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Aphids (*Hemiptera*: *Aphidinea*) and ground beetles (*Coleoptera*: *Carabidae*) in the urban environments of Bydgoszcz and its vicinities

Mszyce (*Hemiptera*: *Aphidinea*) i biegaczowate (*Coleoptera*: *Carabidae*) w środowiskach zurbanizowanych Bydgoszczy i okolicy

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ABSTRACT

The subject of this study was aphids (*Hem.*, *Aphidinea*) in particularly valuable environments called “environmental islands”. In fact, they are specific refuges of beneficial and protected entomofauna in the agricultural landscape. The results can contribute to verification of protection of some arable crops by taking those habitats into consideration in the so-called natural biological pest control. Towns, in turn, are specific ecosystems which are composed of many factors with a clearly different character and intensity than in natural environments. On account of the important role and a small degree of knowing *Carabidae* fauna in urbanized areas, a study was undertaken in 1998 in Bydgoszcz and its neighbourhood, aimed at indicating hanges that occur in the fauna of *Carabidae* in various types of urban green and town protection zone, as well as determining the role of these environments as reservoirs of entomophagous species, which can disperse to agrocenoses.

Keywords: aphids, *Carabidae*, midfield thickets, urban environments, plant protection, nature conservation

STRESZCZENIE

Przykładem szczególnie cennych środowisk są tzw. zarośla śródpolne (inaczej wyspy środowiskowe), które są refugiami entomofauny pożytecznej i chronionej w krajobrazie rolniczym. Przedmiotem badań w tym względzie były zgrupowania mszyc (*Hem.*, *Aphidinea*). Ich rezultaty mogą przyczynić się do zweryfikowania programów ochrony niektórych upraw rolniczych poprzez uwzględnienie tzw. naturalnego

biologicznego zwalczania szkodników. Z kolei miasta to specyficzne ekosystemy, na które składa się szereg czynników o charakterze i natężeniu wyraźnie odmiennym niż w środowiskach naturalnych. Ze względu na rolę a zarazem słaby stopień poznania fauny biegaczowatych w aglomeracjach, kontynuowane są zapoczątkowane w roku 1998 w Bydgoszczy i okolicy badania, których celem jest wykazanie zmian, jakie zachodzą w faunie *Carabidae* w różnych typach zieleni miejskiej i otulinie miasta, a także określenie roli tych środowisk jako rezerwuarów gatunków entomofagicznych, mogących dyspergować do agrocenoz.

Słowa kluczowe: mszyce, *Carabidae,* zarośla śródpolne, środowisko miejskie, ochrona roślin, ochrona środowiska

DETAILED ABSTRACT

Celem podjętych badań było określenie składu gatunkowego i liczebności mszyc (*Hemiptera.*, *Aphidinea*) oraz epigeicznej fauny chrząszczy z rodziny biegaczowatych (*Coleoptera*, *Carabidae*), w różnych typach środowisk miejskich i podmiejskich. Przedmiotem badań były mszyce, odławiane do żółtych pułapek Moericke'a w półnaturalnych siedliskach w okolicy Bydgoszczy w dolinie rzeki Wisły. Pułapki były ustawione na wysokości roślin zielnych. Na każdej powierzchni badawczej umieszczono po trzy pułapki w odległości 10 m w rzędzie, pułapki opróżniano co 10 dni w okresie wegetacji. Badane siedliska znajdowały się w sąsiedztwie pól uprawnych, stanowiąc swoiste miedze śródpolne. Obiektem innej części badań były zgrupowania biegaczowatych zasiedlające różne rodzaje zieleni miejskiej w granicach urbanizacyjnych Bydgoszczy oraz w lasach podmiejskich. Stosowane pułapki Barbera były zakładane transektowo i bez przynęt, po około 20 w rzędzie. Obserwacje nad tą grupą owadów prowadzono przez okres czterech lat (2000-2003). Pułapki były wykorzystywane w okresie od maja do września w każdym sezonie badawczym, a chrząszcze wybierano z nich co 5-7 dni. Wśród odłowionych przez trzy lata (1997- 1999) około 20 gatunków mszyc, najliczniej notowane były: *Phorodon humuli*, *Rhopalosiphum padi*, *Aphis fabae*, *Aphis sambuci*, *Microlophium carnosum*, *Hyalopterus pruni*, *Dysaphis crataegi*, *Cavariella aegopodii* i *Sitobion avenae*. Podsumowując wyniki dotyczące mszyc należy stwierdzić, że często gatunki mszyc uważane za „szkodniki", jak *R.padi* i *A.fabae*, bądź nie zasiedlały licznie badanych siedlisk, bądź traktowały je prawdopodobnie jedynie, jako miejsca do dalszej dyspersji. Z kolei, w oparciu o uzyskany z czterech lat materiał dotyczący chrząszczy epigeicznych, stwierdzono występowanie na badanym obszarze aż 93 gatunków *Carabidae,* co stanowi około 36 % biegaczowatych notowanych na terenie Pomorza i Kujaw. Z badanych powierzchni odłowiono 9683 osobniki tych chrząszczy. Najzasobniejszymi w gatunki okazały się tereny zielone w Bydgoszczy (87 gatunków), znacznie mniej (44 gatunki) zanotowano ich z obszarów leśnych w otulinie miasta, co potwierdza wyniki badań innych autorów. Wśród odłowionych biegaczowatych do chronionych zalicza się wszystkie gatunki z rodzaju biegacz (*Carabus*) oraz z rodzaju tęcznik (*Calosoma*), a inne gatunki były entomofagiczne, w tym afidofagiczne.

INTRODUCTION

Studies have been undertaken for many years concerning the use of entomophages associated with midfield thickets in the so-called “natural biological pest control” (Ehler, 1990)This is connected with the need for determination of the biological potential of these habitats, in order to utilize them optimally for IPM (Integrated Pest Management) (Powell, 1986). Bearing this in mind, it is possible to influence the topography of the agricultural landscape, or, in a wider sense, the arable lands, so that it would include appropriate types of trees, shrubs or other midfield thickets, also referred to as environmental islands (Banaszak ed., 1998) As fragments of the so-called ecological corridors, in the Kujawy and Pomerania region they compose one large corridor, and at the same time a route of fauna dispersion of European importance, which is the Toruń - Eberswalde Proglacial Stream Valley, with a particular consideration given to the Vistula river valley. At the present stage of the study, the results indicate a positive effect of the species diversity of phytophagous insect communities living in midfield thickets on the occurrence of beneficial fauna, particularly natural enemies of aphids (aphidophages), being of importance e.g. in the agrocenoses of beet, poppy or faba bean (Hurej, 1982; Barczak, 1993), or species under legal protection, such as some *Carabidae*, including aphidophages, as well (Barczak, et al., 2000, 2002; Barczak, 2003), and so-called umbrella species (Pawłowski and Witkowski, (1999)2000; Żelazna and Błażejewicz-Zawadzińska, 2003, 2004).

In town ecosystems, in turn, urbanization to a large extent eliminates typical habitats of various animal species and drives out the fauna living there previously. Retaining the existing urban green and creating *de novo* aeras of this type within the limits of towns and in their protection zones, which would enable a further development of networks of the above-mentioned so-called ecological corridors, is of essential importance in the processes of shaping the urban environment (Davis and Glick, 1978). Such biologically active areas, with a relatively high species diversity, can make a food base and provide places of living and nesting for groups of organisms inhabiting them in urban environments. Moreover, they can also be a source of dispersion of invertebrates to suburban agricultural environments (*e.g.* Barczak, 1993). The aim of this study was to estimate the species diversity and number of aphids (*Hem.*, *Aphidinea*) and epigeic fauna of the family of ground beetles (*Col.*, *Carabidae*), in various types of urban and suburban environments in the Vistula river valley.

MATERIAL AND METHODS

The subject of this study were aphids (*Hemiptera, Aphidinea*) caught in yellow Moericke’s traps in semi-natural habitats in the vicinity of Bydgoszcz, in the valley of the Vistula river. The traps were situated at the height of herbaceous plants. Three traps were placed in each research area at a distance of 10 m in a row. The traps were emptied every 10 days during the growing season. The tested habitats were situated in the neighbourhood of fields, constituting specific midfield boundaries. In habitats s I and s II trees and shrubs occurred, whereas habitats s III and s IV were overgrown by herbaceous plants. In habitat s I *Salix alba* L. dominated, as well as *Sambucus nigra* L. and *Rosa canina* L. And of herbaceuous plants, *Urtica dioica* L. and *Elymus repens* Gould. Habitat s II was dominated by shrubs *Prunus spinosa* L., *Crataegus* sp. and *Rhamnus cathartica* L. and open places were overgrown by rich

herbaceous vegetations with *Fragaria vesca* L., *Artemisia vulgaris* L., *Chenopodium album* L. and large amounts of *E. repens*. In habitats s III and s IV, in turn, herbaceuous plants prevailed, with a predominance of *U. dioica*, *E. repens*, *Tanacetum vulgare* L. and *Solidago gigantea* Aiton.The subject of another part of the study were ground beetles (*Coleoptera, Carabidae*) inhabiting various types of urban green areas within the urban limits of Bydgoszcz (Popular Park, Załuski Park, the Planty on the Old Canal, the vicinity of the airport, Smukała), and in suburban forests (Myślęcinek, Las Gdański, Las Jastrzębie). The Barber traps were set transversely, without bait, about 20 in a row. Observations of this group of insects were carried out during four years (2000-2003). The traps were used in the period from May to September in each research season, and beetles were collected from them every 5-7 days. Insects collected in the given environments were compared using the Shannon-Weaver formula, where differences between its values were assessed by means of the Hutcheson test (Hutcheson, 1970), using the analysis of variance. According to Klimaszewski et al. (1980), the following subgroups of aphid species were distinguished: D4 - a very numerous species (a dominant), constituting more than 20 % of material collected in the given habitat; D3 - a numerous species (a subdominant), represented by 10.1 - 20 % of the total number of specimens; D2 - a quite numerous species (a recedent), ranging from 3 to 10 % of collected material; D1 - a rare species, (a subrecedent) - represented by less than 3 % of total number of specimens. In the case of Carabidae, the scale of domination was determined according to the proposal of Górny (1975). A similarity of ground beetle fauna of the tested areas was also determined using the Bray-Curtis dendrogram, following the program BioDiversity Pro.

RESULTS AND DISCUSSION

Among the twenty or so species of aphids caught in three years (1997- 1999), these the most frequently recorded were: *Phorodon humuli* (Schrank), *Rhopalosiphum padi* (L.), *Aphis fabae* Scop., *Aphis sambuci* L., *Microlophium carnosum* (Buck.), *Hyalopterus pruni* (Geoffroy), *Dysaphis crataegi* (Kalt.), *Cavariella aegopodii* (Scop.), and *Sitobion avenae* (Fabr.). The other species occurred individually in various habitats and years (Table 1, Figure 1). Aphid count in the case of the most abundant species ranged from less than 69 % in habitat s III, to 90 % in habitat s I (Table 1, Figure 1). The results concerning aphids indicates that two species can pose a potential threat for agricultural crops: *Rhopalosiphum padi* (cereal pest) and *Aphis fabae* (mostly the pest of beet), occurring numerously in the tested habitats and years. *R. padi* prevailed in habitats s I, s II and s III, whereas *A. fabae* in s I and s III (Table 2). Additionally, the habitats were dominated by aphid species feeding on various species of wild plants, including black thorn - *Phorodon humuli*, the species which prevailed in all the tested habitats. The species *A. sambuci*, in turn, feeding on common elder, was the most numerous among the caught aphids only in habitat s I, *Dysaphis grataegi* (occurring on hawthorn) in habitat s III, and *C. aegopodii* - the aphid feeding on willow, was the most numerous in habitat s IV. The most co-dominating species of aphids were observed in habitat s I and s II (Table 2).

Table 1. Number of aphid species in individual habitats (1997-99)
Tabela 1. Liczebność gatunków mszyc w poszczególnych siedliskach (1997-99)

Aphid species, gatunek mszycy	Mean number of aphids, średnia liczebność mszyc			
	s I	s II	s III	s IV
Aphis fabae	25	12	33	25
Aphis sambuci	17	4	3	0
Cavariella aegopodii	11	2	14	32
Dysaphis crataegii	3	8	22	5
Hyalopterus pruni	6	2	13	10
Microlophium carnosum	16	0	1	14
Phorodon humuli	64	34	30	185
Rhopalosiphum padi	23	89	29	8
Sitobion avenae	2	2	7	3
The other species, inne gatunki	20	37	70	100

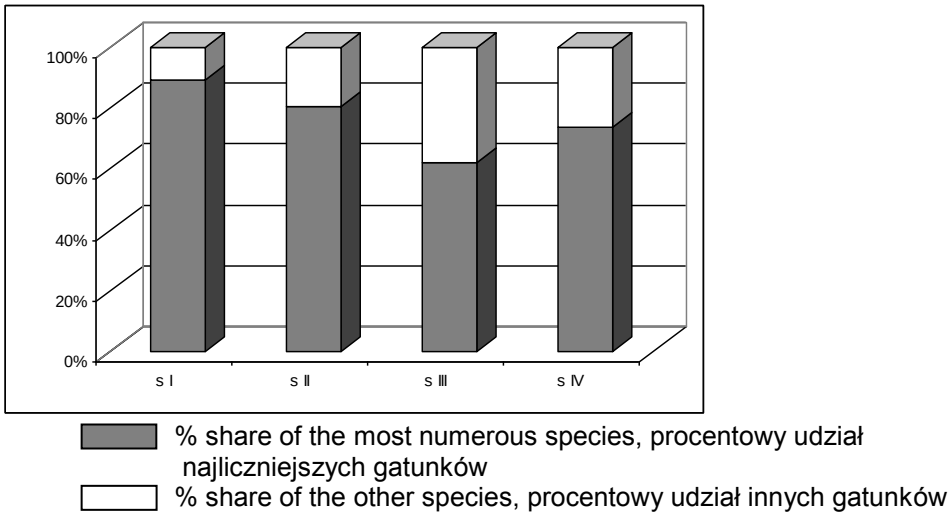

Figure 1. Percentage share of aphid species occurring in tested habitats: s I, s II, s III, s IV – see abbreviations in the text (1997-99)
Rycina 1. Procentowy udział gatunków mszyc występujących w badanych siedliskach: s I, s II, s III, s IV (1997-99)

Table 2. Domination indexes of aphid species occurring in tested habitats (data from 1997-99)*
Tabela 2. Wskaźniki dominacji gatunków mszyc występujących w badanych siedliskach (dane z lat 1997-99)*

Aphid species, gatunek mszycy	s I	s II	s III	s IV
Aphis fabae	D3	D2	D4	D2
Aphis sambuci	D3	D1	D1	-
Cavariella aegopodii	D2	D1	D2	D3
Dysaphis crataegii	D1	D2	D3	D1
Hyalopterus pruni	D2	D1	D2	D2
Microlophium carnosum	D2	-	D1	D2
Phorodon humuli	D4	D4	D3	D4
Rhopalosiphum padi	D3	D4	D3	D1
Sitobion avenae	D1	D1	D2	D1

* / D1 - dominant, D2 – subdominant, D3 - recedent, D4 – subrecedent

Summing up the results concerning aphids, it should be concluded that aphid species regarded as pests, such as *R.padi* and *A.fabae*, often did not inhabit the tested sites in great numbers or treated them probably only as places for further dispersion. Also, as in the case of the black bean aphid, only the subspecies *A. fabae* Scop. *sensu stricto* is a pest of beet and broad bean, and the other subspecies feeding mainly on herbaceous plants. This could be the case in the tested midfield thickets, adjoined to small fields, where mainly maize or cereals were grown, and the found aphid species either are of no economic importance for these monocultures or their presence depends on the season (Barczak, 1993; Barczak, et al., 2000). Aphids also play an important role as links in various food chains. For this reason the tested sites adjacent to ploughlands should not be treated only as potential reservoirs of aphid species harmful for arable crops (Bennewicz, 1996; Bennewicz and Krasicka-Korczyńska, 1997; Bennewicz and Kaczorowski, 1999; Bennewicz, et al., 2001; Kaczorowski and Bennewicz, 1995). These semi-natural sites can also increase the richness (diversity) of beneficial insects (predators and parasitoids), and controlling or limiting their area results in upsetting the ecological balance in the agricultural landscape (Andrzejewska, 2002; Ratyńska and Szwed, 2002; Szwed and Andrzejewski, 2002; Miklaszewska and Adamczewski, 2004; Barczak, et al., 2000, 2002). Moreover, Dixon (2001) notices that as a result of aphid dispersion, 77- 93 % their population dies, not finding the host plants or is destroyed due to mechanical damage. Therefore one may conclude that the harmfulness of thickets as a storehouse of agrophages is rather overestimated. Next, on the basis of material concerning epigeic beetles obtained from four years, the occurrence of as many as 93 species of *Carabidae* was observed in the tested area, which accounts for about 36% of ground beetles recorded in the area of Pomerania and Kujawy (Burakowski, et al., 1973, 1974; Aleksandrowicz, 2004). A total of 9683 specimens of those beetles were caught from the tested areas. Green areas in Bydgoszcz turned out to be the most abundant in species (87 species) (Figure 2), considerably less of them (44 species) were recorded from forest areas in the town protection zone, which is confirmed by results of studies by other authors (Żelazna, et al., 2001; Żelazna and Błażejewicz-Zawadzińska, 2003, 2004; Błażejewicz-Zawadzińska and Żelazna,

2001). In the town parks, the most recorded species belonged to such genera as *Harpalus* Latr., *Amara* Bon. or *Bembidion* Duft. Species of the genus *Pterostichus* Bon. were represented both in suburban forests and in green areas of the town. The species which achieved a position of eudominants (≥ 10 %) in urban habitats were: *Calathus erratus* (21.05 %) and *Pterostichus oblongopunctatus* (11 %) (Table 3), which is confirmed by the results of other studies from the region (Błażejewicz-Zawadzińska, 2004). The former species turned out to be also eudominant in suburban forests (24.87 %), along with *Carabus nemoralis* (17.26 %).The tested areas were also characterized by a high species diversity (H' = 3.70-4.23), whereas differences between H' values for the tested habitats assessed by means of the analysis of variance with the Hutcheson test (Hutcheson, 1970) were not statistically significant between *Carabidae* fauna corresponding to individual areas, although they were characterized by a considerable similarity in the percentage share of dominating species (Figure 3).

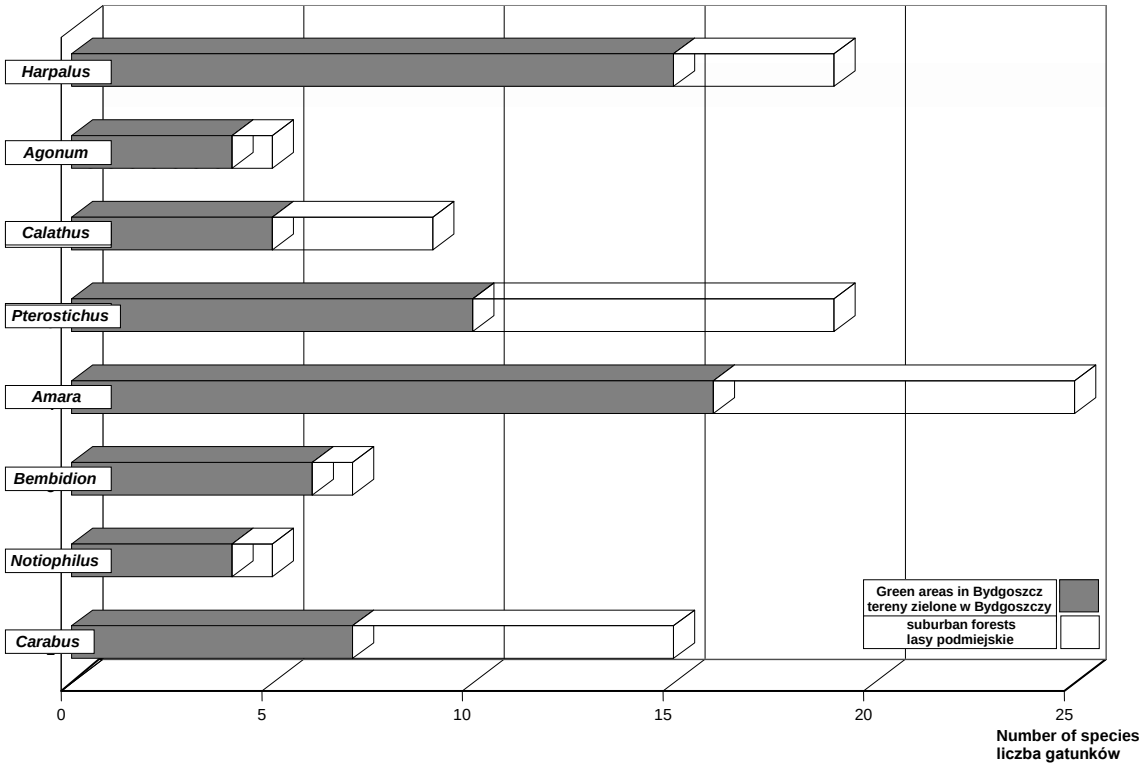

Figure 2. Species richness of the most abundant *Carabidae* genera on the investigated areas
Rycina 2. Porównanie bogactwa gatunkowego w obrębie najliczniej reprezentowanych rodzajów *Carabidae* na badanych terenach

In Poland, among the caught ground beetles, all the species of the genus *Carabus* (Table 3) and of the genus *Calosoma* are protected (Żelazna and Błażejewicz-Zawadzińska, 2004). The species mentioned above, as well as the majority of the others (Table 3), are entomophagous, and even aphidophagous (Barczak, et al. 2000). Hence, we could see them as an element of IPM in case of suburban agrocenoses, to which those carabids can disperse.

Table 3. Comparison of domination indexes (D) of most often caught species of ground beetles: ED - eudominants, D - dominants, SD - subdominants R - recedents, SR - subrecedents

Tabela 3. Porównanie wskaźników dominacji (D) najliczniej odławianych gatunków biegaczowatych: ED-eudominanty, D-dominanty, SD- subdominanty R- recedenty, SR- subrecedenty

Species, gatunek	Bydgoszcz	Suburban forests, lasy podmiejskie
Carabus violaceus L.	1,49 (R)	4,96 (SD)
Carabus arvensis Herbst	0,24 (SR)	1,42 (R)
Carabus nemoralis (O.F. Müller)	9,35 (D)	17,26 (ED)
Carabus hortensis L.	1,77 (R)	7,28 (D)
Nebria brevicollis (F.)	2,38 (SD)	2,20 (D)
Notiophilus biguttatus (F.)	1,10 (R)	4,71 (D)
Bembidion lampros (Herbst)	0,22 (SR)	0,60 (SR)
Amara aenea (De Geer)	0,93 (SR)	0,23 (SR)
Amara communis (Panz.)	0,76 (SR)	0,44 (SR)
Amara lunicollis Schiødte	0,13 (SR)	1,14 (R)
Amara similata (Gyll.)	0,84 (SR)	0,05 (SR)
Stomis pumicatus (Panz.)	0,30 (SR)	0,12 (SR)
Pterostichus cupreus (L.)	0,61 (SR)	0,58 (SR)
Pterostichus angustatus Duft.	0,09 (SR)	0,44 (SR)
Pterostichus oblongopunctatus (F.)	11,00 (ED)	24,87 (ED)
Pterostichus niger (Schall.)	8,88 (D)	8,84 (D)
Pterostichus melanarius (Ill.)	9,07 (D)	6,44 (D)
Pterostichus anthracinus (Ill.)	1,23 (R)	1,09 (R)
Pterostichus nigrita (F.)	0,17 (SR)	3,87 (SD)
Pterostichus diligens (Sturm)	0,32 (SR)	0,12 (SR)
Calathus erratus (C.R.Sahlb)	21,05 (ED)	2,85 (SD)
Calathus fuscipes (Goeze)	6,48 (D)	0,58 (SR)
Calathus melanocephalus (L.)	9,08 (D)	0,44 (SR)
Calathus micropterus (Duft.)	1,68 (R)	0,32 (SR)
Platynus assimilis (Payk.)	0,39 (SR)	0,95 (SR)
Harpalus rufipes (De Geer)	8,00 (D)	0,49 (SR)
Harpalus tardus (Panz.)	1,15 (R)	0,16 (SR)

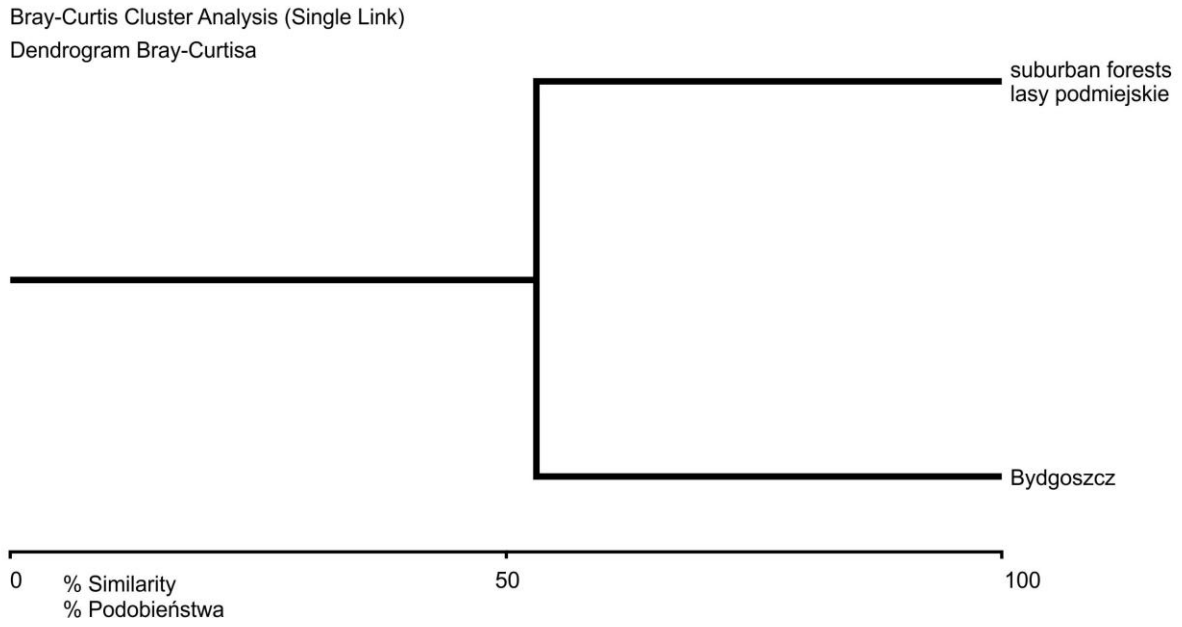

Figure 3. Dendrogram of similarity of *Carabidae* communities of the tested green areas in Bydgoszcz and suburban forests
Rycina 3. Dendrogram podobieństwa zgrupowań biegaczowatych badanych terenów zielonych Bydgoszczy oraz lasów podmiejskich

SUMMING-UP AND CONCLUSIONS

While summing up this study, two suggestions arise. First, there is a need for updating the assessment of both the phytosanitary role of different kinds of midfield thickets in the agricultural landscape, and their importance for beneficial fauna. The polycultural landscape, with preserved biodiversity, stimulates self-regulation mechanisms in agrocenoses, which we can additionally strengthen through protection and creating *de novo* of those specific environments and consequently, increase the count and activity of pest natural enemies (so-called augmentation) (Powell, 1986; Risch, et al., 1983; Szwed and Andrzejewski, 2002; Ruppert and Molthan, 1991; Barczak, 1996; Bennewicz, 2011). This makes the grounds for natural and agricultural indexation of plant communities accompanying those environments and in consequence, for the estimation of possibility of using entomophages associated with them in so-called “natural biological pest control”, within the frames of the integrated plant protection (reservoirs, dispersion centres and alternative food sources). Secondly, urban and suburban environments are reservoirs of fauna of epigeic beetles, including species under protection and beneficial in arable crops protection. The number and species diversity of ground beetles, being a trophically heterogeneous group, is determined mainly be the presence of organisms they feed on. Judging from a considerable number of recorded species of *Carabidae*, it may be suggested that the tested environments, particularly in the urban green areas, can constitute their food resources and be the dispersion centres of those epigeic beetles to agrocenoses as well as important elements of ecological corridors of the lower Vistula valley. Forests adjacent to urbanized areas of Bydgoszcz, are the example of such environments where in spite of progressing degradation processes (clearances) we still can find habitats of high

natural values, which favour keeping biodiversity, particularly for protected species of *Carabus* or *Calosoma* genera.

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