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THE CHARACTERISTICS OF THE ASSEMBLAGES OF CLICK-BEETLES (COLEOPTERA: ELATERIDAE) OF THE SELECTED PLANT COMMUNITIES IN THE KOZŁOWIECKI LANDSCAPE PARK

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Summary. Evaluation of the protected areas of the Lublin Region has been conducted for many years – landscape parks among others – with respect to the fauna of Elateridae. In the years 2004–2005 the studies on the fauna of click-beetles of the selected plant communities in one of the parks of the Lublin Region – the Kozłowiecki Landscape Park – were conducted. The studies communities were: mixed coniferous forests, dry ground forests, skirt communities and fresh meadows. Quantitative samples were taken with the use of the entomological net and entomological umbrella. Together 27 species of Elateridae were recorded – 22 in skirt communities, 9 in mixed coniferous ones, 6 in fresh meadows and 4 in dry ground forests. The highest biodiversity of elaterofauna was found in skit communities. Five rare in the national elaterofauna species were recorded, in which three are new for two regions of Poland. The most numerous were *Dalopius marginatus* and *Ectinus aterrinus*. The ecological analysis with respect to habitat preferences and microbiotope of development as well as zoogeographical analysis were also provided.

Key words: Elateridae, beetles, Kozłowiecki Landscape Park, zoogeography, ecology

INTRODUCTION

The Kozłowiecki Landscape Park is situated in the Lubartów Plain which is the southern mesoregion of the Południwopodlaska Lowland, a few kilometers from the northern edge of the Lublin Upland [Kondracki 2000]. It was established in 1990 in order to protect a large forest complex with the fragment of treestand of almost natural character as well as forest meadows, marshes and ponds. Forests cover over 90% of its area [Fijałkowski 1996]. It is one of the smallest landscape parks in Poland (6121 ha).

Natural evaluation of the protected areas of the Lublin Region has been conducted for many years – landscape parks among others – with respect to the fauna of Elateridae [Ścibior and Pawlęga 1999, Pawlęga 2003, 2004a, 2010a, b, 2011b]. Especially middle and northern part are relatively poorly known in with respect to the fauna of click-beetles [Burakowski *et al*. 1985, 2000].

Information about click-beetles of the the Kozłowiecki Landscape Park is insufficient. It has been only one paper so far concerning the trial of assessing the degree of the preservation of the selected wet habitats in the park on the basis of the fauna of Elateridae [Pawlęga 2006]. In the quoted paper, the elaterofauna of alders, wet meadows and fens was described. This papers is a continuation and complement to the elaboration of the elaterofauna of the park which is the effect of wider group studies on some groups of invertebrates of different types of habitats conducted in the years 2004–2005. The aim of the paper is to present species biodiversity, qualitative and quantitative structure as well as similarities of the assemblages of elaterofauna of the examined plant communities together with ecological and zoologeographical characteristics.

MATERIAL AND METHODS

The studies on click-beetles of the Kozłowiecki Landscape Park were conducted in four plant communities of closed and open biotopes. Those were as follows (Tab. 1):

– mixed coniferous forests (*Leucobryo-Pinetum*, *Molinio-Pinetum*, *Peucedano-Pinetum*) (sites no. 2, 3, 4, 5),

– dry ground forests (*Tilio-Carpinetum*) (sites no. 7),

– skirt communities (sites no. 1, 6, 8),

– fresh meadows (clasis *Arrhenatheretalia*) (sites no. 9).

The quantitative take of adult forms from herbaceous plants was made with the use of the entomological net. One sample consisted of 100 net strokes. The click-beetles from trees and bushes were shaken down to the entomological umbrella. For one quantitative sample the branches of five trees or bushes, accessible from ground level, were shaken. The samples of adult click-beetles were done regularly from April to August, twice a month, in 2004–2005 years.

For the analysis of the collected material the following biocenotic indices were used: dominance (D), constancy of occurrence in samples (C), ecological importance (Q), species diversity indices of Shannon-Weaver, as well as qualitative similarity according to Jaccard formula with the use of Biodiversity Pro program [Kasprzak and Niedbała 1981, Krebs 1996, Neil McAleece *et al*. 1997]. The classes D , C and Q were assumed after Kasprzak and Niedbała [1981], and the values of indices were rounded to tenths. Only in the case of click-beetles collected in fresh meadows those indices were not calculated due to the small numbers of individuals. The ecological analysis with respect to habitat preferences and microbiotope of development as well as zoogeographical analysis were also provided.

RESULTS

As a result of conducted studies on the fauna of Elateridae of the described plant communities, 27 click-beetle species were recorded (Tab. 1). Worth mentioning is the fact that five species are regarded as rare ones in the national elaterofauna and three of them are new to two regions of Poland. *Adrastus lacertosus* has been recorded for the first time for the Lublin Upland. It was shaken down (1 individ.) to the entomological umbrella in the skirt community of oak and birch understory, in the village of Wandzin (date: 20.07.2005) (Tab. 1 and 2).

Table 1. The occurrence of Elateridae at study sites in the Kozłowiecki Landscape Park

Species	Examined stations								
	1	2	3	4	5	6	7	8	9
Agrypnus murinus (L., 1758)	+			+				+	
Cidnopus aeruginosus (OLIV., 1970)	+							+	
Hemicrepidius niger (L., 1758)									+
Athous vittatus (GMELIN, 1790)			+			+		+	
Athous haemorrhoidalis (FABR., 1801)	+							+	
Athous subfuscus (O.F. MÜLL., 1764)		+	+	+		+	+	+	
Denticollis linearis (L., 1758)							+		
Ctenicera pectinicornis (L., 1758)								+	
Actenicerus siaelandicus (O.F. MÜLL., 1764)								+	+
Prosternon tessellatum (L., 1758)	+		+			+		+	
Paraphotistus impressus (FABR., 1792)			+						
Selatosomus aeneus (L., 1758)									+
Selatosomus gravidus (FABR., 1801)									+
Ampedus balteatus (LINNAEUS, 1758)			+			+			
Ampedus elongatulus (FABR., 1787)								+	
Ampedus nigrinus (HERBST, 1784)						+			
Melanotus villosus (GEOFF., 1785)		+	+			+			
Adrastus limbatus (FABR., 1777)								+	
Adrastus pallens (FABR., 1792)								+	
Adrastus lacertosus (ERICHSON, 1841)	+								
Dalopius marginatus (L., 1758)	+	+	+	+	+	+	+	+	+
Ectinus aterrimus (L., 1761)		+	+	+		+	+	+	
Agriotes lineatus (L., 1767)				+					
Cardiophorus ruficollis (L., 1758)	+					+			
Cardiophorus rufipes (GOEZE, 1777)								+	
Dicronychus rubripes (GERMAR, 1824)								+	
Dicronychus cinereus (HERBST, 1784)	+							+	

1 – Wandzin 51°23'45"N 22°37'50"E UTM FB19, 2 – division no. 161 51°23'06"N 22°37'11"E UTM FB19, 3 – „Świerkowa linia" 51°24'59"N 22°31'53"E UTM FB09, 4 – reserve „Kozie Góry" 51°24'05"N 22°35'51"E UTM FB19, 5 – Majdan Kozłowiecki 51°24'18"N 22°34'13"E UTM FB09, 6 – Majdan Kozłowiecki 51°24'42"N 22°34'24"E UTM FB09, 7 – Stary Tartak 51°24'21"N 22°31'05"E UTM FB09, 8 – planned nature reserve „Wielosił" 51°22'20"N 22°34'12"E UTM FB09, 9 – Nowy Staw 51°23'07"N 22°33'46"E UTM FB09

Table 2. List of species and biocenotic indices (in percentage version) of Elateridae found in the examined habitats communities of Kozłowiecki Landscape Park in 2004–2005 years

Species	S	Overall			Mixed coniferous forests			Dry ground forests			Skirt communities			Fresh mead-ows
		D	C	Q	D	C	Q	D	C	Q	D	C	Q	L
Agrypnus murinus	22	4.8	15.1	8.5	1.2	6.3	2.7				7.8	29.2	15.1	
Cidnopus aeruginosus	8	1.7	11.3	4.4							2.9	25.0	8.5	
Hemicrepidius niger	4	0.9	3.8	1.8										4
Athous vittatus	12	2.6	11.3	5.4	1.2	6.3	2.7				4.1	20.8	9.2	
Athous haemorrhoidalis	20	4.4	15.1	8.2							7.4	33.3	15.7	
Athous subfuscus	44	9.6	30.2	17.0	8.5	37.5	17.9	31,4	85,7	51,9	2.2	1.3	1.7	4
Denticollis linearis	2	0.4	1.9	0.9				2,3	1,4	1,8				
Ctenicera pectinicornis	1	0.2	1.9	0.6							0.4	4.2	1.3	
Actenicerus siaelandicus	16	3.5	11.3	6.3							2,6	16.7	6.6	9
Prosternon tessellatum	32	7.1	16.9	10.9	1.2	6.3	2.7				11.5	33.3	19.6	
Paraphotistus impressus	1	0.2	1.9	0.6							0.4	4.2	1.3	
Selatosomus aeneus	+													+
Selatosomus gravidus	4	0.9	3.8	1.8										4
Ampedus balteatus	4	0.9	7.5	2.6							1.5	16.7	5.0	
Ampedus elongatulus	1	0.2	1.9	0.6							0.4	4.2	1.3	
Ampedus nigrinus	1	0.2	1.9	0.6							0.4	4.2	1.3	
Melanotus villosus	2	0.4	3.8	1.2	1.2	6.3	2.7				0.4	4.2	1.3	
Adrastus limbatus	4	0.9	1.9	1.3							1.5	4.2	2.5	
Adrastus pallens	2	0.4	1.9	0.9							1.7	4.2	2.7	
Adrastus lacertosus	1	0.2	1.9	0.6							0.4	4.2	1.3	
Dalopius marginatus	168	36.6	66.0	49.1	61.1	87.5	73.1	51,2	100	71,6	27.1	54.2	38.3	1
Ectinus aterrimus	56	12.2	39.6	21.9	24.4	43.8	32.7	15,1	71,4	32,8	8.6	37.5	17.9	
Agriotes lineatus	1	0.2	1.9	0.6	1.2	6.3	2.7							
Cardiophorus ruficollis	6	1.3	7.6	3.1							2.2	16.7	6.1	
Cardiophorus rufipes	2	0.4	3.8	1.2							1.7	8.3	3.8	
Dicronychus rubripes	21	4.6	9.4	6.6							7.8	20.8	12.7	
Dicronychus cinereus	23	5.0	5.7	5.3							8.6	12.5	10.4	

S – overall numer of individuals of Elateridea in quantitative samples, D – dominance, C – constancy of occurrence in samples, Q – ecological significance, L – number of individuals of Elateridea in quantitative samples in fresh meadows communities, + – qualitative sample

The remaining two – *Ampedus elongatulus* and *Dicronychus rubripes* – are species new to the Masovian Lowland. Both occurred in the skirt community in the planned nature reserve „Wielosił". *Ampedus elongatulus* was caught 25.05.2005 with the entomological net from herbaceous plants. *Dicronychus rubripes* was shaken down from insulated bushes – 1 individual 11.05.2004, 2 individ. 27.05.2004, 17 individ. 15.06.2004 and 1 individ. 15.06.2005 (Tab. 1 and 2). According to physiographic division of Poland, the localities mentioned above belong to the Południowopodlaska Lowland, however, while giving new species the author adopted to the constantly used by entomologists in such types of descriptions (in faunistics) division of Poland into zoogeographical regions included in the Catalogue of the fauna of Poland [Burakowski *et al*. 1985].

In the studied area of the park two species – *Dalopius marginatus* (D = 36.6%) and *Ectinus aterrinus* (D = 12.2%) were collected the most numerously. Those species also occurred most numerously in all of the examined communities, except for *Ectinus aterrinus* in fresh meadows (Tab. 2). *Athous subfuscus* (D = 9.6%) and *Prosternon tessellatum* (D = 7.1) turned out to be the dominants. Six species formed the class of subdominants with the values of the index from 2.6% to 5.0% (Tab. 2). The class of recedents was not numerous – two species: *Cidnopus aeruginosus* (D = 1.7%) and *Cardiophorus ruficollis* (D = 1.3%). Slightly more than the half of the species were caught in small numbers or as a single individual. They comprised the class of recedents (Tab. 2). Particular species occurred in the samples with different frequency. The values of „C" index as well as ecological importance (Q) for every species are given in the Table 2.

Analyzing the species with respect to the microbiotope of development, the following qualitative shares in the particular groups were obtained: soil ones 53.8%, saproxylobiontic 7.7%, soil ones, sometimes developing in microbiotopes of rotten wood 26.9%, saproxylobiontic, sometimes living in soli 11.5%. The analysis of habitat preferences was as follows: forest ones 55.6%, meadow and hygrophilous environments 22.2%, xerothermic grasslands 11.1% and the eurybionts 11.1%.

The richest in species (22) were skirt communities. They also showed the highest species diversity of the fauna of Elateridae which was 2.44. The species of forest habitats were dominating (63.6% of qualitative share and 75.4% of quantitative share), of which *Dalopius marginatus* (D = 27.1%) and *Prosternon tessellatum* (D = 11.5%) turned out to be eudominants. Meadow species were less numerous (18.2% and 5.2% of share, respectively). Two xerothermic and eurytopic species were also collected, and their qualitative share was 19.4%. With respect to the microbiotope of development, the half comprised soil species, however, they were less numerous than soil species sometimes developing in rotten wood (42.5% and 52.9% of quantitative share). Saproxylobiontic sometimes developing in soil comprised 13.6% but their qualitative share was only 2.2%. saproxylobiontic were the least numerous – 1 species.

Definitely less elaterid species were found in mixed coniferous forests (9) and those were forest (8 spec.) and eurytopic species (1 spec.). Biodiversity index reached the value of 1.12. Soil species, sometimes developing in microbiotopes of rotten wood were predominating (44.4% of qualitative share and 95.1% of quantitative share). Soil (3) and saproxylobiontic-soil species (2) were also recorded. Paradoxically, the typical saproxylobiontic species were not collected.

Slightly less species were noted from the communities of fresh meadows (6), the least – in dry ground forests (4). Biodiversity index of elaterofauna for those communities was 1.43 and 1.07 respectively. In the elaterofauna of fresh meadows, forest (2), meadow (2), xerothermic (1) and eurytopic (1) species occurred, however, the most numerous group were evidently meadow species (59.1%). The analysis of the microbiotope of development showed that the assemblage of elaterids of fresh meadows consisted of half of the soil species and soil ones, sometimes developing in rotten wood. However, all of the click-beetle species of dry ground forests were forest species, in which soil species with the probability of the development in rotten wood were strongly predominating (3 spec., 97.7% of quantitative share).

The list of click-beetle species of particular communities with the corresponding values of D, C and Q indices is given in Table 1.

The analysis of qualitative similarities of elaterocenoses of the examined communities showed that the highest similarity was between elaterofauna of mixed coniferous forests and the fauna of dry ground forests and skirt communities (33.3 and 30.4%, respectively), the lowest similarity was between click-beetles of skirt communities and fresh meadows. The arrangement of similarities is shown in Fig. 1.

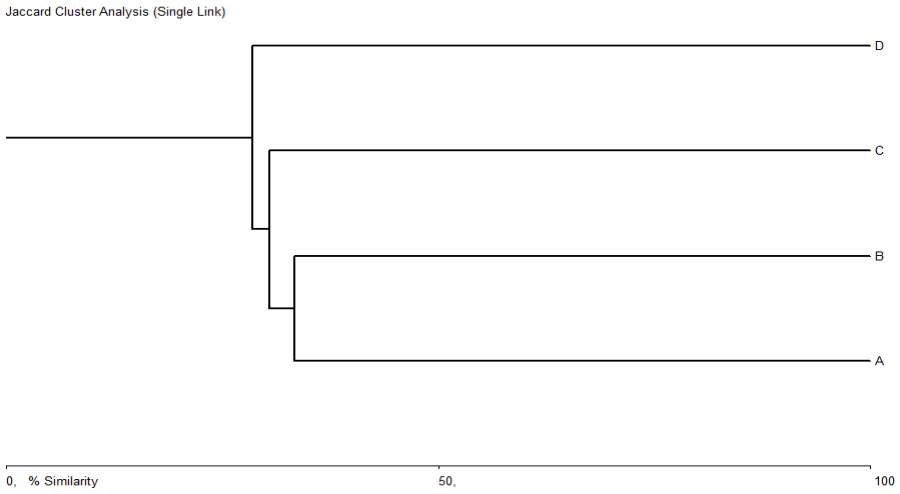

Fig. 1. Faunistic similarities between Elateridae of the examined plant communities in the Kozłowiecki Landscape Park: A – mixed coniferous forest, B – dry ground forest, C – skirt communities, D – fresh meadows

The assemblage of click-beetles of plant communities in the park was characterized by the highest dominance of wide-range zoogeographical elements, both qualitative and quantitative (70.4 and 78.4%, respectively). The smallest share had Pontic-Mediterranean species – the narrow-range species (7.4 and 3.1%, respectively). Qualitative and quantitative shares of particular zoogeographical elements were as follows: Holarctic ones 14.8 and 15.5%, Palearctic 3.7 and 0.4%, Eurosiberian 22.2 and 39.7%, Eurasian 29.6 and 22.7%, European 18.5 and 18.3%, middle European 3.7 and 0.2%.

DISCUSSION

The studies on click-beetles of the selected communities of the Kozłowiecki Landscape Park allowed to record the presence of 27 species of these beetles. So far, 11 species of Elateridae have been found in the park in wet biotopes [Pawlęga 2006]. Taking this data into consideration, the number of species described at present in the area of the park is 28. Obviously, this is not the final number. The conducting of further studies would increase the potential opportunity for its enlargement, especially the penetration of different microhabitats of rotten wood in searching for saproxylophilous species. Validity of the studies of faunistic and ecological character of the elaterofauna not only in the park itself but also other areas of the northern Lublin Region, especially under protection, justify the fact of the discovering rare and 3 new for two zoogeographical regions of Poland species in the studied area. In the case of one of them – *Dicronychus rubripes* – the northern boundary of its range, probably running through Poland, has been moved [Burakowski *et al.* 1985]. So far, the foremost site of this species was Tarnogóra and Dobre [Burakowski *et al*. 1985, Ścibior and Pawlęga 1999]. Nowadays it was caught in the planned nature reserve Wielosił. Comparing the species richness of Elateridae of the park with other parks in the Lublin Region it can be described as the average level. Form the area of „Lasy Janowskie" Landscape Park, Pawlęga [2003, 2004a, 2010a, 2011a] and Pawlęga and Kowalczyk-Pecka [2011b] recorded 38 click-beetle species at the moment, and in the Poleski National Park – 20 species [Pawlęga 2010b].

Most data concerning click-beetles of plant communities described in this paper refers to larval forms of these beetles which limits the wider discussion due to specificity of these papers and narrows it in principle to qualitative comparisons.

Definitely the highest number of species was noted in skirt communities (22). Without doubts this number results from the character of these communities. As ecotone communities they floristically refer to different classes of vegetation [Matuszkiewicz 2001]. The composition of these phyotocenoses is the mosaic of contact communities which creates the conditions for the existence of elaterofauna connected either with forest and thicket habitats or herbaceous vegetation. This reflects in qualitative share of species from particular ecological groups in the studied skirt communities. As the bush thickets were dominating, it

meant slightly higher share of forest species in relation to other habitat groups. In contrast, species typical of soil and more or less associated with soil and microbiotopes of rotten wood occurred in equal shares. (they equally found favourable conditions for living in there). Thermophilous character of skirt communities creates the conditions for the existence of xerothermic species. Apart from fresh meadows those were the communities where such species occurred. The features of a community and species richness of Elateridae and shares of particular species among others formed the high value of species diversity of elaterofauna (H = 2.44) of the studied skirt communities.

The number of species of Elateridae of mixed coniferous forest communities of the Kozłowiecki Landscape Park in comparison to the results of other authors from different regions of Poland was at a bit lower level. The most of these papers refer to larval click-beetles which limits the wider discussion due to specificity of these papers and narrows it in principle to qualitative comparisons. Nowakowski [1981] mentioned 13 species of Elateridae from mixed coniferous and pine forests of Białołęka Dworska, with 4 determined on the basis of adults in it. Tarnawski [1980] from forest habitats of Wrocław described 12 species of larvae and Kornalewicz [1979] from mixed coniferous forests in the vicinity of Wrocław – 6 species. 31 click-beetles species were given by Pawlęga [2004b] from different types of coniferous forests in „Lasy Janowskie" Landscape Park. High diversity of these coniferous forests as well as long-lasting studies encompassing two living forms of click-beetles allowed to distinguish much higher number of Elateridae species in comparison to the Kozłowiecki LP. The penetration of microbiotopes of development of saproxylobiontic species would obviously increase the number of species from the genus *Ampedus*.

Click-beetles of fresh meadows were studied at one site in the area of the park, from which 9 species of these beetles were recorded. Meadow communities cover small percentage of the area of the park [Fijałkowski 1996]. From fresh meadows of the „Lasy Janowskie" Landscape Park, Pawlęga [2010a] gives 18 species of imaginal Elateridae. The qualitative similarity of elaterocenoses of fresh meadows of both parks was 14.3%, which resulted from the difference in number of species most of all – the maximum could reach 33.3%. In the Kozłowiecki LP *Actenicerus siaelandicus* was distinguished by the highest number of specimens. It was also one of the eudominants of fresh meadows of the „Lasy Janowskie" LP. Despite the difference in the number of species, the common feature of elaterofauna of fresh meadows of the KLP and „LJ" LP was the occurrence of click-beetle species of every habitat group in these communities. Similarly, in the elaterofaunas of both parks only soil species and soil ones, sometimes developing in biotopes of rotten wood occurred [Pawlęga 2010a]. From soil biotopes of different types of meadows in poviats of the Lublin region and its vicinities Honczarenko [1956, 1970] recorded respectively 13 and 18 species of larval Elateridae and the most similar to those communities was the elaterofauna of fresh meadows of the KLP (a bit over 26% of similarity). From meadow habitats and pastures of the Western Bieszczady Burakowski [1971]

described 11 Elateridae species among which *Agriotes obscures* was dominating. This species was absent in the Kozłowiecki LP. 13 species of larvae are mentioned by Tarnawski [1987] from different types of meadows in forests of Wrocław.

The poorest in click-beetle species was the community of dry ground forests (4 species). In the park, dry ground forests has a small share which resulted in serious narrowing of study area to one study site. Moreover, the studies refers to imaginal stages and no collecting of larvae were conducted which would extend the list of species without doubts. The typical forest character of dry ground forests was connected with the occurrence of forest elaterid species only and the lack of the species typical of soil. Small number of species and their dominances influenced the lowest index of species diversity of the elaterofauna of this community of the studied communities. There are no many papers in literature referring to Elateridae of dry ground forests *sensu stricto*. Nowakowski [1981] in the studies on click-beetles of Białołęka Dworska recorded 11 species from dry ground forests. Among them only 5 were distinguished from imaginal forms. Species similarity between elaterofauna of dry ground forests in the park and the quoted ones was small (15.4%).

Comparing the shares of zoogeographical elements in the elaterofauna of the Kozłowiecki Landscape Park, „Lasy Janowskie" Landscape Park and Poleski National Park it can be concluded that in all of them wide-range elements were dominating [Pawlęga 2010a, b].

CONCLUSIONS

1. The fauna of click-beetles at the present state of studies is characterized by the average species richness in comparison to the rest of park of the Lublin Region.
2. The Kozłowiecki Landscape Park is the faunistically attractive area for the studies on elaterofauna which is confirmed by the recording of rare and new for two zoogeographical regions of Poland species.
3. Elaterofauna of the examined plant communities was characterized by its own specifics which is confirmed by its own differences and similarities, species diversity and the results of ecological analysis.
4. The continuation of the studies and their complementation in the studies on larval stages in their microhabitats of development would allow to expand the list of Elateridae species of this region of Poland.

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CHARAKTERYSTYKA ZGRUPOWAŃ CHRZĄSZCZY SPRĘŻYKOWATYCH (COLEOPTERA: ELATERIDAE) WYBRANYCH ZBIOROWISK ROŚLINNYCH KOZŁOWIECKIEGO PARKU KRAJOBRAZOWEGO

Streszczenie. Od wielu lat prowadzona jest inwentaryzacja przyrodnicza obszarów chronionych Lubelszczyzny – w tym parków krajobrazowych – pod względem fauny Elateridae. W latach 2004–2005 prowadzono badania nad fauną sprężykowatych wybranych zbiorowisk roślinnych jednego z parków Lubelszczyzny – Kozłowieckiego Parku Krajobrazowego. Badanymi zbiorowiskami były: borowe, grądy, okrajkowe i łąki świeże. Próby ilościowe pobierano czerpakiem i parasolem entomologicznym. Łącznie odnotowano 27 gatunków Elateridae – 22 w zbiorowiskach okrajkowych, 9 w borowych, 6 łąk świeżych i 4 w grądach. Największą bioróżnorodnością elaterofauny cechowały się zbiorowiska okrajkowe. Stwierdzono pięć gatunków rzadkich w elaterofaunie krajowej, a trzy z nich to gatunki nowe dla dwóch krain Polski. Najliczniej występował *Dalopius marginatus* i *Ectinus aterrinus*. Przeprowadzono także analizę ekologiczną ze względu na preferencje siedliskowe i mikrobiotop rozwoju oraz analizę zoogeograficzną.

Słowa kluczowe: Elateridae, chrząszcze, Kozłowiecki Park Krajobrazowy, zoogeografia, ekologia