

PhD Thesis

**SURVEY OF HOVERFLY COMMUNITIES AND
ANALYSIS OF THEIR POLLEN FEEDING IN
CENTRAL EUROPEAN AGROECOSYSTEMS AND
FOREST STRIPS**

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1. Preliminaries and objectives of doctoral thesis

In agroecological research for the last couple of years studies on ecosystem preservation and sparing land use became the focus of attention (Pejchar & Mooney 2009; Prager *et al.* 2012; Gonthier *et al.* 2014). Degradation and exploitative use of environment also threatens agricultural production, therefore preservation of natural resources is key to human welfare (Gallai *et al.* 2009). Intensive land use often eradicates soil fauna (Goulson *et al.* 2008), pesticides pollute soil and water, often killing masses of beneficial organisms or forcing them to leave the area, therefore reducing biodiversity (Fliessbach *et al.* 2007; Kirchmann *et al.* 2007; Filippi-Codaccioni *et al.* 2010). Reduction of biological diversity and degradation of living systems can lead to dropouts in ecosystem services (Cumming *et al.* 2014). As a result, food and water supply of humankind may become endangered (Potts *et al.* 2010; Palm *et al.* 2014). Ecosystem services mean those “advantages and benefits” that people receive from nature (Báldi 2011). This includes pollination by insects and agents of biological control - they are crucial for the functioning of

ecosystems and increase of efficiency of agricultural production (Cardinale *et al.* 2012; Lundin *et al.* 2013; Mitchell *et al.* 2015).

In preservation of agroecosystems a key role is held by semi-natural habitats beside agricultural crops that help maintain the biodiversity (Bates & Harris 2009; Fahrig *et al.* 2015), and balance agroecosystems. These „green corridors” serve as habitat for plants and animals that were pushed out of the cultivated area by the intensive treatment and the homogenous crop structure. By providing or maintaining a suitable habitat the species richness and abundance of beneficial organisms can be increased or their colonization facilitated (Potts *et al.* 2003; Hannon & Sisk 2009). In orchards the between row vegetation or in cultivated lands the woody margins and flowering strips provide food, breeding and overwintering sites for the organisms pushed out of the field and help their relocation (Sarhou *et al.* 2014; Sardiñas & Kremen 2015).

Another alternative of maintaining biodiversity in agriculture is the organic food production with its main

feature being the environment-conscious pest control (Azadi *et al.* 2011). Compared to intensively treated crops the organic food production has a positive influence on the species richness and abundance in case of numerous groups of organisms in the area (Hutton & Giller, 2003; Hole *et al.* 2005; Rundlöf & Smith, 2006).

Both in traditional and organic crop production an important role is held by biological control that also gained prominence because of the costly production of herbicides, fungicides and pesticides, developing of resistance; food safety problems and a change in customer preferences evoked the same (Berezki & Báldi 2011). There are numerous insects that either as imagoes, as larvae or both feed on pests or parasitize them; in other words they are their natural enemies. The hoverflies (Syrphidae) are among them (Tóth 2011).

Syrphids belong to the order Diptera and represent one of its largest families. The number of known species exceeds 6000 worldwide. In Europe the species number is estimated at 800 (Röder 1990), in Hungary 400 (Tóth 2008b). Adults visit flowers, feeding on pollen and nectar. Larvae are partly predaceous, others feed on

decomposing organic substances, but there are also phytophagous species.

Hoverflies are important elements of ecosystems, both by the activities of adults and the larvae. The former take part in pollination (Jauker & Wolters 2008; Rader *et al.* 2011; Jönsson *et al.* 2015), while larvae of certain species are potential biological control agents by consuming aphids (Dib *et al.* 2010; Trzciński & Piekarska-Boniecka 2013).

Studies show that adults are very significant pollinators in agroecosystems (Jauker *et al.* 2009, Meyer *et al.* 2009), at the same time larvae are efficient in aphid control (Rossi *et al.* 2006; Almohamad *et al.* 2010).

Hoverflies are bound to habitats that can supply sufficient amount of food for both adults and larvae. This means that in case of aphidophagous species imagoes have to search for a habitat with enough aphid colonies for egg-laying and development of larvae as well as supplying adults with appropriate amount of pollen and nectar. Therefore woody margins along agricultural fields and flowering strips sown beside arable land positively influence richness of hoverfly fauna (Kleijn & Verbeek

2000; Haenke *et al.* 2009; Ricou *et al.* 2014), by providing necessary pollen supply for adults. In cultivated lands this could increase number of hoverfly individuals during spring and summer, thereby improving efficiency of aphid control (Irvin *et al.* 1999) and success of pollination (Pansarin 2008; Rader *et al.* 2011; Jönsson *et al.* 2015).

Although hoverflies feed on flowers of a wide variety of plants, a question can be raised about what plants are the most suitable for them (Ambrosino *et al.* 2006). Study of pollen consumption by hoverflies can help understanding of the adults' flower visitation habits, then utilizing this by keeping and planting the preferred plant species, increasing diversity of hoverfly fauna on cultivated lands, supporting their natural beneficial activities.

The main objectives of my research were:

- Survey of hoverfly fauna of traditionally treated agricultural fields with woody margins along them and orchards.
- Comparison of different sampling methods and their efficiencies in faunistic survey of hoverflies.

- Determining the species of pollen in the gut content of collected hoverflies and thereby study of the flower visitation habits of adults.
- Based on feeding on pollen to determine which plants provide resource for hoverfly imagoes in agroecosystems.

2. Methods of the research

Studies were carried out in agroecosystems in Hungary and Germany. Among the surveyed areas there were both intensively treated ones, those in organic food production and forest sites.

Collecting of hoverflies was done with Malaise traps, pan traps and modified butterfly net. Malaise traps are often used for determining the composition of hoverfly communities in a certain area (Rossi *et al.* 2006; Tóth 2009, 2011). At the peak of the trap a collecting container captures the insects with 70 percent ethylene glycol in it for preservation of the specimens.

Netting is one of the most frequently used method of hoverfly sampling (Tóth 2008, 2011). In the course of

my work a modified butterfly net was used, with stronger fabric on the rim.

Efficiency of pan traps is based on the attractiveness of yellow and white colours to hoverflies (Wratten *et al.* 1995; Hickman *et al.* 2001; Mózes *et al.* 2013). In the course of the trapping white pans were placed out, in one area supplemented by also yellow and blue traps. The pans were filled with 70 percent ethylene glycol, adding a drop of detergent.

2.1. Description of the sites in Hungary

Arable land

Sampling in 2008 was done near Debrecen, at an intensively treated field, property of DE ATK Debreceni Tangazdaság és Tájkutató Intézet (DTTI) and along a 1500 m long woody margin beside it. Hoverflies were collected by netting and pan traps weekly between April and September. Along woody margin three transects of 50 m each were designated, where netting of insects was standardized at 30 minutes. Pan trapping was done with nine white pans in the transects and along it in the wheat field at 10 and 20 m distances fixed onto wooden sticks at 80-100 cm height. Pans were emptied weekly. During the

survey, hoverfly species were classified in two functional groups according to whether their larvae are aphidophagous or not. The former was called aphidophagous group, the latter named as non-aphidophagous group. The whole collecting season was divided into three periods in order to differentiate gradation phases. During the data analysis I investigated the effect of sampling periods on the species richness and abundance of hoverflies in the netted samples; the effect of distance of pan traps from the margin and of the period and their interaction on the species richness and abundance of hoverflies; the same analyses were carried out for both the aphidophagous and non-aphidophagous groups.

Orchards

Surveys were carried out in an organic apple orchard in the outskirts of the city of Debrecen between April and September 2008. Sampling was done by netting and pan traps, every week. Three transects of 50 m were designated, netted for 30 minutes. In the rows 3-3 white pans were placed out at a height of 80-100 cm, emptied weekly. The third site was at the research station at Pallag

but belonging to DE ATK DTTI. In this orchard the trees received traditional pesticide treatment. In the first third of the area there was a margin composed of tamarisk and common hawthorn, on both sides of it there were a couple of rows of apple trees, however not receiving the pesticide treatment. There was no bottom vegetation, soil was disk-harrowed. Netting was done by the same method as described previously, in between the untreated apple tree rows on both sides of the woody margin in three transects. Sampling was supplemented by the use of nine white pan traps. Comparison was made between samples in the two orchards according to community structures and phenologies of hoverflies.

2.2. Description of the sites in Germany

Forests

Surveys were carried out in the eastern part of Germany in the Tharandt forest where a clear-cut area and a glade at the side a forest with agricultural field in adjacency were chosen. At both sites sampling was done between May and August 2009. A gyűjtések mindkét területen 2009. május és augusztus között történtek. At both sites a Malaise trap was set up, three pan traps were

placed out and netting was done along a 50 m transect for 30 minutes once every week. Pan traps were white, yellow and blue in colour, one of each at both sites, at 80-100 cm height. For data analysis the sampling season was divided into four periods according to the months. Analysis was done for the effect of periods on the total species richness and abundance; effect of periods on the abundance and species richness of the aphidophagous and non-aphidophagous groups; the efficiency of the different sampling methods for both species richness and abundance according to sites and to periods.

Arable lands

In 2010 surveys were carried out on arable lands near Bonn. The site at Klein-Altendorf is composed of several intensively treated agricultural fields for crops, vegetables and fruits. Sampling was done at a rye field where the western side was separated by a row of trees from the neighbouring wheat field and a smaller patch with blue tansy. The second site belonged to the administrative area of Hennef. Survey was carried out at a field with organic food production: rye, spices, horse bean and potato. On the western side it was bordered by a

woody margin. Sampling was done by pan traps between June and September. At both sites 15 white pans were placed out in three 50 m long rows fixed onto wooden sticks. Five pan traps were put along the bordering rows of trees, 5 pans each at both 10 and 20 m distance from it on the field.

Analysis of the samples

Pollen preparations were made of the digestive system of collected hoverfly individuals. Gut contents were embedded in gelatine and stained with safranin, then studied in a compound microscope pollens from different plant species were determined.

Objectives of the research were analysis of hoverflies' gut content and based on this determining what plant species' pollen the imagoes feed on; survey of the hoverfly faunas of the two studied areas; the effect of the row distance; drawing of the food network between hoverflies and plants used as food source.

For analysis of data the R statistical software (R Development Core Team 2009. version 2.13.1, version 3.1.3; Development Core Team 2013. version 3.1.3) was used in all cases.

3. New scientific results of the thesis

1. As a result of the research conducted in Hungary, new records were obtained for the region of the Great Plains, a significant addition to the mapping of the distributions of the species in Hungary and towards a more complete hoverfly database.
2. During the survey *Platycheirus aurolateralis* was first found in the eastern part of Germany, only described as recently as 2002 from Great Britain; both sexes were collected. A further rare hoverfly species, *Sphegina montana* was found in the eastern part of Germany, an interesting faunistic record.
3. By comparison of the three different capturing methods it can be stated that netting and Malaise traps have proved to be the most suitable for surveying of the hoverfly communities of the study areas. While pan traps in themselves are unsuitable for quantitative and qualitative comparison of sites with different vegetations, they provided useful

additional information to the survey made with the aforementioned two methods.

4. Preservation of flowering strips in cultivated lands provides significant benefits for hoverfly communities such a stable food resource for imagoes.

4. Practical use of the results

1. For the region of the Great Plains new faunistic data were obtained, that contributes to the better understanding of Hungarian hoverfly fauna.
2. The hoverfly species *Platycheirus aurolateralis* was first found in the eastern part of Germany, a new faunistic record for the area; the captured material serve as voucher specimens for the distribution data.
3. Of the alternative capture possibilities netting and Malaise traps have proved to be the most efficient. These methods provides both the most species and

the most individuals. Pan traps can be regarded useful as supplementary method but are greatly influenced by the vegetation type.

4. Hoverflies used both wind and insect pollinated plants as food source, but the most important sources were herbaceous plants that are widespread and common in every kind of weed communities.
5. Study of the pollen consumption of hoverflies showed woody margins and flowering strips in agroecosystems as significant food resource for hoverflies. Presence of blue tansy (*Phacelia tanacetifolia*) was especially beneficial for imagoes in the reproduction period. After the cutting down of this plant the number of *Episyrphus balteatus* decreased dramatically.
6. Uncovering hoverfly-plant network connections promotes better understanding of hoverflies' roles in ecosystems.

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6. Publication list



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Registry number: DEENK/144/2015.PL
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List of publications related to the dissertation

Hungarian scientific article(s) in Hungarian journal(s) (3)

1. **Földesi R.:** A zengőlegyek (Diptera: Syrphidae) szerepe a beporzásban és a biológiai védekezésben.
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Non scientific journal article(s) (1)

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Total IF of journals (all publications): 4,587

Total IF of journals (publications related to the dissertation): 0,827

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of Web of Science, Scopus and Journal Citation Report (Impact Factor) databases.

14 July, 2015

