Which carabid species benefit from grassy strips in organic agriculture?

Mazhar RANJHA & Ulrich IRMLER

Abstract: Which carabid species benefit from grassy strips in organic agriculture? - The carabid fauna of three organic arable fields, their grassy strips, and field margins were investigated by pitfall traps in 2009/2010 at Ritzerau and Panten (Schleswig-Holstein, northern Germany). *Bembidion lampros* was mainly found on the organic arable fields, *Amara similata* in grassy strips and *Carabus nemoralis* and *C. coriaceus* in the field margins. Strips were mainly used by species which prefer open areas without tree cover and also by a few species demanding tree cover. In contrast, arable fields were characterised by species avoiding vegetation cover. All species analysed require a soil pH ranging from 4.6 to 5.6. Species that occur where soil pH is lower were absent from the investigated habitats. It can be derived from the results that *Poecilus cupreus*, *Poecilus versicolor* and *Carabus nemoralis* used the grassy strips to invade or cross arable fields, while *Pterostichus melanarius*, *Anchomenus dorsalis*, *Nebria brevicollis* and *Trechus quadristriatus* passed directly into arable fields from field margins. Grassy strips did not affect the species richness of endangered species. Strips and arable fields were characterised by a high species richness of medium-sized carabids, while field edges had low numbers of small sized species.

1 Introduction

The loss of biodiversity in Central Europe is closely related to the intensification of agriculture and the combined effects of changes in the agricultural landscape by the removal of natural habitats (Krebs et al. 1999, Flynn et al. 2009). The size of the area and the pattern of natural and semi-natural habitats in the agricultural landscape are important for the retreat and source potentials of the fauna (Smith et al. 2008). The colonization of arthropods after ploughing or insecticide application depends mainly on the potential of the adjacent non-arable habitats (Tscharntke & Kruess 1999). Thus, sustainable land use, which is expected to solve the contradictory challenges of environmental protection and food production, must also integrate the whole landscape, including agricultural and non-agricultural areas.

Natural and semi-natural habitats such as grassy strips, hedges and hedgerows prevent the loss of biodiversity in agricultural landscapes (Benton et al. 2003). Grassy strips are corridors for dispersal, sources of food, and sites for refuge and for overwintering (Thomas et al. 1991; Bommarco 1998; Asteraki et al. 1995; Frank & Reichhart 2004; Denys & Tscharntke 2002). The benefit of grassy or floral strips for biodiversity has mainly been found for conventional agriculture (Lys et al. 1994, Varchola & Dunn 2001). In a review study, Bengtsson et al. (2005) found positive effects of organic farming on predatory carabids. In addition, the species that benefit from organic agriculture were reviewed by Döring (2003). Recent investigations found that after six years of organic agriculture the diversity in the field centres equals that at field margins, which implies that grassy strips are less effective in organic agriculture than in conventional agriculture (Schröter & Irmler in press).

Ground beetles are one of the most numerous groups of insects that can be found in agroecosystems in the northern hemisphere (Kromp 1999). Because of their feeding behaviour, they played an important role in pre-industrial farming as natural pest and weed control agents, and may be of further interest for sustainable agriculture. The low dispersal ability of many carabids hampers the rapid recuperation of losses in arable fields within a farming year (Thomas et al. 1991). Carabids are therefore regarded as useful model organisms and indicators of the diversity processes in agricultural landscapes (Koivula 2011).

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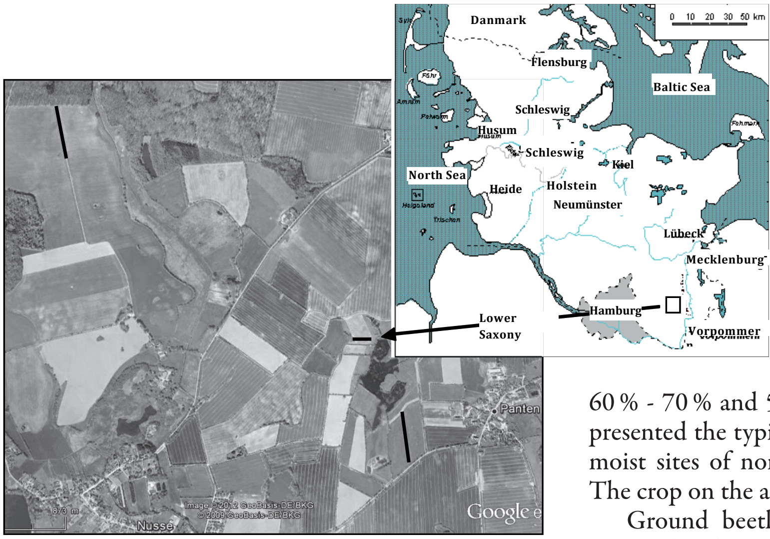

Fig. 1: Map of the investigated strips (black lines) in Schleswig-Holstein, northern Germany.

Using carabids as indicator organisms, this investigation studies the effect of grassy strips in organic fields with a view to answering the following main questions: (1) Which species benefit from grassy strips? (2) Which ecological demands support the use of strips? (3) What effects do the strips have on endangered and differently sized species?

2 Sites and methods

The investigation was performed from September 2009 to October 2010 in three organic arable fields at Panten and Ritzerau (Schleswig-Holstein, northern Germany) (Fig. 1). The region is characterised by a moderate continental climate with 691 mm rainfall and 8.1 °C over a 30-year average. The two farms are adjacent to each other and have soils with approximately 23 – 29 % loamy sand, 20 – 35 % loam and 3 – 12 % sand (Reiss et al. 2008). The farm in Ritzerau (Hof Ritzerau) consisted of 180 ha of arable fields and changed to organic farming in 2001. The farm in Panten (Lämmerhof), comprising 410 ha arable fields, has been managed according to organic standards for decades. A 180 m long grassy strip was investigated in Ritzerau, and two grassy strips (150 m and 330 m) were selected in Panten. The two grassy strips in Panten connected field margins on both sides, whereas only one end of the strip in Ritzerau was connected to a field margin. All field margins were characterised by woods or hedges and a grassy strip running along them adjacent to the field. All grassy strips crossing the arable fields and those of the field margins were approximately 3 m wide. The strips and field margins were dominated by the main grass species, i.e. *Lolium perenne* L., *Poa trivialis* L., and *Elymus repens* (L.) Gould. Both grass coverage and species richness ranged between 60 % - 70 % and 50 - 60 species respectively, and represented the typical grassy vegetation in moderately moist sites of northern Germany (Roweck 2008). The crop on the arable fields was wheat.

Ground beetles were sampled by using pitfall traps. The glass jars used as pitfall traps had an opening of 5.6 cm diameter and were covered by a transparent shield to protect them from direct rainfall. They were half-filled with 90 % glycol and a surface tension reducing agent. Two rows of pitfall traps were installed: one in the arable field and one in the grassy strip. The traps in the rows were placed at 30 m intervals, beginning at a distance of 30 m from the field margins and ending at a maximum distance of 180 m. The distance between the field row and the strip row was also 30 m. Due to the narrow width of the strips, only 2 replicate pitfall traps were installed in each row per 30 m interval at a distance of approximately 1.5 m from each other. In one field on the Lämmerhof, two parallel rows were installed in the arable fields on both sides of the strip. Three pitfall traps were set in each field margin. Thus, a total of 118 pitfall traps were available for analysis. The pitfall traps were changed at monthly intervals, though this varied sometimes due to weather conditions in winter.

For the analysis, activity density was transformed into dominance values, as the capture efficiency of the traps in the three habitats was distinctly different (e.g. Wallin & Ekbom 1988). The indication values according to Irmler & Gürlich (2004) for the analysis of the species environment relationship were used. As only tree cover and soil pH had significant results, these parameters were taken for each species and the indication value of each group was calculated as the average of the specific indication values per group. Additionally, the sign of the correlation

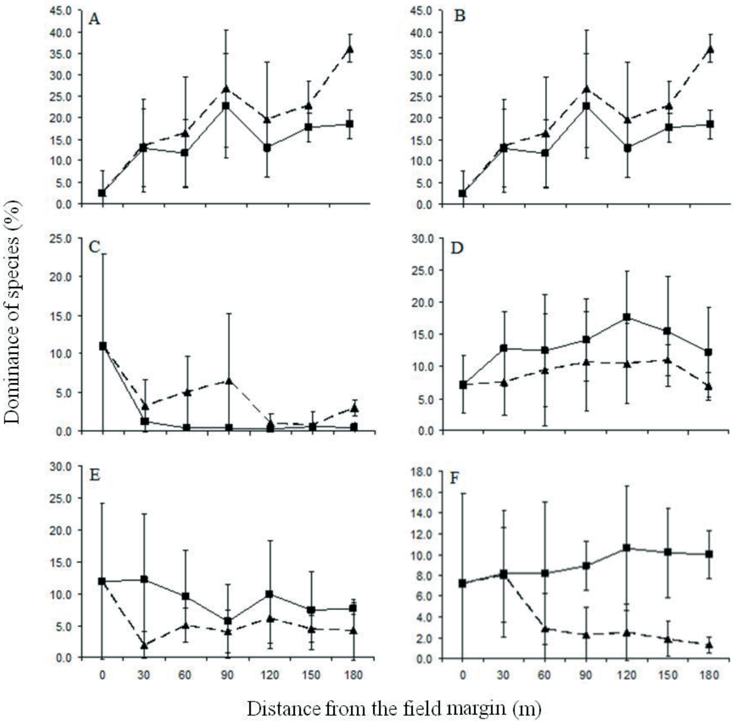

Fig. 2: Dominance pattern of *Poecilus cupreus* (A), *Poecilus versicolor* (B), *Carabus nemoralis* (C), *Pterostichus melanarius* (D), *Anchomenus dorsalis* (E), and *Nebria brevicollis* (F) in the crop area (—■—) and adjacent grassy strips (- -▲- -).

coefficient for tree cover was used. The values of the intervals in strips or arable fields were analysed using the Wilcoxon and Sign-test. The Red List species were selected according to Gürlich et al. (2010). For the size analysis, the mean value of the size range of the species was taken (Müller-Motzfeld 2004). The carabids were classified into 4 groups: small: – 5 mm, medium: > 5 – 10 mm, large: > 10 – 15 mm, and very large: > 15 mm. The groups were statistically compared by nested ANOVA. The STATISTICA 6.1 (Statsoft 2004) program was used for the statistical analyses.

3 Results

3.1 Species composition

A total of 14,527 specimens were captured during the investigation. Arable fields provided the highest number with 10,159 specimens; grassy strips and field margins contributed to 3675 and 693 specimens, respectively (Table 1). Concerning species richness, the arable fields, grassy strips and field margins accounted for 61, 60 and 46 species, respectively. Only six species were found to have a significantly higher dominance in one of the three habitats. Among these species, only a single species, i.e. *Bembidion lampros*, showed the highest dominance in arable fields; three species were more dominant in arable fields and grassy strips; two species were more dominant in field margins. The majority of species was found in all three habitats with no significant preference for any of the habitats. The remaining species were rarely captured and could not be analysed statistically. Nevertheless, their distribution was specific in arable fields, strips or field margins.

The species showing no significantly higher dominance in any of the three habitats were characterised by similar indication values as the species found only in arable fields or in arable fields and strips concerning tree cover or soil pH (Table 2). The field and strip species were generally characterised by their preference for open habitats. In contrast, species found in strips and margins or found only in margins exhibited a higher affinity to tree cover. Both groups were significantly separated according to ANOVA (DF: 4, 43; F: 6.3; $p < 0.001$). The same trend was found when species with positive or negative correlation to tree cover were separated. In arable fields or additional grassy strips, only 1 species each was found that had a positive correlation to tree cover, whereas 6 to 11 species had negative correlations. In contrast, the majority of species from strips and field margins were positively correlated to tree cover. The pH preference of these species was generally around 5. Species found only in arable fields showed no preference for higher pH than species found only in strips (ANOVA: DF: 4, 40; F: 2.4; $p < 0.06$). Only the group of species that occurred in field margins and strips showed a slight,

Tab. 1: Dominance and activity density of carabids in field margins, grassy strips and arable fields; +: < 0.2 %; RL SH: Status according to Red List Schleswig-Holstein; different exponents indicate significant differences according to ANOVA ($p < 0.05$); v: rare species..

	RL	Dominance (%)			Ind 100 days^{-1}		
	SH	Field	Strip	Margin	Field	Strip	Margin
Bembidion lampros		^{a} 9.9	^{b} 5.4	^{b} 3.1	35.82	12.59	0.23
Poecilus cupreus		^{a} 14.2	^{a} 16.8	^{b} 0.8	64.18	37.32	0.08
Pterostichus melanarius		^{a} 12.6	^{ab} 7.9	^{b} 7.2	67.74	19.29	0.75
Amara similata		^{ab} 1.3	^{a} 4.2	^{b} 0.8	3.28	10.83	0.10
Carabus nemoralis		^{b} 0.5	^{ab} 4.5	^{a} 11.5	1.93	5.42	0.73
Carabus coriaceus		^{b} 0.1	^{b} 0.5	^{a} 2.9	0.23	0.59	0.27
Anchomenus dorsalis		10.3	3.9	11.9	35.59	8.47	1.33
Nebria brevicollis		8.2	3.8	6.6	36.00	5.87	0.73
Harpalus rufipes		9.0	6.9	11.2	36.34	9.38	0.96
Bembidion tetracolum		2.6	3.2	1.8	9.22	4.45	0.21
Calathus fuscipes		0.8	0.3	0.6	3.79	0.80	0.06
Trechus quadristriatus		6.6	3.3	5.9	17.61	4.08	0.64
Carabus auratus	3	6.9	14.4	9.0	29.71	13.60	0.55
Harpalus affinis		6.3	8.0	6.1	21.07	17.16	0.43
Poecilus versicolor		3.0	6.2	1.9	13.73	13.07	0.16
Agonum muelleri		1.5	0.7	0.5	5.21	1.20	0.10
Carabus granulatus		0.6	0.5	0.9	2.46	0.89	0.08
Clivina fossor		1.1	1.9	0.9	2.40	1.80	0.06
Amara aenea		0.7	1.0	0.6	2.31	2.31	0.06
Amara familiaris		0.7	1.1	1.6	1.77	3.00	0.11
Loricera pilicornis		0.3	+	0.3	0.66	0.19	0.02
Pterostichus niger		+	0.7	0.2	0.60	0.47	0.02
Synuchus vivalis		+	0.2	1.9	0.61	0.43	0.25
Pterostichus strenuus		+	0.5	1.5	0.21	0.47	0.11
Harpalus latus		+	0.1	0.2	0.45	0.75	0.04
Amara consularis	v	+	0.2	0.2	0.89	0.25	0.02
Pterostichus diligens		+	0.2	0.3	0.42	0.25	0.02
Harpalus rubripes		+	+	0.3	0.10	0.14	0.02
Amara plebeja		+	+	0.5	0.21	0.05	0.04
Stomis pumicatus		+	+	0.8	0.03	0.05	0.10
Oxypselaphus obscurus		+	+	0.9	0.08	0.15	0.04
Anisodactylus binotatus		+	+	0.2	0.04	0.15	0.02
Trichocellus placidus		+	.	0.2	0.04	.	0.02
Bembidion obtusum	v	0.3	.	.	0.39	.	.
Microlestes minutulus		+	.	.	0.39	.	.
Limodromus assimilis		+	.	.	0.16	.	.
Amara communis		+	.	.	0.13	.	.
Philorizus melanocephalus		+	.	.	0.19	.	.
Poecilus lepidus	3	+	.	.	0.09	.	.
Harpalus neglectus	2	+	.	.	0.04	.	.
Pterostichus nigrita		+	.	.	0.04	.	.

Fortsetzung Tab. 1

	RL SH	Dominance (%) Field	Strip	Margin	Ind 100 days^{-1} Field	Strip	Margin
Chlaenius nigricornis	3	+	.	.	0.04	.	.
Zabrus tenebriodes	1	+	.	.	0.04	.	.
Calathus erratus		+	.	.	0.04	.	.
Ophonus rufibarbis		+	.	.	0.04	.	.
Acupalpus exiguus		+	.	.	0.03	.	.
Demetrias atricapillus		+	.	.	0.03	.	.
Bembidion properans		0.5	0.5	.	1.61	1.12	.
Harpalus tardus		0.3	0.3	.	0.87	0.48	.
Notiophilus biguttatus		0.2	+	.	0.41	+	.
Amara aulica		+	+	.	0.33	0.09	.
Calathus melanocephalus		+	0.2	.	0.23	0.30	.
Harpalus signaticornis	v	+	+	.	0.15	0.19	.
Harpalus distinguendus	3	+	+	.	0.14	0.05	.
Acupalpus meridianus	v	+	+	.	0.22	0.10	.
Pterostichus vernalis		+	+	.	0.18	0.05	.
Amara anthobia	3	+	+	.	0.12	0.05	.
Amara lunicollis		+	+	.	0.03	0.20	.
Harpalus rufipalpis		+	0.2	.	0.04	0.11	.
Trechoblemus micros		+	+	.	0.09	0.05	.
Bradycellus harpalinus		+	+	.	0.04	0.05	.
Leistus terminatus		.	+	.	.	0.05	.
Syntomus truncatellus		.	+	.	.	0.05	.
Syntomus foveatus		.	+	.	.	0.05	.
Badister sodalis		.	+	.	.	0.05	.
Amara tibialis		.	+	.	.	0.10	.
Calathus cinctus	v	.	+	.	.	0.05	.
Calosoma auropunctatum	2	.	+	.	.	0.05	.
Abax parallelepipedus		.	0.8	0.7	.	0.38	0.10
Carabus violaceus		.	+	0.2	.	0.05	0.02
Cychrus caraboides		.	+	0.2	.	0.05	0.02
Bembidion guttula		.	+	0.3	.	0.05	0.02
Pterostichus oblongopunctatus		.	1.0	0.9	.	0.12	0.11
Panagaeus bipustulatus	3	.	+	0.3	.	0.05	0.02
Bembidion lunulatum	2	.	.	0.3	.	.	0.02
Bembidion biguttatum		.	.	0.6	.	.	0.02
Leistus rufomarginatus		.	.	0.2	.	.	0.02
Calathus rotundicollis		.	.	0.2	.	.	0.02
Badister bullatus		.	.	0.4	.	.	0.04
Carabus hortensis		.	.	2.1	.	.	0.12
Notiophilus palustris		.	.	0.3	.	.	0.04

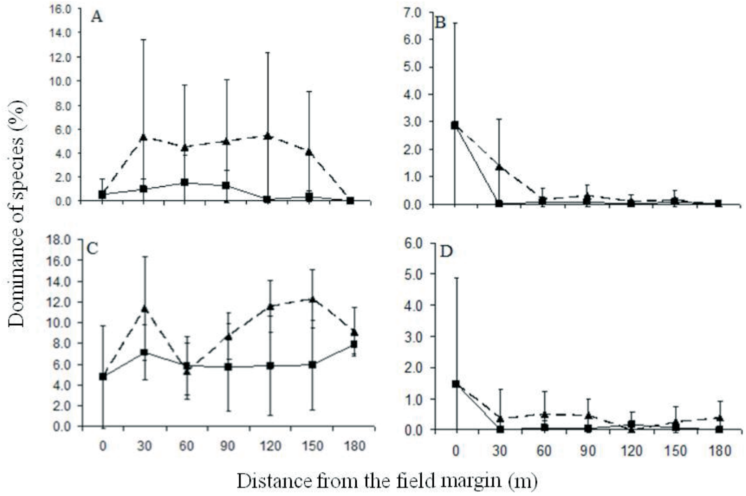

Fig. 3: Dominance pattern of *Amara similata* (A), *Carabus coriaceous* (B), *Harpalus affinis* (C), *Pterostichus strenuus* (D) in the crop area (–■–) and adjacent grassy strip (--▲--)

but significant ($p < 0.05$) lower pH preference than the species of the other groups.

3.2 Distances covered from field margins into arable fields and grassy strips

The comparison of dominances along the intervals using the Wilcoxon and Sign-test showed that the dominance of three species was higher in strips than in adjacent crop areas (Table 3). However, four species occurred in higher abundance in the crop areas than in the strips. Twenty-two species showed no significant differences between the crop areas and the strips, but six of these species showed significant Wilcoxon test results, indicating that the dominance in the two lines of traps were different.

In the first group, *Poecilus cupreus* and *P. versicolor* were less dominant in the field edges than in the strips and crop areas, whereas *Carabus nemoralis* was found to have a higher dominance in the field edges than in the strips and crop areas (Fig. 2). The dominance of *P. cupreus* increased more or less continuously from the field edges to a distance of 180 m into crop areas and strips. *P. versicolor* reached a steady state of dominance at a distance of 30 m from the field edges in both crop areas and strips; however, its dominance in the strips almost doubled that in the crop area at 180 m from the field margin. In contrast, *C. nemoralis* showed a strong decrease of dominance in the first 30 m from the field edges in arable fields; in strips, a slighter decline was found at 30 m and another, stronger one at 90 m.

Among the species with higher dominance in the arable fields than in the strips was *Pterostichus melanarius*, which increased in dominance from the field edge to a distance of 120 m, whereas *Anchomenus dorsalis* showed a slight decline from the field edge to a distance of 180 m into the crop areas. *Nebria brevicollis* was equally dominant in field edges and crop areas, but had a strong decline in the strips after a distance of 30 m. Among other species with significant Wilcoxon test results, *Carabus coriaceous* and *P. strenuus* were nearly absent from the field traps and were found rarely in the strips (Fig. 3). In contrast, *Amara similata* and *Harpalus affinis* occurred in low dominance in the field edges and the crop areas, but had a distinctly higher dominance in the strips.

Preference type of species groups	No. of species	Mean tree cover (%)	Species with correlation coefficient to tree cover (n)		pH
			+	-	
Without preference	27	7.4 ± 9.8	1	15	5.5 ± 0.6
Rare carabids					
Only in fields	14	^{a} 4.7 ± 13.1	1	6	^{a} 5.6 ± 0.4
In fields and strips	15	^{a} 6.8 ± 23.9	1	11	^{a} 5.5 ± 0.9
Only in strips	7	^{a} 13.9 ± 25.1	2	2	^{a} 5.5 ± 0.6
In strips and margins	6	^{b} 63.4 ± 47.4	4	1	^{b} 4.6 ± 0.7
Only in margins	7	^{b} 51.4 ± 50.1	5	0	^{ab} 5.0 ± 1.3

Tab. 2: Affinity of carabid species to canopy cover and soil pH; different exponents indicate significant difference according to ANOVA ($p < 0.05$); +: positive reaction, -: negative reaction.

3.3 Effect of strips on endangered and differently sized species

In total, 15 species were listed as endangered in the Red List for Schleswig-Holstein. Average numbers of species per trap were: 0.9 ± 0.5 (n = 18) in the field margins, 1.4 ± 0.5 (n = 26) in the strips and 1.4 ± 0.8 (n = 44) in the arable fields (DF: 2,115). The differences between the habitats were not significant (F = 6.37, p = 0.2).

The results of the nested ANOVA reflected an effect of carabid size and habitat type on the number of species (F = 78.1, p < 0.001). Size had a greater effect (DF: 3, 382; F: 169.1; p < 0.001) than the habitats (DF: 8, 382; F: 18.1; p < 0.001). The different size groups showed that the very large species were found in equal numbers in all three habitats (Fig. 4). Small species were not found as often in the field margins as in the two other habitats, whereas medium and large-sized species were more frequent in grassy strips and arable fields. No difference in the size classes of carabids was found between grassy strips and arable fields.

Tab. 3: Comparison between crop area and strip in the trap rows from edge to a distance of 180 m, with results of Wilcoxon test and Sign test; F: field, S: strip; Z: Z-value of Wilcoxon test, p: error of probability.

Species	Wilcoxon		F : S ratio	Sign test	
	Z	p		Z	p
Poecilus cupreus	2.2	0.03	F < S	2.0	0.04
Carabus nemoralis	2.2	0.03	F < S	2.0	0.04
Poecilus versicolor	2.2	0.03	F < S	2.0	0.04
Pterostichus melanarius	2.2	0.03	F > S	2.0	0.04
Anchomenus dorsalis	2.2	0.03	F > S	2.0	0.04
Nebria brevicollis	2.2	0.03	F > S	2.0	0.04
Trechus quadristriatus	2.2	0.03	F > S	2.0	0.04
Bembidion lampros	2.0	0.04	-	1.2	n.s.
Amara similata	2.0	0.04	-	1.8	n.s.
Carabus coriaceus	2.0	0.04	-	1.8	n.s.
Harpalus affinis	2.0	0.04	-	1.2	n.s.
Amara aenea	2.0	0.04	-	1.2	n.s.
Pterostichus strenuus	2.0	0.04	-	1.2	n.s.
Pseudoophonus rufipes	1.8	n.s.	-	1.2	n.s.
Pterostichus diligens	1.8	n.s.	-	1.5	n.s.
Harpalus rubripes	1.8	n.s.	-	1.5	n.s.
Amara familiaris	1.6	n.s.	-	1.2	n.s.
Harpalus latus	1.6	n.s.	-	0.4	n.s.
Amara consularis	1.5	n.s.	-	0.5	n.s.
Calathus fuscipes	1.4	n.s.	-	1.2	n.s.
Agonum muelleri	1.4	n.s.	-	1.2	n.s.
Bembidion tetracolum	1.2	n.s.	-	1.2	n.s.
Synuchus vivalis	0.9	n.s.	-	0.9	n.s.
Amara plebeja	0.9	n.s.	-	0.9	n.s.
Loricera pilicornis	0.7	n.s.	-	0.5	n.s.
Pterostichus niger	0.4	n.s.	-	0.0	n.s.
Carabus granulatus	0.3	n.s.	-	0.4	n.s.
Clivina fossor	0.3	n.s.	-	0.4	n.s.
Carabus auratus	0.1	n.s.	-	0.4	n.s.

4 Discussion

Concerning the species composition, the investigated arable fields represented the most common carabid assemblage of arable fields on loamy soils in Schleswig-Holstein (Schröter 2010; Irmler & Gürlich 2004). Compared to that assemblage, the dominance of *Pterostichus melanarius* was low at 12 %, which can be explained by the seven-year period of organic farming (Schröter & Irmler in press). According to Irmler & Gürlich (2004), the high dominance of *Bembidion lampros* on the fields investigated indicated a higher affinity to smaller-sized arable fields and to organic farming than the typical assemblage with a dominance of *P. melanarius*. The positive relationship of *B. lampros* to organic farming was also found by Schröter (2010), although the correlation was still weak after two years of organic farming. Its preference to arable fields showed that the species is not dependent on the field margins or strips. Its dependence on the management of the arable fields makes it a valuable indicator for organic farming. It was astonishing to find that *P. melanarius*, which is generally an indicator of arable fields, also showed high dominance in strips and field margins. In contrast to *B. lampros*, this species also often used habitats adjacent to arable fields. Their nocturnal activity, which is supported by the darker grassy strips, could be an explanation for

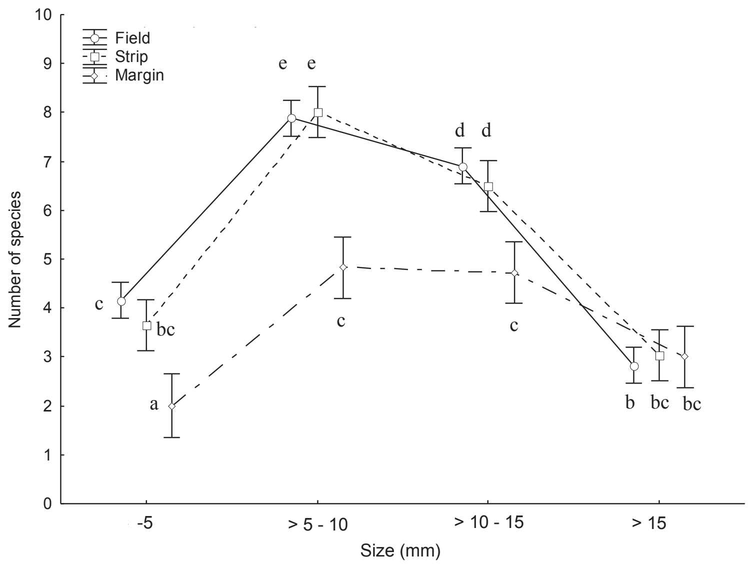

Fig. 4: Mean number of differently-sized species in the three habitats with standard error. Different exponents indicate significant difference according to nested AvNOVA.

this behaviour (Chapman et al. 1999). According to Wallin (1988), *P. melanarius* reproduced and developed larvae in arable fields, but adults also used field margins. Similar results were found for *Poecilus cupreus* as well; reproduction and larval development was reported to occur in arable field areas, while adults used field margins for predation (Wallin 1988).

The effects of grassy strips in agricultural landscapes were investigated in the last decades in both grassland and arable fields. In grasslands, Nentwig (1988) found a higher diversity of carabids under strip-managed areas than in mown areas or mown strips. Perennial grass strips also enhanced abundance and species richness of leafhoppers in comparison to cereal fields (Huusela-Veistola & Vaarainen 2000). Our investigation does not support the positive effect of strips and margins on species richness in organically farmed fields. Under organic farming, species of the field margin invaded the field centres that resembled the field margins after 6 years of organic farming (Schröter & Irmler 2013). Nevertheless, seasonal changes based on the invasion process were found even in small organic fields (Juen & Traugott 2004).

Invasion in our studies should be understood as a process of one year or more, because strips can also function as overwintering habitats. However, grassy strips usually only persist for two to three years and are developed at another site after that time due to the increasing thistle abundance. In our investigation, strips supported the invasion of species preferring no vegetation cover and species preferring vegetation cover, whereas only species avoiding vegetation cover were supported by fields. In particular, species that were found mainly in field margins preferred vegetation cover. In contrast to typical forest species, all species of arable fields, strips and field margins require a soil pH ranging between 4.6 and 5.6. As described by Irmler & Gürlich (2004), forest species that prefer a lower soil pH ranging between 3.4 and 4.4 avoided the strips and field margins. Typical species mainly occurring in field margins and using the strips as corridors into arable fields are *Carabus nemoralis, C. coriaceous* and *P. strenuus*. All three species can be described as euryecious species with a weak preference for forests (Irmler & Gürlich 2004). Our data showed that they invaded from the field margins using the grassy strips and rarely crossed into arable fields. Among these three species, *C. nemoralis* revealed the highest mobility, as it was found in high dominance at a distance of up to 90 m into the grassy strips. The dominance of *C. coriaceus* declined drastically at a distance of 30 to 60 m from the field margin; the dominance of *P. strenuus* was generally low in strips and arable fields.

In contrast to those species that need at least weak tree cover, species demanding open habitats, e.g. *P. cupreus*, *P. versicolor*, and *Amara similata*, avoided field margins. They increased in dominance at increasing distance from the field margin, except for *A. similata* that declined at 150 m distance from the field margins. Thus, it can be assumed that field strips support these species, in particular as they were found in higher dominances in strips than in field margins. The specific conditions of strips seemed to have a positive effect on the species. *Anchomenus dorsalis* was considered to overwinter in hedges of field margins and to invade from there into arable fields in the spring (Jensen et al. 1989; Maudsley et al. 2002).

According to our data, grassy strips do not support this invasion. As expected, dominances were highest in field margins, but decreased more in strips than in arable fields.

Strips do not seem to affect endangered and differently-sized species, because the composition of differently sized carabids was the same in arable fields and grassy strips. In contrast, field margins revealed a different size composition. In field margins, the number of very large species (> 15 mm) was higher than in grassy strips and arable fields, whereas the number of small (< 5 mm) species was lower. In grassy strips and arable fields, medium-sized species between 5 mm and 15 mm dominated. This may be due to flight ability, since brachypterous carabid species benefit from the age of remote areas (Platen et al. 2012). High mobility with high flight potential is generally more developed in small and medium-sized carabids. Thus, agricultural practices such as intensive grazing can influence the corridor dispersal of flightless species, for example *C. nemoralis*, which are less tolerant to disturbances than species with flight ability (Petit & Usher 1998).

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Address of authors

Mazhar Ranjha & Ulrich Irmler
Institut für Ökosystemforschung
Abteilung: Angewandte Ökologie
Olshausenstrasse 40
D-24098 Kiel