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THE IMPACT OF URBAN CONDITIONS ON THE OCCURRENCE OF APHIDS ON *Acer platanoides* L.

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Abstract. Cities devastate the natural habitats of animals, but simultaneously form new ecological niches and create conditions far different from natural environments. In these new conditions some insects, such as aphids, can develop quickly and they become important pests. This paper presents the population dynamics of aphids inhabiting the Norway maple in the urban conditions of Lublin. Also shown are relationships among the aphid species inhabiting the studied tree. We have shown that aphids are abundant on *Acer platanoides* and the most numerous species was *Periphyllus aceris*. This species was clear superdominant in both of the studied sites (the housing estate site and the street site). Using ecological indices allows us to determine that housing estate site is predominantly characterised by a larger species diversity than the street site. We have also presented that weather conditions have a significant influence on the number of aphids on the Norway maple. The highest number of aphids was observed in 2008, which was characterised by a warm spring. This paper is an attempt to answer the question whether the changes in the number of aphids are a result, of weather and habitat conditions, or, perhaps, also of mutual relations among species.

Key words: aphid biodiversity, Norway maple, aphid population dynamics, urban conditions

INTRODUCTION

The city is characterised by an intensely mosaic character of the environment, since the green areas are divided by barriers in the form of biologically inactive areas (pavements, streets, buildings) [Głowacka 1993, McIntyre 2000, Zimny 2005]. Urbanisation forces fauna out of urban areas, destroying the original animal habitats, however, it simultaneously forms new ecological niches, creating conditions far different from natural

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environments [Trojan and Winiarska 2001]. Entomofauna is the basic animal complex forming and transforming urban biocenoses; it is durable, but highly varied internally [Głowacka 1990, Trojan and Winiarska 2001]. Insects have an important role in the circulation of matter and the flow of energy of the urban ecosystem. The natural environment in cities undergoes extreme anthropogenic transformations, creating specific conditions, often unfavourable to the life and development of trees, however herbivores with piercing-sucking mouthparts that inhabit them in urban areas, especially in street sites, find conditions highly advantageous for their development [Boczek and Kiełkiewicz 1986, Cichocka and Goszczyński 2008, Lubiarz et al. 2011].

In seasonal occurrences of aphids on urban trees, there are often significant differences in the number of aphids, not only in terms of planting locations (housing estate and street site), but also research years. The dynamics of aphid populations is a complex phenomenon, influenced by numerous external conditions, as well as internal and interspecies interactions [Dixon 1977, Estay et al. 2011]. Factors regulating the number of aphids include weather conditions (especially temperature), as well as the quality of the host plant [Bale et al. 2002, Awmack and Leather 2007, Dixon and Hopkins 2010]. Climate changes and global warming additionally influence the change of lifecycles, metabolism, and dynamics of the number of aphids [Jamieson et al. 2012, Ciss et al. 2014].

As one of the basic components of urban green, trees play various roles: natural, aesthetic, climate, health, recreational, educational, research, economic, and social [Szczepanowska 2007]. Observation of seasonal changes in the number of aphids may improve our ability to predict possible large occurrences of aphids, and, as a result, allow us to prevent damage caused by these insects in the future. Due to such an important role of trees in cities, it seems justified to begin the research of changes in the number of aphids, that may endanger the health and decorative values of these plants.

One of the species of trees largely inhabited by aphids, and – due to its decorative value and low susceptibility to the pressure of urbanisation – widely utilised in urban areas is *Acer platanoides* [Cichocka and Goszczyński 1991, Cichocka et al. 1998, Wilkaniec and Sztukowska 2008]. The goal of this paper was to attempt to answer the question whether the changes in the number of aphids inhabiting *Acer platanoides* are caused, as is widely believed, by the influence of weather and habitat conditions, or perhaps, also from interspecies interactions. Another goal was to assess the extent of the influence of large numbers of aphids on the Norway maple on the decorative value of these trees in cities.

MATERIAL AND METHODS

Description of locations. The research was carried out in the area of Lublin between 2008 and 2010. Two research sites were established: site 1 – street – a strip of trees growing along a busy street, and site 2 – housing estate – trees growing in a large green complex, surrounded by other plants, far from routes].

Methods and sample collection. In both of the sites 4–5 *Acer platanoides* trees were chosen, from which, every 10–14 days 100 leaves with green and ligneous shoots were collected. Samples were collected from the end of March to the end of the vegetation period. In 2008 samples were collected in 14 series, in 2009 – in 16 series, and in 2010 – in 13 series. The gathered material was examined with a stereo microscope, and the aphids were counted, described and photographed. In order to determine aphid species Műller's identification key [1976] and Blackman's and Eastop's [2000] keys were used. The names of aphis were adapted from Fauna Europea [2014].

In order to trace the influence of weather on the number of aphids, weather conditions in the individual research years were registered. In order to determine the influence of weather changes, meteorological data was compared to long-term averages (tab. 1). The characterization of meteorological conditions was prepared on the basis of data obtained from the Department of Agrometeorology of the University of Life Sciences in Lublin.

Table 1. Weather conditions in the years 2008–2010

Month	Air temperature (°C)				Precipitation (mm)			
	monthly means			multiannual means 1951–2005	monthly totals			multiannual monthly totals 1951–2005
	2008	2009	2010		2008	2009	2010	
I	0.4	-2.7	-8.2	-3.5	36.2	20.2	53.6	22.7
II	2.3	-1.2	-2.3	-2.7	17.8	36.9	34.6	25.6
III	3.4	1.4	3.4	1.1	64.8	69.6	18.6	26.3
IV	9.3	11.4	9.4	7.4	55.8	2.9	24.5	40.2
V	12.8	13.6	14.5	13	101.6	71.1	156.7	57.7
VI	17.7	16.4	18	16.2	25.9	125.5	65.6	65.7
VII	18.3	19.9	21.6	17.8	77.1	57.1	101	83.5
VIII	19.3	19	20.2	17.1	45	54.7	132.8	68.6
IX	12.6	15.3	12.5	12.6	102.2	21	119	51.6
X	10.1	6.9	5.6	7.8	55.5	103.6	11.2	40.1
XI	4.8	5.5	6.4	2.5	33.1	43.1	46	38.1
XII	0.9	-1.7	-4.7	-1.4	43.8	37.7	32.4	31.5

Statistical analysis. For the purpose of statistic verification of the research results, comparisons using two-way analysis of variance and Tukey's test were calculated. That allowed us to assess whether mean densities of particular aphid species clearly differ depending on the research site and year of research. Mean densities of particular aphid species were also compared with each other, which allowed us to unequivocally determine which species was significantly more numerous from the others. Moreover, a calculation of ecological indices was performed in order to determine the differences between the sites, regarding domination, species diversity, evenness, and species similarities. For that purpose, a calculation of appropriate indices was performed in accordance with the below formulas.

Domination index [Kasprzak and Niedbała 1981]:

$$D = \frac{n}{N} \cdot 100\% ,$$

where:

n – number of specimens of a given species from a given area
N – number of all specimens collected from a given area

The following six classes of domination were distinguished [Lubiarz 2009]:

superdominants	SD	above 30%
eudominants	ED	20.01–30.00%
dominants	D	10.01–20%
subdominants	SuD	5.01–10.00%
recedents	R	1.00–5.00%
subrecendents	SuR	below 1.00%

Shannon-Weaver diversity index [Trojan 1992]:

$$H' = -\sum_{i=1}^{S} \frac{n_i}{N} \ln \frac{n_i}{N} ,$$

where

n_i – number of specimens of i species in the sample,
N – total number of specimens in the sample,
S – number of species in a group.

Pielou's evenness index [Pielou 1966]:

The Pielou's evenness index of particular species participation in an aphid group.

$$J' = \frac{H'}{\ln S} ,$$

where:

H' – value of the Shannon-Weaver diversity index for a given group,
S – number of species in the group ($\ln S = H_{max}$).

Marczewski and Steinhaus species similarity index [Marczewski and Steinhaus, 1959]

$$S_{AB} = \frac{w}{a + b - w} \cdot 100\% ,$$

where:

w – number of species common for sites A and B
a – number of species in site A
b – number of species in site B

RESULTS

The first year of research – 2008 – was characterised by a remarkably warm winter and spring, with a large amount of rainfall, as well as a warm and quite dry summer, and a long, warm and moderately humid fall. In 2009, after a moderately cold and humid beginning of the year, there was a warm and unusually dry spring. The beginning of the summer was rainy and chilly, however the following months, until fall were warm and dry. In October a sudden weather change and unexpected snowfall were observed. In the last research period, in 2010, after an unusually cold beginning of the year, there was a warm spring, rich in rainfall. The summer was also quite warm and abundant in rainfall.

Table 2. Number of aphid specimens on *Acer platanoides*

Subfamily		Housing estate site			Street site		
		2008	2009	2010	2008	2009	2010
Drepanosiphinae	*Drepanosiphum platanoidis* (Schrank 1801)	0	4	13	0	3	4
	Eucalipterus tiliae (Linnaeus 1758)	0	1	0	0	40	0
Chaitophorinae	*Periphyllus acericola* (Walker 1848)	0	0	0	6	0	6
	Periphyllus aceris (Linnaeus 1761)	8876	26	51	39278	536	8519
	Periphyllus coracinus (Koch 1854)	618	38	2	363	1059	546
	Periphyllus lyropictus (Kessler 1886)	71	3	3	473	349	345
	Periphyllus testudinaceus (Fernie 1852)	2285	395	9	2934	295	1838

During three years of study on the Norway maple seven species of the Aphididae family, from the Drepanosiphinae and Chaitophorinae subfamilies were observed (tab. 2). The most numerous species inhabiting the investigated tree species was *Periphyllus aceris* (Linnaeus 1761), which reached the highest number of aphids in both research sites (tab. 2). This species showed significantly higher density in the material collected between 2008 and 2010, than the remaining species both in the housing estate site, as well as in the street site (tab. 4). It should be stressed that when we calculate mean densities for individual years – in 2009, in the housing estate site the species showing the most significant density is *Periphyllus testudinaceus* (Fernie 1852) (tab. 5). In 2010, in the housing estate site, there were no statistically significant differences between the densities of aphids inhabiting the Norway maple (tab. 5).

Aphids inhabiting the Norway maple in large numbers showed significantly different densities, especially depending on their research site, and sometimes also on the year of research, or both of these variables. An analysis of variance showed that the

Table 3. Analysis of variance (ANOVA) for mean density of aphids

Sources of variability	df	*P. acericola*		*P. aceris*		*P. coracinus*		*P. lyropictus*		*P. testudinaceus*		*D. platanoidis*		*E. tiliae*	
		F	p	F	p	F	p	F	p	F	p	F	p	F	p
Study site	1	2.05	0.16	5.75	0.018	5.12	0.03	9.58	0.003	1.61	0.21	0.48	0.49	0.95	0.33
Year of research	2	0.60	0.55	8.43	0.0005	0.40	0.66	0.34	0.71	5.67	0.005	1.25	0.29	0.88	0.42
Study site and year of research	2	0.60	0.55	3.59	0.03	3.54	0.03	0.06	0.94	1,06	0.34	0.41	0.67	0.79	0.45

Table 4. Mean density (individuals/sample) of aphids on *Acer platanoides* depending on the study site and depending on the year of research

Source of variance		*P. acericola*			*P. aceris*			*P. coracinus*			*P. lyropictus*			*P. testudinaceus*			*D. platanoidis*			*E. tiliae*		
Study site	housing estate	0	a	x	208.21	a	y	15.30	a	x	1.79	a	x	62.53	a	xy	0.40	a	x	0.02	a	x
	street	0.28	a	x	1124.02	b	y	45.77	b	x	27.14	b	x	117.84	a	x	0.16	a	x	0.93	a	x
Year of research	2008	0.21	a		1720.00	b		35.04	a		19.43	a		186.39	b		0	a		0	a	
	2009	0	a		17.28	a		34.28	a		11.00	a		21.56	a		0.22	a		1.28	a	
	2010	0.23	a		329.85	a		21.08	a		13.38	a		71.00	ab		0.61	a		0	a	

The assignation to homogeneous subsets from Tukey's test was marked with the letters "a b" in columns and with the letter "x" in rows.
Data compared in columns – differences depending on the study site, and on the year of research regarding one species
Data compared in rows – differences between species

Table 5. Mean density (individuals/sample) of aphids on *Acer platanoides* depending on the study site and year of research

Source of variance		*P. acericola*			*P. aceris*			*P. coracinus*			*P. lyropictus*			*P. testudinaceus*			*D. platanoidis*			*E. tiliae*		
Housing estate site	2008	0	a	x	634.00	a	y	44.14	ab	x	5.07	a	x	163.21	a	x	0	a	x	0	a	x
	2009	0	a	x	1.63	a	x	2.38	a	x	0.19	a	x	24.69	a	y	0.25	a	x	0.06	a	x
	2010	0	a	x	3.92	a	x	0.15	ab	x	0.23	a	x	0.69	a	x	1.0	a	x	0	a	x
Street site	2008	0.43	a	x	2805.57	b	y	25.93	ab	x	33.79	a	x	209.57	a	x	0	a	x	0	a	x
	2009	0	a	x	33.50	a	xy	66.19	b	y	21.81	a	xy	18.44	a	xy	0.19	a	x	2.5	a	x
	2010	0.46	a	x	655.31	a	y	42.00	ab	x	26.54	a	x	141.38	a	x	0.31	a	x	0	a	x

The assignation to homogeneous subsets from Tukey's test was marked with the letters "a b" in columns and with the letter "x, y" in rows
Data compared in columns – differences depending on the study site and year of research regarding one species
Data compared in rows – differences between species

mean density of *P. aceris*, *Periphyllus coracinus* (Koch 1854), *Periphyllus lyropictus* (Kessler 1886) was significantly higher in the street site than in the housing estate site (tabs 3 and 4). The mean density of *P. aceris* in 2008 was visibly higher than in 2009 and 2010 (tabs 3 and 5). The mean density of *P. testudinaceus* in 2008 differed significantly from the density in 2009. What is more, as shown by the analysis of variance, the mean density of *P. aceris* in the street site in 2008 dramatically differed statistically from the mean densities of this aphid species in the remaining years and sites. The mean density of *P. coracinus* in the housing estate site in 2009 differed statistically from the mean density of this aphid in the street site in the same year (tabs 3 and 5). In the case of aphids present sporadically: *Periphyllus acericola* (Walker 1848), *Drepanosiphum platanoidis* (Schrank 1801), *Eucalipterus tiliae* (Linnaeus 1758) no statistically differences in the number of aphids in individual research years and sites were found (tabs 4 and 5).

Confirmation of the results of the statistical analysis comparing the mean densities of aphids can be found in the evaluation of aphid domination structure on the Norway maple. The calculation of domination index allowed us to find a clear superdominant which, according to the results of the analysis of variance, is *P. aceris*. A somewhat different domination structure was found in research sites, since other species were located in it right after the superdominant. It should also be stressed that when the domination index was calculated for individual research years, in 2009 *P. aceris* did not belong to the superdominant class, but to the subdominants (in the housing estate site) and eudominants (in the street site). In 2009, the superdominant class included two species of *P. coracinus* (in the street site) and *P. testudinaceus* (in the housing estate site). The remaining species (*P. acericola, P. lyropictus*) in the individual research years belonged to the dominant, recedents, or subrecedents class, thus, their part in the group of aphids was not significant (tab. 6).

Table 6. Domination structure of aphid group in particular year of research

	Housing estate site			Street site		
	2008	2009	2010	2008	2009	2010
Periphyllus acericola	–	–	–	0.01 (SuR)	–	0.05 (SuR)
Periphyllus aceris	74.90 (SD)	5.57 (SuD)	65.38 (SD)	91.23 (SD)	23.15 (ED)	75.67 (SD)
Periphyllus coracinus	5.22 (SuD)	8.14 (SuD)	2.56 (R)	0.84 (SuR)	46.61 (SD)	4.85 (R)
Periphyllus lyropictus	0.60 (SuR)	0.64 (SuR)	3.85 (R)	1.10 (R)	15.36 (D)	3.06 (R)
Periphyllus testudinaceus	19.28 (D)	84.58 (SD)	11.54 (D)	6.81 (SuD)	12.98 (D)	16.33 (D)
Drepanosiphum platanoidis	–	0.86 (SuR)	16.67 (D)	–	0.13 (SuR)	0.04 (SuR)
Eucallipterus tiliae	–	0.21 (SuR)	–	–	1.76 (R)	–

Table 7. Indices of aphid group in particular study sites

Index	Year of the study	Housing estate site	Street site
Shannon-Weaver Index	2008–2010	0.76	0.56
	2008	0.72	0.36
	2009	0.59	1.33
	2010	1.04	0.77
Pielou Index	2008–2010	0.43	0.29
	2008	0.52	0.22
	2009	0.33	0.74
	2010	0.65	0.43
Index of similarity	2008–2010	85.71%	
	2008	80.00%	
	2009	100.00%	
	2010	83.33%	

Comparing the presented data to widely utilised ecological indices such as Shannon-Weaver Index and Pielou's Index allows us to determine that the housing estate site is predominantly characterised by a larger species diversity than the street site (tab. 7). However, it should be stressed that the Shannon-Weaver Index shows a higher value in the street site in 2009, which presents a higher species diversity (tab. 7). Pielou's evenness index shows lower values in the street site, which is an evidence of higher evenness of individual aphid species in the housing estate site. The only exception is the year 2009, since superdominace of *P. testudinaceus* is evident in the housing estate site (tabs 6 and 7). High species similarity was found regarding the entire collected material, as well as regarding the data from individual years. Calculated values of the Index of similarity are supported by the adaptability skills of numerous species of aphids known from literature, since this research shows that the same species can develop both on housing-estate and street-site trees (tab. 7). However, a question arises: how successfully do the individual species develop on the street and housing estate trees.

Aphids on *Acer platanoides* were observed from April to the end of October. They were constantly present on street-site trees throughout the entire vegetation period, whereas in the housing estate site the *P. coracinus* and *P. lyropictus* species were present irregularly. As shown in figure 1., *P. aceris* and *P. testudinaceus*, throughout most of the vegetation period show diapausing morphs, which do not feed, and only during spring and fall – morphs feeding actively.

Weather conditions should also be taken into consideration in order to determine whether the changes in the number of aphids in 2009 correlate with them. 2009 was characterised by a visibly different structure of domination in the group of aphids, as well as higher densities of species, which in other years did not reach such a high number of individuals (*P. coracinus* – in the street site and *P. testudinaceus* – in the housing estate site). It is possible that the dry spring of 2009 was one of the causes of a lower number of specimens of the species dominant in the remaining years – *P. aceris*.

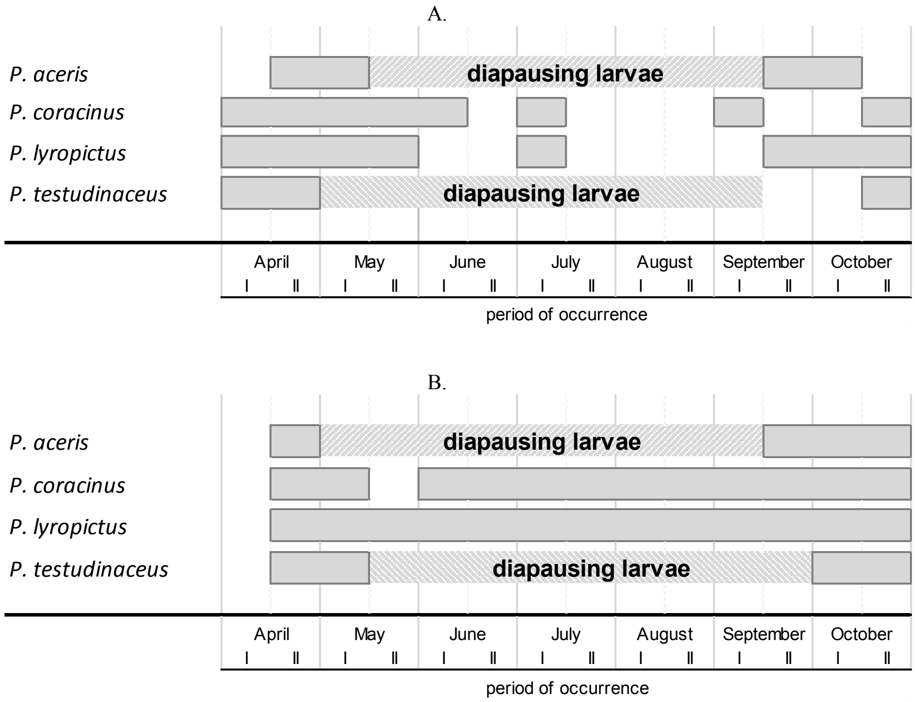

Fig. 1. Aphid occurrence during the vegetation period (2008–2010) A – housing estate, B – street

The analysis of the dynamics of aphid count results in detailed data regarding the variability of individual species inhabiting the same parts of the plant. While comparing data regarding the number of aphids four main species regularly inhabiting leaves and young shoots of the Norway maple were taken into consideration: *P. aceris, P. coracinus, P. lyropictus* and *P. testudinaceus*. The remaining species were present in individual samples, thus, their relations with other species could not be considered permanent.

Population dynamics of aphids. Within housing estate site aphids were the most numerous in 2008, and in the subsequent years they were far less numerous. The lowest number of aphids was noted in 2010. The most numerous in the same site were two aphid species – *P. aceris* and *P. testudinaceus.* In street site, as in the housing estate, the highest number of aphids was observed in 2008 and the lowest – in 2009. In the street site in 2008 and 2010 the dominant species was *P. aceris*, whereas in 2009 – *P. coracinus*. The remaining species were less numerous or observed sporadically.

In 2008 in the housing estate site the first occurrence of aphids was observed at the end of April. Aphids were present throughout the entire vegetation period. The dominant species was *P. aceris*, a very high number of which lasted from the middle of May to the end of July. The peak in the number of specimens of this species was in the middle of July (2708 specimens/100 leaves). It was the only species observed throughout

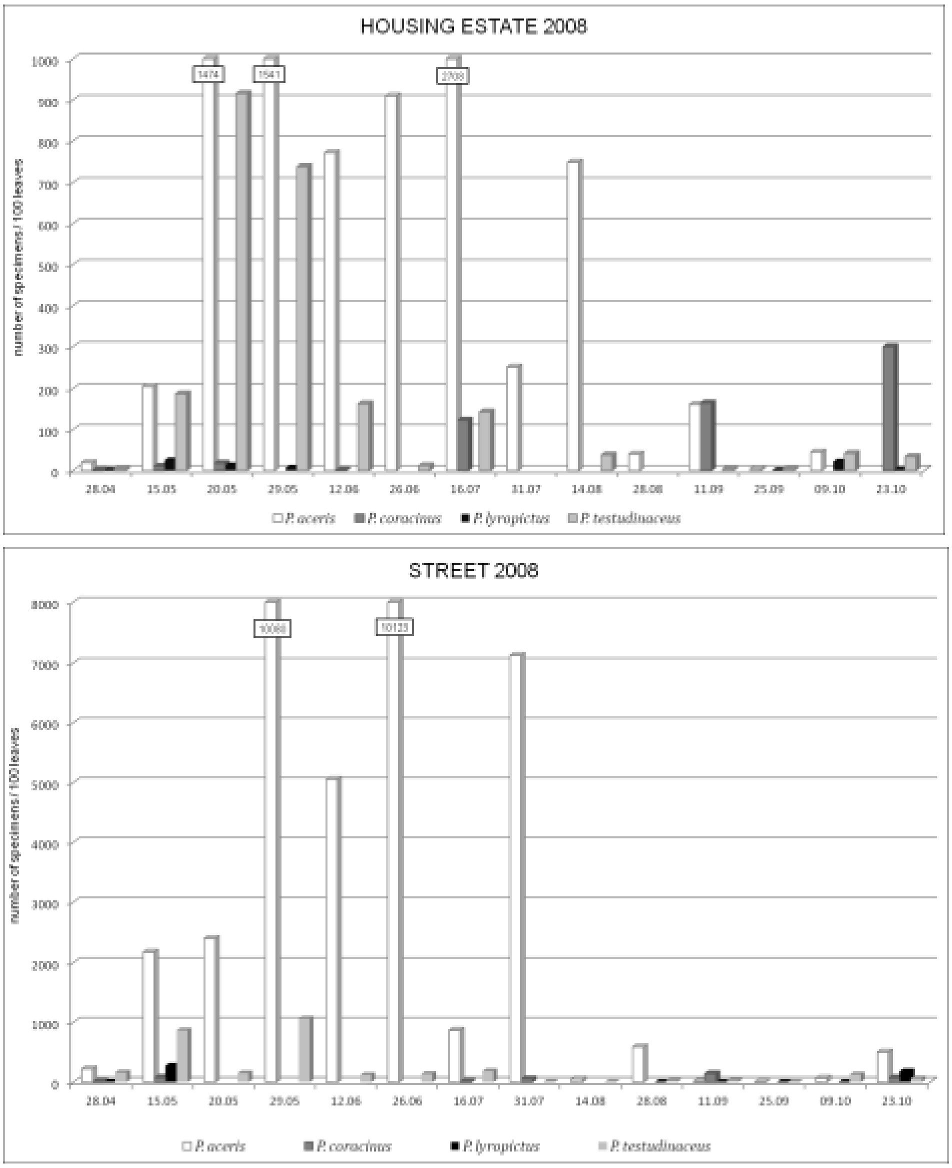

Fig. 2. Aphid population dynamic on *Acer platanoides* in 2008

the entire vegetation period. The second species in terms of the number of specimens was *P. testudinaceus*, the specimens of which were observed most often in May (916 specimens/100 leaves), whereas during summer and fall they were less numerous. During the fall season a higher the number of *P. coracinus* aphids was observed, while they were far less numerous in spring and summer. In spring and fall individual specimens of *P. lyropictus* were observed (fig. 2). In street site in 2008 *P. aceris* and

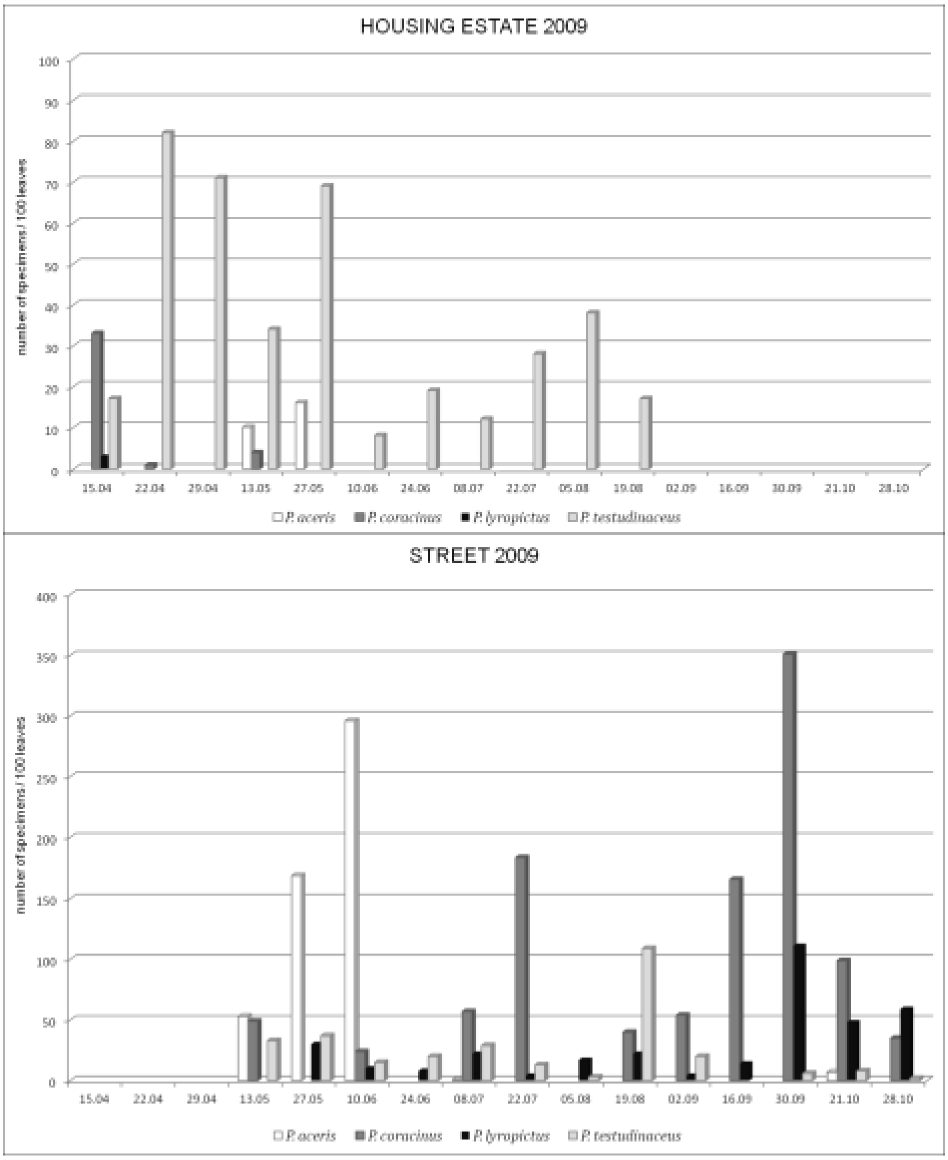

Fig. 3. Aphid population dynamic on *Acer platanoides* in 2009

P. testudinaceus aphids were numerous, while others were sparse. In the middle of May, in the street site, there was a sudden increase of the number of *P. aceris* specimens, which remained at a high level until the end of July. As shown in figure 2, the first peak in the number of aphids of this species was observed at the end of May, while the second one at the end of June. The second species in terms of the number of specimens in this site was *P. testudianceus*. As can be seen in figure 2, the peak in the number of specimens for this species in 2008 was at the end of May. Both *P. testudinaceus*, and *P. aceris* were observed throughout the entire vegetation period. *P. coracinus* aphids were less numerous and seen irregularly in the vegetation period. *P. lyropictus* was observed in spring and fall (fig. 2).

In 2009 the first occurrence of aphids in the housing estate site was noted in the middle of April. The fundatrices of 3 species – *P. coracinus*, *P. lyropictus* and *P.* testudinaceus were observed in that period. The dominant species in 2009 in the housing estate site was *P. testudinaceus*. This species was noted from the middle of April to the end of August. The highest number of *P. testudinaceus* was observed in April and May, and the peak in the number of aphids was in the second half of April, when 82 specimens/100 leaves were observed. A significantly small number of *P. aceris* aphids was noted in May (fig. 3), as well as the occurrence of individual specimens of *E. tiliae* and *D. platanoidis*. In 2009 in the street site, first aphids were seen in the middle of May. These included three species – *P. aceris*, *P. coracinus* and *P. testudinaceus.* The least frequently occurring species in street site trees in 2009 was *P. coracinus*. An increase in the number of aphids of this species was observed predominantly in fall. The least numerous were *P. aceris*, which were seen in large numbers in spring and summer. *P. lyropictus* were seen from the end of May until the end of October, however, they were more numerous during fall. *P. testudinaceus* was present throughout the entire vegetation period, however, it was not numerous (fig. 3). In July and August small number of *E. tiliae* were seen, and in October a few specimens of *D. platanoidis* were observed.

In 2010, in the housing estate site aphids were not numerous. In spring 4 aphid species were found (*P. aceris*, *P. coracinus*, *P. testudinaceus* and *D. platanoidis*), however, they were represented by a small number of specimens. A single colony of *P. aceris* was observed in the summer, as well as individual specimens of *P. lyropictus*, whereas in the fall two specimens of *P. testudinaceus* were found (fig. 4). In 2010, in the street site aphids were numerous in spring and early summer, whereas in August their number began to fall. The most numerous was *P. aceris*, which was seen from the beginning of April to August, whereas in late summer and fall it was sparse. The peak in the number of specimens of this species came in the first half of June (2234 specimens/100 leaves). Similar, however lower, was the number of *P. testudinaceus* and *P. coracinus* aphids. *P. lyropictus* was more numerous in May and June, as well as in October (fig. 4).

The influence of aphids on the decorative value of Norway maple trees. The spring generations feeding in great numbers on the Norway maple excreted large amounts of honeydew, causing the leaves to stick to one another, as well as dust pollution to stick to their surfaces, and in consequence, decreasing the decorative value of trees. In spring, after developing from buds, maple leaves are very thin, delicate and therefore prone to damage. Feeding of larvae of the second generation caused the deformation of leaf blades. Aphid fundatrices feed at the base of leaf buds, thus sometimes leaf development is hindered even before they open. Summer generations were not numerous, with the exception of diapausing larvae, which do not feed. Therefore, it can be assumed that the influence of aphids on the Norway maple in the summer was not significant. Fall generations, as well as the spring ones, produced copious amounts of honeydew. Their low numbers did, however, cause local, hardly visible damage to maple leaves. Additionally, in the fall season maple leaves are rigid, quite thick, and far less susceptible to damage caused by aphids, than they are in spring. Maple leaves did not show evidence of saprophytic fungi which often develop on leaves of other plants covered in honeydew.

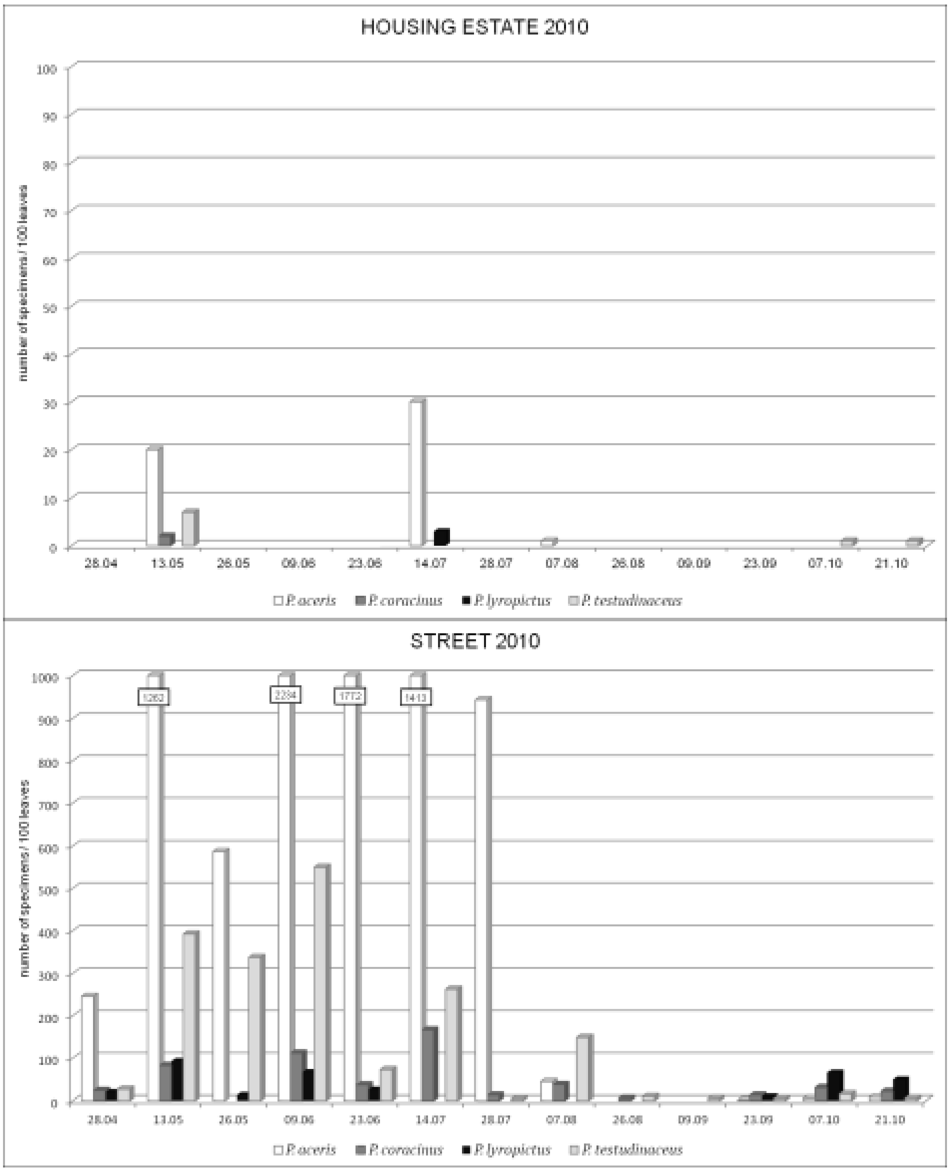

Fig. 4. Aphid population dynamic on *Acer platanoides* in 2010

Despite being infested by large numbers of aphids, the Norway maple proved to possess high decorative value, since the highest numbers of specimens were determined predominantly by diapausing larvae, which do not feed or cause damage.

DISCUSSION

The dynamics of aphid population remains an extremely important and current issue, since aphids are considered one of the most dangerous types of phloem feeders [Klingler et al. 2009]. Due to a short development period of a single generation, as well as high female fertility, aphids can reach astounding numbers, and in a short period of time they can infest plants in massive numbers and cause damage. Due to severe economical losses caused by these insects, research regarding this problem is conducted more often in relation to cultivated plants [Williams et al. 1999, Rondon et al. 2005, Saljoqi 2009, Ciss et al. 2014], rather than trees [Furuta and Sakamoto 1984, Karczmarz 2010, Mackoś-Iwaszko and Lubiarz 2014].

Numerous research has shown the influence of weather conditions on the number of aphids [Jaśkiewicz 2006a b, Ruszkowska 2006, Awmack and Leather 2007, Cichocka and Lubiarz 2010, Dixon and Hopkins 2010]. In the present study the most numerous occurrence of aphids was observed in 2008, which was characterised by a very warm winter with a high amount of rain and snowfall, a warm and humid spring, as well as a quite warm summer with a medium amount of rainfall. A very high number of aphids was also noted in 2010, however, only in the street site. This confirms the results obtained by other authors, who state that a warm spring favours the increase of the number of aphids [Huculak 1966, Karczewska 1969, Cichocka 1995].

It should be stressed that the influence of weather conditions is not the only factor conditioning the number of aphids on the Norway maple. The causes of changes in the number of aphids may also be related to the development of population. A high number of aphids within a single year may lead to deterioration of the quality of the host plant and cause production of winged morphs and their mass emigration. Aphids remaining on the plant are smaller and less fertile, which translates to a low quality of sexuales morphs in fall and may lead to a population collapse in the following year [Dixon 1977]. What is more, in the present study, the housing estate site was characterised by a higher species diversity and evenness of the share of individual species, than the street site, thus, it was more favourable to an even development of all aphid species inhabiting the Norway maple. It confirms the results of studies in which arthropods with piercing-sucking mouthparts are less numerous, however, they are usually more diverse in the housing estate site [Jaśkiewicz 2005, Karczmarz 2010, Lubiarz and Solski 2012, Mackoś-Iwaszko 2012, Wilkaniec et al. 2013, Mackoś-Iwaszko and Lubiarz 2014].

The number of aphids within a population is also influenced by natural predators [Dixon 1977], but their low number on the Norway maple did not significantly affect the number of aphids. What is more, aphids are known to be competitive [Dixon 1992]. However, during their study of mutual relations between aphids inhabiting birch trees, Portha and Detrain [2004] did not find unambiguous evidence of competition. Nonetheless, during the present study, it was observed that the most numerous species among aphids inhabiting *Acer platanoides* was *P. aceris*. Similar results were obtained in the Poznań area by Wilkaniec et al. [2013]. It is one of the diapausing species.

The results of the present study show that in 2009, characterised by a dry spring period, *P. testudinaceus* was significantly more numerous in the housing estate site, than the remaining species. Domination of *P. testudinaceus* in this site was most likely caused by weather conditions. Despite its lower number in 2009 in comparison to 2008, *P. testudinaceus* proved to be the species most resilient in the dry spring conditions among all of the species observed in this research site. A question arises whether the significantly higher number of specimens of this species, in comparison to the others, was only due to advantageous weather conditions. Perhaps the high number of aphids of this species in 2009 was also caused by low numbers of other species of this genus.

Harmfulness of aphids may be direct or indirect in character. While extracting sap from sieve tubes, aphids hinder the flow of nutrients within the plant and can affect plant metabolism [Dedryver et al. 2010, Will et al. 2013, Smith and Chuang 2014]. Direct harmfulness also includes covering the infested leaves with honeydew excreted by aphids. Honeydew, rich in carbohydrates, promotes the development of saprophytic fungi, creating a black residue and decreasing the decorative value of plants, but also decreasing the photosynthetically active area and hindering photosynthesis in leaves [Piechota 1989, Prince 2012, Mackoś-Iwaszko and Lubiarz 2014]. In our study during the spring aphids excreted large amounts of honeydew, but we did not observe saprophytic fungi on leaves.

In consequence, large numbers of aphids on shrubs and trees affect their decorative value, leading to abnormal development of flowers, cause discoloration, drying, and leaf deformations, as well as hinder the development of young shoots, sometimes causing them to wither and die [Cichocka and Lubiarz 2003, Jaśkiewicz 2006a b, Klingler et al. 2009, Mackoś-Iwaszko 2012].

High numbers of aphids do not seem to greatly affect the Norway maple, and do not take part in significant decrease in its decorative value. The cause of such effects on the Norway maple may be the fact that the highest number of aphids infesting the studied tree was in the form of diapausing larvae, which do not feed. Perhaps the maple is less susceptible to feeding of insects with piercing-sucking mouthparts.

CONCLUSIONS

1. High numbers of aphids do not seem to greatly affect decorative value of the Norway maple, because the highest number of aphids infesting the studied tree was in the form of diapausing larvae, which do not feed.

2. Weather conditions have a significant influence on the number of aphids on the Norway maple. The most important conditions occur during a warm spring, which enabled an increase of the number of studied aphid species. A spring with limited rainfall, on the other hand, led to a decrease of the number of aphids on the Norway maple.

3. The housing estate site was more favourable for equal development of all aphid species, which is confirmed by a higher species diversity and higher evenness of share of individual aphid species in comparison to the street site.

4. The number of aphids was significantly higher in the street site, than in the housing estate one.

5. It appears that aphids from the *Periphyllus* genus, with diapausing generations (morphs), are better adjusted to urban conditions, since they reach higher numbers on street trees, than housing estate ones.

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WPŁYW ŚRODOWISKA MIEJSKIEGO NA WYSTĘPOWANIE MSZYC NA KLONIE POSPOLITYM (*Acer platanoides* L.)

Streszczenie. Miasta niszczą naturalne siedliska zwierząt, ale jednocześnie tworzą nowe nisze ekologiczne i stwarzają całkiem odmienne od naturalnych warunki środowiska. W tych nowych warunkach niektóre owady, jak na przykład mszyce, mogą szybko się rozwijać i stają się ważnymi szkodnikami. Niniejsza praca prezentuje dynamikę populacji mszyc zasiedlających klon pospolity w warunkach miejskich Lublina. Ponadto zaprezentowane są wzajemne relacje pomiędzy gatunkami mszyc zasiedlającymi badany gatunek drzewa. Wykazano, że mszyce licznie zasiedlają klon pospolity (*Acer platanoides*), a najliczniejszym gatunkiem okazał się *Periphyllus aceris.* Gatunek ten był wyraźnym superdominantem w obu stanowiskach badawczych (osiedlowym i przyulicznym). Przy zastosowaniu wskaźników ekologicznych wykazano, że stanowisko osiedlowe charakteryzuje się większa różnorodnością gatunkową, niż stanowisko przyuliczne. Wykazano także, że warunki pogodowe istotnie wpływają na liczebność mszyc na klonie pospolitym. Najwyższą liczebność mszyc zanotowano w 2008 r., który charakteryzował się ciepłą wiosną. Niniejsza praca jest próbą odpowiedzi na pytanie, czy zmiany liczebności mszyc wynikają z wpływu warunków pogodowych i siedliskowych, czy być może także z wzajemnych relacji pomiędzy tymi gatunkami.

Słowa kluczowe: bioróżnorodność mszyc, klon pospolity, dynamika liczebności mszyc, warunki miejskie

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