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A Modified Pitfall Trap for Capturing Ground Beetles (Coleoptera: Carabidae)

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Abstract

A modified pitfall trap study was carried out in winter wheat growing in Straszewo village (54°10′N, 17°21′E), Poland. The objective of this study was to compare the functional effectiveness of traditional pitfall traps with those that have a plastic funnel. Ten traps of each kind were used. Specimens were collected from May to July 2006. Cumulatively, 1,866 specimens belonging to 38 ground beetle species (Coleoptera: Carabidae) were trapped. In traditional pitfall traps, 31 species and 1,115 specimens were captured, whereas in modified traps 33 species and 751 specimens were collected. The average catch efficiency of traditional traps (1.5±0.7 specimens per trap per 24 hours) was significantly higher compared to that of modified traps (1.0±0.3 specimens per trap per 24 hours). Considering the habitat and trophic and hygro-preference aspects, the collection of particular groups of specimens, both quantitatively and qualitatively, was similar for both trap variants. The average body size of ground beetles and mean individual biomass values (63.5 mg for beetles in traditional traps compared to 57.6 mg for beetles in modified traps) were not significantly different. However, significant differences were detected for total biomass (7,100 mg in traditional traps versus 4,300 mg in modified traps). Nineteen lizards (*Lacerta* sp.) were caught in the open traps throughout the study period, while only five specimens were taken in the funneled traps.

Key Words: ecology, methodology, assemblages, agriculture fauna, trappability

The use of pitfall (Barber's) traps is the most popular method of collecting epigeic arthropods and other invertebrate animals (Spence and Niemelä 1994; Mommertz *et al.* 1996; Zalewski 1999). This technique is easy to use, convenient, and inexpensive. It has been applied in various types of ecological, behavioral, forest, and agricultural studies (Benest 1989; Spence and Niemielä 1994; Raworth and Man-Young Choi 2001). Such a wide use of the traps has led to their numerous modifications and improvements. This caused many methodological problems, with the question of comparability of results being the most important (Spence and Niemielä 1994). Many studies have shown the influence of various factors, *e.g.*, shape, size, construction, material, and color, on the efficacy and functioning of the traps (Adis 1979; Spence and Niemielä 1994; Sunderland *et al.* 1995; Zalewski 1999; Hébert *et al.* 2000; Buchholz *et al.* 2010). Spence and Niemielä (1994), Mommertz *et al.* (1996), and Zalewski (1999) have also examined the efficacy of traps equipped with accessories, *e.g.*, shields protecting them against sinking or obstruction, or fences providing higher selectivity.

According to Buchholz *et al.* (2010), a pitfall trap is non-selective and usually catches many species of invertebrate and vertebrate animals not included in the main study. Taking the ethical aspect of research into account, we postulate such a selection of traps that would maximally reduce the mortality of accidentally caught animals. A funnel closing the opening of the trap is an element that can reduce by-catch. We did not find any information on the influence of funnel-equipped traps on the catch of Carabidae. Therefore, the aim of this paper is to present the results of catching carabids with traditional and modified (a funnel reducing the diameter of the opening) traps and to analyze the influence of the funnel on the by-catch of lizards (*Lacerta* sp.).

Material and Methods

Considering the higher trappability of carabids in an open area as compared with wooded or waterlogged habitats (Thiele 1977; Handke 1995; Matveev 1990; Huruk 2006), this study was carried out in rural landscape typical of northern Poland (Pomerania). This region is also poorly forested, with podsol of gravel and loose, faintly clayey sand as the main soil type. Climatic conditions determine the types of cultivated crops, mainly rye, wheat, and potatoes. The study site was in a winter wheat field (1-ha area) in the village of Straszewo (54°10′N, 17°21′E) in the Pomerania Voivodeship (northern Poland). The locality was situated near the road leading to the village and bordered by a potato field and a meadow.

Two types of trap were used to catch Carabidae. Traditional traps were made of 0.5-L, plastic, transparent cups, 10 cm in diameter at the top. In the modified traps, a plastic, transparent funnel was mounted on the same type of traditional trap container in order to reduce its opening (Fig. 1). The diameters of the funnel opening and the outlet were 10 cm and 2 cm, respectively.

Traps were installed in the central part of the field in two parallel rows, each comprising 10 traps of each type. The distance between consecutive traps in a row was about 10 m, and the distance between rows was 200 m. Traps were filled up to ¼ of their volume with ethylene glycol solution with a slight amount of detergent to reduce glycol surface tension. Specimens were harvested from the pitfall traps every 7–10 days for a total of nine collections between 15 May and 30 July 2006. Upon cleaning and drying, the insects were stored in paper envelopes. The collected Carabidae were identified using Hŭrka's (1996) key.

Domination classes were described according to Górny and Grüm (1981) who distinguished a eudominants class (>10.0% of all specimens), dominants class (5.1 – 10.0%), subdominants class (2.1 – 5.0%), recedents class (1.1 – 2.0%), and subrecedents class (<1.0%). The ecological characteristics of species were determined according to Lindroth (1945) and Thiele (1977). The species were divided into inhabitants of peatbog, coastal, field, forested, meadow, xerophilic, mesoxerophilic, mesophilic, mesohygrophilic, and hygrophilic habitats. According to known food preferences, species were classified as mostly predator, pantophagous, phytophagous, and predator.

The diversity of an assemblage was estimated by means of the Shannon-Wiener index H':

$$H' = -\sum_{i=1}^{n} p_i ln p_i$$

where p_i is the proportion of the ith species and n is the number of species in the community.

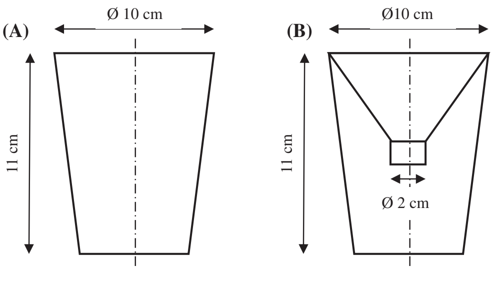


Fig. 1. Pitfall traps. A) Traditional, B) Modified with a plastic funnel.

Evenness was estimated by means of the Pielou index J':

$$J' = \frac{H'}{H'_{max}} = \frac{H'}{lnS}$$

where H' is the value of the Shannon-Wiener diversity index, H'_{max} is the maximum value of H', and S is the total number of species (Trojan 1992).

The mean individual biomass (MIB) was calculated by dividing the biomass of all sampled carabids by the number of specimens caught. Biomass values were obtained using the formula of Schwerk and Szyszko (2006) that describes the relationship between the body length of a single carabid individual (x) and its biomass (y):

$$\ln(y) = -8.92804283 + 2.555492\ln(x)$$

To compare the qualitative features distribution of analyzed variables, chi-squared test (χ^2) was used in accordance with Strzałko and Rożnowski (1992), whereas mean values of trapping efficiency were compared with the non-parametric Mann-Whitney U test (Stanisz 1998).

Results

Trapping Efficiency. A total of 1,866 individuals of Carabidae were caught, including 1,115 in traditional traps and 751 in modified traps. The difference between number of individuals captured was statistically significant (χ^2=47.538, p<0.05), in contrast to the number of species. We identified 38 species of carabids, among them 31 species caught in traditional traps and 33 species caught in modified traps. Five species, *Pterostichus oblongopunctatus* (F., 1787), *Carabus nemoralis* (Müller, 1764), *Harpalus rubripes* (Duftschmid, 1812), *Bembidion femoratum* (Sturm, 1825), and *Anisodactylus binotatus* (F., 1787), were identified solely in the material from traditional traps. Analogously, seven species, *Harpalus signaticornis* (Duftschmid, 1812), *Harpalus griseus* (Duftschmid, 1812), *Calathus melanocephalus* (L., 1758), *Amara majuscule* (Chaudoir, 1850), *Amara lunicollis* (Schiodte, 1837), *Amara bifrons* (Gyllenhal, 1810), and *Carabus granulatus* (L., 1758), were caught solely in the funneled traps. Each of these species was represented by one individual.

The quantitative differences were reflected by mean trapping efficiency which was significantly higher in the case of traditional traps (1.5±0.7 specimens/trap/day) than in the modified traps (1.0±0.3 specimens/trap/day) (Mann-Whitney U test: Z=2.305, p<0.05). Moreover, the analysis of trapping efficiency over time showed

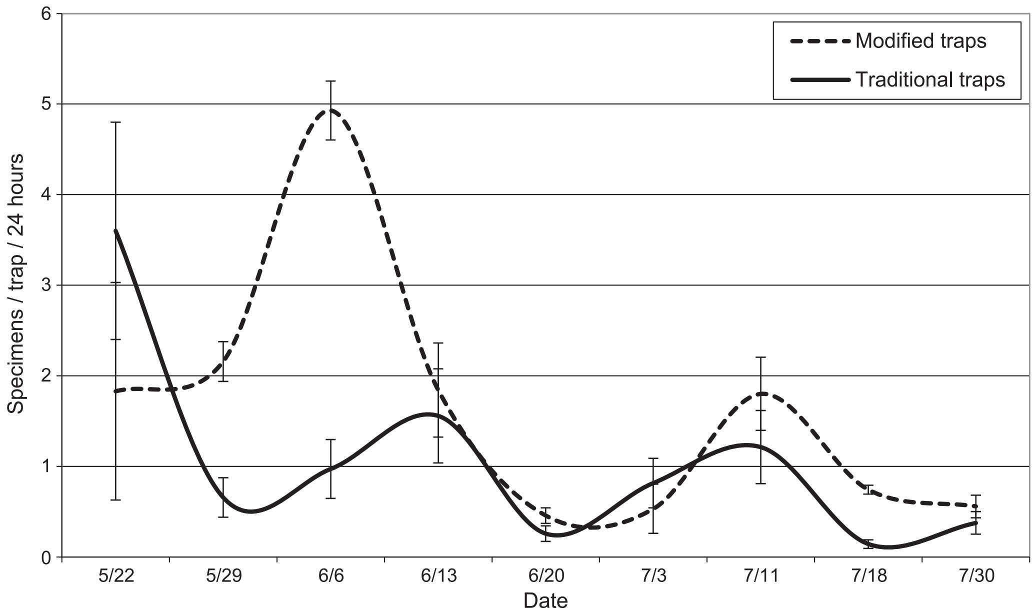


Fig. 2. The seasonal dynamics of trapping efficiency of traditional and modified pitfall traps.

an inverse tendency in the initial period after installing the traps. While the value of this index decreased rapidly in modified traps, it increased in the case of traditional traps (Fig. 2). Three weeks following the installation of the traps, the trapping efficiency was similar for both trap types.

The analysis of material revealed slight differences in body size of beetles captured by the two trap types. The average body size of beetles caught in traditional and modified traps was 10.59±2.21 mm and 10.13±2.08 mm, respectively. This difference did not prove statistically significant (Mann-Whitney U test: Z=1.946, $p>0.05$).

Total biomass of carabids caught in traditional and modified traps equaled 7,100 mg and slightly more than 4,300 mg, respectively, but this difference was not significantly different ($\chi^2 = 4.344$, $p<0.05$). A less evident difference was observed in the case of MIB, amounting to 63.5 mg and 57.6 mg in traditional and modified traps, respectively, but this difference was also insignificant ($\chi^2 = 2.523$, $p>0.05$).

Species Composition, Structure of Domination, and Ecological Structure. The two trap variants differed in terms of domination structure (Fig. 3). Four classes of domination were documented in the case of traditional traps, compared to five classes in modified traps. One species, *Poecilus lepidus* (Leske, 1785), belonged to the subdominant class in modified traps. *Poecilus versicolor* (Sturm, 1824) and *Harpalus rufipes* (De Geer, 1774) were eudominants in traditional traps. Aside from the species mentioned above, the class of eudominants in modified traps included *Poecilus cupreus* (L., 1758) (Fig. 3). The structure of domination in traditional traps was more cumulated, while the structure in modified traps was more evenly spread. The frequency of species in the various classes of domination differed significantly between the traditional and modified traps (χ^2=72.630, $p<0.01$).

The analysis of captured Carabidae according to their habitat, trophic behavior, and humidity preference showed a similar qualitative and quantitative participation of various groups in both types of traps (Fig. 4), with the predominance of mesophilic species characteristic of open areas (fields and meadows), *i.e.*, mostly predators. With regard to the quantity of species and number of captured individuals, the smallest groups were the forest and peat bog species (phytophagous). Xerophilic and hygrophilic species were the most seldom collected.

Diversity and Evenness Indices. The values of the Shannon-Wiener diversity index (H′) and Pielou's evenness index (J') of the collected material over time showed a slight difference between the two types of traps (Fig. 5). The peak values for modified traps occurred in early July and equaled 2.10 and 0.55, respectively. The values of these indices for the entire study period were slightly higher for the modified traps (Fig. 5).

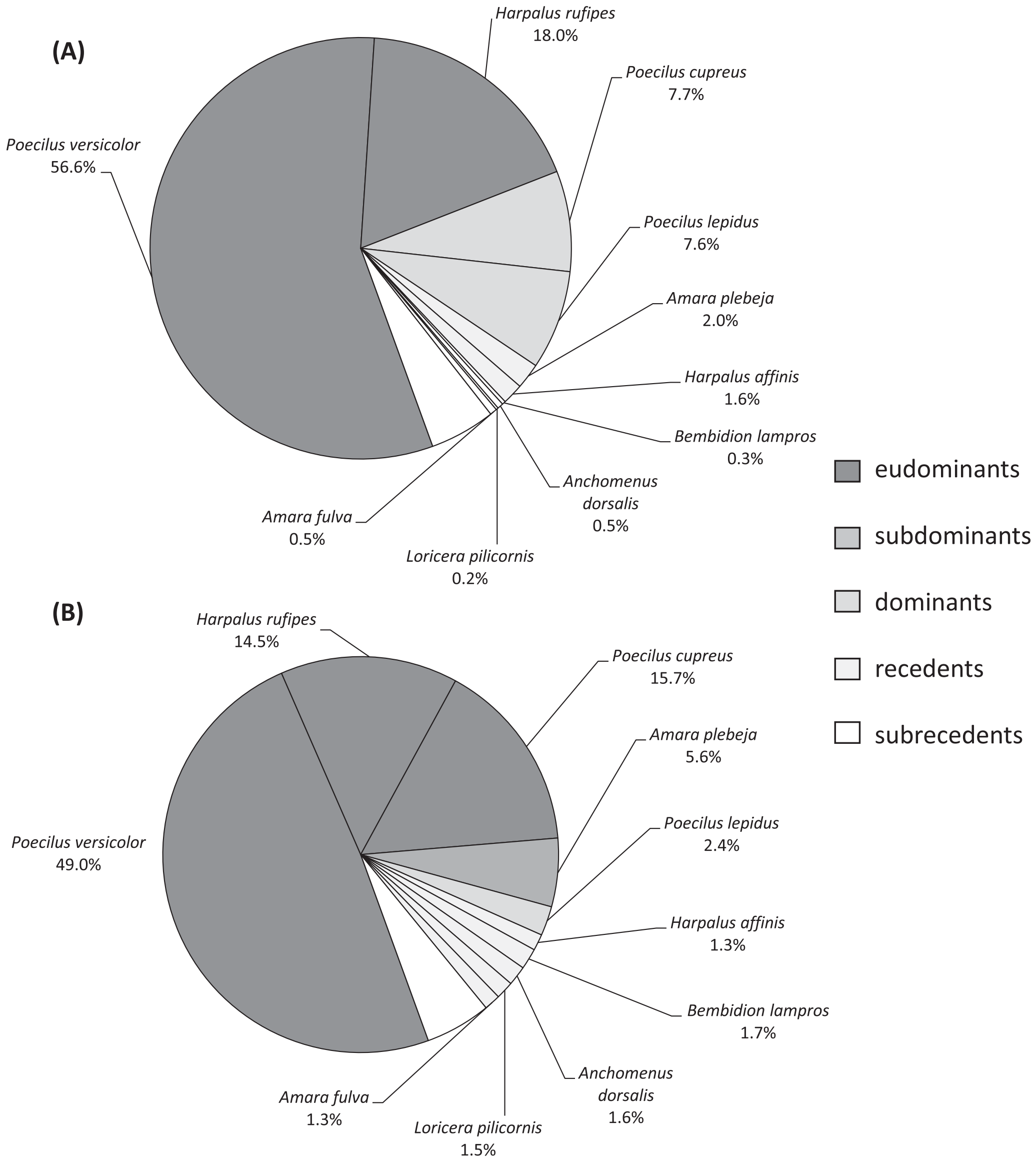


Fig. 3. Domination structure of Carabidae captured in two pitfall trap types. A) Traditional pitfall traps, B) Modified pitfall traps.

Lizard By-catch. By-catch with respect to lizards suggests a limiting effect of the funnel. The attendance of lizards in both kinds of traps was noted only after 20 June, *i.e.*, in the second half of the studied period. A total of 19 specimens were caught in traditional traps throughout the study period, while five specimens were collected from funneled traps. This difference was significant ($\chi^2 = 5.658$, $p<0.05$). All lizards caught in modified traps were smaller than those in traditional traps, and their body length did not exceed about 10 cm.

Discussion

Irrespective of the trap variant, trapping efficiency in this study was comparable to values given by other authors for similar sites (type of cultivation and soil) (Kabacik 1962; Pałosz 1998, 2001; Huruk, 2000, 2002, 2006). However,

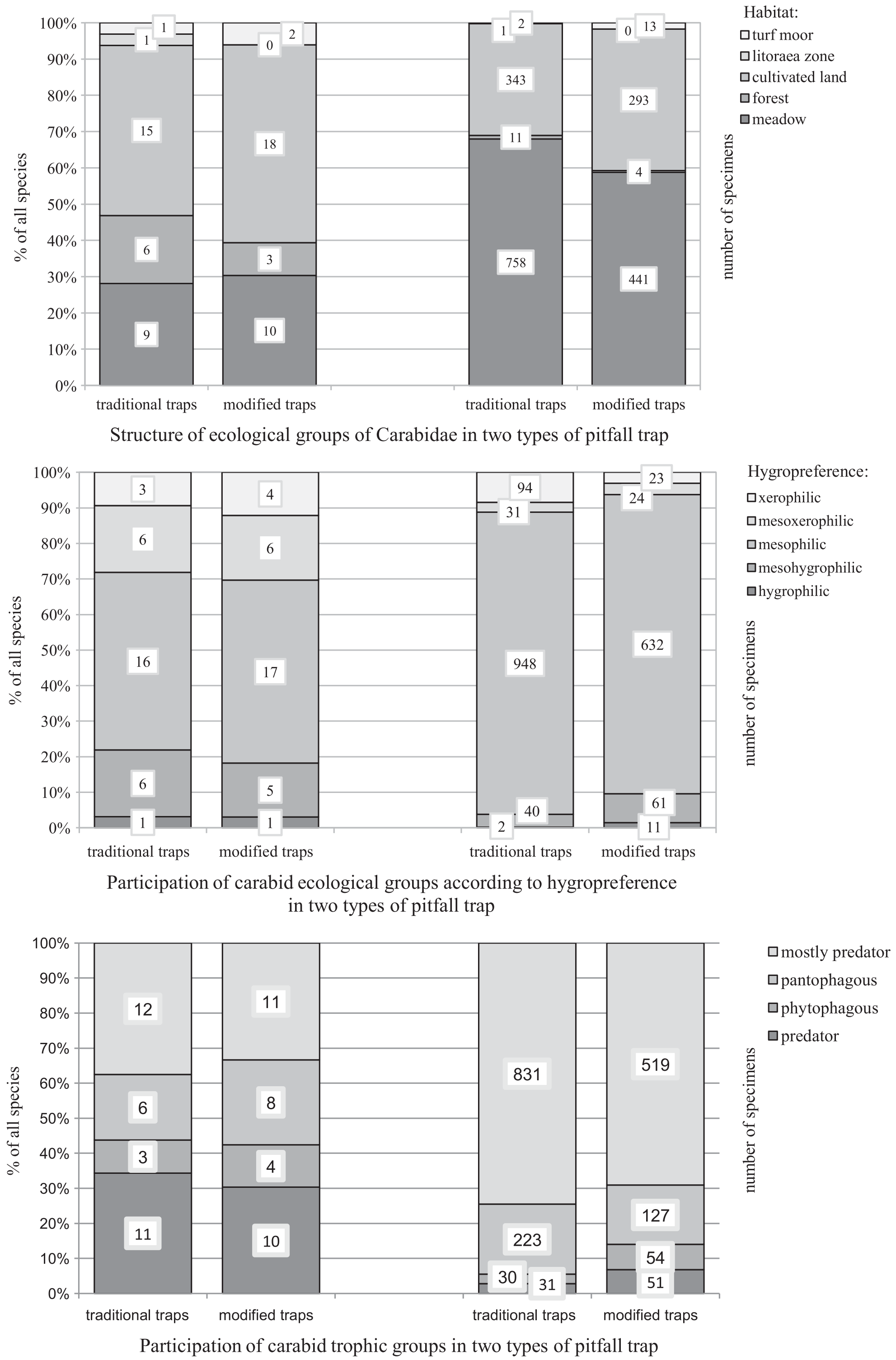
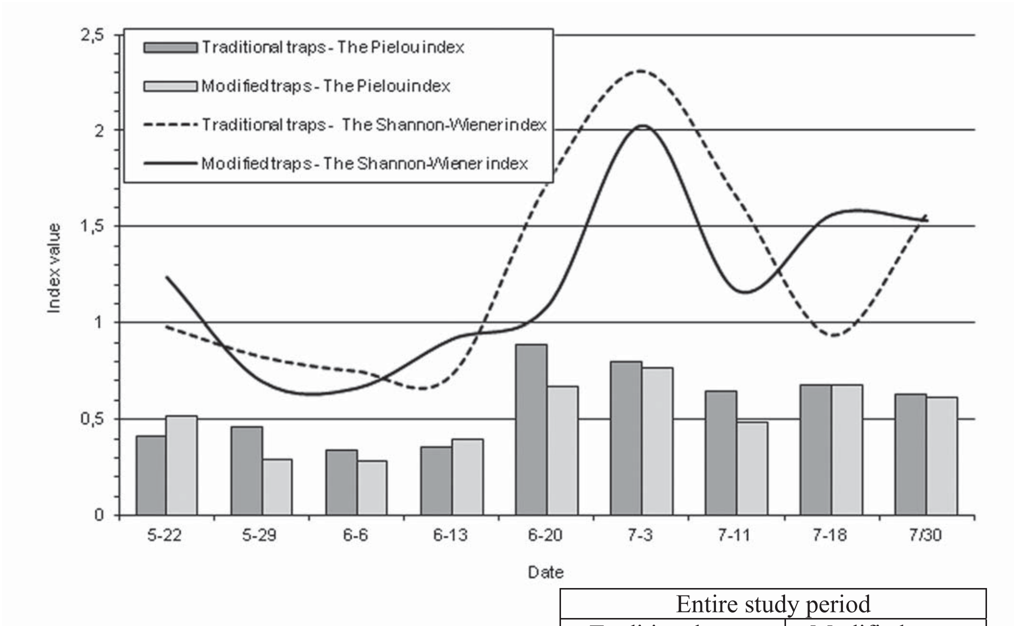


Fig. 4. Ecological and trophic structure of the carabid fauna as measured by traditional and modified pitfall traps.



	Entire study period	
	Traditional traps	Modified traps
Shannon-Wiener (*H*′)	1.54	1.80
Pielou (*J*′)	0.45	0.51

Fig. 5. Shannon-Wiener and Pielou indices for Carabidae captured in traditional and modified pitfall traps.

the differences in trapping efficiency between the two trap types were an expected effect. Many previous studies demonstrated the effect of trap construction on its efficacy (Mommertz *et al.* 1996; Zalewski 1999; Prasifka *et al.* 2007). Szyszko (1985) and Spence and Niemelä (1994) revealed that, compared to open traps, sheltered traps are characterized by lower trapping efficiency. Also, the study by Mommertz *et al.* (1996), who analyzed the function of fenced traps, revealed their lower trapping efficiency. Although we did not find any published research on funneled traps, open traps seem to be characterized by a higher trapping effectiveness than any constrained (shielded, fenced, funneled) traps in most sites. Traps with constraining accessories select for portions of the carabid fauna in various ways. Changing micro-environmental conditions (*e.g.*, degree of shadowing, humidity) around the trap can select for specific Carabidae depending on their preferences, activity, or particularly well-developed sense of vision (Van der Drift 1951; Baars 1979). Also, mechanical constraints such as a funnel or fence differentiate the material depending on the size of insects and their ability to escape after contact with the trap (Zalewski 1999). The use of a funnel may have enabled some species or individuals to escape (Spence and Niemelä 1994). Van der Drift (1951) described species that are able to retain balance and withdraw after contact with the trap. It seems that it is easier for species of larger dimensions to escape from modified traps. However, this was not confirmed by our findings. Perhaps, as suggested by Van der Drift (1951), beetles with serrated tarsal claws, as well as those with a better developed sense of vision, have higher chances to exit the trap.

The quantitative differences between material caught in both variants of pitfall traps were also reflected by total biomass and mean individual biomass (MIB). Similar differences were previously reported by Mommertz *et al.* (1996), who performed a comparative study of the effectiveness of fenced and unfenced traps. The comparison of all parameters of the variables included in our study (trapping efficiency, body size, biomass, and MIB) suggests that they show differences with various degrees of sensitivity. While trapping efficiency and biomass pointed to large and significant differences in the effectiveness of the two trap types, MIB revealed them to a markedly lesser extent, and the differences in body size proved insignificant.

The use of modified traps revealed a different domination structure of assemblage. It is well known that in the assemblages living in environments exposed to the pressure of anthropogenic factors, a marked disproportion in the participation of various species is usually observed, *i.e.* one or more species, better adapted to given environmental conditions, significantly dominate over the others (Odum 1977). According to Huruk (2006), the pressure of factors associated with agriculture can be reflected by the alterations of the domination structure, leading to a predominance of one or two species. Therefore, assuming sufficient statistical power of our samples, the evidently mono-dominant structure of specimens caught in traditional traps seemed more reliable for the studied assemblage. The above thesis supports the results described by Jaworska and Wiącek (2006), Huruk (2006), and Aleksandrowicz *et al.* (2008).

Cultivated fields are habitats in which various ecological groups of Carabidae are observed, usually those characteristic of open areas and eurytopic species (mainly predators) with moderate moisture requirements (Kosewska *et al.* 2009). As expected, both the qualitative and quantitative ecological profile of the carabid fauna was similar in both trap variants. The use of the funnel did not modify the micro-environment around the trap in any way. The ecological characteristic of assemblage reflected the habitat conditions of the studied site. A similar ecological structure of field assemblages was previously reported by Huruk (2002, 2006) and Kosewska *et al.* (2009).

Slight differences in the Shannon-Wiener diversity index and Pielou's evenness index reflect a different frequency of various species in both types of traps. According to Trojan (1992), the common species, living in high concentration and dominating in the structure of assemblage, exert the strongest effect on the value of the Shannon-Wiener index. Quantitative changes in this group of animals are reflected in significant changes in the value of this index. Slightly higher values of these indices for the modified trap resulted from lower disproportion between the participation in eudominant and subdominant class. The use of modified traps did not significantly influence the diversity indices.

The utilization of funneled traps reduced the mortality of lizards, with particular effectiveness for larger specimens. The funnel probably would also limit the by-catch of other vertebrate animals, such as frogs, voles, and mice. It would be worthwhile to confirm this hypothesis in a separate study. Simultaneously, the funneled traps also modulated the quantitative characteristics of trapping Carabidae (number of captured specimens, trapping efficiency, total biomass) and the structure of domination as compared with traditional traps. However, it did not change the ecological structure of the assemblage. Although the use of the funnel reduces the ease of working with traps in the field, it merits consideration, especially in protected areas.

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