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ARTYKUŁ ORYGINALNY

Parazytoidy z podrodzin Pimplinae (Hymenoptera, Ichneumonidae) i Aphidiinae (Hymenoptera, Braconidae) występujące w zieleni miejskiej miasta Poznania

Parasitoids of the subfamilies Pimplinae (Hymenoptera, Ichneumonidae) and Aphidiinae (Hymenoptera, Braconidae) occurring in urban greenery of the Poznań city

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Streszczenie

Celem badań było określenie składu gatunkowego i liczebności parazytoidów z podrodzin Pimplinae (Hymenoptera, Ichneumonidae) i Aphidiinae (Hymenoptera, Braconidae) występujących w różnych siedliskach na terenach zieleni miejskiej oraz wykazanie zależności pomiędzy różnorodnością gatunkową roślin, a strukturą gatunkową zgrupowań parazytoidów. Stwierdzono, że tylko w przypadku podrodziny Aphidiinae stwierdzono istotny wpływ siedliska na liczebności poszczególnych zgrupowań oraz również wpływ lat na łączną liczebność zgrupowań. Wykazano pozytywny związek pomiędzy zróżnicowaniem roślinności, a liczebnością i różnorodnością gatunkową parazytoidów z podrodziny Aphidiinae oraz podobieństwem struktury jakościowo-ilościowej zgrupowań Pimplinae występujących na poszczególnych stanowiskach. Wykazano pozytywne oddziaływanie drzew: *Betula pendula*, *Tilia tomentosa*, *Salix alba* i *Salix caprea*, krzewów: *Berberis julianae*, *Berberis vulgaris* i *Spiraea japonica* oraz roślin zielnych: *Elymus repens*, *Festuca rubra* i *Hypochoeris radicata*, na strukturę jakościowo-ilościową zgrupowań parazytoidów z podrodziny Pimplinae poprzez tworzenie odpowiedniej bazy pokarmowej dla imagines tych entomofagów.

Słowa kluczowe: zieleń miejska, parazytoidy, szkodniki, roślinność, Poznań

Abstract

The study aimed to determine the species composition and abundance of parasitoids from the subfamilies Pimplinae (Hymenoptera, Ichneumonidae) and Aphidiinae (Hymenoptera, Braconidae) found in various habitats in urban greenery and to demonstrate the relationship between plant species diversity and the species structure of parasitoid assemblages. It was found that only for the subfamily Aphidiinae was there a significant effect of habitats on the abundance of individual assemblages and the effect of years on the total abundance of assemblages. A positive relationship was observed between vegetation diversity and the abundance and species diversity of parasitoids of the subfamily Aphidiinae, as well as similarity in the qualitative-quantitative structure of Pimplinae assemblages present in a given habitat. Positive effects of trees: *Betula pendula*, *Tilia tomentosa*, *Salix alba* and *Salix caprea*, shrubs: *Berberis julianae*, *Berberis vulgaris* and *Spiraea japonica*, and herbaceous plants: *Elymus repens*, *Festuca rubra* and *Hypochoeris radicata* on the qualitative-quantitative structure of parasitoid assemblages of the subfamily Pimplinae by creating a suitable food base for these entomophagous imagines were noted.

Key words: greenery, parasitoids, pests, vegetation, Poznań

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Wstęp / Introduction

Urban greenery is an arrangement of planned and maintained or natural vegetation integrated into an urbanised space. Most often, it takes the form of parks, botanical gardens, allotments, squares, lawns and roadside green belts. It is characterised by the high species diversity of trees, shrubs and herbaceous plants growing there. Therefore, it serves many purposes, including those related to leisure, recreation, health and aesthetics. It contributes to improving the quality of urban life and biodiversity in this habitat. Urban green spaces provide a habitat for many animal groups, including insects. Insects that inhabit urban greenery are mainly species that feed on plants and thus reduce their ornamental value. The habitat also contains insectivores that regulate herbivore abundance. These include predatory and parasitic species. The latter include parasitoids of the subfamilies Pimplinae (Hymenoptera, Ichneumonidae) and Aphidiinae (Hymenoptera, Braconidae). Pimplinae are parasitoids of pests belonging to the orders Coleoptera, Lepidoptera, Diptera and Hymenoptera. They parasitise the larvae and pupae of these insects. Aphidiinae reduce the abundance of economically important plant pests, which include aphids (Hemiptera, Aphidoidea). They parasitise the larvae and imagines of these herbivorous insects (Fitton et al. 1988; Gauld et al. 2002; Yu 2012).

The protection of plants against pests and diseases in urban greenery is limited or even hindered by the presence of humans and animals in this habitat. Difficulties also arise because there is no proper communication between municipal services, researchers and the public (Tomalak 2003, 2006). Therefore, learning more about the insectivores that reduce the populations of pests feeding in green spaces seems reasonable.

To date, few studies on Pimplinae and Aphidiinae in urban greenery have been published (Sawoniewicz 1982, 1986; Starý 1987; Davidson and Miller 1990; Teder et al. 1999; Lumbierres et al. 2005; Piekarska-Boniecka et al. 2009a, 2009b; Schnitzler et al. 2011; Kavallieratos et al. 2013; Tanque et al. 2015). The majority of papers are general in nature and deal only with information on the prevalence of a species in that habitat or only on its contribution to pest parasitism.

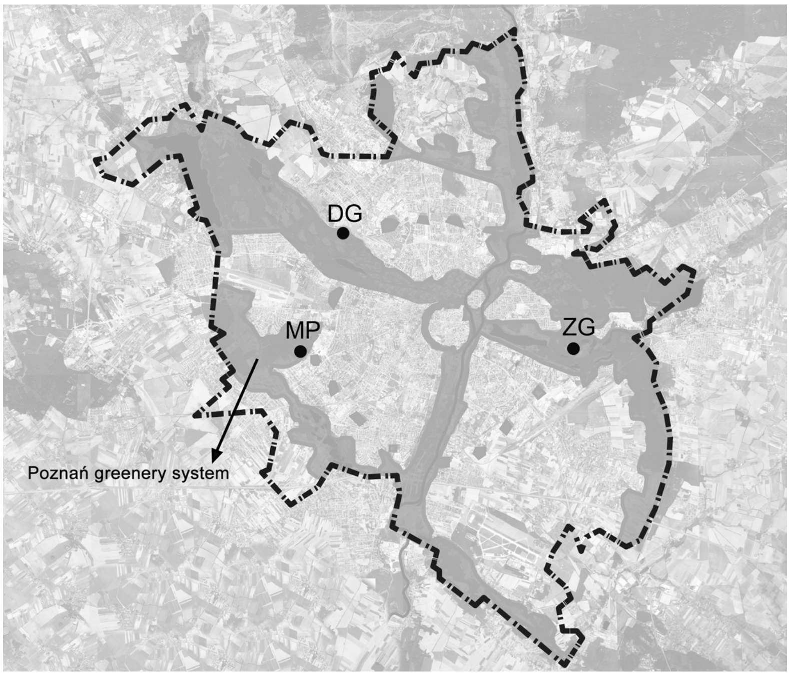
The study aimed to determine the species composition and abundance of parasitoids from the subfamilies Pimplinae (Hymenoptera, Ichneumonidae) and Aphidiinae (Hymenoptera, Braconidae) in urban greenery and to demonstrate the relationship between plant species diversity and the structure of parasitoid assemblages. It was hypothesised that urban green spaces are the habitat of these insectivores, and the more species-diverse the vegetation, the more extensive structure of the assemblages.

Materiały i metody / Materials and methods

The study was conducted between 2016 and 2018 in the city of Poznań (52°25'N 16°58'E) (fig. 1). Poznań is the capital of the Wielkopolska Voivodeship and the historical capital of the Greater Poland region. It is located in western Poland, in the Poznań Gorge of the Warta River, the Poznań Lakeland and the Września Plain. It lies on the Warta River, at the mouth of its right tributaries, the Cybina and Główna, and its left tributary, the Bogdanka. The research was conducted at three sites in green areas. The vascular plant flora for each site was developed on an area of 500 m^2 (50 m^2 around ten traps at each site).

The following sites were selected (fig. 1):

- Dendrological Garden, Poznań University of Life Sciences (DG) (52°25'33"N 16°53'34"E). It covered an area of approximately 20 ha. Specific to the garden were collections of trees and shrubs growing naturally in Poland. A prominent group of shrub collections included native rose (*Rosa* spp.) and blackberry (*Rubus* spp.) species. A total of 150 vascular plant species were found in the study area, and this was the site with the highest species diversity. Herbaceous vegetation [98 (65.3%) species] predominated. The species diversity of trees and shrubs was lower and, at the same time, similar to each other, with 28 species of trees (18.7%) and 24 species (16%) of shrubs, respectively. Dominant trees included *Betula pendula* Roth, *Carpinus betulus* L., *Koelreuteria paniculata* Laxm., *Larix decidua* Mill., *Quercus robur* L., *Picea abies* (L.) H. Karst, *Tilia tomentosa* Moench and *Salix alba* L., *Salix caprea* L. Abundant shrubs included *Amorpha fruticosa* L., *Berberis julianae* C.K. Schneid., *Berberis vulgaris* L., *Crataegus monogyna* Jacq., *Laburnum anagyroides* Medik., *Padus serotina* Ehrh., *Salix caprea* L. and *Spiraea japonica* L. Dominant herbaceous plants included *Aegopodium podagraria* L., *Bromus inermis* Leyss., *Elymus repens* (L.), *Festuca rubra* L., *Hypochoeris radicata* L., *Lapsana communis* L., *Parietaria officinalis* L. and *Veronica chamaedrys* L.,
- Park complex of the Marcelin Experimental Station, Faculty of Horticulture and Landscape Architecture, Poznań University of Life Sciences (MP) (52°25'33"N 16°53'34"E). It covered an area of over 20 ha. The study area had similar species diversity to that found in the Dendrological Garden (DG). It was home to 144 species of vascular plants, among which there were also orchard plantings. Similar to the previous site, herbaceous plants dominated (104 species), and their proportion was the highest (72.2%) in relation to the other sites. Much like in the case of the Dendrological Garden (DG), the species diversity of trees and shrubs was developing. Twenty-two (15.3%) tree species and 18 (12.5%) shrub species were found. Dominant trees included *Aesculus*



Rys. 1. Lokalizacja stanowisk badań w zieleni miejskiej Poznania (DG – Ogród Dendrologiczny, MP – Park w Marcelinie, ZG – Ogród Zoologiczny)
Fig. 1. The location of research sites in urban greenery in Poznań (DG – Dendrological Garden, MP – Marcelin Park, ZG – Zoological Garden)

hippocastanum L., *Betula pendula* Roth, *Malus domestica* Borkh., *Prunus cerasifera* Ehrh., *Prunus domestica* L., *Robinia pseudoacacia* L., *Salix alba* L., *Salix caprea* L., *Thuja plicata* Donn ex D. Don. and *Tilia tomentosa* Moench. Shrubs growing in large numbers included *Berberis julianae* C.K. Schneid., *Berberis vulgaris* L., *Juniperus horizontalis* Moench and *Spiraea japonica* L. Dominant herbaceous species included *Cardamine hirsuta* L., *Cerastium holosteoides* Fr. em Hyl., *Elymus repens* (L.) Gould, *Epilobium adenocaulon* Hausskn., *Festuca arundinacea* Schreb., *Festuca rubra* L., *Hypochoeris radicata* L. and *Miscanthus giganteus* J.M. Greef & Deuter ex Hodk. & Renvoize. The site was characterised by lush herbaceous vegetation and a high dominance index in relation to the individual plant groups at the other sites,

- Zoological Garden (New Zoo) (ZG) (52°24'01"N 16°59'41"E). It covered an area of approximately 117 ha with 60% pine and mixed forests. The study area had the lowest vascular plant species diversity compared to the other sites (DG and MP). Only 61 species were found. Herbaceous vegetation [40 (65.6%) species] was also dominant. The species diversity of trees and shrubs was low. Seven (11.5%) tree species and 14 (22.9%) shrub species were recorded. Among the few tree species, the following were abundant: *Acer platanoides* L., *Fraxinus excelsior* L. and *Robinia pseudoacacia* L. Dominant shrubs were the following: *Crataegus monogyna* Jacq., *Hippophae rhamnoides* L., *Juniperus horizontalis* Moench, *Lonicera maackii* (Rupr.) Maxim. and *Sambucus nigra* L. Abundant herbaceous vegetation included *Carex caryophyllea* L., *Chelidonium majus* L., *Festuca rubra* L., *Geum urbanum* L., *Impatiens parviflora* DC., *Poa nemoralis* L., *Urtica dioica* L. and *Viola odorata* L.

This study used the method of trapping parasitoid imagines into the Moericke yellow pan traps (Moericke 1953). These were plastic vessels of 20 cm in diameter, filled with water with the addition of surfactant and glycol, which acted as a preservative fluid. Ten traps were placed at each research site. They were no less than 20 m apart and suspended approximately 1.5 m above the ground level. Parasitoid trapping was conducted from 1 April to 31 October each year, and samples were collected at ten-day intervals. Insects caught in one trap over ten days were considered one sample.

Species of the subfamily Pimplinae were identified according to the Kasparyan key (1981), and those of the subfamily Aphidiinae according to the Starý key (1970, 1976, 2006).

The normality of data distribution was investigated using the Shapiro-Wilk test (Royston 1982). Due to the lack of normality, the non-parametric Kruskal-Wallis test (Hollander and Wolfe 1973) – was used to assess the effect of habitats on the abundance of parasitoid assemblages from the subfamilies Pimplinae and Aphidiinae. Dunn's multiple comparison test with Benjamini-Hochberg correction (Benjamini and Hochberg 1995) was used to analyse the effect of years on the abundance of parasitoid assemblages. The biocoenotic characteristics of parasitoid assemblages are presented by the following parameters: number of samples, number of specimens, number of species and relative abundance (Magurran 2004). Alpha diversity was assessed using the following non-parametric indices (Magurran 2004): Shannon's diversity index, Pielou's uniformity index and Margalef's diversity index. Estimates of species richness for the Pimplinae and Aphidiinae assemblages were made using ACE (Chao et al. 2000), Chao1 (Chao 1987) and Jack1 estimators (Heltshe and Forrester 1983). In order to compare the beta diversity of parasitoid assemblages across sites, Sørensen's qualitative similarity index (Sørensen 1957; Wolda 1981) and the Renkonen similarity index (Renkonen 1938; Wolda 1981) were used. Similarity analysis of the qualitative-quantitative structure of parasitoid assemblages was performed by hierarchical cluster analysis based on the Euclidean measure using the complete method, and the results are presented on a dendrogram (Mardia et al. 1979). This investigation was completed using principal component analysis (PCA), and the results were presented as a biplot (Mardia et al. 1979).

All calculations, statistical analyses and drawings were performed using R software version 4.2.2 (R Core Team 2022).

Wyniki i dyskusja / Results and discussion

Between 2016 and 2018, in total 1,882 samples were collected in the green areas of the city of Poznań, and 992 parasitoids were caught. Significantly more representatives of Aphidiinae than Pimplinae were, as 613 specimens of Aphidiinae and 379 specimens of Pimplinae were caught

Tabela 1. Wskaźniki biocenotyczne zgrupowań Pimplinae występujących w zieleni miejskiej Poznania w latach 2016–2018
Table 1. The biocenotic indices of Pimplinae communities in urban greenery in Poznań between 2016 and 2018

Stanowisko badań Research sites	Liczba prób Number of samples (n)	Liczba osobników Number of specimens (N)	Liczba gatunków Number of species (S)	Wskaźnik Shannon'a Shannon index (H')	Wskaźnik Pielou Pielou index (J')	Wskaźnik Margalef'a Margalef index (d)
Ogród Dendrologiczny Dendrological Garden (DG)	627	120	26	2.66	0.82	5.22
Park w Marcelinie Marcelin Park (MP)	628	111	30	3.06	0.90	6.16
Ogród Zoologiczny Zoological Garden (ZG)	627	148	29	2.67	0.79	5.60
Ogółem – Total	1882	379	42	–	–	–

Tabela 2. Wskaźniki biocenotyczne zgrupowań Aphidiinae występujących w zieleni miejskiej Poznania w latach 2016–2018
Table 2. The biocenotic indices of Aphidiinae communities in urban greenery in Poznań between 2016 and 2018

Stanowisko badań Research sites	Liczba prób Number of samples (n)	Liczba osobników Number of specimens (N)	Liczba gatunków Number of species (S)	Wskaźnik Shannon'a Shannon index (H')	Wskaźnik Pielou Pielou index (P')	Wskaźnik Margalef'a Margalef index (d)
Ogród Dendrologiczny Dendrological Garden (DG)	627	238	45	2.92	0.77	8.04
Park w Marcelinie Marcelin Park (MP)	628	227	51	3.56	0.90	9.22
Ogród Zoologiczny Zoological Garden (ZG)	627	148	37	3.08	0.85	7.20
Ogółem – Total	1882	613	64	–	–	–

Tabela 3. Wykaz gatunków, liczba osobników (N) i względna liczebność (RA) zgrupowań Pimplinae występujących w zieleni miejskiej Poznania w latach 2016–2018

Table 3. The list of species, the number of specimens (N) and the relative abundance (RA) of Pimplinae communities in urban greenery in Poznań between 2016 and 2018

	Gatunek Species	Stanowisko badań – Research sites							
		Ogród Dendrologiczny Dendrological Garden (DG)		Park w Marcelinie Marcelin Park (MP)		Ogród Zoologiczny Zoological Garden (ZG)		Ogółem Total	
		N	RA	N	RA	N	RA		
P1	*Acropimpla pictipes* (Gravenhorst, 1829)	–	–	–	–	1	0.007	1	0.003
P2	*Apechthis compunctor* (Linnaeus, 1758)	–	–	2	0.018	3	0.02	5	0.013
P3	*Apechthis quadridentate* (Thomson, 1877)	–	–	–	–	1	0.007	1	0.003
P4	*Delomerista mandibularis* (Gravenhorst, 1829)	4	0.033	2	0.018	–	–	6	0.016
P5	*Dolichomitus mesocentrus* (Gravenhorst, 1829)	–	–	1	0.009	2	0.014	3	0.008
P6	*Dolichomitus* sp. 1	–	–	–	–	1	0.007	1	0.003
P7	*Dolichomitus* sp. 2	1	0.008	–	–	–	–	1	0.003
P8	*Endromopoda detrita* (Holmgren, 1860)	2	0.017	3	0.027	1	0.007	6	0.016
P9	*Ephialtes manifestator* (Linnaeus, 1758)	–	–	–	–	1	0.007	1	0.003
P10	*Gregopimpla inquisitor* (Scopoli, 1763)	–	–	1	0.009	2	0.014	3	0.008
P11	*Itoplectis alternans* (Gravenhorst, 1829)	8	0.068	7	0.063	6	0.04	21	0.055
P12	*Itoplectis maculator* (Fabricius, 1775)	16	0.133	13	0.117	4	0.027	33	0.087
P13	*Itoplectis tunetana* (Schmiedeknecht, 1914)	1	0.008	3	0.027	–	–	4	0.011
P14	*Liotryphon caudatus* (Ratzeburg, 1848)	–	–	1	0.009	–	–	1	0.003
P15	*Liotryphon crassiseta* (Thomson, 1877)	2	0.017	6	0.055	3	0.02	11	0.028
P16	*Liotryphon punctulatus* (Ratzeburg, 1848)	3	0.025	1	0.009	2	0.014	6	0.016
P17	*Oxyrrhexis carbonator* (Gravenhorst, 1807)	1	0.008	1	0.009	–	–	2	0.005
P18	*Perithous albicinctus* (Gravenhorst, 1829)*	–	–	–	–	6	0.04	6	0.016
P19	*Perithous divinator* (Rossi, 1790)	–	–	4	0.036	1	0.007	5	0.013
P20	*Perithous septemcinctorius* (Thunberg, 1822)	–	–	–	–	1	0.007	1	0.003
P21	*Pimpla contemplator* (Mueller, 1776)	31	0.258	15	0.135	37	0.25	83	0.219
P22	*Pimpla flavicoxis* Thomson, 1877	10	0.083	4	0.036	28	0.189	42	0.111
P23	*Pimpla insignatoria* (Gravenhorst, 1807)	–	–	1	0.009	5	0.034	6	0.016
P24	*Pimpla rufipes* (Miller, 1759)	2	0.017	5	0.045	8	0.054	15	0.039
P25	*Pimpla spuria* Gravenhorst, 1829	1	0.008	2	0.018	–	–	3	0.008
P26	*Pimpla turionellae* (Linnaeus, 1758)	7	0.059	5	0.045	4	0.027	16	0.041
P27	*Polysphincta boops* Tschek, 1869	–	–	2	0.018	1	0.007	3	0.008
P28	*Scambus brevicornis* (Gravenhorst, 1829)	1	0.008	1	0.009	–	–	2	0.005
P29	*Scambus calobatus* (Gravenhorst, 1829)	3	0.025	–	–	1	0.007	4	0.011
P30	*Scambus inanis* (Schrank, 1802)	2	0.017	–	–	2	0.014	4	0.011
P31	*Scambus nigricans* (Thomson, 1877)	–	–	1	0.009	–	–	1	0.003
P32	*Scambus planatus* (Hartig, 1838)	1	0.008	2	0.018	–	–	3	0.008
P33	*Scambus pomorum* (Ratzeburg, 1848)	1	0.008	3	0.027	3	0.02	7	0.018
P34	*Theronia atalantae* (Poda, 1761)	–	–	1	0.009	–	–	1	0.003
P35	*Theronia laevigata* (Tschek, 1869)*	–	–	–	–	1	0.007	1	0.003
P36	*Tromatobia lineatoria* (Villers, 1789)	2	0.017	5	0.045	–	–	7	0.018
P37	*Tromatobia ovivora* (Boheman, 1821)	4	0.033	4	0.036	–	–	8	0.021
P38	*Zaglyptus multicolor* (Gravenhorst, 1826)	9	0.076	–	–	10	0.067	19	0.049
P39	*Zaglyptus varipes* (Gravenhorst, 1829)	2	0.017	4	0.036	–	–	6	0.016
P40	*Zatypota albicoxa* (Walker, 1874)	1	0.008	–	–	8	0.053	9	0.024
P41	*Zatypota discolor* (Holmgren, 1860)	1	0.008	2	0.018	1	0.007	4	0.011
P42	*Zatypota percontatoria* (Mueller, 1776)	4	0.033	9	0.081	4	0.027	17	0.044
Łączna liczba osobników – Total number of specimens		120	1.0	111	1.0	148	1.0	379	1.0
Łączna liczba gatunków – Total number of species		26		30		29		42	

*po raz pierwszy wykazany w zieleni miejskiej w Polsce – for the first time in green areas in Poland

Tabela 4. Wykaz gatunków, liczba osobników (N) i względna liczebność (RA) zgrupowań Aphidiinae występujących w zieleni miejskiej Poznania w latach 2016–2018

Table 4. The list of species, the number of specimens (N) and the relative abundance (RA) of Aphidiinae communities in urban greenery in Poznań beteen 2016 and 2018

	Gatunek Species	Stanowisko badań – Research sites							
		Ogród Dendrologiczny Dendrological Garden (DG)		Park w Marcelinie Marcelin Park (MP)		Ogród Zoologiczny Zoological Garden (ZG)		Ogółem Total	
		N	RA	N	RA	N	RA		
A1	*Aclitus obscuripennis* Foerster, 1862*	1	0.004	–	–	–	–	1	0.002
A2	*Adialytus salicaphis* (Fitch, 1855)*	1	0.004	1	0.004	1	0.007	3	0.005
A3	*Adialytus thexalis* (Stary, 1961)*	1	0.004	–	–	–	–	1	0.002
A4	*Aphidius absinthii* Marshall, 1896	3	0.013	7	0.031	3	0.02	13	0.021
A5	*Aphidius aquilus* Mackauer, 1961*	2	0.008	4	0.018	–	–	6	0.009
A6	*Aphidius avenae* (Haliday, 1834)*	1	0.004	1	0.004	–	–	2	0.003
A7	*Aphidius cingulatus* Ruthe, 1859*	7	0.03	3	0.013	1	0.007	11	0.018
A8	*Aphidius colemani* Viereck, 1912	6	0.025	4	0.018	6	0.04	16	0.026
A9	*Aphidius eglanteriae* Haliday, 1834*	1	0.004	1	0.004	–	–	2	0.003
A10	*Aphidius ervi* (Haliday, 1834)	1	0.004	5	0.023	2	0.014	8	0.013
A11	*Aphidius hieraciorum* Stary, 1962	–	–	–	–	1	0.007	1	0.002
A12	*Aphidius matricariae* Haliday, 1834	–	–	–	–	3	0.02	3	0.005
A13	*Aphidius phalangomyzi* Stary, 1963*	–	–	4	0.018	–	–	4	0.007
A14	*Aphidius rhopalosiphi* de Stefani-Perez, 1902*	–	–	1	0.004	–	–	1	0.002
A15	*Aphidius ribis* Haliday, 1834	–	–	2	0.009	2	0.014	4	0.007
A16	*Aphidius rosae* Haliday, 1833	7	0.03	10	0.045	8	0.054	25	0.041
A17	*Aphidius salicis* Haliday, 1834	–	–	–	–	1	0.007	1	0.002
A18	*Aphidius sonchi* Marshall, 1896	2	0.008	–	–	2	0.014	4	0.007
A19	*Aphidius urticae* Haliday, 1834*	–	–	1	0.004	–	–	1	0.002
A20	*Aphidius uzbekistanicus* Luzhetzki,1960*	1	0.004	4	0.018	1	0.007	6	0.009
A21	*Areopraon lepelleyi* (Waterston, 1926)	3	0.013	–	–	–	–	3	0.005
A22	*Binodoxys angelicae* (Haliday, 1833)*	5	0.021	8	0.035	1	0.007	14	0.023
A23	*Binodoxys heraclei* (Haliday, 1833)*	–	–	2	0.009	–	–	2	0.003
A24	*Diaeretellus ephippium* (Haliday, 1833)*	–	–	1	0.004	1	0.007	2	0.003
A25	*Diaeretellus heinzei* Mackauer, 1959*	2	0.008	1	0.004	–	–	3	0.005
A26	*Diaeretellus macrocarpus* Mackauer, 1961*	–	–	1	0.004	–	–	1	0.002
A27	*Diaeretiella rapae* (McIntosh, 1855)	1	0.004	2	0.009	–	–	3	0.005
A28	*Diaeretus leucopterus* (Haliday, 1834)*	3	0.013	6	0.026	1	0.007	10	0.016
A29	*Dyscritulus planiceps* (Marshall, 1896)	1	0.004	1	0.004	–	–	2	0.003
A30	*Ephedrus cerasicola* Stary, 1962	7	0.03	20	0.088	1	0.007	28	0.046
A31	*Ephedrus helleni* Mackauer, 1968*	–	–	7	0.031	–	–	7	0.01
A32	*Ephedrus lacertosus* (Haliday, 1833)	4	0.017	12	0.053	6	0.04	22	0.036
A33	*Ephedrus nacheri* Quilis, 1934*	4	0.017	8	0.035	3	0.02	15	0.024
A34	*Ephedrus niger* Gautier, 1929*	–	–	3	0.013	–	–	3	0.005
A35	*Ephedrus persicae* Froggatt, 1904	1	0.004	6	0.026	–	–	7	0.01
A36	*Ephedrus plagiator* (Nees, 1811)	10	0.042	18	0.079	3	0.02	31	0.051
A37	*Ephedrus validus* (Haliday, 1833)*	1	0.004	2	0.009	–	–	3	0.005
A38	*Lipolexis gracilis* Foerster, 1862	2	0.008	3	0.013	4	0.026	9	0.014
A39	*Lysiphlebus cardui* (Marshall, 1896)	–	–	1	0.004	–	–	1	0.002
A40	*Lysiphlebus fabarum* (Marshall, 1896)	3	0.013	7	0.031	1	0.007	11	0.018
A41	*Lysiphlebus fritzmuelleri* Mackauer, 1896*	–	–	–	–	2	0.014	2	0.003

Tabela 4. Wykaz gatunków, liczba osobników (N) i względna liczebność (RA) zgrupowań Aphidiinae występujących w zieleni miejskiej Poznania w latach 2016–2018 – cd.
Table 4. The list of species, the number of specimens (N) and the relative abundance (RA) of Aphidiinae communities in urban greenery in Poznań beteen 2016 and 2018 – continued

	Gatunek Species	Stanowisko badań – Research sites							
		Ogród Dendrologiczny Dendrological Garden (DG)		Park w Marcelinie Marcelin Park (MP)		Ogród Zoologiczny Zoological Garden (ZG)		Ogółem Total	
		N	RA	N	RA	N	RA		
A42	*Monoctonus crepidis* (Haliday, 1834)*	1	0.004	–	–	–	–	1	0.002
A43	*Paralipsis enervis* (Nees, 1834)*	3	0.013	1	0.004	–	–	4	0.007
A44	*Pauesia abietis* (Marshall, 1896)*	1	0.004	2	0.009	–	–	3	0.005
A45	*Pauesia juniperorum* (Stary, 1960)	–	–	5	0.023	1	0.007	6	0.009
A46	*Pauesia laricis* (Haliday, 1834)	2	0.008	–	–	–	–	2	0.003
A47	*Pauesia pini* (Haliday, 1834)	–	–	1	0.004	–	–	1	0.002
A48	*Pauesia unilachni* (Gahan, 1926)	1	0.004	3	0.013	–	–	4	0.007
A49	*Praon bicolor* Mackauer, 1959	–	–	1	0.004	7	0.046	8	0.013
A50	*Praon dorsale* (Haliday, 1833)	–	–	2	0.009	3	0.02	5	0.008
A51	*Praon exsoletum* (Nees, 1811)	1	0.004	–	–	–	–	1	0.002
A52	*Praon flavinode* (Haliday, 1833)	3	0.013	5	0.023	10	0.068	18	0.029
A53	*Praon longicorne* Marshall, 1896*	3	0.013	–	–	5	0.034	8	0.013
A54	*Praon pubescens* Stary, 1961	1	0.004	2	0.009	1	0.007	4	0.007
A55	*Praon rosaecola* Stary, 1961	1	0.004	1	0.004	–	–	2	0.003
A56	*Praon volucre* (Haliday, 1833)	8	0.034	13	0.057	20	0.135	41	0.067
A57	*Praon yomenae* Takada, 1968*	1	0.004	2	0.009	1	0.007	4	0.007
A58	*Trioxys auctus* (Haliday, 1833)*	20	0.084	8	0.035	4	0.026	32	0.052
A59	*Trioxys betulae* Marshall, 1896*	68	0.286	11	0.049	21	0.142	100	0.163
A60	*Trioxys cirsii* (Curtis, 1831)	8	0.034	5	0.023	3	0.02	16	0.026
A61	*Trioxys complanatus* Quilis, 1931*	7	0.03	4	0.018	1	0.007	12	0.02
A62	*Trioxys falcatus* Mackauer, 1959	1	0.004	1	0.004	1	0.007	3	0.005
A63	*Trioxys hortorum* Stary, 1960	–	–	–	–	1	0.007	1	0.002
A64	*Trioxys pallidus* (Haliday, 1833)	27	0.113	3	0.013	15	0.101	45	0.073
Łączna liczba osobników – Total number of specimens		238	1.0	227	1.0	148	1.0	613	1.0
Łączna liczba gatunków – Total number of species		45		51		37		64	

*po raz pierwszy wykazany w zieleni miejskiej w Polsce – for the first time in green areas in Poland

(tab. 1, 2, 3, 4). The species diversity of the subfamilies followed a similar pattern. More species of Aphidiinae were found than Pimplinae. A total of 64 species of Aphidiinae and 42 species of Pimplinae were identified.

The abundance of Pimplinae at each site was analysed, and it was found that the highest number of specimens was found in the Zoological Garden (ZG) (148 specimens) (tab. 1, 3). The other sites yielded slightly fewer specimens as the Dendrological Garden (DG) collected 120 specimens and 111 in Marcelin 11. The abundance of Aphidiinae was different at each site. The Zoological Garden (ZG) yielded the fewest specimens (148). The highest abundance was found in the Dendrological Garden, where 238 specimens were caught, and slightly lower at Marcelin Park (MP), with 227 specimens.

The effect of habitats on assemblage numbers was assessed using the Kruskal-Wallis test. The following values were obtained for the subfamily Pimplinae: chi-squared = 1.3346, df = 2, p-value = 0.5131. This shows that habitats did not have a significant effect on assemblage abundance. The following values were obtained for the subfamily Aphidiinae: chi-squared = 7.2265, df = 2, p-value = 0.02696. Thus, it was found that habitats had a statistically significant effect on the individual assemblages' abundance for this subfamily. The most diverse effect of habitats on abundance was registered between the Dendrological

Garden (DG) and Marcelin Park (MP) assemblages, for which p-value = 0.023.

Dunn's multiple comparison test with Benjamini-Hochberg correction was used to assess the effect of years on the abundance of parasitoid assemblages. No effect of years was shown for the subfamily Pimplinae on the abundance of assemblages caught in all habitats in total. In the case of the subfamily Aphidiinae, the effect of years on total assemblage abundance was found. The years 2016 and 2017 (p-value = 0.0034) and 2016 and 2018 (p-value = 0.0089) differed the most in abundance.

Assemblages with high Pielou's uniformity index values (J') were found at all sites for both subfamilies (tab. 1, 2). This demonstrates a very similar and even distribution of species abundance in the assemblages. Only for the assemblages of Pimplinae in the Zoological Garden (ZG) and Aphidiinae in the Dendrological Garden (DG) did the J' index show slightly lower values, namely 0.79 and 0.77.

The species diversity of Pimplinae at each site was analysed and found to be similar (tab. 1). These ranged from 26 species in the Dendrological Garden (DG), 29 in the Zoological Garden (ZG), and 30 in Marcelin Park. The species diversity of Aphidiinae at individual sites was different in relation to Pimplinae. The lowest species diversity was found in the Zoological Garden (ZG) assemblage (37 species), higher in the Dendrological Garden (ZG) (45) and highest in Marcelin Park (MP) (51).

The above-described species diversity of the assemblages of the two subfamilies in the different habitats was confirmed by the values of Margalef's diversity index (d) (tab. 1, 2). Also, the values of Shannon's diversity index (H') confirmed such species differentiation for most assemblages of both subfamilies (tab. 1, 2). Only for the Aphidiinae assemblage found in the Zoological Garden was the J' value slightly higher (3.08) than in the Dendrological Garden (DG) assemblage (2.92), despite the lowest species diversity of Aphidiinae in this assemblage.

The values of the species richness estimators ACE, Chao1 and Jack1 for all assemblages of both subfamilies indicated that only ACE determined species diversity closest to reality. The number of species caught in the assemblages during the research period was closest to that indicated by this estimator (tab. 5, 6).

Tabela 5. Wartości estymatorów bogactwa gatunkowego zgrupowań Pimplinae występujących w zieleni miejskiej Poznania w latach 2016–2018
Table 5. The values of estimators of species richness in the Pimplinae communities in the urban green areas of Poznań in 2016–2018

Stanowisko badań Research sites	Liczba gatunków Number of species	ACE	Chao1	Jack1
Ogród Dendrologiczny Dendrological Garden (DG)	26	29	33	35
Park w Marcelinie Marcelin Park (MP)	30	33	37	39
Ogród Zoologiczny Zoological Garden (ZG)	29	33	44	40

Tabela 6. Wartości estymatorów bogactwa gatunkowego zgrupowań Aphidiinae występujących w zieleni miejskiej Poznania w latach 2016–2018
Table 6. The values of estimators of species richness in the Aphidiinae communities in the urban green areas of Poznań in 2016–2018

Stanowisko badań Research sites	Liczba gatunków Number of species	ACE	Chao1	Jack1
Ogród Dendrologiczny Dendrological Garden (DG)	45	54	86	66
Park w Marcelinie Marcelin Park (MP)	51	57	68	68
Ogród Zoologiczny Zoological Garden (ZG)	37	44	67	53

The dominance of Pimplinae species in total across all sites was analysed, and it was found that four species were most abundant (tab. 3). These were *Pimpla contemplator* (P21) (0.219), *Pimpla flavicoxis* (P22) (0.111), *Itoplectis maculator* (P12) (0.087) and *Itoplectis alternans* (P11) (0.055). The species dominance in the assemblages caught at each site was also assessed. It was found that not all species dominating the overall assemblages were prevalent in individual assemblages. Other dominant species also emerged. In the Dendrological Garden (DG), *Zaglyptus multicolor* (P38) (0.076) and *Pimpla turionellae* (P26) (0.059) were also classified as dominant species. The assemblage at Marcelin Park (MP) was also dominated by *Zatypota percontatoria* (P42) (0.081), but *Pimpla flavicoxis* (P22) (0.036) was not found to be dominant in numbers in the overall assemblage. In the Zoological Garden (ZG), *Zaglyptus multicolor* (P38) (0.067), *Pimpla rufipes* (P24) (0.053) and *Zatypota albicoxa* (P40) (0.053) were also dominant, but *Itoplectis alternans* (P11) (0.04) and *Itoplectis maculator* (P12) (0.027) were not found as abundant in the overall assemblages.

Similarly, the dominance among the Aphidiinae species was analysed. This subfamily had five dominant species, taking all assemblages as a whole (tab. 4). Abundant species included *Trioxys betulae* (A59) (0.163), *Trioxys pallidus* (A64) (0.073), *Praon volucre* (A56) (0.067), *Trioxys auctus* (A58) (0.052) and *Ephedrus plagiator* (A36) (0.051). As in the case of the Pimplinae, other numerous species also appeared among the dominant species of the Aphidiinae in the individual assemblages, and not all species dominant in the overall assemblages were dominant at individual sites. In the Dendrological Garden (DG), only *Trioxys betulae* (A59) (0.286) and *Trioxys pallidus* (A64) (0.113) ranked among the numerous in the assemblage. The dominant species at Marcelin Park (MP) also included *Ephedrus cerasicola* (A30) (0.088) and *Ephedrus lacertosus* (A32) (0.053), with only *Ephedrus plagiator* (A36) (0.079) and *Praon volucre* (A56) (0.057) among the numerous assemblages overall. The Zoological Garden (ZG) was also dominated by *Praon flavinode* (A52) (0.068), *Aphidius rosae* (A16) (0.054) and *Trioxys betulae* (A59) (0.142), *Praon volucre* (A56) (0.135) and *Trioxys pallidus* (A64) (0.101) among the numerous assemblages overall.

Twelve (28.6%) species of Pimplinae were recorded at all sites and included *Endromopoda detrita* (P8), *Itoplectis alternans* (P11), *Itoplectis maculator* (P12), *Liotryphon crassiseta* (P15), *Liotryphon punctulatus* (P16), *Pimpla contemplator* (P21), *Pimpla flavicoxis* (P22), *Pimpla rufipes* (P24), *Pimpla turionellae* (P26), *Scambus pomorum* (P33), *Zatypota discolor* (P41) and *Zatypota percontatoria* (P42) (tab. 3). The corresponding figure for Aphidiinae was 23 (35.9%) species, which is more numerous than in the case of Pimplinae. These included *Adialytus salicaphis* (A2), *Aphidius absinthii* (A5), *Aphidius cingulatus* (A7), *Aphidius colemani* (A8), *Aphidius ervi* (A10), *Aphidius rosae* (A16), *Diaeretus leucopterus* (A28), *Ephedrus cerasicola* (A30), *Ephedrus lacertosus* (A32), *Ephedrus nacheri* (A33), *Ephedrus plagiator* (A36), *Lipolexis gracilis* (A38), *Lysiphlebus fabarum* (A40), *Praon flavinode* (A51), *Praon pubescens* (A54), *Praon volucre* (A56), *Praon yomenae* (A57), *Trioxys auctus* (A58), *Trioxys betulae* (A59), *Trioxys cirsii* (A60), *Trioxys complanatus* (A61), *Trioxys falcatus* (A62) and *Trioxys pallidus* (A64) (tab. 4).

Assemblages of Pimplinae at each site were compared in quantitative terms with the Renkonen similarity index (Re), and it was found that, for the most part, the assemblages were similar to each other in quantitative structure (tab. 7). Only the Zoological Garden (ZG) and Marcelin Park (MP) assemblages differed, with the Re index value of 0.46. The assemblages of Aphidiinae were analysed analogously, and it was found that they were also mostly similar in quantitative structure. Only the Zoological Garden (ZG) and Marcelin Park (MP) assemblages, with the Re index value of 0.48, showed no similarity (tab. 8).

The qualitative similarity of the Pimplinae assemblages was analysed using Sørensen's qualitative similarity index (So), and it was found that the assemblages were similar to each other. The greatest similarity was between the assemblages in the Dendrological Garden (DG) and Marcelin Park (MP). It yielded the value of the So index of 0.75 (tab. 7). In the case of the Aphidiinae assemblages, it was found that all assemblages showed similarity in qualitative structure. It was slightly higher in relation to the Pimplinae assemblages. The So indicator also peaked for assemblages in the Dendrological Garden (DG) and Marcelin Park (MP). It was 0.77 (tab. 8).

The qualitative-quantitative structure of Pimplinae assemblages at individual sites was compared using hierarchical cluster analysis (fig. 2), and it was also found that the Dendrological Garden (DG) and Marcelin (MP) assemblages were similar to each other. Only the Zoological Garden (ZG) assemblage differed in its qualitative and quantitative structure from the other assemblages. In the case of Aphidiinae assemblages, it was found that the Dendrological Garden (DG) and Zoological Garden (ZG) assemblages showed similarity in qualitative and quantitative structure, while the Marcelin Park (MP) assemblage differed from the others (fig. 3).

Principal component analysis (PCA) complemented the similarity analysis of the qualitative-quantitative structure of the two subfamilies assemblages (fig. 4, 5). It also takes into account the abundance of individual species in the assemblage and thus illustrates the relationship of the species to the site. Both subfamilies demonstrated similarity in the qualitative-quantitative structure of the same assemblages as determined by hierarchical cluster analysis (fig. 2, 3). In the case of the subfamily Pimplinae, the results also confirmed the dominance of *Pimpla contemplator* (P21) at all sites, *Pimpla flavicoxis* (P22) in the Zoological Garden (ZG)

Tabela 7. Wskaźniki podobieństwa Sørensen'a i Renkonen'a zgrupowań Pimplinae występujących w zieleni miejskiej Poznania w latach 2016–2018
Table 7. The Sørensen and Renkonen indexes of similarity of the Pimplinae communities in urban greenery in Poznań between 2016 and 2018

Stanowisko badań Research sites		Wskaźnik Sørensen'a Sørensen index (So)		
		Ogród Dendrologiczny Dendrological Garden (DG)	Park w Marcelinie Marcelin Park (MP)	Ogród Zoologiczny Zoological Garden (ZG)
Wskaźnik Renconen'a Renkonen index (Re)	Ogród Dendrologiczny Dendrological Garden (DG)	–	0.75	0.58
	Park w Marcelinie Marcelin Park (MP)	0.63	–	0.61
	Ogród Zoologiczny Zoological Garden (ZG)	0.62	0.46	–

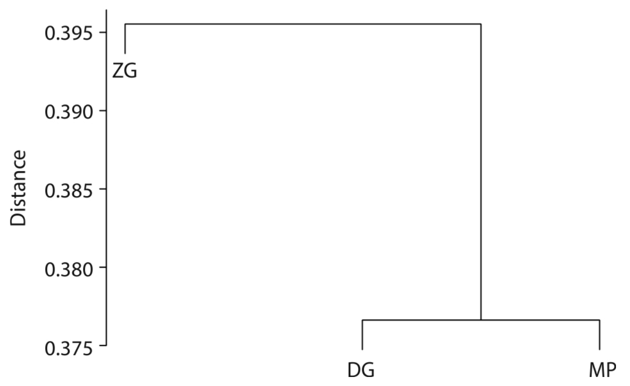
Tabela 8. Wskaźniki podobieństwa Sørensen'a i Renkonen'a zgrupowań Aphidiinae występujących w zieleni miejskiej Poznania w latach 2016–2018
Table 8. The Sørensen and Renkonen indexes of similarity of the Aphidiinae communities in urban greenery in Poznań between 2016 and 2018

Stanowisko badań Research sites		Wskaźnik Sørensen'a Sørensen index (So)		
		Ogród Dendrologiczny Dendrological Garden (DG)	Park w Marcelinie Marcelin Park (MP)	Ogród Zoologiczny Zoological Garden (ZG)
Wskaźnik Renconen'a Renkonen index (Re)	Ogród Dendrologiczny Dendrological Garden (DG)	–	0.77	0.65
	Park w Marcelinie Marcelin Park (MP)	0.50	–	0.67
	Ogród Zoologiczny Zoological Garden (ZG)	0.55	0.48	–

and the Dendrological Garden (DG) and *Itoplectis maculator* (P12) in the Dendrological Garden (DG) and Marcelin Park (MP). With regard to the subfamily Aphidiinae, the dominance of *Trioxys betulae* (A59) and *Trioxys pallidus* (A64) in the Dendrological Garden (DG) and the Zoological Garden (ZG) and *Ephedrus cerasicola* (A30) and *Ephedrus plagiator* (A30) at Marcelin Park (MP) was also confirmed. This demonstrates the strong association of these species of the subfamilies Pimplinae and Aphidiinae with these biocoenoses.

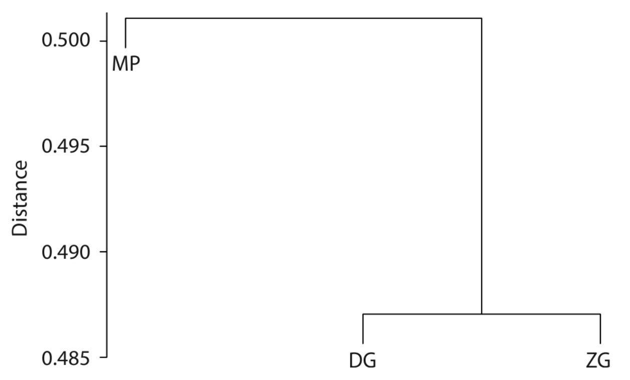
In the green areas of Poznań, 42 species of the subfamily Pimplinae were found, which accounted for 30.4% of the species reported in Poland (Bogdanowicz et al. 2007). This supports the idea that urban greenery is a favourable habitat for these insectivores. The species diversity shown is lower than that previously reported by Sawoniewicz (1982) in Warsaw, as 68 species were caught there. The species diversity of Pimplinae determined in the present study is also lower than that reported by Piekarska-Boniecka et al. (2022) (51 species) in earlier studies of the urban greeneries of Poznań. Nevertheless, the current species diversity is higher than that previously found by Piekarska-Boniecka et al. (2009a, 2009b) because 31 species were caught in the Arboretum in Kórnik and 36 species in the Botanical Garden of the Poznań University of Life Sciences.

The study identified a higher species diversity of Aphidiinae species than Pimplinae. A total of 64 species were found, representing 79% of those reported in Poland (Bogdanowicz et al. 2004). This shows that urban greenery is an attractive habitat for these insectivores. The established species diversity of Aphidiinae in urban greenery is the highest ever recorded in Poland. This can be explained by the specificity of the earlier study, as it was only concerned with determining the parasitoid complex reared from aphids fe-



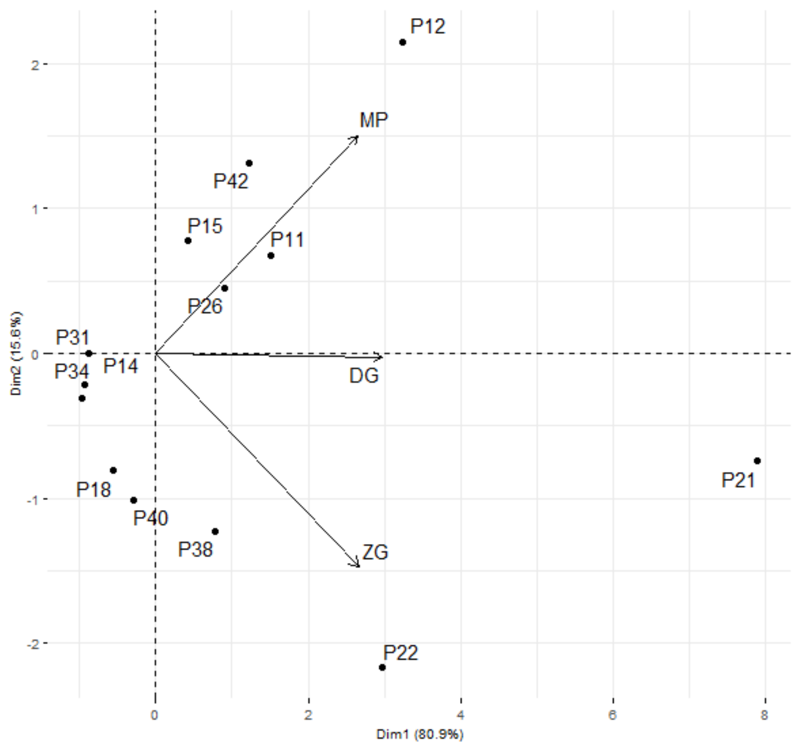
Rys. 2. Dendrogram podobieństwa zgrupowań Pimplinae w zieleni miejskiej Poznania na podstawie hierarchicznej analizy skupień według metody pojedynczych skupień z indeksem niepodobieństwa Braya-Curtisa (DG – Ogród Dendrologiczny, MP – Park w Marcelinie, ZG – Ogród Zoologiczny). Odległość – miara odległości

Fig. 2. A dendrogram of similarity between of the Pimplinae communities in urban greenery in Poznań based on hierarchical cluster analysis according to the single clustering method with Bray-Curtis dissimilarity index (DG – Dendrological Garden, MP – Marcelin Park, ZG – Zoological Garden). Distance – a measure of distance



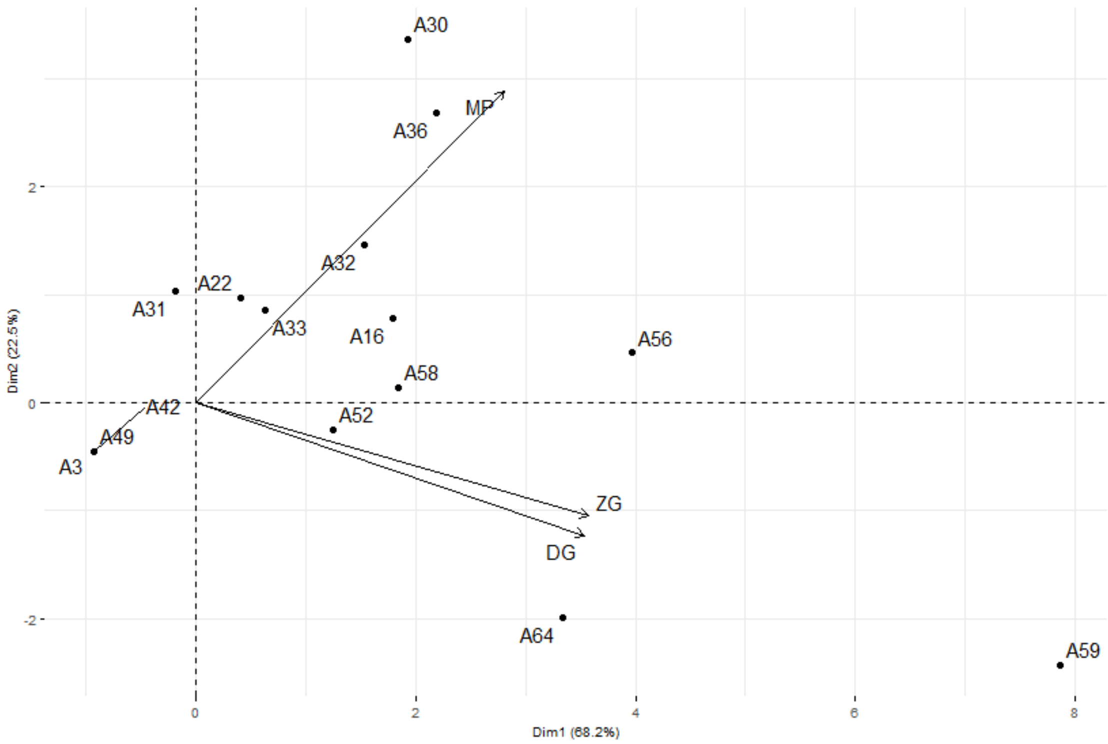
Rys. 3. Dendrogram podobieństwa zgrupowań Aphidiinae w zieleni miejskiej Poznania na podstawie hierarchicznej analizy skupień według metody pojedynczych skupień z indeksem niepodobieństwa Braya-Curtisa (DG – Ogród Dendrologiczny, MP – Park w Marcelinie, ZG – Ogród Zoologiczny). Odległość – miara odległości

Fig. 3. A dendrogram of similarity between of the Aphidiinae communities in urban greenery in Poznań based on hierarchical cluster analysis according to the single clustering method with Bray-Curtis dissimilarity index (DG – Dendrological Garden, MP – Marcelin Park, ZG – Zoological Garden). Distance – a measure of distance



Rys. 4. Analiza składowych głównych (PCA) dla zgrupowań Pimplinae w zieleni miejskiej w Poznaniu (DG – Ogród Dendrologiczny, MP – Park w Marcelinie, ZG – Ogród Zoologiczny). Dim1 – pierwszy główny kierunek, wzdłuż którego próbki wykazują największe zróżnicowanie. Dim2 – drugi najważniejszy kierunek, jest ortogonalny do osi Dim1. 80,9% – procent informacji zawartych w danych jest wyjaśniany przez pierwszą składową główną. 15,6% – procent informacji zawartych w danych jest wyjaśniany przez drugą składową główną

Fig. 4. Principal component analysis (PCA) for the Pimplinae communities in urban greenery in Poznań (DG – Dendrological Garden, MP – Marcelin Park, ZG – Zoological Garden). Dim1 – the first principal direction along which the samples show the largest variation. Dim2 – the second most important direction, it is orthogonal to the Dim1 axis. 80.9% – the percentage of the information contained in the data are explained by the first principal component. 15.6% – the percentage of the information contained in the data are explained by the second principal component



Rys. 5. Analiza składowych głównych (PCA) dla zgrupowań Aphidiinae w zieleni miejskiej w Poznaniu (DG – Ogród Dendrologiczny, MP – Park w Marcelinie, ZG – Ogród Zoologiczny). Dim1 – pierwszy główny kierunek, wzdłuż którego próbki wykazują największe zróżnicowanie. Dim2 – drugi najważniejszy kierunek, jest ortogonalny do osi Dim1. 68,2% – procent informacji zawartych w danych jest wyjaśniany przez pierwszą składową główną. 22,5% – procent informacji zawartych w danych jest wyjaśniany przez drugą składową główną

Fig. 5. Principal component analysis (PCA) for the Aphidiinae communities in urban greenery in Poznań (DG – Dendrological Garden, MP – Marcelin Park, ZG – Zoological Garden). Dim1 – the first principal direction along which the samples show the largest variation. Dim2 – the second most important direction, it is orthogonal to the Dim1 axis. 68.2% – the percentage of the information contained in the data are explained by the first principal component. 22.5% – the percentage of the information contained in the data are explained by the second principal component

eding in urban greenery. Therefore, only a few species of Aphidiinae each were shown in towns in central and south-eastern Poland (Barczak 1998; Goszczyński et al. 2000; Tykarska 2001; Jaśkiewicz 2003, 2004; Barczak et al. 2005; Jaśkiewicz and Sławińska 2005). A more extensive study of aphid parasitoids is Wiąckowski et al. (1997), in which 25 species of Aphidiinae were reported, reared from aphids colonising urban greenery in Kielce, Ostrowiec Świętokrzyski, Klimontów, Nowa Słupia and Pińczów. Another study from this region is Ślusarczyk (1994), which presents 20 species of Aphidiinae, parasitic aphids feeding on ornamental plants in the Kielce area. Also, Werstak and Wiąckowski (1998), conducting research in the urban greenery of Kielce and Ostrowiec Świętokrzyski, reared 52 species of these insectivores. In turn, Barczak et al. (2005), compiling the entomofauna of green areas in Bydgoszcz, Toruń and Włocławek, yielded 12 species of Aphidiinae. Significantly more species of these insectivores were shown by Starý (1987), who studied parks, gardens, avenues and orchards in the Prague area. He caught 85 species in this habitat. On the other hand, Lumbierres et al. (2005), conducting research in urban green areas in Lleida, Spain, reported 19 species of Aphidiinae.

The study confirmed the dominance of the species *Pimpla contemplator* (P21), *Itoplectis maculator* (P12) and *Itoplectis alternans* (P11) in the Pimplinae parasitoid complex in urban greenery, previously shown to be abundant in this habitat by Piekarska-Boniecka et al. (2009a), Rzańska et al. (2015) and Rzańska and Piekarska-Boniecka (2016). At the same time, the dominance of *Pimpla flavicoxis* (P22) (0.111) in green areas was found for the first time. All dominant species are pupal endoparasitoids. Species in the genus *Itoplectis* are polyphagous; *Pimpla contemplator* parasitises Lepidoptera and Hymenoptera, and *Pimpla flavicoxis* parasitises Lepidoptera and Coleoptera (Fitton et al. 1988; Yu 2012).

The study showed the dominance of the following Aphidiinae species: *Trioxys betulae* (A59), *Trioxys pallidus* (A64), *Praon volucre* (A56), *Trioxys auctus* (A58) and *Ephedrus plagiator* (A36). The literature only suggests that *Trioxys pallidus* (A64), *Praon volucre* (A56) and *Ephedrus plagiator* (A36) were previously reared from aphids feeding in this habitat (Ślusarczyk 1994; Werstak and Wiąckowski

1998; Goszczyński et al. 2000). All dominant species are endoparasitoids of aphid larvae and imagines. *Trioxys pallidus*, *Praon volucre* and *Ephedrus plagiator* are polyphagous; *Trioxys betulae* parasitises aphids found on *Alnus* spp., *Betula* spp. and *Tilia* spp., and *Trioxys auctus* parasitises plants in the Poaceae family (Yu 2012).

As a result of the study, two species of the subfamily Pimplinae and 30 species of the subfamily Aphidiinae were found for the first time in the urban greens of Poland. Representatives of the Pimplinae were *Perithous albicinctus* (P18) and *Theronia laevigata* (P35). *Perithous albicinctus* is an ectoparasitoid of larvae of the family Crabronidae (Hymenoptera), and *Theronia laevigata* is an endoparasitoid of Lepidoptera pupae (Yu 2012). The Aphidiinae included *Aclitus obscuripennis* (A1), *Adialytus salicaphis* (A2), *Adialytus thelaxis* (A3), *Aphidius aquilus* (A5), *Aphidius avenae* (A6), *Aphidius cingulatus* (A7), *Aphidius eglanteriae* (A9), *Aphidius phalangomyzi* (A13), *Aphidius rhopalosiphi* (A14), *Aphidius urticae* (A19), *Aphidius uzbekistanicus* (A20), *Binodoxys angelicae* (A22), *Binodoxys heraclei* (A23), *Diaeretellus ephippium* (A24), *Diaeretellus heinzei* (A25), *Diaeretellus macrocarpus* (A26), *Diaeretus leucopterus* (A28), *Ephedrus helleni* (A31), *Ephedrus nacheri* (A33), *Ephedrus niger* (A34), *Ephedrus validus* (A37), *Lysiphlebus fritzmuelleri* (A41), *Monoctonus crepidis* (A42), *Paralipsis enervis* (A43), *Pauesia abietis* (A44), *Praon longicorne* (A53), *Praon yomenae* (A57), *Trioxys auctus* (A58), *Trioxys betulae* (A59) and *Trioxys complanatus* (A61). By listing new species in this habitat, knowledge of insectivorous species diversity in urban green areas in Poland has been significantly increased. This also shows that the habitat is attractive to these insectivores.

The study confirmed the effectiveness of ACE in estimating the species diversity of parasitoid assemblages from both subfamilies at individual sites. Previous studies on the qualitative structure of insectivore assemblages in urban green areas clearly indicated that only this estimator determined the closest species diversity to that found in the study (Piekarska-Boniecka et al. 2022). The other estimators pointed to far greater species diversity.

The study results clearly indicated that only for the subfamily Aphidiinae was there a statistically significant effect of habitats on the abundance of individual assemblages and the effect of years on the total abundance of assemblages. This shows that the abundance of these insectivores varies more between sites and from year to year than the abundance of Pimplinae species assemblages.

The study explicitly indicated a positive relationship between vegetation diversity and the abundance and species diversity of parasitoids in relation to the subfamily Aphidiinae. A higher abundance and greater species diversity of insectivores was found on sites with a higher abundance of vascular plants. This relationship was not confirmed by assemblages of the subfamily Pimplinae. The highest abundance and high species diversity of these insectivores was recorded in the Zoological Garden (ZG), where the lowest plant species diversity was found. Such a qualitative and quantitative structure of this assemblage can only be explained by the species composition of the vascular plants growing there. Among the sparse trees and shrubs and the dominant herbaceous vegetation, nectar-, pollen- and honeydew-producing species were present, providing a food source for adult insects and attracting them to the site. These included trees: *Acer platanoides* L., *Fraxinus excelsior* L., *Prunus insititia* (L.) Bonnier & Layens and *Ulmus laevis* Pall.; shrubs: *Caragana arborescens* Lam., *Crataegus monogyna* Jacq., *Sambucus nigra* L., *Sorbus aria* and *Humulus lupulus* L. representing herbaceous plants. Dąbrowski et al. (2008) and Olszak et al. (2009) provided a list of plant species promoting entomofauna in their papers. These included trees: *Alnus* spp., *Carpinus betulus* L., *Ulmus* spp., *Acer* spp., *Fraxinus excelsior* L., *Malus* spp. and *Prunus* spp., and shrubs: *Crataegus monogyna* Jacq., *Sambucus nigra* L., *Viburnum opulus* L., *Caragana arborescens* Lam., *Prunus* spp., *Euonymus europaeus* L. Olszak et al. (2009) found that *Crataegus* spp., *Sambucus nigra* L. and *Viburnum* spp. were the most abundant insectivore-infested shrubs. Idris and Grafius (1997), on the other hand, found that plants from the Brassicaceae and Apiaceae families are a particularly valuable food source for insectivores and also provide excellent shelter, especially in hot weather when intense sunlight reduces the activity of these insectivores.

The study found a positive relationship between the species diversity of the vegetation and the similarity of the qualitative-quantitative structure of the Pimplinae assemblages at each site. The assemblages in the Dendrological Garden (ZG) and Marcelin Park (MP) were shown to be similar. These sites had vegetation with similar species diversity and a similar proportion of trees, shrubs and herbaceous plants in the vascular plant structure. At both sites, *Betula pendula* Roth, *Tilia tomentosa* Moench, *Salix alba* L. and *Salix caprea* L. dominated among the trees. Abundant shrubs included *Berberis julianae* C.K. Schneid., *Berberis vulgaris* L. and *Spiraea japonica* L. Herbaceous plants were dominated by *Elymus repens* (L.) Gould, *Festuca rubra* L. and *Hypochoeris radicata* L.

The study did not show such a clear relationship between the vegetation of the sites and the similarity of the qualitative-quantitative structure of the Aphidiinae assemblages as was determined for the Pimplinae parasitoids. The qualitative-quantitative similarity of Aphidiinae assemblages found in the Dendrological Garden (DG) and the Zoological Garden (ZG) was established. These sites differed markedly in the number of vascular plants, as more than twice as many species were found in the Dendrological Garden (DG) than in the Zoological Garden (ZG). The Zoological Garden (ZG) was a site with a species-poor composition of trees and shrubs. Both sites were dominated by herbaceous vegetation. Both had two species of shrubs (*Crataegus monogyna* Jacq. and *Symphoricarpos rivularis* Suksd.) and

31 species of herbaceous plants, of which 18 were found at all sites. Of these 18 species, 12 were common to the Dendrological Garden (DG) and Zoological Garden (ZG). These included *Aegopodium podagraria* L., *Cardaminopsis arenosa* (L.) Hayek, *Carex caryophyllea* L., *Chaerophyllum temulum* L., *Euphorbia cyparissias* L., *Festuca gigantea* L. Vill., *Impatiens parviflora* DC, *Lamium album* L., *Moehringia trinervia* (L.) Clairv., *Ranunculus acris* L., *Verbascum lychnitis* L. and *Viola odorata* L. It can be assumed that plant species common to both sites may have determined the similarity in the qualitative-quantitative structure of Aphidiinae assemblages colonising these sites.

Wnioski / Conclusions

1. The influence of habitats and the effect of years on the abundance of parasitoids of the subfamily Aphidiinae was demonstrated.
2. A positive relationship was observed between the species diversity of vascular plants and the abundance and species diversity of parasitoids of the subfamily Aphidiinae, as well as the qualitative-quantitative structure of parasitoid assemblages of the subfamily Pimplinae present at individual sites.
3. Positive effects of vascular plants, i.e. trees: *Betula pendula* Roth, *Tilia tomentosa* Moench, *Salix alba* L. and *Salix caprea* L., shrubs: *Berberis julianae* C.K. Schneid., *Berberis vulgaris* L. and *Spiraea japonica* L., and herbaceous plants: *Elymus repens* (L.) Gould, *Festuca rubra* L. and *Hypochoeris radicata* L., as a food base for parasitoid assemblages of the subfamily Pimplinae were demonstrated. It is therefore recommended to plant these trees and shrubs in individual urban greenery.

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