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Allyl isothiocyanate baited traps to monitor cabbage flea beetles (*Phyllotretra* spp., Coleoptera: Chrysomelidae)

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Summary: A new trapping concept has been proposed based on a volatile compound, allyl isothyocianate, known to be attractant to some of these insects for a long time.
(1) The first question was whether this compound is effectively attractive to all flea beetle species attacking cabbage under our conditions? Field experiments were made at different localities with non-sticky baited traps early and late spring. Eleven *Phyllotreta* species attacking cabbages were captured at baited traps most of them were first observed at this bait. So the bait has proved to be sufficient for use for trapping purposes effectively.
(2) Based on these findings a second question arose whether the captured samples reflected the specific composition of natural flea beetle populations at trapping localities? To reply the question field samples were taken at four different kinds of cabbage crops and at a fallow ground in the close vicinity by a manual sampler device suitable to detect the local composition of flea beetles and trapping was made parallel with baited and unbaited traps from early spring to early autumn. No significant differences were found between the specific structures of *Phyllotreta* assemblages sampled with the different methods applied. This means baited traps reflected the specific composition of local *Phyllotreta* populations fairly well.
(3) Thirdly, the most effective trap design was searched for. Some sticky and non-sticky trap designs which had been developed to capture other insects were compared. The tested sticky and funnel trap designs baited with allyl isothiocyanate captured large numbers of flea beetles attacking cabbages. Results showed that non-sticky funnel traps were more effective than sticky delta traps. Accordingly, non-sticky funnel trap designs can advantageously be used and could possibly be recommended in plant protection practice to monitor flea beetles attacking cabbages as their catching capacity is considerably greater than that of the delta type and additionally captured beetles are much cleaner, more intact and consequently their identification is much easier.

Key words: Cabbage flea beetles, Phyllotretra spp., baited trapping, monitoring, allyl isothiocyanate

Introduction

Flea beetles are serious pests of cultivated cabbages first of all in spring in the period after planting. In warm weather, the overwintered beetles can appear at different cabbage crops in very high density and can make serious harm to the young leaves of the plantings. This can result in retarded development of the plants and even in their decay. To make a correct decision on controlling their damage, we need proper methods to detect their first appearance and the rate of their population increase. This time simple sticky panel-traps are recommended for this purpose (*Benedek* et al. 1974) or simple plant inspections are proposed. Plant inspection, however, is not reliable enough because flea beetles are extremely sensitive to the lack of sunshine and low air temperatures and so they usually take shelter when it is cloudy or when the temperature decreases. It is relatively simple to apply sticky panel-traps, but in case of high population density they get saturated in a short time and so the panels should be replaced very often. Accordingly, sticky panels are inconvenient to use and make harm to the captured beetles that become difficult to identify. So, an efficient and reliable trap would be very useful in crop protection to detect their first appearance in spring and to monitor their flight pattern later on in the season.

Tóth et al. (2004) raised the idea to use isothyocianates to bait cabbage flea beetles because these compounds are known to act as feeding attractants to these insects (*Feeny* et al. 1970, *Hick* 1974), being a secondary metabolite of non-volatile glycosinates that are secondary plant substances at

normal metabolism of cruciferous plants. The attractivity of allyl isothyocianate, the most well known representative of these compounds, has been known for a long time (*Görnitz* 1956, *Feeny* et al. 1970). Based on this idea the following questions arose:

(1) The first question was if this compound is effectively attractive to all flea beetle species attacking cabbage under our conditions?
(2) The second question was whether the captured samples reflect the specific composition of natural flea beetle populations at trapping localities?
(3) The third question was if we had been able to find a trap design more effective and more reliable than the mentioned sticky panels?

To reply the question a series of experiments were made in the past few years (*Tóth* et al. 2003, *Bakcsa* et al. 2004, *Tóth* et al. 2004). The aim of this paper to give a rapid glance over the first results of our studies.

Results and discussion

The species spectrum of flea beetles attracted to allyl isothiocyanate baited traps

Sticky traps baited with allyl isothiocyanate were placed at cabbage fields at several sites of the country for longer or shorter periods and unbaited traps were placed in their close vicinity as a control. The captured beetles were identified.

We captured some 11 *Phylottreta* species attacking cabbages at baited traps (*Table 1*), some of them were first observed at this bait (*Tóth* et al. 2003, *Bakcsa* et al. 2004). So the bait has proved to be sufficient for use for trapping purposes effectively.

At all experimental sites our traps baited with allyl isothiocyanate caught large numbers of *Phyllotreta cruciferae*. Catches in baited traps were always significantly higher than in unbaited ones. Our results confirm earlier reports on the attractivity of this compound towards this species described earlier from other parts of Europe and from North America (Canada). This species is one of the most important pest flea beetles in Hungary.

The second most frequently recorded species captured was *Ph. vittula* in our experiments. Traps with allyl isothiocyanate clearly caught more than unbaited ones showing a strong attraction by this compound. No previous reports on allyl isothiocyanate attraction of this species has been published.

Regularly, significantly more beetles were caught in baited traps from *Ph. procera* as well. Attraction by this compound has not been published before for this species either. At a rape field, baited traps caught considerable numbers of *Ph. balcanica* while no beetle were captured in unbaited traps. Similar results were obtained at another site for *Ph. Nodicornis*. In previus literature, no attraction by allyl isothiocyanate has been mentioned in the case of these species.

In the case of *Ph. undulata, Ph. atra, Ph. diademata, Ph. nemorum, Ph. nigripes,* and *Ph. striolata* more beetles were caught in baited traps than in unbaited ones, that may be an indication for the attractivity of allyl isothiocyanate to these species, but due to the overall low numbers of catches this statement should be confirmed in future tests.

Apart from *Phyllotreta* specimens, also significantly larger numbers of *Psylliodes chrysocephala*, a closely related species, were captured in baited than in unbaited traps, indicating that allyl isothiocyanate may play a role also in the chemical communication of this species. Scientists from the UK have already reported that certain isothiocyanates evoked an electrophysiological response on the antennae of *Ph. chrysocephala*, however, to the best of our knowledge this is the first report on the field activity of the compound.

As for the relative abundance of these flea beetle species in the catches of traps baited with allyl isothiocyanate, 60–90 % of specimens belonged to *Ph. cruciferae*; 10–30 % to *Ph. vittula*, or *Ph. procera*. Other species occured in small percentages only, depending on the experimental site. It is surprising, that such important pest species like *Ph. atra* Fabr., *Ph. undulata* or *Ph. nemorum* L. were captured occasionally at very low numbers. Further studies are needed to decide whether this was caused by the fact that allyl isothiocyanate is not attractive towards these species or they were present in very low population densities at the experimental sites.

Table 1. The attractivity of allyl isothiocyanate to cabbage flea beetles in Hungary

Species captured:	Attractivity of allyl isothiocyanate
Phyllotreta cruciferae	has been known from literature; confirmed by us
Ph. vittula	discovered in this study
Ph. procera	discovered in this study
Ph. balcanica	discovered in this study
Ph. nodicornis	discovered in this study
Ph. undulata	discovered in this study, but should be confirmed
Ph. atra	discovered in this study, but should be confirmed
Ph. diademata	discovered in this study, but should be confirmed
Ph. nemorum	discovered in this study, but should be confirmed
Ph. striolata	discovered in this study, but should be confirmed
Ph. nigripes	discovered in this study, but should be confirmed
Psylloides chrysocephala	discovered in this study; electrophysiological activity has been known before

Relationship between the specific composition of natural and trapped cabbage flea beetle assemblages

All kinds of baits can influence field behaviour of target organisms and for this reason baited traps sometimes do not give a reliable picture on the species proportion of multi-

species insect assemblages. This fact can be greatly misleading when such information is used for decision making in crop protection. Cabbage flea beetle populations are usually multi-species assemblages and so this question is especially important in this case.

We approached this problem with parallel sampling procedures implemented at an experimental site with high-density cabbage flea beetle population. Baited and unbaited traps of the same design were operated in four one-week periods as well as vacuum samplings were made with a small manual sampling device at each time when traps were replaced during the whole season, from early spring to early autumn. Samples were taken at four different kinds of cabbage crops at the site and at a fallow ground in the close vicinity. The manual device and the unbaited sticky-traps did not affect the behaviour of the flea beetles and so this approach gave a reliable picture on the specific composition of the local population for comparing the results to the catches of baited traps.

Table 2. Proportion of flea beetle species at cabbage fields as reflected by different survey methods
(Dunasziget, 26 April – 15 October, 2003)

Species	Per cent proportion of cabbage flea beetles in samples taken with different survey methods			$SD_{5\%}$	F value (P=5% =3,40)
	manual vacuum sampling	non-sticky funnel traps (VARL)			
		unbaited	baited with allyl-isothiocy-anate		
Ph. cruciferae	68.6	65.9	66.0	*21.4*	*0.23*
Ph. vittula	4.7	26.7	30.9	*13.3*	*9.88*
Ph. atra	4.8	1.2	0.7	*3.7*	*2.71*
Ph. diademata	3.1	0.2	0.3	*3.4*	*1.64*
Ph. undulata	6.7	1.6	0.6	*3.2*	*6.67*
Ph. nigripes	11.0	0.6	1.0	*11.1*	*1.86*
Ph. nemorum	0.8	0.0	0.0	*0.7*	*2.21*
Ph. ochripes	0.2	0.0	0.0	*0.3*	*1.00*
Ph. Striolata	0.1	0.3	0.0	*0.5*	*0.67*
Ph. christinae	0.0	0.0	0.01	*0.0*	*1.00*
Total catch. (No. of individuals)	**732**	**690**	**7540**	–	–

No significant differences were found between specific structures of *Phyllotreta* assemblages sampled with the different methods applied (*Table 2*), except for *Ph. vittula* that was captured at significantly greater proportion both at baited and unbaited traps than with the manual sampling. This insect, however, is an exception among cabbage flea beetles because all other cabbage flea beetles are clearly adopted to feed on cabbages and some other crucifers only, but *Ph. vittula* shows preference towards crucifers and some poaceous plants as well (*Sáringer*, 1990). Unbaited and baited catches, however, did not differ significantly from each other even in this case. At the same time, the figures were somewhat higher at several less frequent species with manual sampling than with the trapping techniques but the difference was not significant at all at any case and no significant difference was detected even between the catches of baited and unbaited traps either. Figures for baited and unbaited trappings were greatly similar at most cases. So these findings indicate that the baited traps reflected the specific composition of local *Phyllotreta* populations fairly well. Regarding the variability of some figures and the low abundance of some species, however, this kind of comparison should be repeated and the present statements should be confirmed in the future.

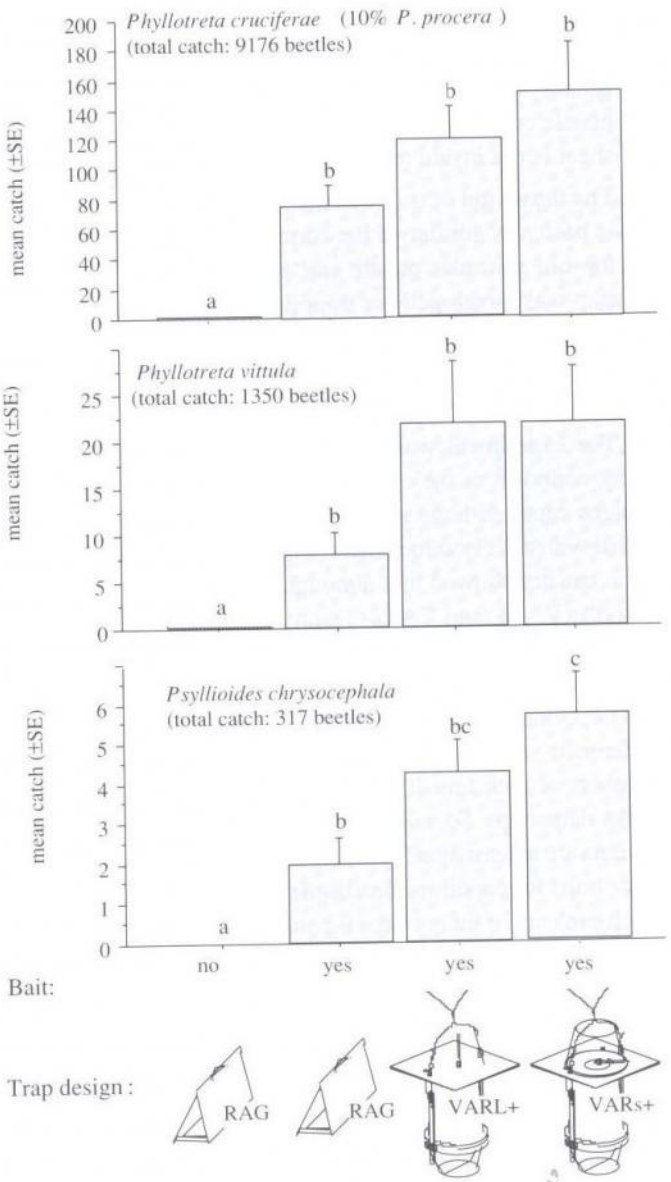

Fig 1. Mean catches of flea beetles at different trap designs (Bait: allyl isothiocyanate) at Agárd, September 11 – October 9, 2000. Means with same letters at the same diagram are not significantly different at P=5% by ANOVA, Games-Howell (after *Tóth* et al. 2004)

Selecting the most efficient trap design

Several trap designs have been developed by the Pheromon Working Group at the Plant Protection Research Institute of HAS (Budapest). Also numerous practical experiences are available there on the applicability of these traps for catching different types of insects with different kinds of flight behaviour. Based on this knowledge, three trap designs were selected for flea beetle experiments.

(a) The first one was the so called RAG-type that was originally developed to study different Microlepidoptera (*Szőcs* 1993, *Tóth* and *Szőcs* 1993). This is a delta type trap with a replaceable plastic panel coated with sticky material placed on the inner bottom of the trap.

(b) The second one is called the VARL-type that was developed for catching large bodied noctuid moths (*Tóth* et al. 2000a). This is a fairly large, transparent plastic funnel with a flat lid on the top and with a replaceable plastic cup at the bottom. A small piece of a moth-killing sheet is put inside to kill the captured insects.

(c) The third kind of trap was the so called VARs+ type. This is basically similar to the former, but there no lid on the top but a similar plastic cap at the bottom. This kind of trap was developed for trapping Western corn rootworm (*Tóth* et al. 2000b). Small pieces of moth killing sheet is placed in both cups.

The experiment was made with three flea beetle species being abundant at the experimental site (*Fig. 1*). All the trap designs captured large numbers of cabbage flea beetles when baited with allyl isothiocyanate (*Fig. 1*). The comparison of the main catches showed that although the non sticky-funnel trap designs (VARL and VARs+) were more efficient, statistically significant difference was detected only in the case of *Psylloides chrysocephala* between the funnel type (VARs+) and the delta-type sticky traps (RAG). There was no significant difference was between the two funnel designs. The catch numbers of both funnel designs were well above those of the sticky delta traps. So, results suggest that non-sticky funnel trap designs are at least as effective, if not more efficient than sticky delta traps for capturing flea beetles (*Tóth* et al. 2004). As the catch capacity of funnel traps is considerably higher than that of sticky delta traps, saturation may not occur even after a long period of time. Additionally, captured beetles are intact in funnel traps, therefore insect material is much more easy to remove and identification is easier because the specimens remain clean in the trap.

Conclusions

As demonstrated above the following conclusions can be drawn from our experimental results:

a) Allyl isothiocyanate is an efficient bait to cabbage flea beetles inhabiting Hungary. This fact has been confirmed in the case of *Phyllotreta cruciferae* and has been demonstrated for the first time in our experiments for *Ph. vittula*, *Ph. procera*, *Ph. balcanica*, *Ph. nodicornis*, *Ph. undulata*, *Ph. atra*, *Ph. diademata*, *Ph. nemorum*, *Ph. striolata*, and *Ph. nigripes*, however, in the case of some species our statement should be confirmed because their population density was very low at our trapping sites.

b) Catches of traps baited with allyl isothiocyanate have reflected the specific composition of natural multi-species Phyllotreta populations fairly well. So, the catches of baited traps seem to provide a fairly reliable measure of the seasonal activity and relative abundance of cabbage flea beetle assemblages and for this reason baited trapping can be recommended as a reliable tool in decision making in crop protection. This statement, however, should be confirmed in the future at other experimental localities because for the small abundance of some species the figures were variable between manual sampling and unbaited trappings.

c) The trap design can affect the trapping efficiency but in the case of cabbage flea beetles greatly different traps designs seem to be of satisfactory efficiency. However, non-sticky funnel-type trap designs seem to be somewhat more effective than delta-type sticky traps so rather these types are to be recommended in the practice than others. Funnel-type traps have got some additional important advantages, too, because for their large catching capacity, saturation practically cannot be a problem even during long trapping periods and for the lack of sticky material the insect specimens remain clean and so their identification is much easier than the material from sticky traps.

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