

Importance of Application of Synthetic Food Lures in Trapping of *Rhagoletis* spp. and *Strauzia longipennis* Wiedemann

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The addition of the synthetic *Rhagoletis* lure (consisting of ammonium carbonate and ammonium acetate, developed previously for *Rhagoletis cerasi* L.) to fluorescent yellow sticky traps invariably increased catches of the European cherry fruit fly (*R. cerasi*), eastern cherry fruit fly (*R. cingulata* Loew.), walnut husk fly (*R. completa* Cresson) and the sunflower maggot (*Strauzia longipennis* Wiedemann). 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. Results of the present study with *S. longipennis* suggest that the synthetic *Rhagoletis* lure can be useful also in trapping non-*Rhagoletis* tephritid flies in future research efforts.

Keywords: *Rhagoletis*, *Strauzia*, food attractant, ammonium carbonate, ammonium acetate, trapping.

A number of important orchard pests in Europe belong to *Rhagoletis* fruit flies (Diptera, Tephritidae). Examples include the European cherry fruit fly (*Rhagoletis cerasi* L.), the eastern cherry fruit fly (*R. cingulata* Loew.) and the walnut husk fly (*R. completa* Cresson).

Both *R. cerasi* (in Europe) and *R. cingulata* (in North America and in Europe) are damaging the fruit of sweet and sour cherry. Quality of fruits infected by the maggots is low and resulting from the damage threshold of 0% as maintained by the canning factories, such fruit can be sold only for fruit juice purposes.

R. completa (in North America and in Europe) is a quality deteriorating pest of walnut production. In Hungary, it can decrease export of early ripening walnuts.

Both *R. cingulata* and *R. completa* are listed in Annex I/A/I of Council Directive 2000/29/EC.

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All of these fruit flies are attracted to yellow colour hues as visual stimulus, so for their detection and monitoring yellow sticky traps are generally applied all over the world. However, since the attraction power of yellow as visual stimulus is relatively weak, there have been efforts to add chemical lures to enhance activity. An opportunity could be found by exploiting the general habit of fruit fly adults to prefer to feed on bird droppings. A typical volatile emerging from bird droppings is ammonia. This is the explanation why ammonia releasing sources are attractive to fruit flies in the vicinity.

In the case of *R. cerasi* for example, several reports in the literature described that the efficacy of yellow traps can be increased by ammonia-releasing synthetic lures (Frick, 1952; Boller and Prokopy, 1976; Prokopy, 1969; Katsoyannos et al., 2000).

Other studies suggested the importance of the presence of acetic acid in attraction of tephritid fruit flies (Keiser et al., 1976; Casana-Giner et al., 1999). Acetic acid is formed by fermenting processes of carbohydrates, and it is commonly believed that orienting to acetic acid emission places helps fruit flies in locating a carbohydrate source for energy intake.

Based on the above, in the present study we used a previously optimized chemical lure for *R. cerasi* consisting of ammonium carbonate and ammonium acetate (Tóth et al., 2004). Ammonia is released from both salts and acetic acid is provided by the acetate. This lure is in wide use in Hungary for the trapping of *R. cerasi* and is applied in combination with a fluorescent yellow sticky trap.

The objective of the present study was to study whether the addition of the synthetic *R. cerasi* lure to yellow sticky traps also increases significantly the catch of other *Rhagoletis* pests and of the related sunflower maggot fly (*Strauzia longipennis* Wiedemann). This latter pest has recently been detected in Europe (Brückner and Korneyev, 2010, Lerche et al., 2013) and is included in the EPPO Alert List (since 2011).

Materials and Methods

Field tests

Tests were conducted at sites in Hungary, Croatia and Germany 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 please refer to Tóth et al., 2004) and PAL (trans-

parent) (produced by Plant Prot. Inst., CAR HAS, Budapest, Hungary) were used. These 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.

Baits

Synthetic food lures used were the commercially available CSALOMON® cherry fruit fly 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). Lures were replaced with new ones after 4 weeks of field exposure.

Experimental details

Experiment 1. This test was aimed at studying the effects of visual (fluorescent yellow) and chemical (*Rhagoletis* lure) stimuli and their interaction. Treatments included yellow sticky or transparent sticky traps with or without chemical lure. Exp. 1 was run at several sites, aiming at different target species. The test targeted on *R. cingulata* (Exp. 1A) was run in a sour cherry orchard at Agárd, Fejér county, Hungary, May 5–August 18, 2007, with 4 blocks of traps. Since in the biotope *R. cerasi* was also present, this test caught sizeable numbers of this latter pest also. Exp. 1B was targeted on *R. completa*, and was run in a walnut plantation at Banfi (nursery Zizek), Medimurje, Croatia, July 18–September 23, 2011, with 4 blocks of traps. The test aimed at *Strauzia longipennis* (Exp. 1C) was performed in a sunflower field at Berlin-Dahlem, Germany, June 12–August 3, 2012, with 2 blocks of traps.

Experiment 2. This test was aimed at comparing the capture efficiency of traps positioned low (ca 2 m) or high (ca 4 m) on walnut trees for catching *R. completa*. In this test fluorescent yellow traps with lure were only used. One pair of traps (one at each height) was set out on a solitary walnut tree at Prelog, another pair at Nedelisce, Croatia, from July 16–October 8, 2013.

Statistical analysis

The catches from field trapping tests were transformed using $(x + 0.5)^{1/2}$ (Roelofs and Cardé, 1977) and analysed by Student *t*-test or ANOVA as appropriate. If the ANOVA yielded significance, then treatment means were separated by Games–Howell test (Games and Howell, 1976; Jaccard et al., 1984). Where one of the treatments caught no insects the Bonferroni–Dunn test (Dunn, 1961) was used to check that mean catches in other treatments were not significantly different from zero catch (see also Figure legends).

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

Results

R. cingulata and *R. cerasi*

Significantly more *R. cingulata* than in the other treatments were caught by fluorescent yellow or transparent traps both baited with the *Rhagoletis* lure (Fig. 1). Some flies were recorded in fluorescent yellow traps with no lure, but the catch was not differing significantly from zero catch of transparent traps with no lure. 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 negligible numbers of the fly and these catches were not sufficient to follow the flight pattern of the pest (Fig. 2). On the other hand, traps with lure produced catches by the help of which the seasonal flight of *R. cingulata* could clearly be monitored.

In *R. cerasi*, the treatment with fluorescent yellow traps with *Rhagoletis* lure caught significantly more flies than both treatments lacking the lure (Fig. 1). Fluorescent yellow traps with no lure or transparent traps with lure caught more than transparent traps with no lure. There was no difference between the catches of fluorescent yellow traps with no lure vs. transparent traps with lure. Seasonal catches in fluorescent yellow traps with lure showed reliably the flight pattern of *R. cerasi* (Fig. 3). Fluorescent yellow traps with no lure although produced some catches during the flight, these were much smaller than catches on the corresponding dates in traps with lure. Total numbers in traps with lure were approximately 6-fold as compared to traps with no lure.

R. completa

Significantly more flies were recorded in fluorescent yellow traps with *Rhagoletis* lure than in treatments with no lure (Fig. 4). Some flies were captured in fluorescent traps with no lure and transparent traps with lure, but these catches did not differ significantly from each other or from zero catch on transparent traps with no lure.

In the comparison of traps set out at different heights, at both sites significantly more (3–4-fold) flies were captured in traps set at 4 m than in traps at 2 m (Fig. 5) (mean catch / trap / inspection at Nedelisce: 1.83 vs. 7.70 for 2 m and 4 m, resp., $P=0.0015$; at Prelog: 3.72 vs. 10.72 for 2 m and 4 m, resp., $P=0.0379$). When seasonal distribution of catches was considered, much more robust catches were recorded at both sites in traps at 4 m than in the ones at 2 m (Figs 6 and 7).

S. longipennis

The numerical trend of catches was similar (Fig. 8) to that recorded in the similar experiments on *Rhagoletis* fruit flies in this study (Figs 1 and 4). Fluorescent traps with lure caught the largest number of flies, followed by transparent traps with lure, fluorescent yellow traps with no lure, and transparent traps with no lure (Fig. 8); fluorescent traps with lure was the only treatment which caught significantly more than transparent traps with no lure.

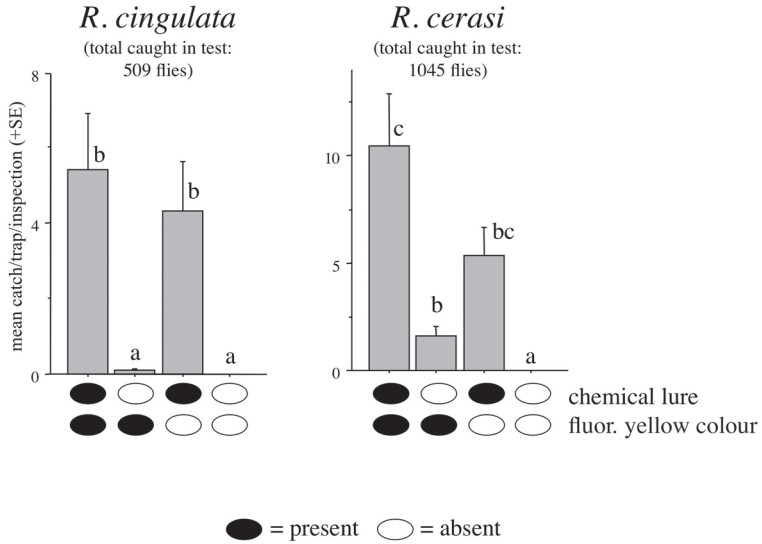


Fig 1. Mean catches of *R. cingulata* and *R. cerasi* in traps with or without visual and chemical stimuli and their combination. Exp. 1A (Agárd, Hungary, 2007). Visual stimulus = fluorescent yellow; chemical stimulus = *Rhagoletis* lure. (Means with same letter within one diagram not significantly different at $P = 5\%$ by ANOVA, Games–Howell, Bonferroni–Dunn)

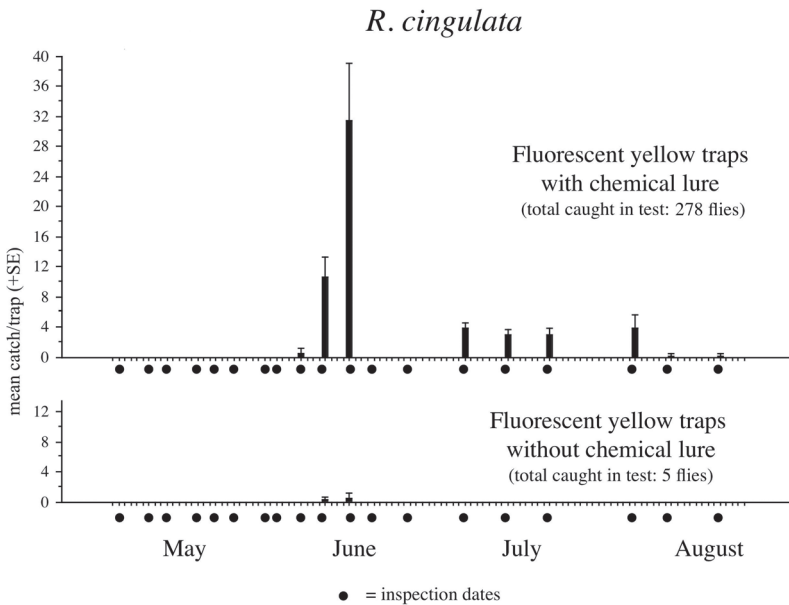


Fig 2. Seasonal distribution of catches of *R. cingulata* in fluorescent yellow sticky traps with or without chemical lure in Exp. 1A (Agárd, Hungary, 2007)

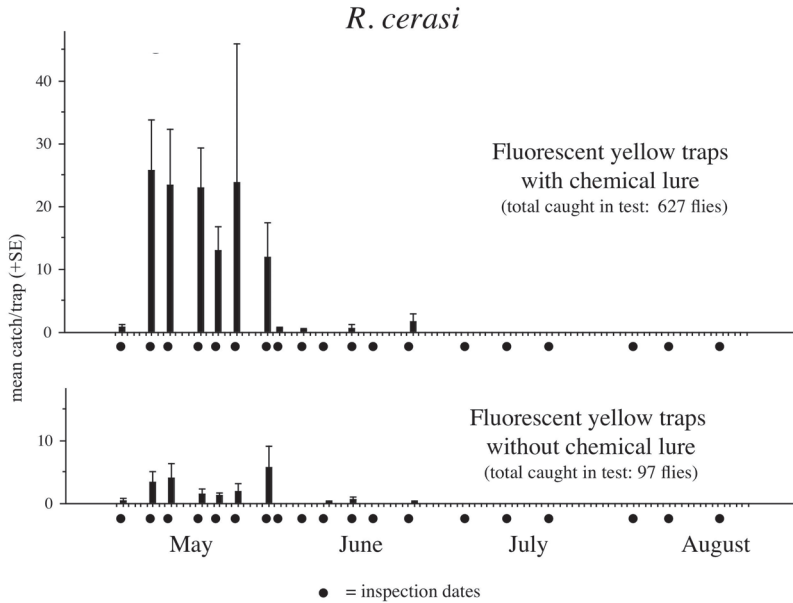


Fig 3. Seasonal distribution of catches of *R. cerasi* in fluorescent yellow sticky traps with or without chemical lure in Exp. 1A (Agárd, Hungary, 2007)

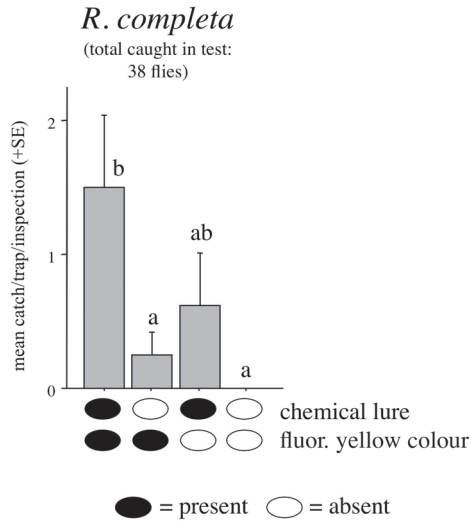


Fig 4. Mean catches of *R. completa* in traps with or without visual and chemical stimuli and their combination. Exp. 1B (Banfi, Croatia, 2011). Visual stimulus = fluorescent yellow; chemical stimulus = *Rhagoletis* lure. (Means with same letter not significantly different at $P = 5\%$ by ANOVA, Games–Howell, Bonferroni–Dunn)

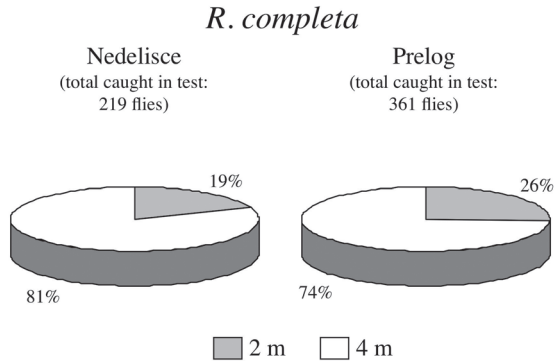


Fig 5. Proportion of catches of *R. completa* in fluorescent yellow traps with chemical lure set at 2 m or 4 m high at Nedelisce and Prelog, Croatia, in Exp. 2

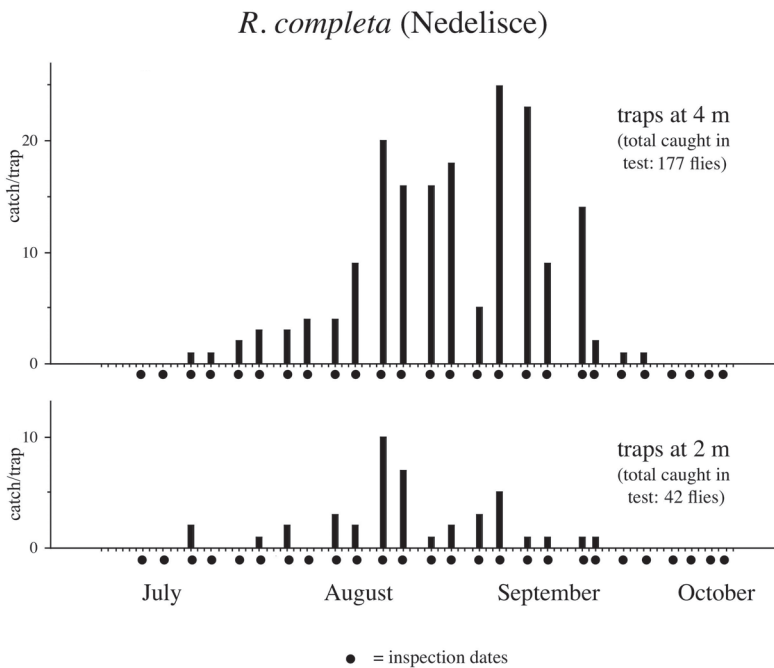


Fig 6. Seasonal distribution of catches of *R. completa* at Nedelisce, Croatia, in fluorescent yellow traps with chemical lure set at 2 m or 4 m high (Exp. 2)

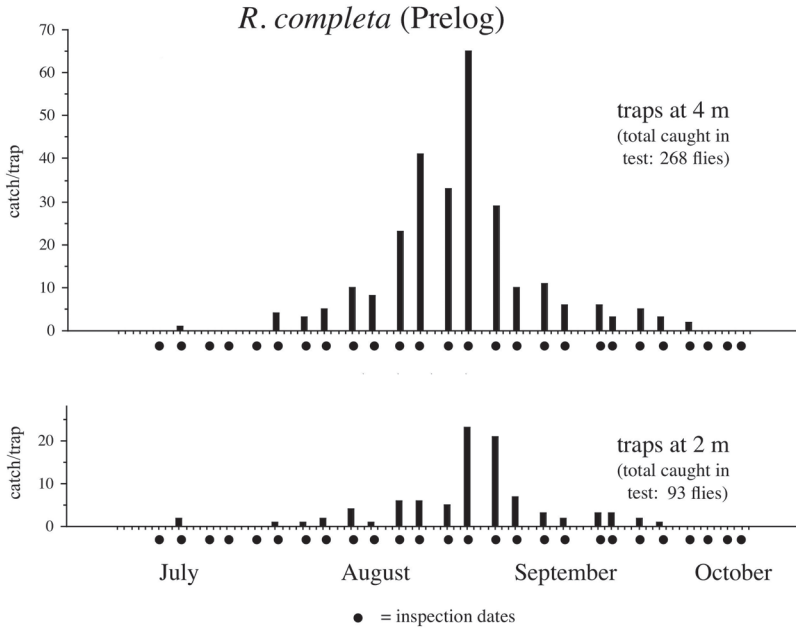


Fig 7. Seasonal distribution of catches of *R. completa* at Prelog, Croatia, in fluorescent yellow traps with chemical lure set at 2 m or 4 m high (Exp. 2)

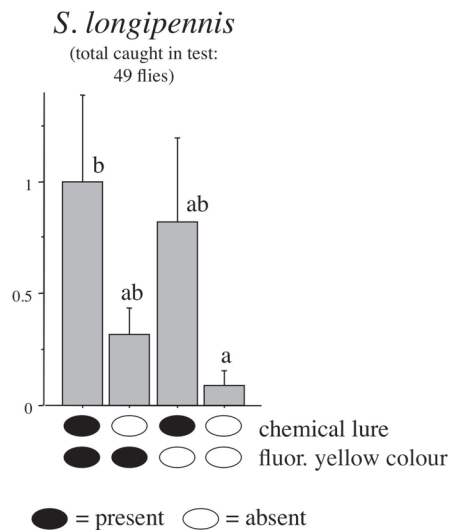


Fig 8. Mean catches of *S. longipennis* in traps with or without visual and chemical stimuli and their combination. Exp. 1C (Berlin-Dahlem, Germany, 2012). Visual stimulus = fluorescent yellow; chemical stimulus = *Rhagoletis* lure. (Means with same letter not significantly different at $P = 5\%$ by ANOVA, Games–Howell, Bonferroni–Dunn)

Discussion

Our results confirm the highly significant effect of the *Rhagoletis* lure on *R. cerasi* (Tóth et al., 2004) and clearly show that the presence of the lure in the trap is highly synergistic in *R. cingulata*, *R. completa* and *S. longipennis* as well. The attractive effect of ammonium acetate has been described before in *R. cingulata* (Liburd et al., 2001; Felz-Stelinski et al., 2006). Also in *R. completa*, the activity of ammonium salts has been documented (Riedl and Hoying, 1981), consequently our results in the present study correspond well to the literature data in all *Rhagoletis* spp. studied. To our knowledge in *S. longipennis* the attraction to ammonium releasing salts has not been reported.

Traps having only the visual attractive cue, fluorescent yellow, worked variably in the present study. In some of the species their performance was very low (i.e. in *R. cingulata*), in other cases they resulted in intermediate catches. The addition of the lure invariably increased catches in all four spp., and seasonal catches 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.

This is apparently most important in projects run in geographical regions where these spp. are regarded as invasive pests. In Hungary, for example, the presence of *R. cingulata* has first been reported in 2006 (Szeőke, 2006), and extensive trapping in following years could show out the presence of this new pest in many orchards of the country (Voigt and Tóth, 2008; Károlyi et al., 2014).

After its first detection in 2004 in Croatia (Budinscak et al., 2005) *R. completa* has spread to most of the western part of the country (Baric et al., 2014). The pest has recently been discovered in Hungary (Tuba et al., 2012; Voigt et al., 2012), and trappings in 2012 and 2013 evidenced that its spread has so far been restricted to the southwestern counties Vas, Zala and Somogy (Orosz et al., 2012; Voigt et al., 2013, 2014).

In the present study traps set out 4 m high in the canopy of walnut trees caught far more *R. completa* than traps set out at 2 m. This underlines the importance of positioning traps in the right way on the trees, since this can heavily influence the success of a detection survey. Also in the case of *R. cerasi*, traps positioned at the highest branches of the cherry trees canopy were far more efficient in catching the flies than traps at lower heights (Tóth et al., 2004).

S. longipennis is a newcomer in Europe, and we trust that fluorescent sticky traps with lure have proved and will prove to be a useful tool in detecting its spread in Europe (Lerche et al., 2013). The results of the present study suggest 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.

Acknowledgement

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