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Hoverflies (Syrphidae: Diptera) in areas contaminated with heavy metals (Cd, Zn, Pb)

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ABSTRACT

The aim of the research was to study the diversity of hoverflies (Syrphidae: Diptera) living in areas under the influence of heavy metal emissions (Cd, Zn and Pb). Although the area of the Olkusz Ore-bearing Region (OOR), where the research was partially conducted, belongs to the contaminated regions, where a relatively high species richness of Syrphids has been noted. During the research period, a total of 1,180 syrphids, belonging to 165 species were caught, which constitutes 39.76% of all the Polish Syrphidae fauna. These species represented all the trophic groups with the dominance of zoophagous species (48.48%); however, the most numerous (quantitatively abundant) were saprophagous. Among the collected syrphids, common and numerous species, such as: *E. arbustorum* (LINNAEUS, 1758), *E. tenax* (LINNAEUS, 1758), *Episyrphus balteatus* (DE GEER, 1776) and *S. pipiens* (LINNAEUS, 1758), as well as rare species such as *Callicera aenea* (FABRICIUS, 1777) (NT), *Chalcosyrphus piger* (FABRICIUS, 1794) (DD), *Epistrophe ochrostoma* (ZETTERSTEDT, 1849) (VU), *Orthonevra geniculata* (MEIGEN, 1830) (DD), *Rhingia rostrata* (LINNAEUS, 1758) (DD), *Sphegina sibirica* STACKELBERG, 1953 (LC) and *Spilomyia diophthalma* (LINNAEUS, 1758) (NT), were noted. Eleven of the collected species have been included in the Polish Red List of Endangered Species. *Melangyna ericarum* (COLLIN, 1946) is recorded as a new one among the Polish fauna. Numerous observations did not indicate that the area covered by the study was characterised by a significantly lower species diversity compared to other sites. In fact, the samples taken were usually characterised by a relatively high biodiversity. The obtained results may suggest that anthropogenic activities, including those leading to environmental pollution with heavy metals and to a strong transformation of natural habitats, do not completely destroy biodiversity, and in some cases leave space for nature to create habitats where even rare species of organisms such as Syrphidae can develop.

KEYWORDS: biodiversity, calamine grasslands, heavy metals, Syrphidae

INTRODUCTION

Syrphidae is one of the most diverse families of flies, with 415 species reported from Poland (Żóralski, 2015; Żóralski and Kowalczyk, 2015). The diversity of this group is distinguished not only by the number of species, but also by the variety of trophic groups or ecological niches occupied, especially by larval forms. Predatory forms, actively feeding most often on aphids, phytophages that dig or mine plants, aquatic and terrestrial saprophages feeding on microorganisms or decaying wood and less common mycophages feeding

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on mushrooms are all included. Syrphidae are very active insects, whose adult forms obtain the energy needed to remain active from nectar and honeydew, while pollen enables the females to produce their eggs (Wnuk, 1978; Wojciechowicz-Żytko and Jankowska, 2017; Wojciechowicz-Żytko, 2019). These features make them, apart from bees, some of the most important pollinating insects. The numerous occurrences of Syrphidae in almost every terrestrial environment make them a good object for research and assessment of biodiversity. Areas strongly influenced by human pressure due to activities, including industrial areas, are places where the occurrence of hoverflies has been poorly known so far, compared to, for example, protected areas. Contaminated areas are characterised by the disappearance of natural systems due to, for example, changes in the landscape, movements of earth masses, impoverishment of the surface water network, environmental pollution, changes in land use, etc. This leads to the creation of new types of habitats that may become a site of the occurrence of a large number of species of plants, animals and other living organisms, and even a refugium of rare taxa, which in more natural habitats are not as successful (Godzik, 2015).

In the Olkusz Ore-bearing Region (OOR), exploitation and processing of zinc-lead ores have been carried out for many centuries. This activity has caused far-reaching changes to the landscape, soil, water and land use. New, often heavily polluted, habitats have arisen and are still being created there.

One of the examples of this type of habitat are calamine grasslands, which consist of species that tolerate or are associated with high levels of heavy metals in the soil (Kapusta et al., 2010; Kowolik et al., 2010) and other transformed, unused areas. The emergence of this type of habitat has resulted in the enrichment of the species composition of the flora in the vicinity of Olkusz. Evaluation of the vegetation has shown that the area is inhabited by plant taxa that are rare in Poland and Europe, and the vegetation in this area should be considered as diverse (Nowak et al., 2011). In the research area, there are plant species under protection and rare in the country, for example, *Biscutella laevigata*. Species diversity and the presence of many rare species may lead to a richness of insect species, including Syrphidae, and consequently the presence of syrphid species – pollinators – in this area would be a valuable factor in maintaining the diversity of rare plant taxa.

The aim of the research was to study the diversity of hoverflies (Syrphidae: Diptera) living in contaminated areas under the influence of heavy metal emissions (Cd, Zn and Pb).

Additionally, the study determined the extent to which the species composition of the hoverflies caught in the OOR was similar to the species composition of the hoverflies recorded in the Ojcowski National Park (ONP) – a region not contaminated with heavy metals.

MATERIALS AND METHODS

Site

Habitats located in the area of the current and historical exploitation of zinc-lead (Zn-Pb) ores in the vicinity of Zakłady Górniczo-Hutnicze 'Bolesław' (southern Poland) were selected as the research area. This region is part of the so-called Olkusz OOR located within the macroregion of the Silesian Upland (Kondracki, 2011). It is characterised by the presence of high concentrations of trace elements in the soil, due to their presence in the bedrock, and contamination of the area with anthropogenic sources (mining and processing of Zn-Pb ores). Both natural and anthropogenic sources of metals make the Zn, Cd and Pb content in the soils of the region at the level of 150–10,500 mg · kg^{-1}, 0.8–100 mg · kg^{-1} and 140–2,600 mg · kg^{-1}, respectively, which many times exceed the standards allowed for Polish soils (Stone et al., 2002). The average annual temperature in this area is 8 °C (Szczypek, 1997). Annual rainfall (for the Olkusz region) is around 700–800 mm, with a peak in the period from June to September (Dziechciarz, 2002).

The OOR area is characterised by a very poor hydrological network. The main drainage watercourses are Biała Przemsza and Sztoła (Godzik, 2015), and the mining activities cause additional limitation of surface waters. Metalliferous soils are accompanied by specific plant complexes, forming the so-called calamine grasslands (Kapusta et al., 2010). They include plant species adapted to growth and development in an environment enriched with heavy metals (including Cd, Zn and Pb), for example, *Biscutella laevigata* subsp. Woycickii, *Armeria maritima* subsp. *halleri*. The unique soil conditions were most likely the reason to the survival of the local population of *B. laevigata* even in the maximum extent of the last glaciation (Wierzbicka et al., 2020). To protect these unique habitats, the areas NATURA 2000 'Armeria' PLH120091 and 'Pleszczotka' PLH120092 have been created here. Also, the NATURA 2000 'Błędowska Desert' as well as other large areas of sand exploitation is strongly associated with mining activities in this area. The calamine grasslands of the Olkusz area are accompanied by plantings of Scots pine (*Pinus sylvestris*), Banks pine (*Pinus banksiana*), black pine (*Pinus nigra*), Eurasian larch *(Larix* spp.), warty birch *(Betula pendula*) and American bird cherry (*Prunus serotina*). Over half of the OOR area is covered by non-forest communities namely meadows, xerothermic grasslands, psammophilous grasslands, segetal and ruderal communities (Godzik, 2015). The areas elevated on limestone, which are often occupied by beech forests or rock-plant communities, are of a completely different character.

The research was conducted in the following localities: Bukowno, Hutki, Klucze, Pazurek, Rasztyn, Ryczów, Rodaki and Ujków Stary (US) (Figure 1).

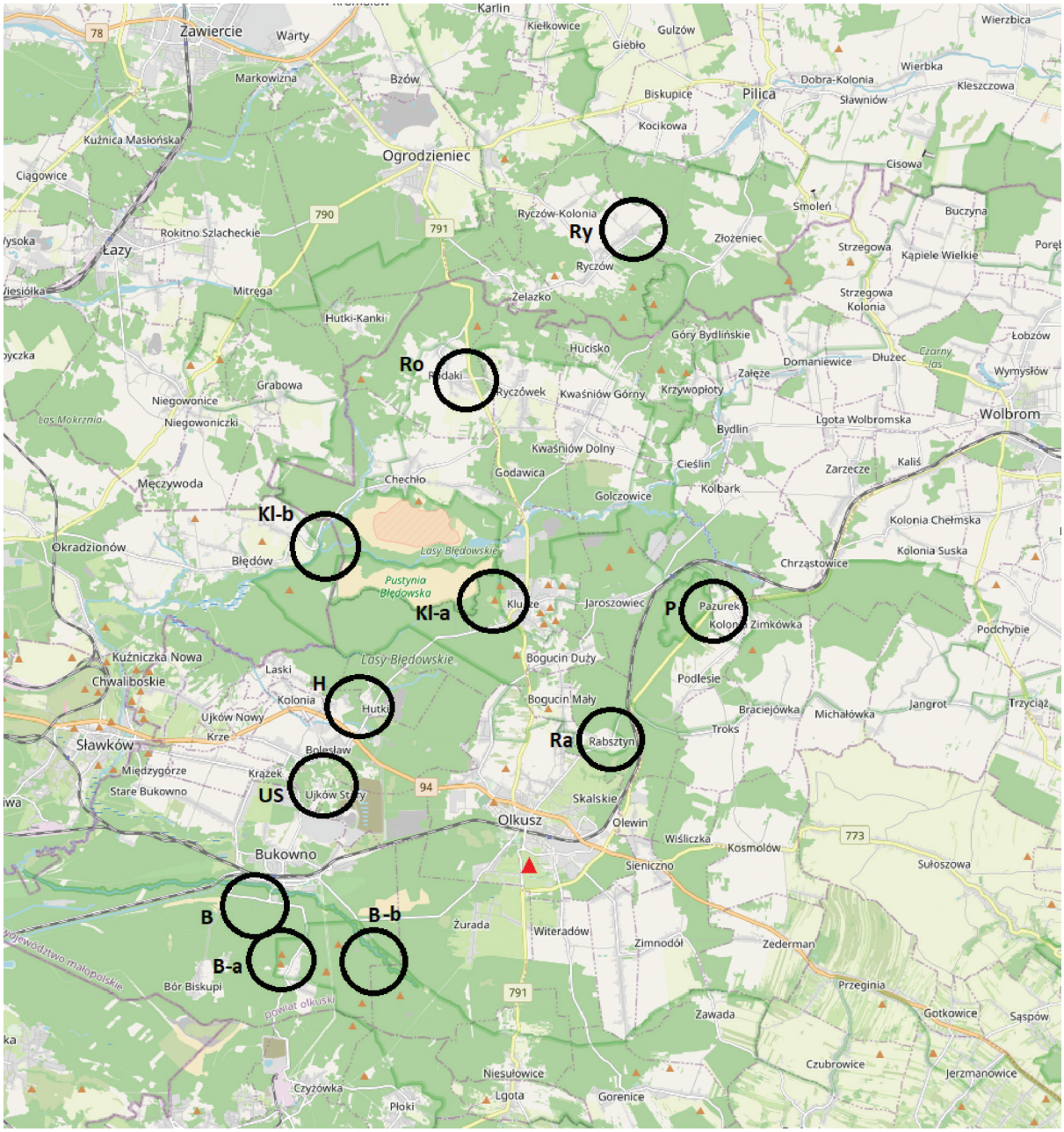


Figure 1. Locality of the research area (©OpenStreetMap authors). B, Bukowno (sand mine); B-a, Bukowno (Diabla Góra); B-b, Bukowno (Sztoła); H, Hutki; Kl-a, Czubatka; Kl-b, Kuźnica Błędowska; P, Pazurek; Ra, Rabsztyn, Ro, Rodaki; Ry, Ryczów; two specimens collected from Olkusz.

Methods

Syrphidae were collected in the years 2015–2021. In the first year of research, quantitative samples of syrphids were collected. In the following years, the material was collected qualitatively. The insects were caught in the period from early spring to late summer using an entomological net in the morning hours. Most of the insects were caught during active flight, while feeding on nectar or pollen, or in food traps – a sugar solution spread over the leaf surface. Captured insects were killed, pinned and identified to species by using the entomological keys: Stubbs and Falk (2002), Bartsch (2009a, 2009b), Van Veen (2004), Speight (2020).

Other collections available to the authors were also analysed for specimens from the area under study (collections of the Museum and Institute of Zoology of the Polish Academy of Sciences in Warsaw and the collection of Bogusław Soszyński [BS]. Only two specimens of species were not confirmed in the current research and were from these two collections *Melangyna ericarum* (COLLIN, 1946) and *Brachypalpus chrysites* EGGER, 1859.

To determine the trophic structure of the caught adults and to facilitate its comparison with the results of research conducted by Klasa and Soszyński (2011) in the ONP, the following division was adopted, taking into account the diet of the larvae: predators and parasites,

aquatic saprophages (SW), terrestrial saprophages, nest saprophages, phytophages, mycophages, coprophages. The significance difference among trophic groups was checked using G-test (Sokal and Rohlf, 1981).

RESULTS

During the years 2015–2021 a total of 1,180 syrphids belonging to 165 species were caught, which constitutes 39.76% of the Syrphidae species of Poland (Table 1).

These species represented all the trophic groups described in the family, dominated by the prescence of zoophagous species (48.48% of all the species). The remaining trophic groups accounted for: 16.37% – species belonging to SW, 15.76% – phytophagous species, 13.94% – terrestrial saprophages, 3.03% – mycophagic species and 1.21% each of coprophagic species and saprophages living in nests.

The percentages for thropic groups in ONP were as follows: zoophagous species (46.59% of all the species). The remaining trophic groups accounted for: 13.07% – species belonging to SWs, 18.75% – phytophagous species, 18.18% – terrestrial saprophages, 0.57% – mycophagic species, 1.70% – coprophagic species and 1.14% – saprophages living in nests.

There were no significant differences between the trophic groups in OOR and ONP on using G-test: G 0.122, P: 0.2731, G 0.7409, P: 0.6106; G 0.5334, P: 0.5348; G 1.1372 P: 0.7138; G 3.2201, P: 0.9273; G 0.143, P: 0.2947; G 0.0036, P 0.0478, respectively.

Although the zoophagous species dominated in the list of species, the most numerous specimens were saprophages quantitatively (e.g. *Syritta pipiens* (LINNAEUS, 1758) – 122 individuals, *Eristalis tenax* (LINNAEUS, 1758) – 113, *E. arbustorum* (LINNAEUS, 1758) – 71, *Eristalinus aeneus* (SCOPOLI, 1763) – 58).

Dominant among the collected flies were the Palearctic species (50%), while the Holarctic (16.46%) and Western Palearctic (15.85%) species also had a large share. The smallest share belongs to the species with a partial Oriental and Afrotropical range, and cosmopolitan species (0.61–2.44%).

Particularly noteworthy are the Syrphidae species that are rarely observed in Poland or occurring only locally in large numbers.

Blera fallax (LINNAEUS, 1758)

Material: 01.05.2020, Bukowno (Diabla Góra), 1M (male), on hawthorn flowers.

Occupies habitats located in forests with pine or spruce. Larvae develop in hollows in pine trees (Vujić et al., 2020).

Brachypalpus chrysites (EGGER, 1859)

Material: 'IX' 1968 (Pustynia Błędowska), 1M, leg. R. Januszek, det. Bańkowska R. (coll, MiIZ PAN). Record is based on a museum collection. According to label data, the specimen was probably collected in the Błędów Desert in 1968. The label was handwritten and there is confusion if 'IX' refers to September which is very unlikely for *B. chrysites* or it is just miswriting of 'IV' April. It is a rare mountain and spring species associated with rich Beech-*Abies* forests. Larvae develop in wet humus on tree cavities (Speight, 2011). Suitable habitats still occur in the east part of Błędów Desert where old beech forest is still present. Numbers of field surveys in spring time during this study in order to rediscover this species in the area were unsuccessful.

Callicera aenea (FABRICIUS, 1777)

Material: 19.05.2015, Ujków Stary (road by the park), 1M, leg. Mielczarek Ł.; 19.05.2015, Ujków Stary, 1M, leg. Mielczarek A.

This is a rare species that prefers deciduous forests with old trees. Larvae are still unknown, but most probably they develop in hollows of deciduous trees. Flight period is from late April to August (Speight, 2011). Threat category – NT on the Red List of Endangered Animals in Poland.

Chalcosyrphus piger (FABRICIUS, 1794)

Material: 18.05.2015, Klucze (Czubatka), 3M, leg. A. Mielczarek.

Although this species prefers pine and spruce stands, which in Poland occupy huge areas, adults are rarely caught. It can be abundant locally under appropriate conditions. Imagines can be found on pine wood yards and on flowers of *Ranunculus*, *Seseli* and *Potentilla erecta*. Flight period is from May to August. Larvae are known to develop under pine bark in wet tree humus formed from the frass of *Ips* and *Acanthocinus* (Speight, 2011). It is a rarely caught species. Threat category is DD on the Red List of Endangered Animals in Poland.

Cheilosia aerea (DUFOUR, 1848)

Material: 19.05.2015, Ujków Stary, 1M, leg. Mielczarek Ł.; 01.05.2020, Pustynia Błędowska (Chechło), 4F (females), leg. Mielczarek Ł.; 06.06.2021, Ujków Stary (ecological site), 1F, leg. Mielczarek Ł.; 06.06.2021, Ujków Stary (ecological site), 9M, leg. Mielczarek Ł.; 10.06.2021, Ujków Stary (Armeria), 2M, leg. Mielczarek Ł.; 10.06.2021, Ujków Stary (Armeria), 1F, leg. Mielczarek Ł.; 23.05.2021, Ujków Stary (ecological site), 1M, leg. Mielczarek Ł.; 23.05.2021, Ujków Stary (ecological site), 4F, leg. Mielczarek Ł.

This species occupies thermophilic deciduous forests and dry grasslands; found in March–June and August–September. They are undescribed larvae, but most likely associated with *Verbascum* (Vujić et al., 2020).

Cheilosia barbata (LOEW, 1857)

Material: 02.07.2015, Ujków Stary, 1M, leg. Mielczarek Ł.; 16.08.2015, Ujków Stary, 3F, leg. Mielczarek Ł.; 28.05.2020, Olkusz (Krucza Góra), 1M, leg. Mielczarek Ł.

It occurs locally in moist deciduous forests and at edges of meadows, clearings and undeveloped pastures and other open areas. Phytophagous larvae; imagines feed on pollen, nectar, honeydew. Flight period is from May to June. Larvae not described, but most likely associated with the roots of *Primula* plants (Vujić et al., 2020).

Table 1. Hoverfly species recorded from the study area.

No.	Species	EZ	GT	DET.	Site									
					US	H	B	Kl	Ry	Ro	Ra	P	Σ	OPN
1	*Anasimyia contracta* CLAUSSEN & TORP, 1980	Pal	SW	ŁM			+						1	
2	*Blera fallax* (LINNAEUS, 1758)	Pal	S	ŁM			+						1	+
3	*Brachypalpus chrysites* EGGER, 1859	E-K	S	RJ				+					1	
4	*Brachyopa insensilis* COLLIN, 1939	W-Pal	S	ŁM	+								4	
5	*Brachypalpus laphriformis* (FALLEN, 1816)	E	S	ŁM			+						1	+
6	*Callicera aenea* (FABRICIUS, 1777)	Pal	S	AM, ŁM	+								2	
7	*Chalcosyrphus nemorum* (FABRICIUS, 1805)	Hol	S	ŁM				+					1	
8	*Chalcosyrphus piger* (FABRICIUS, 1794)	Hol	S	AM				+					3	
9	*Chalcosyrphus valgus* (GMELIN, 1790)	Pal	S	ŁM	+								1	+
10	*Cheilosia aerea* DUFOUR, 1848	W-Pal	F	ŁM	+			+					23	
11	*Cheilosia albitarsis* (MEIGEN, 1822)	Hol	F	ŁM	+	+							5	+
12	*Cheilosia barbata* LOEW, 1857	E	F	ŁM	+								4	+
13	*Cheilosia bergenstammi* (BECKER, 1894)	W-Pal	F	ŁM	+		+						3	+
14	*Cheilosia caerulescens* (MEIGEN, 1822)	E	F	ŁM				+	+				7	+
15	*Cheilosia carbonaria* EGGER, 1860	Pal	F	AM, ŁM	+	+		+					7	+
16	*Cheilosia chrysocoma* (MEIGEN, 1822)	Pal	F	ŁM				+					1	+
17	*Cheilosia fasciata* SCHINER & EGGER, 1853	E	F	ŁM								+	5	+
18	*Cheilosia flavipes* (PANZER, 1798)	W-Pal	F	AM, ŁM		+							2	
19	*Cheilosia gigantea* (ZETTERSTEDT, 1838)	Pal	F	ŁM			+	+					3	+
20	*Cheilosia himantopus* (PANZER, 1798)	E	F	AM				+					1	+
21	*Cheilosia illustrata* (HARRIS,1776)	Pal	F	AM, ŁM	+		+	+					8	+
22	*Cheilosia impressa* LOEW, 1840	Pal	F	ŁM				+					3	+
23	*Cheilosia latifrons* (ZETTERSTEDT, 1843)	Pal	F	ŁM					+				1	+
24	*Cheilosia longula* (ZETTERSTEDT, 1838)	Pal	M	ŁM	+								17	
25	*Cheilosia morio* (ZETTERSTEDT, 1838)	Pal	F	ŁM				+					1	+
26	*Cheilosia nigripes* (MEIGEN, 1822)	Pal	F	ŁM	+								6	+
27	*Cheilosia pagana* (MEIGEN, 1822)	Hol	F	AM, ŁM	+	+							6	+
28	*Cheilosia proxima* (ZETTERSTEDT, 1843)	Pal	F	AM, ŁM	+								3	+

(*Continued*)

Table 1. Continued.

No.	Species	EZ	GT	DET.	Site									
					US	H	B	Kl	Ry	Ro	Ra	P	Σ	OPN
29	*Cheilosia scutellata* (FALLÉN, 1817)	Pal	M	AM, ŁM	+			+					3	+
30	*Cheilosia ruffipes* (PREYSSLER, 1793) = *soror* (ZET.)	Pal	M	ŁM	+						+		3	
31	*Cheilosia semifasciata* BECKER, 1894*	E	F	ŁM									1	+
32	*Cheilosia urbana* (MEIGEN, 1822)	W-Pal	F	ŁM				+					2	+
33	*Cheilosia variabilis* (PANZER, 1798)	Pal	F	ŁM	+			+					2	+
34	*Cheilosia vernalis* (FALLÉN, 1817)	Pal	F	ŁM	+								7	+
35	*Cheilosia vicina* (ZETTERSTEDT, 1849)	W-Pal	F	AM, ŁM			+	+					7	+
36	*Chrysotoxum bicinctum* (LINNAEUS, 1758)	Pal	Z	AM	+					+			2	+
37	*Chrysotoxum cautum* (HARRIS,1776)	W-Pal	Z	AM, ŁM	+			+					14	+
38	*Chrysotoxum festivum* (LINNAEUS, 1758)	Pal	Z	AM, ŁM	+			+		+			13	+
39	*Chrysotoxum vernale* LOEW, 1841	Pal	Z	AM, ŁM	+		+	+					17	+
40	*Chrysotoxum verralli* COLLIN, 1940	W-Pal	Z	ŁM					+				1	
41	*Criorhina asilica* (FALLEN, 1816)	E	S	ŁM			+						1	+
42	*Criorhina berberina* (FABRICIUS, 1805)	W-Pal	S	ŁM	+								1	+
43	*Criorhina ranunculi* (PANZER, 1804)	Pal	S	ŁM			+						1	+
44	*Dasysyrphus albostriatus (*FALLÉN, 1817)	Pal	Z	AM, ŁM	+								9	+
45	*Dasysyrphus hilaris* (ZETTERSTEDT, 1843)	Pal	Z	AM, ŁM	+			+					7	+
46	*Dasysyrphus neovenustus* SOSZYŃSKI & MIELCZAREK, 2013	Pal	Z	AM, ŁM	+			+					9	
47	*Dasysyrphus pauxillus* (WILLISTON, 1887)	Hol	Z	ŁM			+						1	
48	*Dasysyrphus tricinctus* (FALLÉN, 1817)	Pal	Z	AM, ŁM	+			+					13	+
49	*Dasysyrphus venustus* (MEIGEN, 1822)	Hol	Z	AM, ŁM	+			+					4	+
50	*Didea alneti* (FALLÉN, 1817)	Hol	Z	AM, ŁM	+		+	+					8	+
51	*Didea intermedia* LOEW, 1854	Pal	Z	AM, ŁM	+								3	
52	*Epistrophe diaphana* (ZETTERSTEDT, 1843)	Pal	Z	ŁM	+								2	
53	*Epistrophe eligans* (HARRIS, 1780)	W-Pal	Z	AM, ŁM	+		+	+					5	+
54	*Epistrophe flava* DOCZKAL AND SCHMID, 1994	Pal	Z	AM, ŁM	+		+						3	
55	*Epistrophe melanostoma* (ZETTERSTEDT, 1843)	W-Pal	Z	ŁM				+					2	
56	*Epistrophe nitidicollis* (MEIGEN, 1822)	Hol	Z	AM, ŁM	+		+						5	+
57	*Epistrophe ochrostoma* (ZETTERSTEDT, 1849)	Pal	Z	AM	+								1	

(*Continued*)

Table 1. Continued.

No.	Species	EZ	GT	DET.	Site									
					US	H	B	Kl	Ry	Ro	Ra	P	Σ	OPN
58	*Epistrophella euchroma* (KOWARZ, 1885)	W-Pal	Z	AM, ŁM	+		+						4	+
59	*Episyrphus balteatus* (DE GEER, 1776)	Pal+Orient	Z	AM, ŁM	+			+					20	+
60	*Eristalinus aeneus* (SCOPOLI, 1763)	C	SW	AM, ŁM	+								58	+
61	*Eristalinus sepulchlaris* (LINNAEUS, 1758)	Pal+Orient	SW	AM	+								1	+
62	*Eristalis arbustorum* (LINNAEUS, 1758)	Hol	SW	AM, ŁM	+			+					71	+
63	*Eristalis nemorum* (LINNAEUS, 1758)	Hol	SW	AM, ŁM	+			+					15	+
64	*Eristalis pertinax* (SKOPOLI, 1763)	E-K	SW	AM, ŁM	+			+					19	+
65	*Eristalis picea* (FALLÉN, 1817)	Pal	SW	AM				+					2	
66	*Eristalis pseudorupium* KANERVO, 1938	Pal	SW	ŁM				+					1	
67	*Eristalis similis* (FALLÉN, 1817)	Pal	SW	AM	+								6	
68	*Eristalis tenax* (LINNAEUS, 1758)	C	SW	AM	+			+					113	+
69	*Eumerus ovatus* (LOEW, 1848)	E-K	F	ŁM	+								15	
70	*Eupeodes bucculatus* (RONDANI, 1857)	E-K	Z	AM	+								1	
71	*Eupeodes corollae* (FABRICIUS, 1794)	Pal+Afr	Z	AM, ŁM	+								5	+
72	*Eupeodes luniger* (MEIGEN, 1822)	Pal	Z	AM, ŁM	+			+					2	+
73	*Eurinomyia lineata* (FABRICIUS, 1787)	Pal	SW	ŁM	+								8	
74	*Fagisyrphus cinctus* (FALLÉN, 1817)	E-K	Z	AM, ŁM	+								1	+
75	*Ferdinandea cuprea* (SCOPOLI, 1763)	Pal	S	ŁM	+		+	+					5	+
76	*Hammerschmidtia ferruginea* (FALLÉN, 1817)	Hol	S	ŁM				+					1	
77	*Helophilus hybridus* LOEW, 1846	Hol	SW	ŁM	+								1	+
78	*Helophilus pendulus* (LINNAEUS, 1758)	Pal	SW	AM, ŁM	+			+					9	+
79	*Helophilus trivittatus* (FABRICIUS, 1805)	Pal	SW	AM, ŁM	+			+					6	+
80	*Lapposyrphus lapponicus* (ZETTERSTEDT, 1838)	Hol	Z	AM, ŁM	+			+				+	6	+
81	*Leucozona inopinata* DOCZKAL, 2000	Pal	Z	ŁM				+					1	
82	*Leucozona lucorum* (LINNAEUS, 1758)	Hol	Z	ŁM			+						1	+
83	*Megasyrphus erraticus* (LINNAEUS, 1758)	Pal	Z	AM				+					2	+
84	*Melangyna ericarum* (COLLIN, 1946)	E	Z	H- BS				+					2	
85	*Melangyna lasiophthalma* (ZETTERSTEDT, 1843)	Hol	Z	ŁM				+				+	10	+
86	*Melangyna lucifera* NIELSEN, 1980)	Pal	Z	ŁM				+					4	+

(*Continued*)

Table 1. Continued.

No.	Species	EZ	GT	DET.	Site									
					US	H	B	Kl	Ry	Ro	Ra	P	Σ	OPN
87	*Melangyna pavlovskyi* (VIOLOVITSH, 1956)	Pal	Z	ŁM				+				+	9	+
88	*Melangyna quadrimaculata* VERRALL, 1873	Pal	Z	AM, ŁM				+					1	+
89	*Melangyna umbellatarum* (FABRICIUS, 1794)	Hol	Z	AM, ŁM	+								3	+
90	*Melanogaster hirtella* (LOEW, 1843)	E	SW	ŁM			+						1	
91	*Melanogaster nuda* (MACQUART, 1829)	W-Pal	SW	AM	+								1	+
92	*Melanogaster parumplicata* (LOEW, 1840)	E	SW	AM, ŁM	+			+					2	
93	*Melanostoma mellinum* (LINNAEUS, 1758)	Hol	Z	ŁM	+								18	+
94	*Meligramma triangulifera* (ZETTERSTEDT, 1843)	Pal	Z	AM		+							1	+
95	*Merodon equestris* (FABRICIUS, 1794)	C	F	ŁM		+							2	+
96	*Merodon moenium* (WIEDEMANN, 1822)	E-K	F	ŁM				+					2	
97	*Microdon analis* (MACQUART, 1842)	Pal	Z	ŁM			+						1	
98	*Microdon mutabilis* (LINNAEUS, 1758)	Pal	Z	ŁM	+			+					10	
99	*Myathropa florea* (LINNAEUS, 1758)	Pal	S	AM	+			+					5	+
100	*Neoascia meticulosa* (SCOPOLI, 1763)	W-Pal	SW	ŁM		+	+						2	+
101	*Neoascia podagrica* (FABRICIUS, 1775)	Pal	SW	ŁM	+								1	+
102	*Neoascia tenur* (HARRIS, 1780)	W-Pal	SW	ŁM	+								2	+
103	*Neocnemodon larusi* (VUJIĆ, 1999)	E	Z	AM				+					2	+
104	*Neocnemodon vitripennis* (MEIGEN, 1822)	Pal	Z	AM	+								2	+
105	*Orthonevra brevicornis* (LOEW, 1843)	W-Pal	SW	ŁM			+						1	+
106	*Orthonevra geniculata* (MEIGEN, 1830)	Pal	SW	ŁM	+		+						7	
107	*Orthonevra nobilis* (FALLEN, 1817) *	Pal	SW	ŁM									1	+
108	*Paragus albifrons* (FALLEN, 1817)	Pal	Z	AM						+			1	
109	*Paragus constrictus* SIMIC, 1986	Pal	Z	ŁM	+		+						4	
110	*Paragus haemorrhous* MEIGEN, 1822	Hol+Afr	Z	ŁM	+		+	+					9	+
111	*Paragus pecchiolii* RONDANI, 1857	W-Pal	Z	ŁM			+	+	+				3	
112	*Parasyrphus annulatus* (ZETTERSTEDT, 1838)	Pal	Z	AM	+		+	+					16	+
113	*Parasyrphus punctulatus* (VERRALL, 1873)	Pal	Z	AM, ŁM	+		+						3	+
114	*Parasyrphus vittiger* (ZETTERSTEDT, 1843)	Pal	Z	AM, ŁM	+								3	+
115	*Parhelophilus frutetorum* (FABRICIUS, 1775)	W-Pal	SW	AM, ŁM			+	+					5	

(*Continued*)

Table 1. Continued.

No.	Species	EZ	GT	DET.	Site									
					US	H	B	Kl	Ry	Ro	Ra	P	Σ	OPN
116	*Parhelophilus versicolor* (FABRICIUS, 1794)	Pal	SW	AM, ŁM			+	+					3	+
117	*Pelecocera scaevoides* (FALLEN, 1817)	W-Pal	M	AM, ŁM	+		+						10	
118	*Pelecocera tricincta* MEIGEN, 1822	W-Pal	M	AM, ŁM	+		+						4	
119	*Pipiza austriaca* MEIGEN, 1822	Pal	Z	AM, ŁM				+					3	+
120	*Pipiza festiva* MEIGEN, 1822	Pal	Z	AM	+								3	
121	*Pipiza lugubris* (FABRICIUS, 1775)	E-K	Z	AM, ŁM	+								2	+
122	*Pipiza noctiluca* (LINNAEUS, 1758)	W-Pal	Z	ŁM			+						1	+
123	*Pipiza quadrimaculata* (PANZER, 1804)	Pal	Z	AM				+					1	+
124	*Pipizella annulata* (MACQUART, 1829)	E	Z	AM, ŁM	+								10	
125	*Pipizella viduata* (LINNAEUS, 1758)	W-Pal	Z	AM, ŁM	+		+	+					29	+
126	*Pipizella virens* (FABRICIUS, 1805)	Pal	Z	ŁM				+			+		2	+
127	*Platycheirus albimanus* (FABRICIUS, 1781)	Hol	Z	AM, ŁM	+	+	+	+					17	+
128	*Platycheirus ambiguus* (FALLEN, 1817)	Pal	Z	AM	+								1	
129	*Platycheirus angustatus* (ZETTERSTEDT, 1843)	Pal	Z	ŁM	+								1	+
130	*Platycheirus clypeatus* (MEIGEN, 1822)	Hol	Z	ŁM				+					1	+
131	*Platycheirus discimanus* (LOEW, 1871)	Hol	Z	ŁM			+						3	+
132	*Platycheirus europaeus* GOELDLIN, MAIBACH & SPEIGHT, 1990	Pal	Z	AM, ŁM	+	+	+						8	+
133	*Platycheirus fulviventris* (MACQUART, 1829)	Pal	Z	ŁM	+								1	
134	*Platycheirus immarginatus* (ZETTERSTEDT, 1849)	Hol	Z	ŁM			+						1	
135	*Platycheirus peltatus* (MEIGEN, 1822)	Pal	Z	ŁM	+								3	+
136	*Platycheirus scutatus* (MEIGEN, 1822)	Hol	Z	AM, ŁM	+			+					11	
137	*Psilota atra* (FALLÉN, 1817)	W-Pal	S	AM, ŁM				+					2	
138	*Rhingia rostrata* (LINNAEUS, 1758)	W-Pal	K	AM, ŁM	+								3	+
139	*Scaeva pyrastri* (LINNAEUS, 1758)	Hol	Z	AM, ŁM	+								2	+
140	*Scaeva selenitica* (MEIGEN, 1822)	Pal	Z	AM, ŁM	+			+					9	+
141	*Sericomyia lappona* (LINNAEUS, 1758)	Pal	SW	ŁM			+						1	
142	*Sphaerophoria batava* GOELDLIN, 1974	Pal	Z	ŁM	+		+	+					8	+
143	*Sphaerophoria rueppellii* (WIEDEMANN, 1830)	Pal+Afr	Z	AM	+								1	

(*Continued*)

Table 1. Continued.

No.	Species	EZ	GT	DET.	Site									
					US	H	B	Kl	Ry	Ro	Ra	P	Σ	OPN
144	*Sphaerophoria scripta* (LINNAEUS, 1758)	Pal	Z	AM, ŁM	+	+	+	+					25	+
145	*Sphaerophoria taeniata* (MEIGEN, 1822)	Pal	Z	ŁM	+	+	+	+					6	+
146	*Sphegina sibirica* STACKELBERG, 1953	Pal	S	ŁM			+						1	
147	*Sphiximorpha subsesilis* (ILLIGER IN ROSSI, 1807)	W-Pal	S	ŁM	+								2	+
148	*Spilomyia diophtalma* (LINNAEUS, 1758)	Pal	S	ŁM	+			+					2	+
149	*Syritta pipiens* (LINNAEUS, 1758)	C	K	AM, ŁM	+			+					122	+
150	*Syrphus ribesii* (LINNAEUS, 1758)	Hol	Z	AM, ŁM	+								8	+
151	*Syrphus torvus* OSTEN-SACKEN, 1875	Hol	Z	AM, ŁM	+	+	+	+					30	+
152	*Syrphus vitripennis* MEIGEN, 1822	Hol	Z	AM	+								9	+
153	*Temnostoma meridionale* KRIVOSHEINA et MAMAEV, 1962	E-K	S	ŁM				+					2	+
154	*Temnostoma vespiforme* (LINNAEUS, 1758)	Pal	S	ŁM	+			+					2	+
155	*Triglyphus primus* LOEW, 1840	Pal	Z	ŁM	+								1	
156	*Tropidia scita* (HARRIS, 1780)	Pal	SW	ŁM			+						3	
157	*Volucella inanis* (LINNAEUS, 1758)	Pal	Z	AM, ŁM	+								4	+
158	*Volucella pellucens* (LINNAEUS, 1758)	Pal	SG	AM, ŁM	+								4	+
159	*Volucella zonaria* (PODA, 1761)	Pal	SG	ŁM									1	
160	*Xanthandrus comtus* (HARRIS, 1776)	Pal	Z	AM, ŁM	+								5	+
161	*Xanthogramma citrofasciatum* (DE GEER, 1776)	W-Pal	Z	ŁM				+					1	+
162	*Xanthogramma pedissequum* (HARRIS, 1780)	E	Z	AM, ŁM	+		+			+			17	+
163	*Xylota florum* (FABRICIUS, 1805)	Pal	S	ŁM			+						1	
164	*Xylota segnis* (LINNAEUS, 1758)	Hol	S	AM, ŁM	+		+	+					17	+
165	*Xylota sylvarum* (LINNAEUS, 1758)	Pal	S	ŁM				+					1	+

*Specimen caught in Olkusz.

Σ, number of specimens collected; AM, Anna Mielczarek; Afr, Afrotropical; BS, Bogusław Soszyński; B, Bukowno; C, cosmopolitan; DET., detected; E, European; E-K, Euro-Caucasian; EZ, zoogeographical element; F, phytophagous; GT, tropic group; H, Hutki; H, historical statement; Hol, Holarctic; ŁM, Łukasz Mielczarek; K, coprophage; Kl, Klucze; M, mycophagus; ONP, Ojcowski National Park; Orient, Oriental; P, Pazurek; Pal, Palearctic; Ra, Rabsztyn; RJ, R. Januszek; Ro, Rodaki; Ry, Ryczów; S, terrestrial saprophage; SW, aquatic saprophage; SG, nest-dwelling saprophage; US, Ujków Stary; W-Pal, West-Palearctic; Z, zoophagus.

Cheilosia caerulescens (MEIGEN, 1822)

Material: 05.08.2017, Ryczów (limestone inselbergs), 1F, leg. Mielczarek Ł.; 06.2020, Klucze (limestone inselbergs), 3M, leg. Mielczarek Ł.; 08.2020, Klucze (limestone inselbergs), 3F, leg. Mielczarek Ł.

A species found in calcareous grasslands, gardens with *Sempervivum*. Larvae undescribed. The peak of the outbreak is in May and August (Speight, 2011).

Cheilosia fasciata (SCHINER ET EGGER, 1853)

Data published in Żóralski and Mielczarek (2021).

The species occurs in mountainous areas in moist, shady deciduous forests with *Allium ursinum* L. and *A. victorialis* (Schmid and Grossmann, 1998). Larvae (one per leaf) mine the leaves of *Allium* (Renema, 1999).

Cheilosia himantopus (PANZER, 1798)

Material: 31.05.2015, Klucze (Pustynia Błędowska), 1F, leg. Mielczarek A.

Found in moist deciduous forests with a host plant of the *Petasites* genus. Imagines found in May on the flowers of the Apiaceae and Asteraceae families (Vujić et al., 2020).

Cheilosia latifrons (ZETTERSTEDT, 1843)

Material: 05.08.2017, Ryczów, 1M, leg. Mielczarek Ł.

It occurs in deciduous mesophilic forests and within mountain grasslands. Flight period runs from May to August. Imagines visit flowers from the Apiaceae, Asteraceae families. Biology of the larvae remains unknown (Vujić et al., 2020).

Cheilosia longula (ZETTERSTEDT, 1838)

Material: 02.07.2015, Ujków Stary, 1F, leg. Mielczarek Ł.; 16.08.2015, Ujków Stary, 11F, 5M, leg. Mielczarek Ł.

It is found in deciduous and coniferous forests. Flight period is in August, when imagines can be found on flowers of Apiaceae, Asteraceae, *Achillea, Euphorbia* and *Galium*. Larvae develop on fungi of the family Boletaceae (Vujić et al., 2020).

Cheilosia morio (ZETTERSTEDT, 1838)

Material: 30.03.2019, Kuźnica Błędowska, 1M, leg. Mielczarek Ł.

The larvae were described on the basis of the material collected on spruce, in resinous leakages caused by *Dendroctonus micans* (Bańkowska, 1961). Flight period is from March till beginning of May.

Cheilosia nigripes (MEIGEN, 1822)

Material: 19.05.2015, Ujków Stary, 1M, leg. Mielczarek Ł.; 23.05.2021, Ujków Stary (ecological site), 1F, leg. Mielczarek Ł.; 23.05.2021, Bolesław (staw na ‘’Pasterniku’’), 1M, leg. Mielczarek Ł.; 23.05.2021, Bolesław (staw na “Pasterniku”), 1F, leg. Mielczarek Ł.; 23.05.2021, Ujków Stary (Armeria), 1F, leg. Mielczarek Ł.; 23.05.2021, Ujków Stary (Armeria), 1M, leg. Mielczarek Ł.

Adult forms can be found in grasslands or in open deciduous forests from April to June. Imagines visit flowers from Apiaceae, *Euphorbia*, *Prunus* and *Ranunculus*. Larvae are unknown (Vujić et al., 2020).

Cheilosia scutellata (FALLÉN, 1817)

Material: 31.05.2015, Pustynia Błędowska, 1M, leg. Mielczarek A.; 26.07.2015, Klucze (Czubatka), 1M, leg. Mielczarek Ł.; 16.08.2015, Ujków Stary, 1M, leg. Mielczarek Ł.

It is a forest species. Flight is from May to October. Imagines visit plants from Apiaceae, *Crataegus*, *Galium*, *Hedera*, *Hieracium*, *Ranunculus* and *Sorbus*. Larvae develop in fungi of the Boletaceae family (Vujić et al., 2020).

Cheilosia semifasciata (BECKER, 1894)

Observation: 05.2015, Olkusz, 1F, obs. Mielczarek Ł. on *Hylotelephium spectabile*,

Data presented in Żóralski and Mielczarek (2021).

The species occurs in dry deciduous forests, cliffs, strongly sunlight. It is associated with the sites of *Hylotelephium telephium* and *Hylotelephium maximum* (Rotheray, 1988).

Cheilosia ruffipes (PREYSSLER, 1793) = *soror* (ZETTERSTEDT, 1843)

Material: 21.07.2018, Rabsztyn (castle hill), 2M, leg. Mielczarek Ł.; 23.07.2017, Ujków Stary, 1M, leg. Mielczarek Ł.

This species prefers deciduous forests. Imagines found from April to October when they visit flowers from Apiaceae, Asteraceae, *Foeniculum vulgare*, *Taraxacum* and *Cirsium*. Larvae are in the fruiting bodies of *Tuber* truffle*s* (Speight, 2011).

Epistrophe diaphana (ZETTERSTEDT, 1843)

Material: 16.08.2015, Ujków Stary, 1F, leg. Mielczarek Ł.; 06.06.2021, Ujków Stary (ecological site), 1M, leg. Mielczarek Ł.

It cccurrs in wetlands/forests and rivers and streams in deciduous woodland, including carr; also in unimproved, montane grassland. Aduls visit white umbellifers: *Foeniculum*, *Senecio*. Flight period is in May/August (with peak in July) and on into September in southern Europe (Speight, 2011).

Epistrophe flava (DOCZKAL AND SCHMID, 1994)

Material: 23.06.2014, Ujków Stary, 1ex., leg. Mielczarek A.; 06.06.2021, Ujków Stary (ecological site), 1F, leg. Mielczarek Ł.; 06.06.2021, Bukowno (Diabla Góra), 1M, leg. Mielczarek Ł.

It Preferred deciduous forest. Found on meadows, roadsides, forest edges. Flower visited: *Berberis vulgaris*, *Crataegus*, *Tilia cordata*, *Ranunculus* etc. Found to be active in June and July. Larvae described from aphid galls on *Malus* (Speight, 2011).

Epistrophe ochrostoma (ZETTERSTEDT, 1849)

Material: 02.05.2014, Ujków Stary, 1F, leg. Mielczarek A.

Species occur in the conifer and deciduous forest. They visit flowers of *Salix repens*, *Prunus padus*, *Ranunculus ficaria*. Adults can be found during the

period from May to June. Larvae undescribed (Speight, 2011). Threat category – VU on the Red List of Endangered Animals in Poland.

Eumerus ovatus (LOEW, 1848)

Material: 19.05.2015, Ujków Stary, 1M, leg. Mielczarek Ł.; 10.06.2021, Ujków Stary (Armeria), 10M, 4F, leg. Mielczarek Ł.

It occupies open, thermophilic forests and dry, open, calcareous grasslands rich in vegetation. Flight period is from May to July and it is a rare species. Larvae, probably phytophagous, develop in bulbs or rhizomes of host plants. Imagines visit flowers (Vujić et al., 2020).

Eupeodes bucculatus (RONDANI, 1857)

Material: 26.07.2015, Ujków Stary, 1M, leg. Mielczarek A.

Found in deciduous riverside forests with the participation of poplars, willows and birches. Flight period runs in April/May and July/August. Imagines visit flowers from the Asteraceae, *Euphorbia*, *Nartecium*, *Salix*, *Sorbus* and *Stellaria*. Aphidophagous larvae are found on aphids on *Cirsium arvense* (Vujić et al., 2020).

Megasyrphus erraticus (LINNAEUS, 1758)

Material: 18.05.2015, Klucze (Czubatka), 2F, leg. Mielczarek A.

It is found in coniferous forests with *Abies*, *Picea* and *Pinus*. It visit flowers of various plant eg. *Calluna vulgaris*, *Cirsium vulgare*, *Crataegus*, *Prunus spinosa*, *Stellaria* sp. in the period from May to September (Speight, 2011). Although sparse, locally occurring populations tend to be numerous.

Melangyna aff. ericarum (COLLIN, 1946)

Material: 02.05.1994, Pustynia Błędowska, 1F, leg. Soszyński B. det. Soszyński B. det. Mielczarek Ł.

This is new for Poland, but known in Great Britain (Scottish highlands), Denmark, Netherlands, Germany, Czech Republic, France, Switzerland, and Italy (Speight, 2011). Despite probably being associated with Scots Pine forest, it is a rarely collected species. Stubbs and Falk (2002) stated that species occur in native woods of Scots Pine but also in a fen far away from stands with pines. In Sweden occur in alpine heaths close to *Pinus mugo* (Bartsch, 2009b). Features of our specimen fit well with existing identification keys to *Melangyna* species although in general appearance (e.g. broader abdomen) it resembles more *M. lucifera* and *M. lasiophthalma* than the summer *M. umbellatarum*. Stubbs and Falk (2002) stated that the posterior part of the fore and middle femora should have black hairs. In our specimen, the second femur has completely white hairs and the first one only a few. *Melangyna* are presumably univoltine in Europe and occurrence of *M. ericarum* in spring in Poland is quite confusing despite records from the Western Europe show summer months. In our opinion, it is worth to review scarce *M. ericarum* material to check if it is the only one probable bivoltine species or it is a complex of two or more species differing in flight period.

Melangyna pavlovskyi (VIOLOVITSH, 1956)

Material: 10.04.2021, Pazurek, 2M, leg. Mielczarek Ł.; 10.04.2021, Pazurek, 1F, leg. Mielczarek Ł.; 11.04.2021, Kuźnica Błędowska, 1F, leg. Mielczarek Ł.; 01.03.2020, Pazurek, 3M, leg. Mielczarek Ł.; 01.03.2020, Pazurek, 2F, leg. Mielczarek Ł.

It is a common species, inhabiting forest clearings, forest edges, parks and thickets. It occurs in March and April. Larvae are aphidophagous; adults feed on pollen and nectar. The species behaves like an invasive and recently recorded as new for Europe (Bygebjerg, 2011; Mielczarek, 2011) and rapidly extending its range in other countries (van de Meutter et al., 2015). Recorded from Belgium, Denmark, Netherlands, Slovakia; France (Langlois and Speight, 2020), Asiatic Russia (Sakhalin) and Japan.

Melanogaster hirtella (LOEW, 1843)

Material: 01.05.2020, Bukowno (Diabla Góra), 1F, leg. Mielczarek Ł.

It occurs in wetlands, fens, marshes, poorly-drained pastures, along woodland streams or field drains, beside lakes, ponds and rivers. Adults visit white umbellifers, *Caltha*, *Euphorbia*, *Iris pseudacorus*, *Menyanthes*, *Mimulus guttatus*, *Potentilla erecta*, *Pyrus communis Ranunculus*, *Sorbus aucuparia*, *Taraxacum* and *Viburnum opulus*. Flight period: end April/July. Larvae aquatic, associated with various aquatic plants, including *Glyceria* and *Typha* (Speight, 2011). The species was recorded only at Białowieża Primeval forest in Poland by Soszyński (1999). This record was based on one specimen reported by Theo Zeegers and Sander Turrnhout (Dijkstra and Kalkman, 1996). Record of this Atlantic species from Białowieża PF is unlikely and needs further study. The specimen from Diabla Góra was collected on flowering *Crataegus monogyna* at the top of the hill. Areas with marshes – potential habitat of *Melanogaster* larvae are present very close to Diabla Góra, in old sand mine Szczakowa where other aquatic hoverflies were present in numbers.

Melanogaster parumplicata (LOEW, 1840)

Material: 01.05.2020, Bukowno (Diabla Góra), 1F, leg. Mielczarek Ł.

Environment: open ground/forest/freshwater; close to water-bodies in river-flood plain grassland and alluvial forest. Adults visit flowers of umbellifers, *Caltha*, *Crataegus*, *Prunus spinosa*, *Ranunculus*, *Rhamnus cathartica* and *Taraxacum*. Flight period: Mid May/ Mid August, with peak in June. Larvae: undescribed (Speight, 2011).

Microdon mutabilis (LINNAEUS, 1758)

Material: 25.05.2018, Klucze (Czubatka), 1M, leg. Mielczarek Ł.; 10.06.2021, Ujków Stary (Armeria), 6M, leg. Mielczarek Ł.; 10.06.2021, Ujków Stary (Armeria), 3F, leg. Mielczarek Ł.

It is a rare species. It develops in open ground; sparsely-vegetated, dry, rocky ground appropriate for ant nests; unimproved pasture and grassy clearings

in forest. It occurs in May to July. Larvae develop in colonies of *Formica* ants, feeding on their eggs and larvae (Speight, 2011).

Neocnemodon larusi (VUJIĆ, 1999)

Material: 18.05.2015, Klucze (Czubatka), 2F, leg. Mielczarek A.

The species found in clearings in deciduous and mixed forests (Bartsch, 2009a). It is an undescribed larvae, collected by Ł. Mielczarek from spruce galls.

Neocnemodon vitripennis (MEIGEN, 1822)

Material: 13.07.2014, Ujków Stary, 1F, leg. Mielczarek A.; 13.07.2014, Ujków Stary, 1M, leg. Mielczarek A.

The larvae of the species are predators found in the *Dreyfusia piceae* colonies on fir trees and on coccidia on the black poplar, Italian form. A typical habitat is forest paths and forest edges. It flies from May to October with peak occurrence in June and July (Stubbs and Falk 2002).

Orthonevra geniculata (MEIGEN, 1830)

Material: 03.05.2021, Bukowno (sand mine), 2F, leg. Mielczarek Ł.; 01.05.2020, Bukowno (Sztoła), 4M, leg. Mielczarek Ł.

It is a Spring species, often found on the edge of forests with *Salix* or *Alnus* spp. (Bartsch, 2009a). It prefers mid-forest lakes, springs and periodically flooded area (Żóralski and Trzciński, 2015).

Pelecocera scaevoides (FALLÉN, 1817)

Material: 13.09.2015, Ujków Stary, 1F, leg. Mielczarek A.; 05.2019, Bukowno (Diabla Góra), 9F, leg. Mielczarek Ł.

They prefer coniferous forests, especially Pinus. Adults flight in open woodland, clearings etc. They visited flowers of *Myosotis*, *Cerastium* and *Potentilla* in June/September. Larvae are apparently phytophagous (Speight, 2011).

Pelecocera tricincta (MEIGEN, 1822)

Material: 13.09.2015, Ujków Stary, 1F, leg. Mielczarek A.; 07.2018, Bukowno (Spacerowa), 1M, leg. Mielczarek Ł.; 10.06.2021, Bolesław (Armeria), 1M, leg. Mielczarek Ł.; 23.05.2021, Bolesław (Staw na "Pasterniku"), 1M, leg. Mielczarek Ł.

Species found in conifer forests, tracksides, clearings etc. They visited flowers: *Calluna vulgaris*, *Cirsium palustre*, *Hieracium*, *Ranunculus* and *Sedum acre*. Fly period is from June to September (Speight, 2011).

Pipizella annulata (MACQUART, 1829)

Material: 13.07.2014, Ujków Stary, 1M leg. Mielczarek A.; 13.07.2015, Ujków Stary, 1M, leg. Mielczarek A.; 26.07.2015, Ujków Stary, 1F, leg. Mielczarek A.; 02.07.2015, Ujków Stary, 2M, leg. Mielczarek Ł.; 02.07.2015, Ujków Stary, 1F, leg. Mielczarek Ł.; 16.08.2015, Ujków Stary, 1F, leg. Mielczarek Ł.; 26.07.2015, Ujków Stary, 2M, leg. Mielczarek Ł.; 26.07.2015, Ujków Stary, 1F, leg. Mielczarek Ł.

Rare thermophilic species, and can therefore be found on xerothermic grasslands (Stennis and Stennis, 1997).

Platycheirus ambiguus (FALLÉN, 1817)

Material: 19.05.2015, Ujków Stary, 1F, leg. Mielczarek A.

Occurs in deciduous forests; scrub-invaded clearings in woodland and forests, scrub-edged tracks in woodland. Adults visit flowers: *Acer pseudoplatanus*, *Crataegus*, *Prunus mahaleb*, *P. spinosa*, *Pyrus communis*, male flowers of *Salix* spp. (including *S. repens*), *Sorbus aucuparia, Viburnum*. Flight period: beginning April/end May. Larva is aphidophagous (Speight, 2011).

Psilota atra (FALLÉN, 1817)

Material: 07.05.2019, Klucze (Czubatka), 1F, leg. Mielczarek Ł.; 01.05.2014, Klucze (Czubatka), 1M, leg. Mielczarek A. (data published in Żóralski, 2018).

Species is connected with coniferous forests of *Pinus* spp. Adults often drink at damp mud in hot weather. They visited flowers of *Crataegus*, *Salix* etc. in the period May to June (Speight, 2011).

Rhingia rostrata (LINNAEUS, 1758)

Material: 16.08.2015, Ujków Stary, 2F, leg. Mielczarek Ł.; 02.05.2014, Ujków Stary, 1F, leg. Mielczarek A.

Species connected with deciduous forest and scrubs with rich grand flora. Flies visiting flowers in small glades: *Centaurea*, *Cirsium*, *Geranium*, *Hypericum* and *Veronica*. Flight period is from May to August (Speight, 2011).

Sphegina sibirica (STACKELBERG, 1953)

Material: 14.06.2021, Bukowno, 1F, leg. Mielczarek Ł.

The species occurs in moist, deciduous forests with birch and coniferous trees. Adults visit pignut flowers and possibly other umbellifers. It occurs in June and July (Stubbs and Falk, 2002). Larva is undescribed (Bartsch, 2009a).

Spilomyia diophtalma (LINNAEUS, 1758)

Material: 26.07.2015, Klucze, 1F, leg. Mielczarek Ł.; 23.07.2017, Ujków Stary, 1F, leg. Mielczarek Ł.

Species is similar to *S. manicata*. Imagines visit flowers such as *Angelica sylvestris*. It occurs in mixed and deciduous forests with old aspen in the period from July to August. The larvae develop in rotten hollows of deciduous trees (Bartsch, 2009a).

DISCUSSION

Syrphid adults belonging to the Diptera order are valuable pollinators (Dunn et al., 2020). As many as 415 species of hoverflies have already been recorded that are living in Poland (Żóralski and Kowalczyk, 2015). They occupy various types of habitats including meadows, forest clearings and gardens (Oosterbroek, 2006; Soszyński, 2007). In Polish literature, there are

no reports on hoverflies in industrial and post-industrial areas characterised by a high degree of environmental contamination with heavy metals (Zn, Cd and Pb).

Heavy metals have a negative effect on living organisms, including insects. Their toxicity is manifested, for example, in the increased mortality of insects (Moroń et al., 2012), changes in the sex structure and a decrease in the number of brood cells in the species *Osmia rufa* (Moroń et al., 2013), shortening of the lifespan (Stone et al., 2001), a change in body weight of individuals caught in contaminated areas compared to those in uncontaminated ones (Moroń et al., 2013; Stone et al., 2001; Zygmunt et al., 2006), changes in morphological structures (Polidori et al., 2018) or wing asymmetry in *Polistes nimpha* (Mielczarek et al., 2021). Moroń et al. (2012) observed a decrease in the number of species of the genus *Osmia* with an increase in the concentration of heavy metals in their living environment. However, a similar relationship was not found by Szentgyörgyi et al. (2011) in bumblebee taxa. Grześ (2009), in her study of ants from areas contaminated with heavy metals, found an increase in the species with richness of ants along with an increase in the Zn content in the soil. Eeva et al. (2004) found no differences in the number of *Formica* ant species caught in a contaminated area in relation to the control area. Also, Migliorini et al. (2004) included ants in a study comparing the responses of various arthropod communities to contamination with heavy metals, mainly Pb and Sb, but found no clear relationship. Similarly, Nahmani and Lavelle (2002) analysed the diversity of species with the richness of arthropods (Coleoptera, Diptera, Lepidoptera, Hymenoptera, and Hemiptera) developing in soils contaminated with heavy metals. The authors did not consider species richness in relation to individual taxa, but only determined its total size for individual sites. The authors found the lowest species richness on the site characterised by the highest degree of contamination.

As a result of our research work, we collected 165 syrphid species out of 415 Syrphidae species found in Poland (39.76%). As a comparative site, we selected the area of the Ojców National Park, 20 km away from Olkusz, as the closest and the best studied area in terms of the Syrphidae fauna. In the ONP, 176 (excluding questionable species such as *Pipiza bimaculata*, noted in ONP) species from this family had been found (Klasa and Soszyński, 2011; Mielczarek and Klasa, 2017) – 11 species more than those reported in our research area (OOR). When comparing the results of the two studies, it should be emphasised that the research conducted in the ONP lasted almost 30 years (1986–2008, 2008–2015), while the present study is conducted for only 7 years.

The variety of habitat types within which the sites were selected should also be emphasised – in the ONP, the research area was more varied (it covered various types of habitats, such as: rock grasslands, hay meadows, herbaceous plants, mixed forests, oak-hornbeam forest, stream valley and Carpathian beech forest). Our research was conducted mainly in ruderal areas or ones heavily transformed by industrial activities.

As a result of our observations in the research area, we recorded 112 species with syrphid taxa that were the same as those identified in the ONP (68.29%). Like in the ONP, zoophagous species also dominated in our study, which is consistent with the tendency of the hoverfly trophic dominance. The percentages of individual trophic groups in the research area and the ONP were similar i.e.: predators accounted for 48.48% in the research area and 46.59% in the ONP, water saprophages – 16.37% and 13.07%, terrestrial saprophages – 13.94% and 18.18%, nest saprophage – 1.21 and 1.14, phytophages – 15.76 and 18.75, mycophages – 3.03% and 0.57% and coprophages – 1.21% and 1.7%, respectively. There were no significant differences among groups on using the G test. Heavy metals tend to accumulate at successive trophic levels (Zhang et al., 2021). Predatory insects seem to be more exposed to the negative effects of exposure to these substances than, for example, phytophages or saprophages. The effects of heavy metal bioaccumulation in the bodies of insects are well-known and may influence on their mortality, physiology etc. All this factors should lead to decrease the abundance of predatory species in the contaminated areas compared to the control areas. Gospodarek and Jaworska (2001) showed that on *Vicia fabae* plants growing on soils enriched with heavy metals, more numerous colonies of *Aphis fabae* Scop. occurred. Authors also observed lower number of syrphid larvae feeding in aphid colonies compared to the control. Stolpe et al. (2017) report that in the case of hyperaccumulators, heavy metals contained in plant tissues reduce the feeding of phytophages. In our research we did not find significant differences among trophic groups in OOR and ONP. The obtained results do not indicate that heavy metals have an effect on trophic structure of Syrphidae. Nevertheless, it seems justified to extend the research on syrphid larvae which are less mobile than adults and thus constitute a better model to study the impact of heavy metals on this taxon.

Among the collected syrphids, common and numerous species, such as: *Eristalis arbustorum* (LINNAEUS, 1758), *Eristalis tenax* (LINNAEUS, 1758), *Episyrphus balteatus* (DE GEER, 1776), *Syritta pipiens* (LINNAEUS, 1758) and *Myathropa florea* (LINNAEUS, 1758), as well as rare species were noted. Eleven of the collected species have been included in the 'Red List of Endangered Animals in Poland': *Callicera aenea* (FABRICIUS, 1777) (NT category), *Chalcosyrphus piger* (FABRICIUS, 1794) (DD), *Brachypalpus chrysites* EGGER, 1859 (LC), *Epistrophe ochrostoma* (ZETTERSTEDT, 1849) (VU), *Hammerschmidtia ferruginea* (FALLÉN, 1817) (DD), *Orthonevra geniculata* (MEIGEN, 1830) (DD), *Rhingia rostrata* (LINNAEUS, 1758) (DD), *Sericomyia*

lappona (LINNAEUS, 1758) (NT), *Sphegina sibirica* STACKELBERG, 1953 (LC), *Spilomyia diophtalma* (LINNAEUS, 1758) (NT), and *Temnostoma vespiforme* (LINNAEUS, 1758) (DD) (Banaszak et al., 2002).

A very rare species *Melangyna ericarum* (COLLIN, 1946) was caught in this region (the Błędowska Desert) by Soszyński 27 years ago and it is still the only record of this rare species in Poland.

Interestingly, on our research site, *Volucella bombylans* (LINNAEUS, 1758) – a common species whose larvae are associated with nests of bumblebees, was not found. Bumblebees are present in the investigated research area, which was confirmed by the research of Szengyorgyi et al. (2011). It would be valuable to investigate the sensitivity of this species to heavy metals in future research.

Klasa and Soszyński (2011) state that the number of hoverflies indicated by them in the ONP may indirectly result from the large diversity of the fauna of vascular plants occurring in this area (approximately 950 species). Taking into account of the existing food webs, the individual elements such a plant on which aphids – source of food for zoophagous larvae – develop, are crucial for the occurrence of this group of hoverflies. Therefore, the species diversity of the flora in the study area seems to be significant. On the other hand, white or yellow flowers characterised by a shallow calyx structure are a source of pollen necessary for laying eggs by female Syrphidae.

Our research was conducted in a theoretically hostile environment due to strong anthropopressure, but despite this fact, this environment was also rich in diverse vegetation (736 species). It should be emphasised that 47% of the plants available there were rare or very rare species, and the lowest percentage of all the taxa were common species (Nowak et al., 2015). Therefore, in the future, it would be valuable to conduct field observations determining the role of hoverflies in the pollination of rare and protected plants occurring in the area of this study.

The richness of Syrphidae species has also been studied in other protected areas. Żóralski et al. (2017), in their research, which was conducted since 1978, reported 163 Syrphidae species from the Świętokrzyski National Park. Among them were 17 species from the Red List. Also, Żóralski and Kowalczyk (2019) reported 168 species caught in the Trójmiejski Landscape Park. Trzciński and Sienkiewicz (2006), during 1-year observations, recorded the occurrence of 42 species of hoverflies in the area of the Wielkopolski National Park. The richness of the syrphid species has also been studied in the area of the Wigry National Park – 171 species (Żóralski et al., 2017), the Western Beskids – 106 species (Żóralski and Dubiel, 2020) and in the massif of Babia Góra – 101 species (Palaczyk and Klasa, 2003).

Comparing our results with the species richness in the protected areas mentioned above, it can be concluded that the area studied by us is rich and diverse in terms of Syrphidae fauna, not inferior in its richness even to areas recognised as unique in terms of nature.

CONCLUSIONS

On the basis of the obtained results, it can be concluded that the studied area was not characterised by a lower species diversity in comparison with regions where contamination with heavy metals is not so significant. Moreover, the collected samples were usually characterised by a relatively large variety, although indeed some species, such as *Syritta pipiens* (LINNAEUS, 1758) or *Eristalinus aeneus* (SCOPOLI, 1763), dominate, especially in open areas.

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AUTHOR CONTRIBUTIONS

A.M. – collection, identification of research material, writing the paper. Ł.M. – collection, identification of research material, writing an article. E.W.-Ż. – designed the experiment, writing and correcting the manuscript.

CONFLICT OF INTEREST

We inform that the manuscript has not been submitted for publication elsewhere. All co-authors have contributed to this article and all have agreed to submit it into this journal. There is no conflict of interests.

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