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INTERRELATIONS BETWEEN RELIEF AND DISTRIBUTION OF THE BEETLES FROM FAMILY *Carabidae* IN THE KARST UPLAND LANDSCAPE

WOJCIECH MACIEJOWSKI

Institute of Geography and Spatial Management, Jagiellonian University, Gronostajowa 7, 30-387 Cracow, Poland, e-mail: w.maciejowski@geo.uj.edu.pl

Abstract

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The author discusses the piloting research, conducted in the years 2000–2002, concerning interrelations between relief and distribution of beetles from family *Carabidae*. The study area was located in southern part of Cracow-Częstochowa upland, at the catena across the karst canyon of Szklarka river valley. The material was collected during consecutive years 2000–2003 at 8 measurement points. The ground beetles were caught using pitfall traps method. Total sample consisted of 3321 specimens of *Carabidae* belonging to 51 species. The statistic analysis showed strong linear dependence between the species richness and landform. Altitude and intensity of creeping are important factor for abundance. Other geomorphic factors had no influence on the ground beetles activity (analysis of indexes of diversity was insignificant statistically).

Key words: diversity, geomorphic factors, pitfall trap, *Carabidae*

Introduction

The study area is located in the southern part of the karst Cracow-Częstochowa upland, in the Rudawa river drainage basin (Rudawa is a tributary of the Vistula river), about 12 km north–west of Cracow (Fig. 1). It is a catena across a karst canyon of the Szklarka river (Fig. 2), in the village of Dubie. In the physical-geographical division by Kondracki (2000), the discussed area belongs to the southern part of the Olkusz upland.

Flattened ridges' surface is the landform that dominates in the Olkusz upland. Another prevailing landforms are deep karst canyons. The flattened surface is formed by undulated plain with mean altitude of 400–420 m a.s.l. It is a remnant of Paleogene plantation level (Klimaszewski, 1958). The plantation was formed in limestone rocks, in a hot and humid climate (Pokorny, 1963). In the southern part of the Olkusz upland, a part of the planation

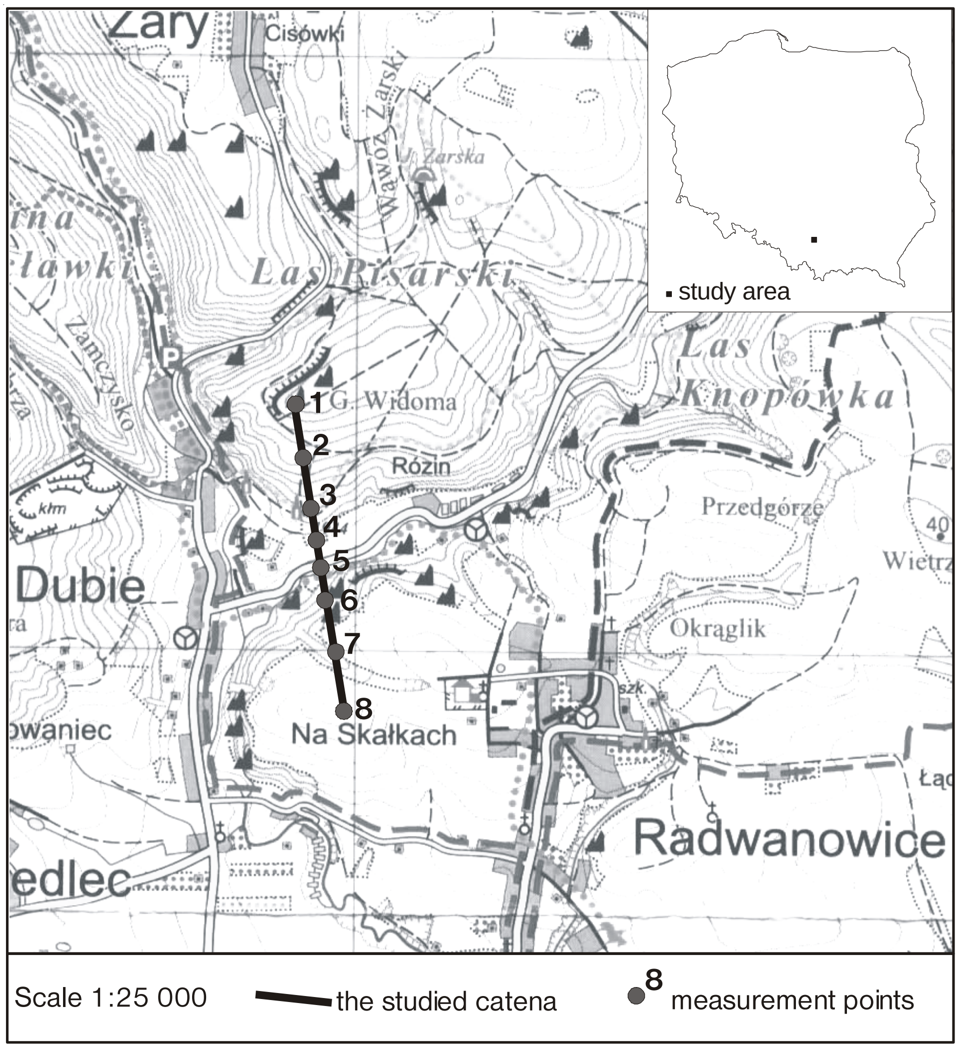

Fig. 1. Study area and measurement points.

surface is lowered along the tectonic fault running evenly with a parallel of latitude, which originated during the Carpathians orogenesis in Miocene. The karst valleys (e.g. the Szklarka valley) which cut the planation surface from north to south got narrower along their course, and in some parts they have the form of deep canyons with rocky slopes. Other karst forms, e.g. dolines, karst springs and caves are also numerous. The Olkusz upland relief is an example of so-called "fluvio-karst", i.e. the relief was formed by karst processes also ac-

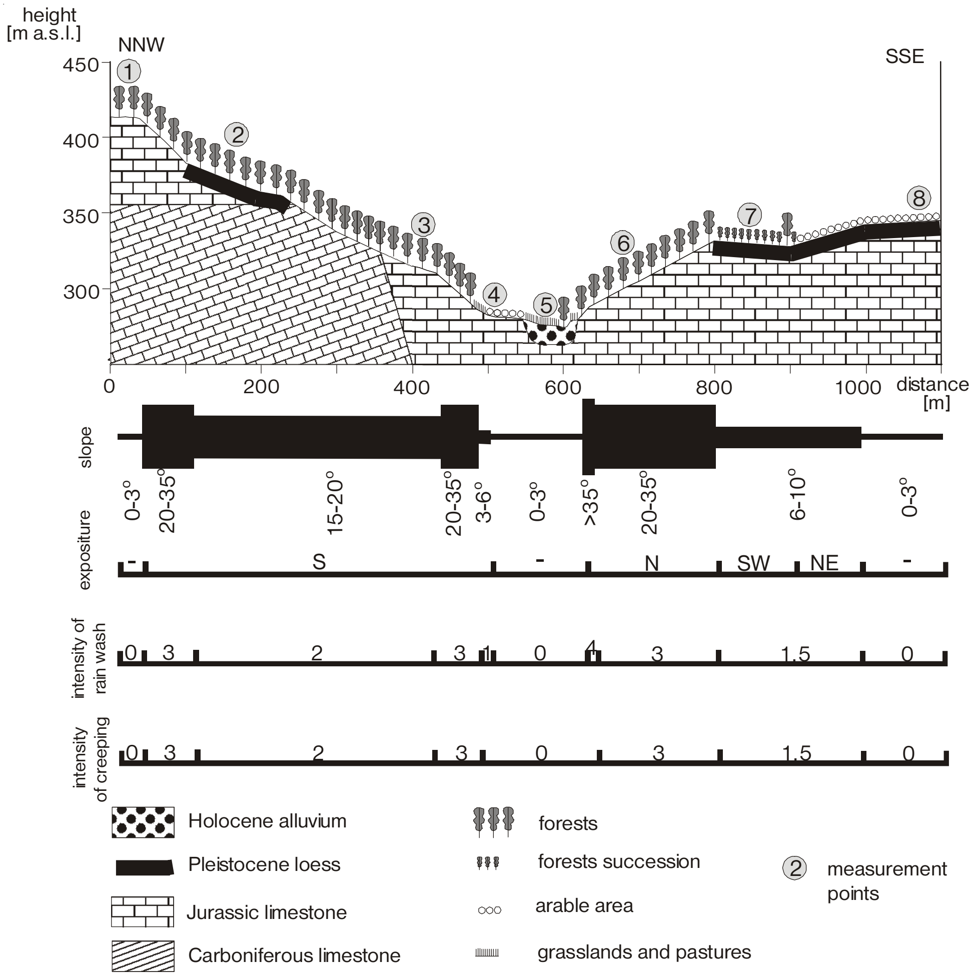

Fig. 2. The studied catena in the Szklarka river valley.

companied by fluvial processes (Klimaszewski, 1981). At the same time, it is a representative for the karst uplands' landscapes.

The discussed catena is 1100 m long and goes from NNW to SSE, across the karst canyon of the Szklarka river, where it reaches 60–90 m of depth. The area is built of resistant limestone of the Lower Carboniferous period and Upper Jurrasic period, covered with Holocene alluvia (The Geological Map..., 1992). The catena is characterised by a large differentiation of landforms, exposure and inclination (Fig. 2), accompanied by morphogenetic processes of various intensity, due to the differences in geological structures and land use. The highest point of the catena is the Widoma Mt. (415 m a.s.l.), and the lowest point is located in the Szklarka river-bed (275.8 m a.s.l.). Therefore, relative altitude is equal to 139.3 m.

Material and methods

The project's aim is to study the relations between the relief and the diversity of beetles from family *Carabidae*.

In the years 2000–2002, the following tasks were accomplished:

- in the lower course of the Szklarka river geomorphologic mapping was completed using the method of Klimaszewski (1981) in order to distinguish the characteristic landforms of the study area
- on the basis of field mapping and analysis of topographic maps (scale 1:10 000), the maps of exposure, inclination and land use were completed, in order to define the intensity of chosen geomorphic processes
- all the mentioned materials were used to choose the catena which is characteristic for the karst canyon of the Szklarka river; additional research was carried in that catena using the method of physical-geographical mapping by Czeppe, German (1978)
- then 8 measurement points were established in the catena, of different geomorphic features (landform, altitude, exposure, inclination, intensity of geomorphic processes)
- in the years 2001–2002, at 8 measurement points, the beetles from family *Carabidae* were caught. At every measurement point 5 pitfall traps were installed following the methods used in the works e.g. by Luff (1986), Thiele (1977), Desender, Pollet (1988); for the traps plastic containers were used, each of them of 33 cm^3 volume, and they were distributed in 5-meter distance one from another; their content was removed every 2–3 weeks
- the obtained material was classified using the identification key by Hurka (1996), and then it was analysed statistically
- the statistic software Statistica was used to find out the relations between geomorphic parameters of the environment and the structure of the beetles grouping; the method of stepwise multiple regression was used (Data analysis..., 1995). The statistic significance of the results was calculated using analysis of variance (ANOVA). The following environmental parameters were taken under consideration: altitude, relative altitude, landform, inclination, exposure, and intensity of rain wash and creeping. The structure of the *Carabidae* assemblage was discribed with the following parameters: abundance, species' richness, species' diversity defined with the Shannon-Wiener index (H') and its eveness (e) (Whittaker, 1970; Magurran, 1988), Simpson index (D) (Ludwig, Reynolds, 1988; Krebs, 1996), Berger-Parker index (B) (Berger, Parker, 1970; Southwood, 1978) and McIntosh index (Q) (Magurran, 1988).

The research presented hereby is a pilot project.

Results and discussion

During the field research, 3321 specimens of carabid beetles from 51 species were captured. The results are presented in Table 1.

The highest number of the *Carabidae* war captured at the measurement point No. 8 (816), and the lowest one at the point No. 4 (58). The highest value of species' richness was found at the point No. 8 (36 species), while the lowest at the point No. 5 (only 4 species). The species *Abax, Carabus* and *Pterostichus* are very common, they were found at several points

T a b l e 1. Abundance and species richness of *Carabidae* in the measurement points

Species	Measurement points							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Carabus arcensis	14	4	4					
Carabus auronitens	9	28						
Carabus cancellatus								5
Carabus coriaceus	6	60	47	7		34		49
Carabus glabratus	44	103	15					
Carabus granulatus				3			2	9
Carabus linnaei		82	17			279	443	3
Carabus nemoralis	81	32	4		3	48		1
Carabus ulrichii	54	8		16		4		
Cychrus attenuatus		23	6					
Leistus ferrugineus								2
Leistus piceus				2	7			2
Nebria brevicollis			9		81			23
Loricera caerulescens							1	
Clivina fossor								1
Broscus cephalotes								1
Asaphidion pallipes								3
Bembidion lampros				1				47
Bembidion quinquestriatum				1				
Bembidion testaceum								2
Bembidion ustulatum								1
Epaphius secalis								5
Amara aulica								1
Amara ovata				7				2
Amara quenseli								2
Amara similata								9
Pterostichus burmeisteri	69	66	5			121	3	
Pterostichus caerulescens		4		16				114
Pterostichus cupreus	1			2				8
Pterostichus niger						4	2	137
Pterostichus oblongopunctatus		30				10	4	
Pterostichus vulgaris	8		34		4	29	14	188
Abax ovalis	87	47	11			38	3	
Abax parallelepipedus	79	18	15			122	34	1
Abax parallelus	8	5	9				8	
Molops piceus						1		
Calathus erratus								15
Dolichus halensis								2
Agonum assimile				2				
Agonum dorsale								38
Agonum muelleri								1
Agonum sexpunctatum								7
Chlaenius nitidulus								1
Harpalus hirtipes								3
Harpalus latus							1	
Harpalus luteicornis				1				
Harpalus quadripunctatus								3
Harpalus rufipes							1	121
Trichotichnus laevicollis								2
Zabrus tenebrioides								6
Drypta dentata								1
Abundance	**460**	**510**	**176**	**58**	**95**	**690**	**516**	**816**
Species richness	**12**	**14**	**12**	**11**	**4**	**11**	**12**	**36**

T a b l e 2. Correlation between the parameters of the carabid assemblages and geomorphic environmental parameters (significance $p < 0.05$)

Assemblages parameters	Geomorphic parameters	B	SE	t	p
Abundance	altitude	5.656	1.116	5.0669	0.00715
	intensity of creeping	236.519	52.853	4.4750	0.01103
$F(3.4) = 11.59$ $p < 0.01926$ $R^2 = 0.90$					
Species' richness	landform	10.120	1.789	5.6555	0.00482
	intensity of creeping	3.971	1.260	3.1527	0.03442
$F(3.4) = 21.71$ $p < 0.00616$ $R^2 = 0.94$					

(mainly 1, 2, 3, 6 and 7). Other species were noted almost exclusively at the point 8 (21 species which makes 41.2%).

The analysis of stepwise multiple regression showed statistically significant correlation between the abundance and species' richness of the ground beetles assemblages, and some morphologic parameters of the environment (Table 2). The variance was explained for over 90% of cases ($R^2 = 0.90$ for the abundance, $R^2 = 0.94$ for the species richness) which is a very high value.

The abundance of ground beetles is positively correlated with the increase of altitude and the increase of creeping intensity. It is caused by the fact that the highest areas are covered with forests typical for the Cracow-Częstochowa upland (beech woods and forest growing on a dry ground). They are found at the measurement points No. 1, 2, 3 and 6. A forest in the phase of succession grows around the point No. 7. Those areas are not cultivated because the inclinations are as high as 15° (points No. 2 and 3) or even 20° (point No. 6). Additionally, the most numerous group of *Carabidae* in this area (e.g. *Carabus* and *Abax*) consists of species that prefer forest habitats.

The correlation between the abundance of ground beetles and the species richness, and the intensity of creeping is also positive. The creeping occurs on slopes with the inclination exceeding 5–7° (Książkiewicz, 1979; Klimaszewski, 1981), and is most intensive on very steep weathered slopes. Such slopes are characteristic for measurement points No. 2, 3 and 6. Other points (No. 4, 5 and 8) are placed in areas of little inclination (0–6°) which are cultivated. Therefore, both abundance and species' richness of ground beetle are lower there.

Interestingly, the largest abundance and species' richness of carabid beetles was found for measurement point No. 8, placed in a flat area (0–3°). The decisive factor was the agricultural land use. The crop rotation provides variety of fauna that become feed for the carabid beetles, used to live in arable lands. That controls the large species' richness, which are not too numerous, unlike in forest habitats.

Landform also plays a certain role in controlling the species' richness. However, it is only the result of the landform's features (inclination, intensity of geomorphic processes and land use).

Conclusion

The research carried in the discussed catena allows making the following conclusions:

- the impact of geomorphic parameters on the structure of the *Carabidae* assemblage is rather low
- the inclination of a slope is the main control of the *Carabidae* assemblage structure; however it is not a direct impact (there is no significant statistical correlation), but it conditions the intensity of morphogenic processes and land use, which in turn controls the abundance and species' richness of the *Carabidae*
- after finishing the pilot project will be tested in larger scale, where more relations between abiotic environmental elements and the spatial distribution of the *Carabidae*.

Translated by the author

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