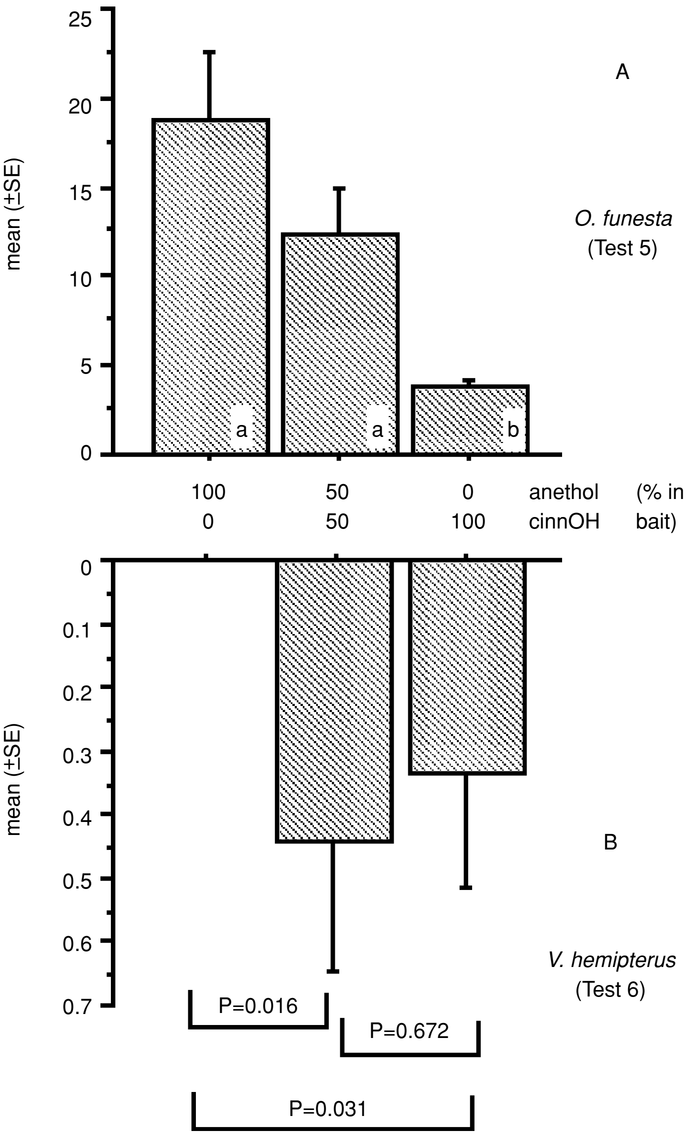

Fig. 1. Catches of *O. funesta* (A) and *V. hemipterus* (B) in trapping tests in Hungary. A: Columns with same letter not significantly different at P=5% by ANOVA followed by Duncan's NMRT *(O. funesta).* B: P value from Student's *t*-test; difference from zero catch by one-sample *t*-test *(V. hemipterus)*

previously been reported to be attractive to the scarabs *Anomala marginata* Robinson (Scarabaeidae, Rutelinae), *Trigonopeltastes delta* Forster (Scarabaeidae, Melolonthinae) (Cherry et al., 1996) and *Eupoecila australasiae* Donovan (Scarabaeidae, Cetoniinae) (Allsopp and Cherry, 1991). This compound is also the major component (together with phenethyl propionate and geraniol) of the food lure of *Anomala octiescostata* Burmeister (Scarabaeidae, Rutelinae) (Leal et al., 1994). Cinnamyl alcohol has been found to be attractive towards the cetonins *Pachnoda* spp. and *Oxythyrea* spp. and the rutelins *Anomala transvaalensis* Arrow and *Adoretus tessulatus* Burmeister (Donaldson et al., 1986, 1990). Cinnamyl acetate was described as attractive for *Oxythyrea* sp. (Scarabaeidae, Cetoniinae) (Donaldson et al., 1986), and phenethyl alcohol is one component of the host-plant derived lure attracting *Anomala octiescostata* (Scarabaeidae, Rutelinae) (Leal et al., 1994).

The ternary mixture of phenethyl propionate, eugenol and geraniol is the optimized food-type lure which is highly attractive to the Japanese beetle, *Popillia japonica* Newman (Scarabaeidae, Rutelinae) (Ladd and McGovern, 1980; Ladd et al., 1981) and was shown to be attractive for the rutelins *P. lewisi* Arrow and the cetoniins *Protaetia ishigakai okinawana* Kurosawa and *Oxycetonia jecunda* Falderman on Okinawa (Klein and Edwards, 1989), and for *O. jecunda* in Korea (Reed et al., 1991). Two of the components, eugenol and geraniol, were attractive for another cetoniin, *Euphoria sepulchralis* Fab. (Cherry et al., 1996). Species reported in the present study all belong to the subfamily Cetoniinae, with the exception of the valgin *V. hemipterus.* We found no other report on attractants for Valginae spp. in the literature.

Acknowledgements

The present research was partially supported by grants OTKA T-029126 and 37569 of the Hungarian Academy of Sciences. Thanks are due to István Ujváry (Chemical Research Centre, HAS) for useful advice and discussions in the course of the study.

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