Folia biologica (Kraków), vol. **53** (2005), Supplement

Parasitic Entomofauna in Urban and Agricultural Landscapes of the Pomorze and Kujawy Region I. Primary Parasitoids of Aphids from the *Aphis* Genera

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Accepted November 4, 2005

BARCZAK T., DĘBEK-JANKOWSKA A., BENNEWICZ J. 2005. Parasitic entomofauna in urban and agricultural landscapes of the Pomorze and Kujawy Region. I. Primary parasitoids of aphids from the *Aphis* genera. Folia biol. (Kraków) **53** (Suppl.): 157-164.

13 species of parasitoids were determined of which 12 belonged to the family *Aphidiidae*. Similarity in species composition between the areas compared, measured with Marczewski-Steinhaus's index (MS) was 81.2%, with 8 species present in all three types of ecosystems (61.5%). The following parasitoid species were dominants in all three types of ecosystems: *Lysiphlebus fabarum* (dominance index D: 48.7-27.7%) and *Trioxys angelicae* (D: 36.5-35.6%); other numerous species included *Lysiphlebus cardui*, *Aphelinus chaonia*, *Aphidus matricariae* and *Praon abjectum*. In terms of basic ecological parameters, dominance and frequency, *L. fabarum* and *T. angelicae* (most common dominants and constants in guilds) turned out to be the species typically associated with colonies of aphids of the genus *Aphis*, irrespective of the type of ecosystem. Guilds of parasitic hymenopterans in all three types of habitats examined were similar in their dominance structure (species composition – MS=72.9%, on average and ratios between species – Renkonen's index: Re=79.1, on average). Generally, the composition of species of parasitoids of the genus *Aphis* in the urban landscape was highly similar to rural areas (similarity rate over 70%).

Key words: Parasitoids, *Aphis*, urban and agricultural landscape, Pomorze, Kujawy.

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Large scale research concerning parasitic entomofauna has been conducted in Bydgoszcz, its surroundings and in northern Poland on aphid parasitoids only. The results were summarized and compared to relevant studies carried out in Poland in another publication (BARCZAK 2003). Some complex investigations have been conducted on the black bean aphid, *Aphis fabae* Scop., and other species of the genus *Aphis* L. Such studies, however, especially when they concern groups of parasitic insects of sanitary, epidemiological or epizootic importance, should be continued on a regional and national scale in parallel.

The aim of the long-term research project in the region of Kujawy and Pomorze has been to work out a comparative qualitative and quantitative description of parasitoid (*Hymenoptera parasitica*) guilds associated with aphids of the genus *Aphis* L., colonies of which settle on agricultural crops and wild plants in rural and urban ecosystems.

Material and Methods

1. Aphid plant hosts and insects (mode of investigations)

The material of the long-term and complex studies completed in 1983-1999 consisted of aphid primary parasitoids of the order *Hymenoptera* (*Hymenoptera parasitica*), referred to as parasitoids, belonging to the aphidiids (*Ichneumonoidea: Aphidiidae*) and, in smaller numbers, to the aphelinids (*Chalcidoidea: Aphelinidae*).

The following biological set was used as a research model: host plants – aphids (phytophages) of the genus *Aphis* L. and parasitoids (aphidophages), of which the following are examples: in urbicenoses (URB): goose-foot (Ko) (*Chenopodium* spp.) and black bean aphid (*Aphis fabae* Scop.) (Af), burdock (Ło) (*Arctium* spp.) or creeping thistle (Op) [*Cirsum arvense* (Scop.) L.] and *Aphis fabae cirsiiacanthoidis* Scop. (Afc); dock (Sz) (*Rumex* spp.) and *Aphis rumicis* L. (Ar), as well as common elder (Bcz) (*Sambucus nigra* L.) and the elder aphid (*Aphis sambuci* L.) (As); in agrocenoses (AGR): sugar beet (Bc) (*Beta vulgaris* L.) or horse bean (Bo) (*Vicia faba* L. spp. *minor* Harz), or opium poppy (Ml) (*Papaver somniferum* L.) and black bean aphid, and in biocenoses of midfield thickets (MT): *Chenopodium album* L. or *Arctium* spp. and *A. fabae*, *C. arvense* and *A. fabae cirsiiacanthoidis*, *Rumex* spp. and *A. rumicis*; *S. nigra* and *A. sambuci*.

2. Study areas

The area investigated in the region of Kujawy and Pomorze consisted of urban green and ruderal areas in Bydgoszcz, Toruń and Włocławek (URB) (green squares, parks and plants growing along streets), fields with plantations of sugar beet, horse bean and poppy (AGR) as well as so-called midfield thickets (MT): boundary strips between fields, groups of trees and bushes, edges of small woods in fields, which constitute ecological corridors, or ecological islands in the rural landscape. The surface area of each site measured between 1 and 2 ha.

3. Sampling and statistical analysis

A sample was composed of a colony of aphids on a leaf or a piece of the stem of a given host plant, which was carried in a plastic bag to the laboratory. On each occasion, at 7 to 14-day intervals, in each season between April and August, a series of three samples was collected from plants of each species. In order to culture parasitoids, the samples were placed in Weck jars covered with steelon gauze.

The material was removed from the jars in late autumn, and afterwards the hymenopterans were determined and guilds of parasitoids were described for the designed biological sets (for details cf. Material & Methods, point 1). The description contained species composition, counts (L), dominance index (D) (= relative abundance), i.e. percentage of each species in the guild and frequency (F), as a percentage of samples in which a given species occurred during the whole research season.

The following classes of dominance were assumed: recedents (R) – 10% of all individuals in a guild, subdominants (SDO) – 10.1 to 20% , and dominants (DO) – ≥ 20.1%. For the estimation of frequency (F), stability classes were applied: accessory (A) – ≤ 9%, subconstant (SK) – 9.1 to 27% and constant species (K) – 27% of the samples in which a given species was present.

Qualitative and quantitative differences between guilds of parasitoids were evaluated, respectively, with Marczewski-Steinhaus's index (MS):

$$MS = \frac{c}{a+b-c},$$

where: a, b – numbers of species in the guilds being compared, c – number of species present in both guilds, or with Renkonen's index Re=$D_{min.}$, where $D_{min.}$ is the minimum value which the dominance index assumes for the same species in the guilds being compared. Guilds were evaluated as similar if both indices attained values ≥50%.

The statistical significance of differences between the values of the dominance index D for particular species of parasitoids was determined with the help of the "arc-sin-t-test" (SOKAL & ROHLF 1969).

Results

1. Parasitoids in the urban landscape – URB

The guilds of parasitoids in urbicenoses were examined on 5 species of plants which were associated with 3 species and 1 subspecies of aphids (Table 1). The number of parasitoid species varied from 4 in the case of guilds associated with elder aphid and *A. rumicis* to 11 in the case of the black bean aphid, and in total 13 species of parasitoids were found in towns. The following belonged to dominants or subdominants: *Trioxys angelicae* (Hal.), *Lysiphlebus fabarum* (Marsh.), *Lysiphlebus cardui* (Marsh.) and *Praon abjectum* (Hal.), with the two former species being significantly (P<0.001) superior in terms of D index to the other species of parasitoids (Table 1). Among the aforementioned species of parasitoids, in the general specification of the material collected from urban biocenoses, *T. angelicae*, *L. fabarum* and, additionally, *L. cardui* turned out to be the most numerous (Table 2). These species were most frequently found in samples collected from each assemblage (Table 1).

When comparing the guilds determined in the urban landscape it should be emphasized that in many cases the criterion of quantitative similarity had been fulfilled, i.e. Re ≥50% (Fig. 1). The guild of parasitoids of elder aphid, *Aphis sambuci*, associated with *Sambucus nigra* was distinctly different from the majority of the other groups (*A. fabae crisiiacanthoidis* – Ło, Op, *A. rumicis* – Sz). Relative to the parasitoids of *A. fabae* on *Chenopodium* spp. (Ko), the quantitative similarity (Re) of the Bcz guild had a borderline value, similarly to the guilds on dock (Sz) and creeping thistle (Op) (Fig. 1). Similar findings were made regarding the qualitative comparison, although in that case the borderline value of MS was rather infrequently exceeded,

Table 1

List of parasitoid species, their number (N), relative abundance (D) and frequency (F) in the guilds associated with a given aphid species in urbicenoses (URB) in 1991-94

	Black bean aphid (*Aphis fabae*) on *Chenopodium* spp.			*Aphis sambuci* on *Sambucus nigra*			*Aphis fabae cirsiiacanthoidis* on *Arctium* spp.			*Aphis rumicis* on *Rumex* spp.			*A. fabae cirsiiacanthoidis* on *Cirsium arvense*		
Species	L	D	F	L	D	F	L	D	F	L	D	F	L	D	F
Aphidiidae															
1. *Ephedrus persicae* Frog.	6	0.7	1.0												
2. *E. plagiator* Nees	8	0.9	4.0	32	3.6	4.0							22	2.3	6.0
3. *Praon abjectum* Hal.	110	$^{***}12.7^{SD}$	12.0^{SK}	153	17.2^{SD}	23.0^{SK}							12	1.3	3.0
4. *P. volucre* Hal.	15	1.7	4.0										6	0.6	1.0
5. *Lysiphlebus fabarum* (Marsh.)	330	38.0^{DO}	42.0^{K}				164	55.4^{DO}	68.0^{K}	562	56.5^{DO}	58.0^{K}	195	20.8^{DO}	23.0^{SK}
6. *L. cardui* (Marsh.)	31	3.6	10.0				58	$^{***}19.6^{SD/DO}$	19.0^{SK}				380	$^{***}40.5^{DO}$	39.0^{K}
7. *Aphidius colemani* Vier	3	0.3	0.5												
8. *A. matricariae* Hal.	11	1.3	5.0										44	4.7	6.5
9. *Diaeretiella rapae* (M'Intosh)	30	3.5	3.0												
10. *Trioxys angelicae* Hal.	301	$^{***}34.7^{DO}$	82.0^{K}	640	$^{***}72.1^{DO}$	64.0^{K}	43	$^{***}14.5^{SD}$	18.5^{SK}	224	$^{***}22.5^{DO}$	38.0^{K}	210	$^{***}22.4^{DO}$	29.0^{K}
11. *T. acalephae* (Hal.)							12	4.1	1.0				11	1.2	2.0
Aphelinidae															
12. *Aphelinus chaonia* Wlk.	23	2.6	5.0	63	7.1	7.0	19	6.4	3.0	198	$^{***}19.9^{SD/DO}$	40.0^{K}	58	6.2	18.0^{SK}
Total	868	100.0	–	888	100.0	–	296	100.0	–	995	100.0	–	938	100.0	–
No. of samples (n)	200			200			200			200			200		

DO – dominant species
SD – subdominant
K – constant
SK – subconstant
$^{***}/P \leq 0.001$ – significance of differences were calculated in relation to the highest value of D in a given guild.

and occurred only in two cases of guild comparisons: Ło and Op (for *A. f. crisiiacanthoidis*) and for Ko and Op (for *A. fabae* and *A. f. crisiiacanthoidis*), or possibly for two pairs of guilds of parasitoids: Sz – Ło (on *A. rumicis* and *A. fabae* colonies), where a borderline value of similarity was determined, i.e. 50% (Fig. 1).

Noteworthy is the distinct difference of the guild of parasitoids associated with *A. sambuci* on *S. nigra* versus the guilds associated with other species of aphids, although some species of parasitoids occur together with other guilds and make up numerous populations, especially *T. angelicae*, for which the value of the dominance index (D) and frequencies of occurrence in samples (F) were high (class K – constant appearance). A similar situation was observed in the case of another species of parasitoid – *P. abjectum* (subdominant – SD in the guild Bcz) (Table 1). In the guild of parasitoids of *A. sambuci*, *T. angelicae* attained significantly higher values of dominance D (P<0.001) relative to any other of the guilds compared. *S. nigra* turned out to be a reservoir for *T. angelicae*, and the aphid *A. sambuci* was a very good host organism for this

	Ko	Bcz	Ło	Sz	Op
Ko		36.4	36.4	27.3	53.8
Bcz	50.9		28.6	33.3	44.4
Ło	58.7	20.9		50.0	55.6
Sz	63.1	29.6	76.3		30.0
Op	53.5	31.2	62.3	49.4	

"MS" (upper right) / "Re" (lower left)

Fig. 1. Qualitative (MS in %) and quantitative (Re in %) similarities of the parasitoid guilds in the urbicenoses (URB). Ko – *Chenopodium spp.*, Bcz – *Sambucus nigra*, Ło – *Arctium* spp., Sz – *Rumex spp.*, Op – *Cirsium arvense*.

Table 2

Summarized data on the number (N), relative abundance (D) and number of species (s) in the study sites

Parasitoid species	AGR		URB		MT		∑	D_{og}
	L	D	L	D	L	D		
Aphidiidae								
1. *E. persicae*	23	0.3	6	0.2			29	0.2
2. *E. plagiator*	21	0.3	62	1.6	166	3.6	249	1.6
3. *P. abjectum*	155	2.3	275	6.9	266	5.8	696	4.6
4. *P. volucre*	51	0.8	21	0.5	51	1.1	123	0.8
5. *L. fabarum*	3214	48.7	1251	31.4	1261	27.7	5726	37.8
6. *L. cardui*			469	11.8	563	12.3	1032	6.8
7. *A. colemani*			3	0.1			3	0.02
8. *A. matricariae*	621	9.4	55	1.4	60	1.3	736	4.9
9. *Aphidius sp.*			11	0.3			11	0.1
10. *D. rapae*	8	0.1	30	0.8			38	0.3
11. *T. acalephae*	45	0.7	23	0.6	50	1.1	118	0.8
12. *T. angelicae*	2389	36.2	1418	35.6	1666	36.5	5473	36.1
Total	6527	98.9	3624	90.9	4083	89.5	14234	94.0
Aphelinidae								
13. *A. chaonia*	74	1.1	361	9.1	477	10.5	912	6.0
SUM	6601	100.0	3985	100.0	4560	100.0	15146	100.0
Mean per plant species	2200.3		797		912		$\overline{643}$	
Mean of species no. – $\bar{s}$	7.3		6.6		6.2		$\sum\bar{s}$-20.1	$\overline{sss}$=6.7
Sum of species – *s*	9		11		9		$\overline{\sum}$=9.7	
No. of samples (n)	600		1000		1000		2600	
*Mean no. of aphid colonies per season (N)	636		238		170		$\sum\bar{N}$=1044	$\overline{NNN}$=348

D_{og} – total relative abundance
*/ data from earlier papers (BARCZAK 1991, 1993, BARCZAK *et al*. 2000)
Note:
– mean percentage parasitization of the colonies of black bean aphid in beet crops was 1% (BARCZAK 1991), on faba bean 10.1% and on opium poppy 41.5% (!) (BARCZAK 1993)
– on weeds average percentage parasitization varied between from a dozen or so to a few dozen (40-60% at maximum) (STARY 1966; BARCZAK unpublished data).

parasitoid species. The whole guild of parasitoids of the aphid *A. sambuci* on *S. nigra* in urbicenoses, on the other hand, was not numerous (Table 1).

Similar seasonal numbers of insects in guilds (ca 900 parasitoids) were noted in urbanized areas, with the guild on burdock being distinctly less numerous. In contrast, the guild on dock exceeded the numbers of parasitoids in the other groups, including the one on common elder (Table 1).

2. Parasitoids in the agricultural landscape

2a. Guilds in agrocenoses of sugar beet, opium poppy and faba bean – AGR

Generally, in all three types of agroecosystems, ten species of primary parasitoids were found for which the black bean aphid was a host (Table 3). The number of species varied from 6 on horse bean to 9 on opium poppy (Table 3). The most numerous and dominant species was typically *L. fabarum*, which in sum constituted nearly 50% of all specimens in agrocenoses (Table 2). The only other species which appeared in comparable total numbers in this type of environment was *T. angelicae*, which made up ca. 36% of all specimens (Table 2), and had significantly more individuals than *L. fabarum* in the guild associated with *A. fabae* on poppy and horse bean. In the former case, *L. fabarum* was only a subdominant (Table 3), while on the horse bean plantation both species codominated (Table 3). Both of these species were either constant or subconstant components in the guilds found in agrocenoses (Table 3).

Considering the qualitative and quantitative criteria, the similarity of parasitoid guilds on horse bean and opium poppy is apparent, and, simultane-

Table 3

List of parasitoid species, their number (N), relative abundance (D) and frequency (F) in the guilds associated with colonies of black bean aphid in agrocenoses (AGR)

Species	*Beta vulgaris* in 1983-86			*Vicia faba* spp. *minor* in 1987-90			*Papaver somniferum* in 1987-90		
	L	D	F	L	D	F	L	D	F
Aphidiidae									
1. *Ephedrus persicae*	23	0.6	1.0						
2. *E. plagiator*	16	0.4	3.7				5	0.2	0.5
3. *Praon abjectum*	40	1.1	7.0	30	4.5	8.5	85	3.6	10.0
4. *P. volucre*	27	0.8	5.3	9	1.3	3.5	15	0.6	2.0
5. *Lysiphlebus fabarum*	2594	***72.9 ^{DO}	37.9 ^{K}	210	***31.2 ^{DO}	13.0 ^{SK}	410	***17.3 ^{SD}	69.0 ^{K}
6. *Aphidius matricariae*	612	17.2 ^{SD}	6.0 ^{A}				9	0.4	
7. *Trioxys angelicae*	249	7.0	15.5	350	52.0 ^{DO}	14.5 ^{SK}	1790	75.6 ^{DO}	58.0 ^{K}
8. *T. acalephae*				25	3.7	6.0	20	0.8	3.0
9. *Diaeretiella rapae*							8	0.3	0.5
Aphelinidae									
10. *Aphelinus chaonia*				49	7.3	4.0	25	1.1	3.0
Total	3561	100.0	–	673	100.0	–	2367	~100.0	–
No. of samples (n)	200			200			200		

^{A} accessory species

	Bc	**Bo**	**Ml**
Bc		**44.4**	**60.0**
Bo	**36.8**		**66.7**
Ml	**26.6**	**75.4**	

"MS" **"Re"**

Fig. 2. Qualitative (MS in %) and quantitative (Re in %) similarities of the parasitoid guilds in the agrocenoses (AGR).

ously, a distinct dissimilarity of the guild on sugar beet, measured with the same parameters, although the latter was shown to have a similar species composition to the guild on poppy (Fig. 2).

Irrespective of the qualitative and quantitative parameters used in this research (MS and Re), guilds of parasitoids associated with sugar beet were considerably more numerous, especially when compared to those found on horse bean, where populations of parasitoids were several times smaller (Table 3).

2b. Primary parasitoids on wild growing plants in midfield thickets – MT

In sum, midfield thickets in the agricultural landscape, with host plants for the aphids *A. fabae*, *A. f. crisiiacanthoids*, *A. sambuci* and *A. rumicis*, were associated with 9 species of parasitoids, among which *T. angelicae* (36.5%) and *L. fabarum* (27.7%) were the most numerous. *L. cardui* and *A. chaonia* also appeared in large numbers (Table 2). Depending on the species of host plant and/or the species of aphid, the dominant species of parasitoids were: *L. fabarum* and *T. angelicae* on goose-foot (*Chenopodium* spp. – *A. fabae*; Table 4), *L. cardui* or *L. fabarum* and *T. angelicae* co-dominated on burdock (*Arctium* spp. – *A. fabae*; Table 4), while *L. fabarum* and *T. angelicae* co-dominated on dock (*Rumex* spp. – *A. rumicis*, Table 4) and on creeping thistle (*C. arvense* – *A. f. crisiiacanthoids*, Table 4). Also *A. chaonia* was numerous on dock (Table 4). In the case of common elder, the dominant species in the colonies of *A. sambuci* was *T. angelicae*, with the subdominants *P. abjectum* and *A. chaonia* (Table 4).

All these species of primary parasitoids showed a high or very high frequency in the guilds, which means that they were permanent and typical components of the analyzed biological sets (Table 4).

The value of the dominance index (D) for *L. fabarum* was the highest in the guild on dock ($P<0.001$), being significantly higher than that for the guild on goose-foot ($P\sim0.01$). *T. angelicae*, on the other hand, formed the most numerous populations and attained significantly higher values of dominance ($P<0.001$) in the guilds of parasitoids associated with *A. sambuci* on *S. nigra* (Table 4) when compared to the other assemblages. Therefore, wild common elder seems to be a reservoir for *T. angelicae*, which grows abundantly in colonies of aphids *A. sambuci*. For *L. fabarum*, how-

Table 4

List of parasitoid species, their number (N), relative abundance (D) and frequency (F) in the guilds associated with colonies of the different aphid species in midfield thickests (MT) in 1996-99

	A. fabae on *Chenopodium* spp.			*Aphis sambuci* on *Sambucus nigra*			*A. fabae* on *Arctium* spp.			*Aphis rumicis* on *Rumex* spp.			*A. f. cirsiiacanthoidis* on *C. arvense*		
Species	L	D	F	L	D	F	L	D	F	L	D	F	L	D	F
Aphidiidae															
1. *Ephedrus plagiator*	71	7.7^{R}	35.0^{K}	54	3.9	9.0							41	3.7	7.0
2. *Praon abjectum*	18	1.9	9.0	230	$^{***}16.9^{SD}$	68.0^{K}							18	1.6	3.0
3. *P. volucre*	8	0.9	4.0	36	2.6	8.0							7	0.6	1.0
4. *Lysiphlebus fabarum*	420	45.3^{DO}	68.0^{K}	29	2.1	8.0	72	$^{***}26.4^{DO}$	31.0^{K}	510	57.8^{DO}	59.0^{K}	230	$^{**}20.6^{SD/DO}$	$26.0^{SK/K}$
5. *L. cardui*	53	5.7	10.0				120	44.0^{DO}	45.0^{K}				390	34.9^{DO}	45.0^{K}
6. *Aphidius matricariae*	10	1.1	4.0										50	4.5	6.0
7. *Trioxys angelicae*	305	$^{***}32.9^{DO}$	38.0^{K}	810	59.6^{DO}	91.0^{K}	81	$^{**}29.7^{DO}$	36.0^{K}	180	$^{***}20.4^{SD/DO}$	38.0^{K}	290	26.0^{DO}	29.0^{K}
8. *T. acalephae*				32	2.4	7.0							18	1.6	2.0
Aphelinidae															
8. *Aphelinus chaonia*	43	4.6	15.0^{SK}	169	12.4^{SD}	55.0^{K}				192	$^{***}21.8^{DO}$	40.0^{K}	73	6.5	17.0^{SK}
Total	928	~100.0	–	1360	~100.0	–	273	~100.0	–	882	100.0	–	1117	100.0	–
No. of samples (n)	200			200			200			200			200		

** $P \leq 0.01$

	Ko-2	Bcz-2	Ło-2	Sz-2	Op-2
Ko-2		66.7	37.5	37.5	88.9
Bcz-2	46.3		25.0	42.9	77.8
Ło-2	61.8	31.8		50.0	33.3
Sz-2	70.3	34.9	46.8		50.0
Op-2	63.9	42.1	81.5	47.5	

"MS"

"Re"

Fig. 3. Qualitative (MS in %) and quantitative (Re in %) similarities of the parasitoid guilds in the midfield thickets (MT).

ever, in the group of guilds found in midfield thickets (MT), the best reservoirs were dock with the aphid *A. rumicis* as a host and goose-foot with the aphid *A. fabae*.

The analysis of qualitative and quantitative similarities between the guilds in the rural landscape reveals distinct characteristics of the guild of parasitoids associated with elder aphid, *A. sambuci* (Fig. 3), mainly because of lower or evidently lower values of the Re index (50%) although as far as the MS index is concerned, in two cases, namely the guild on goose-foot (Ko-2) and even more so on creeping thistle (Op-2), the values of this index were clearly above 50%. The guild of parasitoids on wild common elder was, next to the one on creeping thistle, the most numerous as well (1 360 individuals) (Table 4).

3. Comparative qualitative and quantitative analysis of the guilds

The material collected over the years consisted of 13 species of primary parasitoids, 12 of which belonged to the family *Aphidiidae*. The material used for the breeding of parasitoids consisted of colonies of 3 species and 1 subspecies of the genus *Aphis*, which populated either arable crops (3 species) or 5 species of wild plants growing in urbicenoses and/or in midfield thickets. The material obtained, i.e. parasitoids, was isolated mainly through mass breeding of one species of aphids, that is *A. fabae*, or its subspecies *A. f. crisiiacanthoidis* (72.8% of all the parasitoids).

Although the samples in agrocenoses were collected from only 3 species of host plants (as compared to 5 species in the other habitats), the guilds of parasitoids in agroecosystems (AGR) turned out to be more numerous, and in sum they were composed of 6 601 individuals, that is 1.7-fold more than un the urban habitats (URB) and 1.4-

fold more than on wild plants in midfield thickets (MT) (Table 2).

The number of parasitoid species in each type of ecosystem was comparable and on average reached only 11 taxa, with their maximum number (13) recorded in the urban habitats (Table 2). The qualitative similarity between particular types of ecosystems, as measured with the MS index, in sum and considering all the guilds of parasitoids, was 72.9% on average (Fig. 4). Thus, the guilds distinguished in the course of these investigations fulfill the requirement of qualitative similarity MS. A total of 8 species appeared in all the ecosystems, which means that in 61.5% the guilds were identical in species composition (Table 2).

Analysis of quantitative similarity between the ecosystems was performed (with Renkonen's index – Re, Fig. 5) based on the summarized results of Table 2. The similarity reached 79.1% and was 7% higher than the similarity in the species composition between the ecosystems. The evidently higher similarity between the urban ecosystem and midfield thickets compared to the remaining cases may be due to the fact than in both areas the material was collected from colonies of the same species of aphids, on the same species and the same number of host plants. Based on the parasitoid species present in all three types of ecosystems, and using the dominance indices in the same way as when establishing Re parameters, it is possible to determine a somewhat separate measure of similarity, which in this case would equal: AGR – URB – MT: 69.4%. Therefore, the measures and the criteria used for the purpose of comparison (MS, Re and others) show high similarity in the numbers and species composition between the analysed areas, biological sets and types of ecosystems, in terms of the guilds of parasitoids of aphids of the genus *Aphis* which occur in them.

Type of an ecosystem	AGR	URB	MT
AGR	X		
URB	76.9	X	
MT	72.7	69.2	X

Fig. 4. Qualitative similarities of the guilds under Marczewski-Steinhaus formula (MS in %) – summarizing data in the given type of ecosystems (AGR – agrocenoses, URB – urbicenoses, MT – midfield thickets).

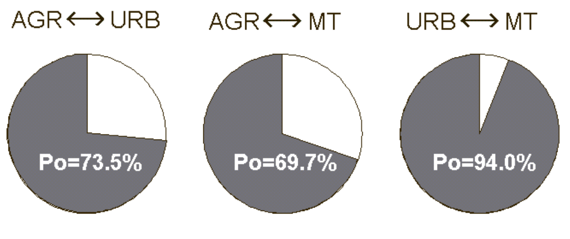

Fig. 5. Quantitative similarity (Po) (as summarized data) between the search areas under Renkonen's index (Re in %).

The biodiversity of primary parasitoids of aphids found in the urban ecosystem is comparable and sometimes superior to that occurring in the rural landscape: 13 versus 11 species, respectively (Table 2). Because of the different numbers of samples taken (1 000 in the urban landscape and 1 600 in the rural areas) and plant species (5 and 8, respectively) from which the samples were collected, obviously there were some differences in the total numbers of parasitoids found in either of the types of ecosystems: 3 985 individuals in the urban areas and 11 161 in the countryside (Table 2). Nevertheless, the difference between the habitats was 2.8-fold, and although the differences were of a similar order if the number of aphids per one host plant was calculated, they were smaller when the urbicenoses (URB) were contrasted with the midfield thickets (MT) (Table 2). In short, however, it is worth underlining the large biological source of the urban areas in primary parasitoids of aphids of the genus *Aphis*.

Discussion

1. Reservoirs of parasitoids – integrated pest management (IPM)

The role of wild plants growing in midfield thickets in the agricultural landscape as a reservoir of parasitoids has been often discussed, both in Poland (e.g. BARCZAK 1993, 1996, 2003; BARCZAK *et al.* 2000; BARCZAK *et al.* 2002; PANKANIN-FRANCZYK 1987, 1995; BILEWICZ-PAWIŃSKA & PANKANIN-FRANCZYK 1995), and in other countries (e.g. STARY 1966, 1986a, 1986b, 1991; POWELL 1986; GROSS 1987; RUSSELL 1989; VAN EMDEN 1990; ANDOW 1991).

Habitats with wild plants form links in the chain of so-called ecological corridors, which in a rural landscape can play an important role for the dispersal of fauna from seminatural habitats to agrocenoses. Evaluation of such habitats as refuges of useful entomofauna is by no means an easy task, as the very same habitats can serve as havens for agrophages (PUSZKAR *et al.* 2002; BANASZAK & CIERZNIAK 2002).

The research done in Poland shows, for example, that a key role in reducing populations of the harmful black bean aphid (*A. fabae*) in agrocenoses can be played by such species of parasitoids as *L. fabarum* and *T. angelicae*. Centers of dispersal for their populations can be mainly *Sambucus nigra*, on which *T. angelicae* thrives on colonies of *A. sam-*

buci, or *Rumex* spp., on which colonies of aphids *A. rumicis* are used as a substitute food supply (so-called alternative host) for *L. fabarum*. Colonies of other species of aphids of the genus *Aphis*, such as *A. f. crisiiacanthoidis* on creeping thistle (*C. arvense*) and *A. fabae* on bridal robe (*Matricaria inodora* L.) and goose-foot can also be considered as refuges of these useful insects (BARCZAK 1993, BARCZAK & DĘBEK-JANKOWSKA 2001).

2. Origin of the parasitoid urban fauna

Dispersal microcentres for parasitoids in agrocenoses are also situated in the urban landscape. Useful aphid parasitoids such as *L. fabarum* and *T. angelicae*, as well as *P. abjectum*, *Ephedrus plagiator* Nees or *A. chaonia* can multiply and grow on the same wild plants that grow in agricultural areas, and on colonies of the same species of aphids of the genus *Aphis* (BARCZAK 1993). As the results of the present study have shown, urbanized habitats can be as rich, if not richer, in the biodiversity of parasitoids as the rural landscape. They are only inferior in the numbers of aphid-eating insects (they comprise less numerous guilds).

Midfield thickets in particular, creating so-called ecological corridors in the agricultural landscape, are highly similar to urban habitats in terms of the guilds of parasitoids of aphids of the genus *Aphis*, which shows that the faunas of parasitoids from both types of habitats have been mixed. This is also proof that populations of parasitoids penetrate urbanized environments by migrating from agrocenoses, midfield thickets and from other seminatural habitats in the agricultural landscape, e.g. from meadows and forests, and vice versa (BARCZAK 1993, BARCZAK *et al.* 2002, CHUDZICKA *et al.* 1990). This suggests that parasitoids of aphids are undergoing the process of synurbization.

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