Rove Beetles (Coleoptera: Staphylinidae) in an Apple Orchard

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Abstract

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Many rove beetle (Coleoptera: Staphylinidae) species are carnivorous. Despite their positive role in the biological control of agricultural arthropod pests rove beetles are relatively poorly studied in general, and little is known about their habitat associations including their occurrence and seasonal activity in the apple-orchard environment. In 1994, abundance and composition of adult staphylinid taxocenosis was established in a 12-years-old apple orchard at Prague-Ruzyně, and compared with taxocenoses inhabiting nearby grassy ridge, winter wheat field and forest. The staphylinids were collected throughout the vegetation season using unbaited pitfall traps. Staphylinid activity was highest in the apple orchard where 28 species were established in the total sample of 1238 individuals. Dominant species *Drusilla canaliculata* (F.), *Ocypus nero semilanatus* Müller, *Dinarea angustula* (Gyllenhal) and *Oxytelus insecatus* Gravenhorst together represented 93% of the total sample. The former two species dominated also the taxocenosis of grassy ridge and could disperse to the orchard from surrounding swards. Most established species are polyphagous predators or parasitoids that might contribute to the biological control of some orchard pests.

Keywords: community; grass sward; field; forest; taxocenosis; seasonal dynamics; abundance; activity; diversity; similarity

Rove beetles (Staphylinidae) are the most species rich family of beetles (Coleoptera) in the Czech Republic (Jelínek 1993) and are an important part of the arthropod fauna of terrestrial habitats (Bohac 1999). A large number of staphylinid species are predators consuming insects, arachnids, molluscs, and nematodes. Other food specialisations include ectoparasitism on insects, pollen and spore eating and scavenging (Balduf 1935; Clausen 1940). Therefore the family takes part in the complex of biological regulators of crop pests.

Since rove beetles have been relatively poorly studied in general, it is no wonder that few studies concern the abundance and composition of their taxocenoses (total of the species of the family Staphylinidae occurring together in the same association, Lincoln *et al.* 1998) in agricultural landscape. This becomes particularly evident in comparison with another "established" group of predators, ground beetles (Coleoptera: Carabidae). A flood of publications concerning different aspects of biology of carabids appears each year, most of them concerning agroecosystems (Kotze *et al.* 2011). Sampling of staphylinids on the ground surface is less easy than in carabids. Pitfall traps used to sample the ground surface fauna catch disproportionately more carabids than staphylinids and the latter thus appear less numerous than they in fact are (Lang 2000; Shah *et al.* 2003; Volkmar *et al.* 2004; Holland *et al.* 2007). An important difficulty

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of community studies is also uneasy identification of staphylinid species. As a result, the study of staphylinid taxocenoses in agroecosystems was frequently neglected (Elliott *et al.* 2006).

Most of the available studies of agroecosystems concern staphylinid taxocenoses of field habitats and/or abandoned or marginal sites important for staphylinid overwintering (Lys & Nentwig 1994; Honek 1997; Krooss & Schaefer 1998a; Geiger *et al.* 2009; Eyre & Leifert 2011). Orchards with only a few recent studies are a typical example of neglected habitats (Majzlan & Holecova 1993; Balog & Marko 2007; Balog *et al.* 2008, 2009). In this study we report on pitfall trap sampling of a taxocenosis of staphylinid beetles in a 12-years-old orchard abandoned for six years. The results were compared with a parallel study at three habitats typical of the surrounding agricultural landscape – winter wheat crop, a grassy ridge on its margin, and oak forest. The scope of the work was to establish typical species of orchard fauna and possible sources of their origin in agricultural landscape.

MATERIAL AND METHODS

Area and sampling. The occurrence and seasonal dynamics of rove beetles were established in parallel at four sites: in an apple orchard, grassy ridge, winter wheat crop and adjacent oak forest. This study concerns beetles collected in a 12-years-old apple orchard at Prague-Ruzyně (centred around 50°05'16.5''N, 14°17'58.9''E, altitude of 340 m a.s.l.). The rectangular 100 × 250 m orchard was situated on a mild south-facing slope and bordered by a 5–10 m wide grassy strip, bordered outside by a 2 m wide weed overgrown strip (*Arctium tomentosum*, *Echinops sphaerocephalus*, *Urtica dioica* and other perennial weeds). The garden was surrounded by fields and, on the southern side, by buildings. The ground surface arthropods were sampled using pitfall traps, plastic cups 8 cm in diameter (50 cm^2 outlet area) and 11 cm deep. The cups were dug into the soil, with the rim flush with the soil surface. No bait was used. A few pieces of soil on the bottom of the cups provided shelter for the trapped arthropods. Five pitfall traps spaced 50 m were placed along a 230 m E–W transect situated in the centre of the orchard parallelly to its long side. The traps were operated from April 12 to October 14, 1994 and emptied in 7–10 d intervals. In the parallel study (Honěk & Kocian 2003) rove beetles were sampled in a suburban agricultural area ca 1000 m away from the orchard, along a 400 m E–W transect crossing a grassy ridge (8 m wide, centred at 50°05'57.4''N, 14°17'51.6''E), winter wheat field (transect 310 m long, 50°05'57.2''N, 14°17'58.8''E) and oak forest (transect 80 m long, 50°05'58.0''N, 14°18'10.1''E). The traps were operated from April 15 to September 11, 1996 and emptied in 2–3 d intervals.

Data processing. Since the catches were low, numbers of individuals of particular species in each trap were summed over the entire catching period. At each sampling site (apple orchard, grassy ridge, wheat field, and oak forest) we listed numbers of individuals belonging to each species. From this data we established species richness (number of species at each site) and calculated their diversity using Shannon-Wiener index H' as follows:

$$H'=-\Sigma p_i \times \log p_i$$

where:

p_i – proportion of the total number of individuals captured at a site composed of species *i*

The value of H' increases with the increasing number of species and decreasing differences in their abundance. Similarity between samples caught at particular sampling sites was calculated using Renkonen coefficient Re as follows:

$$Re = \Sigma \min (x_{ip}, x_{jp})$$

where:

x_{ip}, x_{jp} – proportions of species p in the samples of sites *i* and *j*

The coefficient ranges between 0 when there are no species common to both samples and 1 when the species composition and proportions in samples are identical.

Chi-square test was used to establish an association between taxocenosis composition and sampling site, with species catches as rows and sites as columns of the contingency table. For each pair of taxocenoses (orchard vs. ridge, orchard vs. field, orchard vs. forest) the species were ranked by abundance and the analysis was performed of as many species as to meet the condition that no expected value in the contingency table is < 1 and < 20% is less than 5.

To establish seasonal trends in abundance the average catch of abundant species per trap/day was calculated for periods between successive trap servicing. Average annual catch per trap was calculated to compare abundance (total number of staphylinids collected over the vegetation season) at particular sites.

RESULTS

In the apple orchard, a total of 1236 individuals of 28 species were captured over the sampling period (Table 1). Four dominant species, *Drusilla canaliculata* (F.), *Dinarea angustula* (Gyllenhal), *Oxytelus insecatus* Gravenhorst and *Ocypus nero semilanatus* Müller, represented 93% of the total sample. The majority of species was represented by one (43% of the total established) or two individuals (21%). The staphylinid beetles were active through the whole vegetation period but their seasonal activity differed between species (Figure 1). *Ocypus nero* was captured in spring and autumn, while other species have a unimodal pattern of activity peaking in June (*O. insecatus*) or July (*D. angustula, D. canaliculata*). The activity density (annual catches) was greater in two marginal traps placed near the grassy strip bordering the orchard (327.5 ± 17.50 individuals) than in the traps placed in the centre of the orchard (194.3 ± 8.82 individuals).

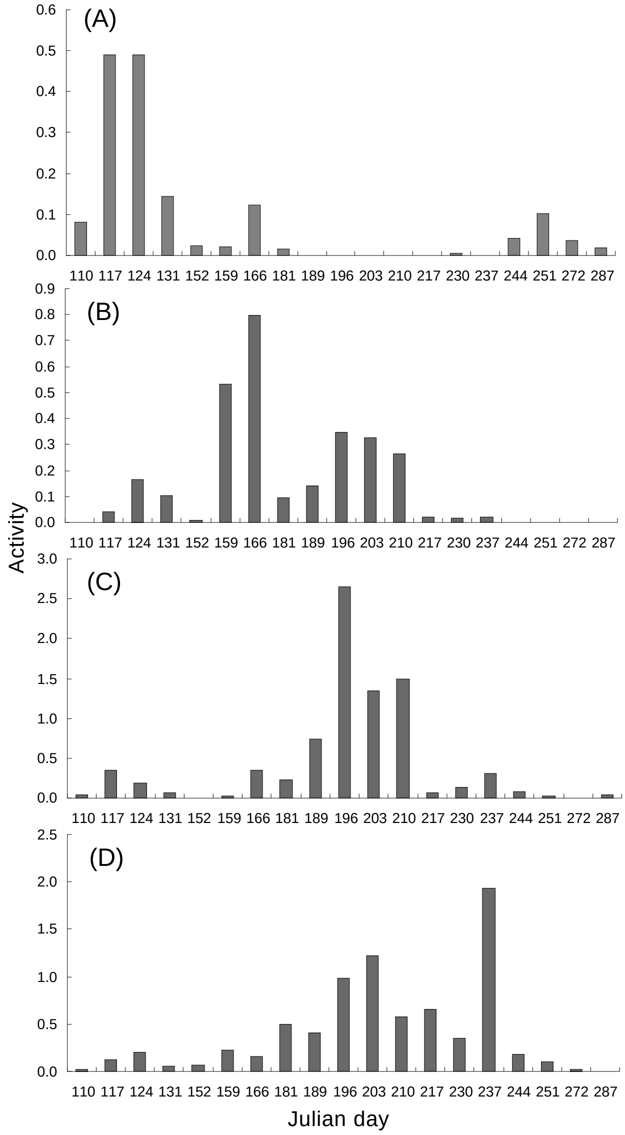

Figure 1. Seasonal activity of abundant staphylinid species in the apple orchard at Prague-Ruzyně in 1994 (A) *Ocypus nero semilanatus*, (B) *Oxytelus insecatus*, (C) *Dinarea angustula*, (D) *Drusilla canaliculata.* The bars indicate the activity of species (mean number of individuals/trap/day) captured over the period terminated by Julian day of emptying the trap

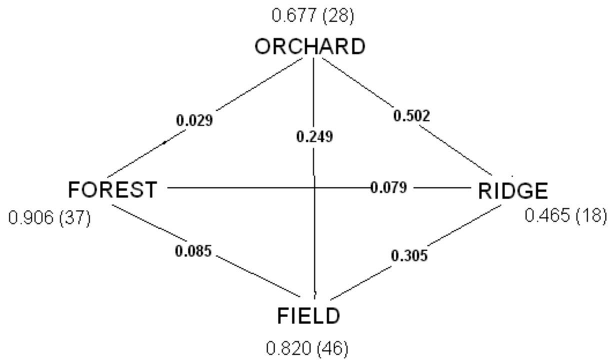

Figure 2. Species diversity (Shannon-Wiener index) and numbers of species (in brackets) in adult staphylinid taxocenoses of apple orchard (sampled in 1994) and taxocenoses of grassy ridge, winter wheat field and oak forest (sampled in 1996) at Prague-Ruzyně, and their similarity (Renkonen coefficient, bold numbers at the connecting lines between the labels of taxocenoses)

The staphylinid taxocenosis of apple orchard differed from the taxocenoses of other sites situated along the nearby transect crossing agricultural landscape (Table 1). The composition of orchard taxocenosis was significantly different form that of grassy ridge (df = 5, χ^2 = 239.0, P < 0.001), winter wheat field (df = 11, χ^2 = 1156.3, P < 0.001) and oak forest (df = 11, χ^2 = 1481.3, P < 0.001). The annual catches per trap at the latter sites were by 38–77% smaller than in the orchard. Species diversity and number were greater in the forest and field taxocenosis but lower at the grassy ridge. The taxocenosis of apple orchard was similar to the taxocenosis of grassy ridge, more than the

Table 1 Staphylinid species (number of individuals in the annual sample) captured in the apple orchard and near habitats of agricultural landscape, grassy ridge, winter wheat field and oak forest, total sample of particular habitats (Total N), number of traps run at the habitat (N traps), and annual catch per trap (N/trap)

Species	Orchard	Ridge	Field	Forest
Aleochara bipustulata (L.)	5			1
Aleochara curtula (Goeze)			2	
Aleochara haematodes ripicola Mulsant et Rey	19		4	5
Aleochara inconspicua Aubé	1			
Aleochara laevigata Gyllenhal			1	
Aleochara sparsa Heer				1
Aloconota gregaria (Erichson)			4	
Amischa analis (Gravenhorst)			1	
Amischa cavifrons Sharp			1	1
Amischa soror (Kraatz)			2	
Atheta amplicollis (Mulsant)			1	1
Atheta crassicornis (F.)				20
Atheta fungi (Gravenhorst)			17	39
Atheta gagatina Baudi				6
Atheta laticollis (Stephens)			2	3
Atheta livida Mulsant et Rey				3
Atheta pittionii Sheerpeltz			1	3
Atheta sodalis (Erichson)				1
Atheta subtilis (Scriba)			11	1
Atheta triangulum (Kraatz)		3	5	1
Bolitobius castaneus (Stephens)	2			
Bolitobius formosus (Gravenhorst)		1	1	2
Dinarea angustula (Gyllenhal)	418		2	
Dinarea linearis (Gravenhorst)			1	1
Drusilla canaliculata (F.)	473	229	133	2
Enalodroma hepatica (Erichson)				3
Gabrius osseticus (Kolenati)	1			
Ilyobates subopacus Palm			5	
Lathrimeum athrocephalum (Gyllenhal)				1
Lathrobium fulvipenne Gravenhorst	1		8	
Lathrobium pallidum Nordmann	2			
Leptacinus sulcifrons (Stephens)			1	
Mniobates forticornis (Boisduval)	2		2	
Ocypus fulvipennis Erichson	1			
Ocypus fuscatus (Gravenhorst)		1	1	
Ocypus melanarius Heer	17			2
Ocypus nero semilanatus J. Müller	100	37	7	1
Omalium caesum Gravenhorst		10	4	130
Omalium rivulare (Paykull)				4
Ontholestes haroldi (Eppelsheim)	1			
Othius punctulatus (Goeze)				1
Oxypoda abdominalis Mannerheim				2
Oxypoda haemorrhoa Mannerheim		1		1
Oxypoda lividipenis Mannerheim			1	5
Oxypoda longipes Mulsant et Rey		5	2	13
Oxypoda spectabilis Märkel				1
Oxypoda vicina Kraatz			1	
Oxytelus insecatus Gravenhorst	163	1	8	

Table 1 to be continued

Species	Orchard	Ridge	Field	Forest
Oxytelus mutator Lohse			1	3
Oxytelus rugosus (F.)	2		2	
Parabemus fossor (Scopoli)		1		1
Philonthus carbonarius (Gravenhorst)	2		4	
Philonthus chalceus Stephens			1	1
Philonthus cognatus Stephens	1	5	323	
Philonthus decorus (Gravenhorst)		1	2	118
Philonthus laminatus (Creutzer)			5	
Platarea dubiosa (Benick)		7	4	2
Platarea nigriceps (Marsham)	13			
Quedius limbatus (Heer)				1
Rugilus orbiculatus (Paykull)	1		1	
Rugilus subtilis (Erichson)	1	1		
Sepedophilus marshami (Stephens)		1	1	1
Sepedophilus testaceus (F.)				1
Staphylinus stercorarius Olivier			1	
Sunius melanocephalus (F.)		1	1	
Tachinus rufipes (DeGeer)		2	23	
Tachyporus chrysomelinus (L.)	1			
Tachyporus hypnorum (F.)	2		12	
Tachyporus nitidulus (F.)	1			
Tachyporus obtusus (L.)			1	
Tachyporus pusillus Gravenhorst			1	
Tachyporus solutus (Erichson)	1		1	
Xantholinus linearis (Olivier)	3		1	
Xantholinus longiventris Heer	1			
Zyras humeralis (Gravenhorst)				2
Zyras limbatus (Paykull)	1	1		
Total N	1236	308	614	385
N traps	5	2	11	3
N/trap	247.2	154.0	55.8	128.3

taxocenoses of the field and the forest (Figure 2). This was mainly caused by sharing two dominant species, *D. canaliculata* and *O. nero semilanatus*. Other dominant species (*D. angustula*, *O. insecatus*) were typical of the orchard. In the orchard the common species shared with the grassy ridge were particularly abundant in marginal traps placed near the grassy strip bordering the orchard compared to the central traps. Consequently, the similarity of grassy ridge taxocenosis and taxocenosis of marginal orchard traps (Re = 0.532) was greater than similarity to the taxocenosis of central orchard traps (Re = 0.399). Diversity of staphylinid taxocenoses of the field and forest was, despite the lower total activity density of staphylinids at these sites, greater than in the orchard (Figure 2), because of the greater species richness of these taxocenoses (Table 1).

DISCUSSION

The staphylinid activity in the apple orchard was higher compared to field and forest sites representing typical habitats of the surrounding agricultural landscape. This contrasted with higher species diversity and richness at the latter sites. Low diversity in the orchard was caused by dominance of a few species, two of which, *D. angustula* and *O. insecatus*, were typical of the orchard. The other dominant orchard species, *D. canaliculata* and *O. nero semilanatus*, were also typical of the taxocenosis of grassy ridge and their common occurrence at both sites was responsible for greater similarity, in terms of Renkonen coefficient, between grassy ridge and orchard taxocenoses than between any other pair of taxocenoses. This similarity was, however, rather apparent because rare species were mostly different at both sites. *Drusilla canaliculata* is a generalist of non-forest areas while *O. nero semilanatus* probably disperses into the orchard from the marginal grassy strip similarly as it disperses from the grassy ridge into the marginal area of wheat stand (Honěk & Kocian 2003).

The species composition of staphylinid taxocenoses of the Czech Republic partly matched the taxocenoses established in other studies of central Europe. The richness of staphylinid taxocenosis in Hungarian apple and pear orchards (Balog & Marko 2007; Balog *et al.* 2008, 2009) was about 10 times greater than in our study, but dominant species *D. canaliculata* and *D. angustula* and subdominant *Xantholinus linearis* (Olivier) were similar to our study. *Omalium caesum* Gravenhorst dominant in Hungary was captured in our study in the grassy ridge and was very abundant in the oak forest. Staphylinid taxocenoses established in orchards of remote countries or in other habitats were not similar to taxocenoses of our study (Pietraszko & DeClercq 1978; Good & Giller 1991; Soboleva-Dokuchaeva *et al.* 2002; Juen *et al.* 2003; Balog *et al.* 2011). This was caused by the presence of species not established in this study or by preference of common species to different habitats.

Most species established in the orchard are predators. Predation was demonstrated for *D. canaliculata* (Novák 1958; Babenko 1985), *D. angustula* (Balduf 1935) and congeners of *Ocypus* (Krooss & Schaefer 1998b; Bonacci *et al.* 2006), *Oxytelus* (Achiano & Giliomee 2006), *Philonthus* (Seymour & Campbell 1993), *Tachyporus* (Balog *et al.* 2011), and *Xantholinus* (Balduf 1935) while *Atheta* spp. was shown to switch between adult predation and larval ectoparasitism (Clausen 1940). Because of wide polyphagy, it is difficult to estimate the effect of staphylinid predation on orchard pests. Food items of staphylinids captured in the apple orchard or their above-mentioned congeners included ants, carabid larvae, aphids, dipteran eggs and pupae, mites, millipedes, slugs and other prey. Which species of orchard pests are eaten by staphylinids and in what quantities remains to be studied. Nevertheless, staphylinids are certainly an important component in the web of relations that maintain balance among phytophagans, zoophagans and scavengers of production orchards. Because of their abundance the role of staphylinids in orchards may be even more important than at other habitats of the agroecosystem included in this study. The importance of staphylinid beetles for the control of pests in agroecosystems should be further studied.

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