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Seasonal dynamics of saproxylic beetles (Coleoptera) occurring in decaying birch (*Betula* spp.) wood in the Kampinos National Park

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Abstract. The aim of the study was to identify the seasonal changes in the number of saproxylic beetles connected with birch in the Kampinos National Park. The research was conducted for 12 consecutive months in research areas representing 10 different site types. The beetles were collected from wood using photoeclectors. The largest number of species was collected in April and the lowest in January. An increase in number occurred during spring and summer months for species associated only with rotting wood, fructifications of tree fungi, the subcortical environment and hollows. In the same period the number of species not associated or potentially associated with decaying trees and wood decreased. During winter months, the differences in the number of trapped specimens were the smallest. The proportion of zoophagous species amongst the collected specimen increased in autumn and winter. The share of saprophagous species was the highest during the summer-autumn period and the share of mycetophages (jointly with myxomycophages) was the highest during spring and summer. We distinguished two separate groups of Coleoptera with the first one ('summer group') including species trapped during late-spring and summer months, while the second one ('winter group') includes species found in autumn, winter and early-spring months. In the 'summer group', an average of 55.8 species was trapped each month with 331.2 specimen of Coleoptera, while in the 'winter group' an average of 56.1 species with 228.4 Coleoptera specimen were caught.

Keywords: saproxylic insects, phenology, dead wood

1. Introduction

Despite the fact that literature concerning decaying trees and beetles connected with them is quite extensive, many interesting and important topics were not mentioned yet. One of these topics is seasonal dynamics in number of saproxylic beetles. This problem was rarely discussed. The one time that it was mentioned, it only concerned the period of vegetation (Schlaghamerský 2000; Byk et Byk 2004; Mokrzycki 2011). Research concerning communities of saproxylic beetles in winter period was conducted by: Wiąckowski (1957), Lik and Barczak (2005) and Hilszczański (2008). Perliński and Sawoniewicz (2011) presented changes in Elateridae larvae number within 12 consecutive months. The lack of publications, so far, showing systematic description of changes in number of saproxylic beetles in particular months is probably connected with difficulties regarding collection of the subject material. Most of beetle traps were not suitable for use during the winter period. This eliminates the use of photoeclector with artificial source of light. Insects, which in natural environment do not show any increased motor activity, can be roused out of touchwood by using this photoeclector. Domestic publications concerning saproxylic beetles caught with the use of photoeclectors with artificial light are those by: Perliński (2007), Perliński and Sawoniewicz (2011), and Sawoniewicz (2013). Hilszczański (2008) used photoeclector traps without artificial light source to catch insects from bark of dead spruce. Many foreign publications are dedicated to saproxylic beetles caught with the use of different types of eclectors (Gibb et al. 2006; Lachat et al. 2006; Topp et al. 2006; Alinvi et al. 2007; Hjältén et al. 2010; Irmler et al. 2010; Bouget et al. 2011). These publications, however, does not concern directly seasonal dynamics of communities of those insects.

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The aim of this study is to learn about seasonal changes in number of saproxylic beetles connected with birch on area of Kampinos National Park.

Within this study, a hypothesis was adopted that during a year, the number of specimen and species of saproxylic beetles settling birch rotten wood microhabitat undergoes changes.

2. Area of research and methodology

The research was conducted in the area of Laski Protective Circle in Kampinos National Park. Experimental areas were localised in 10 most frequently occurring site types (see: Perliński et Sawoniewicz 2011; Sawoniewicz 2013).

Research material was collected for 12 consecutive months, from April 2008 to March 2009. In second half of each month, from every experimental area, collected were three 2-litre samples of birch touchwood (*Betula* spp.). Jointly, from all experimental areas collected were 360 samples in form of strongly decomposed wood from various rotten wood microhabitats. Touchwood collected in the field was subsequently transferred to laboratory, where with the use of photoeclectors (with artificial light), the beetles were roused out. For this study purpose, only adult specimen of beetles were taken into consideration. Precise description of research area, features of particular rotten wood microhabitats and the process of rousing out the beetles was described in publication of Perliński and Sawoniewicz (2011).

Species of caught beetles were classified into appropriate fidelity class:

F3 – species connected necessarily with strongly decomposed wood; F2 – species less strongly connected with decomposed wood, preferring fructification of tree fungi, subcortical environment, hollows and so on; F1 – species optionally connected with decaying trees or decomposed wood; F0 – species not connected with decomposed wood. Particular species were divided also into trophic groups: F – phytophagous, K – xylophagous, M – mycophagous (in this group also myxomycophagous is included), N – necrophagous, S – saprophagous, Z – zoophagous. During calculations, only one form of feeding was taken into consideration, despite the fact that some of the species were qualified into two trophic groups. Professional literature was the base for division of species into suitable fidelity class and trophic group (see: Sawoniewicz 2013).

Ward method (analysis of resemblance) was used for comparing groups of beetles caught in particular months. Program Statistica was used for calculations.

3. Research results

During research, caught were 3256 specimen of beetles in imago stage. They represented 206 species and 37 families. One of the specimen was marked only to genus and was excluded from further analysis. In Sawoniewicz (2013) publication, found can be a list of caught species with division to fidelity classes and trophic groups.

The most species of beetles (78) were caught in April, and the least (43) in January. June was characterised by the highest number of specimen (448) and January by the lowest number (115).

Table 1 shows, in percentage, the seasonal dynamics of occurrence of the most numerous species.

In particular months of research, the birch rotten wood microhabitat was characterised by relatively constant composition of dominant species. Seasonal changes of species com-

Table 1. Seasonal dynamics of the most abundant species

Species	Month											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	(%)											
Pteryx suturalis (Heer, 1841)	0.3	0.3	6.3	10.4	6.6	11.3	17.0	6.3	7.8	16.7	16.7	0.3
Scaphisoma agaricinum (Linnaeus, 1758)	3.4	1.5	1.9	12.8	11.7	11.7	5.6	16.9	9.8	16.2	5.3	3.4
Euplectus nanus (Reichenbach, 1816)	2.0	1.5	6.5	14.1	13.6	12.1	10.1	13.1	4.0	1.0	16.6	5.5
Gabrius splendidulus (Gravenhorst, 1802)	4.6	1.7	20.6	9.7	9.7	6.3	7.4	9.1	8.6	6.3	8.6	7.4
Cerylon histeroides (Fabricius, 1792)	6.0	3.0	3.0	39.8	7.8	5.4	4.2	10.2	3.0	1.2	12.7	3.6
Sepedophilus testaceus (Fabricius, 1793)		0.6	17.6	13.3	15.2	6.7	7.3	15.8	15.2	3.0	1.8	3.6
Microscydmus minimus (Chaudoir, 1845)	17.1	2.4	16.3	2.4	22.0	5.7	7.3	10.6	4.9	4.9	4.9	1.6
Ptinella aptera (Guérin-Ménéville, 1839)		1.6		3.3		58.5	13.8	4.1	9.8	4.1	2.4	2.4
Gyrophaena minima Erichson, 1837						98.0	1.0		1.0			
Bibloporus bicolor (Denny, 1825)	1.3		1.3	11.5	34.6	7.7	14.1	20.5	3.8	5.1		
Cis fagi (Waltl, 1839)	1.4		2.8	2.8	7.0	35.2	2.8	15.5	11.3	1.4	1.4	18.3

Species	Month											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
						(%)						
Ennearthron cornutum (Gyllenhal, 1827)	1.5	6.0	1.5	28.4	14.9	3.0	7.5	4.5	13.4	7.5	11.9	
Dinaraea angustula (Gyllenhal, 1810)	5.5	3.6	7.3	7.3	9.1	9.1	7.3	10.9	10.9	3.6	21.8	3.6
Cis castaneus (Herbst, 1793)	9.3	3.7	1.9	1.9	5.6	11.1	18.5	24.1	20.4	1.9		1.9
Euplectus karstenii (Reichenbach, 1816)	1.9				28.3	20.8	11.3	11.3	7.5	3.8	7.5	7.5
Cis micans (Fabricius, 1792)		37.8		24.4	4.4			33.3				
Bibloplectus tenebrosus (Reitter, 1880)		52.3	9.1	18.2	4.5					11.4	4.5	
Dyschirius globosus (Herbst, 1784)		26.3	13.2	21.1	13.2		2.6	13.2		2.6	2.6	5.3
Corticaria longicollis (Zetterstedt, 1838)		5.4		5.4	35.1	5.4	24.3	2.7	8.1			13.5
Micridium halidaii (Matthews, 1868)	10.8	16.2		8.1		18.9	2.7			35.1	8.1	
Oxypselaphus obscurus (Herbst, 1784)	8.1		27.0	18.9				8.1	10.8	5.4	5.4	16.2
Saulcyella schmidtii (Märkel, 1845)		8.1	10.8	24.3	2.7		2.7	2.7	37.8			10.8
Phosphuga atrata (Linnaeus, 1758)	12.5	9.4	28.1								12.5	37.5
Plegaderus caesus (Herbst, 1792)	6.7	10.0	3.3	16.7	16.7	3.3	13.3	3.3	6.7	10.0	3.3	6.7
Agathidium seminulum (Linnaeus, 1758)	3.8	3.8	3.8	26.9	3.8	3.8	3.8	19.2	7.7	7.7	11.5	3.8
Bolitophagus reticulatus (Linnaeus, 1767)	4.3				8.7			30.4	17.4	26.1	4.3	8.7
Ampedus pomorum (Herbst, 1784)	13.6	13.6	27.3	9.1	4.5				9.1	9.1	13.6	
Dexiogyia corticina Thomson, 1858	5.3			15.8	42.1	15.8	15.8		5.3			
Dinaraea aequata (Erichson, 1837)		5.3	15.8	10.5	5.3			15.8		21.1	21.1	5.3
Octotemnus glabriculus (Gyllenhal, 1827)		10.5	5.3						84.2			
Cortinicara gibbosa (Herbst, 1793)	11.1	22.2	16.7	11.1	5.6			5.6		5.6	16.7	5.6
Euplectus punctatus Mulsant et Rey, 1861		11.1	11.1	61.1	5.6			5.6	5.6			
Geostiba circellaris (Gravenhorst, 1806)	5.6	11.1	11.1	16.7						33.3	22.2	
Phloeocharis subtilissima Mannerheim, 1830				44.4		11.1	11.1	5.6	5.6		22.2	
Phloeopora teres (Gravenhorst, 1802)	5.6	61.1	22.2							5.6	5.6	
Anthobium atrocephalum (Gyllenhal, 1827)	11.8		23.5	23.5	23.5				5.9		5.9	5.9
Lathrobium longulum (Gravenhorst, 1802	5.9	41.2	5.9	23.5					5.9	11.8	5.9	
Phloeonomus punctipennis (Thomson, 1867				5.9							94.1	
Liodopria serricornis (Gyllenhal, 1813)			6.3		75.0	6.3	6.3		6.3			
Stenus humilis (Erichson, 1839)				6.3	6.3	18.8	25.0	18.8	18.8		6.3	
Atheta gagatina (Baudi di Selve, 1848)	6.7			6.7		80.0	67					
Cerylon ferrugineum Stephens, 1830			14.3	21.4		14.3	28.6	14.3				7.1
Scaphidium quadrimaculatum Olivier, 1790					35.7	7.1		14.3	42.9			
Agonum micans (Nicolai, 1822)	15.4		30.8	38.5						15.4		
Agonum viduum (Panzer, 1796)		8.3							50.0	16.7	25.0	
Anisotoma humeralis (Fabricius, 1792)				25.0		16.7	58.3					
Cis boleti (Scopoli, 1763)		8.3	33.3	25.0			8.3	16.7				8.3
Euconnus pubicollis (Müller et Kunze, 1822)				25.0	16.7		16.7	16.7	25.0			
Trixagus dermestoides (Linnaeus, 1767)			8.3	8.3	33.3	8.3	33.3				8.3	
Neuraphes elongatulus (Müller et Kunze, 1822)		18.2		27.3	9.1			9.1			36.4	

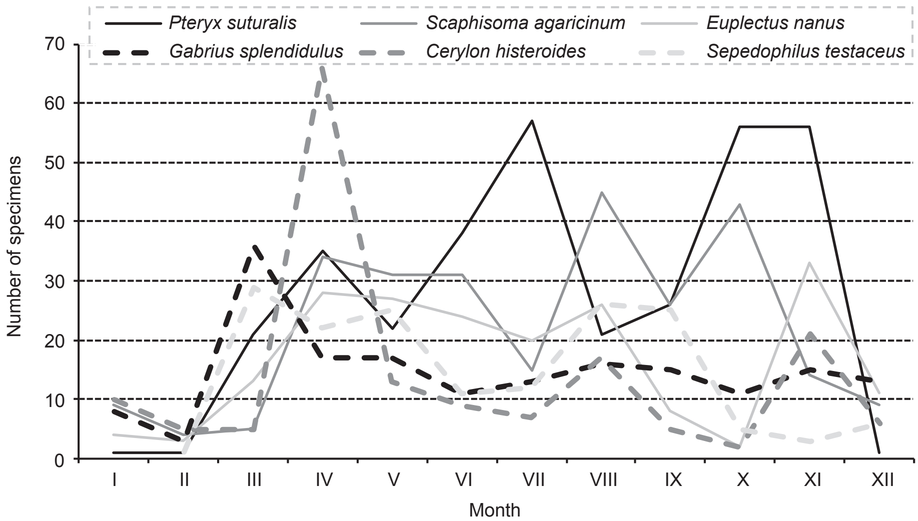

Figure 1. Seasonal dynamics of *P. suturalis, S. agaricinum, E. nanus, G. splendidulus, C. histeroides* i *S. testaceus*

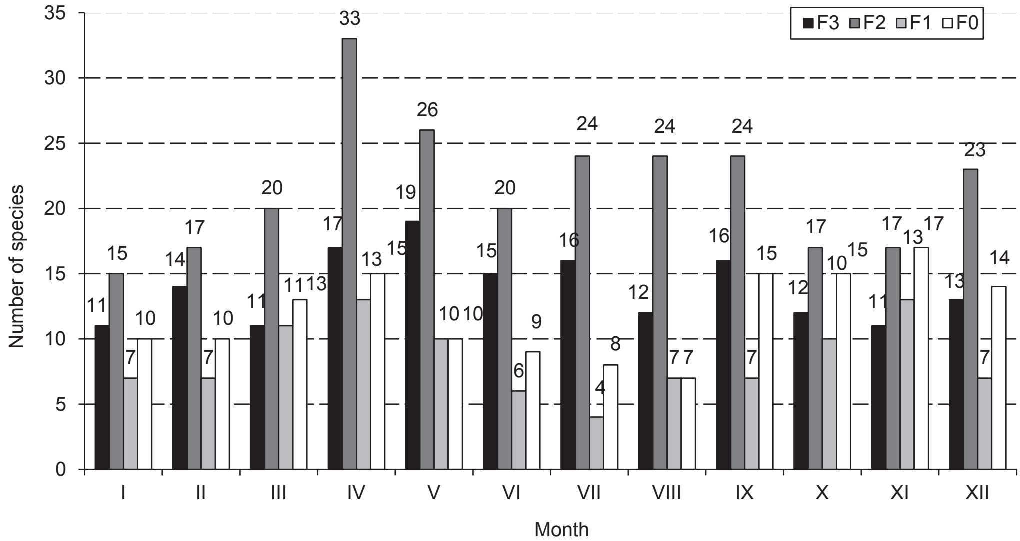

Figure 2. Number of species belonging to different classes of fidelity caught in particular months (F3 – species strongly dependent on decaying wood; F2 – species less dependent on decaying wood, preferring wood fungi, the subcortical environment, tree hollows, etc.; F1 – species optionally associated with decaying wood or weakened trees; F0 – species not associated with decaying wood)

position concerned most of all taxa that were caught in small number. Figure 1 shows seasonal changes in number of six most numerous species of beetles noted in birch touchwood.

Among caught beetles, species connected with subcortical environment, fructifications of tree fungi and hollows (F2) were a dominant group in all months (except for November) (Fig. 2). Second, in terms of number of species, fidelity class was the class of beetles necessarily connected with decomposed wood and rotten wood habitat (F3). Their appearance was noticeable from April to September and in January and February. In remaining months, beetles not connected with decomposed wood (F0) constituted a second fidelity class in terms of number of species. The most species optionally connected with dead wood (F1) were caught in spring and autumn months. In early spring and autumn months, noted was the largest number of species from class F0. In autumn and winter months, the differences in number of species of particular fidelity classes were the smallest.

In spring and summer months, observed can be a vivid disproportion between number of specimen from classes F1 and F0, and F3 and F2 (Fig. 3). The most specimen from class F2 were caught in spring and summer months, and from class F3 in spring, summer and autumn months. In winter months, the differences in number of caught specimen in particular fidelity classes were the smallest.

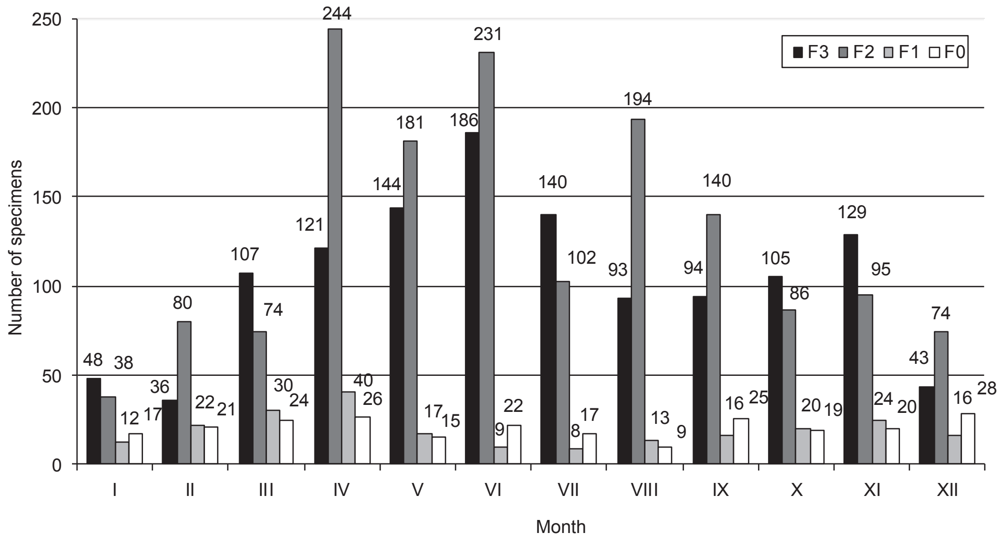

Figure 3. Number of specimens belonging to different classes of fidelity caught in particular months (explanations as in Fig. 2)

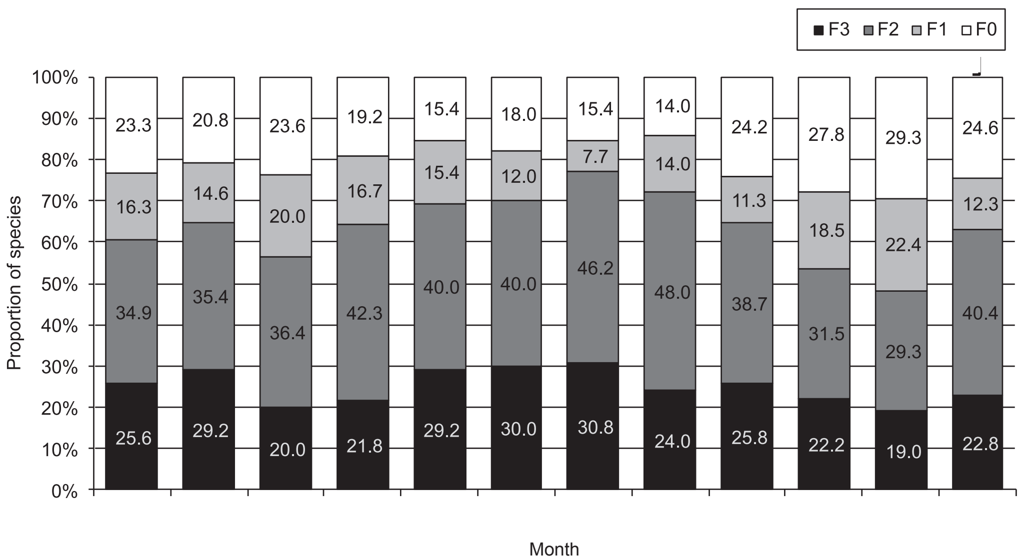

Figure 4. Proportion of species belonging to different classes of fidelity caught in particular months (explanations as in Fig. 2)

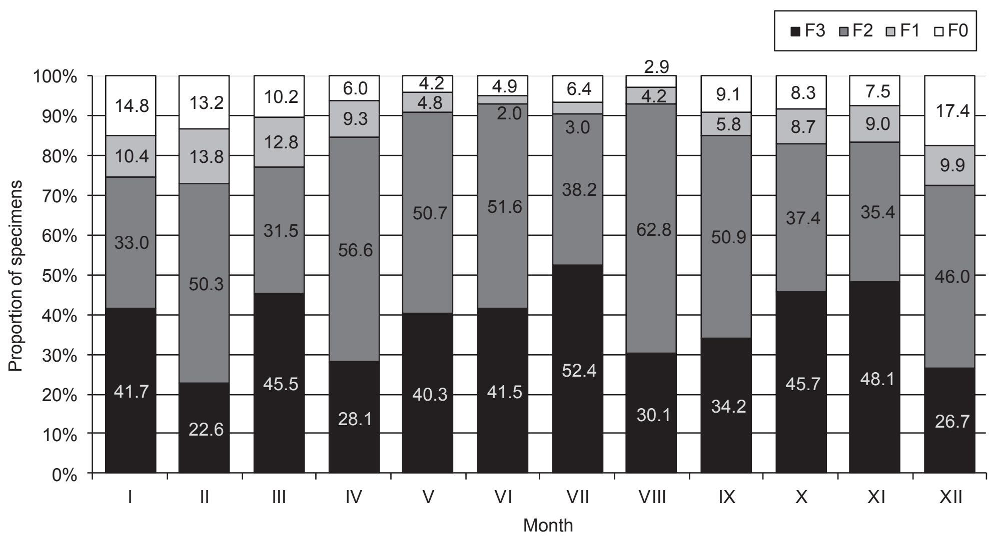

Figure 5. Proportion of specimens belonging to different classes of fidelity caught in particular months (explanations as in Fig. 2)

In spring–summer period, the share of species belonging to fidelity classes F1 and F0 decreased, while the share of classes F3 and F2 increased (Fig. 4). The share of specimen belonging to F1 and F0 fidelity classes decreased in spring–summer period (Fig. 5). In this period, observed was also the increase of share of specimen from F2 class. Changes in percentage share of specimen belonging to F3 class did not show a visible trend in particular months. The number of saprophagous and zoophagous species caught in summer months decreased. However, the most mycophagous species (jointly with myxomycophagous) were caught in spring–summer period (Fig. 6).

In spring–summer period, the number of caught specimen that belonged to mycophagous (jointly with myxomycophagous), saprophagous and zoophagous groups increased. The share of specimen from zoophagous group was the highest in late-autumn and winter. The share of specimen from saprophagous group was the highest in summer and autumn, and mycophagous (jointly with myxomycophagous) in the spring and summer (Fig. 7).

The analysis of resemblance of beetles communities caught in particular months allowed to distinguish two separate communities of beetles (Fig. 8). First one of them (for simplification named 'summer community') includes beetles caught in late spring and summer months (from May to September). The second one ('winter community') includes beetles occurring in autumn, winter and early spring months (from October to April). Both communities are characterised by similar number of species cau-

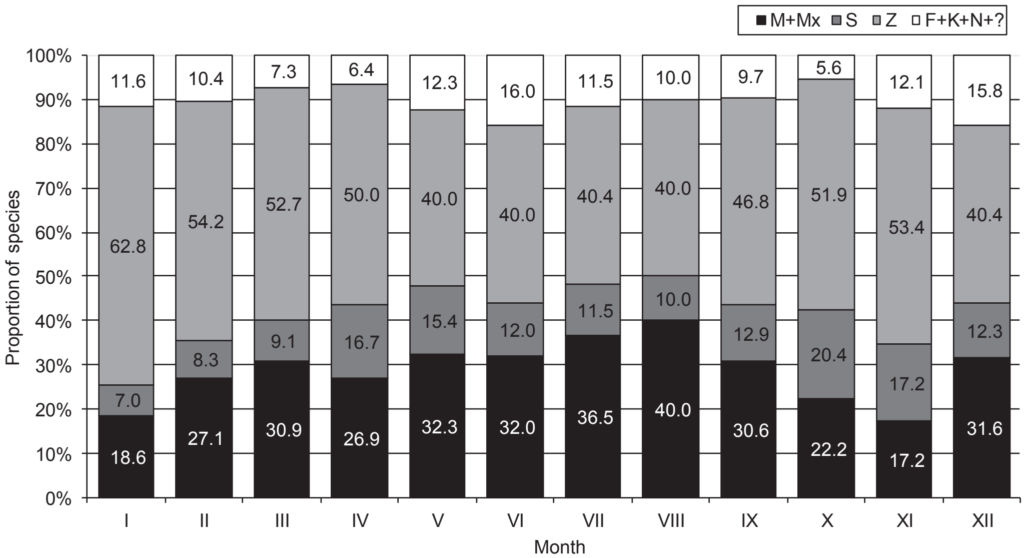

Figure 6. Proportion of species belonging to a trophic group of: phytophagous (F), xylophagous (K), mycophagous (M), myxomycophagous (Mx), necrophagous (N), saprophagous (S), zoophagous (Z) and not assigned to a group of trophic (?) caught in particular months

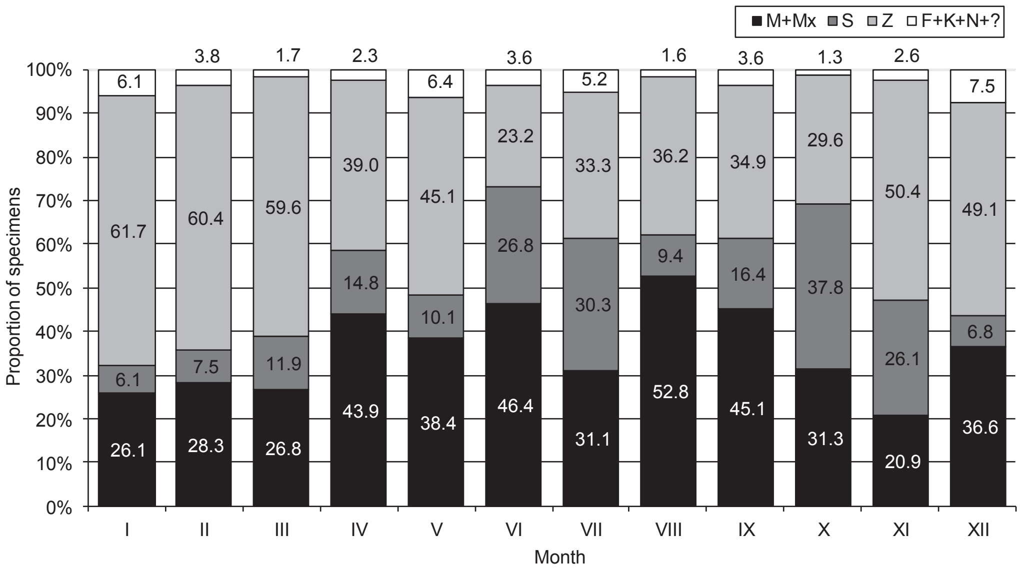

Figure 7. Proportion of specimens belonging to a trophic group of: phytophagous (F), xylophagous (K), mycophagous (M), myxomycophagous (Mx), necrophagous (N), saprophagous (S), zoophagous (Z) and not assigned to a group of trophic (?) caught in particular months

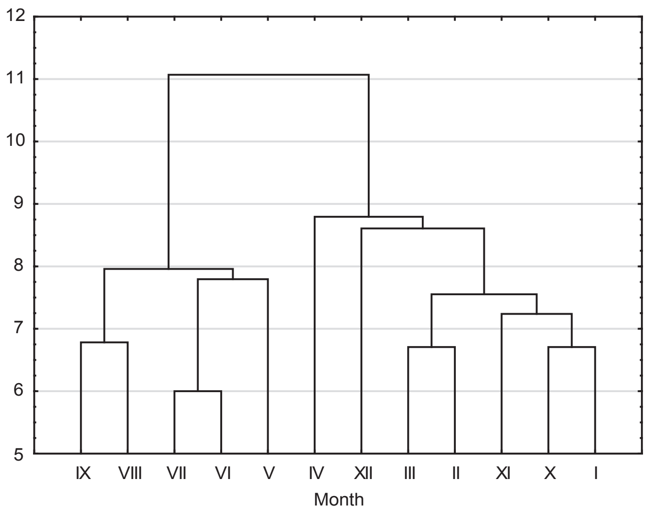

Figure 8. Dendrogram of similarity between communities of beetles collected in particular months (Ward's method) − on the basis of presence or absence of particular species

ght in particular months. In case of 'summer community', on average, caught were 55.8 species (331.2 specimen), while in case of 'winter community' – 56.1 species (228.4 specimen). In 'summer community' dominant species were: *Bibloporus bicolor*, *Cerylon histeroides*, *Cis fagi*, *Euplectus nanus*, *Gabrius splendidulus*, *Gyrophaena minima*, *Microscydmus minimus*, *Octotemnus glabriculus*, *Pteryx suturalis*, *Ptinella aptera*, *Saulcyella schmidtii*, *Scaphisoma agaricinum* and *Sepedophilus testaceus*. In 'winter community', dominant were: *Bibloplectus tenebrosus*, *Cerylon histeroides*, *Cis fagi*, *C. micans*, *Dyschirius globosus*, *Euplectus nanus*, *Gabrius splendidulus*, *Micridium halidaii*, *Microscydmus minimus*, *Phloeonomus punctipennis*, *Phloeopora teres*, *Phosphuga atrata*, *Pteryx suturalis*, *Scaphisoma agaricinum* and *Sepedophilus testaceus*. Average number of species belonging to mycophagous (jointly with myxomycophagous) was higher in 'summer community'. However, average number of zoophagous species was higher in 'winter community'.

4. Discussion

The phenomenon of quantitative and qualitative dynamics in different seasons is characteristic for communities of forest insects. Seasonal dynamics of beetles' numbers can result from intra-population characteristics of species in given community. Seasonal dynamic can be also caused by influence of abiotic environment factors (such as length of the day, temperature, humidity). These factors can influence directly on given insect or indirectly on its host or host plant (Szujecki 1980). Insect development, transfer of younger stages into older, can also be the cause of seasonal changes occurring in saproxylic entomofauna (Wiąckowski 1957).

As much as 53.7% of saproxylic beetles can be found in dead trunks during wintertime, according to Piotrowski and Wołek (1975). Some of them settle in rotten wood microhabitat only during hibernation. Kaczmarek (1958), by examining winter activity of soil invertebrates in Kampinos National Park, stated that some of the species from Carabidae family show higher activity in late autumn than in the summer. This author proved additionally that some beetles, inter alia those from Carabidae and Staphylinidae families, are active during winter. That research did not concern directly saproxylic entomofauna, but it seems likely, that some of the beetles connected with rotten wood microhabitat may show similar activity during winter. Lik and Barczak (2005) showed, that number of species in Ciidae family changes in particular seasons of the year, reaching the highest value during autumn–winter period. Research conducted in Kampinos National Park confirm the differences in composition and structure of communities in particular seasons of the year. Those differences are particularly visible between warm and cold months. That is why in order to receive a full composition of species and a structure of saproxylic beetles communities, the research should be conducted also off the vegetative period.

The biggest seasonal changes in structure of insects appearing on pine trunks in the beginning of vegetative period, as Wiąckowski (1957) claims, occur from April to June. In this period, the majority of insects undergoes pupation, swarm and lay eggs. Similar results were also obtained by different authors who focussed on this subject matter (Schlaghamerský 2000; Byk et Byk 2004; Gutowski et al. 2010; Mokrzycki 2011). Research conducted for the needs of following study confirm the difference between communities of beetles appearing in touchwood in particular months of the year.

Piotrowski and Wołk (1975), Gutowski 2006, and Hilszczański (2008) note that leaving dead trees allow to improve the conditions for development of predatory and parasitic insects. Many of them use decomposing trunks as a shelter during unfavourable thermal conditions. Predatory beetles constituted 40.5% of all specimen caught in birch touchwood (Sawoniewicz 2013), whereof 39.5% of specimen appeared there during hibernation (from November to March). These results confirm, that the wood of dead birches may be very significant as a place to hibernate for predatory beetles.

5. Conclusions

1. The most species and specimen of adult beetles were caught in spring, and the least in winter. It is connected directly with lifecycle of those insects. Many species of beetles metamorphose and smarm in the beginning of vegetative period but hibernate in preimaginal stage.

2. In winter months, the differences in number of specimen in particular classes of fidelity with regard to strongly decomposed wood were the smallest. It is connected with

migration of species not connected with touchwood but searching for a place to hibernate.

3. There are two separate communities of beetles connected with decomposing birch wood. First one of them ('summer community') includes insects occurring in late spring and summer months. The second one ('winter community') includes beetles occurring in this environment in autumn, winter and early spring months.

4. In order to recognise the structure of community of beetles connected with dead trees, it is recommended to conduct the research for a whole year. Photoeclectors with artificial source of light allow to catch the insects during hibernation. That is why those devices seem to be appropriate for this type of research.

Conflict of interest

The Author declares lack of potential conflicts.

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