



Landscape context of organic and conventional farms: Influences on carabid beetle diversity

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Abstract

Carabid species richness and density were studied in 12 pairs of organic versus conventional wheat fields located along a gradient of landscape complexity (quantified as percent cover of grassland, which was correlated with habitat-type diversity). The relative impact of local and landscape features was analyzed by comparing sites with similar landscape context but different management systems using pitfall traps. Organic and conventional management did not differ with respect to species richness and activity density. Seven species were more abundant under organic management, and eight species were more abundant under conventional management. The effect of landscape complexity was independent of management system. Species richness increased with percent cover of grassland in the surrounding landscape, and activity density followed the same trend. Hence, surrounding grassland appeared to act as a major source of diversity for farmland carabids. In particular, the activity density of spring breeders on organic fields benefited from the increased availability of overwintering habitats in their close surrounding. It was concluded that landscape features were much more important than organic farming management for enhancement of local biodiversity and should thus be considered in agri-environment schemes.

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1. Introduction

Many natural landscapes and habitats have been shaped by arable farming over centuries (Stanners and

Bourdeau, 1995). Nearly 23% of Europe is covered by arable land (European Communities, 2002). Among the many types of agricultural management, the European Union nowadays supports organic farming via agri-environmental schemes (Council Regulation, 1992, 1999). Organic farming in Europe has gone through major changes over the last 20 years. A break-through was achieved during the 1990s when it increased from nearly zero to around 2% of the main part of European

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agriculture by 1999 (Michelsen, 2001). A national program of the German government aims to increase the share of organic land-use from the current level of 3.2–20% over the next 10 years (BEL, 2003). Organic and low intensity farming systems are supposed to produce healthy food under conditions of more sustainable management practices (Reganold et al., 2001). Conventional farming with mineral fertilizers and chemical pesticides adversely affects soil arthropods directly through toxicity and indirectly by decreasing both food availability and habitat quality (Kromp, 1999; Holland and Luff, 2000). Organic farming, in contrast, may contribute to the protection of biodiversity (Dritschilo and Erwin, 1982; Paoletti, 1995; The Soil Association, 2000; Hyvönen et al., 2003).

Here, the impact of organic farming on carabid communities was investigated. The majority of studies on this issue focused on the response of individual species to management intensity at the field level (Kromp, 1989; Pfiffner and Niggli, 1996; Moreby et al., 1994; Andersen and Eltun, 2000; Mäder et al., 2002; Döring et al., 2003; Melnychuk et al., 2003; Pfiffner and Luka, 2003; Shah et al., 2003). This seems to be a much too narrow approach, because many factors that determine ecological patterns and processes take place at larger spatial scales such as landscapes and regions (Wiens et al., 1993; Ricklefs and Schluter, 1993; Thies and Tschardtke, 1999; Bestelmeyer et al., 2003). For example, landscape conditions have been proven to significantly affect population viability (Dunning et al., 1992; Burel et al., 2004). The study thus focused on species richness and activity density of carabids in 24 wheat fields (conventional farming versus organic farming) located in 12 agricultural landscapes differing in landscape composition in southern Lower Saxony (Germany). The relative impact of local and regional effects was quantified by comparing fields with similar landscape features but different farming management systems. It was expected that the quantity of the surrounding grasslands affects carabids by providing sites for reproduction and hibernation.

Studies investigating the relative importance of farming practices and landscape context are rare (De Blois et al., 2001; Weibull and Östman, 2003). Weibull et al. (2003) compared cereal farms managed either organically or conventionally and showed that the mode of farming had a small effect on the species richness of

carabids relative to landscape effects. Therefore, the present study focused on: (i) the relative effect of management intensity on carabid species richness and activity density in winter-wheat fields, and on (ii) the modification of this effect by the surrounding landscape. Moreover, many carabid species hibernate in adjacent non-crop areas around the field and disperse in the fields during spring where they later reproduce (Coombes and Sotherton, 1986; Desender, 1982; Riedel, 1995; Andersen, 1997; Wallin, 1988; Kennedy, 1994; Holland et al., 1999; Petersen, 1999). The abundance of carabids on farmland is thus in part determined by the distribution and availability of suitable overwintering habitats (Sotherton, 1984). However, the multi-habitat use of carabids is different for different overwintering and hibernating strategies. Based on univoltine life cycles carabids have been classified as spring and autumn breeders, with the former group mainly hibernating as adults, and the latter group mainly hibernating as larvae (Thiele, 1977). Therefore, an additional question was (iii) whether the impact of landscape and management factors differs between carabids with different life cycles.

2. Material and methods

The study was conducted in 12 agricultural landscapes close to the city of Göttingen (Southern Lower Saxony, Central Germany). About 75% of the 1350 km² area is covered by arable land/grassland mosaics. The remaining area is characterized by patchily distributed fragments of natural and semi-natural habitats such as forests, fallows, and hedgerows. Nearly 50% of the grassland sites in the study region are meadows (of which nearly two-thirds are extensively managed by mowing at most twice a year) and approx. one-third of the grassland sites are both intensively and extensively managed pastures (Finke, 2001). Twelve non-overlapping landscape sectors of 1.5 km radius along a gradient from structurally simple, with >80% arable land, to structurally complex, with >50% non-crop habitats, were selected. The percent cover of grassland ranged from 5.4 to 25.9%. Simple and complex landscapes were geographically interspersed. One conventionally and one organically managed (according to European Union Regulation 2092/91/EEC) winter-wheat field were chosen in the centre of each

landscape sector to avoid differences in landscape context between the two management forms. There were no major differences between management techniques within each of the two farming forms. Preceding crops were mostly winter wheat and oilseed rape in conventional and a mixture of clover and grass in organic fields. Study sites on conventional farms were treated with mineral fertilizers ($183.09 \text{ kg N ha}^{-1} \pm 36.5$), herbicides, fungicides and usually one insecticide spray in June (see Roschewitz et al. (2005) for details), whereas organic fields were fertilized with manure and weed was controlled mechanically. The mean field size was 3.3 ha. The percent cover of grassland [grassland (%)] within a radius of 1.5 km around the study fields was used as a simple measure of landscape complexity. Grassland cover was positively correlated with habitat-type diversity (Shannon-Index; Spearman $R = 0.64$, $N = 24$, $p < 0.001$). Landscape data was calculated from official digital thematic maps (ATKIS – Digitales Landschaftsmodell 25/1; Landesvermessung und Geobasisinformation, Hannover, Germany 1991–1996) using the Geographical Information System ArcView 3.3 (ESRI Geoinformatik GmbH, Hannover, Germany).

2.1. Carabid data

Carabids were sampled with pitfall traps consisting of 500 ml polyethylene beakers (diameter 88 mm) filled with approx. 0.12 L of a mixture (1:2) of ethylene glycol (antifreeze) and water. A detergent was added to reduce surface tension. Pieces of 2 cm mesh hardware cloth were inserted 3 cm beneath the opening to prevent vertebrates from entering. Acrylic glass roofs (250 mm \times 250 mm) were positioned approximately 10 cm above each trap to prevent flooding by rain. Four pitfall traps were placed in a square of 10 m \times 10 m with a minimum distance of 15 m from the field edge. Sampling took place in 2002 over the course of two 14-day periods, starting on 8 May, and 28 June. During the study period from May to July 2002 the average temperature was 16.1 °C (long-term mean of average annual temperature is 8.7 °C) and the rainfall was 282.9 mm (long-term mean of annual rainfall is 672 mm; data from the meteorological station in Göttingen). All individuals were determined to species level (Freude, 1976) and sorted into functional groups according to their

breeding type, i.e. spring and autumn breeders (Barndt et al., 1991; Lindroth, 1992; Ribera et al., 2001). Species for which no functional group classification was possible were excluded from the analysis. Site specific estimates of species richness and activity density of all carabids were gained by pooling the pitfall catches of each site.

2.2. Data analysis

Effects of management and landscape complexity on species richness and activity density were analyzed using general linear models (GLM). Management type (organic, conventional) was used as factor, and landscape complexity (grassland% = percent cover of grassland in the surrounding matrix) as the covariate. Additional GLMs were carried out to test the effects of management and landscape complexity on species richness and activity density of the different functional groups (spring breeders, autumn breeders). Homogeneity of variances was tested with Levene's test. Data were checked for normal distribution using Kolmogorov–Smirnov test. At the species level, increased probabilities of falsely rejecting null hypotheses in multiple comparisons were avoided by considering Bonferroni corrections and by calculating the overall probability for the observed incidence of outcomes falling below the nominal significance level $p = 0.05$ with Bernoulli equations (Moran, 2003). The effect of management on activity density was analyzed using paired *t*-tests. Statistical treatments were performed using SPSS for Windows package 11.0 (SPSS Inc., Illinois, USA) and Statistica for Windows Package 6.0 (StatSoft Inc., Tulsa, USA). In the text, arithmetic means \pm standard deviations (S.D.) are given.

3. Results

In total, 11,562 carabids belonging to 66 species were trapped at the 24 study sites. Organic and conventional fields had the same species richness (55 species; see Appendix A for the density of all species in conventional and organic fields). The effect of management on both species richness and activity density was not significant (Table 1).

Species richness was positively related to the percent cover of grassland in the surrounding land-

Table 1

General linear models on the effects of management (conventional vs. organic [M]) and the percent cover of grassland in the surrounding landscape [G (%)] on carabid communities in winter-wheat fields (numerator degrees of freedom: 1, denominator degrees of freedom: 20)

	M		G (%)		M × G (%)	
	F	p	F	p	F	p
Species richness						
Total species richness	–	–	9.778	0.005	–	–
Spring breeders	–	–	5.724	0.027	–	–
Autumn breeders	–	–	8.235	0.009	–	–
Activity density						
Total activity density	–	–	3.481	0.077	–	–
Spring breeders	–	–	5.930	0.024	5.0393	0.0362
Autumn breeders	–	–	–	–	–	–

scape independent of management type (Table 1, Fig. 1A). Although activity density tended to be higher in organic than in conventional fields, no significant effect of management could be established (Table 1). The effect of grassland (%) on this parameter was only marginally significant (Table 1, Fig. 1B). Additionally, species richness of both spring and autumn breeders was positively related to grassland cover independent of management type (Table 1, Fig. 2). In contrast, only the activity density of spring breeders in organic fields was related to grassland (%), as manifested by the management × grassland (%) interaction in the global test (Table 1, Fig. 3).

The effect of management was significant at the species level. A sign test indicated that the majority of the 66 species did not display a trend towards higher activity density in response to one of the farming management types over the other ($Z = 0.63$, $p = 0.5$). Matched pair tests for the 29 species occurring at six or

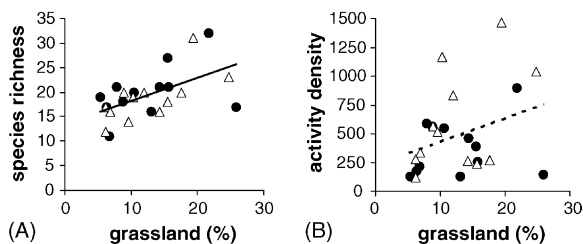


Fig. 1. Correlation between the percent cover of grassland [grassland (%)] and carabid community parameters on differently managed wheat fields (● conventional fields; △ organic fields): (A) carabid species richness, and (B) activity density. (—) Significant main effect, (---) marginal significant effect.

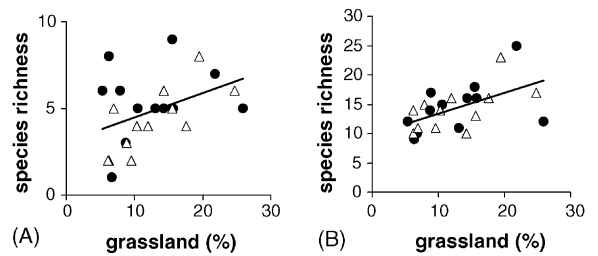


Fig. 2. Correlation between the percent cover of grassland [grassland (%)] and carabid functional groups on differently managed wheat fields (● conventional fields; △ organic fields): (A) autumn breeders, and (B) spring breeders. (—) Significant main effect.

more site pairs revealed that seven species had higher activity density under organic management, and eight species had higher activity density under conventional management ($\alpha < 0.05$, Table 2). This is significant according to the Bernoulli equation ($p < 0.0001$).

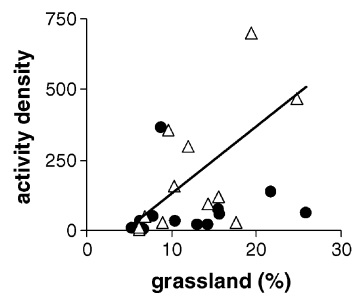


Fig. 3. Correlation between the percent cover of grassland [grassland (%)] and the activity density of spring breeders on differently managed wheat fields (● conventional fields; △ organic fields). (—) Significant effect of the interaction management × grassland (%) for the organic fields.

Table 2

Significant results of the *t*-test for matched pairs for the 29 carabid species with six or more occurrences, comparing conventional vs. organic farming

	<i>t</i> -Value	<i>p</i>
Higher activity density in organic than in conventional farming		
<i>Amara plebeja</i>	−2.617	0.010
<i>Carabus auratus</i>	−3.236	0.001
<i>Carabus granulatus</i>	−3.012	0.003
<i>Agonum mülleri</i>	−2.988	0.003
<i>Poecilus cupreus</i>	−2.935	0.004
<i>Platynus dorsalis</i>	−2.902	0.004
<i>Amara similata</i>	−2.978	0.003
Higher activity density in conventional than in organic farming		
<i>Loricera pilicornis</i>	3.366	0.001
<i>Clivina fossor</i>	3.075	0.002
<i>Nebria salina</i>	2.769	0.006
<i>Asaphidion flavipes</i>	2.759	0.006
<i>Notiophilus biguttatus</i>	2.381	0.018
<i>Amara eurynota</i>	2.326	0.021
<i>Pterostichus strenuous</i>	2.280	0.024
<i>Bembidion tetracolum</i>	2.180	0.030

4. Discussion

The relative importance of landscape context and local farming management (organic versus conventional) on carabid diversity in cereal fields was analyzed. In contrast to common expectations (e.g. Mäder et al., 2002), organic management did not enhance species richness. Moreover, landscape context (i.e., percent cover of surrounding grassland) had an effect on species richness irrespective of management type, whereas activity density showed only a marginally significant response. Andersen and Eltun (2000) also found no effect of organic farming on carabid species richness, whereas other authors report a slightly negative effect (Shah et al., 2003; Weibull et al., 2003), or even positive effects (Döring and Kromp, 2003; Irmeler, 2003). It could not be fully excluded that effects of management may have been partly offset in the study by species exchange among sites due to the paired farms approach (Hadjicharalampous et al., 2002).

The results strongly support the conclusion of Weibull et al. (2003) that landscape structure is important for the species richness of carabids. The effect of surrounding grassland was statistically independent of the type of management, so there is

convincing evidence that – within a certain range – the diversity of arthropods in agroecosystems is affected much less by management practices than by landscape features (Schneider and Fry, 2001; Elliott et al., 2002; Boivin and Hance, 2003). The close link to the heterogeneity of surrounding habitats is explained by two factors. First, high habitat diversity in complex landscapes increases the species pools. Second, exchange of species that use multiple habitats during their life cycle can generate higher species richness in complex landscapes with a number of undisturbed semi-natural habitats (Zobel, 1997; Srivastava, 1999). This is very much true for carabids (Sotherton, 1984; Pfiffner and Luka, 2000). Hence, the results clearly demonstrate that surrounding grassland can act as a source of diversity for farmland carabids by offering refuges and corridors for beetles dispersing between and across fields.

The results found contrast with the higher activity density of carabids in organic systems reported by other authors (Mäder et al., 2002; Shah et al., 2003). Higher activity densities in organic fields may be caused by omitting pesticide applications, which negatively affect the carabid fauna in fields (Kromp, 1999). The findings could be partly due to the fact that no insecticides were used in the studied conventional fields prior to the first sampling period. Moreover, carabids benefit from the higher food sources from weed seeds and the higher abundance of carabid prey available from invertebrates associated with organic farming (Basedow, 1994; Hokkanen and Holopainen, 1986). At the species level, the results confirm the findings of Kromp and Steinberger (1992), Döring and Kromp (2003), and Irmeler (2003) who described the same species to benefit from organic management due to microclimatic conditions and food supply. However, there was no evidence of a positive effect of better food availability in organic fields on total activity density, even though total coverage and species richness of arable weeds were higher (158 and 87%, respectively; IR unpublished data).

Species richness of spring and autumn breeders was not affected by management, whereas it was positively related to the surrounding landscape for both groups. Nevertheless, group specific differences in the impact of landscape and management on activity density were found. Spring breeders particularly benefit from the surrounding landscape, because

they usually hibernate as adults and migrate into the fields from surrounding overwintering sites and establish the ‘early season’ carabid community (Wallin, 1985; Coombes and Sotherton, 1986). This confirms that the response of autumn breeders, in contrast, is much more variable. Some species leave the fields and move into adjacent uncultivated habitats in response to prey availability in late summer (Wallin, 1988; Fournier and Loreau, 2001). Others overwinter in the field as larvae (Noordhuis et al., 2001). Therefore, a universal effect of landscape complexity on the activity density of autumn breeders cannot be expected.

Significant interactions between landscape and management reflect that the increased activity density of spring breeders on organic fields was confined to landscapes with higher amounts of grassland. The interaction with management in complex landscapes can be explained by the condition of the carabids. Spring breeders in particular, such as *Poecilus cupreus*, are in better condition and have higher fecundity on organic farms situated in complex landscapes (Bommarco, 1998). This may cause higher activity densities on organic fields as the activity is related to the condition of the beetles (Fournier and Loreau, 2001), suggesting that positive landscape effects are related to carabid diet (e.g., aphids: Thies et al., 2003; weeds: Gabriel et al., 2002). This positive landscape effect might only be observed in organic fields, because intensive management on conventional fields may suppress it.

5. Conclusion

A high percentage of grassland habitats in agricultural landscapes enhanced carabids and their possible function as biocontrol agents in wheat fields.

Appendix A

Mean activity density of carabids captured on 12 conventional and 12 organic fields (mean \pm S.D.). Classification of breeding type (BT) follows Barndt et al. (1991), Lindroth (1992), and Ribera et al. (2001).

	BT ^a	Conventional	Organic
<i>Abax ovalis</i> (DUFTSCHMID)	SB	0 \pm 0.2	0 \pm 0.2
<i>Abax parallelepipedus</i> (PILLER)	AB	0.2 \pm 0.4	0.3 \pm 0.8
<i>Acupalpus meridianus</i> (LINNÉ)	SB	–	0.2 \pm 0.8

This landscape effect obscured the potential local effect of management intensity and thereby did not reveal an additional contribution of organic farming to the protection of biodiversity. Consequently, the restriction of agri-environmental schemes to land-use intensity and management type of agroecosystems does not take into account the much more important influence of the surrounding landscape for local diversity. On a landscape scale, converting arable land into perennial habitats should enrich local diversity. Further studies should consider the landscape context of ecological functions in addition to the role of different management systems. Such studies will reveal whether the findings are of general importance and apply to other landscape types. Given that the strength of predator impact on biocontrol depends on landscape features (Östman et al., 2001), the focus in maintaining biodiversity as well as ecosystem services in cultivated landscapes should expand to the landscape level.

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Appendix A (Continued).

	BT ^a	Conventional	Organic
<i>Agonum muelleri</i> (HERBST)	SB	1.5 ± 2.8	6.3 ± 11.7
<i>Agonum sexpunctatum</i> (LINNÉ)	SB	–	0.3 ± 0.7
<i>Amara aenea</i> (DeGEER)	SB	0 ± 0.2	0.1 ± 0.3
<i>Amara aulica</i> (PANZER)	AB	–	0 ± 0.2
<i>Amara communis</i> (PANZER)	SB	0 ± 0.2	0.1 ± 0.3
<i>Amara eurynota</i> (PANZER)	SB	1.2 ± 3	0.3 ± 0.9
<i>Amara familiaris</i> (DUFTSCHMID)	AB	0.2 ± 0.5	0.2 ± 0.5
<i>Amara lunicollis</i> (SCHIÖDTE)	AB	0.1 ± 0.3	0 ± 0.2
<i>Amara montivaga</i> (STURM)	SB	–	0.1 ± 0.4
<i>Amara ovata</i> (FABRICIUS)	SB	0.2 ± 1	0.4 ± 1.7
<i>Amara plebeja</i> (GYLLENHAL)	SB	1.5 ± 3.8	9.2 ± 25.6
<i>Amara similata</i> (GYLLENHAL)	SB	0.4 ± 1.1	8.7 ± 26.4
<i>Anisodactylus binotatus</i> (FABRICIUS)	SB	0 ± 0.2	0.1 ± 0.3
<i>Asaphidion flavipes</i> (LINNÉ)	SB	2 ± 4.6	0.3 ± 0.8
<i>Badister bipustulatus</i> (FABRICIUS)	SB	–	0.1 ± 0.3
<i>Bembidion guttula</i> (FABRICIUS)	SB	–	0 ± 0.2
<i>Bembidion lampros</i> (HERBST)	SB	1.6 ± 3	0.8 ± 1.6
<i>Bembidion lunulatum</i> (FOURCROY)	SB	0.3 ± 1.4	–
<i>Bembidion obtusum</i> (SERVILLE)	AB	0.7 ± 2.5	0 ± 0.2
<i>Bembidion tetracolum</i> (SAY)	SB	1.7 ± 3.5	0.5 ± 1.5
<i>Calathus fuscipes</i> (GOEZE)	AB	0.3 ± 0.9	0.7 ± 2.5
<i>Calathus melanocephalus</i> (LINNÉ)	AB	0 ± 0.2	0 ± 0.2
<i>Carabus auratus</i> (LINNÉ)	SB	3 ± 6.8	35.6 ± 97.2
<i>Carabus auronitens</i> (FABRICIUS)	AB	–	0 ± 0.2
<i>Carabus cancellatus</i> (ILLIGER)	SB	0 ± 0.2	4.8 ± 16.3
<i>Carabus convexus</i> (FABRICIUS)	SB	0.1 ± 0.4	0.3 ± 1.2
<i>Carabus coriaceus</i> (LINNÉ)	AB	0.1 ± 0.4	–
<i>Carabus granulatus</i> (LINNÉ)	SB	6.5 ± 6.7	11.8 ± 11.1
<i>Carabus nemoralis</i> (MÜLLER)	SB	1.8 ± 2	2.8 ± 4.8
<i>Clivina fossor</i> (LINNÉ)	SB	1.6 ± 4.1	–
<i>Demetrias atricapillus</i> (LINNÉ)	?	0.1 ± 0.3	0 ± 0.2
<i>Harpalus affinis</i> (SCHRANK)	SB	0 ± 0.2	–
<i>Harpalus dimidiatus</i> (ROSSI)	SB	3.7 ± 7.3	4 ± 5.7
<i>Harpalus latus</i> (LINNÉ)	AB	–	0.1 ± 0.3
<i>Harpalus rubripes</i> (DeGEER)	AB	0.2 ± 0.4	0.1 ± 0.3
<i>Harpalus rufitarsis</i> (DUFTSCHMID)	AB	0 ± 0.2	–
<i>Harpalus tardus</i> (PANZER)	SB	0 ± 0.2	–
<i>Loricera pilicornis</i> (FABRICIUS)	SB	7.2 ± 13.7	1.9 ± 1.7
<i>Molops elatus</i> (FABRICIUS)	?	0.2 ± 0.8	–
<i>Nebria brevicollis</i> (FABRICIUS)	AB	1.4 ± 6.1	3.6 ± 8.4
<i>Nebria salina</i> (FAIRMAIRE)	AB	6.4 ± 10.8	2.2 ± 5.3
<i>Nothiophilus aquaticus</i> (LINNÉ)	SB	0.1 ± 0.4	0 ± 0.2
<i>Nothiophilus biguttatus</i> (FABRICIUS)	SB	0.6 ± 1.4	0.1 ± 0.6
<i>Nothiophilus palustris</i> (DUFTSCHMID)	SB	0.2 ± 0.4	0 ± 0.2

Appendix A (Continued).

	BT ^a	Conventional	Organic
<i>Panagaeus bipustulatus</i> (FABRICIUS)	AB	0 ± 0.2	0.1 ± 0.3
<i>Panagaeus cruxmajor</i> (LINNÉ)	AB	0 ± 0.2	–
<i>Platynus assimilis</i> (PAYKULL)	SB	0.5 ± 0.9	0.9 ± 2.5
<i>Platynus dorsalis</i> (PONTOPPIAN)	SB	25.6 ± 29.9	44.4 ± 48.8
<i>Poecilus cupreus</i> (LINNÉ)	SB	26 ± 71.1	79.4 ± 145.6
<i>Poecilus versicolor</i> (STURM)	AB	4 ± 11.2	8.9 ± 32.9
<i>Pseudophonus rufipes</i> (DeGEER)	AB	5.8 ± 10.8	7.6 ± 15.5
<i>Pterostichus burmeisteri</i> (HEER)	AB	0.2 ± 0.4	0.1 ± 0.3
<i>Pterostichus madidus</i> (FABRICIUS)	?	–	0.1 ± 0.4
<i>Pterostichus melanarius</i> (ILLIGER)	AB	73.8 ± 103.8	56.3 ± 59.3
<i>Pterostichus niger</i> (SCHALLER)	AB	3.4 ± 12.7	0.6 ± 1.2
<i>Pterostichus oblongopunctatus</i> (FABRICIUS)	SB	0 ± 0.2	–
<i>Pterostichus ovoideus</i> (STURM)	?	–	0 ± 0.2
<i>Pterostichus strenuus</i> (PANZER)	SB	1.2 ± 4.1	0 ± 0.2
<i>Pterostichus vernalis</i> (PANZER)	SB	0.5 ± 1.1	0.5 ± 0.8
<i>Stomis pumicatus</i> (PANZER)	SB	–	0 ± 0.2
<i>Synuchus vivalis</i> (ILLIGER)	AB	0 ± 0.2	–
<i>Trechus obtusus</i> (ERICHSON)	AB	0.2 ± 0.8	0.3 ± 0.7
<i>Trechus quadristriatus</i> (SCHRANK)	AB	0 ± 0.2	–

^a SB: spring breeder, AB: autumn breeder, ?: no classification possible.

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