Aphidivorous hoverflies (Diptera: Syrphidae) at field boundaries and woodland edges in an agricultural landscape

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ABSTRACT. The aim of this study was to assess the occurrence and structure of the populations and communities of hoverflies (Diptera: Syrphidae) in particular types of midfield thickets (field boundaries and forest islands) characteristic of the lower Vistula valley. The investigation was carried out in 1998-2001. The midfield thickets were situated in an agricultural area. Syrphids were caught in yellow MOERICKE traps and with an entomological net. In the agricultural landscape the forest islands were visited by the highest percentage of aphidophagous syrphid species. Such midfield thickets (margins of forest islands) – habitats with a stable and diverse vegetation – can provide an attractive food resource for syrphids. Moreover, they offer hoverflies favourable conditions for shelter and, probably, development. Such habitats are thus key aspects of comprehensive crop protection.

KEY WORDS: Syrphidae, midfield thickets, agricultural landscape.

INTRODUCTION

In an agricultural landscape, sunny areas of woodland (hereafter “forest islands”) and their margins, rich in herbaceous plants and numerous trees, offer a convenient food resource and shelter to various species of herbivorous and predatory insects (BARCZAK et al. 2000, BARCZAK et al. 2002, BENNEWICZ & BARCZAK 2002, PIEKARSKA-BONIECKA 2005, RIIHIMÄKI et al. 2005, WILKANIEC 2001, 2003). Particular importance is attached to the forest islands, as they are the most sustainable and at the same time the most diverse semi-natural environment in an agricultural landscape (DĄBROWSKA-PROT 1991, 1998).

According to this author, the importance of forest islands in an agricultural landscape is determined by their size, the nature of the plant community, its succession and isolation from similar areas. Arable fields should be separated by different types of midfield thicket, a general term covering such landscape features as copses, clumps of bushes, baulks, forest islands, watercourses and tree-lined roads (RATYŃSKA & SZWED 1998).

It is thought that communities of perennial plants with established species diversity play a greater role in biological control and are more stable and richer refugia (GĘBICKI et al. 1977, HAŁAJ & WOJCIECHOWSKI 1996, BARCZAK et al. 2000, DENYS & TSCHARNTKE 2002). Moreover, WRATTEN et al. (2003) claim that midfield boundaries contribute to a temporal synchronization of agrophages with their natural enemies. Therefore, the role of boundaries as a source of beneficial arthropods must be taken into account. The lack of trees, which could set up a barrier to the migration of these beneficial organisms, is an advantage of such habitats. At the same time, when cultivated fields lack a food resource, i.e. agrophages, the number of beneficial insects like the seven-spot ladybird (*Coccinella septempunctata*) in aphid colonies grows constantly (BIANCHI & WERF 2004).

One of the main objectives of plant protection today is to use the natural resistance of the environment in agrophage control. Thus, the creation of a suitable cultivated crop – agrophage – natural enemy system will favour the protection of crops, and help to reduce the amounts of pesticides applied to arable fields.

In the context of the literature data and study results mentioned above, the next stage of the study of syrphids was carried out for the natural and agricultural evaluation of semi-natural habitats in an agricultural landscape. The objectives of this work were as follows:

- to conduct a qualitative and quantitative assessment of aphidophages (Diptera: Syrphidae) associated with populations of different aphid species in the habitats under scrutiny,
- to indicate the types of midfield thickets that are attractive as a food resource for these aphidophage communities.

STUDY AREA

In terms of physical geography, the sites examined are situated in the Central European Lowland province, the South Baltic Lake District subprovince, the Chełmno-Dobrzyń Lake District macroregion, and the Chełmno Lake District mesoregion. Administratively, this area is part of the province of Kujawy-Pomerania, in the district of Toruń, the commune of Łubianka, the village of Leszcz and the commune of Łysomice, and the village of Świerczynki. This is a typically agricultural area with large fields of several dozen hectares surrounded by field margins (baulks) and “islands” of woodland.

The research area, i.e. the localities studied, are situated in UTM (Universal

Transverse Mercator) grid CD 38.

Phytosociological records of the midfield thickets were carried out by Ewa KRASICKA-KORCZYŃSKA (co-author of the monograph BARCZAK, KACZOROWSKI, BENNEWICZ, KRASICKA-KORCZYŃSKA 2000) at about the same time as the present study; only those records relevant to the current data are given here.

Locality M1 is a field boundary (ditch margin) with field vegetation – *Lamio-Veronicetum politae* and *Tanaceto-Artemisietum* with a predominance of *Elymus repens* – near the village of Leszcz. During this study only the numbers of common stinging nettle and scentless mayweed increased.

Locality L1 is the margin of a forest island consisting of Scotch pine *Pinus sylvestris* L. and common stinging nettle *Urtica dioica* L. in a dry-ground forest habitat near the village of Leszcz. No major changes in the herbaceous plant cover were observed.

Locality M2 is a field boundary (ditch margin) (*Tanaceto-Artemisietum* and the predominant grass *Bromus inermiswe*) near the village of Świerczynki.

The first bushes of blackthorn *Prunus spinosa* L., European elder *Sambucus nigra* L. and European dewberry *Rubus caesius* L. – signs of ongoing secondary succession – were also observed during this study.

Locality L2 is the edge of a forest island consisting of *Ribo nigri-Alnetum* near the village of Świerczynki. No significant qualitative or quantitative changes were observed there during the study period.

MATERIAL AND METHODS

The study was conducted between 1998 and 2001. The study material included specialized natural enemies of aphids – Diptera of the family Syrphidae.

Field observations at the research localities (semi-natural habitats) were carried out each year from May to October.

The occurrence of syrphid flies in various midfield thickets was documented on the basis of two methods:

- in 1998-1999 the material was collected by catching specimens in ca 13 cm diameter yellow MOERICKE traps in three replicates. The traps were placed level with the tops of herbaceous plants and filled with a 10% solution of ethylene glycol with added surfactant. In each replicate in each locality, three traps were placed in a row 10 m apart.
- in 2000-2001 hoverflies were caught by sweeping with an entomological net at each locality in three replicates, assuming 100 hits with the net per replicate.

The material was characterized faunistically and ecologically on the basis of the following parameters: species composition, structure of relative abundance and similarity of dominance structure – the RENKONEN index (Re) – it is assumed that a populations or

communities are similar if their values of Re are equal or more than 50%, e.g. PAWLIKOWSKI (1985). The HUTCHESON test (1970) was applied to the qualitative and quantitative assessment, as was the general species diversity H' index (SHANNON & WEAVER 1963).

The following dominance classes were adopted for the analysis of dominance structure in the hoverfly communities: eudominants – ED – were species making up > 10% of all the aphidophagous species collected; dominants – D: 5.1-10%; subdominants – SD: 2.1-5.0%; reccedents – R: 1.1-2.1%; subreccedents – SR – species making up < 1.1% (WNUK & GUT 1994).

RESULTS

In 1998-2001 catches in MOERICKE traps and with the entomological net yielded a total of 35 species of hoverflies: 14 saprophagous species from the subfamily Milesiinae and 21 aphidophagous species of the subfamily Syrphinae (Table 1).

Table 1. Mean number of hoverfly species (Syrphidae) caught in MOERICKE traps during 1998-1999 and with an entomological net during 2000-2001.

Midfield thickets	Edges of forest islands				Boundary (ditch margin)			
	L1		L2		M1		M2	
Species	Moericke traps	Ent. net	Moericke traps	Ent. net	Moericke traps	Ent. net	Moericke traps	Ent. net
Eristalinae								
<i>Eristalis</i> sp.	○							■
<i>Eristalis arbustorum</i> (L.)						□	●	■□
<i>Eristalis cryptarum</i> (FAB.)						□		
<i>Eristalis lineacta</i> (HARR.)					●	□	●○	□
<i>Eristalis tenax</i> (L.)	●			■□	●○	□	●○	■□
<i>Helophilus</i> sp.							●	
<i>Helophilus affinis</i> WAHL.					○			
<i>Helophilus hybridus</i> LOEW		□					○	□
<i>Helophilus trivittatus</i> (FAB.)								□
<i>Helophilus pendulus</i> (L.)	○					□		□
Milesiinae								
<i>Xylota segnis</i> (L.)	●○							
<i>Syrpitta pipiens</i> (L.)	●	■			●	■□	●	■□
Pipizinae								
<i>Pipiza carbonaria</i> MEIG.						□		

Syrphinae								
<i>Melanostoma</i> sp.								■
<i>Melanostoma mellinum</i> (L.)	●○	■□	●○	■□	●	■□		■□
<i>Melanostoma scalare</i> (FAB.)	○		○			□		□
<i>Platycheirus</i> sp.				□				□
<i>Platycheirus angustatus</i> (ZETT.)				□		□		□
<i>Platycheirus clypeatus</i> (MEIG.)		□	○	□		□	●	■□
<i>Platycheirus discimanus</i> LOEW		□						
<i>Platycheirus peltatus</i> (MEIG.)	●	□		■□	●	■□	○	□
<i>Platycheirus podagratus</i> (ZETT.)		□		□		□		□
<i>Scaeva pyrastris</i> (L.)	○		●		●		●○	■
<i>Eupeodes corollae</i> (FAB.)	●○	■	●	■	●○	□	●○	■□
<i>Syrphus ribesii</i> (L.)	●○	■	●		●	■	●	■
<i>Syrphus vitripennis</i> MEIG.	●○		●○	■	●○	□	●	
<i>Parasyrphus annulatus</i> (ZETT.)		□						
<i>Episyrphus balteatus</i> (DE GEER)	●○	□	●○	■□	●○	■□	●○	□
<i>Sphaerophoria menthastris</i> (L.)						□		
<i>Sphaerophoria rueppellii</i> (WIED.)		■		■		■		■
<i>Sphaerophoria scripta</i> (L.)	●	■□		■□	●	■□	●	■□
<i>Sphaerophoria taeniata</i> (MEIG.)		□		■□		■□		□
<i>Chrysotoxum arcuatum</i> (L.)	●							
<i>Chrysotoxum octomaculatum</i> CURT.			○				●	

Description

● 1998, ○ 1999, □ 2000, ■ 2001

L1 – edge of the forest island at Leszcz

L2 – edge of the forest island at Świerczynki

M1 – field boundary (ditch margin) at Leszcz

M2 – field boundary (ditch margin) at Świerczynki

In 1998-1999, the aphidophagous species of syrphids most often recorded in the midfield thickets were *Episyrphus balteatus* (DE GEER), *Eupeodes corollae* (FAB.), *Sphaerophoria scripta* (L.), *Melanostoma mellinum* (L.), *Syrphus ribesii* (L.), *Syrphus vitripennis* MEIG. and *Platycheirus peltatus* (MEIG.).

E. balteatus and *E. corollae* occurred in all the midfield thickets, irrespective of the catching method.

According to the trap catches, *E. balteatus* was present in all the habitats in both years of the study. In the entomological net catches, *S. scripta* was also recorded in all the habitats in both years.

In 1998-1999, the most numerous communities of aphidophagous syrphids were caught in the traps in the ditch margin M2 at Świerczynki, on average about 200 specimens (Fig. 1). In 2000-2001 in the same habitat in the most frequent communities of these flies were also caught with the entomological net, i.e. about 100 specimens. A greater number (about 100 specimens) of syrphid flies were netted along the second field boundary at Leszcz (M1) than at the edge of the forest islands (about 50 specimens) (Fig. 2).

In 1998 more flies were caught in all the midfield thickets than in 1999, and very large numbers of syrphid flies were caught in locality M2 at Świerczynki (on average about 400 specimens) compared with other habitats (Fig. 3).

In 2000 considerably fewer aphidophagous syrphids were caught in all the midfield thickets than in 2001. The differences in the counts between the habitats were also smaller (Fig. 4).

Generally, more aphidophagous Syrphidae were caught at ditch margin M2 than at the edges of the forest islands, both with the entomological net and in the MOERICKE traps.

In all the years of the present study, more than 86% of the syrphid flies caught were aphidophages (Figs 5 and 6).

In 1998, the percentage of aphidophagous syrphid flies found in the traps ranged from 89% (M1) to 98% (L2). In the next year, most (97%) of the hoverflies were caught at L2 and fewest (64%) at M1 (Figs 7 and 8).

In 2000, the smallest percentage of aphidophagous hoverflies (54%) was caught with the entomological net at L1, compared with most of the other midfield thickets, where on average over 70% of all the syrphid species caught were aphidophagous (Fig. 9). In the next year, the percentage of aphidophagous flies netted was even higher and ranged from 84% at M1 to 90% at L1 and L2.

From the above data it follows that the majority of syrphid flies netted and trapped were aphidophagous species and that the largest percentage of them were caught at the edge of the forest islands.

Of the aphidophagous syrphids caught in 1998-1999, the species *Episyrphus balteatus* stands out: it was eudominant (ED) in all the midfield thickets; *Eupeodes corollae* also achieved a eudominant position at the forest edges (Table 2).

As regards the occurrence of aphidophagous syrphid flies in the various years, apart from the above-mentioned species, *Syrphus vitripennis* was always present at the edge of forest islands L1 and L2, being eudominant or subdominant (Table 2).

Of the aphidophagous syrphid flies caught in 2000-2001, *E. balteatus*, *Melanostoma mellinum* and *Sphaerophoria scripta* were dominant in all the midfield thickets (eudominant and dominant) (Table 3).

Fig. 1. Mean number of aphidivorous hoverfly species caught in MOERICKE traps in the midfield thickets in 1998-1999.

Description

L2 – edge of forest island at Leszcz, L2 – edge of forest island at Świerczynki, M1 – field boundary (ditch margin) at Leszcz, M2 – field boundary (ditch margin) at Świerczynki.

Fig. 2. Mean number of aphidivorous hoverfly species caught with an entomological net in the midfield thickets in 2000-2001.

For description see Fig. 1.

Fig. 3. Mean number of aphidivorous hoverfly species caught in MOERICKE traps in the midfield thickets in 1998 and 1999.

For description see Fig. 1.

Fig. 4. Mean number of aphidophagous hoverfly species caught with an entomological net in the midfield thickets in 2000 and 2001.

For description see Fig. 1.

Fig. 5. Percentage of aphidophagous hoverfly species caught in MOERICKE traps in the midfield thickets in 1998-1999.

For description see Fig. 1.

Fig. 6. Percentage of aphidophagous hoverfly species caught with an entomological net in the midfield thickets in 2000-2001.

For description see Fig. 1.

Fig. 7. Percentage of aphidophagous hoverfly species caught in MOERICKE traps in the midfield thickets in 1998.

For description see Fig. 1.

Fig. 8. Percentage of aphidophagous hoverfly species caught in MOERICKE traps in the midfield thickets in 1999.

For description see Fig. 1.

Fig. 9. Percentage of aphidophagous hoverfly species caught with an entomological net in the midfield thickets in 2000.

For description see Fig. 1.

Table 2. Structure of the relative abundance of aphidophagous hoverfly species caught in MOERICKE traps at the edges of the forest islands and field boundaries (ditch margins) in 1998-1999.

Species \ Year	L1		L2		M1		M2	
	1998	1999	1998	1999	1998	1999	1998	1999
<i>Episyrphus balteatus</i> (DE GEER)	ED	ED	ED	ED	ED	ED	ED	ED
<i>Melanostoma mellinum</i> (L.)	SR	D	R	D	R			
<i>Melanostoma scalare</i> (FAB.)		ED		D				
<i>Eupeodes corollae</i> (FAB.)	SD	D	R		ED	ED	ED	ED
<i>Platycheirus clypeatus</i> (MEIG.)				SD			SR	
<i>Platycheirus peltatus</i> (MEIG.)	SD				SD			SD
<i>Scaeva pyrastris</i> (L.)		D	SD		R		SR	D
<i>Sphaerophoria scripta</i> (L.)	R				D		SD	
<i>Syrphus ribesii</i> (L.)	SR	D	R		R		SR	
<i>Syrphus vitripennis</i> MEIG.	ED	ED	SD	SD	SD	ED	SD	

Description

ED – eudominant

D – dominant

R – numerous species

SR – uncommon species

For other descriptions, see Table 1.

Table 3. The relative abundance structure of aphidophagous hoverfly species caught with an entomological net in the midfield thickets in 2000-2001.

Species \ years	L1		L2		M1		M2	
	2000	2001	2000	2001	2000	2001	2000	2001
<i>Episyrphus balteatus</i> (DE GEER)		ED	D	ED	D	ED	ED	ED
<i>Ischyrosyrphus liophthalmus</i> (SCHIN. & EGG.)				R				
<i>Melanostoma mellinum</i> (L.)	ED	ED	D	ED	D	ED	ED	ED
<i>Melanostoma scalare</i> (FAB.)					SD			SR
<i>Melanostoma</i> spp.							SD	
<i>Eupeodes corollae</i> (FAB.)	ED		ED			D	SD	D
<i>Parasyrphus annulatus</i> (ZETT.)		SD						
<i>Platycheirus</i> spp.				SD				SR

<i>Platycheirus angustatus</i> (ZETT.)				R		R		SR
<i>Platycheirus clypeatus</i> (MEIG.)		SD		D		SR	SD	SD
<i>Platycheirus discimanus</i> LOEW		SD						
<i>Platycheirus peltatus</i> (MEIG.)		SD	ED	SD	SD	SR		SR
<i>Platycheirus podagratus</i> (ZETT.)		SD		ED		SR		D
<i>Pipiza carbonaria</i> MEIG.						SR		
<i>Scaeva pyrastris</i> (L.)							SD	
<i>Sphaerophoria menthastri</i> (L.)						SR		
<i>Sphaerophoria rueppellii</i> (WIED.)	ED		ED		D		SD	
<i>Sphaerophoria scripta</i> (L.)	ED	D	ED	D	ED	ED	ED	ED
<i>Sphaerophoria taeniata</i> (MEIG.)		SD	D	SD	ED	ED		D
<i>Syrphus ribesii</i> (L.)	ED				D		SD	
<i>Syrphus vitripennis</i> MEIG.			D			SR		

For description see Tables 1 and 2.

The edge of forest island L2 at Świerczynki had a larger number of co-dominant species (10) than the other habitats. *M. mellinum* and *S. scripta* were eudominant and dominant in the net catches in both years in all the midfield thickets. To summarize, among the dominant species of syrphid flies, *E. balteatus*, *M. mellinum* and *S. scripta* were eudominant and dominant in all the habitats.

Episyrphus balteatus, a very common species in our climatic zone, was eudominant and dominant in all the midfield thicket habitats in catches using both methods throughout the study. In addition, *S. vitripennis*, *E. corollae*, *M. mellinum* and *S. scripta* were dominant in these communities.

During the four years of the study, the species diversity index H' for these syrphid flies in the midfield thickets was low and did not exceed 2.5. This indicates a low count and a small number of species in the habitats compared (Figs 11-16). In most cases the H' value of these communities of these hoverflies did not differ significantly. Only the communities caught in MOERICKE traps at the edge of forest island L2 had a value of H' significantly lower than that of the other communities (Fig. 11, Figs 13-14).

The majority of the communities of aphidophagous syrphid flies caught in these habitats in 1998-2001 exhibited a similar dominance structure, which was probably due to the small number of the flies caught (Figs 17-22). Only the hoverflies caught in the MOERICKE traps at the edge of forest island L2 and on ditch margin M1 did not display such a similarity in dominance structure (Figs 17, 19 and 20).

Fig. 10. Percentage of aphidophagous hoverfly species caught with an entomological net in the midfield thickets in 2001.

For description see Fig. 1.

Fig. 11. Diversity of aphidophagous hoverfly species caught in MOERICKE traps in the midfield thickets in 1998-1999.

Fig. 12. Diversity of aphidophagous hoverfly species caught with an entomological net in the midfield thickets in 2000-2001.

For description see Figs 1 and 11; differences insignificant.

Fig. 13. Diversity of aphidivorous hoverflies caught in MOERICKE traps in the midfield thickets in 1998.

For description see Figs 1 and 11.

Fig. 14. Diversity of aphidivorous hoverflies caught in MOERICKE traps in the midfield thickets in 1999.

For description see Figs 1 and 11.

Fig. 15. Diversity of aphidivorous hoverflies caught with an entomological net in the midfield thickets in 2000.

For description see Figs 1 and 11; insignificant differences.

Fig. 16. Diversity of aphidophagous hoverflies caught with an entomological net in the midfield thickets in 2001.

For description see Figs 1 and 11.

Fig. 17. Similarity of dominance structure between aphidophagous hoverfly species caught in MOERICKE traps in the midfield thickets in 1998-1999.

For description see Fig. 1.

Fig. 18. Similarity of dominance structure between aphidophagous hoverfly species caught with an entomological net in the midfield thickets in 2000-2001.

For description see Fig. 1.

Fig. 19. Similarity of dominance structure between aphidivorous hoverfly species caught in MOERICKE traps in the midfield thickets in 1998.

For description see Fig. 1.

Fig. 20. Similarity of dominance structure between aphidivorous hoverfly species caught in MOERICKE traps in the midfield thickets in 1999.

For description see Fig. 1.

Fig. 21. Similarity of dominance structure between aphidivorous hoverfly species caught with an entomological net in the midfield thickets in 2000.

For description see Fig. 1.

Fig. 22. Similarity of dominance structure between aphidophagous hoverfly species caught with an entomological net in the midfield thickets in 2001.

For description see Fig. 1.

DISCUSSION AND CONCLUSIONS

An important function of natural refugia is the occurrence not only of various phytophages, but also their predators and parasites (OLSZAK 1999, FRANK 1999, GRABARKIEWICZ 2005). It is also assumed that the predators from the families Coccinellidae, Chrysopidae and Carabidae, and particularly the specialized Syrphidae, play a major role in limiting aphid populations (BUGG 1993, KINDLMANN & DIXON 1999, MÜLLER & GODFREY 1999, OLSZAK 1999, BROWN 2004, GOSPODAREK 2004, BENNEWICZ 2004, GRABARKIEWICZ 2005). Habitats rich in flowering plants, constituting a source of food for adult aphidophagous syrphids, are of great importance for these insects, not to mention other beneficial organisms (WNUK & GUT 1994). These reports indicate that in aphid colonies more larvae of syrphid flies have been observed in environments with abundant vegetation. Moreover, wild plants are more attractive than garden plants to syrphid flies. The species composition of the vegetation also affects the occurrence of Syrphidae: for example, plants of the family Brassicaceae (Cruciferae) are more attractive than those of Apiaceae (Umbelliferae) (WNUK 1972, WNUK & WOJCIECHOWICZ-ŻYTKO 1991, BARCZAK 1994, WNUK & GUT 1994). Similarly, the density of the aphid population is important to specialized predators like hoverflies (BAŃKOWSKA et al. 1978, GOSPODAREK 2004). The spring occurrence of aphids, for which trees and bushes are the winter hosts, is of great importance for syrphid flies: the former are the first important source of food for the latter. The voracity of syrphid larvae puts them among the most dangerous natural enemies of aphids (WNUK 1972, TENHUMBERG & POEHLING 1995, BROWN 2004).

In the midfield thickets investigated in this research, aphidophagous Syrphidae made up the majority of the hoverflies collected. Other studies have also shown that aphidophagous

species were dominant in Syrphidae communities in various habitats (KACZOROWSKI & DĘBEK-JANKOWSKA 1997, BARCZAK et al. 2000, BENNEWICZ 2001, BENNEWICZ 2004). The study on flowering plants by WNUK & GUT (1994) indicated that only 25% of Syrphidae species were aphidophagous. This may demonstrate that not only flowering plants, but also the smell of aphid excretions (honeydew) and the density of aphids on plants, are attractive to syrphid flies (WNUK 1973).

In the present study, *Episyrphus balteatus* was the eudominant hoverfly species in all the midfield thickets. This species can have four or more generations annually. It is found in the colonies of a number of aphid species throughout the growing season. The co-dominant species *Eupeodes corollae* (formerly *Metasyrphus corollae*) and *Syrphus vitripennis* also have more than one generation per year; they are found in the whole of Poland from April to late autumn (BAŃKOWSKA 1963, WNUK 1973). These species live both on herbaceous plants and on trees and bushes; they are therefore not closely connected with any particular type of vegetation, in contrast to many other hoverfly species, whose occurrence is governed by plant height and the environment of aphids (WNUK 1973, SUTHERLAND et al. 2001). This has been confirmed by many other authors, according to whom *E. balteatus* and *E. corollae* are predominant among the aphidophagous Syrphidae (WNUK & WOJCIECHOWICZ-ŻYTKO 1991, TENHUMBERG & POEHLING 1995, STARÝ 1995, KACZOROWSKI & DĘBEK-JANKOWSKA 1997, GRABARKIEWICZ & TROJANOWSKI 1998, SALVETER 1998 b, FRANK 1999, HICKMAN et al. 2001, BENNEWICZ 2004, GOSPODAREK 2004).

The aphidophagous fly *Sphaerophoria scripta*, like other species of the genus *Sphaerophoria*, is a species typical of dry, open spaces (SUTHERLAND et al. 2001); in the present study it was among the species dominant on the field boundaries (ditch margins). This lends further support to the claim that particular syrphid fly species are associated with the species of plants in particular habitats rather than with the habitats themselves.

Many researchers investigating the importance of aphidophagous syrphid flies stress the role of individual species of flowering plants attracting their adult forms (WNUK & WOJCIECHOWICZ-ŻYTKO 1991, WNUK & GUT 1994, SALVETER 1998 a). These authors have noted the attractiveness of such plant species as *Sinapis alba* L., *S. arvensis* L., *Raphanus raphanistrum* L., *Sisymbrium officinale* (L.), *Conium maculatum* L. or *Aegopodium podagraria* L. to the imagines of *E. balteatus*, *E. corollae*, *Melanostoma mellinum*, *Sphaerophoria scripta*, *S. menthastris* and others. *Sinapis alba* and *S. arvensis* were common plants in the midfield thickets examined in this study (except at the edge of forest island L1). *C. maculatum* and *A. podagraria* were also recorded there (BARCZAK et al. 2000).

The study by SADEGHI & GILBERT (2000 a) of egg laying by *E. balteatus* and *S. ribesii* indicated that both syrphids lay eggs in colonies of many aphid species on different wild

plants. This takes place, for example, in colonies of *Aphis fabae* feeding on *Rumex obtusifolius*, of *Aphis sambuci* on *Sambucus nigra*, of *Macrosiphum rosae* on *Rosa* sp., or of *Microlophium carnosum* on *Urtica dioica*. In studies of aphids conducted in the same midfield thickets, colonies of *A. fabae* feeding on *Rumex obtusifolius* were observed at the edge of forest island L2 and at ditch margin M1 (BARCZAK et al. 2000, BENNEWICZ 2010). In most of the habitats examined, the common *U. dioica* was infested by *M. carnosum*. Since both species of syrphid flies examined by SADEGHI & GILBERT (2000 a) were common in the thickets examined and larvae of syrphid flies were frequently found in colonies of these aphids, it can be assumed that they included the larvae of *E. balteatus* and *S. ribesii*. It follows from other studies by these authors (SADEGHI & GILBERT 2000 b) that *E. balteatus* lay eggs most readily in aphid colonies on *Vicia fabae*, but also on *Rosa*, *Rumex* and *Sambucus nigra*. They found that the smallest percentage of eggs had been laid on *U. dioica*, whereas *S. ribesii* laid the highest percentage of eggs on *Acer* sp., *Rosa* sp. and *V. fabae*, and the lowest on *S. nigra* and *U. dioica*. Additionally, those authors claim that *S. ribesii* lays eggs more selectively and in smaller numbers than *E. balteatus*. Their results (SADEGHI & GILBERT 2000 a, b) indicate that *U. dioica*, though present in great abundance in the midfield thickets under scrutiny, is not a very valuable food resource as regards the development of common hoverfly species. Hence, the occurrence of individual plant species and the area covered by these species in particular types of thickets should be taken into consideration in any evaluation of natural refugia for aphidophagous flies.

Midfield thickets are a source of food or shelter for the adult forms of many species of melitophages and aphidophages. They make up an integral part of the agricultural landscape and play a crucial role in Integrated Pest Management (IPM) in agricultural production (LANDIS et al. 2000). The present research has shown that the edge of the forest island at Świerczynki, situated among fields many hectares in area, was the most valuable habitat.

Increases in insect abundance in midfield thickets in the agricultural landscape is determined by the diversity of these habitats, which is reflected in the rich species composition of the plants constituting a food resource for herbivores (PAWLIKOWSKI 1991, BANASZAK & CIERZNIAK 2000, CIERZNIAK 2003). Many authors claim that trees, bushes, midfield copses, roadsides and other edge habitats, providing habitat corridors between arable fields, have the richest species diversity (WNUK 1973, PAWLIKOWSKI 1989, BENNEWICZ & KRASICKA-KORCZYŃSKA 1997, GRABARKIEWICZ & TROJANOWSKI 1998, SALVETER 1998 b, WILKANIEC et al. 1999, BANASZAK & CIERZNIAK 2000, BARCZAK et al. 2000, WILKANIEC et al. 2000, BENNEWICZ 2001, BENNEWICZ et al. 2001, WILKANIEC 2001, BENNEWICZ 2002, CIERZNIAK 2003, BENNEWICZ & KRASICKA-KORCZYŃSKA 2004).

It can be concluded that in an agricultural landscape forest islands – habitats with stable and diverse vegetation, at an advanced stage of secondary succession – can provide the best

habitats from the point of view of comprehensive crop protection. They offer beneficial insects both shelter and a good food resource. These semi-natural habitats should therefore be maintained among arable fields, since their stability ensures correct Integrated Pest Management and consequently, their participation in the self-regulation of agrocenoses.

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