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ORIGINAL RESEARCH ARTICLE

Beetles (Coleoptera) occurring in decaying birch (*Betula* spp.) wood in the Kampinos National Park

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Abstract. The composition and structure of beetle clusters living in rotting birch wood in Kampinos National Park was investigated. Photoeclectors were used to remove beetles from collected wood samples. Ten different research plots, each corresponding to a different forest type, were sampled every month over a 1-year period. A collection of 3256 beetles from 37 families comprising 206 species was amassed during the study. The collected beetles were divided into trophic families, species rareness, and constancy and site fidelity classes. At the more fertile sites, species only able to live on highly-decayed wood were collected (F3), also species facultatively able to live on either dying trees or decaying wood (F1), species that do not live on decayed wood (F0) and other rare species. Trophic group of carnivores (Z) provided most species on more fertile sites. At coniferous forest sites, as well as mixed deciduous forest sites, most individuals collected belonged to mycophagous and myxomycophagous trophic groups. At the other sites, the largest group of collected individuals was zoophagous. The number of rare species was positively related to site fertility. The average number of species increased in accordance with increasing site fertility, however this trend was only statistically significant when applied to moist coniferous forest (Bw) and moist mixed broadleaved forest (LMw) sites. The study revealed differences in the composition and structure of beetle clusters from different forest types. These differences were probably not directly related to site type, but more likely to the form of nature conservation imposed on a particular area and the potential number of decayed deciduous tree trunks. Two different clusters of saproxylic Coleoptera related to birch rot were distinguished: the first includes strictly protected deciduous forest types, the second contains the remaining forest types.

Key words: forest type, Coleoptera, saproxylic insects, *Betula*, Kampinos National Park

1. Introduction

Many articles about lifeless trees and associated organisms were published in recent years. Many researchers pointed out the importance of decaying wood in ecosystem and began studies on this important issue. One of the largest ecological groups living in this environment is of saproxylic beetles. Beetles associated to decaying wood, in Poland, belong to over 70 families and about 1300 species (Gutowski 2006). According to Ammer (1991), about 700 species can be found on lifeless birches. Largest fauna of saproxylic beetles can be found in forests similar to natural forests, with a large number of lifeless trees forming diversified rotten wood areas. Such forests can still be found in national parks and nature preservation areas under strict protection, where no harvesting takes place (Gutowski 2006).

Kampinos National Park (KNP) is one of the most valuable yet less known (in the entomological way) national parks in Poland (Banaszak et al. 2004). Chudzicka and others (2003) reported that 656 species of beetles can be found in the area of KNP and its buffer zone. Following are the pieces of research that were conducted on beetles in Kampinos National Park: Kaczmarek 1963, Plewka 1981, Byk and others 1998, Kubisz and others 2000, Jędryczkowski 2006, Owieśny and Grzywacz 2007, Marczak 2010. Lots of scrappy data on KNP beetles can be found in catalogs, monographs, and systematic revisions on fauna. Perliński and Sawoniewicz (2011) have published an article that is fully dedicated to saproxylic beetles in this area. Data of

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saproxylic coleopterofauna related to birches in Poland can be found in the following studies: Starzyk (1995), Byk (2001a, 2001b, 2007), Rutkiewicz (2001, 2007), Byk and Byk (2004), Kuś and Kuś (2004), Gawroński and Oleksy (2006), Staniec (2006), Byk and Mokrzycki (2007), Mokrzycki (2007, 2011), and Perliński (2007).

The aim of this study was investigation on composition and structure of saproxylic beetle clusters associated to birch that can be found on different forest site types in the Kampinos National Park area.

2. Research area

Research was conducted in the area of Protective Zone Laski in Kampinos National Park. Ten different sample plots were chosen where each corresponded to the following forest site types: fresh coniferous forest (Bśw), wet coniferous forest (Bw), fresh mixed coniferous forest (BMśw), wet mixed coniferous forest (BMw), fresh mixed deciduous forest (LMśw), wet mixed deciduous forest (LMw), fresh deciduous forest (Lśw), wet deciduous forest (Lw), alder forest (Ol), and alder-ash wet forest (OLJ). Four of these plots (Lśw, Lw, Ol, and OlJ) were located in Strict Protected Area of Sieraków. A detailed description of sample plots can be found in the work of Perliński and Sawoniewicz (2011).

3. Methodology

Beetles' collection came from rot samples collected from rotten wood areas in the last three phases of decay. Research had been conducted for 12 consecutive months, since April 2008 to March 2009. At the second half of each month, three 2-liter samples of birch rot were collected from each sample plot. A total of 360 samples were collected, 36 from each sample plot (720 liters of rot). During material harvesting, whole research plots were penetrated in order to select the most diverse rotten wood areas. Only one, two liters of big sample, were collected from each rotten wood area. Detailed description of particular features of rotten wood area, where samples were collected, can be found in the work of Perliński and Sawoniewicz (2011).

Rot collected at research plots was placed in labeled folic bags and transported to a laboratory. The process of scaring out the insects in photoeclector, using 25-Watt bulb, lasted 10 days. After that time insects were prepared and determined. Individuals only in imago stadium were considered in this research.

Collected species were classified in one of the following classes of fidelity:

F3 – species obligatorily associated with decayed wood; F2 – species less associated with the state of decomposition of wood, but prefer the fructifications of wood fungi, the subcortical environment, tree hollows, etc.; F1 – species facultatively associated with decaying wood or weakened trees; and F0 – species not associated with occupying wood.

Particular species were also divided into trophic groups as follows: F – phytophagous, K – xylophagous, M – mycophagous, Mx – myxomycophagous, N – necrophagous, S – saprophagous, Z – zoophagous. Some species were classified in more than one trophic group; however in statistical calculation only one, most important trophic form of particular species, was taken (in tab.1 trophic form named as first).

Rare species (R) were also selected, occurring on isolated, single plots and/or relics of primeval forests which require natural environment with large number of diverse rotten wood areas.

Determination index (*D*) was calculated to determine part of individuals from particular species relative to total number of individuals from particular systematic (Szujecki 1980):

$$D = \frac{s}{S} 100 \ (\%)$$

where:
D – determination index,
s – number of individuals of particular species,
S – total number of insects collected at particular research area.

Based on determination index value, six classes were determined (Kasprzak, Niedbała 1981): superdominants ≥ 30,01%, eudominants 10,01 – 30,00%, dominants 5,01 – 10,00%, subdominants 2,01 – 5,00%, recedents 1,01 – 2,00%, subrecedents ≤ 1,00%.

Constancy index (*C*) was calculated; it shows percentage of samples, where particular species was found (Szujecki 1980):

$$C = \frac{q}{Q} 100 \ (\%)$$

where:
C – constancy index,
Q – total number of samples,
q – number of samples, where particular species was found.

Based on constancy index values, 4 different classes were divided (Kasprzak, Niedbała 1981) and following ranges were established: eukonstants ≥ 50,01%, konstants 20,01–50,00%, accessory species 5,01– 20,00%, akcydenty ≤ 5,00%.

Collected beetles were mostly marked by the author of this study. Species belonging to subfamilies:

Aleocharinae, Oxytelinae, Paederinae, Phloeocharinae, Staphylininae, and Steninae within family Staphylinidae were marked by prof. A. Szujecki and the mark of most individuals from subfamilies Euaesthetinae, Habrocerinae, Omaliinae, and Tachyporinae (Staphylinidae) was also verified.

The evidence is placed in author's private collection, in collection of Department of Forest Protection and Ecology SGGW in Warsaw and in private collection of prof. A. Szujecki. Species nomenclature and systematic design were taken after "Catalogue of Palaearctic Coleoptera" (Löbl, Smetana 2003-2008) and "A new checklist of the weevils of Poland, Coleoptera: Curculionoidea" (Wanat, Mokrzycki 2005).

Due to lack of normality distribution of variables, the impact of forest site type on number of collected individuals and saproxylic Coleoptera species was analyzed using the Kruskal-Wallis test. Calculations were done using Statistica.

4. Results

3256 beetles (individuals in imago stadium) belonging to 206 species and 37 families (tab. 1) were collected during the research. The largest family in terms of number of species were Staphylinidae (47,68%), subsequently Ptiliidae (15,76%), Ciidae (8,36%), Cerylonidae (5,56%), Scydmaenidae (4,92%) and Carabidae (4,27%). Smaller share in families' structure were of: Leiodidae (2,18%), Latridiidae (2,06%), Elateridae (1,54%), and Tenebrionidae (1,04%). All remaining families' share was less than 1%. *Pteryx suturalis* turned out to be eudominant species, its share came to 10,29%. *Scaphisoma agaricinum* (8,17%), *Euplectus nanus* (6,11%), *Gabrius splendidulus* (5,38%), *Cerylon histeroides* (5,10%), and *Sepedophilus testaceus* (5,07%) can be considered as dominant species.

Subdominants were *Microscydmus minimus* (3,78%), *Ptinella aptera* (3,78%), *Gyrophaena minima*, (3,13%), *Bibloporus bicolor* (2,40%), *Cis fagi* (2,18%), and *Ennearthron cornutum* (2,06%). Smaller role in species' structure had recedents like *Dinaraea angustula* (1,69%), *Cis castaneus* (1,66%), *Euplectus karstenii* (1,63%), *Cis micans* (1,38%), *Bibloplectus tenebrosus* (1,35%), *Dyschirius globosus* (1,17%), *Corticaria longicollis* (1,14%), *Micridium halidaii* (1,14%), *Oxypselaphus obscurus* (1,14%), and *Saulcyella schmidtii* (1,14%). The remaining subrecedent species share came out to be less than 1%.

Beetles belonging to rare fauna and relics of primeval forests (R) composed 13,59% of species and 9,62% of individuals. Fidelity class grouping by insects obligatorily associated to the decayed wood (F3)consisted of 18,93% of species and 38,28% of individuals. Insects associated with the state of decomposition of wood, but preferring the fructifications of wood fungi, the subcortical environment, and tree hollows (F2) presented 33,01% of species and 47,28% of individuals. Beetles facultatively associated with decaying wood or weakened trees (F1) composed 16,99% of species and 6,97% of individuals. Fidelity class formed by insects not associated with occupying wood (F0) included 31,07% of species and 7,47% of individuals.

The largest trophic group were predatory beetles; they composed 40,52% of all collected individuals and 44,66% species. Next in terms of number were beetles feeding on fungi and myxomycetes; their share was 37,76% of individuals and 23,79% of species. Beetles feeding on dead organic matter composed 18,13% of individuals and 14,56% of species. Least numerous groups were beetles, their main diet components are living plant components (0,71% of individuals and 5,34% of species), wood (0,40% of individuals and 2,43% of species), and dead animals (0,09% and 0,97% of species). For remaining 2,40% of individuals and 8,25% of species we do not know food preferences as they were not identified adequately.

Most individuals were collected in wet mixed deciduous forest while least in wet mixed coniferous forest. The richest in terms of species was alder forest while the poorest was wet coniferous forest (tab. 1).

Number of rare species or relics of primeval forests (R) was the largest on four most fertile forest site types (Ol, Lśw, Lw, and OlJ). Species from this group were the least frequently collected on weaker forest site types (Bśw, BMw, and Bw). Species obligatorily associated to decoyed wood (F3) were most frequent at fresh deciduous forest site and alder-ash wet forest site. The F3 class was less frequent in species at weaker site types (Bśw, Bw, and BMśw). At almost all site types (except LMśw, Lśw, and Ol) most frequent collected species were less associated to the state of decomposition of wood, but prefer the fructifications of wood fungi, the subcortical environment, and tree hollows (F2). The number of species from this class was the largest at less fertile forest site types (BMśw, LMw, Bw, and Bśw). Species from fidelity class F1 were mostly collected at four most fertile sites (Ol, Lw, Lśw, and OlJ). They were barely found at fresh coniferous forest, wet coniferous forest, and wet mixed coniferous forest sites. Species representing F0 class were the most frequent at 5 most fertile forest site types (Ol, LMw, Lśw, Lw, and OlJ). To recap, on fertile sites more species from classes F3, F1, and F0; and rare (R) were collected. Number of species from class F2 was larger on less fertile sites (fig. 1).

Table 1. Beetles collected in birch mould in the Kampinos National Park (KPN) in particular forest habitats

Taxon	F	R	T	Number of specimens									
				Bśw	Bw	BMśw	BMw	LMśw	LMw	Lśw	Lw	Ol	OlJ
1	2	3	4	6	7	8	9	10	11	12	13	14	15
Carabidae													
Agonum micans (Nicolai, 1822)	F1		Z								6	6	1
Agonum muelleri (Herbst, 1784)	F1		Z		1								
Agonum viduum (Panzer, 1796)	F1		Z							1		2	9
Amara brunnea (Gyllenhal, 1810)	F0		ZF	1									
Amara pulpani Kult, 1949	F0		ZF				1			1			
Badister unipustulatus Bonelli, 1813	F1		Z									1	
Bembidion doris (Panzer, 1796)	F0		Z									1	
Bembidion properans (Stephens, 1828)	F0		Z			1							
Calathus micropterus (Duftschmid, 1812)	F1		Z					2					
Carabus arcensis Herbst, 1784	F0		Z	1								2	
Carabus granulatus Linnaeus, 1758	F1		Z							1		4	2
Dyschirius globosus (Herbst, 1784)	F1		Z						1	2	5	22	8
Loricera pilicornis (Fabricius, 1775)	F1		Z							1		1	
Microlestes minutulus (Goeze, 1777)	F0		Z	4		1							
Oxypselaphus obscurus (Herbst, 1784)	F1		Z						19		8	10	
Pterostichus anthracinus (Illiger, 1798)	F1		Z								1	2	2
Pterostichus oblongopunctatus (Fabricius, 1787)	F1		Z	1				1		1		2	
Tachyta nana (Gyllenhal, 1810)	F2		Z	2		1							
Hydrophilidae													
Cercyon lateralis (Marsham, 1802)	F0		?				1			1	2		
Histeridae													
Eblisia minor (Rossi, 1790)	F2		Z			1							
Paromalus flavicornis (Herbst, 1792)	F2		Z						1				
Plegaderus caesus (Herbst, 1792)	F3		Z	3		1	1	6	5		13		1
Ptiliidae													
Acrotrichis atomaria (De Geer, 1774)	F0		S						1	2			5
Micridium halidaii (Matthews, 1868)	F3	R	S	1		5		5		3	2	4	17
Millidium minutissimum (Ljungh, 1804)	F0	R	S									1	
Ptenidium pusillum (Gyllenhal, 1808)	F1		S									2	7
Pteryx suturalis (Heer, 1841)	F3		S	54		37	34	3	69	4	36	72	26
Ptinella aptera (Guérin-Ménéville, 1839)	F3		S	1	4	72	12	7	8		3	9	7
Leiodidae													
Agathidium atrum (Paykull, 1798)	F2		Mx				1						
Agathidium rotundatum (Gyllenhal, 1827)	F2	R	Mx				4						
Agathidium seminulum (Linnaeus, 1758)	F2		Mx	1	2	3			6	5	5	2	2
Anisotoma castanea (Herbst, 1792)	F3		Mx							2			
Anisotoma glabra (Fabricius, 1787)	F3	R	Mx					4		1	2	1	2
Anisotoma humeralis (Fabricius, 1792)	F3		Mx	1				3	7				1
Liodopria serricornis (Gyllenhal, 1813)	F3	R	M							14		2	
Scydmaenidae													
Euconnus maklinii (Mannerheim, 1844)	F2		Z			1							
Euconnus pubicollis (Müller et Kunze, 1822)	F2		Z			1	1	1	3		3		3

Taxon	F	R	T	Number of specimens									
				Bśw	Bw	BMśw	BMw	LMśw	LMw	Lśw	Lw	Ol	OlJ
1	2	3	4	6	7	8	9	10	11	12	13	14	15
Eutheia linearis (Mulsant et Rey, 1861)	F2	R	Z			2							
Microscydmus minimus (Chaudoir, 1845)	F3		Z	3	26	11	19	13	2	25	8	11	5
Neuraphes elongatulus (Müller et Kunze, 1822)	F1		Z						4			5	2
Stenichnus godarti (Latreille, 1806)	F3		Z					1		2	3	4	1
Silphidae													
Phosphuga atrata (Linnaeus, 1758)	F0		ZN	1	8		4	7	7	2		1	2
Staphylinidae													
Acrotona fungi (Gravenhorst, 1806)	F0		ZM							1			
Anomognathus cuspidatus (Erichson, 1839)	F2		?	1		1	4					2	
Anotylus rugosus (Fabricius, 1775)	F0		?									1	
Anthobium atrocephalum (Gyllenhal, 1827)	F0		SN	1	1				5	10			
Atheta benickiella Brundin, 1948	F0	R	ZS							1			
Atheta boletophila (Thomson, 1856)	F2	R	ZM			1							
Atheta crassicornis (Fabricius, 1793)	F1		ZS				3						1
Atheta cribrata (Kraatz, 1856)	F1	R	ZS						1				
Atheta euryptera (Stephens, 1832)	F2		ZS						1				
Atheta fungivora (Thomson, 1867)	F2	R	ZM			1							1
Atheta gagatina (Baudi di Selve, 1848)	F0		ZS			2	12		1				
Atheta sp.								1					
Batrisodes adnexus (Hampe, 1863)	F2		Z			2							1
Bibloplectus tenebrosus (Reitter, 1880)	F2		Z							3	25	14	2
Bibloporus bicolor (Denny, 1825)	F2		Z	3	26	7	7	12	9		5	1	8
Bolitochara obliqua Erichson, 1837	F3		Z										1
Bryaxis bulbifer (Reichenbach, 1816)	F1		Z								5		
Bryaxis puncticollis (Denny, 1825)	F2		Z		1					3			4
Carpelimus gracilis (Mannerheim, 1830)	F0		?							1			7
Cypha longicornis (Paykull, 1800)	F1		?					1					
Dexiogyia corticina Thomson, 1858	F2		?	2	1	5	1	8	2				
Dinaraea aequata (Erichson, 1837)	F3		Z		1		3	1	3		1	1	9
Dinaraea angustula (Gyllenhal, 1810)	F2		Z	10		24	1	8	2		2	1	7
Dinaraea linearis (Gravenhorst, 1802)	F2		Z										3
Euaesthetus bipunctatus (Ljungh, 1804)	F0		S								3	1	
Euaesthetus ruficapillus (Lacordaire, 1835)	F0		S								3		
Euplectus karstenii (Reichenbach, 1816)	F2		Z	4	14	5	1	5	6	6	2	2	8
Euplectus nanus (Reichenbach, 1816)	F3		Z	17	22	39	7	12	33	37	20	1	11
Euplectus punctatus Mulsant et Rey, 1861	F2		Z	2	4		2	1	1	1		2	5
Euryusa castanoptera Kraatz, 1856	F3	R	?								1		
Gabrius splendidulus (Gravenhorst, 1802)	F3		Z	36	8	20	7	30	41	2	23	4	4
Gabrius trossulus (Nordmann, 1837)	F0		Z							1		1	
Geostiba circellaris (Gravenhorst, 1806)	F1		Z			7			2	3	3	3	
Gyrophaena lucidula Erichson, 1837	F2		M		1								
Gyrophaena minima Erichson, 1837	F2	R	M						1	100		1	
Habrocerus capillaricornis (Gravenhorst, 1806)	F0		S	1	1		1			1	2		1
Ischnosoma splendidum (Gravenhorst, 1806)	F0		S			3						2	
Lathrobium fovulum Stephens, 1833	F0	R	ZS								2	1	
Lathrobium geminum Kraatz, 1857	F0		ZS									1	2
Lathrobium impressum Heer, 1841	F0		ZS									1	

Taxon	F	R	T	Number of specimens									
				Bśw	Bw	BMśw	BMw	LMśw	LMw	Lśw	Lw	Ol	OlJ
1	2	3	4	6	7	8	9	10	11	12	13	14	15
Lathrobium longulum Gravenhorst, 1802	F0		ZS							4	3	2	8
Leptacinus formicetorum Märkel, 1841	F1		Z			1							
Leptusa pulchella (Mannerheim, 1830)	F3		ZS		2			8					
Lordithon lunulatus (Linnaeus, 1760)	F1		MS							1			
Mycetoporus baudueri Mulsant & Rey, 1875	F0		S			1							
Mycetoporus lepidus (Gravenhorst, 1806)	F0		S								1		
Mycetoporus rufescens (Stephens, 1832)	F0		S							2			1
Myllaena intermedia Erichson, 1837	F0		?									1	
Ocypus picipennis (Fabricius, 1793)	F0		?						1				
Ocyusa maura (Erichson, 1837)	F0	R	?								1		
Othius subuliformis Stephens, 1833	F0		?	1	2				6		1		
Oxypoda mutata Sharp, 1871	F0		ZS									2	
Oxypoda procerula Mannerheim, 1830	F0		ZS								1	1	
Oxypoda recondita Kraatz, 1856	F0	R	ZS									1	
Parabolitobius formosus (Gravenhorst, 1806)	F0		S						1				
Philonthus fumarius (Gravenhorst, 1806)	F0		S								1	3	
Phloeocharis subtilissima Mannerheim, 1830	F2		Z		6	5			1	6			
Phloeonomus punctipennis Thomson, 1867	F2		ZS	1	16								
Phloeopora nitidiventris Fauvel, 1900	F2	R	Z									1	
Phloeopora scribae (Eppelsheim, 1884)	F2		Z			1							
Phloeopora teres (Gravenhorst, 1802)	F2		Z							13		4	1
Placusa tachyporoides (Waltl, 1838)	F2		Z			5							
Pselaphus heisei Herbst, 1792	F1		Z								1		
Quedius scitus (Gravenhorst, 1806)	F3	R	Z		1	1		2	1				1
Rugilus rufipes Germar, 1836	F0		S						1			1	
Rybaxis longicornis (Leach, 1817)	F1		Z									1	
Saulcyella schmidtii (Märkel, 1845)	F3	R	Z		2			3	2	20	6	4	
Scaphidium quadrimaculatum Olivier, 1790	F2		M	1			1	9	1	1	1		
Scaphisoma agaricinum (Linnaeus, 1758)	F2		M	32	18	94	6	32	82	1			1
Sepedophilus bipunctatus (Gravenhorst, 1802)	F3	R	Z						6	1	3		
Sepedophilus immaculatus (Stephens, 1832)	F2		Z	1		1							
Sepedophilus marshami (Stephens, 1832)	F2		Z						1				
Sepedophilus testaceus (Fabricius, 1793)	F2		M	15	48	8	14	20	25	7	17	2	9
Staphylinus erythropterus Linnaeus, 1758	F0		Z						1			2	
Stenus atratulus Erichson, 1839	F0		Z								1		
Stenus humilis Erichson, 1839	F0		Z	5			4		4	2		1	
Tachyporus chrysomelinus (Linnaeus, 1758)	F1		S			1							
Tachyporus hypnorum (Fabricius, 1775)	F0		S						1				1
Tachyporus transversalis Gravenhorst, 1806	F1	R	S								1		
Trimium brevicorne (Reichenbach, 1816)	F3		Z		1		1		1	1		2	2
Tyrus mucronatus (Panzer, 1805)	F2		?							1			
Xantholinus linearis (Olivier, 1795)	F0		SN						2				
Xantholinus longiventris Heer, 1839	F0		S	1		1	1						
Xantholinus tricolor (Fabricius, 1787)	F0		S					1					
Scirtidae													
Cyphon ochraceus Stephens, 1830	F0		?							1	3	1	
Microcara testacea (Linnaeus, 1767)	F0		?									1	1

Taxon	**F**	**R**	**T**	Number of specimens									
				Bśw	Bw	BMśw	BMw	LMśw	LMw	Lśw	Lw	OI	OIJ
1	2	3	4	6	7	8	9	10	11	12	13	14	15
Byrrhidae													
Cytilus sericeus (Forster, 1771)	F0		?										1
Eucnemidae													
Xylophilus testaceus (Herbst, 1806)	F3	R	K										6
Throscidae													
Trixagus dermestoides (Linnaeus, 1767)	F1		?		3		1		2	2	1	1	2
Elateridae													
Ampedus balteatus (Linnaeus, 1758)	F3		Z				1			2		1	
Ampedus elegantulus (Schönherr, 1817)	F3	R	Z							2			2
Ampedus nigrinus (Herbst, 1784)	F3		Z							3			
Ampedus nigroflavus (Goeze, 1777)	F3		Z					2	1				
Ampedus pomonae (Stephens, 1830)	F3		Z									5	1
Ampedus pomorum (Herbst, 1784)	F3		Z	1		1	1		1	10	1	6	1
Athous subfuscus (Müller, 1764)	F1		S					1					
Cardiophorus ruficollis (Linnaeus, 1758)	F1		Z			1							
Dalopius marginatus (Linnaeus, 1758)	F1		S			1		2					
Melanotus villosus (Geoffroy, 1785)	F3		Z					3					
Cantharidae													
Malthodes crassicornis (Maeklin, 1846)	F3		Z							4			1
Dermestidae													
Anthrenus museorum (Linnaeus, 1761)	F1		N								2		
Globicornis emarginata (Gyllenhal, 1808)	F3	R	N				1						
Ptinidae													
Ptinus raptor Sturm, 1837	F1		S					1					
Dasytidae													
Dasytes plumbeus (Müller, 1776)	F3		Z					3					
Sphindidae													
Aspidiphorus orbiculatus (Gyllenhal, 1808)	F2		Mx	2							2		
Sphindus dubius (Gyllenhal, 1808)	F3		Mx				2		2				
Nitidulidae													
Cyllodes ater (Herbst, 1792)	F2		S								1		
Epuraea biguttata (Thunberg, 1784)	F1		S							1			
Epuraea variegata (Herbst, 1793)	F2		MS										1
Monotomidae													
Monotoma conicicollis Chevrolat, 1837	F2		SZ			3							
Rhizophagus bipustulatus (Fabricius, 1792)	F2		SZ	3	1		2		1	2			
Silvanidae													
Uleiota planata (Linnaeus, 1761)	F2		MZ		3			1					
Cryptophagidae													
Atomaria elongatula Erichson, 1846	F2		M	8	1				1				
Cryptophagus badius Sturm, 1845	F1		M							1	4	1	1
Erotylidae													
Dacne bipustulata (Thunberg, 1781)	F2		M	1									

Taxon	F	R	T	Number of specimens									
				Bśw	Bw	BMśw	BMw	LMśw	LMw	Lśw	Lw	OI	OlJ
1	2	3	4	6	7	8	9	10	11	12	13	14	15
Cerylonidae													
Cerylon ferrugineum Stephens, 1830	F2		Mx	2	2	3		4	1				2
Cerylon histeroides (Fabricius, 1792)	F2		Mx	16	8	22	6	62	28	8	14	2	
Cerylon impressum Erichson, 1845	F2		Mx			1							
Endomychidae													
Endomychus coccineus (Linnaeus, 1758)	F2		M		1								
Leiestes seminiger (Gyllenhal, 1808)	F2	R	M	7									
Coccinellidae													
Adalia decempunctata (Linnaeus, 1758)	F0		Z							1			
Coccidula rufa (Herbst, 1783)	F0		Z						2				
Coccinella septempunctata Linnaeus, 1758	F0		Z				1						
Psyllobora vigintiduopunctata (Linnaeus, 1758)	F0		Z					1					
Corylophidae													
Orthoperus corticalis (Redtenbacher, 1845)	F3		M									2	
Sericoderus lateralis (Gyllenhal, 1827)	F1		M									1	
Latridiidae													
Corticaria lapponica (Zetterstedt, 1838)	F2	R	M									1	
Corticaria longicollis (Zetterstedt, 1838)	F2		M		20		2				15		
Cortinicara gibbosa (Herbst, 1793)	F1		M	1	3		1	2	4	2	3	1	1
Enicmus fungicola (Thomson, 1868)	F2		Mx				1						
Enicmus rugosus (Herbst, 1793)	F2		Mx	1	1	3	1	2			2		
Mycetophagidae													
Litargus connexus (Fourcroy, 1785)	F2		MZ		2								
Mycetophagus fulvicollis Fabricius, 1792	F2	R	MZ									1	
Mycetophagus quadriguttatus Müller, 1821	F2		MZ						3				
Ciidae													
Cis boleti (Scopoli, 1763)	F2		M		1	1		2	8				
Cis castaneus (Herbst, 1793)	F2	R	M	3	9	3		2	3	1	21	7	5
Cis fagi Waltl, 1839	F2		M	1	40		3	1			3	22	1
Cis micans (Fabricius, 1792)	F2		M	2				15	24		4		
Ennearthron cornutum (Gyllenhal, 1827)	F2		M	1	14	1	21	17	3		3	1	6
Octotemnus glabriculus (Gyllenhal, 1827)	F2		M						19				
Rhopalodontus perforatus (Gyllenhal, 1813)	F2	R	M				1						1
Sulcacis affinis (Gyllenhal, 1827)	F2		M			1			1				
Melandryidae													
Orchesia micans (Panzer, 1792)	F2		M				4						
Zopheridae													
Bitoma crenata (Fabricius, 1775)	F2		MZ	2							2		
Tenebrionidae													
Bolitophagus reticulatus (Linnaeus, 1767)	F2		M		6		2		2			13	
Diaperis boleti (Linnaeus, 1758)	F2		M						4				
Mycetochara flavipes (Fabricius, 1792)	F3	R	K				1						
Myrmechixenus subterraneus Chevrolat, 1835	F1	R	?			2							
Neomidia haemorrhoidalis (Fabricius, 1787)	F2	R	M		2							1	
Uloma rufa (Piller et Mitterpacher, 1783)	F3		KM			1							

Taxon	F	R	T	Number of specimens									
				Bśw	Bw	BMśw	BMw	LMśw	LMw	Lśw	Lw	Ol	OlJ
1	2	3	4	6	7	8	9	10	11	12	13	14	15
Pyrochroidae													
Schizotus pectinicornis (Linnaeus, 1758)	F3		ZS				1	1	1	1			
Scraptiidae													
Anaspis flava (Linnaeus, 1758)	F3		K						3				
Anaspis rufilabris (Gyllenhal, 1827)	F3		K		1					1			
Chrysomelidae													
Chaetocnema concinna (Marsham, 1802)	F0		F						1				
Chaetocnema confusa (Boheman, 1851)	F0		F									1	
Cryptocephalus parvulus Müller, 1776	F0		F				1						
Oulema melanopus (Linnaeus, 1758)	F0		F				1		1				
Phyllotreta exclamationis (Thunberg, 1784)	F0		F	1								1	2
Phyllotreta nemorum (Linnaeus, 1758)	F0		F				1	2	1				
Prasocuris marginella (Linnaeus, 1758)	F0		F									1	
Curculionidae													
Anthonomus pomorum (Linnaeus, 1758)	F0		F					1					
Ceutorhynchus ignitus Germar, 1824	F0		F										1
Sirocalodes depressicollis (Gyllenhal, 1813)	F0		F							1			1
Strophosoma capitatum (DeGeer, 1775)	F0		F	1				4					
Trypodendron signatum (Fabricius, 1792)	F1		MK								1		2
Total number of specimens				261	335	417	210	336	495	341	314	306	241
Total number of species				48	43	51	50	49	68	61	58	77	64

Sites: Bśw – fresh coniferous forest, Bw – wet coniferous forest, BMśw – fresh mixed coniferous forest, BMw – wet mixed coniferous forest, LMśw –fresh mixed deciduous forest, LMw – wet mixed deciduous forest, Lśw – fresh deciduous forest, Lw – wet deciduous forest, Ol – alder forest, OLJ – alder-ash wet forest

F – Class of fidelity in relation to highly decomposed wood: F3 – species obligatorily associated with decayed wood, F2 – species less associated with the state of decomposition of wood, but prefer the fructifications of wood fungi, the subcortical environment, tree hollows, etc., F1 – species facultatively associated with decaying wood or weakened trees, F0 – species not associated with occupying wood

R – species representing faunal rarities and /or relics of primeval forests

T – trophic group: F – phytophagous, K – xylophagous, M – mycophagous, Mx – myxomycophagous, N – necrophagous, S – saprophagous, Z – zoophagous

The greatest number of individuals belonging to rare species or relics of primeval forests (R) was collected on four most fertile sites (Lśw, Lw, OlJ, and Ol). Smaller disproportion between number of individuals from particular classes collected on more fertile forest site types can be observed (fig. 2).

The most of collected species belonged to trophic group of zoophagous. This group was especially formed by species on more fertile sites (fig. 3). At coniferous forest sites as well as mixed deciduous forest sites, the most collected individuals belong to trophic groups of mycophagous and myxomycophagous. At the other sites, the largest group of collected individuals was of zoophagous (fig. 4).

Together with growth of site fertility grew number of accessory species (fig. 5). The least species belonging to constants were characteristic for four most fertile forest site types (OlJ, Lśw, Lw, and Ol).

We will now make an analysis of similarities between particular forest site types, conducted on the basis of presence or lack of species in the community; let us distinguish two separate beetle communities (fig. 6). The first one includes beetles collected from most fertile forest site types (Lw, Lśw, Ol, OLJ). Dominating species in this community are *Bibloplectus tenebrosus*, *Cis castaneus*, *Cis fagi*, *Dyschirius globosus*, *Euplectus nanus*, *Gabrius splendidulus*, *Gyrophaena minima*, *Micridium halidaii*, *Microscydmus minimus*, *Pteryx suturalis*, *Saulcyella schmidtii*, and *Sepedophilus testaceus*. Second community is made of beetles from less fertile sites (Bśw, Bw, BMśw, BMw, LMśw, LMw). Dominating species in this community are *Atheta gagatina*, *Biblоporus bicolor*, *Cerylon histeroides*, *Cis fagi*, *Corticaria longicollis*, *Dinaraea angustula*, *Ennearthron cornutum*, *Euplectus nanus*, *Gabrius splendidulus*, *Microscydmus minimus*, *Pteryx suturalis*, *Ptinella aptera*, *Scaphisoma agaricinum*, and *Sepedophilus testaceus*. Both communities differ in number of species and individuals collected on average at particular forest site types. In case of community from less fertile sites, there were on average 342,17 of individuals and 51,5 species collected, while in community from more fertile sites – respectively 300,5 of individuals and 65 species. Average number of individuals from classes of fidelity F3 and F2 collected in particular

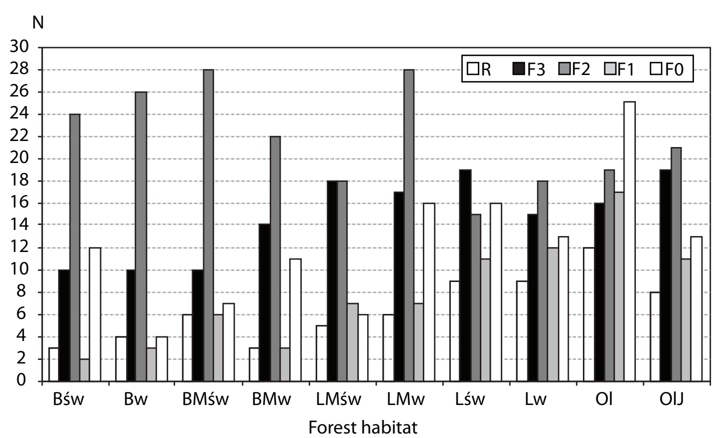

Figure 1. Number of species belonging to different classes of fidelity and rarely caught in particular forest habitats

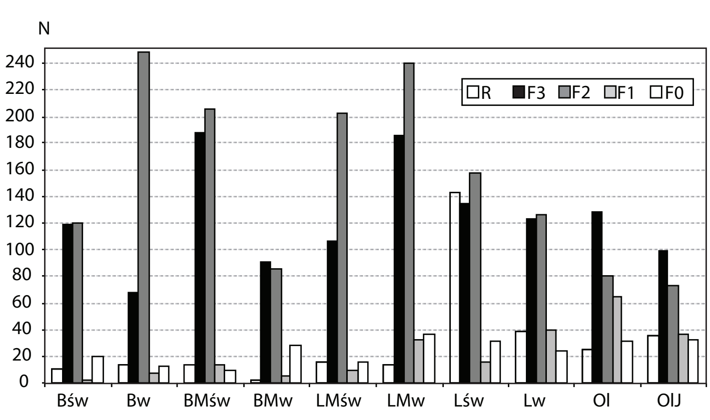

Figure 2. Number of specimens belonging to different classes of fidelity and rarely caught in particular forest habitats

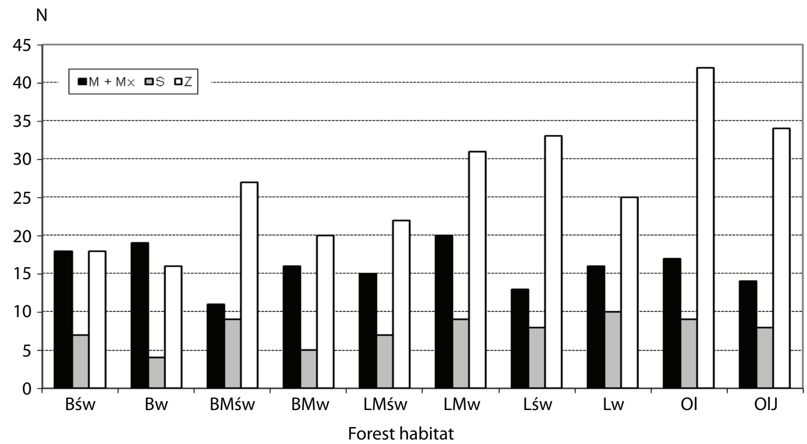

Figure 3. Number of species belonging to a group of trophic consisting of mycophagous (M), myxomycophagous (Mx), saprophagous (S), and zoophagous (Z) caught in particular forest habitatscaught in particular forest habitats

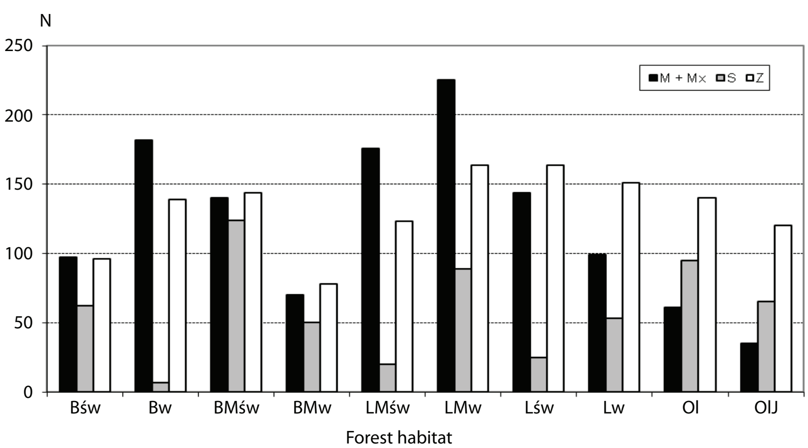

Figure 4. Number of specimens belonging to a group of trophic consisting of mycophagous (M), myxomycophagous (Mx), saprophagous (S), and zoophagous (Z) caught in particular forest habitats

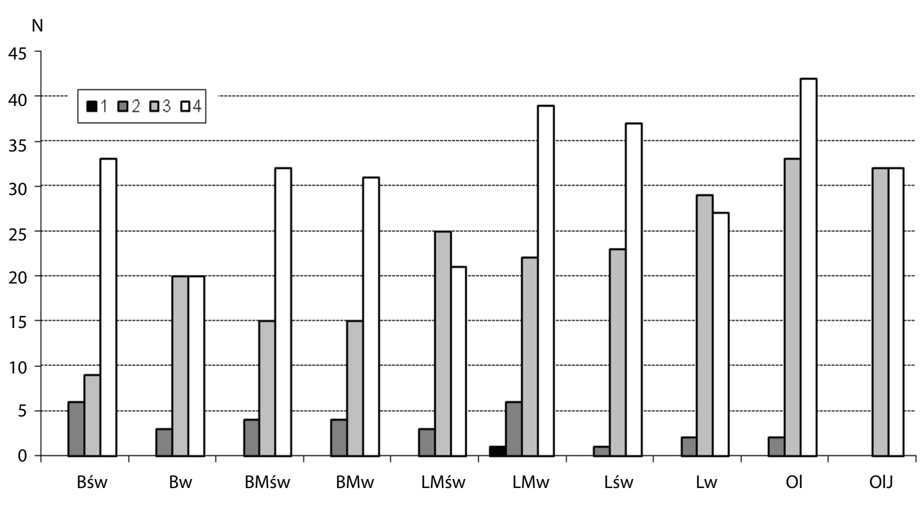

Figure 5. Number of species belonging to different classes of constancy caught in particular forest habitats:
1 – absolute species having constancy of 50,01–100%,
2 – konstant species having constancy of 20,01–50,00%,
3 – accessory species having constancy of 5,01–20,00%,
4 – accidental species having constancy lower than 5,00%

forest site types was larger than in community of less fertile sites. Average number of species and individuals belonging to classes of fidelity F1 and F0 collected in particular forest site types was bigger in community of more fertile sites. Average number of species and individuals belonging to rare fauna and relics of primeval forests collected on particular forest site types was bigger in community of more fertile sites. Average number of individuals belonging to the trophic groups of saprophagous and zoophagous collected on particular forest site types was bigger in community of more fertile sites. The average number of individuals belonging to mycophagous and myxomycophagous was bigger in the community of less fertile sites.

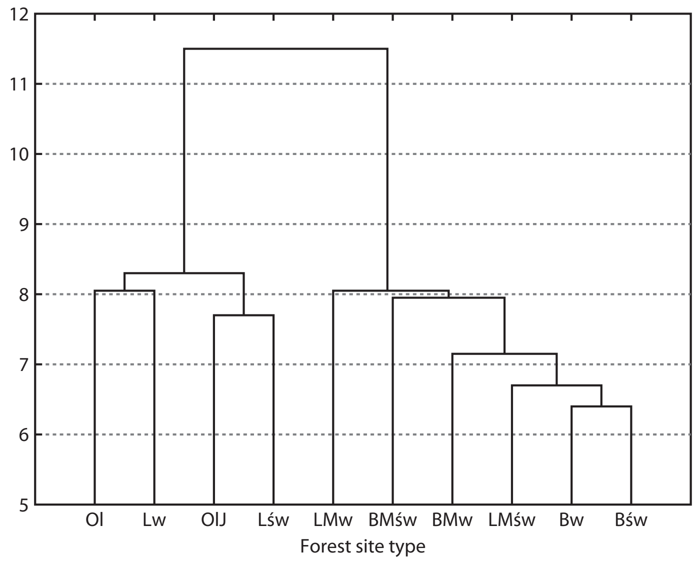

Figure 6. Dendrogram of similarity between communities of beetles collected in particularforest sites (Ward's method) – on the basis of presence or absence of particular species
(Bśw – fresh coniferous forest, Bw – wet coniferous forest, BMśw – fresh mixed coniferous forest, BMw – wet mixed coniferous forest,
LMśw – fresh mixed deciduous forest,
LMw – wet mixed deciduous forest,
Lśw – fresh deciduous forest,
Lw – wet deciduous forest, Ol – alder forest,
OLJ – alder-ash wet forest)

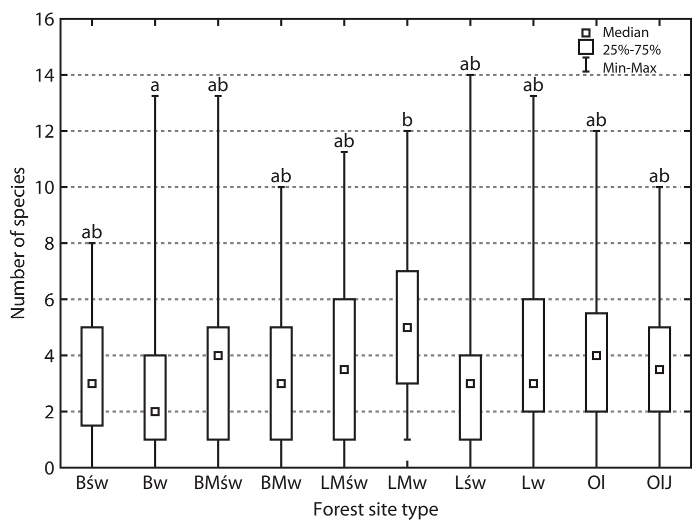

Figure 7. Median number of species caught in particular forest habitats (same letters indicate lack of statistical differences, α=0,05)

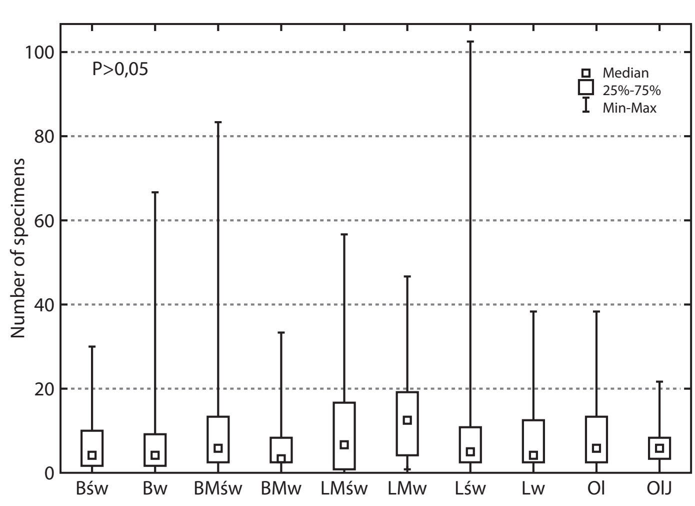

Figure 8. Median number of specimens caught in particular forest habitats (same letters indicate lack of statistical differences, α=0,05)

Numerous data analyses pointed differences in number of saproxylic beetle species collected on particular forest site types (p=0,0291; H=18,58; df=9; N=360), but these differences were only between wet mixed deciduous forest and wet coniferous forest (p=0,0142) (fig. 7). Significant differences between number of collected individuals (p=0,0553; H=16,60; df=9; N=360) (fig. 8) were not found.

5. Discussion

According to Szujecki (1980) every forest site type, according to specific conditions such as floristic composition, soil conditions, microclimate, vegetation levels, and history of its forming, creates specific living conditions for insects. Saproxylic beetles, in general, have wider environment toleration ranges than plants based on forest site types were determined. This fact creates the problem in defining potential relationship between particular species and forest site type. The most abundant species were found in all or in almost all forest site types, while rare species were collected only in some of them. It seems likely, that continuation of research would let us collect them also in other forest site types.

Number of beetle species associated to environment of lifeless birches in KNP demonstrates slightly upward trend according to growing fertility of sites. Byk (2001a) noticed similar regularity during studies in Hajnówka Forest District. Beetles settled in lifeless, standing trees and hollows were mostly collected at alder forest sites while less species at coniferous forest sites and deciduous forest sites were found. Other studies from this author, conducted in Białowieża National Park (Byk 2001a, 2001b), Hajnówka Forest District (Byk 2001b) and Holly Cross Mountains (Byk 2007) do not corroborate this dependence.

The increase of average number of rare species (R), collected from birch rot, with increasing site's fertility could be caused by other factors than forest site type. Probably the most important fact is that most of strict protection areas in KNP are at wet and fertile sites. Ambiguous results of studies conducted by Byk (2001a, 2001b) in Białowieża National Park and Hajnówka Forest District also do not affirm existence of close dependence between the rare species occurrence and forest site type. Analogous situation can be observed at average number of beetles from F3 class associated to lifeless birches environment. Increase in the number of species from this class of fidelity was probably related to specific character of research area; strict protection areas were mostly localized at deciduous forest site types. Variability of results obtained by Byk (2001a, 2001b) also show lack of dependence between number of species F3 and site type. Large number of rare beetles, individuals (R) collected in birch rot on fresh deciduous forest site, should also be pointed. It was due to the collection of rare species such as *Gyrophaena minima*, which tends to occur in communities rather than the direct influence of forest site type.

Comparing results of this study with literature data, it is difficult to draw unequivocal conclusions on impact of forest fertility and humidity on species composition and structure of communities of saproxylic beetles associated to birch rot. It should be noted that four most fertile forest site types were areas of strict preservation (see chapter 2: Research area). At this point the question that arises is: Which factor, forest site type, or preservation form has stronger influence at natural value of entomoceonosis associated to birch rotten wood? It seems that the preservation form connected with number of rotten wood is of great importance. However site's fertility and wetness, which have impact on share of deciduous trees in a stand, influence only indirectly on entomofauna's abundance. Comparing number of rare species (R) and those belonging to F3 class with percentage share of deciduous trees in a stand on particular sites (Perliński, Sawoniewicz 2011), a dependence on these elements can be noticed. It is hard to notice strong dependence between number of rare species (R) and from F3 class and percentage share of birch in a stand. It indicates lack of strong connection between communities of saproxylic beetles and tree genus or species. The basic condition for these species (Coleoptera) to occur is the existence of lifeless deciduous trees. Decaying birch wood occurring on all studied sites seems to be appropriate microclimate for them (Byk et Byk 2004).With the increase of site's fertility and partial wetness as well as preservation level, potential quantity of deciduous rot increases. The main factor determining the composition and abundance of beetle communities is the number and diversity of rotten wood areas available to insects, not only the forest site type.

According to Økland and others (1996) relationships between the number of rotten wood areas and abundance of beetle species can be noticed only in the objects of bigger scale (100–400 ha). Research plots at Strict Preservation, Sieraków, experienced collection of the largest number of rare species. This shows that passive preservation at big areas has a positive influence. The fauna of saproxylic Coleoptera, sensitive to influence of anthropogenic impact, on such an area can find refugium free from intensive forest management, which is a big threat for them (Kaila et al. 1997; Niemelä 1997). Although many species can survive in harvested forests, communities from these environments differ drastically from natural forests (Väisänen et al. 1993).

Analyzing number of saproxylic beetle species associated to birch in different classes of constancy in relation to particular forest site types, some regularity can be noticed (fig. 5). Number of accessory species (lower constancy of occurring) was positively related to site's fertility. Species from class of konstants were the least numerous at the four most fertile forest site types, all in strict preservation areas. These data show that species from less fertile sites have a wide range of ecological tolerance and create bigger communities. By settling on impermanent, often quite far from each other, e.g., microclimates, they also have quite high disposition to dispersion (Jonsson et al. 2005). On the other hand, on more fertile sites, more species can be found, but less numerous and characterized by narrow range of ecological tolerance. This fact points out greater naturalness and balance of these ecosystems. At strict preservation areas accumulation of lifeless trees is higher, so stenotopic species can choose rotten wood area optimal for their development. At less fertile sites lack of diversified rotten wood areas is a factor significantly reducing number of specialized species.

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