4

Association of Ground Beetles *(Carabidae)* Occurrence with Sandy and Loam Sandy Soils

Tadeusz Pałosz
Koszalin University of Technology

1. Introduction

Great majority of ground beetles *(Carabidae)* species is a desirable element of agricultural ecosystems in view of the useful function of these insects in control of many phytophagous organisms. The occurrence of *Carabidae* on agricultural fields is since at least of 50 years a research subject of many authors. In these researches predominated such problems as number of individuals and species composition of these insects in different agricultural crops as well as in different agricultural management systems regarding the intensity of chemical plant protection, soil management, crop rotation etc. [1, 5, 6]. Occurrence of *Carabidae* depending on soil texture is dealt in a literature in a small degree besides of some publications of Kirchner (1960), Scherney (1960), Tischler (1955) and Heydemann (1964) [8, 12, 14, 15].

The problem of *Carabidae* association with different soil habitats is so much important that its recognition could define the possibility of a potential immigration or even introduction of some beneficial species on new areas of agricultural ecosystems. The impact of the soil factor on the *Carabidae* occurrence in some agricultural habitats was in our earlier publication defined as dominant [10].

The material presented in this publication was partly already employed for evaluation of an influence of soil management, intensity of chemical plant protection and other factors on the *Carabidae* occurrence [9, 10].

2. Material and methods

The investigations were carried out during 10 years (1995÷2005) on 11 agrosystems in Middle Pomerania in Poland (districts: Człuchów, Debrzno and Koszalin in Pomeranian and West Pomeranian provinces). There were 25 sites on agricultural fields and on allotment gardens. The sites no 8, 9 and 10 were situated on the allotment gardens and the remaining on agricultural fields (no 1, 2, 3, 4, 5, 6 and 7) or on reclaimed area (no 11). The number of sites was greater than that of the investigated agrosystems because on some fields the investigations were carried out during several years. The sites were covered with normally cultivated vegetation under practicable agricultural measures with an exception of site no 11 being in a process of reclamation after waste disposal site.

The analysis of soil texture was made with a densimetric method of Cassagrande'a in a modification of Prószyński [3] and with an organoleptic method according to Soil Science Education Standards (USA-2004).

The soils being under investigation were divided into two groups:
I – soils containing until 10.0% of <0.02 mm particles (sandy soils),
II – soils containing 11.0÷18.0% of <0.02 mm particles (loam sandy soils).

The trapping of *Carabidae* was made using Barber's pitfall traps consisted of plastic containers with a diameter of 120 mm and a volume of 600 ml with a solution of ethylene glycol, positioned at ground level. On each site, the randomly placed 10 traps were emptied once a week and the revealed ground beetles were identified to species, whenever possible. The material adopted in this paper include results comprised solely the period of June-July of each year of investigations. Mean number of *Carabidae* individuals trapped per one trap during one week was the standard value assumed in this work.

Statistical assessment of the differences in trapping numbers of *Carabidae* on two examined soil groups was made with a sign test of Dixon and Mood [7] which doesn't require an obligatory material uniformity regarding a place and time. A species diversity indices of Cieślak (1993) and that of Shannon-Wiener and a similarity index of Sorensen were implemented in this work [2, 4, 13].

3. Results

The results of *Carabidae* trapping (table 1) are compiled of five sites and of ten years of investigation on sandy soils and gave a mean number of 19.2 individuals (with confidence limits of 13.8÷24.6) per one trap and during one week. On loam sandy soils six sites were examined during 10 years of investigation what resulted with the mean number of 77.7 individuals respectively (with confidence limits of 46.0÷109.4).

Since the differences between mean numbers of *Carabidae* on loam sandy and sandy soils were in all years to the advantage of the first soil group and had in all cases a positive signs (+), so according to the sign test it could be consider these numbers as belonged to different populations and the difference (77.7÷19.2) as statistically significant at 0.01 level.

In each of the examined soil texture groups at least 17 *Carabidae* species were found with some essential differences in a community composition (table 2). On sandy soils as dominant species (>5%): *Amara sp.* (20.8%), *Poecilus cupreus* (19.8%), *Pseudoophonus rufipes* (17.6%), *Calathus fuscipes* (7.8%), *Pterostichus melanarius* (7.6%) and *Harpalus affinis* (6.8%) can be considered. On loam sandy soils dominated: *Pterostichus melanarius* (22.9%), *Poecilus cupreus* (20.9%), *Carabus auratus* (17.8%), *Pseudoophonus rufipes* (12.8%) and *Amara sp.* (5.8%).

From among of the revealed carabids for typical phytophagous species: *Amara sp.* and *Harpalus affinis* and for typical carnivorous ones: *Carabus auratus, Pterostichus lepidus, Calatus fuscipes, C. erratus, Bembidion sp.* and *Broscus cephalotes* may be numbered [14]. The remaining revealed species feed, as it is supposed on mixed food. So the first species group (phytophagous) made up on sandy soils 27.3% and on loam sandy soils only 10.1%. The second species group (carnivorous) made up on sandy soils 24.8% and on loam sandy soils 28.3%.

On the other hand a typical zoophagous carabid *Broscus cephalotes* was inherent only for sandy soils (0.6%) and *Nebria brevicollis* only for loam sandy soils (1.2%).

As regards the carabids species diversity expressed by generally accepted indices, no significant differences between the two soil types were found. It was clearly proved with the diversity indices of Shannon-Wiener, of Cieślak and with the similarity index of Sorensen (table 2).

Table 1. Trapping number of *Carabidae* in period of June-July on sites with different soil texture (no of individuals per 1 trap per week)

Tabela 1. Liczebność odłowów *Carabidae* w okresie czerwiec-lipiec na stanowiskach o różnym składzie mechanicznym gleb (liczba osobników na 1 pułapkę na tydzień)

Soil texture groups Rodzaj gleb	*No. of site* Stanowisko	*Years* - Lata										*Mean number (confidence limits)* Średnio (przedz. ufn.)
		1995	1996	1997	1998	1999	2001	2002	2003	2004	2005	
I. Sandy Piaszczyste	4	13.7	13.1	17.6	10.5	36.1						**19.2** (13.8÷24.6)
	5									22.0		
	6								32.0	17.0		
	8							21.2			14.0	
	11						14.0					
II. Loam sandy Gliniasto-piaszczyste	1						47.0	63.0	44.5			**77.7** (46.0÷109.4)
	2	37.2	122.6	63.1	119.7	65.0		28.2	254.0			
	3							39.2	109.0			
	7									66.0		
	9										34.0	
	10										73.0	

Table 2. Number (individuals per trap and week) and percentage species composition of *Carabidae* on two soil groups
Tabela 2. Liczebność (szt/pułapkę/tydzień) i skład procentowy gatunków *Carabidae* na dwóch rodzajach gleb

Carabidae species Gatunki *Carabidae*	*Sandy soils* Gleby piaszczyste		*Loam sandy soils* Gleby glin.-piaszczyste	
	number liczebność	%	*number* liczebność	%
1.*Poecilus cupreus* L.	3.80	19.8	16.20	20.9
2. *Pterostichus melanarius* Ill.	1.45	7.6	17.80	22.9
3. *Poecilus lepidus* Les.	0.94	4.9	0.54	0.7
4. *Pseudoophonus rufipes* De Geer	3.38	17.6	9.94	12.8
5. *Semiophonus signaticornis* Duft.	0.03	0.2	0.23	0.3
6. *Carabus auratus* L.	0.53	2.8	13.83	17.8
7. *Amara sp.*	3.99	20.8	4.50	5.8
8. *Calathus fuscipes* (Goeze)	1.49	7.8	1.16	1.5
9. *Calathus erratus* (Sahl.)	0.86	4.5	0.70	0.9
10. *Calathus melanocephalus* L.	0.25	1.3	1.24	1.6
11.*Harpalus affinis* (Schrank)	1.24	6.5	3.36	4.3
12. *Broscus cephalotes* L.	0.11	0.6	-	-
13. *Clivina fossor* L.	0.05	0.3	0.54	0.7
14. *Loricera pilicornis* Fabr.	0.13	0.7	0.78	1.0
15. *Nebria brevicollis* Fabr.	-	-	0.93	1.2
16.*Bembidion sp.*	0.17	0.9	3.73	4.8
17. *Agonum dorsale* Pont.	0.63	3.3	2.02	2.6
18. *Asaphidion flavipes* L.	0.07	0.4	0.15	0.2
Similarity index of Sorensen	94.1%			
Diversity index of Cieślak	4.81		4.36	
Diversity index of Shannon-Wiener	1.99		2.17	

4. Discussion

As Thiele [14] has already pointed out, the qualitative and quantitative differences between heavy and light soils are larger than that between the fauna of various crops. Kirchner (after Thiele [14]) has for example observed fivefold more numerous carabid fauna on clay soil than on sandy one, with a species ratio of 17:11. Similar results were mentioned as well by Tischler [15], Scherney [12] and Heydemann [8]. As it was emphasized both water content and better plant cover and consequently the favorable microclimate on heavy soils may be the good explanation of this phenomenon.

The results presented in this work are very consistent with the mentioned data from literature with reference to the number of carabids on both soil types but not for the species diversity expressed by adequate indices of biodi-

versity. This may be however resulting from a inadequacy in applying of these indices especially in reference to ground beetles where the differences in sample size may be large [11].

On the basis of the mentioned results it my be suggested that the number ratio of phytophagous carabids to the zoophagous ones may be a better index pointing out the differences between the examined agricultural habitats especially from the economic point of view.

5. Conclusions

1. The number of carabids trapped on loam sandy soils was about four times higher than on the sandy ones.
2. No differences in species number of *Carabidae* between the two soil types were observed.
3. The percent composition of the *Carabidae* species on examined soil types differed especially with reference to the amount of typical phytophagous species which was significantly higher on the sandy soils than on loam sandy ones.

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Występowanie owadów biegaczowatych (Carabidae) na glebach piaszczystych i gliniasto-piaszczystych

Streszczenie

Zgodnie z powszechną opinią, owady biegaczowate (*Carabidae)* są w większości pożądanym elementem ekosystemów ze względu na ich rolę w ograniczaniu populacji wielu szkodliwych fitofagów. Występowanie tych owadów w agrocenozach jest co najmniej od 50 lat przedmiotem badań wielu autorów. Większość tych badań dotyczy jednak wpływu różnych systemów rolniczych czy poszczególnych zabiegów agrotechnicznych i agrochemikaliów na liczebność i strukturę gatunkową *Carabidae.* Wpływ składu mechanicznego gleby na występowanie tych owadów jest rozpoznany w mniejszym stopniu szczególnie dla warunków naszego kraju, chociaż istnieje zgodna opinia że czynnik glebowy ma tu decydujące znaczenie.

W niniejszej pracy przedstawiono dziesięcioletnie wyniki badań wykonane na polach uprawnych i kilku ogrodach działkowych Pomorza Środkowego (ogółem 11 stanowisk). Celem tych badań było porównanie liczebności i struktury gatunkowej *Carabidae* na dwóch rodzajach gleb pod względem ich składu mechanicznego: na glebach piaszczystych (do 10% części spławialnych) i na glebach gliniasto-piaszczystych (11÷18% części spławialnych).

Na obu rodzajach gleb stwierdzono jednakową liczbę gatunków owadów biegaczowatych (17 gatunków) lecz istotne różnice co do ogólnej liczebności odłowów wykonanych metodą pułapek Barbera oraz struktury gatunkowej. Na glebach gliniasto-piaszczystych średnia liczebność odłowionych *Carabidae* była czterokrotnie większa niż na glebach piaszczystych (77,7:19,2). Na tych ostatnich udział typowych gatunków fitofagicznych był jednak istotnie większy niż na glebach gliniasto-piaszczystych (odpowiednio: 27,3% i 10,1%). Taki gatunek drapieżny jak biegacz złocisty (*Carabus auratus)* występował na glebach piaszczystych jedynie sporadycznie, a na glebach gliniasto-piaszczystych stanowił 17,8% udziału. Zastosowane współczynniki różnorodności Shannona-Wienera i Cieślaka oraz współczynnik podobieństwa Sorensena nie wykazały jednak istnienia różnic miedzy zgrupowaniami *Carabidae* na badanych rodzajach gleb. Wskazuje to na ich małą przydatność do oceny wyników tego typu badań.