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# EFFICACY ASSESSMENT OF FIELD TRAPPING OF THE CURRANT BORER *Synanthedon tipuliformis* (Lepidoptera: Sesiidae) USING DIFFERENT LURES WITH SYNTHETIC SEX PHEROMONE

*Summary*

*Two-component blends of (2E,13Z)-2,13-octadecadienyl acetate (E2,Z13-18:Ac) and (3E,13Z)-3,13-octadecadienyl acetate (E3,Z13-18:Ac) used in pheromone dispenser were as attractive to males of Synanthedon tipuliformis as standard lure from the Csalomon company, based on field trapping tests. The attractiveness of dispensers with pheromone blend combined in a E2,Z13-18:Ac/E3,Z13-18:Ac - mixture ratio 97:3 at dose of 1000 µg was the highest. Field experiments were performed in central Poland at three commercial black currant plantations and one commercial plantation of gooseberry (no plantation was treated with an insecticide) during the seasons of 2015 and 2017. The use of lures tested to evaluate effectiveness of a pest management programs (monitoring) is discussed.*
***Key words**: Synanthedon tipuliformis, pheromone blend, lures, sticky traps, field experiments*

# OCENA SKUTECZNOŚCI RÓŻNYCH RODZAJÓW WABIKÓW Z SYNTETYCZNYM FEROMONEM W ODŁAWIANIU SAMCÓW PRZEZIERNIKA PORZECZKOWCA *Synanthedon tipuliformis* (Lepidoptera: Sesiidae)

*Streszczenie*

*Zastosowane w testach dyspensery feromonowe z dwukomponentowymi mieszankami zawierającymi octany (2E,13Z)-2,13-oktadekadienylu (E2,Z13-18:Ac) i (3E,13Z)-3,13-oktadekadienylu (E3,Z13-18:Ac) miały podobne własności wabiące samce motyli przeziernika porzeczkowca Synanthedon tipuliformis do wzorcowych wabików z węgierskiej firmy Csalomon. Najlepsze własności wabiące miała dwuskładnikowa mieszanina zawierająca E2,Z13-18:Ac i E3,Z13-18:Ac w proporcji 97:3 i w dawce 1000 µg, dozowana do szarego korka gumowego i umieszczona w lepowej pułapce typu delta. Badania polowe przeprowadzono w centralnej Polsce w trzech produkcyjnych plantacjach czarnej porzeczki i jednej plantacji agrestu (na żadnej z plantacji nie stosowano środków chemicznych do zwalczania szkodników) w latach 2015 i 2017. W pracy omówiono możliwość zastosowania dwuskładnikowych feromonów wabiących motyle S. tipuliformis jako wabika wykorzystywanego w pułapkach z feromonem na produkcyjnych plantacjach porzeczki i agrestu do monitoringu lotu motyli.*
**Słowa kluczowe**: *Synanthedon tipuliformis, mieszanka feromonowa, wabiki, pułapki lepowe, badania polowe*

## 1. Introduction

*Synanthedon tipuliformis* is a species *Sesiidae* known by the common name currant borer. It is an economically important pest of bush fruits, black currant (*Ribes nigrum*), red currant (*Ribes rubrum*) and gooseberry (*Ribes uva-crispa*) in particular [1]. *S. tipuliformis* is widespread in Eurasia, North America as well as Australia and New Zealand [2-6]. The larvae of *S. tipuliformis* burrow into the cane and feed on the medulla part of the shoots. They can destroy shoots and whole bushes, which significantly reduces fruit yield. Therefore, it is necessary to control it systematically. Generally, the control of this pest is based on chemical insecticides. However, it is difficult to control with insecticides because the larvae are feeding and develop inside the shoots of the bush. Synthetic pheromones may be used for monitoring moth flight activity [7-9] and as an alternative control method for mating disruption of currant borer [10]. In 1984, Voerman et al. [11] found that the (2*E*,13*Z*)-2,13-octadecadienyl acetate (1) attracts males of *S. tipuliformis* moths. A slightly later, Szocs [12] identified this compound as major component of the sex pheromone produced by virgin females of *S. tipuliformis*. The addition of a small amount (3%) of (3*E*,13*Z*)-3,13-octadecadienyl acetate (2) to the acetate (1) resulted in a significant increase of attractiveness of (2*E*,13*Z*)-2,13-octadecadienyl acetate [13]. This strong synergistic effect was observed in the population of insects in Europe [14], North America [14] and New Zealand [15]. Next, other authors [10, 16] reported that a two-component blend of compounds **1** and **2** at ratio of 97:3 was also suitable for control populations of *S. tipuliformis.*

In the present paper we report results of the experiments with selected combinations of the binary mixtures which were tested against currant borer moths in two locations on the three blackcurrant and one gooseberry plantations in central Poland. The aim of the research was to obtain a cheaper and highly effective pheromone dispensers for flight monitoring of *S. tipuliformis* by fruit growers.

## 2. Material and methods

E x p e r i m e n t a l s i t e s : The studies were conducted on four plantations, in two organic black currant plantations in Nowy Szwarocin village (region of Sochaczew) as well as commercial plantations of black currant and gooseberry in Józefów village (near Rogów), in Poland. The black currant bushes cv. Ben Hope were ca.

1 m in height in Nowy Szwarocin site and ca. 1.5 m high in Józefów site. Bushes of gooseberry were ca. 0.5 m high in Józefów village (Biały Triumf cultivar). The selection of the plantations was based on the fact that they were infested by currant borer in the previous years.

Materials: Based on the trials of Szocs et al. [14] and James et al. [16] two pheromone mixtures containing (*E*2,*Z*13-18:Ac) and (*E*3,*Z*13-18:Ac) at ratios of 100:3 (blend A) and 97:3 (blend B) by dissolving in hexane the appropriate amounts of both acetates were prepared. Acetate 1 was synthesized as described by Grodner [17] (purity 96%) or by acetylation of (2*E*,13*Z*)-2,13-octadecadien-1-ol (commercially available from Pherobank, Wageningen, Netherlands) with acetic anhydride/pyridine in $CH_2Cl_2$ (purity >98%) as described previously [18]. Second component (2) was ordered from Pherobank and then it was additionally purified on a chromatographic column to purity over 97%.

Pheromone lures (dispensers) were prepared by loading the pheromone blend A or B (without an antioxidant) onto gray rubber cap (commercial rubber penicillinum vial caps LK-6 (L) and LK-7/1 (S), purchased from Sanok Rubber Company S.A. PL) and plastic fittings (purchased from P. H. N. Bracia Darscy Company, Warszawa, PL) as well as red rubber septa in hexane and the solvent was allowed to evaporate in a fume hood. The rubber caps were extracted with acetone in a Soxhlet extractor prior to use. To determine the optimal dose of pheromone blends to use in carriers, doses of 500, 1000, and 2000 μg for blend A and doses of 500, 1000, 1500 and 2000 μg blend B were tested in the field. Loading of the blend A onto the large cap L at dose 500, 1000 and 2000 μg gave the pheromone dispenser LA1, LA2 and LA3, respectively. Similarly for a small cap S - dispensers SA1 (dose of blend A 500 μg), SA2 (dose of blend A 1000 μg), SA3 (dose of blend A 2000 μg) were obtained and for plastic dispensers: PA1, PA2 and PA3, respectively. In the case of blend B, it was incorporated into cap L at dose of 500 μg (dispenser LB1), 1000 μg (dispenser LB2), 1500 μg (dispenser LB3) and 2000 μg (dispenser LB4). In the same way we obtained dispensers SB1, SB2, SB3, SB4 when the cap S as carrier was used. For plastic fittings dispensers: PB1, PB2, PB3 and PB4 were obtained respectively. Incorporating the blend B at dose of 1000 μg into the red rubber septa gave dispenser RB2 and dispenser RB3 for dose of 1500 μg.

Experiments with lures: All the pheromone dispensers made previously and standard lures FCB (purchased from the Hungarian company Csalomon) were placed in traps with sticky floor (140 x 180 mm). Traps without lures were included as controls (trap C). Pheromone traps were set up in blocks in the area of four Experiments. The distance between traps within a block was ca. 20 m. The distances between blocks ranged from 40 to 100 m. At every experimental site the traps were hung on shoots of the bush at a height of 0.5-1.0 m above the ground. Pheromone dispensers were not replaced. The sticky floors were replaced when they were more covered with insects or when the glue was dusty and no longer effective. The insects caught on the sticky floors were identified by morphological features.

Experiment 1. Field test of dispensers LB2, LB3, SB2, SB3, PB2, PB3, RB2, RB3, containing pheromone blend B (for obtaining the blend, acetate 1 with 96% purity was used) and standard lure FCB. The experiment was run from 15 May – 16 July 2015 at organic black currant plantation (ca. 50 $m^2$/trap) in Nowy Szwarocin site (52°13'00.0"N 20°07'01.9"E), captures of male *S. tipuliformis*, three replicates of each lure-type at delta trap and one trap C were placed in blocks.

Experiment 2. Field tests of dispensers LB2, LB3, SB2, SB3, PB2, PB3, RB2, RB3, containing pheromone blend B (for obtaining the blend, acetate **1** with >98% purity was used) and standard lure FCB. The experiment was run from 15 May – 16 July 2015 at organic black currant plantation (ca. 40 $m^2$/trap) in Nowy Szwarocin site (52°12'57.1"N 20°08'19.3"E), captures of male *S. tipuliformis*, three replicates of each lure-type at delta trap and one trap C were placed in blocks.

Experiment 3. Field test of dispensers containing pheromone blend A (LA2, LA4, SA2, SA4, PA2, PA4) and blend B (LB2, LB4, SB2, SB4, PB2, PB4). For the both blends used acetate **1** with >98% purity. In addition, one standard lure FCB was used: The experiment was run from 12 May – 4 August 2017 at commercial black currant plantation (40 $m^2$/trap) in Józefów site (51°49'37.0"N 19°51'45.2"E), captures of male *S. tipuliformis*, three replicates of each lure-type at delta trap and one trap C were placed in blocks.

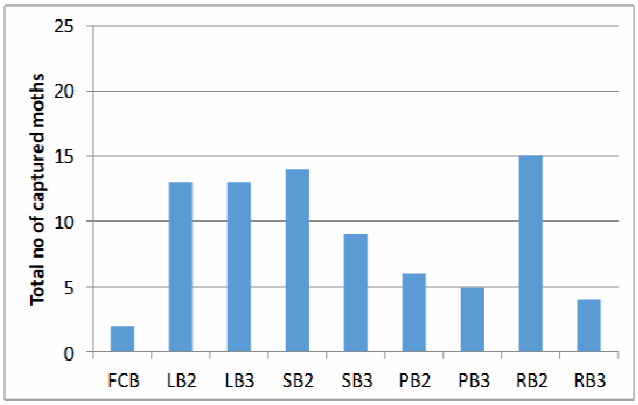
Experiment 4. Field test of dispensers containing pheromone blend A (LA1, LA2, LA4, SA1, SA2, SA4, PA1, PA2, PA4) and blend B (LB1, LB2, LB4, SB1, SB2, SB4, PB1, PB2, PB4). For the both blends used acetate **1** with >98% purity. In addition, two standard lure FCB was used. The experiment was run from 12 May – 4 August 2017 at commercial gooseberry plantation (50 $m^2$/trap) in Józefów site (51°49'39.6"N 19°51'37.0"E), captures of male *S. tipuliformis*, three replicates of each lure-type at delta trap and one trap C were placed in blocks.

Treatment efficacy: Efficacy of the tested dispensers was estimated by comparison with the standard lures Csalomon in the experiments in Nowy Szwarocin and Józefów sites.

Data analysis: Data were analyzed statistically by ANOVA in the Statistica 13 programm. Multiple comparisons of means were performed with Duncan test at P = 0.05. The numerical data were analyzed statistically on the data transformed according to logarithmic function $y= \log_{10}(x+1)$, were x is number of moths found in each trap, counted during the all monitoring season on each plantation. The data (in the Tables) that were not significantly different are marked with the same letter. In addition, error bars as standard deviation (SD) were calculated.

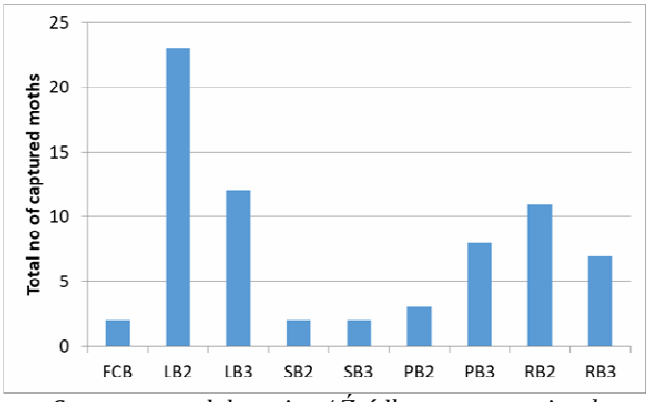
## 3. Results and discussion

During the field experiments, the weather conditions were moderately diversified for both sites at Nowy Szwarocin and Józefów. In Experiments 1 and 2, traps baited with the sexual pheromone blends B caught currant borer moths to all pheromone traps in both experiments. However, number of *S. tipuliformis* males captured in traps was low (Figs 1-2). The total number of males captured was approximately 81 (Experiment 1) and 70 (Experiment 2), and the largest number was captured in the mid- June and in the second week of July. Only one generation of the pest during season was observed. No moths were caught in the control traps.




*Source: own elaboration / Źródło: opracowanie własne*

Fig. 1. Sum of *S. tipuliformis* captured to trap by various pheromone lures in Experiment 1
*Rys. 1. Całkowita ilość S. tipuliformis odławianych w pułapkę przy użyciu różnych feromonowych wabików w Eksperymencie 1*




*Source: own elaboration / Źródło: opracowanie własne*

Fig. 2. Sum of *S. tipuliformis* captured to trap by various pheromone lures in Experiment 2
*Rys. 2. Całkowita ilość S. tipuliformis odławianych w pułapkę przy użyciu różnych feromonowych wabików w Eksperymencie 2*

Table 1. Number of moths of *S. tipuliformis* on black currant attracted to traps by various pheromone lures. Nowy Szwarocin, Poland 2015
*Tab. 1. Ilość odławianych motyli S. tipuliformis w pułapkę na czarnej porzeczce przy użyciu różnych feromonowych wabików. Nowy Szwarocin, Polska 2015*

| Pheromone lure | Average number of moths ± SD | |
|---|---|---|
| | Experiment 1 | Experiment 2 |
| FCB | 0.7 ± 0.6 a** | 0.7 ± 1.2 a** |
| LB2 | 4.3 ± 5.8 ab | 7.7 ± 6.7 b |
| LB3 | 4.3 ± 3.2 ab | 4.0 ± 1.0 ab |
| SB2 | 4.7 ± 5.5 b | 0.7 ± 1.2 a |
| SB3 | 3.0 ± 3.5 a | 0.7 ± 1.2 a |
| PB2 | 2.0 ± 3.5 a | 1.0 ± 1.0 a |
| PB3 | 1.7 ± 0.6 a | 2.7 ± 3.1 ab |
| RB2 | 5.0 ± 6.2 b | 3.7 ± 3.2 ab |
| RB3 | 1.3 ± 0.6 a | 2.3 ± 3.2 a |
| Control* | 0.0 ± 0.0 a | 0.0 ± 0.0 a |

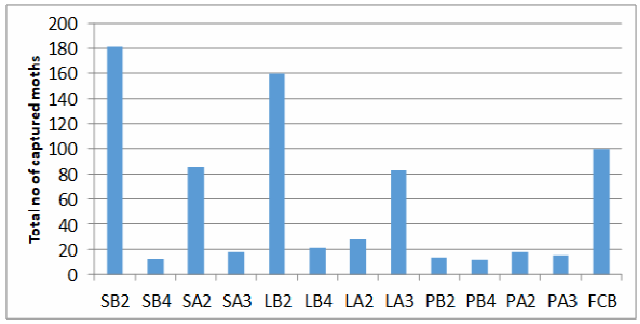
* Traps without lures;
** Means followed by the same letter in each column are not significantly different (Duncan test, p = 0.05).

*Source: own elaboration / Źródło: opracowanie własne*

In Experiment 1, the most males were caught in traps with pheromone dispenser LB2, LB3, SB2, RB2, a little less with SB3, and the least with standard lure FCB (Table 1). In the case of the Experiment 2, the most males were caught in traps with dispenser LB2, a little less RB2, LB3, and the least with dispenser FCB as well as SB2 and SB3 (Table 1).

Experiment 3 involved the testing of dispensers with blend A and B on plantation of black currant at Józefów site in 2017. In total, 746 males *S. tipuliformis* were captured in the traps during the entire monitoring period (Fig. 3). The flight of currant borer started in early June and lasted to the end of July, but the vast majority of male were captured between the beginning and mid- July.

Significantly more moths were captured in traps with dispenser SB2 and LB2 than in the other traps (Table 2). Moreover, more male were captured in traps with dispenser FCB, SA2, LA3 than with dispensers containing the plastic carrier. No moths were caught in the control traps.




*Source: own elaboration / Źródło: opracowanie własne*

Fig. 3. Sum of *S. tipuliformis* captured to trap by various pheromone lures in Experiment 3
Rys. 3. Całkowita ilość *S. tipuliformis* odławianych w pułapkę przy użyciu różnych feromonowych wabików w Eksperymencie 3

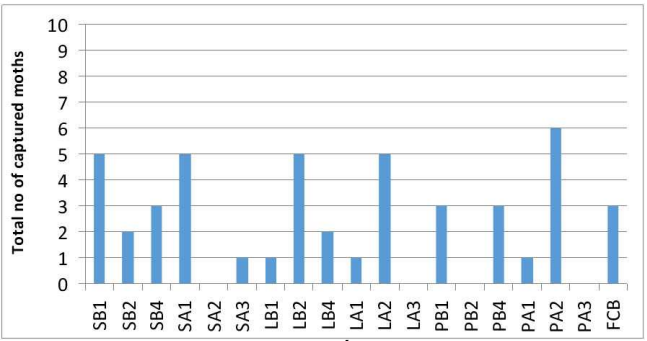
Table 2. Number of moths of *S. tipuliformis* on black currant attracted to traps by various pheromone lures. Józefów, Poland 2017
*Tab. 2. Ilość odławianych motyli S. tipuliformis w pułapkę na czarnej porzeczce przy użyciu różnych feromonowych wabików. Józefów, Polska 2017*

| Pheromone lure | Average number of moths ± SD |
|---|---|
| | Experiment 3 |
| SB2 | 60.3 ± 51.5 b** |
| SB4 | 4.0 ± 1.7 ab |
| SA2 | 28.3 ± 36.2 ab |
| SA3 | 6.0 ± 5.6 ab |
| LB2 | 53.3 ± 88.1 b |
| LB4 | 7.0 ± 6.0 ab |
| LA2 | 9.3 ± 2.3 ab |
| LA3 | 27.7 ± 27.5 ab |
| PB2 | 4.7 ± 6.4 ab |
| PB4 | 3.7 ± 4.0 a |
| PA2 | 6.0 ± 1.0 ab |
| PA3 | 5.0 ± 2.6 ab |
| FCB | 33.3 ± 48.4 ab |
| Control* | 0.0 ± 0.0 a |

* Traps without lures;
** Means followed by the same letter in each column are not significantly different (Duncan test, p = 0.05).

*Source: own elaboration / Źródło: opracowanie własne*

No moths were caught in the control traps. On the plantation of gooseberry (Experiment 4), the pattern of flight activity of *S. tipuliformis* was similar to the previous experiment. However, the currant moths were caught in traps in much smaller numbers than in experiment 3 (45 males total, Fig. 4). The low level of trapping of males *S. tipuliformis* did not allow to correctly estimate the activity of tested dispensers. However, we could observe that dispensers with blend B was a little more active then dispensers with the blend A (Table 3). As in previous experiments, no males of currant borer were caught in the control traps.




*Source: own elaboration / Źródło: opracowanie własne*

Fig. 4. Sum of *S. tipuliformis* captured to trap by various pheromone lures in Experiment 4
*Rys. 4. Całkowita ilość S. tipuliformis odławianych w pułapkę przy użyciu różnych feromonowych wabików w Eksperymencie 4*

Table 3. Number of moths of *S. tipuliformis* on gooseberry attracted to traps by various pheromone lures. Józefów, Poland 2017
*Tab. 3. Ilość odławianych motyli S. tipuliformis w pułapkę na agreście przy użyciu różnych feromonowych wabików. Józefów, Polska 2017*

| Pheromone lure | Average number of moths ± SD |
|---|---|
| | Experiment 4 |
| SB1 | 1.7 ± 1.2 a** |
| SB2 | 0.7 ± 1.2 a |
| SB4 | 1.0 ± 1.0 a |
| SA1 | 1.7 ± 2.9 a |
| SA2 | 0.0 ± 0.0 a |
| SA3 | 0.3 ± 0.6 a |
| LB1 | 0.3 ± 0.6 a |
| LB2 | 1.7 ± 2.9 a |
| LB4 | 0.7 ± 1.2 a |
| LA1 | 0.3 ± 0.6 a |
| LA2 | 1.7 ± 2.1 a |
| LA3 | 0.0 ± 0.0 a |
| PB1 | 1.0 ± 1.0 a |
| PB2 | 0.0 ± 0.0 a |
| PB4 | 1.0 ± 1.0 a |
| PA1 | 0.3 ± 0.6 a |
| PA2 | 2.0 ± 3.5 a |
| PA3 | 0.0 ± 0.0 a |
| FCB | 0.5 ± 0.6 a |
| Control* | 0.0 ± 0.0 a |

* Traps without lures;
** Means followed by the same letter in each column are not significantly different (Duncan test, p = 0.05).

*Source: own elaboration / Źródło: opracowanie własne*

## 4. Conclusions

Since 2004, research on the monitoring of *S. tipuliformis* population has been carried out at the Department of Synthesis, Technology and Biotechnology of Biologically Active Products of the Institute of Industrial Organic Chemistry (I.P.O.) in Warsaw. In that year, a new method of the synthesis of acetate **1** was invented in our laboratory [17]. The samples of this compound (impregnated into different carriers) were tested in field trials by the Research Institute of Horticulture in Skierniewice. The attractiveness of dispensers with the obtained (2*E*,13*Z*)-2,13-octadecadienyl acetate to males of *S. tipuliformis* was much weaker than the attractiveness of standard lures from the Csalomon company [19]. It is interesting that that in Australia strain of *S. tipuliformis* was found to respond optimally to the single component, acetate 1 [14].

This study was resumed only in the next decade, using as a pheromone a binary mixture of acetate 1 and 2 in ratio of 97:3 (blend B). The blend B was tested in two organic black currant plantations in season 2015. On both experimental plots the number of moths trapped in the traps with tested dispensers and standard lures was small and comparable. Although the results could not indicate the best lure, they showed that the tested dispensers were not worse than the standard dispensers. In 2017 field trials were repeated on a commercial black currant and gooseberry plantations with blend B and a blend containing acetates **1** and **2** at ratio of 100 : 3 (blend A). These blends were applied to various types of carriers in different doses. The results of the tests on the gooseberry plantation were similar to the results obtained earlier in 2015. In a case of an experiment on a plot of black currant, males of *S. tipuliformis* were trapped more than ten times more efficiently than in the gooseberry plantation. The best binary mixture tested was 1000 µg 97:3 E2,Z13-18:Ac/E3,Z13-18:Ac dispensed into a grey rubber cup (dispensers LB2, SB2). The dispensers LB2 and SB2 were at least as attractive to males of *S. tipuliformis* as standard lures. This suggestion is not inconsistent with the results obtained in the remaining trapping experiments. Thus, it can be considered that the selected LB2 and SB2 dispensers may be useful for monitoring and protecting bush fruits against *S. tipuliformis*. The lower price of the rubber cup LK-7/1 compared to the LK-6 should make the dispenser SB2 more preferable as the target lure for the commercial use.

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