New Sex Attractants for Five *Chamaesphecia* Species (Lepidoptera, Sesiidae) from the Ukraine and Turkmenistan

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Field screening tests of (3*Z*,13*Z*)- and (3*E*,13*Z*)-octadecadienols, (2*Z*,13*Z*)- and (2*E*,13*Z*)-octadecadienols and their acetates as well as some binary mixtures of these compounds in dosages of 0.5 mg/dispenser were carried out in the Crimea, the Ukraine, and in the West Kopetdag mountains, Turkmenistan, in 1989–1993. New sex attractants for five clearwing moth species of the genus *Chamaesphecia* (Lepidoptera, Sesiidae) were discovered. Males of *Ch. chalciformis* were attracted by a 1:1 mixture of 3*Z*,13*Z*-18:OH and 2*E*,13*Z*-18:OAc, *Ch. schmidtiformis* by a 9:1 mixture of 3*Z*,13*Z*-18:OAc and 3*Z*,13*Z*-18:OH in the Ukraine as well as in the ratios 9:1 and 1:1 in Turkmenistan, *Ch. mezentzevi* by a 9:1 mixture of 3*Z*,13*Z*-18:OAc and the corresponding alcohol, *Ch. zimmermanni* by a 1:9 mixture of 3*Z*,13*Z*-18:OAc and 3*E*,13*Z*-18:OH, and *Ch. specia nova* in Turkmenistan by a 1:1 mixture of 3*Z*,13*Z*-18:OH and 3*E*,13*Z*-18:OAc. Two inhibitors, 3*Z*,13*Z*-18:OH and 3*E*,13*Z*-18:OAc, of the sex attractant were found for *Ch. zimmermanni*. The periods of attraction to the traps were registered for males of *Ch. zimmermanni* and *Ch. specia* nova and were found to occur at 19^{00}–21^{00} and 14^{30}–17^{00} local time, respectively. Males of *Ch. chalciformis* and *Ch. schmidtiformis* were attracted to the traps in the afternoon.

Introduction

At the first glance, clearwing moths bear more resemblance to wasps than to typical moths and this similarity makes it difficult to distinguish them in nature and collect them in the traditional way, using entomological nets. Sesiids are active during the light period of the day and are not attracted by light traps at night. For handling these peculiar moths, sex attractants and sex pheromones are especially valuable tools, making it comparatively easy to detect and catch them.

Up to now, only 14 clearwing moth species (Lepidoptera, Sesiidae) are known from Turkmenistan (Buda *et al.,* 1993; Gorbunov, 1995), while Transcaucasia, which is adjacent to Central Asia and smaller in area, possesses about 70 species (Gorbunov, 1995). A region as vast as Turkmenistan must be expected to contain a much richer sesiid fauna, and further studies of clearwing moths in this area might result in the description of new endemic species and broaden the ecological and zoogeographical knowledge of sesiid species already known.

In this paper we present new sex attractants for 5 and inhibitors of the sex attractant for 1 clearwing moth species as well as some data on the daily rhythm of the attraction of males to traps baited with sex attractants for 4 species.

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Materials and Methods

Chemicals

The compounds used in the field tests were synthesized in Tartu, Estonia. The diastereomeric and chemical purities of the chemicals were determined by GC and were over 98%, except the chemical purity of 2*Z*,13*Z*-18:OAc, which was 95%.

Field tests

The compounds were tested under field conditions both alone and in binary mixtures in the three ratios 9:1, 1:1 and 1:9, in doses of 0.5 mg/

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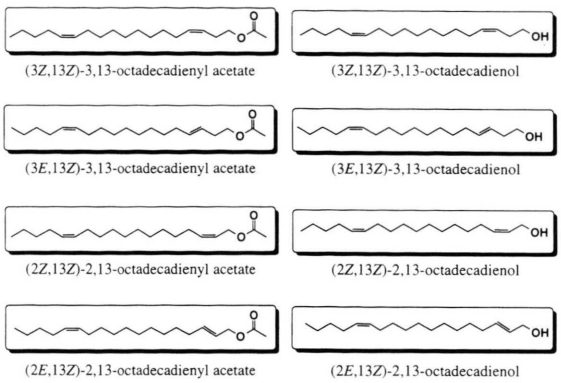

Fig. 1. Structural formulas of compounds used in the field tests.

dispenser (see Table I). Each compound or mixture was dissolved in hexane and was impregnated into a red rubber tube dispenser (8×15 mm). Each lure was fixed into an opaque white delta trap (trapping window 10×11×10 cm and trap length 18 cm), which had an exchangeable bottom (11×18 cm), coated with sticky material ("Atracon A" trap and Pestifix glue, both from Flora Co., Tartu, Estonia).

The field tests were carried out in the Crimea, the Ukraine, and in the West Kopetdag mountains, southwestern Turkmenistan, on the following samples, in the following localities and during the following periods:

I. The Ukraine, the Crimea, Karadag Reserve, June 7–15, 1991. Three replications of each compound and mixture listed in Table I. The traps

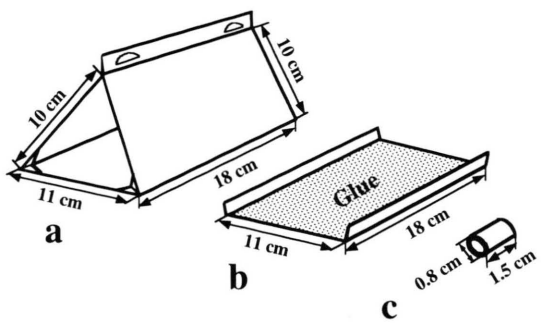

Fig. 2. Scheme of the pheromone trap and dispenser used in the field tests a) pheromone trap "Attracon A", b) exchangeable bottom coated with sticky material (glue) "Pestifix", c) red rubber tube dispenser. (Traps, glue and dispensers were obtained from Flora Co., Tartu, Estonia.)

were fixed 1 to 2 m above the ground to branches of shrubs and trees growing on hillsides of the valleys Karadag and Tumanova and were inspected every two days. The distance between the traps was at least 30 m. Typical species in this phytocenosis are *Quercus pubescens* Willd., *Carpinus betulus* L., *Smyrnium perfoliatum* L., *Anthriscus sylvestris* (L.), *Physospermum cornubiense* Grossh., *Ranunculus constantinopolitanus* Urv., *Corydalis marschalliana* (Pall.), *Galanthus plicatus* Pers., *Bromopsis riparia* Rehm., *Asphodeline taurica* (Pall.), *Astragalus arnacantha* M. B., *Teucrium polium* L., and *Veronica multifida* L. The total number of species reaches the figure 130 (based on Golubiev and Mironova, 1989).

II. The Ukraine, the Crimea, Karadag Reserve, July 4–14, 1991. Three replications of each compound and mixture listed in Table I. The same locality as above. The traps were fixed 1 to 2 m above the ground to the branches of shrubs and trees growing on the hillsides.

III. Southwestern Turkmenistan, Syunt-Khoserdag Reserve, (A). Youl-Dere valley, May 5–17, 1989. Three replications of each compound and mixture listed in Table I. Youl-Dere valley is well defined and has a 1–2 m wide rivulet, flowing in the flat ground of the valley which is 20 to 80 m wide. Dominant species of trees and shrubs growing on this flat ground are *Crategus turcestanica* Pojark., *Ulmus caprini* Rupp. *et* Suchow., *Lonicera floribunda* Boiss. *et* Buch., *Vitis vinifera* L., *Acer turcomanica* Pojark., *Salix alba* L., *Paraliurus spinachristi* Mill., *Celtis caucasia* Willd., *Prunus divaricata* Lebed., and *Rubus sanguineus* Friv. On the hillsides, multiherbaceous meadows, shrubs, semi-desert, and mountainous xerophytobiont communities are found. The traps were fixed 1 to 2 m above the ground to the branches of shrubs growing on the foothills and were inspected every two days. The distance between the traps was at least 25 m.

(B). In addition, two replications of each compound and mixture listed in Table I were tested in the Ai-Dere canyon of the same reserve, May 30–July 5, 1991. *Punica granatum* L., *Ficus carica* L., *Platanus orientalis* L., *Elaeagnus* orientalis L., *Juglans regia* L., *Cydonia oblonga* Mill., *Spyrae hypercifolia* L., *Amygdalus communis* L., and several species of the genus *Pyrus* are common in the Ai-Dere locality in addition to those mentioned as

Table I. Attraction of males of the genus *Chamaesphecia* to synthetic compounds at a dosage of 0.5 mg/dispenser under field tests in the Ukraine and Turkmenistan.

Compounds	Ratios	*Ch. chalciformis*	*Ch. schmidtiformis* (Crimea, Ukraine)	*Ch. schmidtiformis* (Turkmenistan)	*Ch. mezentzevi*	*Ch. zimmermanni*	*Ch. sp. nova*
Localities of field tests		I	II	III	IV	V	V
3*Z*,13*Z*-18:OAc		.	.	.	.	.	.
3*Z*,13*Z*-18:OH		2 a	.	.	.	.	.
3*E*,13*Z*-18:OAc		.	.	.	.	.	.
3*E*,13*Z*-18:OH		.	.	.	.	9 bc	.
2*E*,13*Z*-18:OAc		.	.	.	.	.	.
2*E*,13*Z*-18:OH		.	.	.	.	.	.
3*Z*,13*Z*-18:OAc/3 *Z*,13*Z*-18:OH	9 : 1	.	7 b	17 c	10 c	.	.
3*Z*,13*Z*-18:OAc/3 *Z*,13*Z*-18:OH	1 : 1	1 a	.	11 bc	3 b	.	.
3*Z*,13*Z*-18:OAc/3 *Z*,13*Z*-18:OH	1 : 9	2 a	.	10 b	.	1 a	.
3*Z*,13*Z*-18:OAc/3 *E*,13*Z*-18:OAc	9 : 1	.	.	.	.	.	.
3*Z*,13*Z*-18:OAc/3 *E*,13*Z*-18:OAc	1 : 1	.	.	.	.	.	.
3*Z*,13*Z*-18:OAc/3 *E*,13*Z*-18:OAc	1 : 9	.	.	.	.	.	.
3*Z*,13*Z*-18:OAc/3 *E*,13*Z*-18:OH	9 : 1	.	.	.	.	.	.
3*Z*,13*Z*-18:OAc/3 *E*,13*Z*-18:OH	1 : 1	.	.	.	.	2 a	.
3*Z*,13*Z*-18:OAc/3 *E*,13*Z*-18:OH	1 : 9	.	.	.	.	43 d	.
3*Z*,13*Z*-18:OAc/2 *E*,13*Z*-18:OAc	9 : 1	.	.	.	.	.	.
3*Z*,13*Z*-18:OAc/2 *E*,13*Z*-18:OAc	1 : 1	.	.	.	.	.	.
3*Z*,13*Z*-18:OAc/2 *E*,13*Z*-18:OAc	1 : 9	.	.	.	.	.	.
3*Z*,13*Z*-18:OAc/2 *E*,13*Z*-18:OH	9 : 1	.	.	.	.	.	.
3*Z*,13*Z*-18:OAc/2 *E*,13*Z*-18:OH	1 : 1	.	.	.	.	.	.
3*Z*,13*Z*-18:OAc/2 *E*,13*Z*-18:OH	1 : 9	.	.	.	.	.	.
3*Z*,13*Z*-18:OH/3 *E*,13*Z*-18:OAc	9 : 1	18 cd	.	.	.	.	.
3*Z*,13*Z*-18:OH/3 *E*,13*Z*-18:OAc	1 : 1	3 a	.	.	.	.	42 c
3*Z*,13*Z*-18:OH/3 *E*,13*Z*-18:OAc	1 : 9	.	.	.	.	.	26 b
3*Z*,13*Z*-18:OH/3 *E*,13*Z*-18:OH	9 : 1	.	.	.	.	.	.
3*Z*,13*Z*-18:OH/3 *E*,13*Z*-18:OH	1 : 1	.	.	.	.	.	.
3*Z*,13*Z*-18:OH/3 *E*,13*Z*-18:OH	1 : 9	.	.	.	.	2 a	.
3*Z*,13*Z*-18:OH/2 *E*,13*Z*-18:OAc	9 : 1	8 abc	.	.	.	.	.
3*Z*,13*Z*-18:OH/2 *E*,13*Z*-18:OAc	1 : 1	42 e	.	.	.	.	.
3*Z*,13*Z*-18:OH/2 *E*,13*Z*-18:OAc	1 : 9	4 ab	.	.	.	.	.
3*Z*,13*Z*-18:OH/2 *E*,13*Z*-18:OH	9 : 1	12 cd	.	.	.	.	.
3*Z*,13*Z*-18:OH/2 *E*,13*Z*-18:OH	1 : 1	21 cd	.	.	.	.	.
3*Z*,13*Z*-18:OH/2 *E*,13*Z*-18:OH	1 : 9	4 ab	.	.	.	.	.
3*Z*,13*Z*-18:OH/2 *Z*,13*Z*-18:OAc	1 : 1	23 d	.	–	–	–	–
3*Z*,13*Z*-18:OH/2 *Z*,13*Z*-18:OH	1 : 1	10 bcd	.	–	–	–	–
3*E*,13*Z*-18:OAc/3 *E*,13*Z*-18:OH	9 : 1	.	.	.	.	.	.
3*E*,13*Z*-18:OAc/3 *E*,13*Z*-18:OH	1 : 1	.	.	.	.	.	.
3*E*,13*Z*-18:OAc/3 *E*,13*Z*-18:OH	1 : 9	.	.	.	.	1 a	.
3*E*,13*Z*-18:OAc/2 *E*,13*Z*-18:OAc	9 : 1	.	.	.	.	.	.
3*E*,13*Z*-18:OAc/2 *E*,13*Z*-18:OAc	1 : 1	.	.	.	.	.	.
3*E*,13*Z*-18:OAc/2 *E*,13*Z*-18:OAc	1 : 9	.	.	.	.	.	.
3*E*,13*Z*-18:OAc/2 *E*,13*Z*-18:OH	9 : 1	.	.	.	.	.	.
3*E*,13*Z*-18:OAc/2 *E*,13*Z*-18:OH	1 : 1	.	.	.	.	.	.
3*E*,13*Z*-18:OAc/2 *E*,13*Z*-18:OH	1 : 9	.	.	.	.	.	.
3*E*,13*Z*-18:OH/2 *E*,13*Z*-18:OAc	9 : 1	.	.	.	.	9 abc	.
3*E*,13*Z*-18:OH/2 *E*,13*Z*-18:OAc	1 : 1	.	.	.	.	2 a	.
3*E*,13*Z*-18:OH/2 *E*,13*Z*-18:OAc	1 : 9	.	.	.	.	.	.
3*E*,13*Z*-18:OH/2 *E*,13*Z*-18:OH	9 : 1	.	.	.	.	14 c	.
3*E*,13*Z*-18:OH/2 *E*,13*Z*-18:OH	1 : 1	.	.	.	.	4 ab	.
3*E*,13*Z*-18:OH/2 *E*,13*Z*-18:OH	1 : 9	.	.	.	.	.	.
2*E*,13*Z*-18:OAc/2 *E*,13*Z*-18:OH	9 : 1	.	.	.	.	.	.
2*E*,13*Z*-18:OAc/2 *E*,13*Z*-18:OH	1 : 1	.	.	.	.	.	.
2*E*,13*Z*-18:OAc/2 *E*,13*Z*-18:OH	1 : 9	.	.	.	.	.	.
Control		.	.	.	.	.	.
TOTAL		150	7	38	13	87	68

Each figure denotes the total number of moths trapped, charged as indicated in the Table. If the numbers in the same column are followed by different letters, the difference between them is statistically significant at $P < 0.05$. A dot means 0 a.

occurring in the Youl-Dere valley. The traps were fixed 1 to 2 m above the ground to the branches of shrubs growing on the bottom of the valley and were inspected every two days. The distance between the traps was at least 25 m.

IV. Southwestern Turkmenistan, vicinity of the Parkhai settlement, 6 km northwest of Garrygala, April 22-May 15, 1992, three replications of each compound and mixture mentioned in Table I. The same locality, May 3–June 10, 1993, three replications. The area of the test is situated at the foot of a mountain ridge. Typical elements of the landscape are hills, about 15–25 m high. The solitary trees are *Paraliurus spinachristi* Mill. and *Cerasus microcaupa* Boiss. The semi-desert shrubs *Amygdalus scoparia* Spach., *Atraphaxis spinosa* L., *Colutea gracilis* Freyn. *et* Sint., *Hulthemia persica* Borum., *Rhamnus sintenisii* Rech., *Salix alba* L., and *Vitis vinifera* L. grow on the foothills on the sides of a small spring. On the hillsides, the shrubs grow solitarily and higher up they are replaced by dominant semi-desert species of the genera *Arthemia*, *Astragalus*, *Euphorbia*, *Ferula*, *Phlomis*, *Salsola*, *Scutellaria* and *Tragacantha*. The traps were fixed 1 to 2 m above the ground to branches of solitary shrubs growing on the hillsides and were inspected every two days. The distance between the traps was at least 25 m.

V. Southwestern Turkmenistan, vicinity of the Parkhai settlement: 6 km northwest of Garrygala, 3 replications, Ikdedzhyk valley 3 km east of Parkhai, 1 replication, and in the Sychindere valley 2 km East from Ikdedzyk, 1 replication, May 3–June 10, 1993. The biotopes and landscapes in the last two test areas mentioned are similar to those in the Parkhai settlement. In addition, a garden of *Punica granatum* L., *Amygdalus communis* L., and *Zizyphus jujuba* Mill. is situated at the bottom of the Ikdedzyk valley. The traps were fixed 1 to 2 m above the ground to branches of shrubs growing solitarily on the hillsides and were inspected every two days. In the Sychindere locality, the hillsides were bordering on an apple-orchard. The distance between the traps was at least 25 m.

The above description of the test areas in Turkmenistan and their dominant species is based on information found in Fet and Kamakhina (1982) and Gudkova *et al.* (1982).

Identification of the species

The moth specimens captured were identified by analysis of the colouring pattern of their wings and bodies. When both body and wings were covered by sticky material, the moths were rinsed in hexane before identification. The identification was confirmed by examination of the genitalia of selected specimens. In case a wing pattern was erased, the moth was identified by analysis of its genitalia (Suchareva, 1981).

Representative specimens are kept in an insect collection at the Institute of Ecology, Vilnius, Lithuania.

Statistical analyses

Data from the field tests were transformed by the formula $(x + 1)^{0.5}$, where x was the number of moths captured per trap. The values obtained were subjected to Duncan's multiple range test and significantly different values were marked with different letters.

Results and Discussion

Ch. chalciformis (Esper) = *Ch. chalcidiformis* (Hb.) (Sesiidae, Lepidoptera, Insecta). In total 150 males were captured in the Karadag reserve, the Crimea, the Ukraine (locality I). Catches of 3*Z*,13*Z*-18:OH with either 3*E*,13*Z*-18:OAc in the ratio 9:1 or 2*E*,13*Z*-18:OAc in the ratio 1:1 or 2*E*,13*Z*-18:OH in the ratio 9:1 or 1:1 or 2*Z*,13*Z*-18:OAc in the ratio 1:1 or 2*Z*,13*Z*-18:OH in the ratio 1:1 differed significantly from those of the control and the other lures listed in Table I. The binary mixture containing 3*Z*,13*Z*-18:OH and 2*E*,13*Z*-18:OAc in the ratio 1:1 attracted 42 males and was the most effective one, differing significantly from all of the other lures tested. Only 2 males were caught in the traps baited with 3*Z*,13*Z*-18:OH, when the compounds were tested separately, and the difference between this catch and that of the control was not statistically significant. Thus, the binary blend containing 3*Z*,13*Z*-18:OH and 2*E*,13*Z*-18:OAc in the ratio 1:1 should be considered as the sex attractant for *Ch. chalciformis* males.

According to preliminary data, the males of this sesiid species were caught by the traps at 14^{00}–18^{00} o'clock, local time.

Ch. schmidtiformis (Frr.). Seven and 38 males were trapped in the Crimea, the Ukraine (locality II) and Turkmenistan (locality III), respectively (Table I). In Crimea, all 7 males were caught by traps baited with 3*Z*,13*Z*-18:OAc and the corresponding alcohol in the ratio 9:1, while in Turkmenistan, the reaction limits of the males to three ratios of the compounds just mentioned were wider as the attractivity of all these blends differed significantly from those of the control and the other lures tested. When tested alone, the compounds were not attractive for the males of this sesiid species. In conclusion, the binary mixture of 3*Z*,13*Z*-18:OAc/3*Z*,13*Z*-18:OH in the ratio 9:1 should be considered as the sex attractant for *Ch. schmidtiformis* males in the Ukraine and the same blend in the ratios 9:1 and 1:1 in Turkmenistan.

Direct observations of the flights of males to the traps showed that *Ch. schmidtiformis* males were sexually active between 15^{00} and 17^{00} o'clock, local time, in Turkmenistan.

According to preliminary data published by Buda *et al.* (1993) *Ch. chalciformis* males (in their paper this species is named *Bembecia chalciformis* (Esp.)) were attracted to binary mixtures containing 3*Z*,13*Z*-18:OH/3*Z*,13*Z*-18:OAc (11 males in Turkmenistan) and to 3*Z*,13*Z*-18:OH/2*E*,13*Z*-18:OAc (5 males in Armenia). After revision of these data we have found that all 11 males caught in Turkmenistan belong to the species *Ch. schmidtiformis* and the 5 males trapped in Armenia belong to the species *Ch. chalciformis.*

Ch. mezentzevi Gorbunov. 3*Z*,13*Z*-18:OAc and the corresponding alcohol in the ratio 9:1 was found to be the most attractive mixture for males of this species in Turkmenistan (locality IV) (Table I). The catch of the same compounds in the ratio 1:1 differed significantly from that of the control as well, but this mixture was less effective than the 9:1 blend. When tested separately, the compounds were not attractive. Thus, a 9:1 mixture of 3*Z*,13*Z*-18:OAc with the corresponding alcohol should be considered as the sex attractant for *Ch. mezentzevi* males.

Ch. zimmermanni (Lederer). The traps baited with 3*E*,13*Z*-18:OH alone caught 9 males and this catch differed significantly from that of the control (Turkmenistan, locality V) (Table I). 3*Z*,13*Z*-18:OAc alone trapped none, but in the 1:9 mixture with 3*E*,13*Z*-18:OH it acted as a synergist. The blend attracted 43 males, and this catch differed significantly from those of all the other lures tested. Thus, the binary mixture 3*Z*,13*Z*-18:OAc/3*E*,13*Z*-18:OH in the ratio 1:9 should be considered as the sex attractant for *Ch. zimmermanni* males.

The admixture of 1 part of either 3*Z*,13*Z*-18:OH or 3*E*,13*Z*-18:OAc to 9 parts of 3*E*,13*Z*-18:OH inhibited the attractivity of the alcohol last mentioned significantly, while 2*E*,13*Z*-18:OAc and 2*E*,13*Z*-18:OH had no effect on the catches of the traps when they were added to 3*E*,13*Z*-18:OH in the same ratio. So, 3*Z*,13*Z*-18:OH and 3*E*,13*Z*-18:OAc are inhibitors of 3*E*,13*Z*-18:OH for this sesiid species.

Ch. zimmermanni males were caught by the traps baited with 3*E*,13*Z*-18:OH and with the binary mixtures containing this alcohol at 19^{00}–21^{00} o'clock, local time.

Ch. specia nova. Sixty-eight males were captured in the traps baited with binary mixtures of 3*Z*,13*Z*-18:OH and 3*E*,13*Z*-18:OAc in Turkmenistan (locality V) (Table I). This binary blend in the ratio 1:1 attracted 42 males and it was the most effective one as its catch differed significantly from those of the other lures tested. In conclusion, 3*Z*,13*Z*-18:OH and 3*E*,13*Z*-18:OAc in the ratio 1:1 should be considered as the sex attractant for the males of this *Chamaesphecia* species.

The attraction period was registered for 18 males flying to the traps baited with the most effective lure and it was found to be 14^{00}-17^{00} o'clock, local time.

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