Aggregation of Ground Beetles (Carabidae, Coleoptera) on Winter Rape Seeds Dispersed on the Ground

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Abstract

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The preference of adult polyphagous ground beetles (Carabidae, Coleoptera) for winter rape seeds was investigated using an indirect method. Rape seeds were scattered around pitfall traps. The catches of carabid beetles in these traps and control traps without seeds were compared. The traps were exposed in two stands of winter wheat. In the wheat stand where overall carabid activity density was high, the presence of rape seeds significantly increased the catches of total seed-eating carabids, and of the two species *Pseudoophonus rufipes* and *Calathus fuscipes*. The effect was not significant in the other wheat stand where activity density was low. The aggregation of carabids at places with winter rape seeds indicated the importance of carabid predation on seeds scattered on the ground.

Keywords: winter rape; seeds; predation; activity density; Carabidae; *Pseudoophonus rufipes*

Ground beetles (Carabidae, Coleoptera) are important polyphagous predators of arthropods. However, many carabid species accept also plant food and may become obligatory or occasional pests of field and garden crops (MILLER 1956; BALACHOWSKY 1962). These species accept a variety of plant food including leaves of green plants and their fruits, but also pollen and fungi (SKUHRAVÝ 1959; THIELE 1977; HENGEVELD 1980; LUFF 1987; LÖVEI & SUNDERLAND 1996; KROMP 1999). Damage is therefore caused to young crop plants or at the stage of fruit ripening (JOHNSON & CAMERON 1969; LUKA *et al.* 1998). Eating plant seeds, granivory, is a more widespread mode of phytophagy than eating soft plant parts. Granivory is an important part in the food budget of many species, particularly of the tribus Zabrini (*Amara* spp.) and Harpalini (*Harpalus* spp., *Ophonus* spp., *Pseudoophonus* spp.) (LINDROTH 1949; THIELE 1977; HŮRKA 1996). Seeds are accepted also by polyphagous species which prefer animal prey (GOLDSCHMIDT & TOFT 1997). Although granivory had been observed for over 100 years (FORBES 1883; WEBSTER 1900), the importance of seed consumption was recognized only recently (BRIGGS 1965; KOCK 1975; LUND & TURPIN 1977; ALLEN 1979; BRANDMAYR 1990). Seeds are eaten by adults as well as by the larvae (KIRK 1972; JORGENSEN & TOFT 1997; HARTKE *et al.* 1998; HŮRKA 1998; SASKA & JAROŠÍK 2001). The overall effect of granivory is positive since most consumed seeds belong to grasses or forbs that may become weeds of agricultural crops. However, besides wild herb seeds some species consume also the crop seeds. Eating rape seeds elicited the research on pre-sowing treatments of seed materials (BÜCHS *et al.* 1991).

At the time of seed ripening, seeds liberated from pods and scattered on the ground may attract and cause aggregation of several carabid species (KOKTA 1988; KROMP 1990). Availability of winter rape seeds apparently increased carabid abundance (HONĚK & JAROŠÍK 2000). The aggregation response of carabid species to rape seeds was demonstrated experimentally, using pitfall traps "baited" with winter rape seeds. Scattering rape seeds around

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and inside the traps significantly increased catches of the granivorous species *Harpalus affinis* (Schrank) and *H. distinguendus* (Duftschmid) compared to catches from traps where the seeds were not scattered. Effect on activity density of other granivorous and carnivorous species was not significant. The increase of activity density of seed eating carabid species at places where seeds are available is an indirect proof of their predation on seeds.

Experiments reported in this paper extended the research on the attractivity of winter rape seeds. The experiment design was similar to HONĚK and JAROŠÍK (2000) and the traps were placed in two winter wheat stands where there were no or few seed dispersing weed plants. The overall abundance of carabids also differed between the stands. This enabled to recognize the role of the "overall" activity density of carabids on their aggregation around the rape seeds.

MATERIAL AND METHODS

Study Site. Field experiments were made between July 10–19, 2000, at Prague-Ruzyně (50°06´N 14°16´E, average May, June and July temperatures 12.7, 16.3 and 17.6°C and precipitation 57, 64 and 70 mm). The short duration of the study prevented the bias caused by temporal variation of activity density of carabid species. It was compensated by increasing the number of traps and frequency of trap servicing. The 0.2 km^2 study area was located on a southern facing slope (4% inclination), at 330–340 m a.s.l. altitude, with uniform soil quality. The area was divided between production and experimental fields surrounded by ridges and hedges. The experiment was made in both a production and experimental part of the study area. The production field (Stand 1) was sown to a winter wheat crop which was grown using standard practices recommended in the Czech Republic. The experimental fields were used for minimum tillage experiments; the area was divided into 20 × 50 m plots sown by different crops. For our study, a winter wheat plot (Stand 2) next to a winter rape crop was used. Due to the minimum tillage, the experimental fields (particularly the winter rape one) contained weed stands that liberated seeds at the time of the experiment.

Activity Density Experiments. The effect of scattering winter rape seeds on the ground surface on carabid activity density was investigated using an experimental design similar to HONĚK & JAROŠÍK (2000), using freshly collected rape seeds. We compared the catches of (i) traps where rape seeds were artificially scattered outside the trap ("baited traps"), and (ii) traps with no seeds inside or outside the trap ("controls"). The seeds around the trap were scattered at a density of ca. eight seeds per 1 cm^2, about 3 cm around its edge. The traps were exposed in series consisting of five "baited" and five "control" traps. The traps were placed alternatively on a line transect, with 6 m (Stand 1) or 4 m (Stand 2) spacing. To prevent the bias caused by the distance of traps from the field edge, the line transects were situated in parallel with the field margin, at a minimum distance of 6 m (Stand 1) and 4 m (Stand 2) from the field edge. To prevent the effect of repeated collecting at the same place ("repeated measure data") each series was run only once, then the traps were relocated and placed along another transect. Changing the trap position also prevented rape seed germination.

Pitfall Traps. The pitfall traps were plastic cups of 7 cm diameter (38.5 cm^2 outlet area), 8 cm deep. The cups were dug into the soil, with the rim at the soil surface, and screened from rain and sunshine by a dish wrapped in aluminium foil. A few pieces of soil at the bottom of the cups provided shelter for the trapped arthropods. The traps were serviced in 1d, 2 d or 3 d (weekends) intervals. The beetles were determined to species, counted and immediately released. The carabids were divided into seed "consumers" (facultatively or obligatorily granivorous polyphagans) and "non-consumers" (carnivores that only rarely may be granivorous) according to published information (THIELE 1977; HŮRKA 1996; GOLDSCHMIDT & TOFT 1997) and our unpublished experiments (HONĚK *et al.* in prep.).

Data Processing and Statistics. For each experiment series the cumulative catches of each species in baited and control traps were calculated. The data were then recalculated to daily catches (numbers of individuals/trap per day). Means ± standard errors of mean (SE) are indicated throughout the text. Since the duration of the experiment was short, average daily catches in particular series of pitfall traps within stands were not statistically different. We used one-way ANOVA to test the differences in total carabid daily catches between stands and between baited traps and control traps within stands. The differences between baited and control traps were tested for total catches of seed "consumers" and "non-consumers" and for dominant species. All calculations were made using STATISTICA for Windows (STATSOFT 1994).

RESULTS

In total we captured 17 carabid species. Eleven species were seed "consumers": *Amara aulica* (Panzer), *A. littorea* C.G.Thomson, *A. ovata* (F.), *Calathus ambiguus* (Paykull), *C. fuscipes* (Goeze), *Harpalus affinis*, *H. distinguendus*, *H. signaticornis* (Duftschmid), *H. tardus* (Panzer), *Pseudoophonus rufipes* (DeGeer) and *Trechus quadristriatus* (Schrank) (the last species was caught only once, it eats small seeds but is unlikely to accept winter rape seeds). Six species were "non-consumers": *Anchomenus dorsalis* (Pontoppidan), *Brachinus explodens* Duftschmid, *Carabus cancellatus* Illiger, *C. granulatus* L., *Poecilus cupreus* (L.), *Pterostichus melanarius* (Illiger). Seven species were abundant, with an average daily catch

Table 1. Abundant carabid species (average catch > 0.1 individuals/trap per day, mean ± SE) in control traps and traps "baited" with winter rape seeds, in two winter wheat stands

	Total	Control	Baited
Stand 1			
P. rufipes	5.7 ± 0.6	4.0 ± 0.6	7.5 ± 0.8
P. melanarius	0.4 ± 0.1	0.3 ± 0.1	0.5 ± 0.1
C. fuscipes	0.3 ± 0.1	0.1 ± 0.1	0.5 ± 0.1
A. dorsalis	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1
H. affinis	0.1 ± 0.0	0.0 ± 0.0	0.2 ± 0.1
Stand 2			
P. rufipes	1.1 ± 0.3	0.9 ± 0.4	1.3 ± 0.4
C. cancellatus	0.3 ± 0.1	0.4 ± 0.2	0.3 ± 0.1
P. melanarius	0.3 ± 0.1	0.2 ± 0.1	0.4 ± 0.1
A. dorsalis	0.2 ± 0.0	0.2 ± 0.1	0.3 ± 0.1
H. distinguendus	0.1 ± 0.1	0.1 ± 0.1	0.0 ± 0.0

greater than 0.1 individuals/trap per day (Table 1). *P. rufipes* was the dominant species in both Stand 1 (5.7 ± 0.6 individuals/trap per day) and Stand 2 (1.1 ± 0.3 individuals per trap per day), while other species were less abundant. For both "consumer" and "non-consumer" species the catches were greater in "baited" traps than "control" traps.

There were significant differences (Fig. 1) in the carabid activity density between Stand 1 with an average daily catch of 6.8 ± 0.5 individuals/trap per day, and Stand 2 with an average catch of 2.3 ± 0.4 individuals/trap per day ($F_{1,88}$ = 26.01, P = 1.93E-6). The catches of "consumer" species in Stand 1 were significantly ($F_{1,58}$ = 15.45, P = 0.0002) greater in baited traps (8.3 ± 0.8 individuals/trap per day) than in the control traps (4.1 ± 0.7 individuals/trap per day). In Stand 2 the catches of baited traps (1.5 ± 0.5 individuals/trap per day) and control traps (1.2 ± 0.4 individuals/trap per day) were not significantly different ($F_{1,28}$ = 0.2630, P = 0.6121). The catches of "non-consumer" species did not significantly differ either in Stand 1 ($F_{1,58}$ = 0.7387, P = 0.3936; baited traps 0.8 ± 0.2 individuals/trap per day, control traps 0.5 ± 0.2 individuals/trap per day) or Stand 2 ($F_{1,28}$ = 1.480; baited traps 1.1 ± 0.2 individuals/trap per day, control traps 0.7 ± 0.2 individuals/trap per day).

The catches of two "consumer" species, *P. rufipes* and *C. fuscipes*, were significantly ($P < 0.05$) greater in baited traps than in control traps (Table 2). The difference was observed only in Stand 1, where overall carabid abundance was higher than in Stand 2. In *H. affinis* and *P. melanarius*, the differences between catches in baited and control traps were marginally significant ($0.05 < P < 0.10$).

DISCUSSION

Scattering of winter rape seeds around the pitfall traps significantly increased the catches of seed consuming carabid species. *P. melanarius,* whose abundance was also marginally significantly affected, is mostly carnivorous. However, even this species may occasionaly accept seeds (GOLDSCHMIDT & TOFT 1997). The work thus confirmed our earlier results (HONĚK & JAROŠÍK 2000) which demonstrated the arrestant and/or attractant effect of winter rape seeds on granivorous carabid species. The effect could only be demonstrated in a stand where overall activity density of carabids was high, but was not significant in another stand where carabid activity density was low. This indicates that the presence of seeds did not attract the beetles at a distance. More likely, seeds are arrestants for randomly walking beetles who stop long distance searching after contact with a seed supply. In the surroundings of baited traps, granivorous carabids probably start local searching and eating seeds scattered close to the trap. This increases the probability to fall into the trap. With dense carabid populations the numbers of aggregated beetles was significant, while with a low population density the number of beetles encountering seeds

Table 2. ANOVA of significant ($P < 0.05$) and marginally significant ($0.05 < P < 0.10$) differences between catches of carabid species in traps "baited" with winter rape seeds and control traps, in two winter wheat stands

	Effect			Error			*F*	*P*
	SS	df	MS	SS	df	MS		
Stand 1								
P. rufipes	185.50	1	185.50	950.64	58	16.39	11.318	0.0014
C. fuscipes	2.02	1	2.02	22.08	58	0.38	5.297	0.0250
H. affinis	0.34	1	0.34	4.91	58	0.08	3.988	0.0505
P. melanarius	0.82	1	0.82	13.62	58	0.23	3.479	0.0672
Stand 2								
H. affinis	0.08	1	0.08	0.60	28	0.02	3.500	0.0719

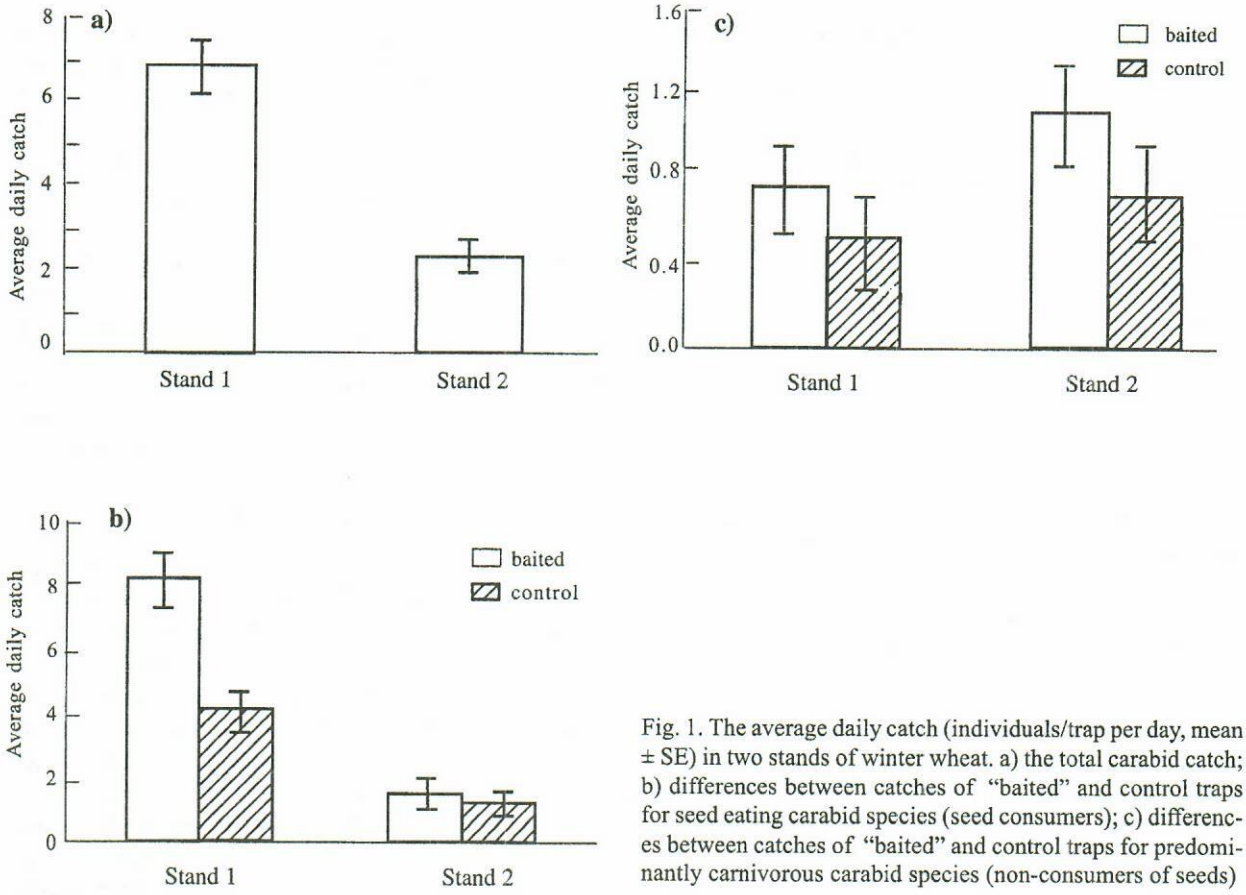

Fig. 1. The average daily catch (individuals/trap per day, mean ± SE) in two stands of winter wheat. a) the total carabid catch; b) differences between catches of "baited" and control traps for seed eating carabid species (seed consumers); c) differences between catches of "baited" and control traps for predominantly carnivorous carabid species (non-consumers of seeds)

was small and the catches of baited traps were not significantly higher than in traps without seeds. The carabids were apparently not attracted from the nearby winter rape stand where further granivorous species, *A. aenea* (DeGeer), *A. familiaris* (Duftschmid), *A. littorea, A. ovata*, *A. similata* (Gyllenhal) and *H. signaticornis*, were abundant (HONĚK *et al.* in prep.). The effect of low carabid abundance may be increased by feeding on seeds liberated from weed stands that increased carabid satiation and thus decreased the attractivity of exposed rape seeds.

The attractivity of winter rape seeds for polyphagous carabids indicates the importance of carabid granivory. Carabid granivory may decrease the number of weed seeds germinating or entering the soil seed bank (READER 1991; READER & BEISNER 1991; HONĚK *et al.* in prep.). Our work demonstrated also a predation on seeds of a crop species. However, this is probably not an evidence for negative effects of carabid granivory on winter rape stands after sowing. The seeds of winter rape are drilled several centimeters below the ground surface and are then inaccessible to carabid predation. The only negative carabid effect on winter rape stands thus may be the biting of ripening pods by *Amara* species (LUKA *et al.* 1998) whose importance in production stands of the Czech Republic remains to be studied.

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Souhrn

HONĚK A., MARTINKOVÁ Z. (2001): **Vliv semen řepky olejky na agregaci střevlíkovitých** (Coleoptera: Carabidae). Plant Protect. Sci., **37**: 97–102.

Byl sledován vliv přítomnosti semen řepky olejky rozptýlených na povrchu půdy na agregaci dospělců polyfágních střevlíkovitých (Carabidae, Coleoptera). Semena řepky byla hustě rozptýlena v blízkém okolí zemních pastí sloužících k odchytu střevlíkovitých. Poté byla srovnávána velikost odchytů střevlíkovitých v těchto pastech a v kontrolních pastech bez semen řepky. Pasti byly vystaveny ve dvou porostech pšenice ozimé. V porostu, na němž celková abundance střevlíkovitých byla vysoká, přítomnost semen řepky významně zvýšila úlovky celého komplexu druhů polyfágních semenožravých střevlíkovitých a dvou druhů,

Pseudoophonus rufipes a *Calathus fuscipes*. V druhém porostu pšenice ozimé, kde celková abundance střevlíkovitých byla nízká, nebyl vliv přítomnosti semen řepky významný. Agregace semenožravých polyfágních střevlíkovitých v místech expozice řepkových semen ukazuje na význam střevlíkovitých jako predátorů semen ležících na povrchu půdy.

Klíčová slova: řepka olejka; semena; predace; aktivita; abundance; Carabidae; *Pseudoophonus rufipes*

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