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Patterns in distribution, abundance and prey preferences of parasitoid rove beetles *Aleochara bipustulata* (L.) (*Coleoptera: Staphylinidae, Aleocharinae*) in Hungarian agroecosystems

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Abstract. The abundance, habitat preference, seasonal dynamics and prey preferences of parasitoid rove beetles *Aleochara bipustulata* (L.) (*Coleoptera: Staphylinidae: Aleocharinae*) were investigated in 16 Hungarian agricultural fields. *Aleochara bipustulata* was the 7th most frequent species in the cumulative samples, and widely occurred in woodland areas of mountains with medium height. The species has no particular soil preferences and its activity density was high in conventionally treated crops. Under laboratory conditions we observed that the adults may consume up to five root maggot larvae (*Delia radicum*) per day. Laboratory studies revealed that adults are often cannibalistic, eating their own eggs. Adults also consume other fly pests as *D. platura* and *D. florilega*. *Aleochara bipustulata* consumed significantly more *D. radicum* than *D. platura* and *D. florilega*. *Aleochara bipustulata* may be important biological control agent against *Delia* species in Hungarian agricultural fields because of its widespread distribution, high host specificity and host acceptance, and a development time which is well synchronised with its host.

Key words: abundance, activity density, dynamics, prey preferences

Introduction

The Central and Eastern European fauna of Aleochara genus is rich in species but is very poorly known. There are some 50 described species but probably the majority of species remains undescribed. The original species descriptions are scattered in the literature and are difficult to use because their authors failed to study the genitalic structures so crucial for species identification (Freude et al. 1964, 1974, Ádám 1998, Klimaszewski & Maus 1999). Several scientific names used in the literature differ from those considered valid today; in these cases the original name of the most widespread species of Alocharianae from Hungary is given following the citation: *Aleochara bipustulata* (L.) named *Coprochara bipustulata* by Ádám (1998). *Aleochara brevipennis* Gravenhorst, named *Euryodma brevipennis* by Ádám (1998). *Aleochara lanuginosa* Gravenhorst, named *Polychara lanu-*

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ginose by Ádám (1998). *Aleochara ripicola* Mulsant et Rey. *Aleochara ruficornis* Gravenhorst, named *Ceranota ruficornis* by Ádám (1998). *Aleochara sparsa* Heer, named *Polychara sparsa* by Ádám (1998), (Ádám 1998, Merkl 2001).

The Eurasian parasitoid *Aleochara bipustulata* is a prospective biological control agent for different dipteran pests. Researchers have found the parasitoid in fifteen different habitats and reported complete development within puparia of fly species from seven families of *Diptera, Cyclorrapha* (Finch 1995, 1996, Maus et al. 1998, Andreassen et al. 2005). Adults prey mainly on eggs, larvae, and pupae of *Delia* species, while larvae feed on pupae inside puparia.

The female beetles lay eggs where there is general evidence of hosts (Godfray 1994). However, the precise finding and selection of hosts is performed only by the mobile first-instar larva, which starts to search for hosts immediately after hatching. Therefore, in comparison with most hymenopteran parasitoids, adult coleopteran parasitoids are considered to have only a minor influence on the parasitism success and fitness of their progeny, as they do not directly select and evaluate host suitability (Godfray 1994). Other studies demonstrated that larvae were able to discriminate between unparasitized hosts and hosts parasitized by conspecifics in a choice experiment. Such behaviour has never been described previously for a coleopteran parasitoid or for a parasitoid species whose larvae perform host searching. Host discrimination in this species was not based on the presence of visual or tactile cues (e.g. entrance holes) but rather on chemical cues (Royer et al. 1999, Prasad & Snyder 2004).

No sexual dimorphism in weight was observed at the emergence of adults. The weight of adults was strongly correlated with the size of the pupa in which the parasitoid developed. Newly emerged adults increased in weight after feeding, and this increase was greater in females than in males, reflecting the beginning of oogenesis (Langlet et al. 1998).

The mortality, egg production and fertility were also studied on *Aleochara* species. Insecticides increased the mortality; the egg production and fertility were also affected. Generally, insecticides/acaricides had a pronounced effect on the beetles whereas fungicides and herbicides were less detrimental. Exceptions were the insecticides Tedion V 18 and Kilval, classified as harmless, and the fungicides Morestan, Pomarsol forte and Afugan rated as moderately harmful. Among growth regulators Prosevor 85 was highly detrimental while Cycocel Extra and Rhodofix had no effects. Excepting Morestan, Pomarsol forte and Ustinex PA the pesticides did not affect the hatching of eggs (Samsøe-Petersen 1993, 1995 a, 1995 b).

Materials and methods

Farms and sampling procedures

Studies were performed in wheat fields and its alternation crops in 2006 and 2007 in

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eight conventionally farmed plots of 5 ha each. The soil structure was sandy-loam and the treatments consisted of foliar fungicides during the vegetation period. The crop rotation consisted of cruciferous crops, especially brassicas, for four farms and beans for other four. Samples collected between 2000 and 2003 in eight apple orchards were also considered. Four investigated orchards were located on sand, whereas four on clay. Six apple plantations were treated with mainly organophosphate insecticides (methidation, fosalon, fosfamidon) and named "conventionally treated orchards" (CON). These insecticides were applied on average of 10 times during the vegetation period. Two apple plantations were untreated – named "abandoned" (ABA) - and neither pesticides nor fertilizers had been used for five years before we started our investigation. The investigated agroecosystems were placed in three geographical regions with different environmental conditions. These were agricultural lowland environment (ALE), regularly flooded area (RFA) and woodland area from medium height mountains (WAM). Ten covered pitfall traps (300 cm^3 in size, 8 cm in diameter, half-filled with ethylene glycol 30% solution) were placed in transect from a field margin towards the field centre at 10m intervals within each site. All staphylinidae were sorted and identified up to species level with a stereomicroscope. Species identification was based on the works of Freude et al. (1964, 1974), Tóth (1982, 1984) and Zerche (1994).

Laboratory studies of prey preferences

The prey preferences of adult *A. bipustulata* were studied under laboratory conditions, at room temperature. Five living individuals were placed in 90 mm diameter Petri dishes and for each three types of prey were offered daily, each in three exemplars (larvae of *Delia radicum* (L.), *D. platura* (Meigen) and *D. florilega* Zetterstedt).

D. radicum (cabbage root fly) can attack wild and cultivated brassicas as radish, turnip, Swedish turnip, cabbage, cauliflower, rape, etc. *D. platura* (seedcorn maggots) can be serious pests of sown seeds of beans and maize. Additional crops attacked include corn, cucumber, green beans, lettuce, onion, peas, seed potatoes, spinach. *D. florilega* (bean seed fly) can damage sea-spurrey beans and other large seeded vegetables. Damaged plants by these pests are weak and may not develop. As a result, stands can be thinned, sometimes as high as 80% (Jonasson et al. 1995).

The experiments lasted ten days with two repetitions. Partially and/or fully consumed individuals were considered and the $\log_{10}$ transformed prey numbers were computed.

Data analyses

The Analysis of Variance (ANOVA) were performed and similarities were compared with O'Brien and Levene tests to determine whether there were any differences in habitat and prey preferences and in disturbance tolerance of *Aleochara* species in Hungarian agroecosystems. Back-transformed means and P < 99% confidence limits were considered as statistically significant differences (Tóthmérész, 1993, 1995). The following standardizations were used for the test: the cumulative data from two sites for WAM were compared with cumulative data from other two sites for ALE and two for RFA. For treatments effects, cumulative data from the two abandoned orchards were compared with cumulative data from two conventionally treated orchards, all located on sand in ALE. The habitat preferences of the species were compared with DECORANA, which is able to detect relationships between species and external (environmental) variables. These relationships can be "unimodal", rising and falling again as the optimum environmental conditions for a species are approached and passed. DECORANA avoids the arch or horseshoe problem where the second axis is frequently a quadratic distortion of the first axis. For this method *A. bipustulata* were compared to other frequently found species. (Oksanen & Minchin 1997). For seasonal dynamics the cumulative number of specimens was used.

Results

Abundance, habitat preferences and seasonal dynamics

During the survey a total number of 5.420 individuals were collected belonging to 246 species and 11 subfamilies (tab.1.). The parasitoid species *A. bipustulata* was the 7th most widely occurring with a relative abundance of 4.15% (tab.2.). In spite of its low relative abundance, the species was widely distributed and present in all of the investigated agroecosystems. Other parasitoid rove beetles found in Hungarian agricultural fields are *Aleochara curtula* (Goeze), *A. forticornis* (Strand), *A. lateralis* Erichson and *A. spissicornis* Erichson. *A. bipustulata* was frequently found in all geographical regions but its activity density was significantly higher in woodland areas from medium height mountains (WAM) ($F_{[2,8]}$ = 8.28, P = 0.001) and lower in regularly flooded areas (RFA) ($F_{[2,8]}$ = 11.39, P = 0.001). Other parasitoid rove beetles as *A. curtula* preferred agricultural lowland environments (ALE) ($F_{[2,8]}$ = 7.91, P = 0.001, $F_{[2,8]}$ = 7.05, P = 0.002). The species *A. forticornis* and *A. lateralis* were captured only in woodland areas from medium height mountains, while *A. spissicornis* was missing in regularly flooded areas (fig.1).

For apple orchards the activity density of *A. bipustulata* was significantly higher in conventionally treated fields ($F_{[2,12]}$ = 6.81, P = 0.002). *A. curtula* also preferred conventionally treated fields but its activity density was insignificant compared with abandoned plots, ($F_{[2,12]}$ = 2.90, P = 0.06). The species *A. forticornis, A. lateralis* and *A. asissicornis* were only captured in conventionally treated plantations (fig. 2).

Table 1. Systematic order of rove beetle subfamilies collected in Hungarian agricultural fields.

Subfamilies	Species no.	Individuals no.
Omaliinae	7	732
Proteininae	1	2
Micropeplinae	1	15
Tachyporinae	28	927
Habrocerinae	1	1
Aleocharinae	79	1,277
Oxytelinae	20	407
Steninae	7	57
Paederinae	21	320
Xantholininae	19	572
Staphylininae	62	1,110
TOTAL	**246**	**5,420**

Due to its widespread distribution and abundance, *A. bipustulata* may play significant role in biological and integrated pest management control. Therefore its habitat preferences and seasonal dynamics in Hungarian agricultural fields were also computed. In figure 3 rove beetles frequent in conventionally treated agro-ecosystems are plotted. Along the axis 2, species captured in farms with sandy soil are located underneath, while species frequent in clay farms are located above. *A. bipustulata* was present in relatively high number in conventionally treated farms situated on clay and sand (fig.3).

Considering the seasonal dynamics of the species, we observed that the greatest abundance occurred in June, July and August while the lowest in spring and autumn. This activity density is well synchronized with *Delia spp*. development time in Hungarian agricultural crops (fig.4).

Prey preferences of adult

The larvae parasitoid behaviour has been widely investigated, but there is less information about adult prey preferences. Under laboratory conditions the adults may consume up to five root maggot larvae per day. Adults are often cannibalistic, eating their own eggs. They also consume other fly pests as *D. platura* and *D. florilega* - both common in Hungarian fauna. The frequency of *D. radicum* consumption is significantly higher than of *D. platura* ($F_{[2,10]}$ = 13.74, $P <$ 0.003) and *D. florilega* ($F_{[2,10]}$ = 79.5, $P <$ 0.002). The acceptance and consumption of *D. platura* is also higher than the *D. florilega* ($F_{[2,10]}$ = 65.77, $P <$ 0.002) (Fig. 5).

The laboratory studies confirmed that in August and September, two to three days after mating, females begin laying white elliptical eggs about 8-15 per day. Larvae hatch in about 5 to 10 days. The larva punctures the host puparium and the entire host pupa is consumed. The larvae pupated inside the host puparium.

Table 2. The most widespread rove beetles species collected in Hungarian agricultural fields.

	Species	Abun-dance
1	*Omalium caesum* Gravenhorst	9.55%
2	*Drusilla canaliculata* (F.)	9.46%
3	*Sphenoma abdominale* Mannerheim	7.36%
4	*Palporus nitidulus* (F.)	6.88%
5	*Dexiogyia corticina* (Erichson)	5.33%
6	*Xantholinus linearis* (Olivier)	5.23%
7	***Aleochara bipustulata* (L.)**	**4.15%**
8	*Mocyta orbata* (Erichson)	4.11%
9	*Oligota pumilio* Kiesenwetter	3.87%
10	*Platydracus stercorarius* (Olivier)	3.65%
11	*Xantholinus longiventris* (Olivier)	3.43%
12	*Olophrum assimile* (Paykull)	2.23%
13	*Pycnota vicina* Kraatz	2.02%
14	*Tachyporus hypnorum* (F.)	1.95%
	TOTAL	**69.28%**

Discussions

Aleochara bipustulata appears to be a good candidate as biological control agent against *Delia* species in Hungarian agro-ecosystems because of its widespread distribution, high host specificity and host acceptance, and a development time which is well synchronised with its host. The species also consumes other pests common in Hungarian fauna, such as *D. platura* and *D. florilega.* These were de-monstrated for *A. bilineata* in other

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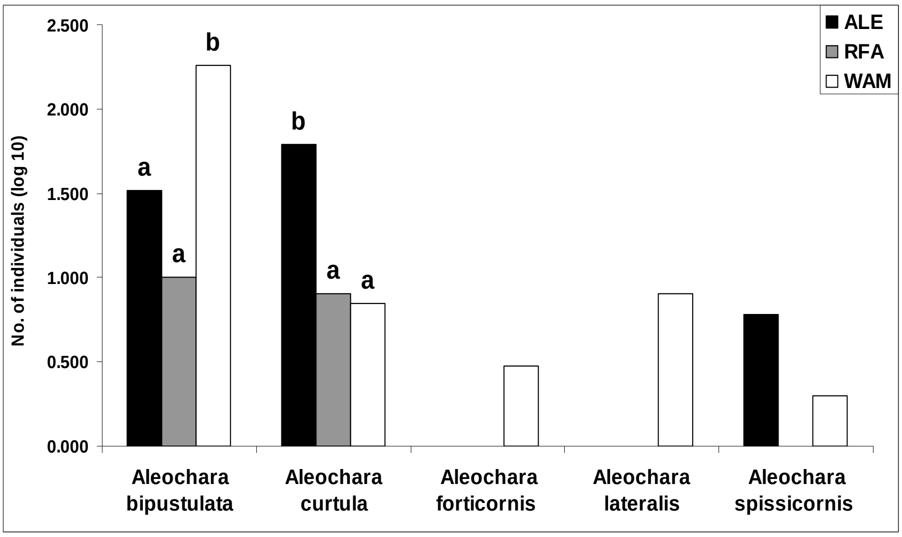

Figure 1. The habitat preference of the *Aleochara* species in Hungarian agricultural fields (ANOVA) (ALE – agricultural lowland environments, RFA – regularly flooded areas, WAM – woodland area from medium height mountains).

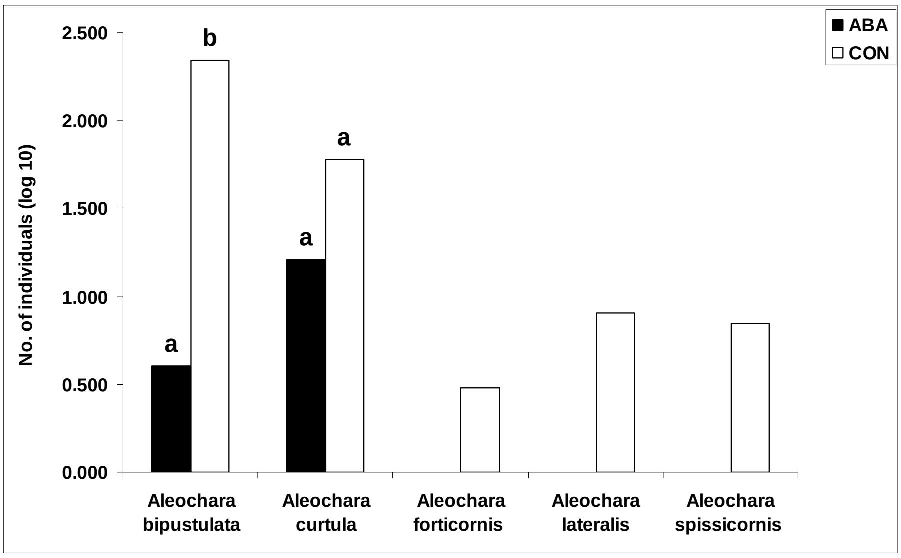

Figure 2. The insecticide tolerance of the *Aleochara* species in Hungarian agricultural fields (ANOVA) (ABA - abandoned plots, CON - conventionally treated plots).

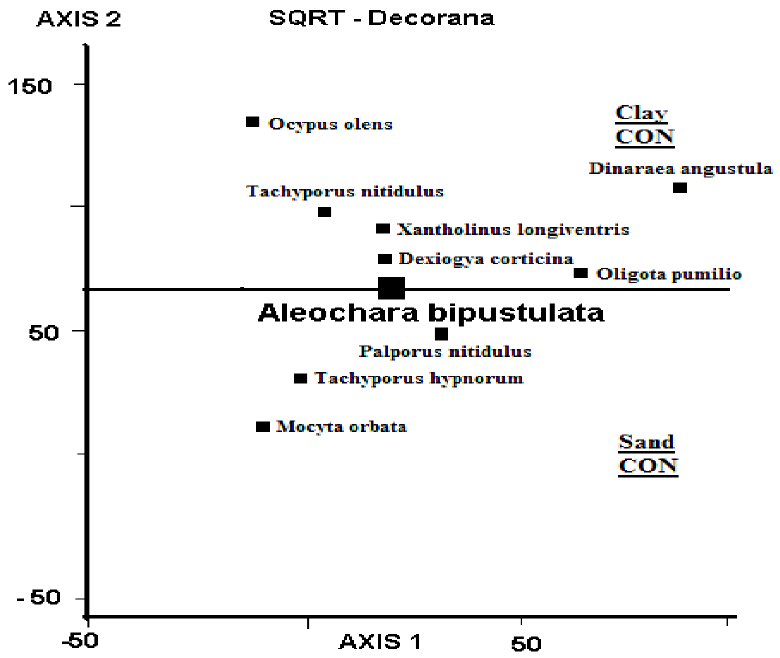

Figure 3. The habitat preferences of the staphylinid species in conventionally treated Hungarian agricultural fields with different soil composition (DECORANA).

regions in Western Europe and Canada (Finch 1995, 1996, Fournet et al. 2000, 2001, Andreassen et al. 2005).

The insecticide tolerance of the *Aleochara* species that occurred in Hungarian agricultural fields was high, as also demonstrated by other authors with *A. bilineata* during several field and laboratory experiences (Samsøe-Petersen 1993, 1995a, 1995b, Bonsal et al. 2004). There was a little information about the insecticide tolerance of other members of the genera. Its relative low activity density in abandoned crops may be explained with competition by other predacious coleopteran species. Intraguild predators may reduce activity densities of smaller beetles, and thus weaken fly egg predation, as demonstrated by other authors (Godfray 1994, Fournet et al. 2001). Both intraguild predation and the presence of alternative prey could limit biological control and feeding behaviour that targets *Aleochara* species. The best strategy for the use of *A. bipustulata* in pest management control may be exploitation of the potential held by its natural populations.

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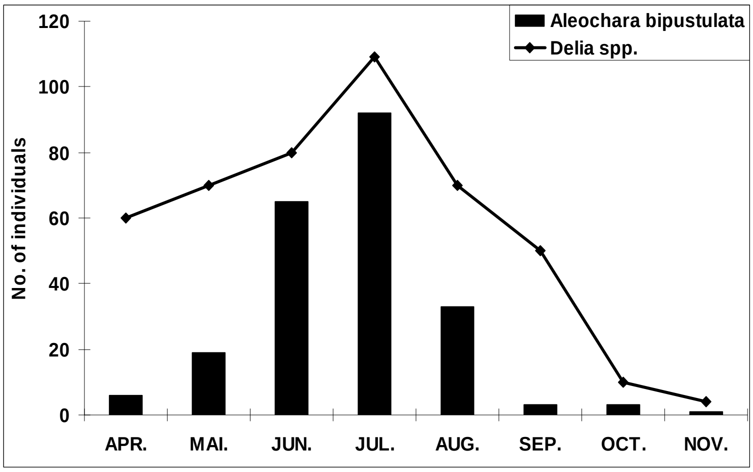

Figure 4. The seasonal dynamics of the *Aleochara bipustulata* and *Delia spp* in Hungarian agricultural fields. (Data of *Delia spp.* were reconstituted from literature (Jenser et al. 1998).

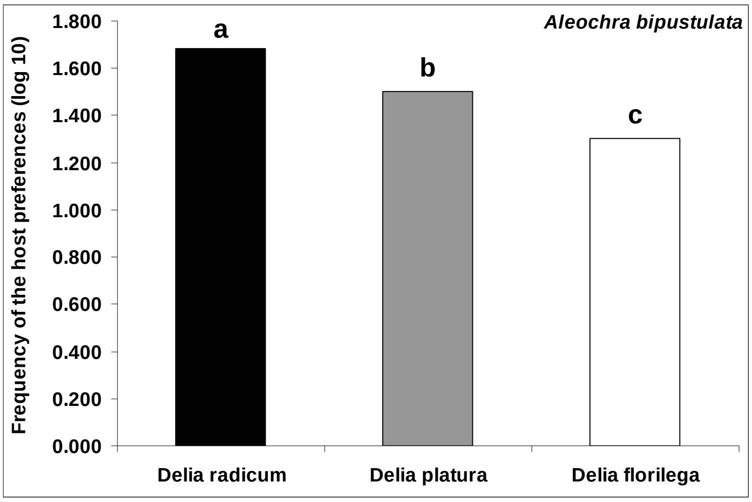

Figure 5. The host preferences of *Aleochara bipustulata* under laboratory conditions (ANOVA).

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