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ORIGINAL ARTICLE

Changes over the last ten years in the fauna structure of aphids inhabiting the vegetation of allotment gardens in Poznań

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Abstract

The vegetation of allotment gardens is an important element of urban green areas and constitutes a habitat where many groups of insects exist, including aphids. This research involved the monitoring of winged morphs of aphids in allotment gardens in the area of Poznań with the use of Moericke traps. The fauna structure of aphids in two large allotment gardens was demonstrated by comparing the activity of winged morphs of aphids in 2000–2001 and 2014–2015. The vegetation of these gardens was accompanied by the rich fauna of aphids. For four growing seasons, 113 species or groups of aphid species were captured with the traps. Major changes were reported in the structure of the collected fauna in the period of time when the research was conducted. The differences concerned particular positions of collected species in aphid communities. The abundance of *Anoecia corni*, *Aphis sambuci*, *Phorodon humuli* and *Periphyllus testudinaceus* increased, and now hold the position of subdominants of the communities, whereas *Myzus persicae* and *Hyalopterus pruni* decreased in comparison with the situation more than ten years ago. *Rhopalosiphum padi* still remains an eudominant in the communities. The main reason for this phenomenon is thought to be due to changes in the vegetation composition of gardens because the gardens are being used differently. The production function has changed to recreation.

Key words: aphid, allotment gardens, flight activity, urban greenery

Introduction

Allotment gardens, just as some other types of urban agriculture, can exhibit high levels of biodiversity, often exceeding that of other green areas within the city. Additionally, it is likely that variation in vegetation cover, diversity, and structure also influence the quantity and quality of ecosystem services such as pollination, local climate regulation, flood protection and an opportunity to socialize in a pleasant environment (Speak *et al*. 2015).

Urban agriculture may be especially important for biodiversity conservation in cities because vegetative structural complexity in simplified landscapes contributes disproportionally more to conservation than in more natural landscapes (Tscharntke *et al.* 2012).

Allotment gardens provide substantial levels of vegetative biodiversity. Such areas are often extremely rich in plant diversity, with more than 440 different plant species recorded in a single 400 m^2 allotment garden (Colding *et al.* 2006). Plant diversity is a principle predictor of insect diversity at small spatial scales (Southwood *et al.* 1979), and is important for tree-dwelling arthropods (Halaj *et al.* 2000), ground-dwelling arthropods (Byrne *et al.* 2000), grasshoppers (Davidowitz 1998), bees (Iha 2010), and ground-dwelling

beetles (Romero-Alcaraz 2000). Likewise, in domestic gardens in the UK, invertebrate species richness was positively affected by vegetation complexity, especially the abundance of trees (Smith *et al.* 2006a).

Overall, many studies support the idea that urban agricultural management with high vegetation diversity can have positive effects on invertebrate biodiversity in urban systems. The aim of this research was to compare the fauna structure of aphids in allotment gardens over the last ten years in relation to changes in the way of using them. The established research hypothesis holds that a change in the way of using gardens, evidenced in a change in the vegetation composition of gardens, impacts the fauna structure of aphid groupings. This change was seen in a considerable decrease of the area where vegetables, shrubs, and fruit trees were cultivated in favour of decorative plants-grasses, annuals, perennials, shrubs, and trees. The comparisons were based on the analysis of flight activity of winged morphs of aphids in two allotment gardens in Poznań in 2000–2001 and 2014–2015.

Materials and Methods

The studies were conducted in two large allotment gardens in Poznań: Pod Lipami Allotment Gardens in 2000–2001, and in Bielniki Allotment Gardens in 2014–2015. The former was established in 1976 and covers 24.5 ha. The latter was founded in 1925 and covers 21.3 ha. Aphids were collected with the use of Moericke traps, where five traps were used in 2000–2001, and 10 other traps in 2014–2015. The traps were yellow containers 18 cm in diameter and 11 cm in height, which were filled with an aqueous solution of ethylene glycol with the addition of a detergent, and placed at the height of 1.5 m. Each year insects were collected every 10 days throughout the whole season, from April to October. Specimens were stored in 75% ethylene alcohol before their identification. The material was classified with the use of Heie (1982, 1986, 1992, 1994, 1995), Taylor's (1984) and Blackman and Eastop's identification keys (1994). When assessing the structure of aphid groupings, class domination was adopted after Durak and Wojciechowski (2008): eudominants – >20%, dominants – 10–20%, subdominants – 5–10%, recedents – 1–5% and subrecedents – <1% of the collected material from the aphid community.

Results

The research results confirm the activity of the rich aphid fauna that accompanies the vegetation in allotment gardens in Poznań. During four growing seasons (2000–2001 and 2014–2015), a total of 113 aphid species or groups of species were found in Moericke traps: the representatives of two families – Adelgidae and Aphididae, with 11 subfamilies: Adelginae, Eriosomatinae, Anoeciinae, Thelaxinae, Drepanosiphinae, Phyllaphidinae, Calaphidinae, Saltusaphidinae, Chaitophorinae, Aphidinae and Lachninae. The subfamily Aphidinae was represented the most – by 68 aphid species (Table 1). The occurrence of 17 taxa was confirmed at both sites and during each year of the research. Based on this they can be considered to be a species characteristic for this environment. This group contained two polyphagous species *Aphis fabae* and *Myzus persicae*, inhabiting both vegetable and decorative plants. Species considered as dangerous pests to fruit cultivation included: *Brachycaudus schwartzi*, *Dysaphis plantaginea*, *Hyalopterus pruni*, *Myzus cerasi*, *Hyperomyzus lactucae*, *Panaphis juglandis*; to vegetable cultivation: *Cavariella aegopodii*; to decorative plants: *Aphis sambuci*, *Capitophorus elaeagni*, *Macrosiphum rosae*, *Periphyllus testudinaceus*, *Phorodon humuli*; and to grasses: *Rhopalosiphum padi* and *Anoecia corni*.

The results demonstrate a significant difference in the number of aphids collected between the seasons, and across the two research seasons of 2000–2001 and 2014–2015. It is a very common phenomenon for aphids, which react strongly to weather changes during the season. The studies show very distinctly fewer overall numbers of winged morphs collected in 2014–2015. It must be emphasized that in the years 2000–2001, half the number of traps was used. Undoubtedly changes in the use of allotment gardens impacted the aphid fauna. At the end of the previous century allotment gardeners focused mainly on cultivating vegetables, trees, and fruit shrubs. Since the beginning of the new century there has been a distinct turn towards recreational gardens. Currently, allotment gardeners are abandoning the production of vegetables and fruits in favor of cultivating decorative plants (grasses, annuals, perennials, decorative shrubs and trees). The reason for this reduction or the total elimination of an economic function of gardens is a growing knowledge of the society about environmental degradation in urban areas. Furthermore there have been observable changes in social behavior associated with a general increased affluence, as seen in recent years by the rising rate of the growth and development of the country's socio-economy.

The progressing changes in the vegetation composition of the gardens that accompany this phenomenon can explain the different structure of the collected fauna of aphids, found throughout the studied period of time. Only the position of *R. padi* as an eudominant of the groupings at the two earlier studied sites and during the last two-year research remained the same (Table 2). *Rhopalosiphum padi* was collected in abun-

Table 1. A list of aphid species and their number in the Family Allotment Gardens in Poznań in 2000–2001 and 2014–2015

Aphid species	Family Allotment Gardens			
	Pod Lipami		Bielniki	
	2000	2001	2014	2015
Acyrthosiphum pisum (Harris)	2	—	1	—
Adelges sp.	3	48	—	1
Amphorophora idaei (Börn.)	—	—	1	1
Anoecia corni (F.)	59	33	36	38
Anoecia vagans (Koch)	—	1	—	—
Aphis craccivora Koch	2	—	4	7
Aphis idaei V.D.Goot	4	1	—	1
Aphis fabae Scop.	62	22	29	24
Aphis pomi De Geer	16	4	5	—
Aphis sambuci L.	10	7	14	33
Aphis spp.	8	13	19	17
Atheroides serrulatus Hal.	—	1	—	—
Aulacorthum solani (Kalt.)	—	1	—	1
Aulacorthum speyeri Börn.	1	—	—	—
Brachycaudus cardui (L.)	3	—	2	4
Brachycaudus divaricatae Shap.	—	—	41	23
Brachycaudus helichrysi (Kalt.)	8	4	5	1
Brachycaudus schwartzi (Börn.)	5	2	—	17
Brevicoryne brassicae (L.)	1	—	—	—
Calaphis betulicola (Kalt.)	—	1	—	—
Capitophorus elaeagni (Del Gu.)	31	6	1	2
Capitophorus hippophaeus (Walk.)	1	1	—	—
Cavariella aegopodii (Scop.)	76	4	12	9
Cavariella archangelicae (Scop.)	—	—	2	1
Cavariella pastinaceae (L.)	—	1	—	1
Cavariella theobaldi (Gill. et Bragg)	2	1	—	—
Ceruraphis eriophori (Walk.)	2	—	1	—
Chaitophorus leucomelas Koch	—	1	1	1
Chaitophorus populeti (Panz.)	2	—	2	1
Chaitophorus populialbae (B. de F.)	—	1	1	—
Cinara costata (Zett.)	—	1	—	1
Cinara juniper (De Geer)	—	—	1	—
Cinara spp.	—	1	—	1
Clethrobius comes (Walk.)	—	—	—	1
Cryptomyzus galeopsidis (Kalt.)	5	1	—	—
Cryptomyzus korschelti Börn.	2	—	—	—
Cryptomyzus ribis (L.)	6	4	—	—
Delphiniobium junankianum (Karsch)	1	—	—	—
Drepanosiphum aceris Koch	—	—	3	1
Drepanosiphum platanoidis (Schrk.)	21	4	1	6
Dysaphis plantaginea (Pass.)	42	45	1	4
Dysaphis pyri (B. de F.)	—	2	—	—
Dysaphis spp.	7	1	4	—
Elatobium abietinum (Walk.)	—	9	2	6

Table 1. A list of aphid species and their number in the Family Allotment Gardens in Poznań in 2000–2001 and 2014–2015 *– continuation*

Aphid species	Family Allotment Gardens			
	Pod Lipami		Bielniki	
	2000	2001	2014	2015
Eriosoma patchiae (Börn. & Blunck)	—	1	—	—
Eriosoma ulmi (L.)	1	4	15	16
Eucallipterus tiliae (L.)	8	—	1	25
Euceraphis betulae (Koch)	2	—	7	8
Euceraphis punctipennis (Zett.)	—	—	1	
Eulachnus rileyi (Will.)	—	2	—	1
Holcaphis sp.	—	2	—	—
Hayhurstia atriplicis (L.)	—	—	—	1
Hyadaphis foeniculi (Pass.)	1	—	1	1
Hyalopterus pruni (Geoff.)	342	63	12	9
Hypertomyzus lactucae (L.)	10	11	6	12
Hypromyzus picridis (Börn. & Blunck)	1	—	1	1
Lipaphis erysimi (Kalt.)	—	—	1	1
Longicaudus thrirhodus (Walk.)	—	1	—	
Macrosiphoniella tanacetaria (Kalt.)	2		—	1
Macrosiphoniella spp.	1	—	—	2
Macrosiphum euphorbiae (Thom.)	—	—	1	3
Macrosiphum gei (Koch)	—	1	—	—
Macrosiphum rosae (L.)	4	1	4	6
Megourella purpurea H.R.L.	—	—	1	—
Metopolophium albidum H.R.L.	2	—	—	—
Metopolophium dirhodum (Walk.)	26	4	3	—
Microlophium carnosum (Buckt.)	—	1	—	—
Mimeuria ulmiphila (Del Gu.)	—	—	—	1
Myzocallis castanicola Baker	—	—	—	1
Myzus ascolonicus Donc.	—	1	—	3
Myzus cerasi (F.)	78	36	5	3
Myzus ligustri Mosl.	1	3		1
Myzus lythri (Schrk.)	29	2	1	—
Myzus ornatus Laing	1	—	—	—
Myzus persicae (Sulz.)	1612	378	10	6
Nasonovia ribisnigri (Mosl.)	1	3	—	—
Ovatus crataegarius (Walk.)	1	1	—	—
Ovatus insitus (Walk.)	1	1	—	—
Panaphis juglandis (Goetze)	2	1	1	1
Pemphigus sp.	3	—	1	—
Periphyllus acericola (Walk.)	—	—	—	—
Periphyllus aceris (L.)	2	—	—	—
Periphyllus hirticornis (Walk.)	1	—	—	—
Periphyllus testudinaceus (Fern.)	2	1	1	8
Phorodon humuli (Schrk.)	32	12	112	39
Phyllaphis fagi (L.)	14	—	1	5
Prociphilus bumeliae (Schrk.)	—	—	1	—
Prociphilus fraxini (F.)	—	1	—	—

Table 1. A list of aphid species and their number in the Family Allotment Gardens in Poznań in 2000–2001 and 2014–2015 – *continuation*

Aphid species	Family Allotment Gardens			
	Pod Lipami		Bielniki	
	2000	2001	2014	2015
Prociphilus pini (Burm.)	—	2	—	—
Protrama flavescens (Koch)	—	—	1	—
Pterocomma pilosum Buckt.	1	—	—	5
Pterocomma populeum (Kalt.)	—	—	18	8
Pterocomma salicis (L.)	1	—	—	—
Rhopalomyzus lonicerae (Sieb.)	—	—	1	1
Rhopalomyzus poe (Gill.)	1	—	—	—
Rhopalosiphoninus staphyleae (Koch)	1	—	—	—
Rhopalosiphum insertum (Walk.)	37	32	2	—
Rhopalosiphum nymphaeae (L.)	2	10	—	—
Rhopalosiphum padi (L.)	11,540	1587	2325	252
Schizaphis longicaudata (H.R.L.)	1	—	—	—
Schizolachnus pineti (f.)	—	—	—	3
Sipha maydis Pass.	—	1	2	—
Sitobion fragariae (Walk.)	1	—	—	—
Sitobion avenae (F.)	4	3	—	3
Subsaitusaphis sp.	1	—	—	—
Tetraneura ulmi (L.)	—	—	3	4
Thelaxes dryophila (Schrk.)	1	—	—	—
Therioaphis luteola (Börn.)	—	—	—	—
Therioaphis trifolii (Mon.)	1	—	1	—
Tinocallis platani (Kalt.)	1	—	—	—
Trichosiphonaphis corticis	5	4	—	—
Uroleucon sp.	2	4	1	—
Uromelan sp.	4		1	2
Number of species	71	60	56	57
Number of individuals	14,166	2394	2731	636

Table 2. Species numerously represented in the aphid communities collected with Moericke traps in the Family Allotment Gardens in Poznań in 2000–2001 and 2014–2015

Aphid species	Dominancy index [%]			
	FAG „Pod Lipami" in 2000–2001		FAG „Bielniki" in 2014–2015	
Rhopalosiphum padi (L.)	81.5	66.3	85.0	39.6
Myzus persicae (Sulz.)	11.4	15.8	0.4	0.9
Aphis fabae Scop.	0.4	0.9	1.1	3.7
Hyalopterus pruni (Geoff.)	2.4	2.6	0.4	1.4
Anoecia corni (F.)	0.4	1.3	1.3	5.9
Drepanosiphum platanoidis (Schrk.)	0.15	0.16	0.04	0.9
Aphis sambuci L.	0.1	0.3	0.4	5.9
Phorodon humuli (Schrk.)	0.2	0.5	4.1	6.1
Periphyllus testudinaceus (Fern.)	0.01	0.04	4.1	6.1
Brachycaudus divaricatae Shap.	0	0	1.5	3.7

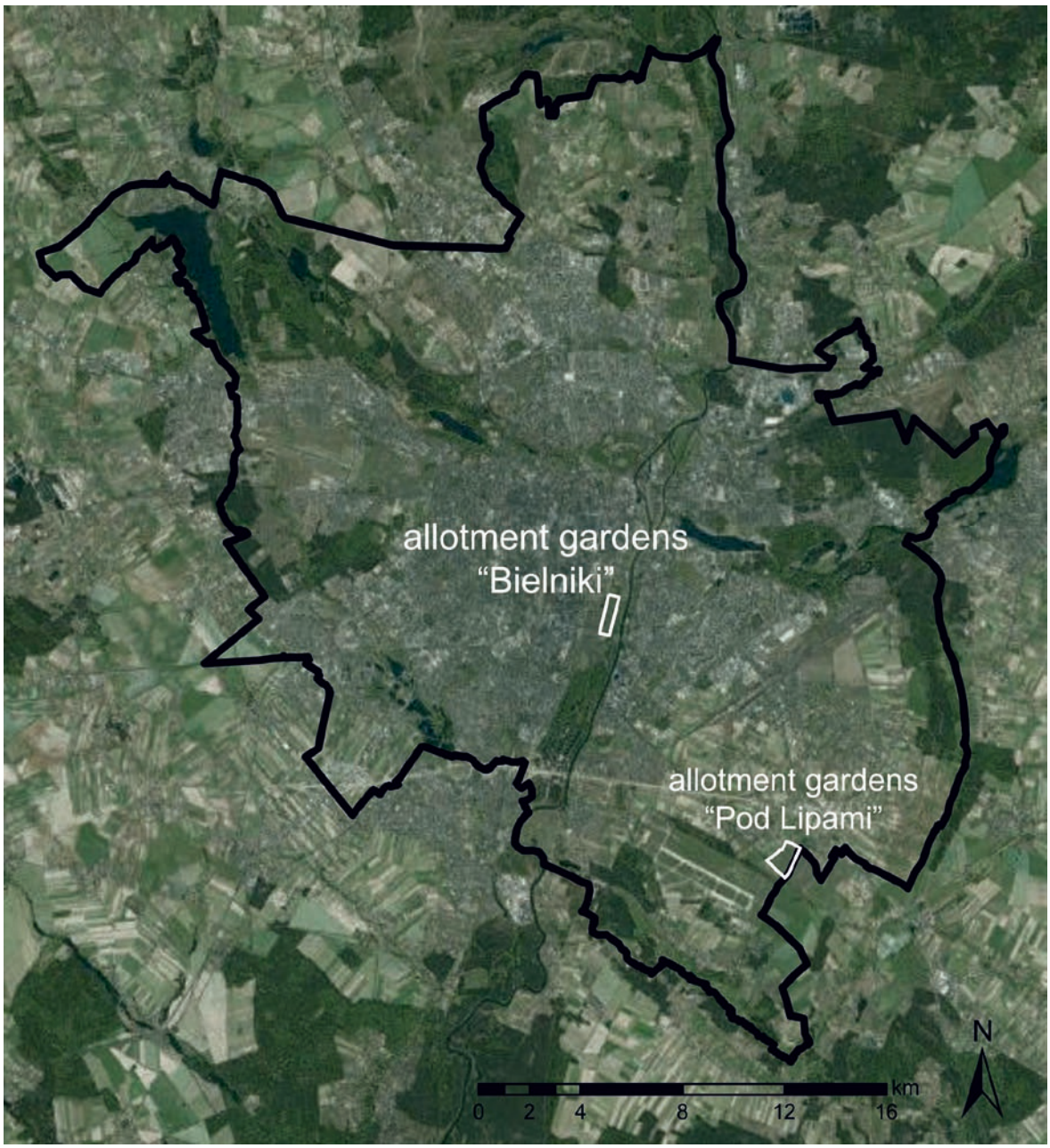

Fig. 1. The location of Bielniki allotment gardens and Pod Lipami allotment gardens within the Poznań city limits (own elaboration based on http://www.geoportal.gov.pl/)

dance predominantly during autumn. It is a holocyclic and heterocyclic species, migrating from the bird cherry to grasses. Comparing the structure of aphids from the studied communities at the beginning of the current century and today, changes concerning the position of other collected species are distinctly visible, where one part of them gains significance, and the other part evinces decreasing trends in the structure of communities (Table 2). The group that is gaining significance includes: *A. fabae*, *A. corni*, *D. platanoidis*, *A. sambuci*, *P. humuli*, *P. testudinaceus*. Four of the mentioned taxa – *A. corni*, *A. sambuci*, *P. humuli* and *P. testudinaceus* – have currently shifted into the position of subdominants. This group had not been represented earlier in the communities of this insect in the gardens. The downward group includes *M. persicae* and *H. pruni*. The earlier high position of *M. persicae* as a dominant (11.4 and 15.8% of the aphid communities in 2000 and 2001, respectively) fell to the group of subrecedents (0.4 and 0.9% in 2014 and 2015, respectively).

Discussion

Allotment gardens, community gardens, city farms – today in many European countries these forms of urban agriculture are again the subject of interest of many local gardeners and scientists. In the structure

of a city, these places are examples of independent spaces which provide many ecosystem functions for green infrastructure and make it possible to maintain sustainable development in the city in the context of ecology, economy, and residents' quality of life (Giedych and Poniży 2013; Szumilas 2014).

Urban landscapes are typically highly simplified, intensively developed ecosystems with low levels of native biodiversity. However, urban green spaces such as allotment gardens can bring diverse green infrastructure back into the urban system, providing vegetative structure and biodiversity for the ecosystem function and services across fragmented habitats and special scales (Tscharntke *et al*. 2012). Allotment gardens can include the cultivation of vegetables, medicinal plants, spices, mushrooms, fruit trees, and ornamental plants. This wide range of produce means that they are highly heterogeneous in size, form, and function. Over the last decade, the vegetation composition cultivated in gardens changed enormously (Speak *et al.* 2015; Spilkova and Vagner 2016). Ecosystem services are often reliant on the functional traits of the underlying plant communities. Flora is a good indication of biodiversity since it shapes the structure of organisms at higher trophic levels (Smith *et al.* 2006b). This has its consequences in the fauna that inhabits those environments. Proof for such shifts may include our research results concerning the changes in the structure of the aphid fauna.

However, this research shows that it is very important to recognize allotment gardens as a part of the green structure of the city and as a means of supporting biodiversity in the city; thus, they are of great importance for sustainable development within the city.

Poznań is a city in which green urban spaces play a significant role in the spatial structure. In the city's greenery system, allotment gardens play an elemental role, besides forests and parks. They constitute 3.2% of the overall city area, and cover 827 ha (Mierzejewska 2001). Progressing environmental degradation within urban areas is a reason behind the reduction or complete elimination of its economic function in favor of a leisure-recreational one. It is connected with the major changes in the vegetation composition of these areas, which, in turn, has a significant impact on the fauna that inhabits them. An example of this can be seen by the changes that have occurred in recent years in the structure of the aphid fauna.

In Poznań only a third of plots, on average, were observed to be growing vegetables and this usually consisted of a vegetable bed with a mean size of 30 m^2, less than 10% of the average allotment area. Poznań allotment gardens have many large trees, and a high proportion of evergreen trees. Tree cover and species composition are similar to that of parks (Speak *et al.* 2015).

The trend of changes in the function of allotment gardens however, is not unique for Poland, and has also been seen elsewhere. Van den Berg *et al.* (2010) in their research confirm that younger gardeners prefer passive rather than production function of allotment gardens, such as relaxation and recreation. Also in Germany (Holmer and Drescher 2005) and in Czechia (Spilkova and Vagner 2016) gardens are perceived as hobby and recreation spaces.

The presented changes appear to be crucial from the perspective of the significance of given aphid species as dangerous plant pests. What primarily draws one's attention is the shift in the fauna structure concerning the position of two important polyphagous species – *M. persicae* and *A. fabae*, which react in different ways. In the former, there has been a distinct population decrease, and as for the latter – an increase. Noticeable also is an apparent rise in the significance of the species that inhabit trees and decorative shrubs, among others, *A. sambuci, P. humuli, P. testudinaceus*, and *A. corni.* A special position among taxa numerously represented in aphid communities belongs to *Brachycaudus divaricatae*, now found in the group of recendents. It is a new species in our fauna. It was found for the first time in 2002 in Southern Poland (Cichocka and Lubiarz 2003), and three years later recorded in Poznań from *P. cerasifera* (Wilkaniec and Wilkaniec 2013). Since then, the species has been constantly collected from various objects of urban green areas in Poznań (Wilkaniec *et al.* 2015, 2016).

Conclusions

1. The vegetation of the allotment gardens in Poznań was accompanied by a rich fauna of aphids.
2. Trends in decreasing numbers of aphids and changes in the structure of their communities were detected in the studies.
3. The differences in structure of aphid communities concerned the position of particular aphid species over the last 15-years.
4. The main reason for changes in aphid fauna is thought to be found in changes of the vegetation composition of allotment gardens due to an alternate way of using them – from production to recreation.

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