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CURRENT STRUCTURE OF LEAF BEETLE ASSEMBLAGES (COLEOPTERA, CHRYSOMELIDAE) OF FOREST COMMUNITIES IN THE KRZEMIONKI OPATOWSKIE RESERVE AS A RESULT OF SUCCESSION OF VEGETATION

Radosław Ścibior*, Robert Stryjecki*, Urszula Bronowicka-Mielniczuk**, Danuta Kowalczyk-Pecka*

* Department of Zoology, Animal Ecology and Wildlife Management, University of Life Sciences in Lublin, Akademicka str. 13, 20-950 Lublin, e-mail: radoslaw.scibior@up.lublin.pl
** Department of Applied Mathematics and Computer Science, University of Life Sciences in Lublin, Głęboka str. 28, 20-612 Lublin

Abstract. The aim of the study was to specify the current status and direction of transformations of leaf beetle assemblages taking part in the rapid process of succession of vegetation towards the types of forest communities occurring in the Krzemionki Opatowskie reserve. At five sampling sites (in five plant associations) 30 species of Chrysomelidae were recorded. Five typical forest species (*Chrysomela populi*, *Pyrrhalta viburni*, *Calomicrus pinicola*, *Altica brevicollis* and *Cryptocephalus labiatus*) accounted for 16.67% of the number of species and 12.85% of the number of individuals caught in the reserve. The forest association richest in species (18) was *Querco roboris-Pinetum* (Que_Pin). This was followed by *Tilio-Carpinetum* association (Til_Car, 15 spp.), and then a mosaic of *Tilio-Carpinetum* and *Querco roboris-Pinetum* (Til_Car/Que_Pin), and *Peucedano-Pinetum* (Peu_Pin) (11 spp. each). The fewest number of species (10) were noted in *Potentillo albae-Quercetum* (Pot_Que). The most similar were the fauna of *Potentillo albae-Quercetum* (Pot_Que) and *Querco roboris-Pinetum* (Que_Pin) (55.08% similarity). The most distinct was the fauna of *Peucedano-Pinetum* (Peu_Pin). We can conclude that the structure of the leaf beetle assemblages in the forest associations studied in the reserve is at present an adaptive mixture of faunas characteristic of all the intermediate successional stages of vegetation, changing in this area in a relatively short time. The considerable diversity of fauna is the result of an 'ecotone in time', i.e. the continuous presence of open-land species, which until recently had dominated here, accompanied by forest species characteristic of the current habitat types.

Key words: Chrysomelidae, succession, forest species, open-land species, ecotone in time

INTRODUCTION

The Krzemionki Opatowskie reserve is a small faunistic landscape reserve with an area of 378.79 ha, protecting molluscs, rare (including protected) plants (often calciphilous) occurring here in parts of the forests receiving more sunlight, mining excavations, and traces of striped flint mining camps [Walczak *et al*. 2001]. The territory of the Krzemionki Opatowskie reserve is a very interesting example of restructuring of vegetation, accompanied by a transformation of the phytophagous fauna, which has proceeded very rapidly and in many directions: from deforested agricultural fields (from the 18th century to 1967) on the site of an inactive flint mine, to the presence of calcareous thermophilous communities, followed by scrub communities, and finally several types of forest associations, characteristic of a strip of uplands, which are currently dominant [Stachurski *et al*. 2006].

A following hypothesis has been assumed: because of rapid succession in vegetation in the reserve – from deforested agricultural fields into several types of forest associations – leaf beetle assemblages should be a mix of open-land species and typical forest species. Open-land species should predominate on this area as forest associations have lasted for pretty short time. The main objective of the study was to verify that hypothesis by specifying the current status and direction of transformations of leaf beetle assemblages taking part in the rapid process of succession of vegetation towards the several types of forest communities currently present in the reserve. The value and availability of these communities for the Chrysomelidae colonizing them were evaluated as well. Leaf beetles have been used for several decades in bioindicator studies in Poland and other European countries [Warchałowski 1978, Gräf and Koch 1981, Wąsowska 1989, 1994, 1996, 1999, Raj 1996, 1997]. In Poland, for over a decade [Gutowski 2004, Wąsowska 2005] and up to the present [Gutowski – oral information] leaf beetles have been used in long-term monitoring of forest habitats of the Białowieża Forest and a few other, larger forest complexes in the country [Gutowski *et al*. 2006]. An in-depth review of the literature on the use of invertebrates in monitoring of forest habitats can be found in a study by Gutowski and Krzysztofiak [1995].

In addition, the study took into account the need for a detailed nature valuation in the reserve based on the example of leaf beetles, postulated by the authors of joint studies of this area, which is of great interest in many other respects [Cieśliński *et al*. 2006, Stachurski *et al*. 2006], as the level of knowledge of invertebrates of nearly all systematic groups in the reserve is negligible or non-existent.

STUDY AREA

Krzemionki Opatowskie is part of the Dolina Kamiennej Protected Landscape Area and is situated in the Przedgórze Iłżeckie region of the Małopolska Upland, a few kilometres northeast of Ostrowiec Świętokrzyski (Fig. 1). The region (mesoregion) is characterized by outcrops from Jurassic Period forming low monoclines,

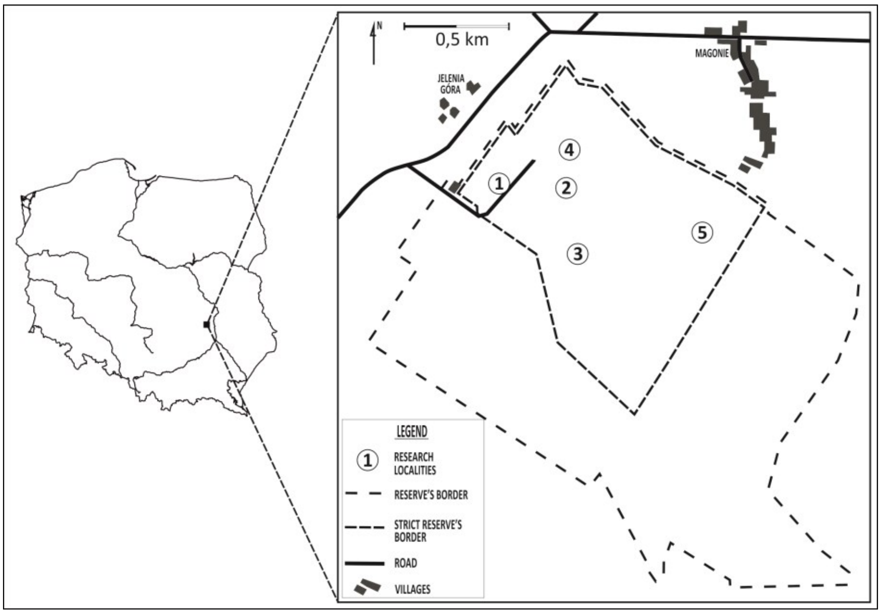

Fig. 1. Location of the sampling sites corresponding to particular types of forest communities occurring in the Krzemionki Opatowskie reserve

between which Quaternary sand and loam lie in depressions [Kondracki 2014]. The study area is largely a forest ecosystem in various stages of succession and differentiation of forest associations. For the purpose of valuation of individual forest associations in the reserve based on leaf beetle communities, five study sites were established with different types of plant associations:

1. an anthropogenic *Peucedano-Pinetum* (Peu_Pin) association – a phytocoenosis serving as a substitute for a degenerated mixed coniferous forest, 50°58’20.3”N, 21°29’34.18”E;

2. *Potentillo albae-Quercetum* (Pot_Que), with a relatively sparse tree stand (30%) ensuring that light can reach the forest floor, 50°58’22.2”N, 21°29’48.27”E;

3. *Tilio-Carpinetum* habitat (Til_Car), with a large area and numerous scattered depressions, which are the remains of Neolithic mine shafts, 50°58’13.58”N, 21°29’44.28”E;

Table 1. Total number of species (taxa) and numbers of leaf beetles collected in particular types of forest communities in the Krzemionki Opatowskie reserve

No	Species/ Taxon	SNF	PS	N	Site/ Type of forest community				
					1	2	3	4	5
1	*Bruchus atomarius* (Linnaeus, 1760)	Bru_ato	O	6				6	
2	*Lilioceris lilii* (Scopoli, 1763)	Lil_lil	O	1		1			
-	*Oulema melanopus/duftschmidi*[*] ♀	-	-	0	1	2	2	2	3
3	*Oulema duftschmidi* (Redtenbacher, 1874)	Oul_duf	O	2	1			1	
4	*Oulema gallaeciana* (Heyden, 1870)	Oul_gal	O	6			2	1	3
5	*Oulema melanopus* (Linnaeus, 1758)	Oul_mel	O	7	1		2	3	1
6	*Cassida prasina* Illiger, 1798	Cas_pra	O	1				1	
7	*Hispa atra* Linnaeus, 1767	His_atr	O	1				1	
8	*Chrysomela populi* Linnaeus, 1758	Chs_pop	F	2			1		1
9	*Chrysolina polita* (Linnaeus, 1758)	Chr_pol	O	12	1	1	4		6
10	*Chrysolina varians* (Schaller, 1783)	Chr_var	O	14	1		9	2	2
11	*Pyrrhalta viburni* (Paykull, 1799)	Pyr_vib	F	36		29	1	6	
12	*Sermylassa halensis* (Linnaeus, 1767)	Ser_hal	O	2	2				
13	*Calomicrus pinicola* (Duftschmid, 1825)	Cal_pin	F	9		9			
-	*Altica* n. det[*] ♀	-	-	0		11	47	10	
14	*Altica brevicollis* Foudras, 1861	Alt_bre	F	30		5	17	7	1
15	*Aphthona ovata* Foudras, 1861	Aph_ova	O	101		9	13	77	2
-	*Chaetocnem aconcinna/picipes*[*] ♀	-	-	0	1			1	1
16	*Derocrepis rufipes* (Linnaeus, 1758)	Der_ruf	O	376		243	7	126	
-	*Longitarsus succineus/noricus*[*] ♀	-	-	0	1				
17	*Longitarsus anchusae*(Paykull, 1799)	Lon_anc	O	2			2		
18	*Longitarsus luridus* (Scopoli, 1763)	Lon_lur	O	4		1		3	
19	*Longitarsus melanocephalus* (De Geer, 1775)	Lon_mel	O	5	1				4
20	*Longitarsus nasturtii* (Fabricius, 1792)	Lon_nas	O	1				1	
21	*Longitarsus parvulus* (Paykull, 1799)	Lon_par	O	1				1	
22	*Longitarsus pratensis* (Panzer, 1794)	Lon_pra	O	1			1		
23	*Neocrepidodera ferruginea* (Scopoli, 1763)	Neo_fer	O	2			1		1
24	*Phyllotreta nemorum* (Linnaeus, 1758)	Phy_nem	O	2				1	1
25	*Phyllotreta vittula* (Redtenbacher, 1849)	Phy_vit	O	2	1		1		
26	*Sphaerodermates taceum* (Fabricius, 1775)	Sph_test	O	7	4		2	1	
27	*Cryptocephalus aureolus* Suffrian, 1847	Cry_aur	O	2	2				

28	*Cryptocephalus labiatus* (Linnaeus, 1760)	Cry_lab	F	6	3		1	1	1
29	*Cryptocephalus moraei* (Linnaeus, 1758)	Cry_mor	O	1				1	
30	*Cryptocephalus sericeus* (Linnaeus, 1758)	Cry_ser	O	2	1	1			
	Total numer of specimens				21	312	113	253	27
	Total numer of species				11	10	15	18	11

SNF – abbreviation of the species name used in the diagrams. 1–5 – sites/types of forest communities. 1. Peu_Pin – *Peucedano-Pinetum*, 2. Pot_Que – *Potentilloalbae-Quercetum*, 3. Til_Car – *Tilio-Carpinetum*, 4. Que_Pin – *Quercoroboris-Pinetum*, 5. Til_Car/Que_Pin – *Tilio-Carpinetum*/*Quercoroboris-Pinetum*. PS – habitat preferences: F – typical forest species, O – open-land species
* That could not be identified to species level and omitted in quantitative analysis

4. *Querco roboris-Pinetum* (Que_Pin), bearing signs of a degraded oak forest in places, 50°58'26.85"N, 21°29'44.28"E;

5. *Tilio-Carpinetum*/*Querco roboris-Pinetum* (Til_Car/Que_Pin), arranged in a mosaic, 50°58'19.23"N, 21°30'17.5"E.

MATERIAL AND METHODS

Leaf beetles were caught using a sweep net (4 × 50 sweeps) in the forest floor cover and low undergrowth, every month from April to August 2009 at the five study sites (Fig. 1). They included all types of forest associations dominant in the reserve: subcontinental mesic pine forest (Peu_Pin, site 1), thermophilous oak forest (Pot_Que, site 2), subcontinental linden-oak-hornbeam association (Til_Car, site 3), continental mixed coniferous forest (Que_Pin, site 4), and a mosaic of subcontinental linden-oak-hornbeam and degenerated continental mixed coniferous forest (Til_Car/Que_Pin, site 5). Two of the associations analysed, the subcontinental linden-oak-hornbeam and thermophilous oak forest, are priority habitats on the continent and covered by the Natura 2000 programme [Herbich 2004].

The summary table (Table 1) presents the numbers of leaf beetles in individual assemblages of the forest associations studied. The dominance of the most numerous taxa in individual communities is given in the text. The organization and analysis of the data also included calculation of the Shannon-Wiener indices of diversity (H) and evenness (E) [Shannon and Weaver 1949]. All taxa were divided into two groups with different habitat preferences (F – inhabiting trees and shrubs and O – open habitats, Table 1).

Statistical analysis was performed using indirect ordination methods. First the Multidimensional Scaling method (MDS) was used, followed by Principal Components Analysis (PCA), which was chosen for the analysis due to the value obtained for gradient length (3.24). It was conducted with type I scaling using the Hellinger transformation for the data [Legendre and Birks 2012]. The *vegan* package of R software ver. 3.0.1 was used for the computations [Oksanen *et al*. 2013, R Core Team 2014].

Systematic classification of the leaf beetles was according to Löbel and Smetana [2010], with minor changes from a study by Borowiec *et al*. [2011], while the nomenclature and division of range types were according to Wąsowska [1994] and Pawłowski *et al*. [1994]. Plant nomenclature was according to the International Plant Names Index, and that of forest communities according to Matuszkiewicz [2001].

RESULTS

At the five sites (in the five plant associations) of the Krzemionki Opatowskie reserve 726 leaf beetle (Chrysomelidae) individuals were caught (Table 1). For quantitative analyses 644 individuals identified to species (30 taxa) were used, and the remaining 82 individuals that could not be identified were excluded: *Altica* n. det. (females; 68 ind.), *Chaetocnema concinna/picipes* (females; 3 ind.), *Oulema melanopus/duftschmidi* (females; 10 ind.), *Longitarsus succineus/noricus* (female; 1 ind.) (Table 1).

Five umbrophilous taxa (16.67% qualitative share and 12.85% quantitative share in the material collected) were recognized as typically forest species (F), feeding on trees and shrubs of five botanical families (Salicaeae, Caprifoliaceae, Pinaceae, Corylaceae and Betulaceae). These were *Chrysomela populi*, *Pyrrhalta viburni*, *Calomicrus pinicola*, *Altica brevicollis* and *Cryptocephalus labiatus*. All others were open habitat species (O) feeding on herbaceous vegetation (Table 1).

The forest association richest in species (18) was the continental mixed forest (Que_Pin, site 4). It was closely followed by the subcontinental linden-oak-hornbeam association (Til_Car, site 3) (15 sp.), and then the mosaic of subcontinental linden-oak-hornbeam and degenerated continental mixed coniferous forest (Til_Car/Que_Pin, site 5) and the continental fresh pine forest (Peu_Pin, site 1) (11 sp. each). The fewest species (10) were recorded in the thermophilous oak forest (Pot_Que, site 2) (Table 1). A very low (0.25) correlation between number of specimens and number of species was found. In practically all of these forest types the eudominant and dominant classes consisted of different species. In pine forests predominated: *Sphaeroderma testaceum* (D = 22.2%), *Cryptocephalus labiatus* (16.7%), *Sermylasa halensis* and *Cryptocephalus aureolus* (both with 11.1%). In thermophilous oak forest the highest percentage share (D = 80,7%) had heliophilous *Derocrepis rufipes* (Table 1).

Analysis of the similarity of the leaf beetle assemblages at each of the study sites revealed the greatest similarity between the fauna of the subcontinental thermophilous oak forest (Pot_Que, site 2) and the continental mixed pine forest (Que_Pin, site 4) (Fig. 2). The faunas of these two associations were 55.08% similar. Five common species were recorded for the two associations (Table 1).

The second group distinguished, with similarity at a level of 34.48%, consisted of the leaf beetle assemblages of the subcontinental linden-oak-hornbeam association (Til_Car, site 3) and the degenerated continental mixed pine forest (Til_Car/Que_Pin, site 5). For these two associations nine common species were noted. The most distinct fauna was that of the continental fresh pine forest (Peu_Pin, site 1) (Fig. 1).

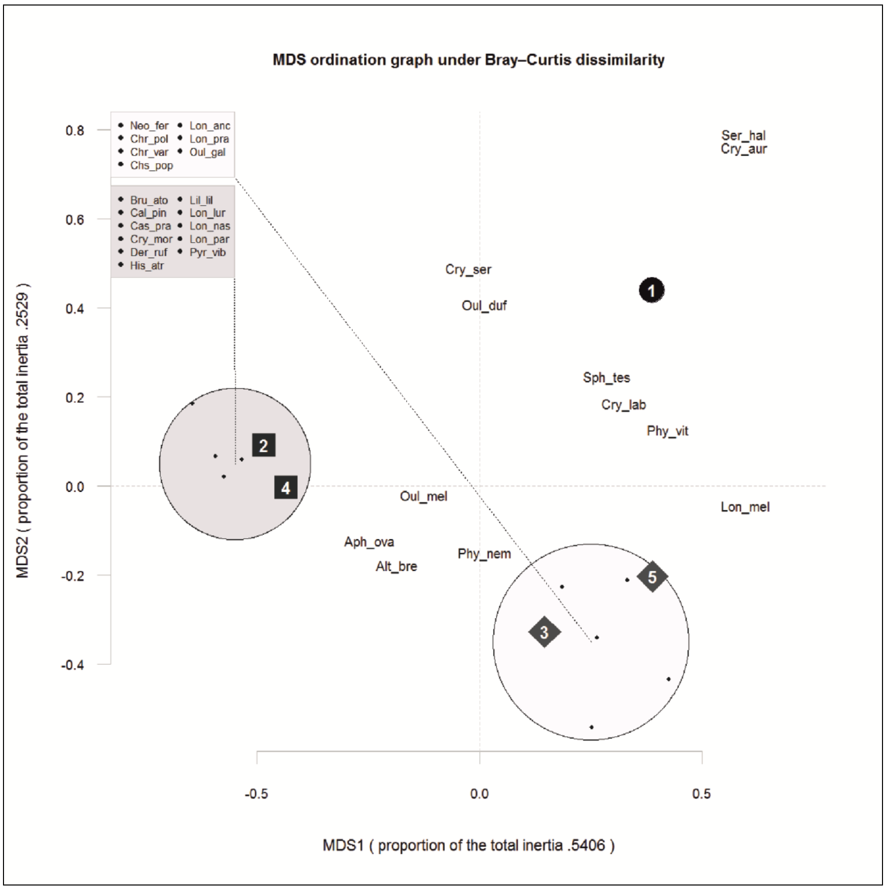

Fig. 2. Multidimensional scaling diagram (MDS) – similarities between leaf beetle assemblages occurring in particular types of forest communities. Designations for types of forest communities (Arabic numerals) – see Table 1

Fig. 3 presents the degree of association of individual Chrysomelidae species with the forest communities analysed. The species caught in the highest numbers, *Derocrepis rufipes* (58.4% of the total material), was mainly associated with the *Potentillo albae-Quercetum* community (Pot_Que, site 2) (Fig. 3). In this

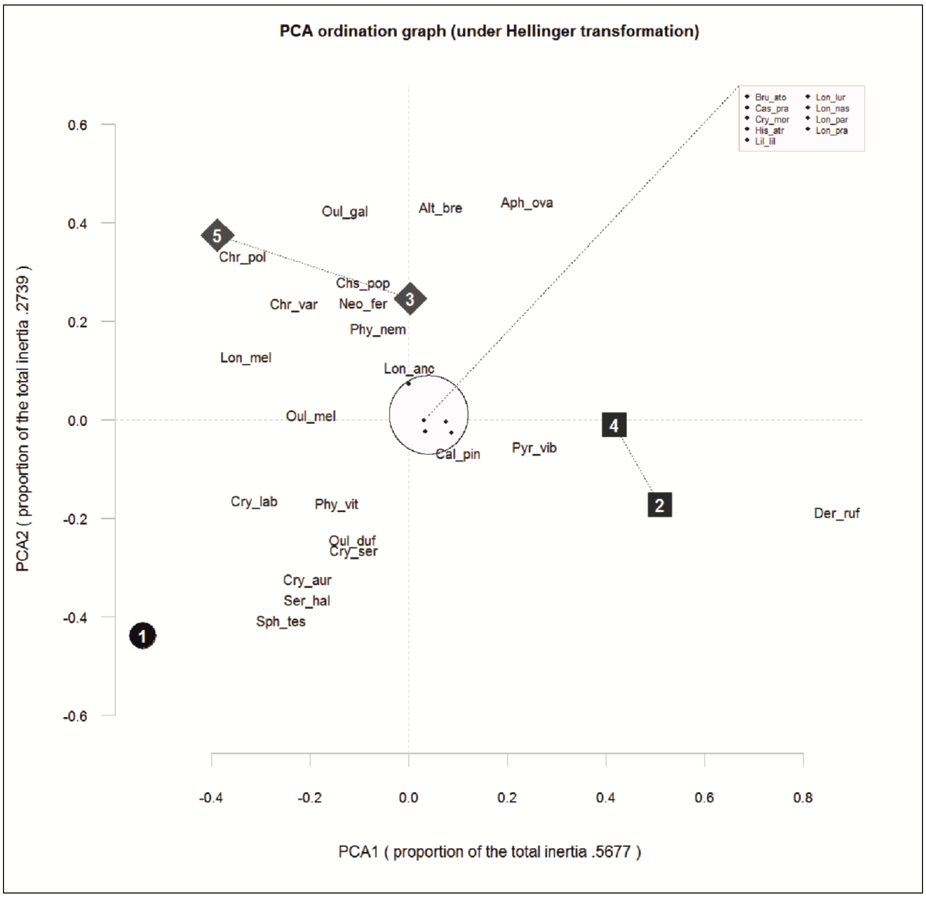

Fig. 3. Principal component analysis diagram (PCA) – connection between particular Chrysomelidae species and types of forest communities

forest association as many as 243 *Derocrepis rufipes* individuals were caught and a strong positive correlation was noted between the abundance of this beetle and the habitat (Table 1). *Derocrepis rufipes* was also associated with the Querco roboris-Pinetum community (Que_Pin, site 4; Fig. 3), but this was a much weaker degree of association than in the case of the Pot_Que community. At site 4 (Que_Pin) 126 *Derocrepis rufipes* were caught and a considerably lower correlation was noted between the number of individuals and the habitat. For the second most abundant species, *Aphthona ovata* (D = 15.7%), a strong positive correlation was noted with the continental mixed pine forest (Que_Pin, site 4) (Table 1). In this community 77 individuals of this species were caught, but a fairly large number were also caught at site 3 (13 ind.), which is the reason for its position in the PCA diagram between these two sites (Fig. 3).

The most *Chrysomelidae* species in the reserve were recorded on plants of the families Asteraceae (6 sp.) and Poaceae (5), and the most individuals on plants of the Fabaceae (382) and Euphorbiaceae (101) families. The most host plant families fed on by beetles were noted in the *Tilio-Carpinetum* and *Querco roboris-Pinetum* communities (11 each), and the fewest in the *Peucedano-Pinetum* community (8). The highest qualitative share of forest species was observed in the *Tilio--Carpinetum* association (17.7%), and the lowest in the *Querco roboris-Pinetum* association (5.5%). For the quantitative share the percentages were 33.3% for *Potentillo albae-Quercetum* and 9.1% for *Peucedano-Pinetum*.

The highest species diversity index was calculated for the assemblage of the Peu_Pin community (H = 2.24; E = 0.94), closely followed by the Til_Car (H = 2.19; E = 0.81) and Til_Car/Que_Pin (H = 2.16, E = 0.9) assemblages. The lowest values were noted for the Que_Pin (H = 1.37; E = 0.47) and Pot_Que (H = 0.79; E = 0.34) taxocenes.

DISCUSSION

Leaf beetles are a good tool for evaluating rapid successional changes in forest associations. This is because most species are quickly eliminated from the habitat by increased shade or by changes in host plants due to successional series [Borowiec 1984]. This process is clearly evident in the Krzemionki Opatowskie reserve, where over a few decades the landscape of fields and xerothermic grasses, associated with limestone in the substrate, was replaced by the few types of forest associations currently covering the reserve. The response to this rapid habitat change is the leaf beetle species currently present here, associated with arable fields, dry meadows, xerothermic grasses, and ground cover of thermophilous forests, which dynamically attempt to adapt their own life cycles to the rapid changes in vegetation. The presence of varied fauna – species typical of open areas and newly appearing species typical of forest communities – can be described as an ‘ecotone in time’ effect.

Comparison of the results of the present study with similar studies from Romania and Turkey [Crişan 2006, Şen and Gök 2009] runs into difficulties primarily involving differences in the habitat types of the forests being compared or in their species composition, which determines the presence of specific Chrysomelidae species. It is interesting to note the high qualitative similarity, reaching 50%, of the Chrysomelidae species composition of the ground cover between the oak forests of Turkey and the linden-oak-hornbeam and continental mixed pine forest of the Krzemionki reserve. This involves eight widely distributed, mainly Holarctic and Palearctic taxa of the subfamily Alticinae, usually common in the fauna of Poland as well (*Longitarsus anchusae*, *L. luridus*, *L. melanocephalus*, *L. nasturtii*, *L. parvulus*, *L. pratensis*, *Phyllotreta nemorum*, and *Ph. vittula*).

There have been few multi-faceted studies conducted in Poland that offer a detailed characterization of the composition of the chrysomelid fauna of particular forest habitats. In the case of *Tilio-Carpinetum* these are mainly faunistic studies noting only the presence of individual species in various regions of Poland [Stypa-Mirek 1963, Warchałowski 1975, Bartkowska 1989, 1994], whereas studies attempting a valuation and analysing selected faunistic and ecological indices in the leaf beetle assemblages of this association have been conducted: in the Mazovian Lowland [Wąsowska 1989], the Miechowska Uplands [Wąsowska 1996], Pogórze Wielickie [Wąsowska 1999] and Białowieża Forest [Wąsowska 2005]. In these areas the number of leaf beetle species ranged from 17 to 34. Most taxa were open-habitat Chrysomelidae, while typical forest species were recorded only sporadically [Wąsowska 1989, 1996, 1999, 2005]. In the case of *Peucedano-Pinetum*, the number of species caught in the Krzemionki reserve was slightly higher than in the layers of ground cover and trees (together with shrubs) recorded in the analogous association by Wąsowska [1989] in Puszcza Biała (10 sp.) and markedly lower than in Białowieża Forest (27 sp.) [Wąsowska 2005]. In comparison with the regions studied by Wąsowska [1989, 1996, 1999, 2005], the distinct individual faunistic character of the Chrysomelidae of the Krzemionki Opatowskie reserve should be emphasized.

A study by Gutowski *et al.* [2006] in pine forests of Białowieża Forest, Biebrza National Park, Tuchola Forest, Kozienicka Forest and the Świerklaniec Forest Inspectorate reported a combined 62 Chrysomelidae species in this habitat. Adult forms of as many as 25 species were associated with trees. One of the characteristic features of the leaf beetle assemblages of all the forest communities studied in Krzemionki, besides the small number of dendrophilous species (5), the marginal share of leaf beetles trophically associated with willows and poplars (e.g. the absence of species of the genera *Smaragdina*, *Phratora* and *Gonioctena* and the small number of *Chrysomela*), which is due to the small share of these trees in the underbrush. It should be remembered, however, that their small number may also be due to the fact that the habitats of the reserve, as compared to the large forest complexes named above, have a significantly smaller area and are distributed in a mosaic on a small area, and often cannot be colonized from larger forest complexes.

At present all forest associations of the reserve are distinctive habitats of leaf beetle assemblages with a characteristic, though somewhat impoverished species composition in comparison with the long-standing forest formations in other regions of the country. The assemblages here are currently based on eurytopic heliophilous species of diverse habitats which were present here before the area was overgrown by forest – from beetles characteristic of open, mesic habitats (fields and meadows), to those associated with meso- and xerothermic thermophilic shrubs, to species typical of various forest associations and their ground cover. Finally, and in a relatively short time, we can expect stabilization, and even a slight increase in the number of forest species (including ground cover species) and further elimination of heliophilous thermophilous species (until they are completely absent), magnified by transformation of vegetation (disappearance of host species) as light conditions deteriorate in the fully developed tree stand. The restructuring of the vegetation towards forest formations in the case of leaf beetles effectively reduces the number of species, as pointed out by many authors [Warchałowki 1978, Borowiec 1984, Wąsowska 2005, Şen and Gök 2014].

CONCLUSIONS

1. The 30 leaf beetles caught in the relatively small area of the Krzemionki Opatowskie reserve should be considered a fairly high number. The considerable species richness is due to the effect of an 'ecotone in time', i.e. the continuous presence of open habitat species which until recently dominated in the area, together with the presence of forest species characteristic of the current habitat types.
2. The structure of the leaf beetle assemblages in the forest associations studied in the reserve is currently an adaptive mixture of faunas characteristic of all intermediate successional stages of vegetation, changing in this area in a relatively short time.
3. More thermophilous species, found on plants in more well-lit parts of forests with $CaCO_3$ in the substrate (such as *Aphthona ovata*, *Longitarsus anchusae*, *Cryptocephalus sericeus* and *Derocrepis rufipes*), are still present in the reserve. These will probably be the first to leave the reserve when the tree stand becomes denser and more completely covers its surface.

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AKTUALNA STRUKTURA ZGRUPOWAŃ CHRZĄSZCZY STONKOWATYCH (COLEOPTERA, CHRYSOMELIDAE) ZESPOŁÓW LEŚNYCH REZERWATU KRZEMIONKI OPATOWSKIE JAKO ODPOWIEDŹ NA ZMIANY SUKCESYJNE ROŚLINNOŚCI

Streszczenie. Celem pracy było uchwycenie obecnego statusu oraz kierunku przekształceń zgrupowań stonkowatych biorących udział w szybkim procesie sukcesji roślinności w kierunku kilku typów zbiorowisk leśnych występujących w rezerwacie Krzemionki Opatowskie. Na pięciu stanowiskach (w pięciu zespołach roślinnych) rezerwatu Krzemionki Opatowskie stwierdzono 30 gatunków Chrysomelidae. Pięć gatunków typowo leśnych (*Chrysomela populi*, *Pyrrhalta viburni*, *Calomicrus pinicola*, *Altica brevicollis* i *Cryptocephalus labiatus*) stanowiło 16,67% liczby gatunków i 12,85% liczby osobników złowionych w rezerwacie. Najbogatszym w gatunki (18) zespołem leśnym rezerwatu był kontynentalny bór mieszany (Que_Pin). Nieco tylko ustępował mu grąd subkontynentalny (Til_Car, 15 gat.), następnie mozaika grądu subkontynentalnego i zdegenerowanego kontynentalnego boru mieszanego (Til_Car/Que_Pin) oraz kontynentalny bór sosnowy świeży (Peu_Pin) (po 11 gat.). Najmniej gatunków (10) stwierdzono w świetlistej dąbrowie subkontynentalnej (Pot_Que). Najbardziej podobne były fauna świetlistej dąbrowy subkontynentalnej (Pot_Que) i fauna kontynentalnego boru mieszanego (Que_Pin) (podobieństwo 55,08%). Najbardziej odmienna była fauna kontynentalnego boru sosnowego świeżego (Peu_Pin). Można stwierdzić, iż struktura zgrupowań stonkowatych w badanych zespołach leśnych rezerwatu jest w chwili obecnej mieszanką adaptacyjną rodzajów fauny charakterystycznych dla wszystkich pośrednich stadiów sukcesyjnych roślinności, zmieniających się na tym terenie w stosunkowo krótkim czasie. Znaczne zróżnicowanie fauny jest efektem zarówno „ekotonu w skali czasowej", tzn. ciągłej obecności gatunków terenów otwartych, jakie jeszcze niedawno dominowały na tym obszarze, jak i występowania gatunków leśnych, charakterystycznych dla obecnych typów siedlisk.

Słowa kluczowe: Chrysomelidae, sukcesja, gatunki leśne, gatunki terenów otwartych, ekoton w skali czasowej