# Sex Attractants for Six Moth Species of the Families Brachodidae, Choreutidae and Tineidae from Kazakhstan and Lithuania

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Sex attractants were established for one Brachodidae, three Choreutidae and two Tineidae moth species during field screening tests with (2*E*,13*Z*)-octadecadien-1-al, (2*E*,13*Z*)-, (3*E*,13*Z*)-, (3*Z*,13*Z*)-octadecadien-1-ols and their acetates (2*E*,13*Z*-18:Ald, 2*E*,13*Z*-, 3*E*,13*Z*-, 3*Z*,13*Z*-18:OH/OAc) as well as of binary mixtures of these compounds in West-Kazakhstan and Lithuania. Males of *Brachodes appendiculata* were attracted by 3*E*,13*Z*-18:OAc, *Prochoreutis ultimana* and *P. myllerana* by 2*E*,13*Z*-18:OH, *Monopis palidella* by 2*E*,13*Z*-18:Ald and *Triaxomera fulvimitrella* by binary mixtures of 3*Z*,13*Z*-18:OAc with either 3*E*,13*Z*-18:OH in the ratio of 5:5 or 3*Z*,13*Z*-18:OH in the ratio of 9:1 (v/v). The 3-component mixture composed of 2*E*,13*Z*-18:OH, 3*Z*,13*Z*-18:OH and 2*E*,13*Z*-18:Ald in the ratio 1:1:1 was developed to attract *Prochoreutis sehestediana* males. Attraction antagonists for *B. appendiculata*, *P. ultimana* and *M. palidella* were shown.

*Key words:* Octadecadienal, Octadecadienol, Octadecadienyl Acetate

## Introduction

Insect sex pheromones and related attractants are important tools both in pest management and in environmental research programs. Data on the chemical composition of sex attractants for as many species as possible are of high value. Up to now no sex attractants are known for little bear moths (Brachodidae). Data of only two species of metalmark moths (Choreutidae) are available: *Anthophila fabriciana* (Linnaeus) males are known to be attracted by mixtures of (8*E*)-dodec-8-en-1-yl acetate and (8*Z*)-dodec-8-en-1-yl acetate (Alford, 1978), and *Prochoreutis sehestediana* (Fabricius) males are attracted by mixtures of (2*E*,13*Z*)-octadeca-2,13-dien-1-ol and (3*E*,13*Z*)-octadeca-3,13-dien-1-yl acetate (Būda *et al.*, 1993). Consequently, the sex attractants of little bear moths and metalmark moths are the main objects of this study.

Brachodidae and Choreutidae are closely related to Sesiidae, with which they form the Sesioidea superfamily (Heppner and Duckworth, 1981). Related Lepidoptera groups often use similar chemical constituents for sex communication. The main compounds, composing known sex pheromones and attractants of sesiids, are the following 7 octadecadienes: (3*Z*,13*Z*)-octadeca-3,13-dien-1-ol (3*Z*,13*Z*-18:OH), (3*E*,13*Z*)-octadeca-3,13-dien-1-ol (3*E*,13*Z*-18:OH), (2*E*,13*Z*)-octadeca-2,13-dien-1-ol (2*E*,13*Z*-18:OH), (3*Z*,13*Z*)-octadeca-3,13-dien-1-yl acetate (3*Z*,13*Z*-18:OAc), (3*E*,13*Z*)-octadeca-3,13-dien-1-yl acetate (3*E*,13*Z*-18:OAc), (2*E*,13*Z*)-octadeca-2,13-dien-1-yl acetate (2*E*,13*Z*-18:OAc) (Witzgall *et al.*, 2004) and (2*E*,13*Z*)-octadeca-2,13-dien-1-al (2*E*,13*Z*-18:Ald) (Francke *et al.*, 2004).

These 7 chemicals and their mixtures were selected for screening as candidate compounds in our search for sex attractants for Brachodidae and Choreutidae males. The field screening tests of these compounds and their binary mixtures were conducted in localities with high varieties of target species. Steppes in the European part of Kazakhstan were selected as test sites for Brachodidae and mixed forests in Lithuania for Choreutidae moths. Tineidae species, attracted by the compounds tested, were studied as well.

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## Materials and Methods

### *Chemicals and baits*

2*E*,13*Z*-, 3*Z*,13*Z*-, 3*E*,13*Z*-18:OH and their acetates were obtained from the "Flora" company, Tartu, Estonia. 2*E*,13*Z*-18:Ald was synthesized at the Royal Institute of Technology, Stockholm, Sweden, by Dess-Martin periodinane oxidation of the corresponding alcohol as described by Myles and Danishefsky (1990).

The isomeric and chemical purities of each compound were checked by gas chromatography. If necessary, the compounds were purified by preparative liquid chromatography (Karalius *et al.*, 2001). The purity of each compound used in the tests exceeded 99%.

### *Field tests*

Attractiveness tests were carried out using two different sets of baits. The set A included 2*E*,13*Z*-, 3*E*,13*Z*- and 3*Z*,13*Z*-18:OH/OAc as single components and, in their binary mixtures, in the ratios 9:1, 5:5 and 1:9. The set B included the same single compounds as set A and their binary mixtures with 2*E*,13*Z*-18:Ald in the ratios 9:1, 5:5 and 1:9 as well as single 2*E*,13*Z*-18:Ald. The dosage 0.3 mg per dispenser was used both for single compounds and for mixtures. Each compound was dissolved in hexane. The single compounds and their binary mixtures were impregnated into a red rubber tube septum ($8 \times 15$ mm). Each bait was fixed into an opaque white delta trap Atracon A with an exchangeable bottom coated by Pestifix glue (for a detailed description of the trap, see Mozūraitis *et al.*, 1999). A trap supplied with an empty dispenser served as a control. Three replicates were used in every test.

The field tests were carried out in Kazakhstan and Lithuania in the following localities and during the following periods:

I. The European part of Kazakhstan, Kidibay locality, 20 km east of the village Bisen, Sajkhin district, May 27–June 11, 2001, sets A and B, sandy–hill steppe with *Salix caspica* and *Eleagnus orientalis* growing in hollows.

II. Lithuania, vicinities of Žemaitėliai village, 20 km north of Vilnius; IIa) July 20–August 24, 2000, set A, edges of mixed forest, bordered by meadows; IIb) July 3–August 12, 2001, set B, old mixed forest; IIc) June 2–June 27, 2004, set A, old mixed forest.

III. Lithuania, Antakalnis, Vilnius city; IIIa) August 3–September 5, 2001, set B, small mixed forests; IIIb) August 21–September 17, 2001, 3-component bait tests for *Prochoreutis sehestediana*, 5 replicates, small mixed forests.

The traps were fixed 1 to 2 m above ground to the branches of trees or shrubs and were inspected twice a week. The distance between the traps was at least 10 m. In order to diminish the impact of habitat variation on the trapping results, the rotation within the replication by moving each trap to the position of the next trap was made during every checking and the rotations of replication sets were made once a week.

### *Identification of the species*

The moths captured were identified by analyses of their external morphological characters, colouring patterns and genitalia (Medvedev, 1981). When body and wings were covered by sticky material, the moths were rinsed in octane before identification. Representative specimens were deposited in the insect collection at the Institute of Ecology, Vilnius University, Vilnius, Lithuania.

### *Statistical analysis*

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 analysed by Duncan's multiple range test and significantly different values at $p \leq 0.05$ were marked with different letters (Sokal and Rohlf, 1995) as presented in Tables I–IV.

## Results and Discussion

Sex attractants for one little bear (Brachodidae), three metalmark (Choreutidae) and two fungus moth (Tineidae) species were revealed during the field tests.

### *Brachodidae*

*Brachodes appendiculata* (Esper). Fifteen males were attracted to the lures of set A, and 24 males to the lures of set B in the Kidibay locality, Kazakhstan (Tables I and II). 3*E*,13*Z*-18:OAc was the most effective lure, both in set A and set B. The mixture of 3*E*,13*Z*-18:OAc and 2*E*,13*Z*-18:Ald in the ratio 9:1 was also attractive (Table II), but a higher proportion of 2*E*,13*Z*-18:Ald significantly reduced the attractiveness of the blend. In conclu-

Table I. Attraction of moths to octadecadienols, corresponding acetates and their binary mixtures of set A.

| Chemicals | Ratio | *Brachodes appendiculata* | *Prochoreutis ultimana* | *Prochoreutis myllerana* | *Triaxomera fulvimitrella* |
|---|---|---|---|---|---|
| 3*Z*,13*Z*-18:OAc | | . | . | . | 8bc |
| 3*Z*,13*Z*-18:OAc + 3*Z*,13*Z*-18:OH | 5:5 | . | . | . | 13bc |
| 3*Z*,13*Z*-18:OAc + 3*Z*,13*Z*-18:OH | 9:1 | . | . | . | 81a |
| 3*Z*,13*Z*-18:OAc + 3*Z*,13*Z*-18:OH | 1:9 | . | . | . | . |
| 3*Z*,13*Z*-18:OAc + 3*E*,13*Z*-18:OAc | 5:5 | . | . | . | . |
| 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 | 1:9 | . | . | . | . |
| 3*Z*,13*Z*-18:OAc + 3*E*,13*Z*-18:OH | 5:5 | . | . | . | 94a |
| 3*Z*,13*Z*-18:OAc + 3*E*,13*Z*-18:OH | 9:1 | . | . | . | 18b |
| 3*Z*,13*Z*-18:OAc + 3*E*,13*Z*-18:OH | 1:9 | . | . | . | 5c |
| 3*Z*,13*Z*-18:OAc + 2*E*,13*Z*-18:OAc | 5:5 | . | . | . | . |
| 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 | 1:9 | . | . | . | . |
| 3*Z*,13*Z*-18:OAc + 2*E*,13*Z*-18:OH | 5:5 | . | 1b | . | 7bc |
| 3*Z*,13*Z*-18:OAc + 2*E*,13*Z*-18:OH | 9:1 | . | . | . | 6c |
| 3*Z*,13*Z*-18:OAc + 2*E*,13*Z*-18:OH | 1:9 | . | 5a | . | 4cd |
| 3*Z*,13*Z*-18:OH | | . | . | . | . |
| 3*Z*,13*Z*-18:OH + 3*E*,13*Z*-18:OAc | 5:5 | . | . | . | . |
| 3*Z*,13*Z*-18:OH + 3*E*,13*Z*-18:OAc | 9:1 | . | . | . | . |
| 3*Z*,13*Z*-18:OH + 3*E*,13*Z*-18:OAc | 1:9 | 2b | . | . | . |
| 3*Z*,13*Z*-18:OH + 3*E*,13*Z*-18:OH | 5:5 | . | . | . | . |
| 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 | 1:9 | . | . | . | . |
| 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:OAc | 5:5 | . | . | . | . |
| 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:OAc | 9:1 | . | . | . | . |
| 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:OAc | 1:9 | . | . | . | . |
| 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:OH | 5:5 | . | 4ab | . | . |
| 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:OH | 9:1 | . | . | . | . |
| 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:OH | 1:9 | . | 2ab | . | . |
| 3*E*,13*Z*-18:OAc | | 8a | . | . | . |
| 3*E*,13*Z*-18:OAc + 3*Z*,13*Z*-18:OH | 5:5 | 3ab | . | . | . |
| 3*E*,13*Z*-18:OAc + 3*Z*,13*Z*-18:OH | 9:1 | 1b | . | . | . |
| 3*E*,13*Z*-18:OAc + 3*E*,13*Z*-18:OH | 1:9 | . | . | . | . |
| 3*E*,13*Z*-18:OAc + 2*E*,13*Z*-18:OAc | 5:5 | . | . | . | . |
| 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 | 1:9 | . | . | . | . |
| 3*E*,13*Z*-18:OAc + 2*E*,13*Z*-18:OH | 5:5 | . | . | . | . |
| 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 | 1:9 | . | 5a | . | . |
| 3*E*,13*Z*-18:OH | | 1b | . | . | 1d |
| 3*E*,13*Z*-18:OH + 2*E*,13*Z*-18:OAc | 5:5 | . | . | . | . |
| 3*E*,13*Z*-18:OH + 2*E*,13*Z*-18:OAc | 9:1 | . | . | . | . |
| 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 | 5:5 | . | . | . | . |
| 3*E*,13*Z*-18:OH + 2*E*,13*Z*-18:OH | 9:1 | . | . | . | . |
| 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:OAc + 2*E*,13*Z*-18:OH | 5:5 | . | . | . | . |
| 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 | 1:9 | . | . | . | . |
| 2*E*,13*Z*-18:OH | | . | 7a | 2a | . |
| Control | | . | . | . | . |
| Total | | 15 | 24 | 2 | 237 |
| Locality | | I | IIa | IIa | IIc |

Figures are numbers of moths trapped; numbers in a column followed by the same letter don't differ significantly, $p \geq 0.05$; dots indicate catches corresponding to 0.

Table II. Attraction of moths to 3*Z*,13*Z*-, 3*E*,13*Z*- and 2*E*,13*Z*-18:OH/Ac and their binary mixtures with 2*E*,13*Z*-18:Ald (set B).

| Compounds | Ratio | *Brachodes appendiculata* | *Prochoreutis ultimana* | *Prochoreutis myllerana* | *Prochoreutis sehestediana* | *Monopis palidella* |
|---|---|---|---|---|---|---|
| 3*Z*,13*Z*-18:OAc | | . | . | . | . | . |
| 3*Z*,13*Z*-18:OAc + 2*E*,13*Z*-18:Ald | 5:5 | . | . | . | . | 13ab |
| 3*Z*,13*Z*-18:OAc + 2*E*,13*Z*-18:Ald | 9:1 | . | . | . | . | 3bc |
| 3*Z*,13*Z*-18:OAc + 2*E*,13*Z*-18:Ald | 1:9 | . | . | . | . | 8b |
| 3*Z*,13*Z*-18:OH | | . | . | . | . | . |
| 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 5:5 | . | . | . | 1b | 2bc |
| 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 9:1 | . | . | . | . | . |
| 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 1:9 | . | . | . | . | 17ab |
| 3*E*,13*Z*-18:OAc | | 13a | . | . | . | . |
| 3*E*,13*Z*-18:OAc + 2*E*,13*Z*-18:Ald | 5:5 | 2b | . | . | . | 10b |
| 3*E*,13*Z*-18:OAc + 2*E*,13*Z*-18:Ald | 9:1 | 9a | . | . | . | . |
| 3*E*,13*Z*-18:OAc + 2*E*,13*Z*-18:Ald | 1:9 | . | . | . | 5a | 15ab |
| 3*E*,13*Z*-18:OH | | . | . | . | . | . |
| 3*E*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 5:5 | . | . | . | . | . |
| 3*E*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 9:1 | . | . | . | . | . |
| 3*E*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 1:9 | . | . | . | . | . |
| 2*E*,13*Z*-18:OAc | | . | . | . | . | . |
| 2*E*,13*Z*-18:OAc + 2*E*,13*Z*-18:Ald | 5:5 | . | . | . | 1b | 4bc |
| 2*E*,13*Z*-18:OAc + 2*E*,13*Z*-18:Ald | 9:1 | . | . | . | . | 7b |
| 2*E*,13*Z*-18:OAc + 2*E*,13*Z*-18:Ald | 1:9 | . | . | . | 1b | 19ab |
| 2*E*,13*Z*-18:OH | | . | 9a | 8a | . | . |
| 2*E*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 5:5 | . | 1b | 1b | 1b | 4bc |
| 2*E*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 9:1 | . | 2b | 10a | 1b | 1bc |
| 2*E*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 1:9 | . | . | . | . | 3bc |
| 2*E*,13*Z*-18:Ald | | . | . | . | . | 23a |
| Control | | . | . | . | . | . |
| Total | | 24 | 12 | 19 | 10 | 129 |
| Locality | | I | IIb | IIb | IIIa | I |

Figures are numbers of moths trapped; numbers in a column followed by the same letter don't differ significantly, $p \geq 0.05$; dots indicate catches corresponding to 0.

sion, 3*E*,13*Z*-18:OAc should be considered as the sex attractant for *B. appendiculata* males. A sex attractant for this species was not known before.

Since 3*E*,13*Z*-18:OAc was the only compound found to be attractive for *B. appendiculata*, it was possible to state the antagonistic effects of some compounds tested as admixtures in the ratio 9:1. Data presented in Table I demonstrated, that admixture of either 3*Z*,13*Z*-18:OAc, 3*Z*,13*Z*-18:OH, 3*E*,13*Z*-18:OH, 2*E*,13*Z*-18:OAc or 2*E*,13*Z*-18:OH resulted in significant decrease and even loss of attractivity of the 3*E*,13*Z*-18:OAc. So, all of the 5 compounds mentioned were sex attraction antagonists for *B. appendiculata* males.

In the field, the sexual activity of *B. appendiculata* was observed in the morning. Copulation on grass was registered at 9.10 a.m., local time. The attractions of 6 males to the lures were observed between 8.30 and 12.00 a.m. Oriented male flights to the lures composed with 3*E*,13*Z*-18:OAc were often observed to cease reaching 1–2 m downwind of the dispenser. That suggests, that some unknown additional compound(s) might be necessary for the moth to complete the reaction and to reach the sex attractant source.

### *Choreutidae*

*Prochoreutis ultimana* (Krulikovsky). Twenty-four males were trapped while testing lures of set A in Lithuania, locality IIa (Table I). 2*E*,13*Z*-18:OH was attractive single as well as in binary mixtures with 3*Z*,13*Z*-18:OH, 3*Z*,13*Z*-18:OAc or 3*E*,13*Z*-18:OAc in the ratio 9:1. The attractiveness of none of the binary mixtures tested exceeded the efficiency of single 2*E*,13*Z*-18:OH. When baits of set B were tested in the locality IIb, 2*E*,13*Z*-18:OH attracted 9 *P. ultimana* males and was the most attractive also in comparison with other lures ($p < 0.05$) (Table II).

Thus, the 2*E*,13*Z*-18:OH proved to be the sex attractant for *P. ultimana* males. There were no earlier data on any sex attractant for *P. ultimana*.

The admixture of 3*E*,13*Z*-18:OH or 2*E*,13*Z*-18:OAc totally suppressed and 2*E*,13*Z*-18:Ald significantly reduced the attractiveness of 2*E*,13*Z*-18:OH (Tables I and II). Consequently, the three compounds were found to act as sex attraction antagonists against *P. ultimana* males.

*Prochoreutis myllerana* (Fabricius). Two males were trapped at the locality IIa (Table I), both of them by the traps containing only 2*E*,13*Z*-18:OH. Nineteen males were attracted at the locality IIb (Table II) to three baits, all containing 2*E*,13*Z*-18:OH. None of the admixtures significantly increased the attractiveness compared to that of single 2*E*,13*Z*-18:OH. So, this compound proved to be the sex attractant for *P. myllerana* males. Sex attractants for *P. myllerana* were previously unknown.

The total amount of moths captured during the screening tests was low. This might be the result of lack of some species-specific minor compounds, able to increase both the attractiveness and the specificity of the alcohol. It is interesting to point out, that two related metalmark moth species, *P. ultimana* and *P. myllerana*, occurring in the same habitat, were attracted by the same sex attractant. The flying period seems to be important for the species isolation. *P. myllerana* males were trapped earlier in the summer, during the first half of July, and *P. ultimana* later, during the end of July and the beginning of August.

*Prochoreutis sehestediana* (Fabricius). Octadecadienes were not attractive, when tested separately (Table II). Out of 18 binary mixtures tested, the most attractive one was the mixture of 3*E*,13*Z*-18:OAc and 2*E*,13*Z*-18:Ald in the ratio 1:9.

An analysis of our results, obtained on the attractiveness of single compounds and that of their binary blends, as well as the results published by Būda *et al.* (1993), suggested that the sex attractant of *P. sehestediana* males could consist of a three-component blend. 2*E*,13*Z*-18:OH and 2*E*,13*Z*-18:Ald, as the most often occurring compounds in the attractive mixtures for this species, were selected as basic components, and as the third constituent either 3*Z*,13*Z*-18:OAc, 3*E*,13*Z*-18:OAc or 3*Z*,13*Z*-18:OH was chosen. The ratio of the compounds was selected to be 1:1:1. The trapping results of the 3-component blends, presented in Table III, indicated, that the 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald blend was the most attractive one for males of the metalmark moth *P. sehestediana* ($p < 0.01$).

To reveal the most effective ratio of the compounds, the baits with different component ratios (Table IV) were tested. The results obtained demonstrated, that the ratio of the alcohols should be close to 1:1 and the proportion of aldehyde could be equal to that of alcohol, or reduced by 10 times, without causing a statistically significant reduction of the attractiveness. So, the 3-component mixture of 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald in the ratio 1:1:1 or 1:1:0.1 should be considered as the most effective sex attractant for *P. sehestediana* males.

### *Tineidae*

*Triaxomera fulvimitrella* (Sodoffsky). 237 males were trapped in Lithuania, locality IIc (Table I). Binary mixtures containing 3*Z*,13*Z*-18:OAc and either 3*E*,13*Z*-18:OH in the ratio 5:5 or 3*Z*,13*Z*-18:OH in the ratio 9:1 were the most effective baits, differing from other ones significantly at $p < 0.05$. 3*Z*,13*Z*-18:OAc tested as a single compound was also attractive, but significantly less in comparison with the most efficient binary mixtures. 3*Z*,13*Z*-18:OH and 3*E*,13*Z*-18:OH as single components were not active. Since both 3*E*,13*Z*-18:OH and 3*Z*,13*Z*-18:OH acted synergistically in binary mixtures with 3*Z*,13*Z*-18:OAc, it seemed

Table III. Attractiveness of 3-component blends for *P. sehestediana* males.

| Composition | Amounts [$\mu$g] | Males trapped |
|---|---|---|
| 3*Z*,13*Z*-18:OAc + 2*E*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 100 + 100 + 100 | 0 |
| 3*E*,13*Z*-18:OAc + 2*E*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 100 + 100 + 100 | 1b |
| 3*Z*,13*Z*-18:OH + 2*E*,13*Z*-18:OH + 2*E*,13*Z*-18:Ald | 100 + 100 + 100 | 149a |

Numbers in a column followed by the same letter don't differ significantly, $p \geq 0.05$.

Table IV. Effect of compond ratio on the attractiveness of 3*Z*,13*Z* –18:OH + 2*E*,13*Z*-18:OH + 2*E*, 13*Z*-18:Ald blend to the *P. sehestediana* males.

| 3*Z*,13*Z*-18:OH [$\mu$g] | 2*E*,13*Z*-18:OH [$\mu$g] | 2*E*,13*Z*-18:Ald [$\mu$g] | Males trapped |
|---|---|---|---|
| 100 | 100 | 100 | 81a |
| 100 | 100 | 10 | 55a |
| 100 | 10 | 100 | 7b |
| 10 | 100 | 100 | 0c |
| 100 | 10 | 10 | 1c |
| 10 | 100 | 10 | 0c |
| 10 | 10 | 100 | 0c |

Numbers of males trapped followed by the same letter don't differ significantly, $p \geq 0.05$.

promising to test the attractiveness of their 3-component blends to find out the most effective blend.

3*Z*,13*Z*-18:OAc was known as the sex attractant of *T. fulvimitrella* (Būda *et al.*, 1993). In the present work we found, that admixtures of 3*E*,13*Z*-18:OH or 3*Z*,13*Z*-18:OH increased the attractiveness of the mixture up to 10 times in comparison to the attractiveness of single 3*Z*,13*Z*-18:OAc. So, the binary mixtures of 3*Z*,13*Z*-18:OAc with 3*E*,13*Z*-18:OH in the ratio 5:5 and with 3*Z*,13*Z*-18:OH in ratio 9:1 should be considered as the new sex attractant compositions for *T. fulvimitrella* males, significantly more attractive than the single component investigated before.

*Monopis palidella* Zagulajev. In total, 129 males were trapped in Kazakhstan, locality I (Table II). The most attractive lures were those containing 2*E*,13*Z*-18:Ald and its binary mixtures with small amounts of either 2*E*,13*Z*-, 3*E*13*Z*-, 3*Z*,13*Z*-18:OAc or 3*Z*,13*Z*-18:OH (differences compared to the other lures were statistically significant ($p <$ 0.05). The attractiveness of the binary mixtures mentioned were not higher than the attractiveness of 2*E*,13*Z*-18:Ald alone; hence 2*E*,13*Z*-18:Ald should be considered as the sex attractant for *M. palidella.* The sex attractant for this species was not known before.

In the ratio 1:9, admixture of 2*E*,13*Z*-18:OH significantly reduced ($p < 0.05$) and 3*E*,13*Z*-18:OH totally suppressed the attractiveness of 2*E*,13*Z*-18:Ald. We conclude, that 3*E*,13*Z*-18:OH and 2*E*,13*Z*-18:OH are attractiveness antagonists for *M. palidella*.

Our results and those published by other authors (review by Witzgall *et al.*, 2004) demonstrated high similarity in the sex attractants of Brachodidae, Choreutidae and Sesiidae. This was in agreement with the hypothesis of close phylogenetic relation between these 3 families (Heppner and Duckworth, 1981). This similarity also suggested, that the use of octadecadienes in sex communication, well documented and highly characteristic of Sesiidae, appeared phylogeneticly earlier, at least in the ancestor group of Sesioidea, later splitting into the Sesiidae, Brachodidae, and Choreutidae families. Furthermore, some Cossidae species from the superfamily Cossoidea, recently recognized as closely related to Sesioidea (Edwards *et al.*, 1999), also possessed octadecadiene-based sex communication (Malosse *et al.*, 1993).

The present work as well as investigations by others (Szöcs *et al.*, 1989; Būda *et al.*, 1993; Karalius *et al.*, 2001; Takacs *et al.*, 2001) confirm, that octadecadienes are characteristic for the Tineidae sex communication too.

Assuming that octadecadiene sex communication has been formed in ancestors of Sesioidea, it seems to be logical to explain the high similarity of Sesioidea and Tineidae sex attractants and pheromones as a result of their phylogenetic relationship. However, authors studying the classification of Lepidoptera deny the existence of close relationship between those taxa (*e.g.* Robinson, 1988). Thus, octadecadiene sex communication systems may have appeared independently in Sesioidea and Tineidae.

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