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Addition of Synthetic Feeding Attractant Increases Catches of *Rhagoletis batava* Hering and *Carpomyia schineri* Loew. in Fluorescent Yellow Sticky Traps

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The addition of the synthetic *Rhagoletis* feeding attractant (consisting of ammonium carbonate and ammonium acetate, developed previously for *Rhagoletis cerasi* L.) to both fluorescent yellow or transparent sticky traps significantly increased catches of the fruit flies *Rhagoletis batava* Hering (pest of sea buckthorn) and *Carpomyia schineri* Loew. (pest of rose hips). Traps with lures were detecting the occurrence of both species 1–2 weeks before as compared to traps without lure, and quantitative aspects of the flight could be followed in more detail in traps with lure. Thus in detection and monitoring surveys, where sensitivity of the trap is highly important, the use of traps with synthetic lure added is strongly recommended.

Keywords: feeding attractant, ammonium carbonate, ammonium acetate, trapping, sea buckthorn, rose hips, fruit fly, monitoring.

The fruits of the common sea buckthorn (*Hippophae rhamnoides* L.) are pseudo-drupes, commonly referred to as “berries”. The pseudo-drupes contain a high amount of vitamins, flavonoids, oils and other healthful components. Therefore the plant is important for traditional medicine, cosmetic and food production. The plant originates from China and Siberia but it has been introduced to many countries of the world. Nowadays it is cultivated in sandy regions of Europe and North America as well as Asia. Maggots of the fruit fly *Rhagoletis batava* Hering (Diptera, Tephritidae) develop inside sea buckthorn pseudo-drupes and can cause severe damages with up to 100% loss of yield (Shamanskaya, 2014).

The pest is regarded as a non-invasive species in Europe (Stalažs, 2012). Nevertheless, in some countries like Germany first findings are dating back only a few years (Plate

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et al., 2014; Höhne and Kuhnke, 2015). Therefore *R. batava* is considered to be an alien species (Stalažs, 2012). At present we know of no reports of the occurrence of *R. batava* in Hungary. In such a situation tools for sensitive detection and for being able to follow the spread of the pest are highly needed.

Rose-hips, the fruits of the *Rosa canina* group (which includes several *Rosa* spp.) are an important source of ascorbic acid in health food for humans. Dried fruits are important for making tea, and the jam produced from berries is also consumed by many people, what is more, it is used also in wine making. The hips can be damaged by maggots of the fruit fly *Carpomyia schineri* Loew. (Dipera, Tephritidae) (Eichhorn, 1967). The species has a palaearctic distribution (Balduf, 1959; Carroll et al., 2005) so it is indigenous in Europe as well. In Hungary, first records on the damage of the fly date back to 1947 from the arboretum of Horticultural University and later (1953–1955) its presence was reported also at Budatétény (Budapest, Hungary) (Balás and Tóth, 1958; Voigt et al., 2015). The species has been thought to be of minor importance as a pest, and there is relatively little information about its mode of life. A local outbreak has been reported in recent years (Surányi and Haltrich, 2006; Tuba, 2009). Sensitive trapping tools could assist in the future in evaluation of the pest status and importance of *C. schineri*.

Similar to many other insects, fruit flies are generally attracted to yellow colour hues as visual stimulus, so for their detection and monitoring yellow sticky traps are widely applied. In several cases ammonia or acetic acid releasing synthetic feeding attractants significantly increased captures of flies thus rendering the yellow sticky traps more sensitive (i.e. for *Rhagoletis cerasi* L. refer to Frick, 1952; Prokopy, 1969; Boller and Prokopy, 1976; Katsoyannos et al., 2000). Our laboratory has previously developed such a lure containing ammonium carbonate and ammonium acetate for the capture of *R. cerasi* (Tóth et al., 2004). Ammonia is released from both salts and acetic acid is provided by the acetate. This lure was recently found to be attractive also for the related fruit flies *R. cingulata* Loew, *R. completa* Cresson and *Strauzia longipennis* Wiedemann (Diptera, Tephritidae) (Tóth et al., 2014). This lure is in wide use in Hungary and neighbouring countries for the trapping of these fruit flies and is applied in combination with a fluorescent yellow sticky trap.

The objective of the present study was to investigate whether the addition of this synthetic *Rhagoletis* lure to yellow sticky traps also enhances their performance in case of *R. batava* and *C. schnineri*, resulting in a more sensitive trapping tool.

Materials and Methods

Field tests

Tests were conducted in Germany (*R. batava*) and in Hungary (*C. schineri*) using accepted methods in trapping experiments of the same nature (Roelofs and Cardé, 1977). Traps were arranged as blocks so that each block contained one trap of each treatment. Traps within blocks were separated by 8–10 m, and blocks were sited at least 30 m apart.

Traps were inspected at some days' intervals (preferably twice weekly), when captured insects were recorded and removed.

Traps

In the tests, sticky cloak traps CSALOMON® PALz (fluorescent yellow – for reflectance spectrum of the colour hue used pls refer to Tóth et al., 2004) and PAL (transparent) (produced by Plant Prot. Inst., CAR HAS, Budapest, Hungary) were used. The sticky surface of both of these traps was 805 cm^2. The traps have routinely been used for the trapping of the European fruit fly *R. cerasi* L. in Hungary (Tóth et al., 2004); photos of the trap can be viewed at www.csalomontraps.com.

In the test on *R. batava* in Germany REBELL® yellow sticky traps (obtained from Andermatt Biocontrol AG, Grossdietwil, Switzerland) with sticky surfaces of 1189 cm^2, unbaited, were also tested for reference.

Baits

Synthetic food lures used were the commercially available CSALOMON® cherry fruit fly lures (= *Rhagoletis* lures; produced by Plant Prot. Inst., CAR HAS, Budapest, Hungary), which contained ammonium carbonate and ammonium acetate salts (1:1, total load 2 g) (Tóth et al., 2004).

Experimental details

Experiment 1. This test was aimed at studying the effects of visual (fluorescent yellow) and chemical (*Rhagoletis* lure) stimuli and their interaction on *R. batava*. Treatments included yellow sticky or transparent sticky traps with or without chemical lure. The test was run in public ground, with buckthorn bushes and with heterogeneous vegetation at Frankfurt/Oder, Germany, June 12–August 31, 2015, with 1 block of traps. The traps were checked at 3 to 4 day intervals. During the test time, the traps were circulated within the whole area regularly by repositioning them at the times of inspections. The lure was not replaced during the testing.

Experiment 2. This test was aimed at studying the effect of the addition of the *Rhagoletis* lure to fluorescent yellow sticky traps on catches of *C. schineri*. In this test fluorescent yellow traps (CSALOMON® PALz) with or without lure were only used. The test was started paralelly at Nadap (Fejér county, Hungary) and Érd Elviramajor (Fejér county, Hungary) with 4 blocks at each site, on August 28 the 4 blocks of traps at Nadap were moved to Érd Elviramajor, totalling altogether 8 blocks at this single site. The test was run from July 17 to September 22, 2015. Traps were set out in hedges where *R canina* group bushes were part of the natural vegetation, at the height of 1.0–1.5 m on rose bushes with ripening hips. Lures were replaced with new ones after 4 weeks of field exposure.

Statistical analysis

The catch figures from field trapping tests were transformed using $(x+0.5)^{1/2}$ to normalize distributions (Roelofs and Cardé, 1977) and were analysed by ANOVA (Experiment 1) or Student *t*-test (Experiment 2) as appropriate. If the ANOVA yielded significance, then treatment means were separated by Fisher's Protected Least Significant Difference (PLSD) test (Fisher, 1949). Inspection dates when no flies were caught by any of the traps were excluded from analyses.

All statistical procedures were conducted using the software packages StatView® v4.01 and SuperANOVA® v1.11 (Abacus Concepts, Inc., Berkeley, CA, USA).

Results

R. batava

Significantly more *R. batava* were caught both in fluorescent yellow (PALz) or transparent (PAL) sticky cloak traps, both baited with the *Rhagoletis* lure, than in the same types of traps without lure (Exp. 1, Table 1). High mean catches of these two treatments containing the lure did not differ. The REBELL® traps without lure caught an intermediate mean number of flies, not lower than the catch in the two treatments with lure and not larger than in the sticky cloak traps without lure.

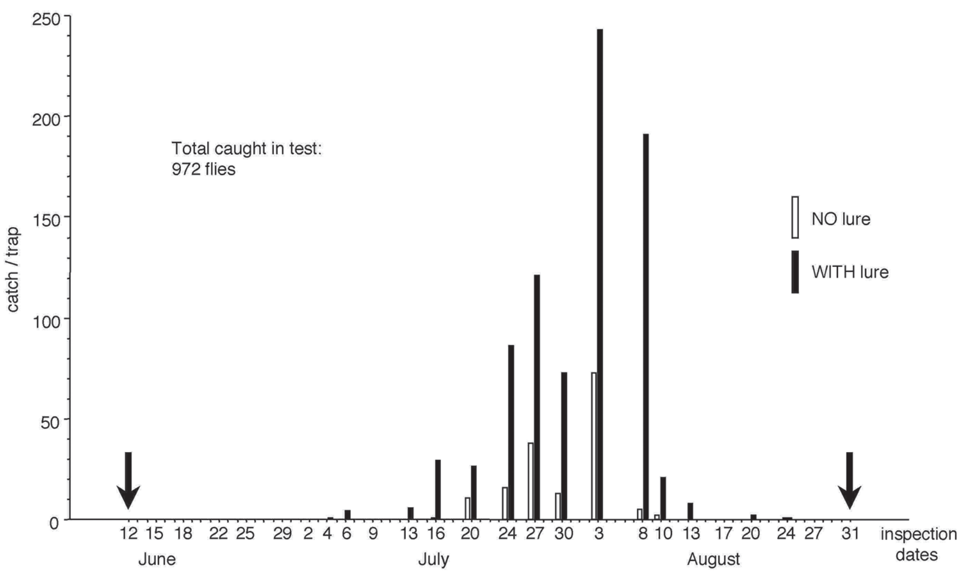

Fig. 1. Seasonal distribution of catches of *R. batava* in fluorescent yellow traps with or without the synthetic *Rhagoletis* lure. Frankfurt-Oder, Germany, 2015 (Exp. 1). Arrows show beginning and finishing of observations

Table 1

Mean (± SE) catches of *Rhagoletis* spp. in traps combining visual stimulus (yellow colour) and synthetic *Rhagoletis* lure in a field test in Germany (Exp. 1).

Trap			Mean / trap / inspection (+SE) catches of *Rhagoletis* spp.					
type	colour	lure	*batava*			*cerasi*	*cingulata*	*meigenii*
PAL	transparent	no	1.53	a	(0.70)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
PAL	transparent	YES	60.27	b	(26.20)	0.08 (0.06)	0.08 (0.06)	0.00 (0.00)
PALz	fluor yellow	no	10.67	a	(5.18)	0.04 (0.04)	0.04 (0.04)	0.00 (0.00)
PALz	fluor yellow	YES	54.13	b	(19.64)	0.09 (0.09)	0.04 (0.04)	0.00 (0.00)
REBELL®	yellow	no	19.53	ab	(8.29)	0.38 (0.16)	0.33 (0.22)	0.04 (0.04)
Total caught			2192			14	12	1

R. batava mean catches with same letter are not significantly different from each other at P = 5% by ANOVA, Fisher's PLSD. Catches of other spp. were not statistically evaluated due to the overall low numbers caught.

When the seasonal distribution of catches was compared in the two treatments of fluorescent yellow traps with or without lure, the traps with no lure caught low numbers of the fly and these catches were not sufficient to follow the flight pattern of the pest (Fig. 1). The traps with lure detected the presence of flies more than a week before traps without lure did, and were still catching flies ca. one week after catches stopped in the traps without lure.

Low numbers of both *R. cerasi* and *R. cingulata* were registered in all treatments except transparent traps with no lure (Table 1). A single specimen of *R. meigenii* Loew (Diptera, Tephritidae) was captured in a REBELL® trap.

C. schineri

The trend of catches was similar to that recorded in Experiment 1 for *R. batava* in this study (Table 1), albeit the total number of flies caught were considerably lower

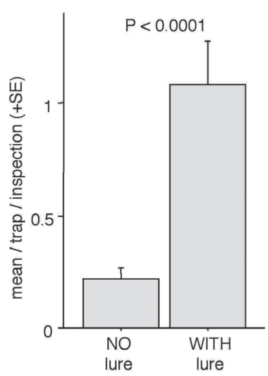

Fig. 2. Mean catches of *C. schineri* in fluorescent yellow traps with or without the *Rhagoletis* lure in a field test in Hungary (Exp. 2). Total caught in test: 113 flies

in Experiment 2. Greater mean catches of *C. schineri* flies were recorded in fluorescent yellow traps with *Rhagoletis* lure than in traps with no lure (Exp. 2, Fig. 2), the difference being highly significant. When seasonal distribution of catches was considered, much more robust catches of *C. schineri* were recorded in traps with lure than in the ones without lure (Fig. 3). Traps with lure detected the presence of the flies ca. two weeks before traps without lure did.

Discussion

The present results confirm the highly significant effect of the *Rhagoletis* synthetic lure on *Rhagoletis* and related tephritid fruit flies. Previously the addition of this lure to yellow sticky traps was reported to be significantly increasing captures in *R. cerasi*, *R. cingulata, R. completa* and *S. longipennis* (refer to Tóth et al., 2004, 2014 and references therein). Based on results of the present study, to this list *R. batava* and *C. schineri* can be added with certainity. To our knowledge in these two spp. the attraction to ammonium releasing salts has not been reported before.

The relative importance of the chemical (*Rhagoletis* lure) and visual (yellow colour) stimuli provided by the traps may have differing significance for the different species. The effect of the addition of the *Rhagoletis* lure was especially striking in *R. batava*, where traps with lure caught similar mean numbers of flies no matter whether they were fluorescent yellow or not, thus suggesting that in this species the importance of the chemical stimulus of the lure was overwhelmingly more important than the general visual stim-

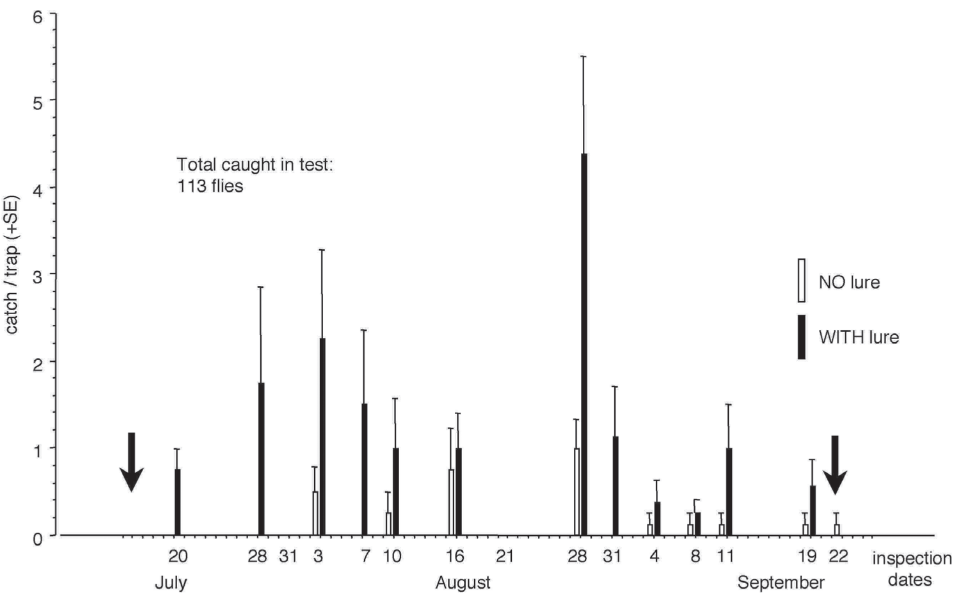

Fig. 3. Seasonal distribution of catches of *C. schineri* in fluorescent yellow traps with or without the synthetic *Rhagoletis* lure. Érd-Elviramajor, Hungary, 2015 (Exp. 2). Arrows show beginning and finishing of observations

ulus of yellow. A similar case was reported for *R. cingulata* (Voigt and Tóth, 2008; Tóth et al., 2014).

The seasonal distribution of catches in both *R. batava* and *C. schineri* in this study clearly showed the superiority of traps containing also the chemical lure over traps with the visual cue only. Consequently the success and reliability of detection and monitoring surveys appear to be greatly influenced by the trap type used, and traps containing both the visual and chemical cues should be preferred, as evidenced in recent detection efforts on the invasive *R. completa* in Croatia and Hungary (Voigt and Tóth, 2013; Baric et al., 2014; Voigt et al., 2014). This is apparently of utmost important in case of *R. batava* which has potential for causing high yield losses in sea buckthorn production within Europe as well as Asia (Shamanskaya, 2014).

Fluorescent sticky traps with lure may also be a useful tool in trapping *C. schineri*. In any case the results of the present study confirm that the synthetic *Rhagoletis* lure can become handy in trapping efforts directed also on non-*Rhagoletis* tephritid flies and this opportunity should be kept in mind for the future.

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