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WROCŁAW – WARSZAWA – KRAKÓW – GDAŃSK
ZAKŁAD NARODOWY IMIENIA OSSOLIŃSKICH
WYDAWNICTWO POLSKIEJ AKADEMII NAUK
1980

MEMORABILIA ZOOLOGICA, VOLUME 33, 1980

World-list abbreviation: Memorabilia Zool.

The volume has been edited by
ELŻBIETA ZOLICH

Polish Academy of Sciences
Institute of Zoology
ul. Wilcza 64, 00-679 Warszawa, Poland

PL ISSN 0076-6372
ISBN 83-04-00555-7

Printed in Poland

Zakład Narodowy im. Ossolińskich — Wydawnictwo Polskiej Akademii Nauk. Wrocław, Oddział w Warszawie 1980. Wydanie I. Nakład: 750 egz. Objętość: 6,70 ark. wyd.; 6,00 ark. druk: 7,98 ark. A1. Papier druk. sat. III kl. 80 g B1, 70×100. Oddano do składania 28 XII 1979 r. Podpisano do druku 4 IV 1980. Wydrukowano w kwietniu 1980 r. w Warszawskiej Drukarni Naukowej przy ul. Śniadeckich 8; nr zam.: 787/79.
Cena 30,00 zł

POLISH ACADEMY OF SCIENCES • INSTITUTE OF ZOOLOGY

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REGINA BAŃKOWSKA

FLY COMMUNITIES OF THE FAMILY *SYRPHIDAE* IN NATURAL AND ANTHROPOGENIC HABITATS OF POLAND

ABSTRACT

An attempt has been made to distinguish syrphid associations in nature, taking their relation to the habitat as a starting point.

The quantitative analysis of the material shows that these dipterans, inhabiting various habitats in Poland, form 8 major communities, each of them being made up of 4 associations distinguished on the basis of food habits of larvae. These are associations of zoophages, phytophages, terrestrial saprophages, and aquatic saprophages. The diversity of syrphid associations is related to food supply and humidity of the habitat. These two factors are particularly limiting for saprophagous and phytophagous syrphids.

The structure of syrphid associations is particularly affected by anthropogenic pressure. In both urbi- and agrocoenoses the number of species decreased and the abundance of dominants increased. These are mainly species with high ecological amplitude (eurytopic), mostly polyphagous, and with large geographical ranges. Many of them have high fecundity and produce several generations a year. Moreover, the abundance of predators markedly increased, while the abundance of the other three associations was reduced.

INTRODUCTION

OBJECTIVE AND SCOPE OF THE STUDY

The faunistic studies on dipterans of the family *Syrphidae* carried out so far, have been of a fragmentary character and involved small areas of Poland [2—5]. In this paper an attempt has been made to prepare a comprehensive review of the material collected in typical habitats of Poland. One of the more promising trends developed recently in faunistic studies is an analysis of the relationships between animal communities and habitat conditions, including the associated plant cover.

The aim of the study was 1) to distinguish the communities, and, within them, the associations of *Syrphidae* in typical units of the landscape of Poland, to determine their species composition and structure; 2) to determine to what a degree the human activity which changes habitat conditions can influence the species composition and structure of some syrphid associations.

The study involves the structure of syrphid associations in natural or little transformed habitats, as well as changes occurring in them under heavy anthropogenic pressure in urban ecosystems, croplands, and in areas subjected to some branches of industry and mining.

ORIGIN OF THE SYRPHIDS OF POLAND

The family *Syrphidae* belongs to the suborder *Brachycera-Cyclorrhapha.* Phylogenetically the *Cyclorrhapha* occupy the highest position of all the dipterans, having evolved relatively most recently, probably in the Lower Cretaceous period, from the suborder *Asilomorpha* [15, 16]. Rohdendorf [36], who made attempts at creating a new classification of dipterans which would reflect actual relationships among them, used both palaeontological materials and morphological characters of adults and larvae. He derived the superfamily *Syrphoidea* from the primitive superfamily *Platypezidea* that in the mid-Cretaceous period had diverged into the *Syrphoidea* and a hypothetical group *Protoschizophora,* from which *Calyptratae* and *Acalyptratae* developed.

A luxuriant development of melliphagous insects such as dipterans, lepidopterans and hymenopterans coincided with a rich development of angiospermous plants in the Upper Cretaceous and the early Tertiary periods. Palaeobotanists suggest that a high differentiation and large distribution of angiospermous plants were related to the cooling and gradual drying of the climate, as due to this new forestless biotopes were formed where herbaceous plants could rapidly develop [42]. Changes in the flora and, particularly, a rapid development of flowering plants, were followed by the speciation of melliphages. It is possible that the genera of *Syrphidae* existing at present were formed early in the Tertiary period. The earliest fossil syrphids are known from the Eocene [17]. Most well-presented syrphids were found in the Baltic amber from the Oligocene. The majority of the syrphid genera living now are known from this epoch.

The Pleistocene glaciations largely destroyed the flora and fauna of Central Europe. When the post-glacial tundra retreated northward, Poland was dominated by pine-birch mixed forests. When the climate grew warmer they were replaced by multispecies broad-leaved forests with the hornbeam, oaks, ash, maple, and hazel. It may be assumed that syrphids living at that time were similar to those living in broad-leaved forests now, and only in small forestless areas, moors and riverine meadows the fauna specific of grassland communities could be developed. Human management (clearing of forests, settlements, agriculture and pasturage) extended open areas and accounted for an expansion of the species associated with herbaceous plants. With increasing deforestation the habitats of syrphids associated with forests were largely reduced, thus they had to look for new food resources. Gradually they colonized all orchards and gardens, as well as some crop fields. At present, the species associated with both forests and grasslands are a permanent component of the agricultural landscape of Poland.

Most probably, the species composition of syrphids occurring in Central Europe, including Poland, represents a mixture of several genetic groups. Euro-Siberian and boreal elements in the fauna of Poland are remains of the taiga of the post-glacial period. The European species (most species of the genus *Cheilosia*) came from southern and western Europe with broad-leaved forests rich in herbs and undergrowth. The submediterranean and Pontic species, scarce in our fauna, derive from southern Europe and east-European steppes.

REVIEW OF MAJOR TROPHIC GROUPS AND GEOGRAPHICAL DISTRIBUTION OF SYRPHIDS

Flies of the family *Syrphidae* differ largely in their habitat requirements and food habits of larvae. They mostly inhabit forests but many species occur also in open areas such as meadows, crop fields, mountain meadows, or moors. Some dipterans, like a group of species of the subfamily *Pelecocerinae*, prefer xerothermal habitats such as sands, coastal dunes and inland dunes. Other syrphids are associated with broad-leaved forests and they live in humid decaying plant material. Some syrphids mine leaves, twigs, or belowground parts of living plants. A large group of hover flies (about 25%) lives in aquatic habitats, mostly in small mudded water bodies, soggy places in mountains, artificial drainage channels, and marshes. Some species are predators. Most of them belong to aphidophages. Only species of the genus *Volucella* are adapted to life in the nests of wasps and bumble-bees, while the species of the genus *Xanthandrus* feed mainly on the scale insects.

It is difficult to distinguish trophic groups of syrphid larvae since the diet of particular species is poorly known and, moreover, it is not sure if saprophagous larvae, feeding mostly on dead plant parts, cannot in some cases feed on live tissues, and conversely. Similarly, it is not known if the predatory larvae of *Volucella* feed on dead or on live larvae of hymenopterans, whether they are predators or cleaners of wasp nests.

All adult syrphids are melliphages, thus it is difficult to associate particular species with definite habitats. Adult hover flies can cover vast areas in search of food such as pollen and nectar.

The larvae of syrphids can be classified into three major trophic groups: phytophages, saprophages, and zoophages.

Phytophages

The phytophagous larvae belong to three groups of hover flies, taxonomically rather distant. Some authors even classify them into three subfamilies: *Cheilosiinae, Merodontinae,* and *Eumerinae.* Also genetically and ecologically they represent three different elements. The species of the genus *Cheilosia* are associated with woodlands, mainly with wet broad-leaved forests and with herbaceous vegetation of the temperate zone. This is visible in the distribution of the species of this genus in both the Palaearctic region and North America [18]. This genus probably evolved separately early in the Tertiary and developed parallel groups of species.

The genera *Merodon* and *Eumerus* occupy open areas of xerothermal character. The species of the genus *Merodon* originate from the Pontic region. They found suitable conditions in the steppes of the Black Sea region, where there are plenty of bulbous plants and other plants with fleshy rhizomes and tubers. The species of the genus *Eumerus* inhabit mostly dry steppes and semi-arid areas of Central Asia and the Mediterranean basin. The centre of the development divergence of these species was likely to be in Asia Minor [37].

The larvae of the genus *Cheilosia* feed mostly on live tissues of herbaceous plants. Some of them mine leaf blades, other live in twigs, or in belowground plant parts. Some species, e.g. *Cheilosia scutellata,* feed on tissues of mushrooms.

So far, little is known of food specialization in the species of this genus, and only in few cases the host plant is known. The lack of interest in the genus *Cheilosia* results from the fact that so far these syrphids have not been met in crop fields, thus they are not of economic importance to horticulture and agriculture.

The genus *Cheilosia* is richly represented in the fauna of Poland. It involves about 60 species, or about 90% of the Central-European fauna. Most species occur in the mountains, particularly in the lower montane forest zone and in the submontane zone, which are predominated by humid deciduous forests with rich undergrowth and tall perennial forbs. A little less species occur in the upper montane forest zone (subalpine zone), covered almost exclusively with spruce forests nearly without undergrowth. Only several species reach the alpine and subnival zones.

The richness of phytophagous species in the mountains is mostly related to a great diversity of habitats and a high soil moisture favouring a luxuriant development of tall perennial forbs being host plants for many hover flies. In addition, mountain areas are relatively little subjected to human activity, thus they support almost unchanged, natural plant communities. Stream valleys of the submontane and the lower montane zones are covered by alder carrs with the grey alder (*Alnus incana*) and a rich herb layer. Both in the lower and the upper montane zones, near water effusions and along streams, there are various tall perennial forbs with large leaves and fleshy stems, such as *Archangelica officinalis, Aconitum, Doronicum,* and *Petasites kablikianus.* Thick stems of the latter plant are inhabited by larvae of *Cheilosia canicularis,* one of the most abundant species in the mountains. The stems of the thistles *Carduus crispus* and *C. nutans* are occupied by the larvae of *Ch. chloris* and *Ch. cynocephala.* Larval *Ch. gigantea* and *Ch. variabilis* live in roots of *Scrophularia nodosa.* Larval *Ch. maculata* and *Ch. fasciata* mine galleries in leaf blades of *Allium ursinum.* The larvae of *Ch. semifasciata* develop in fleshy leaves of stonecrops (*Sedum*).

Several species of the genus *Cheilosia* occur only in the mountains. They include *Ch. montana* (also met in the Alps), *Ch. chrysocoma* (in addition to the Carpathians and the Alps, occurring also in the Altai mountains and in other high Siberian mountains), *Ch. sahlbergi,* and *Ch. nasutula.* Some mountain species occur also in the lowland, but in considerably lower numbers. They inhabit mostly woodlands, particularly larger natural forests such as the Białowieża Wilderness and beech forests of West Pomerania or Lower Silesia. This group includes *Ch. illustrata, Ch. coerulescens, Ch. rhynchops,* and already mentioned *Ch. canicularis.* In the lower montane, upper montane and alpine zones of the Bieszczady mountain range, *Ch. canicularis* is the dominant species, and it accounts for 16% of all syrphids caught in this area [4]. This is a similarly common species in the Tatras, the Beskids, and the Sudetes, while in the lowland it is rare and occurs singly.

Many mountain species of this genus inhabit also lowlands, mainly woodlands such as oak-hornbeam forests, beech forests, and carrs. Some species, e.g. *Ch. albitarsis* and *Ch. variabilis,* occur mainly in wet forests such as alder swamps or carrs, while *Ch. vernalis, Ch. ruralis,* and *Ch. pagana* prefer open areas, mostly moist and wet meadows. Most common of them, *Ch. vernalis,* lives in stems of *Sonchus oleraceus* and *Matricaria chamomilla.* This species most successfully adapted to habitat conditions transformed by man, occurring abundantly in fields, gardens, and also in the urban green.

This survey shows that the genus *Cheilosia* forms a rather uniform group of species with similar ecological requirements. Their geographical distribution is almost exclusively restricted to the Holarctic region. They inhabit the temperate zone where the plant cover is represented by broad-leaved deciduous forests. Some species are adapted to more rigorous climate and occur in boreal coniferous forests of the taiga type.

An analysis of the geographical distribution of 90 species occurring in Poland, shows that 46% of them represent the European element, 23% belong to the Euro-Siberian species associated with taiga and reaching the eastern margin of Asia, 21% are mountain and boreal-mountain species, and the remaining 10% are the species widely distributed over the Palaearctic region. Many of them, e.g. *Ch. scutellata*, *Ch. mutabilis*, or *Ch. albitarsis*, are common over the country and are adapted to various habitat conditions.

The hover flies of the genus *Merodon* are native of the steppes north of the Black Sea. Their larvae feed on belowground plant parts, mainly on bulbs and fleshy rhizomes. In Poland they can find suitable habitat conditions only in few places such as xerothermal enclaves with preserved remains of the steppe vegetation. Most species occur only in southern part of Poland, mainly in the submontane zone and in the lower montane zone. *M. spinipes* is a more frequently met species. It sporadically occurs throughout Poland, in warm oak-hornbeam forests, xerothermal oak forests, and on xerothermal calcareous hills covered with steppe vegetation.

Only one species of this genus, *Merodon equestris*, is adapted to decorative plants cultivated by man, and it became an important pest of hyacinths and narcissus, living on their bulbs. Under natural conditions it occurs in small numbers in the meadows of submontane and lower montane zones. In addition, it is met all over Poland in human settlements, particularly in the plantations of decorative bulbous plants. Due to man, *M. equestris* is rather widely distributed in Europe, and recently it has been carried with bulbs to North America [46]. The other species have small ranges restricted to the Mediterranean and Black Sea regions, and few of them reach Central Europe.

Another group feeding on belowground plant parts consists of larvae of the genus *Eumerus*. It is commonly believed that these are saprophagous larvae, feeding on dead plant material. However, it has recently been found that they cause great damage to vegetables in Central Asia. Among others, they destroy plantations of carrot and onion [38]. In Poland, two species are pests of vegetable plants: *E. strigatus* and *E. tuberculatus*. Particularly the former is a permanent component of the fauna of our fields and gardens, and it frequently produces outbreaks. The two species feed not only on onion but also on turnip, carrot, potato tubers, and even on the rhizome of decorative plants, thus their diet is rather rich and diversified. Both of them have large geographical ranges covering the whole Palaearctic region, and recently they have been brought over to North America. The other species are very rare in Poland. They mainly occur in the southern part of the country, in the submontane and montane zones. Some of them occasionally occur in other regions of Poland, mostly on xerothermal sites with remains of the steppe vegetation.

The species of the genus *Eumerus* inhabit South and Central Europe, North Africa, Asia Minor, southern Siberia, Central Asia, and India.

The phytophagous *Syrphidae* of Poland are dominated by the European element, which accounts for 36.5% (Tab. 1). This is mainly due to the presence of many species of the genus *Cheilosia*, closely associated with the zone of broad-leaved forests of Central Europe. Also the Euro-Siberian and Mediterranean elements are rich, accounting for 21% and 15% respectively, the latter due mostly to the occurrence of the species of the genera *Eumerus* and *Merodon* in the group of xerophilous phytophages. The mountain species associated with alpine vegetation are relatively rich as they account for 10% of the phytophagous syrphids.

Table 1. Percentage of zoogeographical elements in trophic groups of syrphids estimated on the basis of species composition of the fauna of Poland

Trophic groups \ Zoogeographical elements	Cosmopolitan	Holarctic	Palaearctic	Euro-Siberian	European	Boreal	Mountain	Submediterranean
Zoophages	1.0	36.0	14.5	29.0	14.5	1.5	1.5	2.0
Phytophages	—	4.0	8.0	21.0	36.5	5.5	10.0	15.0
Terrestrial saprophages	—	14.0	10.0	43.0	31.0	1.0	1.0	—
Aquatic saprophages	2.5	19.0	19.0	42.5	12.0	2.5	2.5	—

Saprophages

Saprophagous larvae of hover flies have greatly diversified food and habitat requirements. Two major groups can be distinguished: terrestrial saprophages and aquatic saprophages.

Some larvae of terrestrial saprophages live in partly decomposed plant material such as decaying bulbs, rhizomes, and roots. This group is represented by the species of the genera *Rhingia*, *Syritta*, and *Tropidia*. Their larvae often develop in the dung of cattle, and are typical coprophages. Among natural habitats they occupy mainly wet oak-hornbeam forests, carrs, and alder swamps. Moreover, they occur in pastures and near farm buildings. *Tropidia scita* can be caught in large amounts on wet meadows covered with stagnant water. Relatively little is known of food habits of the larvae of the subfamily *Spheginінae*. Hover flies of the genus *Neoascia* being the member of this subfamily, are abundant on stream banks and in wet meadows. Their larvae were found in decaying stems of butterburs. Syrphids of the genus *Sphegina* are rare, single specimens being recorded mainly in broad-leaved forests, often in the mountains. Larvae of the most frequent species, *Sphegina clunipes*, were found in humid, decaying wood.

Also larvae of almost the whole subfamily *Milesiinae* feed on wood in different stages of decomposition. The species of the genera *Spilomyia* and *Temnostoma* feed on still hard wood of trunks of broad-leaved trees and they are considered as typical xylophages. The species of the genera *Brachypalpus* or *Criorrhina* prefer more decomposed wood. The larval development of many saprophagous hover flies occurs in humid, rich in detritus holes of both broad-leaved and coniferous trees. Larval *Callicera* were met in holes of pines and beeches, larvae of the genus *Brachyopa* in injured trunks of elms and willows, larval *Pocota apiformis* and *Ferdinandea cuprea* in holes of oaks and other broad-leaved trees. Also larvae of the genus *Mallota*, subfamily *Eristalinae*, were caught in holes of broad-leaved trees. Decaying and humid trunks of broad-leaved trees are inhabited by larvae of the genera *Myolepta* and *Calliprobola* and of the two species of the genus *Cerioides*. Also the majority of larvae of the genus *Xylota* live on decaying wood. Saprophagous hover flies associated with decaying wood occur mostly in oak-hornbeam forests, beech forests, carrs, alder swamps, and, rarely, in coniferous forests, except for bog pine forests and moor-grass coniferous forests. A distinct group of saprophages consists of the hover flies of the subfamily *Sericomyiinae*. Their occurrence depends on the presence of marshy soils with a high content of humus. These syrphids are frequently met in wet deciduous forests, at margins of water bodies, and in moors.

Zoogeographical analysis of the distribution of particular species of terrestrial saprophages, shows that they are dominated by the Euro--Siberian elements with account for 43% (Tab. 1). Then there is the European element contributing to 32%. The species with very large geographical ranges are scarce, the Holarctic element being represented by 14% and Palaearctic element by merely 10%.

The aquatic saprophages also form a diversified group. They belong to two subfamilies: *Cheilosiinae* and *Eristalinae*.

Larval hover flies of the subfamily *Eristalinae* live in small mudded water bodies, rich in plant detritus, in ponds overgrown with vegetation, in artificial drainage channels, marshes, soggy mountain ground, oxbows, etc. They are adapted to liquid habitats, which is reflected in their morphology. The spiracle siphon is markedly elongated so that the larva submerged in mud can keep the spiracles above the water surface. Most species of the family *Eristalinae* are common over Poland, and they cover rather uniformly mountains and lowlands (Tab. 11). *Eristalis jugorum* is an exception here; it inhabits mountains of Central Europe, and in Poland it was caught only in the submontane and montane zones of the Carpathians and Sudetes. Little is known of the occurrence of some rarely caught species such as *Eristalis oestraceus, E. antrophorinus,* or *E. cryptarum.* They prefer large woodlands with wet sites, including marshes, moors, carrs, and alder swamps. Also the species of the genera *Helophilus* and *Eurinomyia* abundantly occur only in very wet habitats like alder swamps and moors. It is interesting that the hover flies of the genus *Eurinomyia* usually occur in the lowland sites of Poland. So far, only *E. frutetorum* has been caught in the submontane zone and in lower parts of the lower montane zone of the Sudetes.

Several species of the genus *Eristalis* have been synanthropized in part. Their larvae live in semi-liquid content of cesspools, manure pits, and in neglected buildings for livestock. The mass occurrence of adult syrphids, particularly *Eristalis tenax,* can be a good indicator of sanitary conditions in buildings.

Saprophagous syrphids of the subfamily *Cheilosiinae* live in stagnant water, mainly in meadows on the site of carrs, in soggy mountain areas, and in temporary flood waters. They occur in the mountains and in the lowland, and prefer open, deforested sites. Some larvae of the genus *Chrysogaster* bore the stems of aquatic plants (*Glyceria*) and use oxygen stored in air spaces [11]. Their main food consists of dead, decaying parts of submerged vegetation, but they frequently injure live tissues and account for the decay of sound plants. *Ch. viduata* is the most abundant species in Poland. In the spring it is the dominant species in wet meadows. The second rather frequently met species is *Ch. solstitialis,* also in wet meadows and in soggy mountain areas. Other species of the genera *Orthoneura, Chrysogaster,* or *Liogaster* are much rarer, single specimens being usually recorded. All these syrphids are restricted to the Palaearctic region. They are largely predominated by the Euro-Siberian element which contribute to 67%, and the other represent the European and Palaearctic elements.

The aquatic saprophages (Tab. 1) are dominated by the Euro-Siberian element (42.5%). The proportion of Holarctic and Palaearctic elements is also high (19%). But the European element contributes to only 12%. In the group of saprophages there are no submediterranean elements. These data indicate that most saprophages occurring in Poland arrived with taiga from north-central Asia in the post-glacial period, and when the climate became warmer they were enriched with European species, characteristic of warmer, broad-leaved forests.

Zoophages

The last trophic group involves predatory species. Their larvae, though legless and blind, can manage with small, little active insects, particularly those living in larger groups or colonies. The predatory larvae of syrphids prey firstly upon aphids forming colonies on leaves of trees, or on herbaceous plants, grasses, and roots of many plants. Some larvae attack scale insects, small caterpillars of lepidopterans, and *Psyllidae*. Most aphidophagous hover flies belong to polyphages, but some of them are more specialized and their diet is restricted to a narrow group or single species. For example, the larvae of *Triglyphus primus* have been found on wormwoods (*Artemisia*) in *Cryptosiphum artemisiae* Bucht. colonies, larval *Syrphus cinctus* were met in *Phyllaphis fagi* (L.) colonies on the beech (*Fagus silvatica*), larval *Heringia heringii* occur in galls of the aphid *Tetraneura ulmi* (L) on elms, and in galls of *Pemphigus bursarius* (L.) on poplars [48]. Some larvae, e.g. *Pipizella varipes*, destroy root aphids living on grasses, thus the often occur in meadows and grain crops. Some predatory species prefer open, sandy, warm areas. Here belong species of the subfamily *Pelecocerinae*, and also the species of the genus *Paragus*, caught in aphid colonies on the sea buckthorn (*Hippophaë rhamnoides*).

A distinct group is represented by myrmecophilous species. They overcome the defensive barriers of ant nests and feed on root aphids raised by ants in underground corridors. Such food habits are characteristic of larval *Doros conopseus* and of the two species of the genus *Xanthogramma*, living in nests of *Lasius alienus* Foerst., *L. flavus* Fabr., and *L. niger* L. Similarly, the larvae of the genus *Microdon* inhabit nests of the same *Lasius* species and in addition the nests of *Formica fusca* L., *F. rufa* L., and *F. rufibarbis* Fabr. All myrmecophilous syrphids occur mainly in forests, clearings, and adjacent meadows.

The larvae of a group of zoophages of the genus *Volucella* live in nests of wasps and bumble-bees, and they feed on larval hymenopterans. *Volucella zonaria* attacks nests of *Vespa crabro* L. and *V. germanica* Fabr. Larval *Volucella pellucens* were caught in nests of *Vespa vulgaris*, larval *Volucella bombylans* were most often found in nests of *Bombus lapidarius* L. and *Vespa germanica* Fabr.

A large majority of predatory syrphids are closely associated with forests, mainly broad-leaved ones, some species also inhabit pine forests. Only few predatory species are associated with open areas, particularly with meadows. Here there are included small hover flies of the genera *Sphaerophoria*, *Melanostoma*, and *Platycheirus* or *Pipizella*.

Predatory syrphids inhabit almost all continents, only few genera being restricted to the Holarctic region (*Doros*, *Didea*, or *Leukozona*) or to the Palaearctic region (*Eriozona*). The predatory syrphids of Poland have also large geographical ranges. They are dominated by the Holarctic element, which contributes to 36% of all the predatory syrphids (Tab. 1). Also the proportion of Euro-Siberian and Palaearctic elements is high.

THE ROLE OF SYRPHIDS

In both the natural and the anthropogenic ecosystems, syrphids play an important part in matter cycling, if only because of a large number of their populations and high abundance.

Phytophagous larvae have usually a positive effect on biocoenotic processes since they include into cycling a part of primary production. Only when the ecological balance is disturbed, this being most often the case in habitats subjected to heavy anthropogenic pressure, an outbreak of a species harmful to human economy can occur. In Poland, such species as *Eumerus strigatus* and *E. tuberculatus* are potential pests which under some environmental conditions can threaten root crops.

Saprophagous larvae are of great importance, particularly in breaking down and transformation of various organic substances, including wood, and also in soil-forming processes as they enrich humus with readily available organic and mineral compounds. Their sanitary role is also significant as they speed up the decomposition of dead organic matter and manure. Aquatic saprophages contribute to the purification of water bodies containing decaying organic remains, and due to this they inhibit the development of pathogenic bacteria and improve sanitary conditions in the environment.

Predatory larvae of syrphids, particularly the abundant group of aphidophages, are especially useful to man. They permanently occur in agricultural landscape and account largely for aphid control, besides golden-eyed flies and ladybirds.

All adult syrphids are melliphages. It should be emphasized that they play an important part in the pollination of entomophilous trees and herbs in natural habitats as well as in orchards and croplands. This aspect is generally disregarded; what is more, as they occur in large numbers during the period of flowering, they markedly assist bees and account for an increase in yields.

STUDY AREA, MATERIAL AND METHODS

Biogeographic studies based on the relationship between animal communities and plant communities were initiated by P a l m g r e n [32] in 1930. This direction is also followed at present and applied to analyses of many terrestrial and aquatic biocoenoses. In the face of rapid environmental changes caused by human activity, such analyses can provide basis for bioindicatory studies. Insects are very susceptible indicators of changes occurring in the environment. Often small disturbances that cannot be recorded in the structure of plant communities, are reflected in animal communities, their dominance structure or species composition being modified. Transformations in the structure of animal communities enable us to follow changes occurring in the environment, on the condition that we know the original state of a given community under natural or slightly changed conditions. Having this in mind, many materials in the present study have been collected in nature reserves, large woodlands, and in unmanaged meadows.

Adopting the scale of anthropogenic pressure on ecosystems developed by Finnish and German ecologists [19, 40], the study areas can be classified as follows. Ahemerobic habitats involve ecosystems beyond the direct effect of anthropogenic factors. In this study it will be the high-mountain zone above the timber line. The group of oligohemerobic habitats is made up of natural ecosystems subjected, often only temporarily, to anthropogenic pressure (industrial emissions, etc.). These are natural forests, dunes, moors. Mesohemerobic ecosystems are partly transformed by man but not subjected to his permanent interference. These are extensively used meadows, pastures, and some forests. Euhemerobic ecosystems are completely transformed by man and permanently managed. Here there are croplands, intensively used meadows and pastures, gardens and orchards, forest plantations and urban green areas.

The development of syrphid larvae depends on many factors, the most important of which are site moisture and fertility, thus, indirectly, the type of plant cover and associated phytophages (aphids in this case). Since plant communities are good indicators of site conditions and their distribution in Poland is generally known, their nomenclature being well established, they are used to arrange and distinguish natural associations of syrphids. Earlier studies of the author have shown that there are some relationships between syrphid communities and the type of plant cover [2, 4, 5]. Now an attempt is made to distinguish syrphid associations on the basis of large, natural plant communities, representing final stages of succession. To classify plant communities, the following contributions were used: Bury-Zalewska and Prończuk [10], Faliński [14], Kobendza [20], Kondracki [21], Kostrowicki [25], Matuszkiewicz [29], Nowiński [30], Pawłowski [33], Piotrowska [35], and Szafer [41].

The plant communities of Poland are rather distinctly geographically diversified into mountain and lowland-upland ones, covering most of the country. Severe mountain climate diversifies vertically both the plant cover and the fauna so that they are stratified in a characteristic way. In this paper the following strata are distinguished: the alpine zone (above the upper forest limit), the upper montane zone (subalpine zone), the lower montane zone, and the submontane zone.

The syrphids of the alpine zone were collected in the Tatra, the Sudetes and in the Bieszczady mountain range. Taking into account a specific character of the group, particularly a high mobility of hover flies, the zone above the timber line was considered as a unit. In sum, 71 syrphid species were found there. On the average, there were 16 specimens caught per sample, thus not many.

The syrphids of the upper montane zone were collected in the Tatra, in higher ranges of the Sudetes (the Karkonosze), and in the Babia Góra range. Tree stands of this zone consist of humid, dark spruce forests of the alliance *Piceion excelse*. A total of 90 syrphid species were caught in this zone. An average sample size was 20 specimens.

The syrphids of the lower montane and submontane zones were collected in the Sudetes, Tatra, Pieniny, Babia Góra, and Bieszczady. The main forest community of the lower montane zone is the Carpathian beech forest (*Fagetum carpaticum*). 144 syrphid species were caught there. An average sample size was 28 specimens.

The submontane zone has a more complex character. It is dominated by plant communities growing also in the lowland, but communities characteristic of the lower montane zone are present there as well. They include beech forests, communities of tall perennial forbs in stream valleys, the Carpathian alderwood (*Alnetum incanae*), and mat-grass communities (*Nardetalia*). Therefore, the submontane zone has a transitional character between the mountain and lowland vegetation type. A total of 139 syrphid species were recorded there. An average sample size was 40 specimens.

In the lowland, samples were taken in several types of grassland and forest ecosystems. The syrphids associated with moist coniferous forests (*Pineto-Vaccinietum myrtilli*) were caught in the Kampinos Forest, Pisz Forest, Białowieża Forest, Lasy Janowskie Forest in the Lublin region, and in the forests near Częstochowa. A total of 75 syrphid species were recorded there. An average sample size did not exceed 11 specimens.

The syrphids of mixed forests (*Pineto-Quercetum*) were collected in the Kampinos Forest near Warsaw, in the Białowieża Forest, and in the Kielce region near Pińczów and Jędrzejów. In these communities 83 syrphid species were caught. An average sample size was about 17 specimens.

Among multispecies broad-leaved forests growing on the lowland, the oak-hornbeam forest (*Querco-Carpinetum*) was selected. The syrphids of these forests were sampled in the Kampinos Forest, in the Radziejowice region (Warsaw province), Jura Krakowsko-Częstochowska, Pińczów region, and in the Białowieża Forest. 128 syrphid species were caught. An average sample size was 24 specimens.

Among deciduous woodlands also lowland beech forests (*Fagetum boreoatlanticum*) were under study. The syrphids of this community were caught in the Masurian Lake District (near Mikołajki and Mrągowo), on the Vistula Haff (near Tolkmicko), and in Western Pomerania (near Koszalin and the island of Wolin). Here 96 species were recorded. An average sample size did not exceed 20 specimens.

Among wet forests, alder swamps (*Alnetum glutinosae*) and riverine carrs were considered. The syrphids of alder swamps were caught in the Kampinos and Białowieża Forests. A total of 72 syrphid species were caught. An average sample size was 25 specimens.

The riverine carrs were mainly represented by the alder-ash carr (*Fraxino-alnetum*). The syrphids of this community were sampled in Radziejowice near Warsaw, in Białołęka, Skierniewice, on the river Nida near Pińczów, and in the Białowieża Forest. The syrphids of willow-poplar carrs (*Saliceto-populetum*), were caught in the Vistula valley at Jabłonna near Warsaw, Kępa Polska near Płock, and Łomna near Nowy Dwór Mazowiecki. In all riverine carrs 106 syrphid species were recorded. An average sample size was 31 specimens.

Among typical communities of open areas, xerothermal grasslands of the class *Festuco-Brometea* were under study. They often occur on gypsum, marls, limestones, and loess. The syrphids of xerothermal grasslands were collected on gypsous hills at Krzyżanowice and Skorocice near Pińczów, in loess areas near Sandomierz and Kazimierz Dolny on the Vistula, near Puławy, and near Zamość on the Lublin upland. A total of 54 syrphid species were caught. An average sample size did not exceed 15 specimens.

The next community under study represented moors. The syrphids were collected in a raised bog in the Białowieża Forest, in the nature reserve "Czerwone bagno" near Grajewo, in the transitional moor "Rakowskie Bagno" near Frampol (the province of Tarnobrzeg) and in a fen of the Sandomierz Forest. In all these habitats 70 syrphid species were recorded. An average sample size was low — 7 specimens.

Among grassland ecosystems, wet meadows of the order *Molinietalia* and moist meadows (*Arrhenatheretalia*) were sampled. The two associations are secondary communities covering forest clearings created by man (mesohemerobic habitats). The syrphids of wet meadows were collected at Młodzawy near Pińczów in the Nida valley, at Białowieża, in the region of Sochaczew, and at Nowa Wieś near Warsaw. A total of 78 syrphid species were recorded in the wet meadows. An average size sample was high — 46 specimens.

The syrphids of moist meadows were collected at Łomna near Warsaw, at Otrębusy, Podkowa Leśna, Skierniewice, and in the Nida valley near Pińczów. In these habitats 94 species were caught. An average sample size was 36 specimens.

The syrphids of anthropogenic habitats were mainly collected in agro- and urbicoenoses (euhemerobic habitats). The urban fauna was studied in Warsaw over the recent 5 years. A total of 73 syrphid species were collected. An average sample size did not exceed 10 specimens.

The syrphids of agrocoenoses were studied mainly in 1971—1975 in crop fields at Łomna near Warsaw, Chylice near Grodzisk Mazowiecki, Skierniewice near Pińczów (the province of Kielce), in the region of Sandomierz, Zamość, and near Byczyna, the province of Opole. Most important crop types were under study, such as grain crops, root crops, rape, perennial plants grown for fodder (alfalfa and clover), as well as orchards and gardens. A total of 74 syrphid species were recorded in agrocoenoses. An average sample size was 16 specimens.

The study of the areas subjected to industrial and sulphur emissions were conducted during one season. In 1976, syrphids were collected in the region of a nitrogen plant in Puławy and of a cement plant "Nowiny" near Kielce. In 1977 preliminary materials were collected at a

sulphur mine in Grzybów and at a store of dust sulphur at Dobrów near Staszów.

The study plots are shown on a map (p. 17).

The materials used to distinguish syrphid associations have been collected for many years since 1955. They were partly used for faunistic characteristics of particular regions of Poland, but most data on the structure and numbers have not been published so far. Syrphids were caught by the method of quantitative sampling per time unit, by means of an entomological mesh screen. This method consists in catching, within a given area, all hover flies of the family under study noticed in half-hour periods. In earlier papers of the author [5, 6], the representativeness of quantitative samples for the syrphids collected by this method is analysed. It has proved sufficient to take 30 half-hour samples to characterize syrphid fauna of the study area. The material used to recognize syrphid associations consisted of 36 thousand specimens.

In addition to the method of sampling per time unit, also other quantitative methods were used, such as sweeping and yellow Moerick's traps placed in tree crowns and on the ground. The two methods were used in urbi- and agrocoenoses as supplementary methods.

Preliminary studies on syrphids occurring in areas polluted with industrial emissions and sulphur, were based only on a series of sampling provided by means of Moerick's traps put on the ground in fenced study plots of the Institute of Soil Science and Cultivation of Plants in Puławy. A total of 1500 syrphid specimens were collected.

Zoogeographical analysis of the material follows the system adopted by the Centre of Faunistic Documentation of the Institute of Zoology PAS, which is mainly based on papers by Kostrowicki [22] and Olsufjev [31]. Moreover, the following contributions were used: Darlington [12], Bartenev [8], MacArthur [26], Kostrowicki [24], Udvardy [45], and Tischler [43].

SYRPHID ASSOCIATIONS IN SELECTED ECOSYSTEMS OF POLAND

CHARACTERISTICS OF THE ASSOCIATIONS

It is difficult to distinguish associations in dipterans of the family *Syrphidae* because of complex trophic relationships between them. Trophic relationships of the first order, which are of the exploitative character, occur in larvae, and they have been discussed in the Introduction. Trophic relationships of the second order, called paratrophic, occur in adult syrphids which feed on nectar and pollen. Only adult forms are melliphages and this feature joins all trophic groups of the first order in a unit, since feeding on nectar and pollen can lead to competitive relationships among syrphid species. Nutrients taken by syrphids from flowers are used not only as food but they also condition the development of ovaries, this being of basic importance to reproduction. Syrphid communities distinguished according to plant communities are based on adult individuals. So far this has been the only method of obtaining comparable quantitative materials characterizing the family, the densities of larvae being low.

A question arises whether syrphid communities distinguished on the basic of plant communities really characterize particular ecosystems or landscape zones. To answer this question, statistical methods commonly used in biocoenology have been applied. To compare syrphid communities in various sites, the Marczewski and Steinhaus [28] formula was used to determine the similarity of their species composition:

$$S = \frac{w}{a+b-w} \cdot 100$$

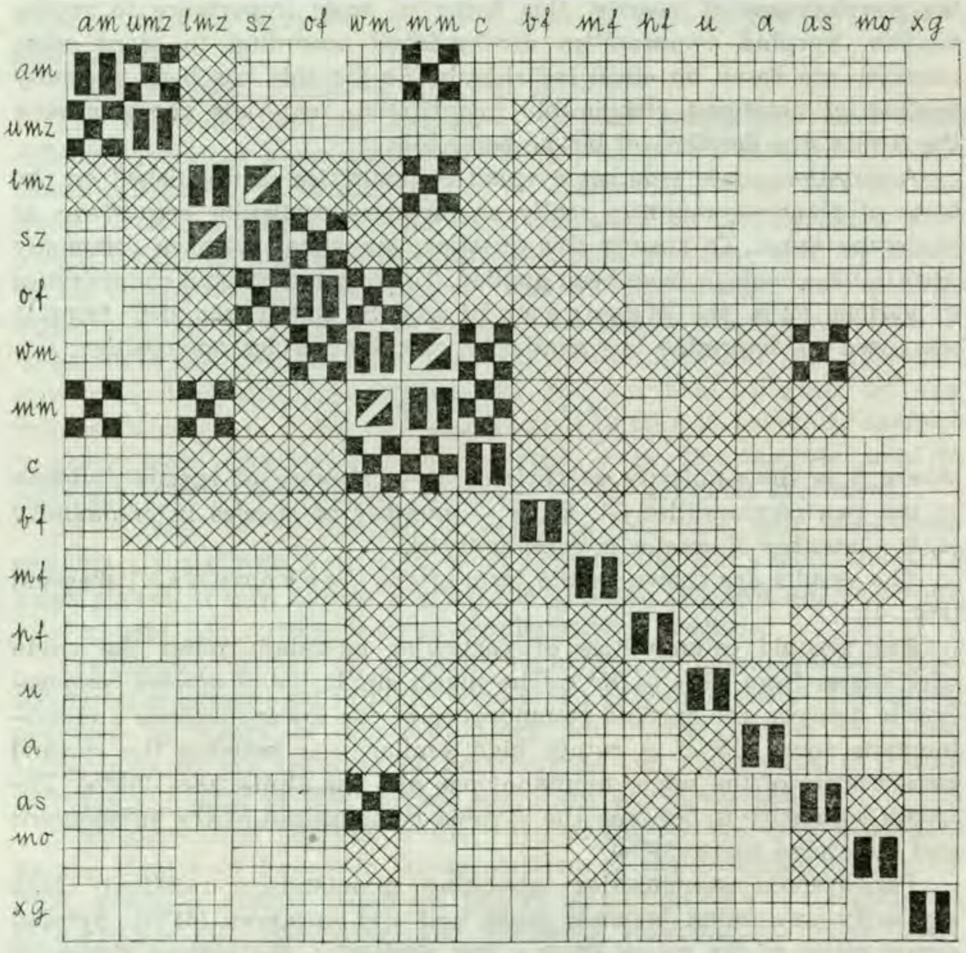
where S is the similarity coefficient, w — number of species common to the two communities (A, B), a — number of species in community A, b — number of species in community B.

The results are shown in the form of the Czekanowski diagram (Fig. 1).

For syrphid communities of particular mountain zones the value of S varies from 39% to 75%. The higest similarity of species composition is between the syrphid communities of the lower montane and submontane zones (75%). A rather high similarity is between the syrphid communities of the upper montane zone and the alpine zone (53%). The lowest similarity is between the syrphid communities of the submontane and the alpine zones (39%).

For syrphid communities inhabiting grasslands a relatively high similarity was found between moist and wet meadows (61%). Syrphid communities of the moors show a low similarity, the highest similarity being between wet meadows and alder swamps (41%), and the lowest with syrphid communities of xerothermal grasslands (22%). A still lower similarity is between the syrphid community of xerothermal grasslands and those of the other habitats (22—38%). A very low similarity is between syrphid communities of these grasslands and moist meadows. The lack of a distinct similarity in the species composition of syrphids inhabiting moors and xerothermal grasslands with syrphid communities of other ecosystem types, shows that these are extremely distinct communities.

The species composition of syrphids inhabiting forest ecosystems does not show much similarity. The value of S varies between 34 and 48%. For example, the highest similarity of 48% occurs between the Pomeranian beech forests and oak-hornbeam forests or carrs. The syrphid community of moist coniferous forests is most similar to that inhabiting mixed forests (45%).



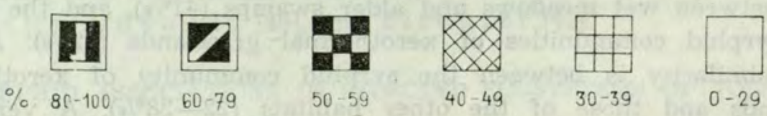


Fig. 1. Diagram of the similarity of syrphids in various habitats, calculated from M a r c z e w s k i and S t e i n h a u s' formula.
am — alpine meadows, umz — upper montane zone, lmz — lower montane zone, sz — submontane zone, mm — moist meadows, wm — wet meadows, xg — xerothermal grasslands, mo — moors, as — alder swamps, c — carrs, of — oak-hornbeam forests, bf — Pomeranian beech forests, pf — pine forests, mf — mixed forests, a — agrocoenoses, u — urbicoenoses.

It follows from the results presented above that the syrphid fauna of the mountains significantly differs from that in the lowland. Also the syrphids associated with meadows can be easily distinguished. There is a high similarity between the syrphid communities of meadows, particularly of wet meadows, and those of carrs and alder woods (51—55%). A high humidity of these sites favours the development of the same hygrophilous species in all of them.

A dominance index was calculated for particular syrphid species in the communities distinguished, according to the formula:

$$D = \frac{Sa}{N} \cdot 100$$

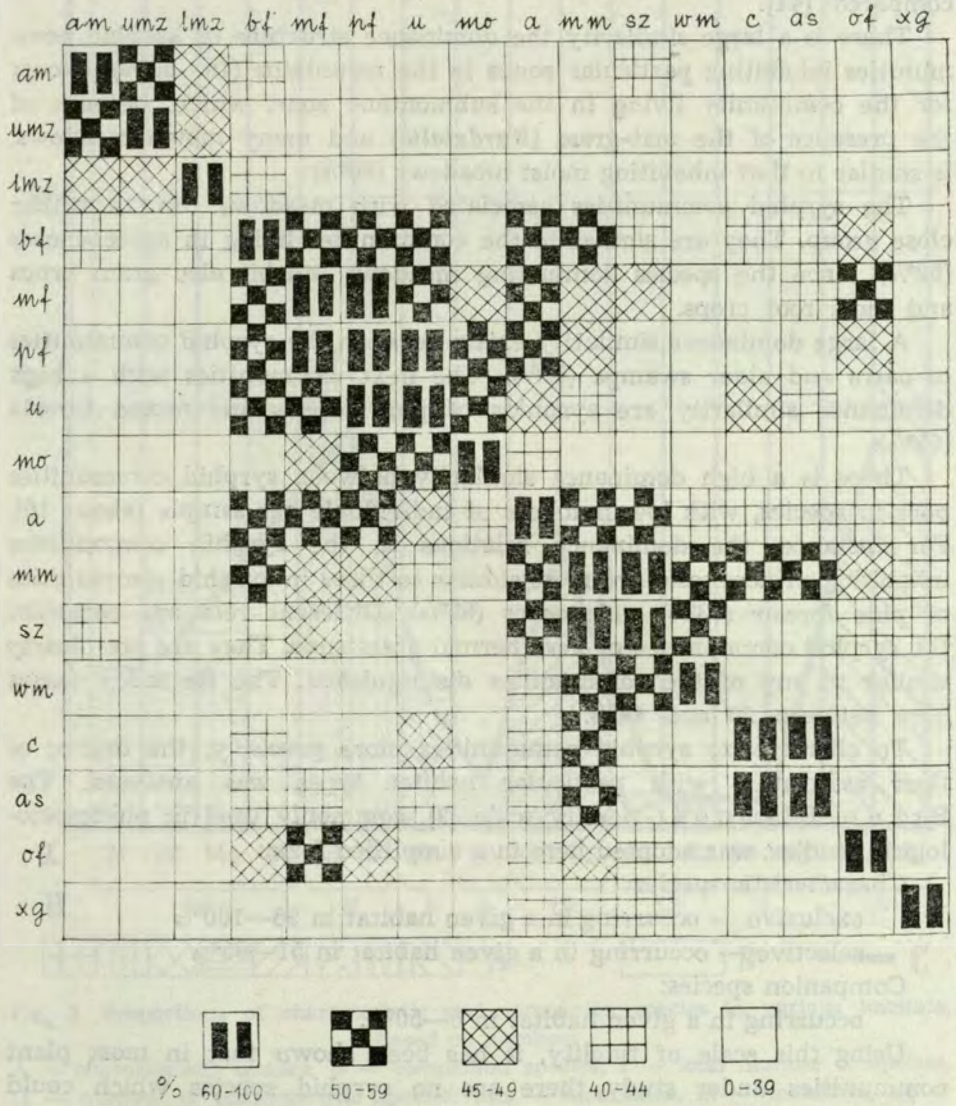


Fig. 2. Diagram of the dominance structure of syrphids in various habitats, calculated as the Renkonen number (Re). Symbols of habitats as in Fig. 1.

where N is the dominance index, Sa — total number of individuals of a given species in all samples, N — total number of individuals of the whole community in all samples.

Then using the Renkonen number (*Re*), by summing the lowest values of the dominance index for pairs of successive syrphid communities, a diagram was obtained illustrating the dominance similarity for the syrphids of all ecosystems (Fig. 2). The *Re* index enables us to estimate the similarity of the quantitative structure of the communities compared [44].

There is a large similarity the dominance structure of syrphid communities inhabiting particular zones in the mountains (49—50%), except for the community living in the submontane zone, which, because of the presence of the mat-grass (*Nardetalia*) and many mown meadows, is similar to that inhabiting moist meadows (60%).

The syrphid communities associated with meadows form a rather close group. They are similar to the communities living in agrocoenoses (58%), since the species dominating meadows inhabit also grain crops and most root crops.

A large dominance similarity exists between the syrphid communities of carrs and alder swamps (60%). The next communities with a high dominance similarity are syrphids of pine forests and mixed forests (65%).

There is a high dominance similarity between syrphid communities poor in species, with low numbers of individuals per sample (about 10). For instance, the dominance relations in the syrphid communities inhabiting urbicoenoses are most similar to those in syrphid communities of pine forests (63%) and moors (55%). Different relations occur in the syrphid communities of xerothermal grasslands. They are not clearly similar to any of the communities distinguished. The Re index varies here between 20 and 44%.

To characterize syrphid communities more precisely, the degree of their association with particular habitat types was analysed. The Braun-Blanquet fidelity scale [9], commonly used in phytosociological studies, was adopted here in a simplified form:

Characteristic species:

exclusive — occurring in a given habitat in 96—100%

selective — occurring in a given habitat in 51—95%

Companion species:

occurring in a given habitat in 0—50%.

Using this scale of fidelity, it has been shown that in most plant communities under study there are no syrphid species which could characterize these communities. Only syrphid communities of moors and xerothermal grasslands are very distinct and these habitats have their own characteristic species.

In this situation, some syrphid communities sharing characteristic species have been joined and in this way distinguished from other communities (Fig. 3). For example, the syrphid communities of carrs and alder swamps together, thus of wet forests, included 15 characteristic

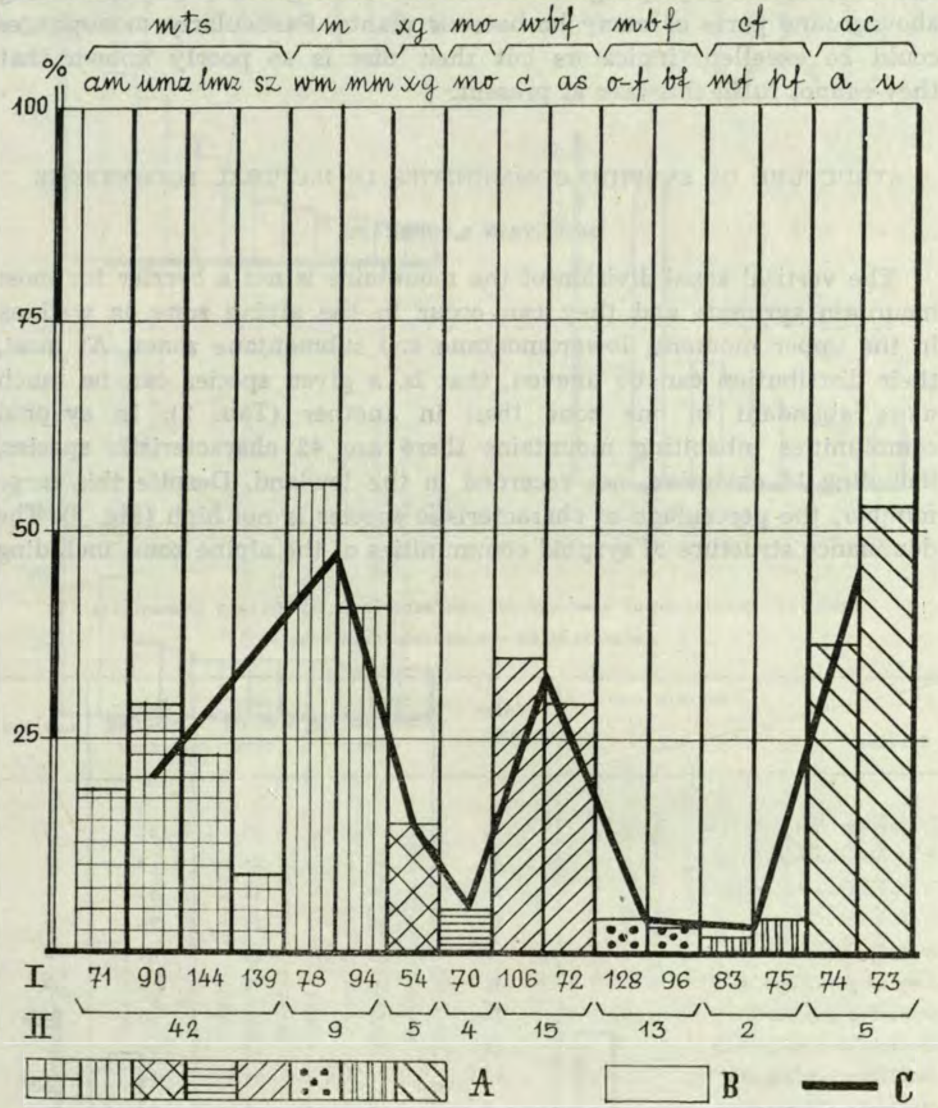


Fig. 3. Proportions of characteristic and companion species in various habitats, based on numbers.

A — characteristic species, B — companion species; I — total number of species, II — number of characteristic species; mts — mountains, m — meadows, xg — xerothermal grasslands, mo — moors, wbf — wet broad-leaved forests, mbf — moist broad-leaved forests, cf — coniferous forests, ac — anthropogenic coenoses. The other symbols as in Fig. 1.

species, but none of them was characteristic either of carrs or of alders woods since they inhabited both these plant communities.

It follows from this that syrphids are associated rather with the site type, while plant cover is of secondary importance. This is not true only of the phytophagous hover flies of the genus *Cheilosia*, mining aboveground parts of many herbaceous plants. Particularly monophages could be excellent indicators but their diet is so poorly known that they cannot fulfil this task at present.

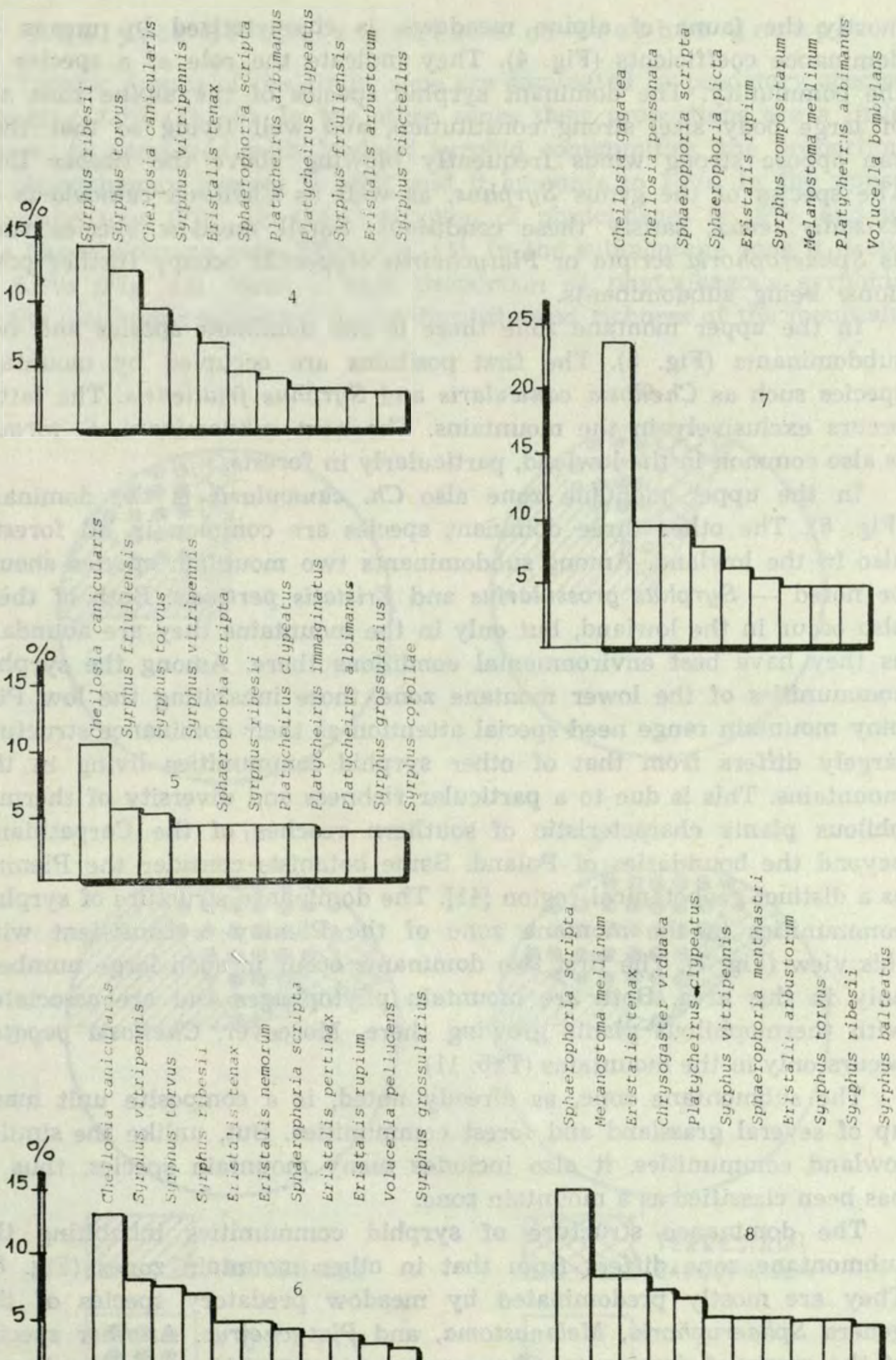
STRUCTURE OF SYRPHID COMMUNITIES IN NATURAL ECOSYSTEMS

MOUNTAIN LANDSCAPE

The vertical zonal division of the mountains is not a barrier for most mountain syrphids and they can occur in the alpine zone as well as in the upper montane, lower montane and submontane zones. At most, their distribution can be uneven, that is, a given species can be much more abundant in one zone than in another (Tab. 2). In syrphid communities inhabiting mountains there are 42 characteristic species, including 14 exclusive, not recorded in the lowland. Despite this large number, the percentage of characteristic species is not high (Fig. 3). The dominance structure of syrphid communities of the alpine zone, including

Table 2. Percentage of some species characteristic of syrphid communities occurring in various mountain zone

Species \ Montain zone	Alpine zone	Upper mountain zone	Lower montane zone	Sub-montane zone	Lowland
Ischyrosyrphus glaucius	2	5	25	52	16
Platycheirus manicatus	31	29	21	8	11
Platycheirus melanopsis	12	60	14	14	–
Didea alneti	20	20	25	26	9
Spathiogaster ambulans	7	7	23	63	–
Syrphus friuliensis	32	50	18	–	–
Eristalis jugorum	24	12	34	30	–
Arctophila bombiformis	23	15	47	15	–
Cheilosia canicularis	13	11	35	38	3
Cheilosia illustrata	1	9	8	74	8
Cheilosia coerulescens	–	12	48	27	13
Cheilosia personata	5	6	77	7	5
Cheilosia sahlbergi	36	18	46	–	–
Cheilosia gagatea	–	8	84	8	–
Cheilosia nasutula	16	38	23	23	–



Figs 4—8. Dominance structure of syrphid communities in different altitudinal mountain zones: — 4 alpine meadows, 5 — upper montane zone, 6 — lower montane zone, 7 — lower montane zone (Pieniny), 8 — submontane zone.

mostly the fauna of alpine meadows, is characterized by means of dominance coefficients (Fig. 4). They indicate the role of a species in the community. The dominant syrphid species of the alpine zone are of large body size, strong constitution, and well flying so that they can oppose strong winds frequently blowing above the timber line. The species of the genus *Syrphus,* as well as *Cheilosia canicularis* or *Eristalis tenax,* satisfy these conditions. Small meadow species such as *Sphaerophoria scripta* or *Platycheirus clypeatus* occupy further positions, being subdominants.

In the upper montane zone there is one dominant species and two subdominants (Fig. 5). The first positions are occupied by mountain species such as *Cheilosia canicularis* and *Syrphus friuliensis.* The latter occurs exclusively in the mountains. The next subdominant, *S. torvus,* is also common in the lowland, particularly in forests.

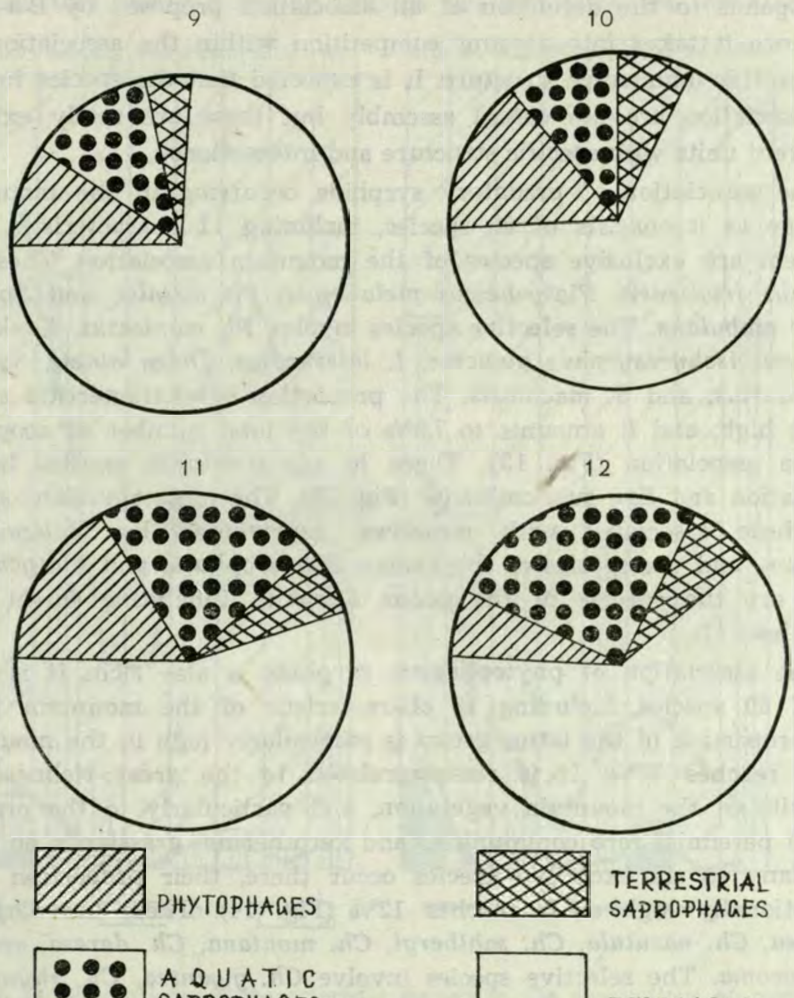
In the upper montane zone also *Ch. canicularis* is the dominant (Fig. 6). The other three dominant species are common in all forests, also in the lowland. Among subdominants two mountain species should be noted — *Syrphus grossularius* and *Eristalis pertinax.* Both of them also occur in the lowland, but only in the mountains they are abundant as they have best environmental conditions there. Among the syrphid communities of the lower montane zone, those inhabiting the low Pieniny mountain range need special attention as their dominance structure largely differs from that of other syrphid communities living in the mountains. This is due to a particular richness and diversity of thermophilous plants characteristic of southern reaches of the Carpathians, beyond the boundaries of Poland. Some botanists consider the Pieniny as a distinct geobotanical region [41]. The dominance structure of syrphid communities in the montane zone of the Pieniny is consistent with this view (Fig. 7). The first two dominants occur in such large numbers only in this area. Both are mountain phytophages and are associated with thermophilous plants growing there. Moreover, *Cheilosia gagatea* occurs only in the mountains (Tab. 11).

The submontane zone, as already noted, is a composite unit made up of several grassland and forest communities. But, unlike the similar lowland communities, it also includes many mountain species, thus it has been classified as a mountain zone.

The dominance structure of syrphid communities inhabiting the submontane zone differs from that in other mountain zones (Fig. 8). They are mostly predominated by meadow predatory species of the genera *Sphaerophoria, Melanostoma,* and *Platycheirus.* Another species of the group of dominants, *Chrysogaster viduata,* is a saprophage associated with wet meadows, this habitat being frequent in the submontane zone. *Eristalis tenax* is a hemisynanthropic species and it can develop at human dwellings as well as in natural water bodies.

Analysis of the structure of trophic groups

Trophic groups of the alpine zone are dominated by predatory species reaching 73% (Fig. 9). In the other zones their proportions are a little lower. As compared with lowland syrphid communities, the proportion of phytophagous species is high, and it amounts to 10%. In the upper montane zone (Fig. 10) the proportion of phytophages is 16%, and in the lower montane zone 17% (Fig. 11). In the submontane zone it drops to 6.5% (Fig. 12). Such a high proportion of phytophagous syrphids in the mountains is related to the diversity and richness of the mountain



Figs 9—12. Percentage contribution of trophic groups in syrphid communities inhabiting various mountain zones: 9 — alpine zone, 10 — upper montane zone, 11 — lower montane zone, 12 — submontane zone.

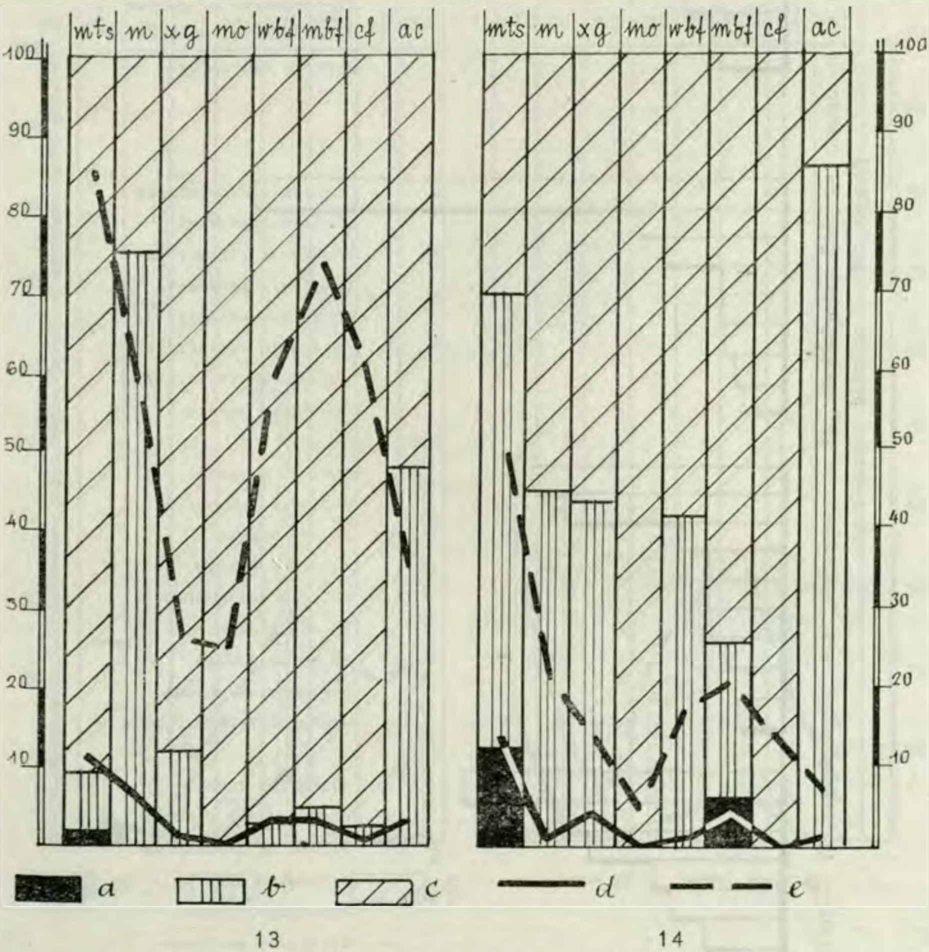
vegetation. The proportion of saprophagous species associated with forests is low in particular mountain zones. The highest proportion of 8% they reached in the upper montane zone. Aquatic saprophages are poorly represented in higher parts, and only in the lower montane and submontane zones they reach 23% and 26.5% respectively. This is closely related to water relations in particular zones. In lower parts there are more soggy and flooded areas in stream valleys where the larvae of these syrphids develop.

An association is considered here as a group of organisms belonging to the same taxon, the larvae of which have similar food habits. It corresponds to the definition of an association proposed by Balogh [1], since it takes into account competition within the association and a respective dominance structure. It is expected that the species forming an association are not casual assembly but these are really existing, recurrent units with specific structure and interactions.

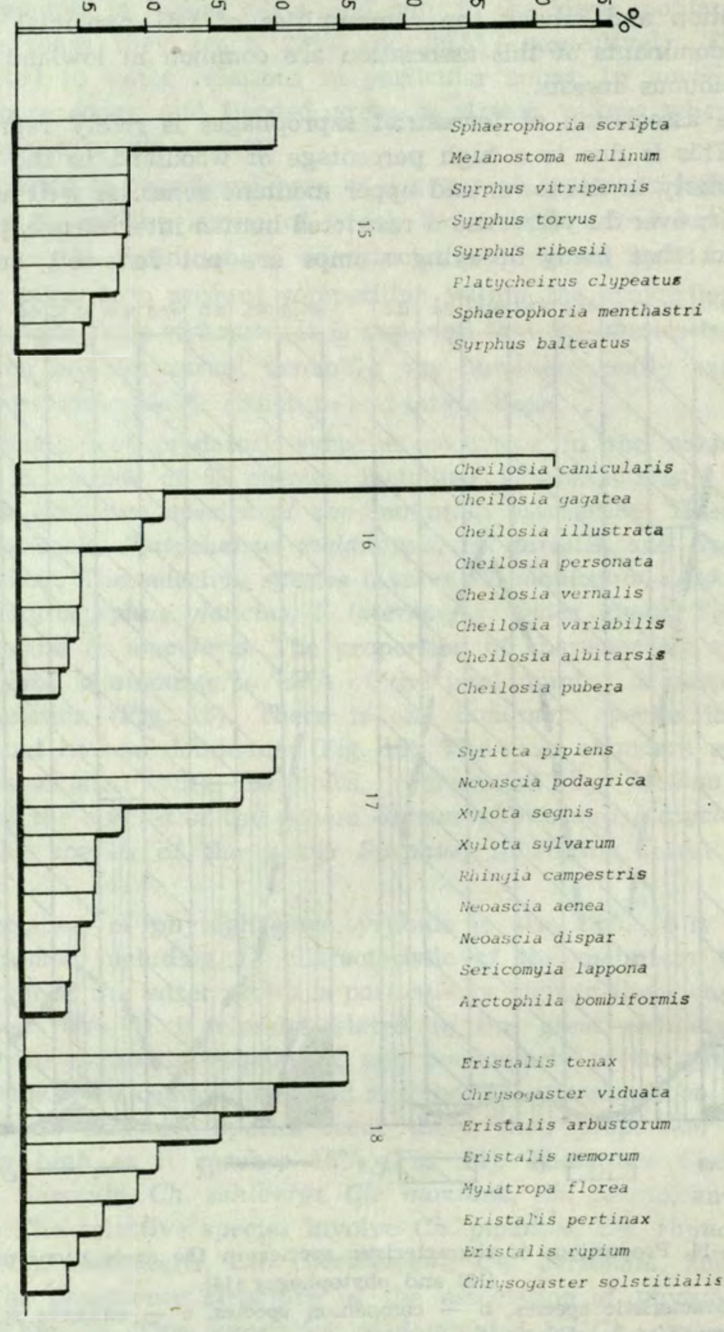
The association of predatory syrphids occurring in the mountains is large as it consists of 85 species, including 11 characteristic. Four of them are exclusive species of the mountain association. These are *Syrphus friuliensis, Platycheirus melanopsis, Pl. tarsalis*, and *Spathiogaster ambulans*. The selective species involve *Pl. manicatus, Leukozona lucorum, Ischyrosyrphus glaucius, I. laternarius, Didea alneti, Syrphus grossularius*, and *S. macularis*. The proportion of characteristic species is not high, and it amounts to 7.5% of the total number of zoophages in the association (Fig. 13). There is one dominant species in this association and five subdominants (Fig. 15). The most abundant species are those associated with meadows, represented by *Melanostoma mellium*, and the species of the genera *Sphaerophoria* and *Platycheirus*. Next are the species of the genus *Syrphus*, inhabiting forest communities.

The association of phytophagous syrphids is also rich. It is made up of 50 species, including 13 characteristic of the mountain fauna. The proportion of the latter group is particularly high in the mountains as it reaches 70%. It is closely related to the great richness and diversity of the mountain vegetation, and particularly to the presence of tall perennial forb communities and xerothermal grasslands on rocks. As many as six exclusive species occur there, their proportion being exceptionally high as it reaches 12% (Fig. 14). These are *Cheilosia gagatea, Ch. nasutula, Ch. sahlbergi, Ch. montana, Ch. deresa*, and *Ch. chrysocoma*. The selective species involve *Ch. gigantea, Ch. rhynchops, Ch. vicina, Ch. canicularis, Ch. coerulescens, Ch. personata*, and *Ch. illustrata*. The dominance structure of the association of phytophages is shown in Fig. 16. This association is dominated by *Ch. canicularis*, the species associated with the communities of riverside tall perennial forbs, known as the ***Petasitetum kablikiani*** association [41]. Larvae of this syrphid mine fleshy stems of butterburs (*Petasites*) and feed on their tissues. The next three dominants are also characteristic of the association and inhabit the communities of tall perennial forbs. The other dominants of this association are common in lowland grasslands or deciduous forests.

The association of terrestrial saprophages is richly represented as well. This is due to a high percentage of woodland in the mountains, particularly in the lower and upper montane zones, as well as to a high humidity over the year. Also a restricted human interference, particularly the fact that many decaying stumps are not removed, enhance the

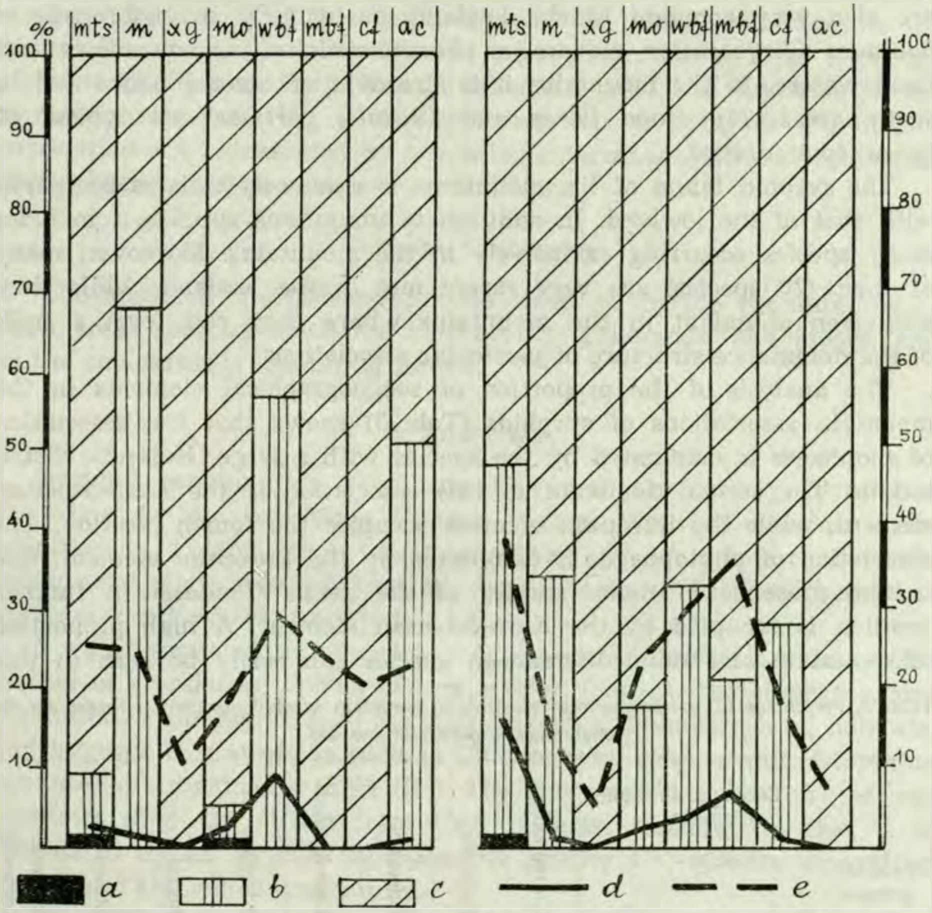


Figs 13—14. Proportions of characteristic species in the associations of zoophages (13) and phytophages (14).
a — characteristic species, b — companion species, c — exlusive species, d — total number of species in the association, e — number of characteristic species in the association. The other symbols as in Fig. 3.



Figs 15—18. Dominance structure of mountain syrphid associations: 15 — zoophages, 16 — phytophages, 17 — terrestrial saprophages, 18 — aquatic saprophages.

development of this association. It involves 38 species, including 16 characteristic, which account for 41% of the total number of terrestrial saprophages inhabiting mountains (Fig. 20). The exclusive species contribute to 4%. These are *Arctophila bombiformis, Sphegina latifrons,* and *S. sibirica.* The other characteristic species involve *Calliprobola speciosa, Brachyopa dorsata, B. bicolor, Xylota sylvarum, X. xanthocnema, Sphegina verecunda, S. kimakoviczi, Neoascia interrupta, N. obliqua, N. aenea, N. podagrica, N. floralis,* and *Callicera aenea.* The dominance structure of this association is shown in Figure 17. The dominant species is *Syritta pipiens.* Its larvae live in decaying plant



Figs 19—20. Proportions of characteristic species in the associations of aquatic saprophages (19) and terrestrial saprophages (20).
a — characteristic species, b — companion species, c — exclusive species, d — total number of species in the association, e — number of characteristic species in the association. The other symbols as in Fig. 3.

remains or in livestock manure. A similar type of feeding occurs in *Rhingia campestris*. Larvae of the genus *Neoascia* feed on decaying plant remains. They were found in large numbers in decaying stems of butterburs near mountain streams. Larvae of the genera *Arctophila* and *Xylota* feed on decaying wood and other plant material.

The association of aquatic saprophages is relatively poor in the mountains. It consits of only 25 species, including two characteristic ones: *Eristalis jugorum*, an exclusive species, and *E. pertinax*, a selective species. They both contribute to 7.8% of the total number of individuals in the association (Fig. 19). The dominance structure of the association is shown in Figure 18. Three dominant species of the genus *Eristalis* are also very common in the lowland, particularly in anthropogenic habitats. *Chrysogaster viduata* is characteristic of wet meadows and flood waters. In the mountains it is abundant on stream banks and in soggy areas. *Myiatropa florea* and *Eristalis pertinax* are typical of forest communities.

The syrphid fauna of the mountains is extremely rich as compared with that of the lowland. In addition to ubiquitous species, it includes many species occurring exclusively in the mountains. Moreover, many of them (28 species) are very rarely met in the lowland, while they are often abundant in the mountains where they can form a bulk of the dominance structure of particular associations.

The analysis of the proportion of zoogeographical elements in the mountain associations of syrphids (Tab. 3) shows that the association of zoophages is dominated by the species with a large, Holarctic distribution. The second dominant of this association is the Euro-Siberian element, while the European element occupies the fourth position. The association of phytophages is dominated by the European element, due to the presence of many species of the genus *Cheilosia*. A further position is occupied by the Euro-Siberian element. A high proportion of mountain and submediterranean species can easily be seen in this

Table 3. Percentage of zoogeographical elements in mountain syrphid association (based on the abundance of particular species)

Trophic groups \ Zoogeographical elements	Cosmopolitan	Holarctic	Palaearctic	Euro-Siberian	European	Boreal	Mountain	Submediterranean
Zoophages	1.0	36.0	16.0	27.0	11.0	2.0	4.0	3.0
Phytophages	—	1.5	9.0	17.0	45.0	3.0	14.5	10.0
Terrestrial saprophages	—	11.5	15.5	42.0	25.0	2.0	4.0	—
Aquatic saprophages	4.0	17.0	29.0	33.5	8.5	4.0	4.0	—
Total	1.0	20.0	15.0	28.0	23.0	2.0	7.0	4.0

association. The mountain element is represented mainly by species of the genus *Cheilosia*, while the submediterranean element by the species of the genera *Eumerus* and *Merodon*. The proportion of Holarctic and Palaearctic elements is particularly low in the association of phytophages. Terrestrial saprophages, like other thropic groups (Tab. 1), are mostly represented by the Euro-Siberian and European elements. This is due to a large number of species living in decaying wood of broad-leaved and coniferous trees growing in the two montane zones.

Aquatic saprophages, rather not numerous in the mountains, usually have large geographical ranges and belong to eurytopic species. They are dominated by the Euro-Siberian, Palaearctic and Holarctic elements.

As compared with the lowland syrphids, those occurring in the mountains are characterized by a large proportion of the European element (23%) and Euro-Siberian element (28%). In addition to the mountain element (7%), it is interesting that as many as 4% of this association are represented by the submediterranean element containing phytophagous and zoophagous hover flies.

LOWLAND LANDSCAPE

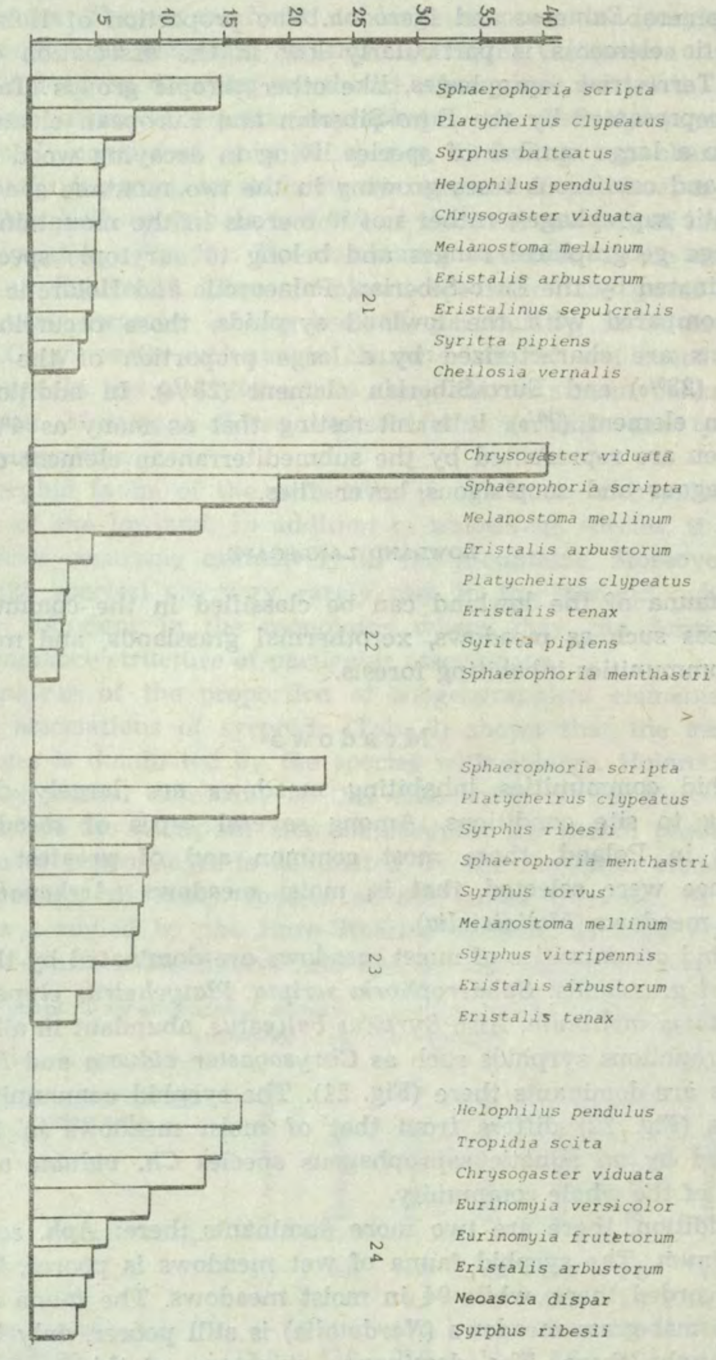
The fauna of the lowland can be classified in the communities of open areas such as meadows, xerothermal grasslands, and moors, and in the communities inhabiting forests.

Meadows

Syrphid communities inhabiting meadows are largely diversified according to site conditions. Among several types of meadow communities in Poland, those most common and of greatest economic importance were selected, that is, moist meadows (*Arrhenatheretalia*) and wet meadows (*Molinietalia*).

Syrphid communities of moist meadows are dominated by the species typical of grasslands: *Sphaerophoria scripta, Platycheirus clypeatus,* and *Melanostoma mellinum*. Also *Syrphus balteatus,* abundant in all habitats, and hygrophilous syrphids such as *Chrysogaster viduata* and *Helophilus pendulus* are dominants there (Fig. 21). The syrphid community of wet meadows (Fig. 22) differs from that of moist meadows in that it is dominated by an aquatic saprophagous species *Ch. viduata* accounting for 40% of the whole community.

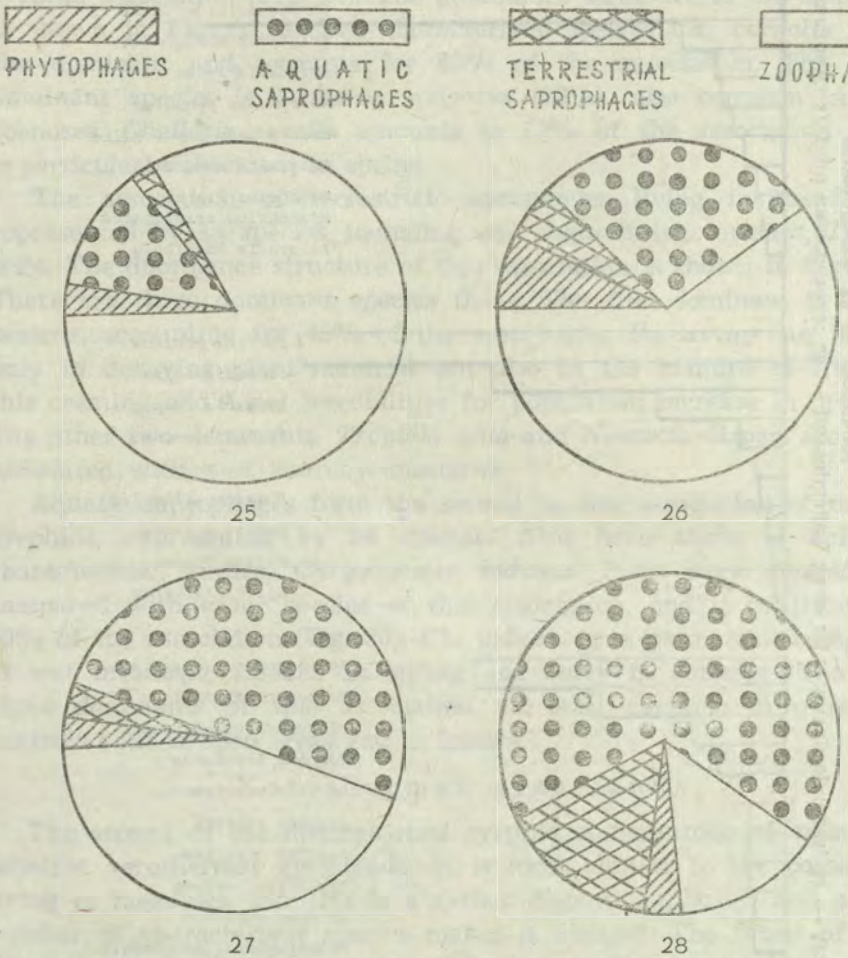
In addition, there are two more dominants there: *Aph. scripta* and *M. mellinum*. The syrphid fauna of wet meadows is poorer, 78 species being recorded there, while 94 in moist meadows. The fauna associated with the mat-grass meadows (*Nardetalia*) is still poorer, only 34 species being caught there. The dominance structure of this community is similar to that in moist meadows. It is dominated by the same species,



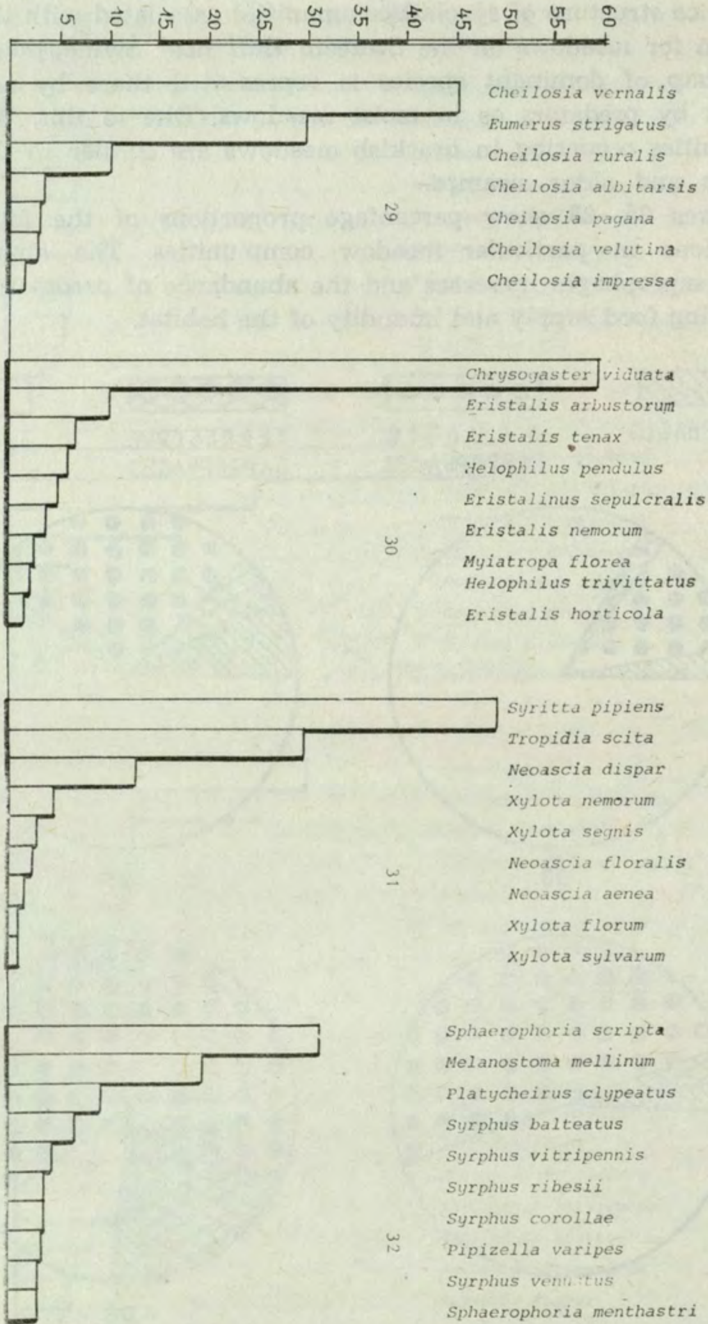
Figs 21—24. Dominance structure of syrphid communities in different meadow types: 21 — moist meadows, 22 — wet meadows, 23 — mat-grass meadows (*Nardetalia*), 24 — brackish meadows.

i.e., *Sp. scripta* and *Pl. clypeatus* (Fig. 23). The fauna of partly submerged brackish meadows is of a quite different character. The dominance structure of syrphid communities associated with this habitat, is shown for meadows on the Szczecin Haff near Świnoujście (Fig. 24). The group of dominant species is represented there by saprophages and not by predators as in moist meadows. Due to this, the syrphid communities occurring in brackish meadows are similar to those living in carrs and alder swamps.

Figures 25—28 show percentage proportions of the four syrphid associations in particular meadow communities. The abundance of aquatic saprophages increases and the abundance of predators decreases with rising food supply and humidity of the habitat.



Figs 25—28. Percentage contribution of trophic groups in syrphid communities of different meadow types: 25 — mat-grass meadows (*Nardetalia*), 26 — moist meadows, 27 — wet meadows, 28 — brackish meadows.



Figs. 29—32. Dominance structure of meadow syrphid associations: 29 — phytophages, 30 — aquatic saprophages, 31 — terrestrial saprophages, 32 — zoophages.

To distinguish meadow association of syrphids, the syrphid communities of moist and wet meadows have been considered as a unit with 9 characteristic species in common (Fig. 3). Most of these species are dominants and they account for 47% of the community.

In meadow habitats the association of predators comparises the highest number of species (58) and individuals. It includes 6 characteristic species (Fig. 13) such as *Sphaerophoria scripta, Sph. menthastri, Sph. picta, Melanostoma mellinum, Platycheirus clypeatus,* and *Pipizella varipes,* accounting for 65% of the association. Moreover, three of them are dominants in the association of meadow zoophages (Fig. 32).

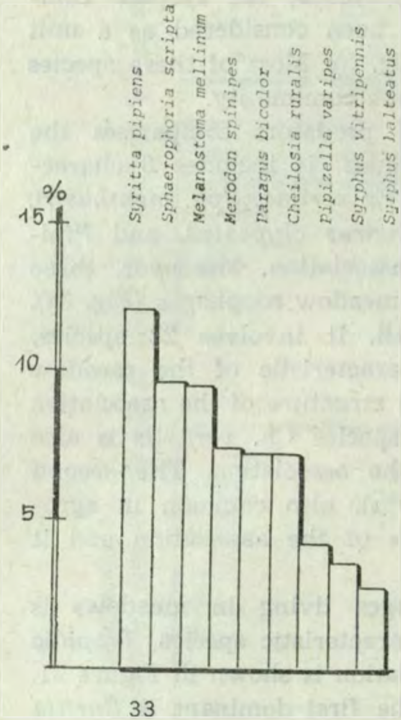
The association of phytophages is small. It involves 22 species, including one — *Cheilosia vernalis* — characteristic of the meadow syrphid association (Fig. 14). The dominance structure of the association is shown in Figure 29. The characteristic species *Ch. vernalis* is also the dominant and accounts for 45% of the association. The second dominant species is *Eumerus strigatus* (29%), also common in agrocoenoses. *Cheilosia ruralis* amounts to 10% of the association and it is particularly abundant in spring.

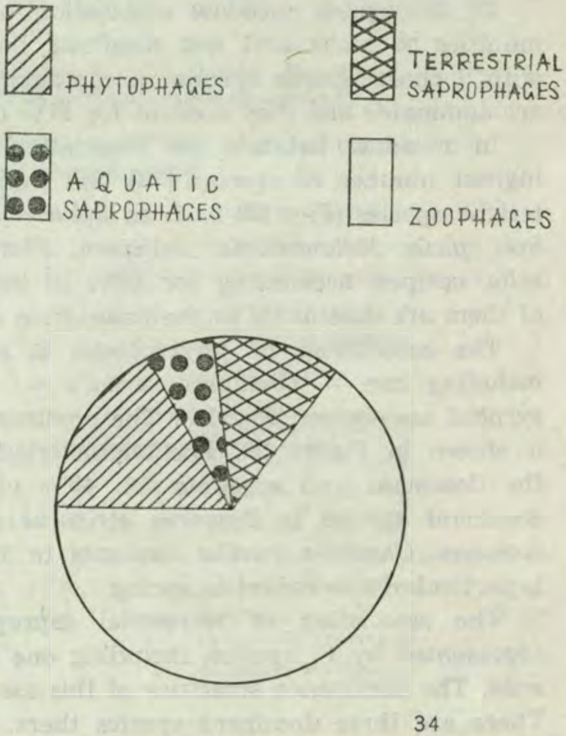
The association of terrestrial saprophages living in meadows is represented by 13 species, including one characteristic species, *Tropidia scita*. The dominance structure of this association is shown in Figure 31. There are three dominant species there. The first dominant is *Syritta pipiens,* accounting for 48% of the association. Its larvae can live not only in decaying plant material but also in the manure of livestock, this creating additional possibilities for population increase in meadows. The other two dominants, *Tropidia scita* and *Neoascia dispar,* are rather associated with wet, marshy meadows.

Aquatic saprophages form the second in size association of meadow syrphids, represented by 24 species. Also here there is only one characteristic species, *Chrysogaster viduata*. It is very abundant as compared with other species of this association, and it contributes to 59% of the association (Fig. 30). *Ch. viduata* is a permanent component of wet meadows, flooded in spring and early in summer. The other three dominants of this association are also common in other wet habitats both in open areas and in forests.

Xerothermal grasslands

The second of the distinguished syrphid communities of open areas inhabits xerothermal grasslands. It is most similar to the community living in meadows, but this is a rather distant similarity, and a large number of characteristic species makes it distinct. The fauna of xerothermal grasslands is very poor, only 54 syrphid species being found there. The analysis of the dominance structure shows that *Syritta pipiens* is relatively abundant (Fig. 34). This habitat is frequently

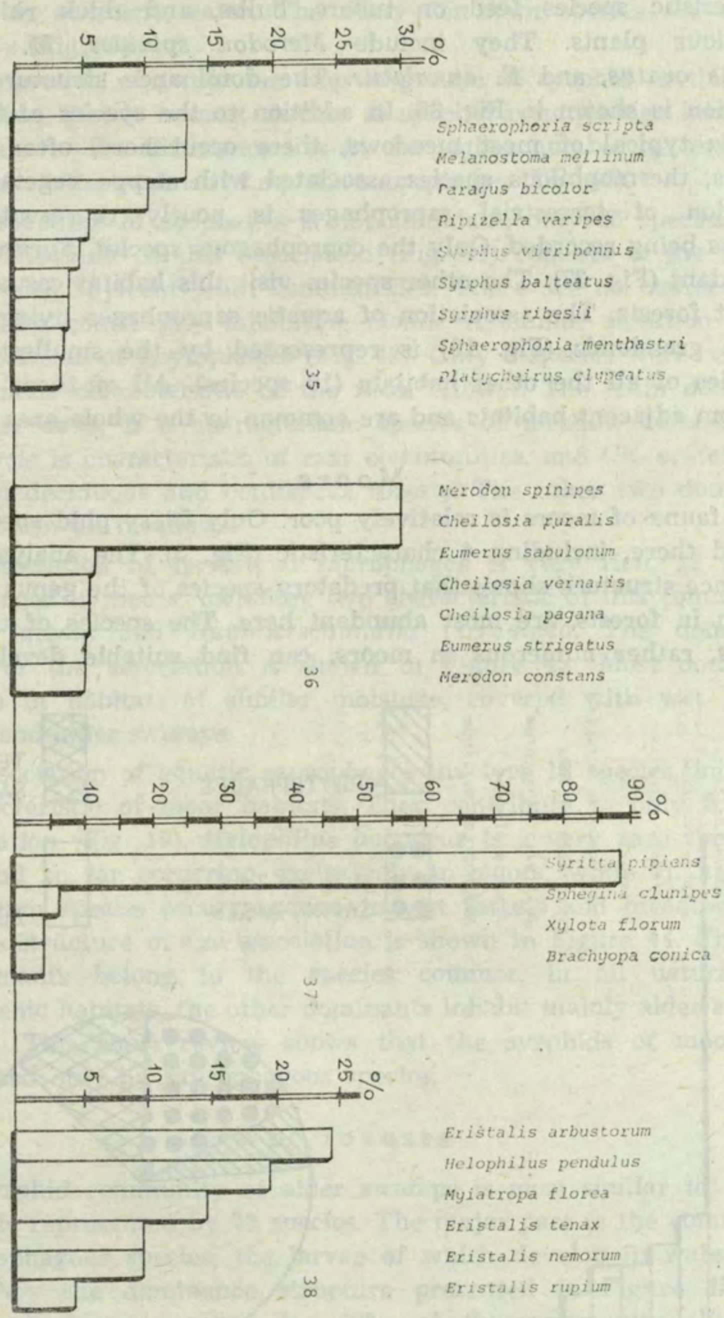




Figs 33—34. Dominance structure (33) of syrphid communities inhabiting xerothermal grasslands, and percentage contribution of trophic groups (34).

grazed by cattle and sheep, thus this coprophagous species can be abundant there. The other dominant species, of the genera *Sphaerophoria* or *Melanostoma*, as well as *Cheilosia ruralis*, are typical of meadow communities. Only the presence of the Pontic species *Merodon spinipes* and thermophilous *Paragus bicolor* in the group of dominants, indicates the xerothermal character of the community.

Considering the proportions of particular syrphid associations of xerothermal grasslands (Fig. 33), it can be seen that phytophages are relatively abundant and they account for 16% of the association. Also the proportion of terrestrial saprophages is high (12%), while that of aquatic saprophages very low (8%) since they cannot develop in dry habitats, and they visit xerothermal grasslands only in search of flowers. The most abundant association is made up of zoophages. In these materials 27 zoophagous species have been found. One of them, *Paragus bicolor*, is a characteristic species and at the same time the only dominant, accounting for 10% of the association (Fig. 35). The other dominants are associated with grassland communities. The association of phytophages consists of 13 species, including 4 characteristic, which account for 44% of the association (Fig. 14). All

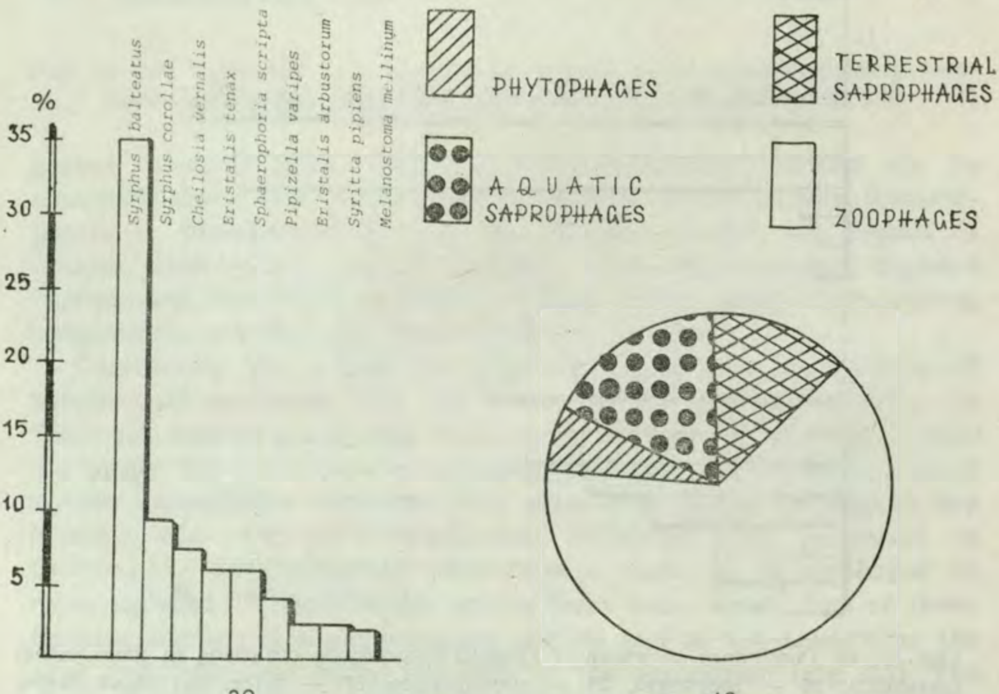


Figs 35—38. Dominance structure of syrphid associations occurring in xerothermal grasslands: 35 — zoophages, 36 — phytophages, 37 — terrestrial saprophages, 38 — aquatic saprophages.

characteristic species feed on tubers, bulbs, and thick rhizomes of xerophilous plants. They include *Merodon spinipes, M. constans, Eumerus ovatus,* and *E. annulatus.* The dominance structure of this association is shown in Fig. 36. In addition to the species of the genus *Cheilosia* typical of most meadows, there occur here, often in large numbers, thermophilous species associated with steppe vegetation. The association of terrestrial saprophages is poorly represented, only 4 species being recorded. Only the coprophagous species, *Syritta pipiens,* is abundant (Fig. 37). The other species visit this habitat casually, from adjacent forests. The association of aquatic saprophages living in xerothermal grasslands (Fig. 19) is represented by the smallest number of species of all the other habitats (10 species). All of them visit this area from adjacent habitats and are common in the whole area (Fig. 38).

Moors

The fauna of moors is relatively poor. Only 59 syrphid species were recorded there, including 4 characteristic (Fig. 3). The analysis of the dominance structure shows that predatory species of the genus *Syrphus,* common in forests, are most abundant here. The species of the genus *Eristalis,* rather numerous in moors, can find suitable developmental



Figs 39—40. Dominance structure of syrphid communities occurring in moors (39) and the percentage of trophic groups in them (40).

conditions in stagnant water. The other dominant species are typical of meadows (Fig. 39).

The proportion of particular trophic groups of syrphid in this community shows that it is most similar to syrphid communities inhabiting moist meadows. The difference lies in the higher number of terrestrial saprophages at the expense of aquatic saprophages (Fig. 40).

The association of zoophages is not abundant, only 25 species being recorded. The bulk of this association (Fig. 41) consists of the species inhabiting also adjacent plant communities. There are no characteristic species of the community inhabiting moors. A similar situation occurs in the association of phytophages (Fig. 42). Only 5 species were recorded here and none characteristic of the moor habitat. The main dominant, *Cheilosia vernalis*, is a characteristic species of meadow communities. *Ch. albitarsis* is characteristic of carr communities, and *Ch. scutellata* is common in deciduous and coniferous forests. The other two dominants are common in all meadows.

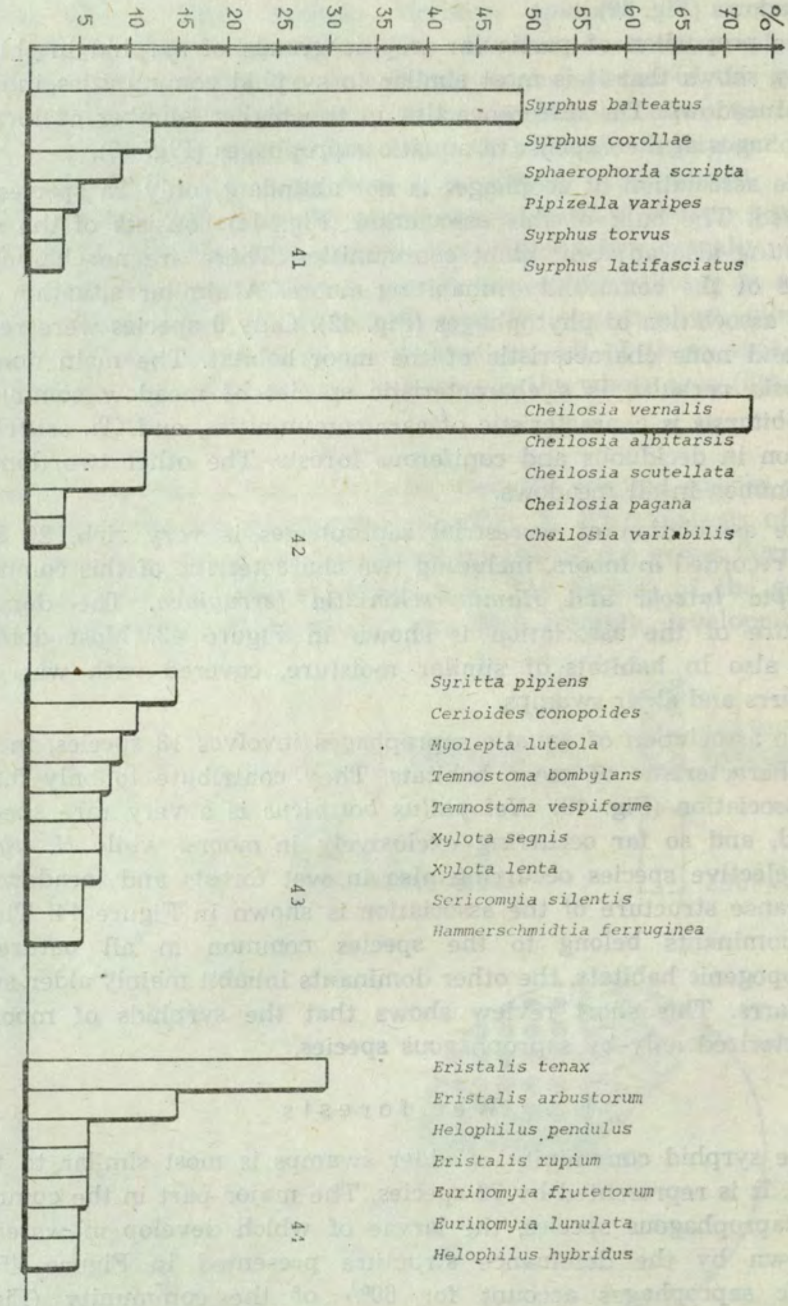
The association of terrestrial saprophages is very rich, 22 species being recorded in moors, including two characteristic of this community: *Myolepta luteola* and *Hammerschmidtia ferruginea*. The dominance structure of the association is shown in Figure 43. Most dominants occur also in habitats of similar moisture, covered with wet forests like carrs and alder swamps.

The association of aquatic saprophages involves 18 species, including two characteristic of moor habitats. They contribute to only 5.2% of the association (Fig. 19). *Helophilus bottnicus* is a very rare species in Poland, and so far occurring exclusively in moors, while *H. hybridus* is a selective species occurring also in wet forests and meadows. The dominance structure of the association is shown in Figure 44. The first two dominants belong to the species common in all natural and anthropogenic habitats, the other dominants inhabit mainly alder swamps and carrs. This short review shows that the syrphids of moors are characterized only by saprophagous species.

Wet forests

The syrphid community of alder swamps is most similar to that of moors. It is represented by 72 species. The major part in the community play saprophagous species, the larvae of which develop in water. This is shown by the dominance structure presented in Figure 45. The aquatic saprophages account for 60% of the community (Fig. 47). Predatory syrphids, instead, account for only 29% of the community.

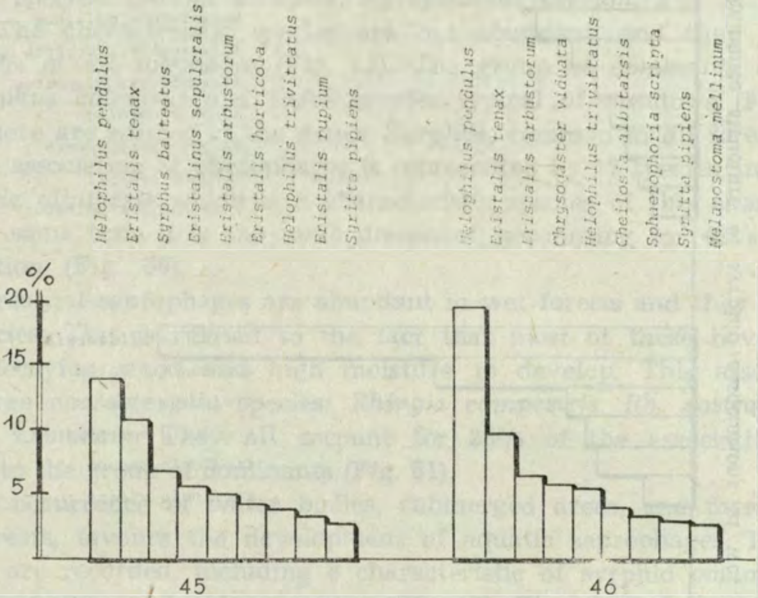
The syrphid community inhabiting alder swamps has no characteristic species, and only when it is combined with the most similar community occurring in carrs, a composite unit — syrphid community



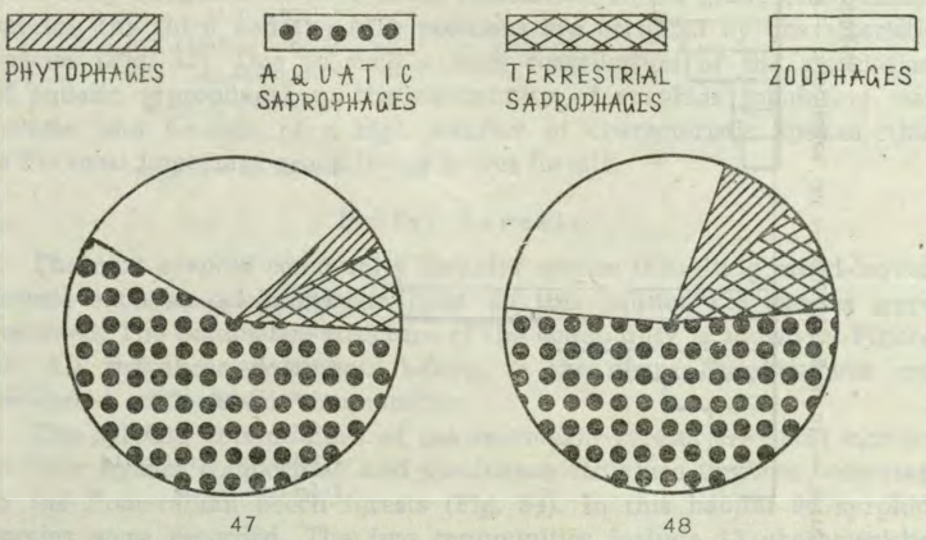
Figs 41—44. Dominance structure of syrphid associations in moors: 41 — zoophages, 42 — phytophages, 43 — terrestrial saprophages, 44 — aquatic saprophages.

of wet forests — can be distinguished. It includes 15 characteristic species accounting for 41% of the community numbers (Fig. 3).

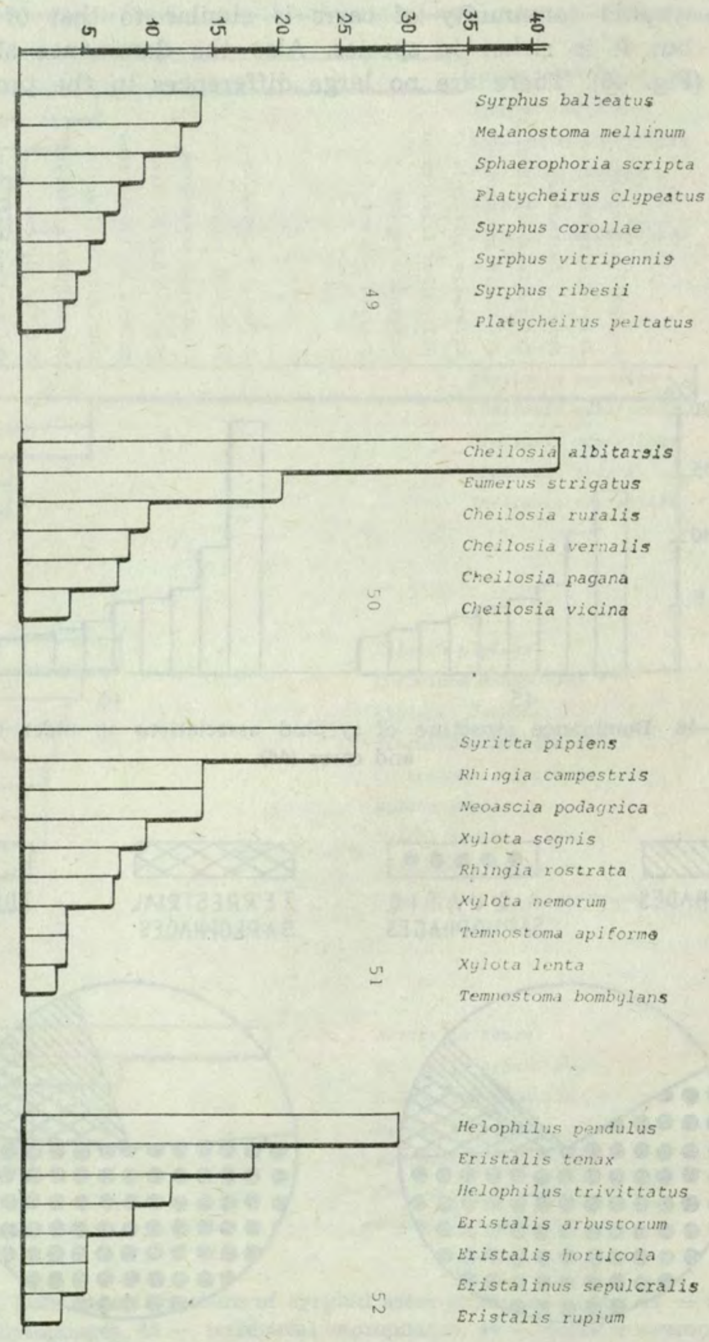
The syrphid community of carrs is similar to that of the alder swamp, but it is richer in species. Also the dominance structure is similar (Fig. 46). There are no large differences in the proportion of



Figs 45—46. Dominance structure of syrphid associations in alder swamps (45) and carrs (46).



Figs 47—48. Percentage of trophic groups in syrphid communities of alder swamps (47) and carrs (48).



Figs 49—52. Dominance structure of syrphid associations in wet forests: 49 — zoophages, 50 — phytophages, 51 — terrestrial saprophages, 52 — aquatic saprophages.

particular trophic groups between these habitats (Fig. 48). Both are dominated by aquatic saprophages (54%), the proportion of predators being low (29% in the carr).

The association of zoophages inhabiting wet forests is richest in species. There are 59 species recorded there, including three characteristic species: *Baccha elongate, Pyrophaena rosarum,* and *P. granditarsa.* The characteristic species are not abundant, and they involve only 2% of all zoophages (Fig. 13). The group of dominants consists of *Syrphus balteatus* and three species typical of meadows (Fig. 49), then there are species of the genus *Syrphus,* common in all forests.

The association of phytophages is represented by 17 species, including *Cheilosia albitarsis* which is a characteristic species of this association. At the same time it is the main dominant, accounting for 42% of the association (Fig. 50).

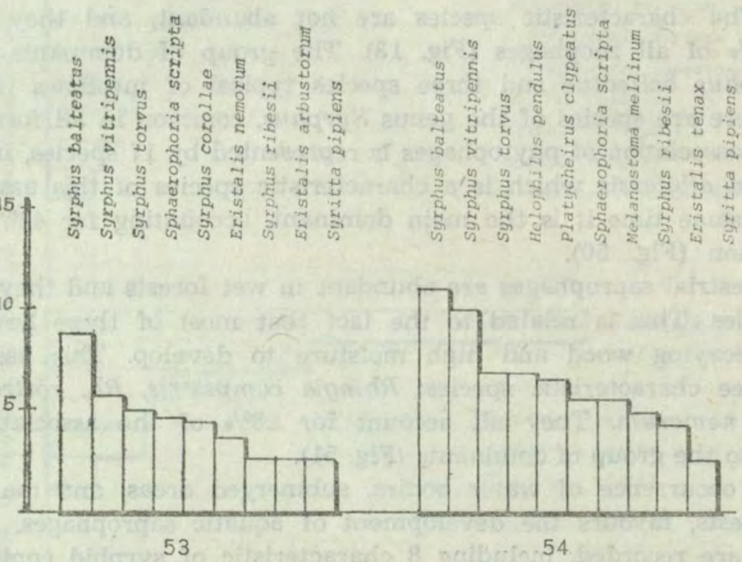
Terrestrial saprophages are abundant in wet forests and they involve 30 species. This is related to the fact that most of these hover flies need decaying wood and high moisture to develop. This association has three characteristic species: *Rhingia campestris, Rh. rostrata,* and *Xylota nemorum.* They all account for 28% of the association and belong to the group of dominants (Fig. 51).

The occurrence of water bodies, submerged areas, and marshes in wet forests, favours the development of aquatic saprophages. Here 29 species are recorded, including 8 characteristic of syrphid communities inhabiting carrs and alder swamps (Fig. 19). The characteristic species involve *Helophilus pendulus, H. trivittatus, H. affinis, Eurinomyia lineata, E. frutetorum, E. versicolor, Eristalis cryptarum,* and *E. horticola.* They contribute to 50% of the association. In the group of dominant species, the third and the fifth positions are occupied by characteristic species (Fig. 52). Due to such a high contribution of the association of aquatic saprophages to the community of syrphids inhabiting wet forests, and because of a high number of characteristic species, this is the most important group living in wet forests.

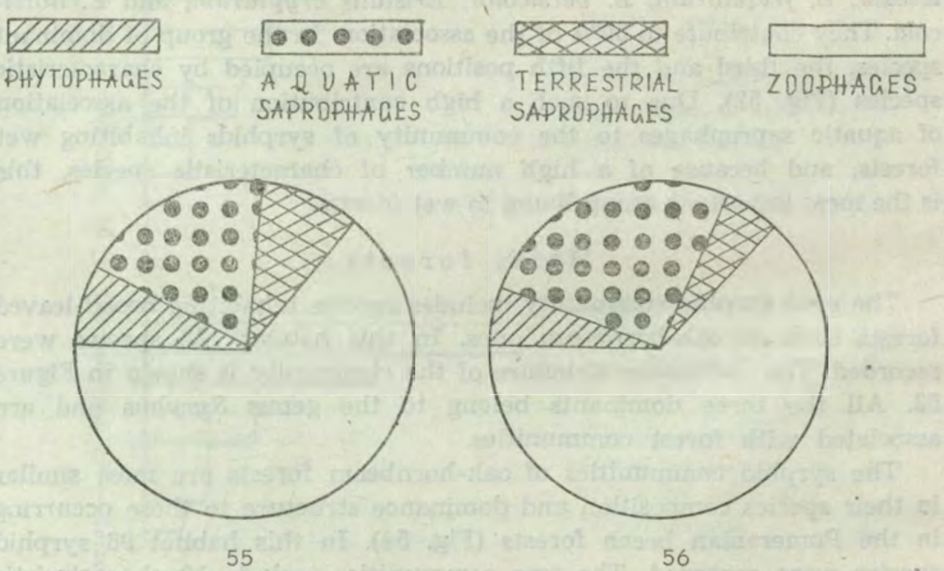
Moist forests

The next syrphid community includes species inhabiting broad-leaved forests such as oak-hornbeam ones. In this habitat 128 species were recorded. The dominance structure of the community is shown in Figure 53. All the three dominants belong to the genus *Syrphus* and are associated with forest communities.

The syrphid communities of oak-hornbeam forests are most similar in their species composition and dominance structure to those occurring in the Pomeranian beech forests (Fig. 54). In this habitat 96 syrphid species were recorded. The two communities include 13 characteristic species, but their proportion is small (Fig. 3). The proportion of particular trophic groups of syrphids is similar in the two forest habitats (Figs 55 and 56). The oak-hornbeam forests have more abundant phytophages and terrestrial saprophages. As compared with the trophic structure of syrphids inhabiting wet forests (Figs 47 and 48), the proportion of zoophages is higher at the expense of aquatic saprophages, reaching



Figs 53—54. Dominance structure of syrphid communities in oak-hornbeam forests (53) and Pomeranian beech forests (54).



Figs 55—56. Percentage of trophic groups in syrphid communities of oak-hornbeam forests (55) and Pomeranian beech forests (56).

only 21% in the oak-hornbeam forest and 25% in the beech forest. This close similarity in the syrphid fauna between the two forest communities makes it possible to distinguish a composite unit of moist deciduous forests.

In moist forests the association of zoophages is richest in species (73) and individuals (Fig. 13). It involves three characteristic species: *Syrphus bifasciatus*, *S. albostriatus*, and *Microdon devius*. They are not abundant and account for 4% of the association. The main dominants are *Syrphus balteatus*, *S. vitripennis*, *S. torvus*, and *S. ribesii*, the species typical of forest communities. Other dominants, such as *Sphaerophoria scripta*, *Melanostoma mellinum*, and *Platycheirus clypeatus*, are characteristic of grasslands, while in forests they occupy clearings and other non-shaded places. It is interesting that the proportion of predatory syrphids of the genus *Volucella*, living in nests of wasps and bumble-bees, is high (Fig. 57).

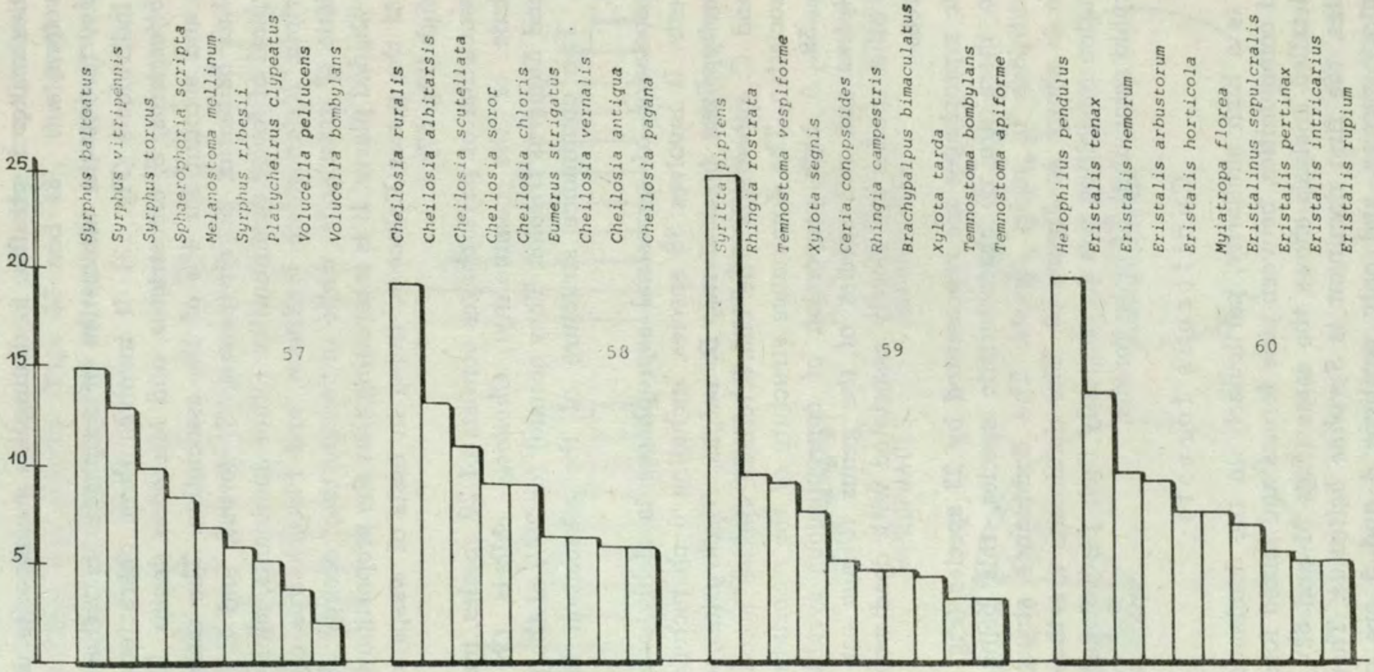
The association of phytophages consists of 20 species, including four characteristic of the community: *Cheilosia chloris*, *Ch. soror*, *Ch. antiqua*, and *Eumerus tricolor*. They account for 26% of the phytophages (Fig. 14). The dominance structure of the association is shown in Figure 58.

The association of terrestrial saprophages is richly represented in moist forests. It involves 36 species, including 6 characteristic: *Xylota tarda*, *Brachypalpus bimaculatus*, *B. valgus*, *B. chrysites*, *Ceria conopsoides*, and *C. subsessilis*. The characteristic species account for 18% of the association. The dominance structure of the association is shown in Figure 59. A high proportion of coprophagous syrphids such as *Syritta pipiens* and two species of the genus *Rhinga* can readily be seen. The other species are closely associated with dead wood of broad-leaved trees

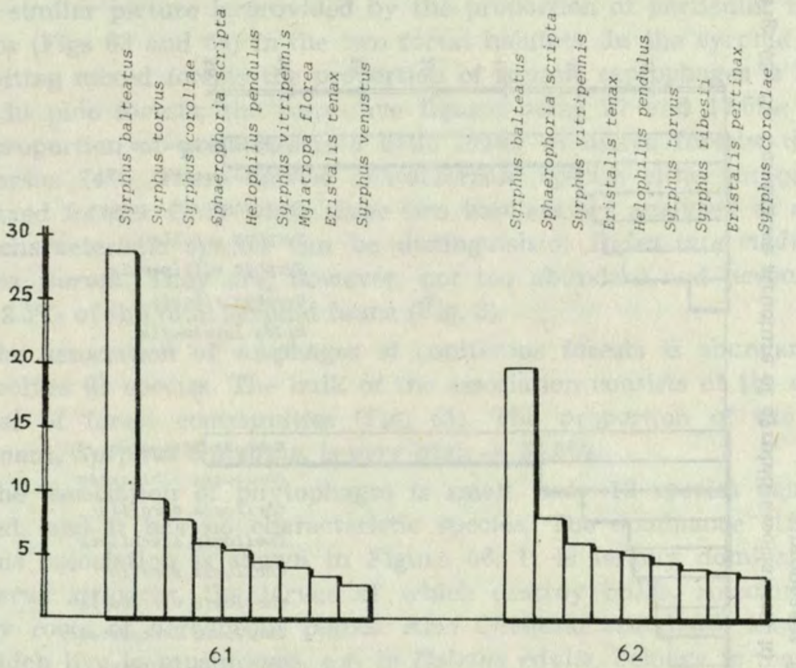
Aquatic saprophages are represented by 23 species (Fig. 19). In this association there are no characteristic species, this being related to water conditions in moist forests. The dominance structure of the association is shown in Figure 60. The dominants are the same as in the association inhabiting wet forests, only their percentage being lower in the syrphid community of moist forests.

Coniferous forests

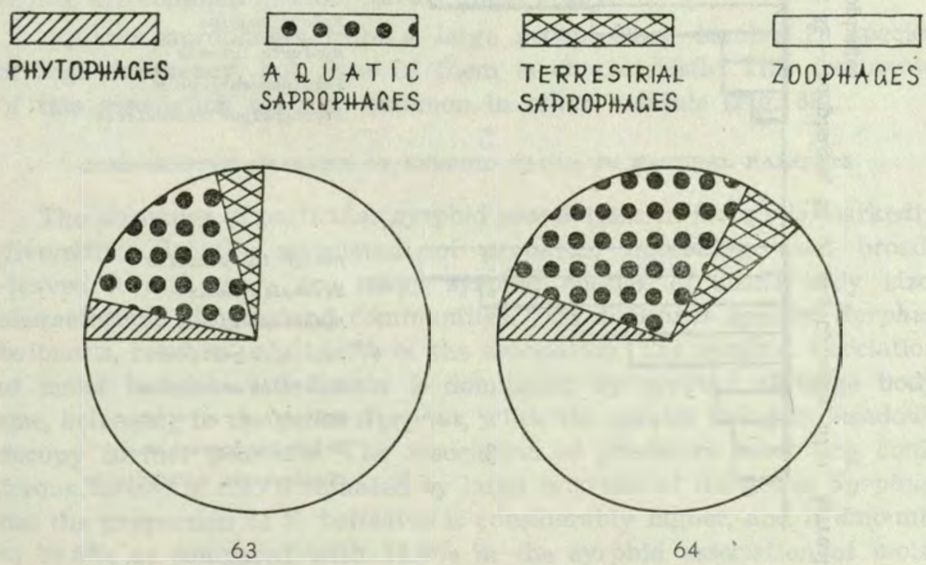
There is a high similarity, particularly in the dominance structure of syrphid communities, between pine forests and mixed forests (Fig. 2). A more detailed analysis shows the same (Figs 61 and 62). In the two communities, the first dominant is *Syrphus balteatus*. Then there are also predatory species, and only positions 4 and 5 are occupied by aquatic saprophages such as *Eristalis tenax* and *Helophilus pendulus*.



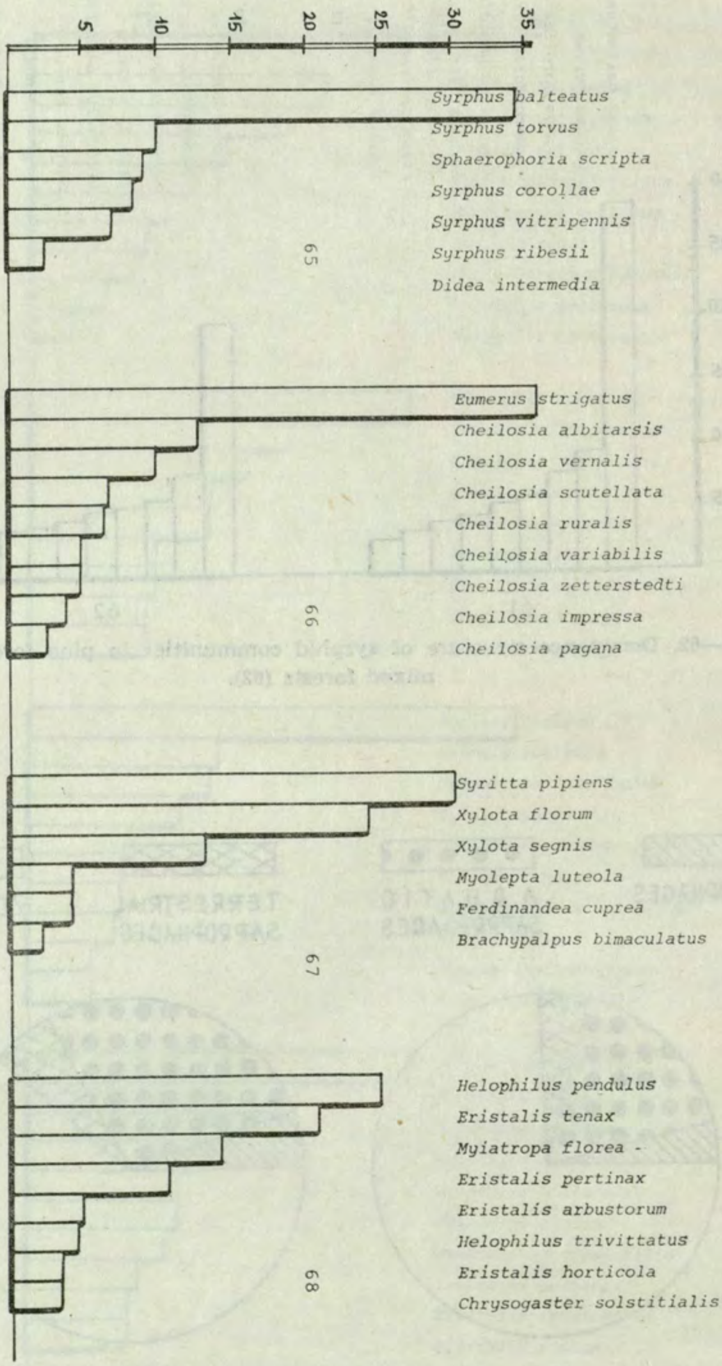
Figs 57—60. Dominance structure of syrphid associations in moist forests: 57 — zoophages, 58 — phytophages, 59 — terrestrial saprophages, 60 — aquatic saprophages.



Figs 61—62. Dominance structure of syrphid communities in pine forests (61) and mixed forests (62).



Figs 63—64. Percentage of trophic groups in pine forests (63) and mixed forests (64).



Figs 65—68. Dominance structure of syrphid associations in coniferous forests: 65 — zoophages, 66 — phytophages, 67 — terrestrial saprophages, 68 — aquatic saprophages.

A similar picture is provided by the proportion of particular trophic groups (Figs 63 and 64) in the two forest habitats. In the syrphid fauna inhabiting mixed forests the proportion of aquatic saprophages is higher than in pine forests, the respective figures being 27 and 17.5%, while the proportion of predators is a little lower in mixed forests, that is, 63 versus 74%. There are no characteristic species either in pine or in mixed forests. Only when these two habitats are analysed as a unit, two characteristic species can be distinguished: *Didea intermedia* and *Xylota florum*. They are, however, not too abundant and account for only 2.5% of the total syrphid fauna (Fig. 3).

The association of zoophages of coniferous forests is abundant and it involves 61 species. The bulk of the association consists of the species typical of forest communities (Fig. 65). The proportion of the main dominant, *Syrphus balteatus*, is very high — 34.5%.

The association of phytophages is small, only 13 species being recorded, and it has no characteristic species. The dominance structure of this association is shown in Figure 66. It is largely dominated by *Eumerus strigatus*, the larvae of which destroy bulbs, rhizomes, and fleshy roots of herbaceous plants. Also *Cheilosia scutellata*, the larvae of which live in mushrooms, e.g. in *Boletus edulis*, belongs to the group of dominants

Terrestrial saprophages are represented by 17 species, including one species characteristic of coniferous forests, *Xylota florum* (Fig. 20). The proportion of this species is high, amounting to 24% of the association (Fig. 67). The other dominants such as *Syritta pipiens* and *Xylota segnis*, are common in most forests under study.

Aquatic saprophages form a large group. They involve 20 species of high frequency, but none of them is characteristic. The dominants of this association are also common in other habitats (Fig. 68).

COMPARATIVE ANALYSIS OF SYRPHID FAUNA IN NATURAL HABITATS

The structure of particular syrphid associations in forests is markedly diversified. In the association of predators inhabiting west broad-leaved forests there are many syrphid species of small body size, characteristic of grassland communities. The dominant species, *Syrphus balteatus*, reaches only 14.3% of the association. The syrphid association of moist broad-leaved forests is dominated by syrphid of large body size, belonging to the genus *Syrphus*, while the species living in meadows occupy further positions. The association of predators inhabiting coniferous forests is also dominated by large syrphids of the genus *Syrphus*, but the proportion of *S. balteatus* is considerably higher, and it amounts to 34.5% as compared with 14.8% in the syrphid association of moist forests.

The associations of phytophages are still more diversified. Wet broad-leaved forests are mostly inhabited by *Cheilosia albitarsis*, the species accounting for 42% of the association. In moist broad-leaved forests it is replaced by *Cheilosia ruralis*. Phytophages inhabiting coniferous forests are largely dominated by *Eumerus strigatus*, the species accounting for 35.5% of the association. It is not so abundant in other forest associations, still it belongs to the group of dominants.

The associations of aquatic saprophages have most similar structure. In forests they are most dominated by *Helophilus pendulus* and *Eristalis tenax*, which reach similar numbers. The other dominants differ in particular forest types.

The associations of terrestrial saprophages are largely dominated by one eudominant, *Syritta pipiens*. It is an eurytopic species living in both wet and dry habitats, which largely increases its competitive ability. In rather rich and diversified forest syrphid associations its proportion varies from 24 to 30%, while in poor associations, inhabiting for instance xerothermal grasslands, its proportion can rise up to 88%.

*

* *

There are large differences in the structure of syrphid associations between forests and open habitats. The associations of zoophages inhabiting forests are dominated by *Syrphus balteatus*, while in meadows and xerothermal grasslands two major dominants are *Sphaerophoria scripta* and *Melanostoma mellinum*. Only the structure of the association of zoophages inhabiting moors is similar to the one in forest associations. It is largely dominated by *S. balteatus*, which contributes to 48% of the association. Moors are often surrounded by forests and generally covered with clumps of alders and willow scrub. This provides favourable conditions for the development of this species, which is reinforced by the fact that trees surrounding moors are often weakened and susceptible to infestation with pests, including aphids.

The associations of phytophages living in forests markedly differ from those inhabiting grasslands, both being dominated by *Cheilosia vernalis* (Figs 29 and 42). The structure of this association in xerothermal grasslands is different (Fig. 36), as in addition to meadow species also thermophilous species of the genera *Merodon* and *Eumerus* occur there.

The associations of terrestrial saprophages inhabiting grasslands are poor as compared with those inhabiting forests, this being reflected in their dominance structure (Figs 31 and 37). A remarkable feature is a very high abundance of *Syritta pipiens*. A slightly different picture is presented by the structure of this association in moors (Fig. 43). The proportion of *Syritta pipiens* is lower there, and the other dominants form a group in rather even numbers. Moors provide suitable conditions for the development of larvae of many syrphids of this association on the one hand, and the proximity of forests as well as high humidity enhance the penetration by syrphids on the other.

All the associations of aquatic saprophages inhabiting forests under study are largely predominated by *Helophilus pendulus* (Figs 52, 60 and 68). Such a dominance structure does not occur in grassland habitats. Moors are dominated by *Eristalis tenax*, while *H. pendulus* is on the third position (Fig. 44).

The association of aquatic saprophages inhabiting meadows is largely dominated by *Chrysogaster viduata*, the characteristic species of this association (Fig. 30). *H. pendulus* contributes to merely 5.6% of the association and it is on the fourth position. Xerothermal grasslands have no characteristic aquatic saprophages, hence the structure of their association reflects the situation in surrounding areas.

The association of zoophages living in the mountains is dominated by the species occurring in meadows (as compared with lowland associations), while the species of the genus *Syrphus* occurring in forests are of less importance (Fig. 15). Among dominants there are no characteristic species distinguishing mountain associations from lowland associations. Only companion species meet this condition. In contrast to the association of zoophages, the association of phytophages has three dominant species which, at the same time, are characteristic of the mountain association of syrphids and make it distinct (Fig. 16).

The association of terrestrial saprophages living in the mountains has the dominance structure similar to syrphid associations of wet forests (Figs 17 and 51). In both these associations hygrophilous species of the genera *Rhingia* and *Neoascia* are very abundant. This is related to a high humidity of mountain habitats, particularly in the lower and upper montane zones.

The mountain association of aquatic saprophages involves the species associated with forests, such as *Myiatropa florea* and *Eristalis pertinax*, and the species typical of meadows, such as *Chrysogaster viduata* (Fig. 19). Wet mountain meadows, stream banks, soggy ground, provide suitable conditions for hygrophilous hover flies, thus their numbers are high in the mountains.

An analysis of the proportion of particular zoogeographical elements in syrphid associations inhabiting lowland grasslands, shows that the associations occurring in meadows are most similar to one another (Tab. 4). In the associations of phytophages and terrestrial saprophages only the proportion of the Holarctic element increases. A different proportion of zoogeographical elements is in the associations inhabiting moors (Tab. 5). The submediterranean and mountain elements are lacking, the proportion of the European element is lowered, while the proportion of the Holarctic element is higher, particularly in the associations of zoophages. The syrphid associations of xerothermal grasslands are characterized by a very high proportion of the submediterranean element. This is particularly the case of the association of phytophages (Tab. 6).

The syrphid associations occurring in forests do not show clear differences in the proportion of zoogeographical elements. In the association of phytophages occurring in broad-leaved forests (Table 7 and 8), the proportion of the European and mountain elements is increased, while in the associations inhabiting coniferous forest there are no mountain elements (Tab. 9), and the European element accounts for only 19% (Tab. 9). The submediterranean element occurs only in the association inhabiting moist forests (Tab. 8). The association of aquatic saprophages inhabiting coniferous forests has an increased proportion of the Holarctic and Palaearctic elements and a considerably decreased proportion of the Euro-Siberian element, these being related to the occurrence of eurytopic species which can live in drier habitats.

Table 4. Percentage of zoogeographical elements in meadow syrphid associations

Trophic groups \ Zoogeographical elements	Cosmopolitan	Holarctic	Palaearctic	Euro-Siberian	European	Boreal	Mountain	Submediterranean
Zoophages	1.0	37.0	16.0	28.0	15.0	2.0	—	1.0
Phytophages	—	9.5	19.0	28.0	34.5	—	6.0	3.0
Terrestrial saprophages	—	31.5	12.5	44.0	6.0	6.0	—	—
Aquatic saprophages	3.0	17.5	23.0	41.0	12.5	3.0	—	—
Total	1.0	28.5	18.0	31.5	17.0	2.0	1.0	1.0

Table 5. Percentage of zoogeographical elements in moor syrphid associations

Trophic groups \ Zoogeographical elements	Cosmopolitan	Holarctic	Palaearctic	Euro-Siberian	European	Boreal	Mountain	Submediterranean
Zoophages	3.0	59.0	19.0	19.0	—	—	—	—
Phytophages	—	—	40.0	40.0	—	20.0	—	—
Terrestrial saprophages	—	27.5	13.5	41.0	18.0	—	—	—
Aquatic saprophages	5.0	28.0	28.0	28.0	11.0	—	—	—
Total	2.5	39.0	21.0	28.5	8.0	1.0	—	—

Table 6. Percentage of zoogeographical elements in syrphid associations of xerothermal grasslands

Trophic groups \ Zoogeographical elements	Cosmopolitan	Holarctic	Palaearctic	Euro-Siberian	European	Boreal	Mountain	Submedi-terranean
Zoophages	—	36.0	25.0	23.0	9.0	3.5	—	3.5
Phytophages	—	15.5	15.5	15.5	23.0	—	—	30.5
Terrestrial saprophages	—	25.0	—	50.0	—	25.0	—	—
Aquatic saprophages	11.0	22.0	22.0	22.0	22.0	—	—	—
Total	1.0	30.5	22.0	23.0	12.0	4.0	—	7.5

Table 7. Percentage of zoogeographical elements in syrphid associations of wet forests

Trophic groups \ Zoogeographical elements	Cosmopolitan	Holarctic	Palaearctic	Euro-Siberian	European	Boreal	Mountain	Submedi-terranean
Zoophages	1.5	48.0	24.0	19.0	6.0	1.5	—	—
Phytophages	—	5.0	19.0	33.0	28.5	5.0	9.5	—
Terrestrial saprophages	—	14.0	17.0	45.0	24.0	—	—	—
Aquatic saprophages	3.0	24.5	21.0	35.5	12.0	3.0	—	—
Total	1.5	30.0	21.0	30.0	14.0	2.0	1.5	—

Table 8. Percentage of zoogeographical elements in syrphid associations of moist forests

Trophic groups \ Zoogeographical elements	Cosmopolitan	Holarctic	Palaearctic	Euro-Siberian	European	Boreal	Mountain	Submedi-terranean
Zoophages	1.0	41.0	20.0	28.0	10.0	—	—	—
Phytophages	—	3.0	8.0	38.0	32.0	3.0	11.0	5.0
Terrestrial saprophages	—	27.5	12.0	33.5	24.0	3.0	—	—
Aquatic saprophages	4.0	17.0	21.0	42.0	12.0	4.0	—	—
Total	1.0	27.0	16.0	33.0	18.0	2.0	2.0	1.0

Table 9. Percentage of zoogeographical elements in syrphid associations of coniferous forests

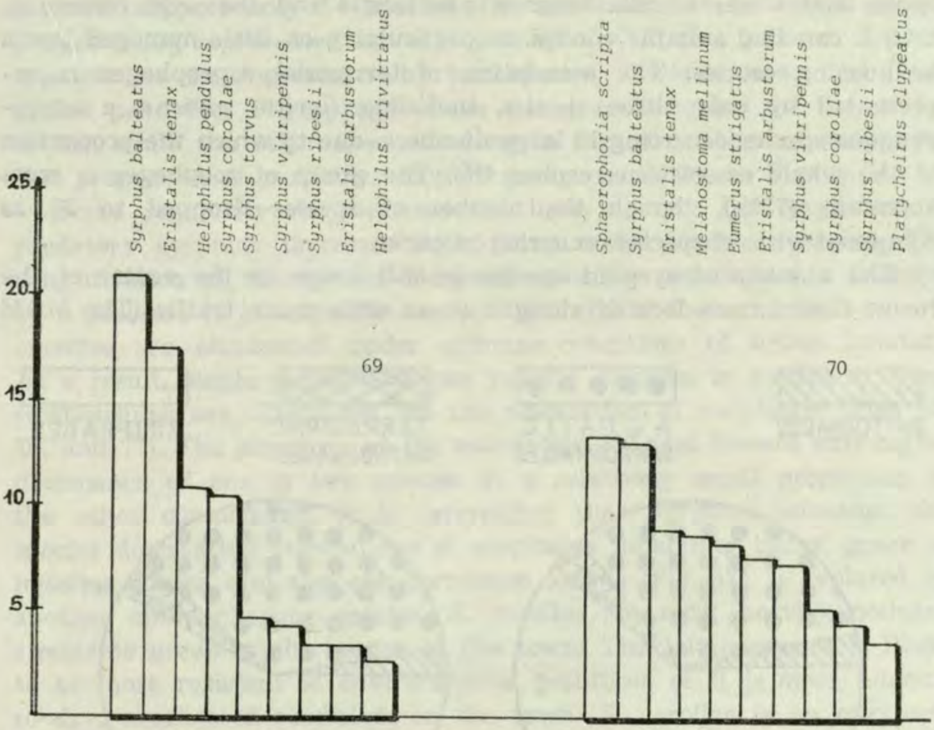
Trophic groups \ Zoogeographical elements	Cosmopolitan	Holarctic	Palaearctic	Euro-Siberian	European	Boreal	Mountain	Submediterranean
Zoophages	1.5	41.0	21.0	24.5	9.0	3.0	—	—
Phytophages	—	6.0	31.0	38.0	19.0	6.0	—	—
Terrestrial saprophages	—	31.5	16.0	31.5	21.0	—	—	—
Aquatic saprophages	5.0	29.0	33.0	19.0	14.0	—	—	—
Total	1.5	33.0	24.0	26.0	13.0	2.5	—	—

STRUCTURE OF SYRPHID COMMUNITIES INHABITING ANTHROPOGENIC HABITATS

URBICOENOSES

The syrphid communities analysed above occur in plant communities relatively little influenced by human activity. The subsequent analysis concerns hover flies living in ecosystems partly or totally transformed by man, in S u k o p p's scale called euhemerobes.

Urban ecosystems, though largely transformed, preserve basic elements, and function in a similar way as natural ecosystems. In towns there are many factor accounting for anthropogenic pressure. It is enough to mention heavy air pollution with car exhaust and industrial emissions, soil pollution with salt, herbicides, and many other substances toxic to animals. Also the quality of plant cover is important to the majority of urban zoocoenoses. Urban vegetation is strongly transformed by man and it is permanently subjected to this interference. A characteristic feature of urban green areas is their high diversity. Their size ranges from several-metre bands of streetside lawns to more than 10-ha parks, and they differ in the structure of vegetation and the degree of pollution. Quantitative samples were taken along the gradient of increasing anthropogenic pressure, that is from urban parks, through green areas of housing estates, to extremely polluted narrow streetside lawns. The gradient sampling permits to follow the directions of changes in the fauna caused by increasing anthropogenic pressure. First of all, a decrease in the number of syrphid species can be noted. Since Warsaw is established on the site of oak-hornbeam forests, its fauna can be compared with the fauna of natural oak-hornbeam forests. The total material collected in Warsaw consists of 73 syrphid species, while in natural oak-hornbeam forests 128 species are recorded.



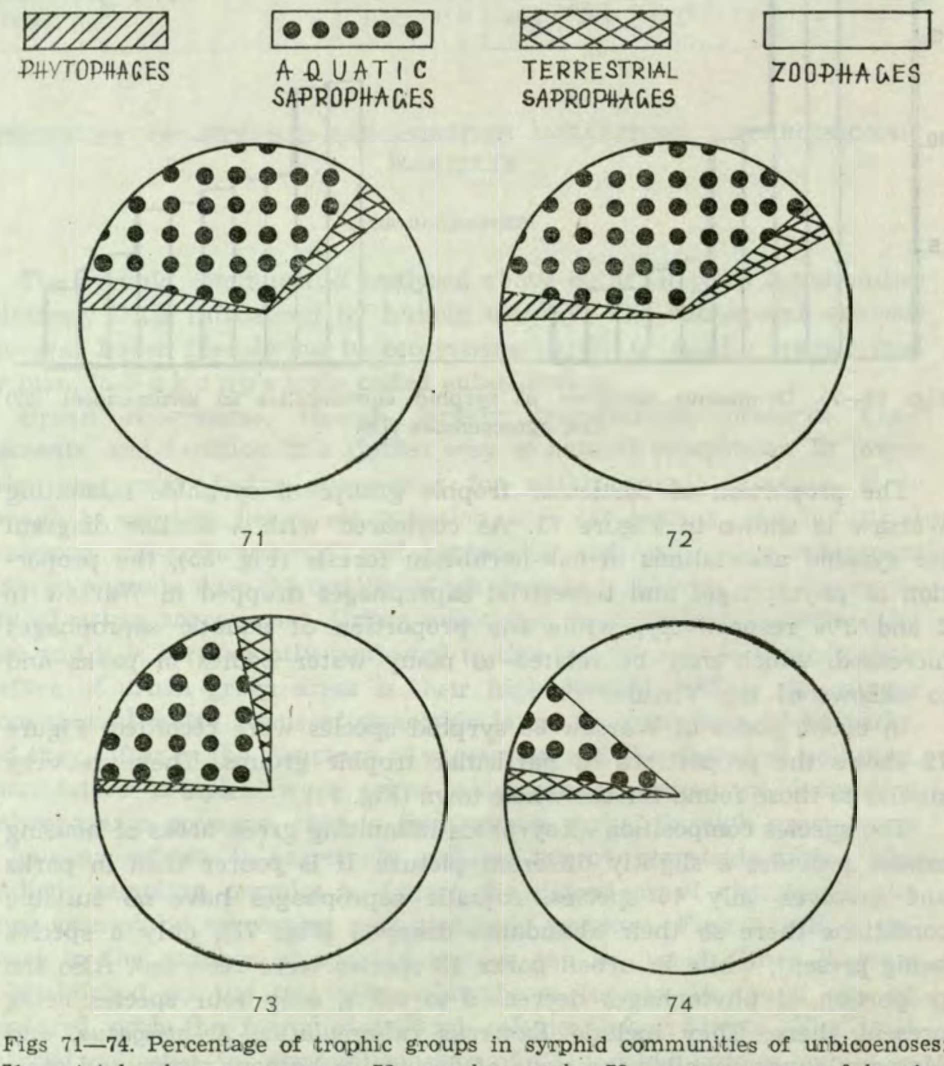
Figs 69—70. Dominance structure of syrphid communities in urbicoenoses (69) and agrocoenoses (70).

The proportion of particular trophic groups of syrphids inhabiting Warsaw is shown in Figure 71. As compared with a similar diagram for syrphid associations in oak-hornbeam forests (Fig. 55), the proportion of phytophages and terrestrial saprophages dropped in Warsaw to 2 and 3% respectively, while the proportion of aquatic saprophages increased, which may be related to many water bodies in parks and to oxbows of the Vistula.

In urban parks of Warsaw 66 syrphid species were recorded. Figure 72 shows the proportions of particular trophic groups. They are very similar to those found for the whole town (Fig. 71).

The species composition of syrphids inhabiting green areas of housing estates provides a slightly different picture. It is poorer than in parks and involves only 46 species. Aquatic saprophages have no suitable conditions there so their abundance dropped (Fig. 73), only 6 species being present, while in urban parks 13 species were recorded. Also the proportion of phytophages decreased to 0.5%, only four species being present there. They include *Eumerus tuberculatus, E. strigatus,* and *Merodon equestris,* all being pests of decorative bulbous plants and some perennials with fleshy rhizomes and tubers. *Cheilosia vernalis* mines leaves and stems of the common sow-thistle and the wild camomile, thus it can find suitable conditions particularly on little managed lawns in housing estates. The association of terrestrial saprophages is represented by only three species, including *Syritta pipiens*, a coprophagous species occurring in large numbers, due to which the proportion of the whole association reaches 4%. The group of zoophages is most abundant (73%), though the number of species dropped to 33 as compared with 46 species occurring in parks.

The number of syrphid species is still lower in the centre of the town. Green areas located along a street with much traffic (The MDM

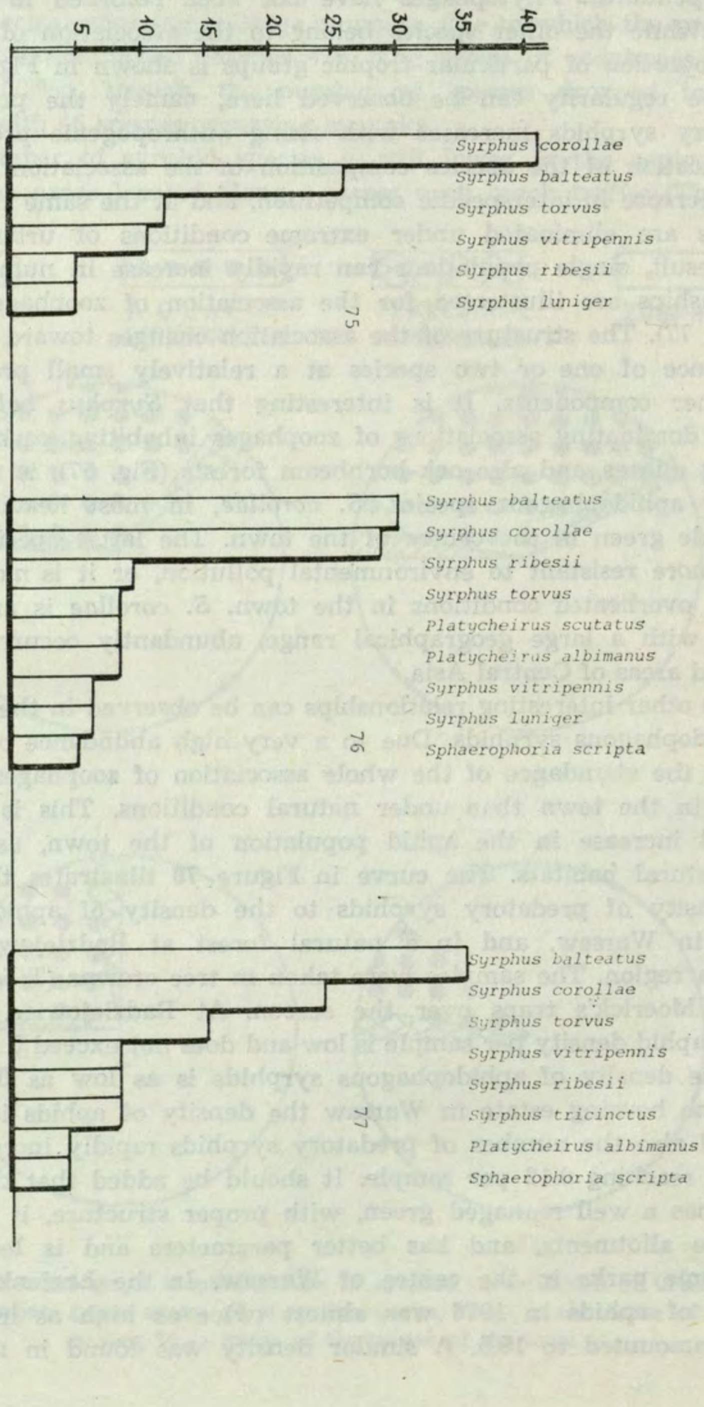


Figs 71—74. Percentage of trophic groups in syrphid communities of urbicoenoses: 71 — total urban green areas, 72 — urban parks, 73 — green areas of housing estates, 74 — green of the centre of the town.

quarter) support only 14 species, the association of terrestrial saprophages being represented by only one species, *Syritta pipiens*. Aquatic saprophages are represented by two species, *Eristalis tenax* and *Helophilus pendulus*. Phytophages have not been recorded in the centre so far, while the other species belong to the association of zoophages. The proportion of particular trophic groups is shown in Figure 74.

Some regularity can be observed here, namely the proportion of predatory syrphids increases with rising anthropogenic pressure. The simplification of the species composition of the association is followed by a decrease in interspecific competition, and at the same time natural enemies are eliminated under extreme conditions of urban habitats. As a result, single populations can rapidly increase in numbers. These relationships are illustrated for the association of zoophages (Figs 75, 76, and 77). The structure of the association changes toward still higher dominance of one or two species at a relatively small proportion of the other components. It is interesting that *Syrphus balteatus*, the species dominating associations of zoophages inhabiting parks, green of housing estates, and also oak-hornbeam forests (Fig. 57), is replaced by another aphidophagous species, *S. corollae*, in most heavily polluted streetside green in the centre of the town. The latter species is likely to be more resistant to environmental pollution, or it is more tolerant to dry, overheated conditions in the town. *S. corollae* is an eurytopic species with a large geographical range, abundantly occurring also in semiarid areas of Central Asia.

Also other interesting relationships can be observed in the association of aphidophagous syrphids. Due to a very high abundance of dominant species, the abundance of the whole association of zoophages is usually higher in the town than under natural conditions. This is related to a rapid increase in the aphid population of the town, as compared with natural habitats. The curve in Figure 78 illustrates the ratio of the density of predatory syrphids to the density of aphids at some points in Warsaw, and in a natural forest at Radziejowice in the Mazovia region. The samples were taken in tree crowns (*Tilia sp.*) using yellow Moerick's traps over the season. At Radziejowice, the mean annual aphid density per sample is low and does not exceed 5 individuals. Also the density of aphidophagous syrphids is as low as 0.07. In the Wierzbno housing estate in Warsaw the density of aphids increased to 8.2, and also the number of predatory syrphids rapidly increased, their density reaching 0.12 per sample. It should be added that this housing estate has a well managed green, with proper structure, it is adjacent to large allotments, and has better parameters and is less polluted than some parks in the centre of Warsaw. In the Łazienki park the density of aphids in 1976 was almost twice as high as in Wierzbno and it amounted to 15.5. A similar density was found in the housing



Figs 75—77. Dominance structure of the association of zoophages in green areas of Warsaw: 75 — centre of the town. 76 — green of housing estates, 77 — urban parks.

estate of Stawki (16.0) which has a very poor green, isolated from larger parks, and is heavily polluted with car exhaust. In the two cases the density of predatory syrphids is lower than in Wierzbno and it reaches only 0.08, though the food supply is twice as high. The anthropogenic pressure is so heavy there that it limits the abundance of aphidophages, this group being more susceptible to pollution than phytophages with piercing mouth parts. This relationship is still better pronounced in streetside green patches of the MDM quarter, where the density of predatory syrphids dropped to 0.06, while the density of aphids increased to 42.4 per sample. Here the biocoenotic balance has been disturbed so that the group of phytophages overcame the barrier of biocoenotic regulation and spontaneously developed without limitations set up by biological factors. As a result it destroys green of the centre of the town.

The syrphid community of the urban ecosystem is highly dominated by four species (Fig. 69). Two of them, *Syrphus balteatus* and *S. corollae*, are aphidophages, the other two, *Eristalis tenax* and *Helophilus pendulus*, are saprophages. The predatory species are rather evenly distributed over the whole area under study, while the saprophages inhabit mainly urban parks, allotments, and riverside areas. The group of subdominants consists mostly of aphidophagous species, characteristic of broad-leaved forests. The meadow species of syrphids are less abundant, probably as an effect of frequent mowing both in urban parks and in housing estates. Zoophages form the largest associations in urbicoenoses, 50 species being recorded in Warsaw. Phytophages and terrestrial saprophages, instead, are poorly represented, only 5 species of each of these groups being recorded. The most abundant phytophage is *Eumerus strigatus*, a pest of decorative plants, and the most abundant terrestrial saprophage is *Syritta pipiens*, a coprophagous species.

Heavily transformed habitat conditions and a high toxicity of the environment in towns, form a barrier for many species occupying surrounding areas. Large urban parks, such as Łazienki, Cemetery of Soviet Soldiers, as well as housing estates with well planned green areas of a proper structure, such as Wierzbno, provide suitable conditions for a rather large number of syrphid species. Aphidophages, the most important group from the point of view of the protection of the urban green, are abundant there and can efficiently control aphid numbers. This cannot be stated in relation to the green of small inner courtyards, squares and streetside belts in the centre of the town. Aphidophagous syrphids are very scarce there and they cannot efficiently control dense aphid populations of these habitats. Practically, it is not possible at all to maintain biocoenotic balance in the centre of the town which is heavily polluted, closely built-up, and deprived of green of a proper structure.

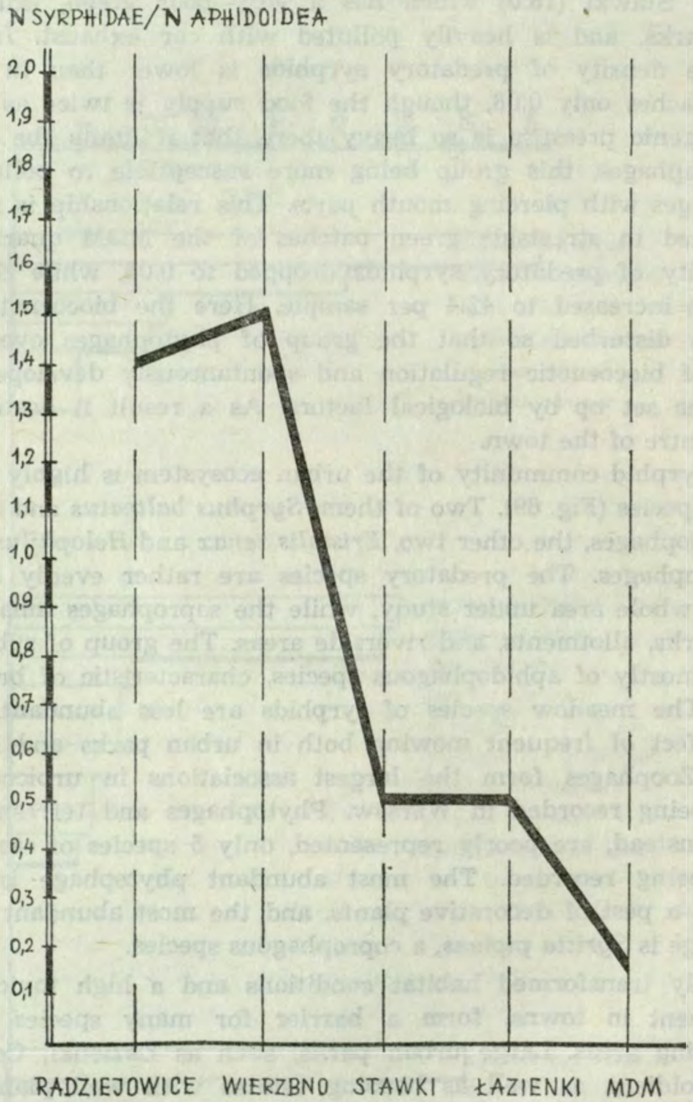
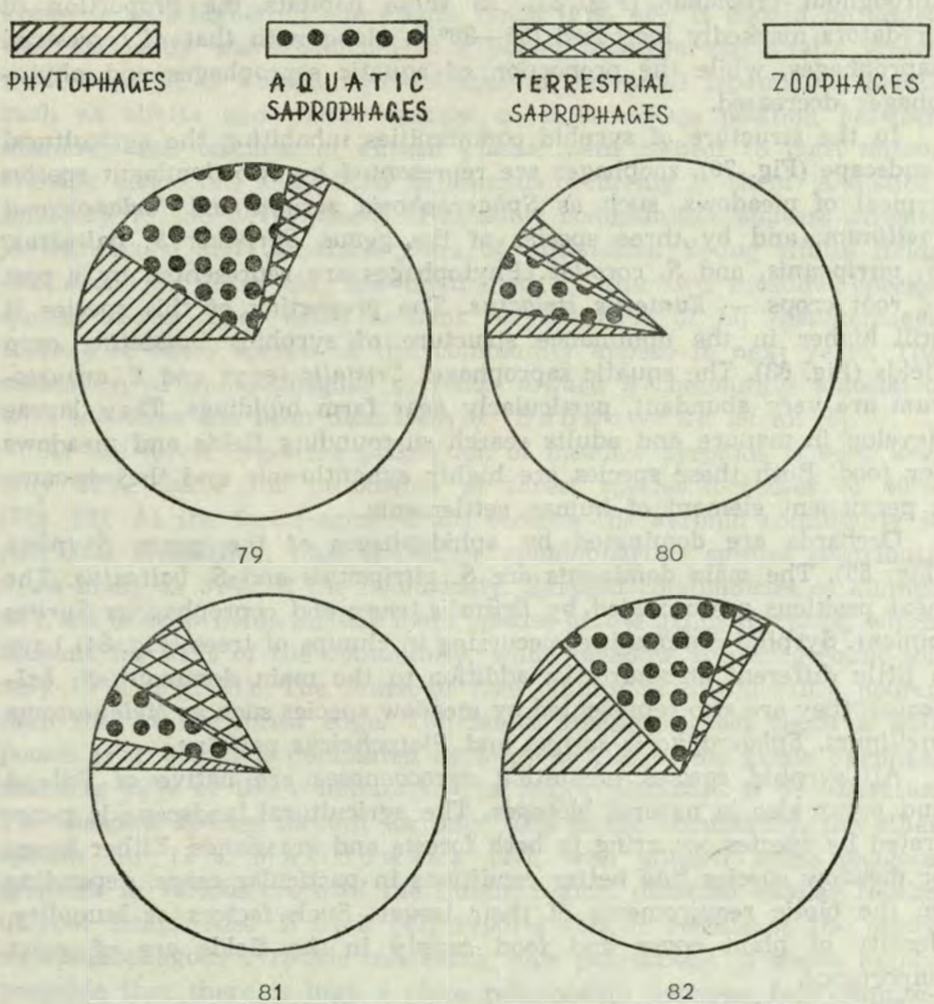


Fig. 78. Ratio of the density of predatory syrphids to the density of aphids in several habitats, as obtained by the method of Moerick's traps in lime crowns in 1976.

AGROCOENOSES

The origins of agriculture and animal husbandry in Central Europe date back to the Mesolithic Age. At that time man produced large changes in the plant cover. Vast areas of woodland were burnt out, then ploughed and sawn with usable plants, cattle were grazed and settlements developed. All these factors gradually transformed the primeval landscape. Recently, agricultural areas have covered about 60% of

Europe. The agricultural landscape is not uniform. It is a mosaic made up of crop fields, orchards, gardens, clumps of trees, and also human settlements. The species composition of syrphids inhabiting agricultural areas is also rather diversified and characteristic of some crop types grown in the temperate zone. The long-term study on the fauna of syrphids associated with alfalfa in various regions of Poland, shows that this habitat supports a permanent syrphid community which is indentical in western part of the country (the region of Opole, surroundings of Wrocław, the regions of Kielce, Mazovia, and Zamość) [6]. Similar results were obtained for syrphid communities occurring in grain crops, root crops, orchards, and other plantations. The bulk



Figs 79—82. Percentage of trophic groups in syrphid communities of agricultural landscape: 79 — total agrocoenoses, 80 — orchards, 81 — tree clumps in crop fields, 82 — crop fields.

of dominant species remains unchanged, only the companion species are different. Some deviations are possible in small cultivated areas strongly affected by large forests, or other natural plant communities.

The proportion of particular trophic groups in syrphids of the agricultural landscape is shown in Figure 79. Predators have a large contribution here, then aquatic saprophages and phytophages, while the proportion of terrestrial saprophages is low (3%).

The structure of syrphid community living only in crop fields (Fig. 82) does not differ much from the pattern described above, only the proportion of phytophages — crop pests is higher. A little different situation is in orchards (Fig. 80) and in clumps of trees scattered throughout croplands (Fig. 81). In these habitats the proportion of predators markedly increased (85—88%), along with that of terrestrial saprophages, while the proportion of aquatic saprophages and phytophages decreased.

In the structure of syrphid communities inhabiting the agricultural landscape (Fig. 70), zoophages are represented by two dominant species typical of meadows, such as *Sphaerophoria scripta* and *Melanostoma mellinum*, and by three species of the genus *Syrphus*: *S. balteatus*, *S. vitripennis*, and *S. corollae*. Phytophages are represented by a pest of root crops — *Eumerus strigatus*. The proportion of this species is still higher in the dominance structure of syrphids inhabiting crop fields (Fig. 83). The aquatic saprophages *Eristalis tenax* and *E. arbustorum* are very abundant, particularly near farm buildings. Their larvae develop in manure and adults search surrounding fields and meadows for food. Both these species are highly synanthropic and they became a permanent element of human settlements.

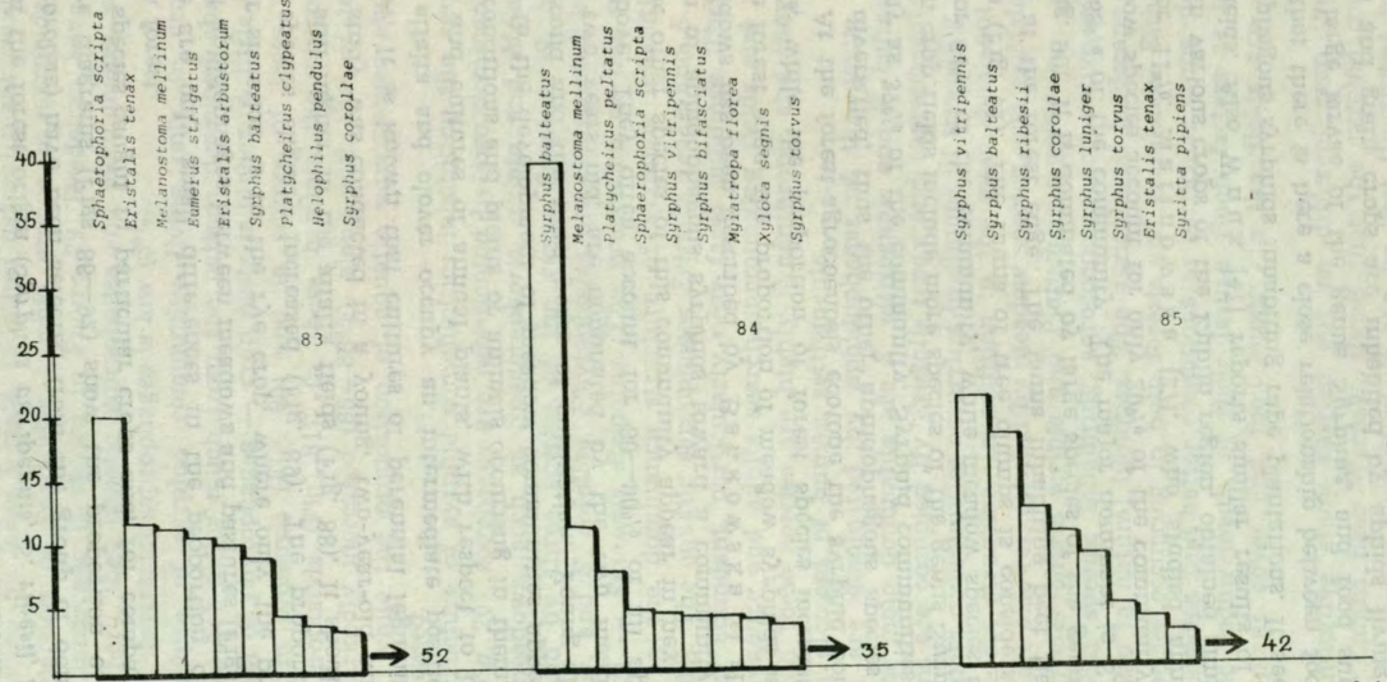
Orchards are dominated by aphidophages of the genus *Syrphus* (Fig. 85). The main dominants are *S. vitripennis* and *S. balteatus*. The next positions are occupied by *Eristalis tenax* and coprophagous *Syritta pipiens*. Syrphid communities occurring in clumps of trees (Fig. 84) have a little different structure. In addition to the main dominant, *S. balteatus*, they are also represented by meadow species such as *Melanostoma mellinum*, *Sphaerophoria scripta* and *Platycheirus peltatus*.

All syrphid species inhabiting agrocoenoses are native of Poland and occur also in natural biotopes. The agricultural landscape is penetrated by species occurring in both forests and grasslands. Either forest or meadow species find better conditions in particular crops, depending on the biotic requirements of their larvae. Such factors as humidity, density of plant cover and food supply in the fields are of great importance.

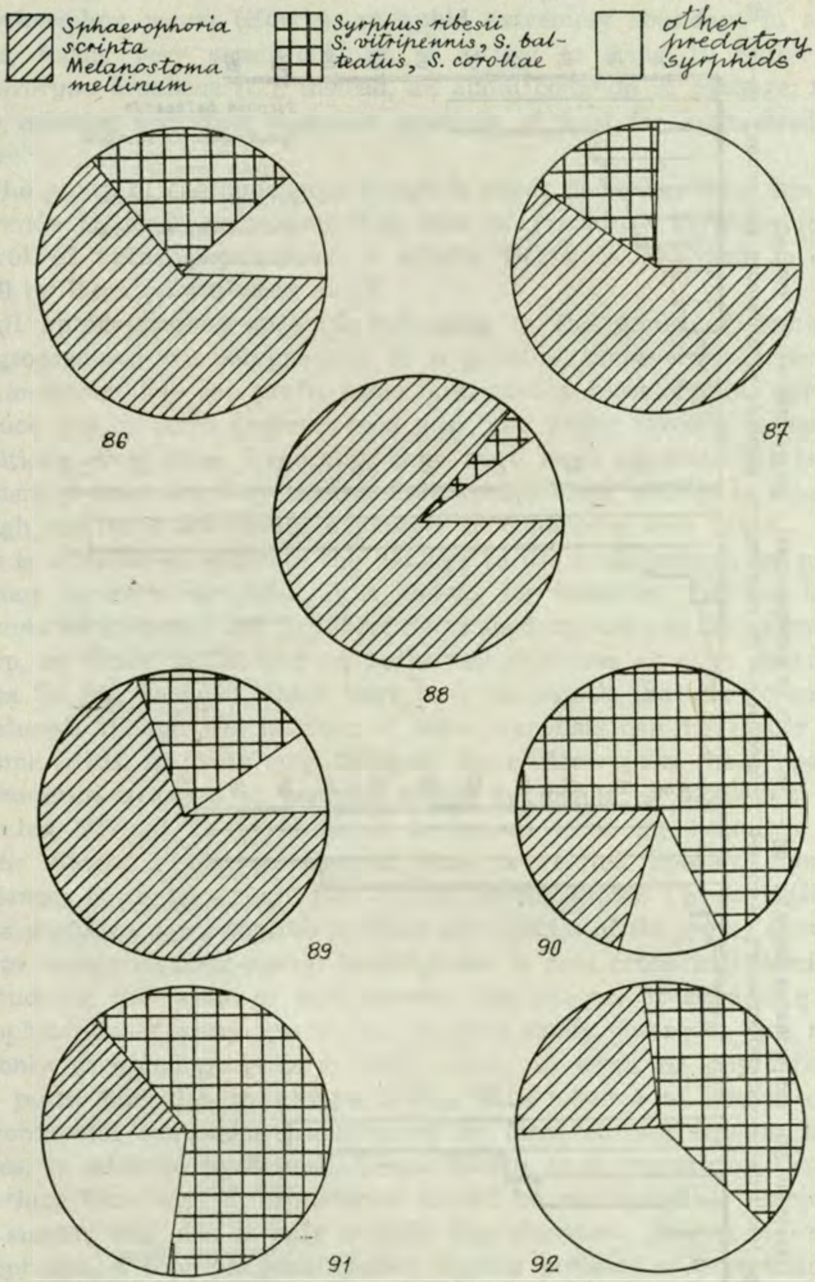
The quantitative study carried out on different crop types concurrently at Łomna near Warsaw, shows that the syrphid community of this area is largely diversified. It can be best illustrated by taking aphidophagous syrphids as an example. Two species derived from meadows (*Sphaerophoria scripta* and *Melanostoma mellinum*) and four species of the forest origin (*Syrphus vitripennis, S. ribesii, S. balteatus,* and *S. corollae*) have been selected from the group of dominants. The successive diagrams (Figs 86—92) show the proportion of forest and meadow species caught in particular crops and, for comparison, at the edge of a forest.

There are only small differences in the proportion of particular groups of aphidophages between meadows and pastures (Figs 86 and 87). A similar situation is in the rye crop, where only the proportion of meadow species slightly increased (Fig. 89). The proportion of this group is still higher in the alfalfa fields (Fig. 88). It should be added that the study was conducted in a young, two-year-old alfalfa grown for fodder. It is known that cultures of perennial leguminous plants such as alfalta and clover occupy an intermediate position between meadows and cultures of annual plants, with respect to both microclimatic conditions and plants or animals occurring in them. A distinct tendency to the development of meadow communities appears already in the second and the third years of cultivation. Young alfalfa fields one and two years old, are dominated by the two meadow species quoted above. They often account for 80—90% of all aphidophages there. The other species of this community appear in next years. The succession of aphidophagous syrphids toward a community associated with meadows has been described by Bańkowska et al. [6].

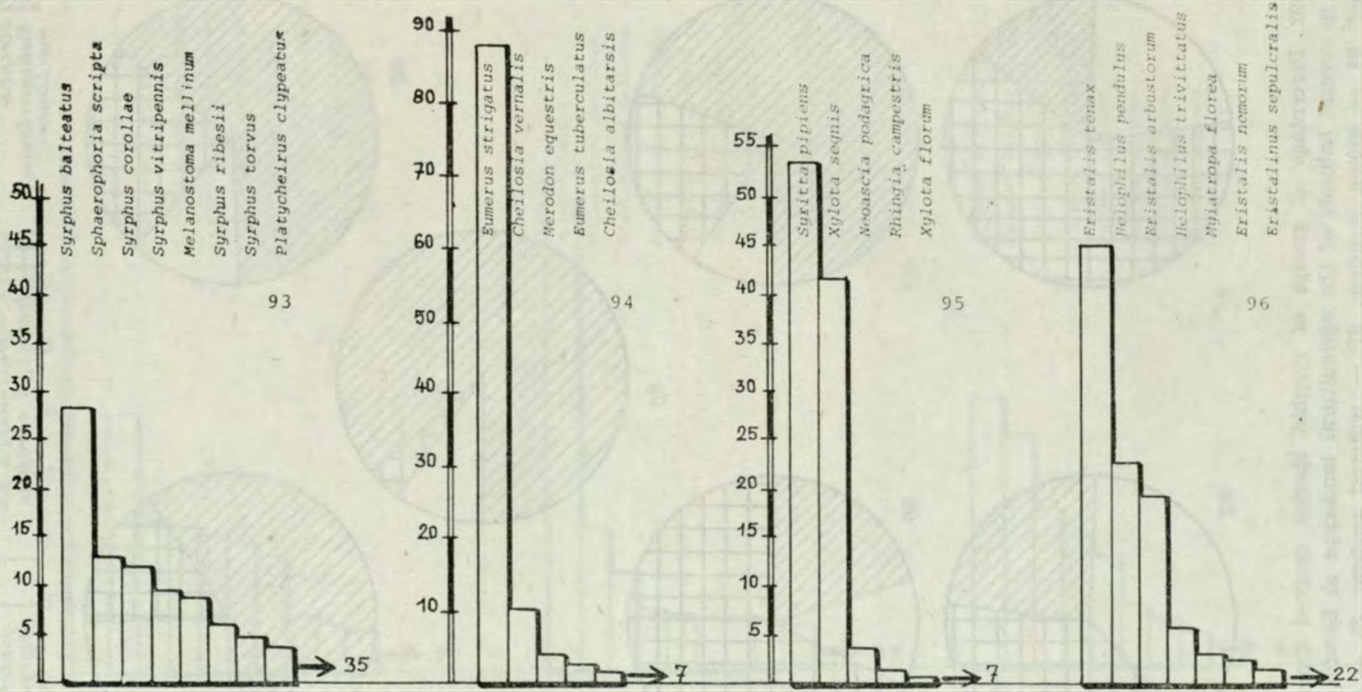
At the forest edge, the proportion of meadow syrphids is very low, only 23%, while the proportion of forest species increases to 40% (Fig. 92). At the forest-agrocoenosis ecotone the syrphid community is rich and diversified, thus the other aphidophagous species contribute to as many as 37% of the community. Syrphid communities of clumps of trees in crop fields include more species of the genus *Syrphus*, which account for 64% of the community, while meadow species account for only 15% (Fig. 91). The fauna of tree clumps is considerably poorer than that at the forest edge. The fauna inhabiting beet fields is still poorer (Fig. 90). It is dominated by large species of the genus *Syrphus*, reaching 69% of the community. The major dominant is *S. balteatus*. The meadow species account for only 20% of the community, the other species for 11%. Malinowska [27], who studied aphidophagous syrphids in various crops of the Lublin region, obtained similar results in root fields. Also Wnuk [47] reports similar results of the study on aphidophagous syrphids inhabiting rape plantations. It seems highly probable that there is here a close relationship between food requirements in large larvae of the genus *Syrphus*, and food supply. Both grasslands and grain crops are inhabited by aphids living in small, dispersed colonies which can provide food only for small larvae of



Figs 83—85. Dominance structure of syrphid communities in agrocoenoses: 83 — crop fields (52 species), 84 — clumps of trees in crop fields (35 species), 85 — orchards (42 species).



Figs 86—92. Percentage of groups of syrphid species derived from forests and meadows in several habitats of the agricultural landscape at Łomna, the province of Warsaw: 86 — mown meadow, 87 — watered pasture, 88 — alfalfa field, 89 — rye field, 90 — beets grown for fodder, 91 — clumps of trees in crop fields, 92 — forest edge.



Figs 93—96. Dominance structure of syrphid associations in anthropogenic habitats: 93 — zoophages (35 species), 94 — phytophages (7 species), 95 — terrestrial saprophages (7 species), — 96 aquatic saprophages (22 species).

meadow species, with considerably lower food requirements. Also *Acyrthosiphon pisum* (Harris), an aphid extremely abundant in alfalfa fields, forms very small colonies of a few to some 10 individuals. *Brevicoryne brassicae* (L.), instead, an aphid common in cabbage, forms huge colonies providing adequate amounts of food for large predatory larvae.

The group of aphidophagous syrphids needs particular attention with reference to plant protection. The role of predatory syrphids in the control of aphid populations in alfalfa fields, is analysed in more detail by Bańkowska et al. [7].

All aphidophagous syrphids belonging to the group of dominants in agrocoenoses are polyphagous. It is possible, however, that in some circumstances they can prefer some host species. Most of these syrphids produce two or three generations a year, and under favourable weather conditions even more. Generally, they have large geographical ranges, frequently extending beyond the Palaearctic. Their ecological tolerance is high and they are rather expansive in colonizing new areas.

It is difficult to estimate the damage to the crops caused by phytophagous larvae of syrphids. It is known, for instance, that the larvae of *Eumerus strigatus* and *E. tuberculatus* feed on roots of the carrot and turnip, on union bulbs, and on bulbs and rhizomes of some decorative plants. So far, however, there have been no signals that root crops are threatened, though the number of adult syrphids can be rather high in some fields. In many crop fields of the Kielce region, the proportion of *Eumerus strigatus* in samples taken by means of Moerick's traps exceeded 50% of all syrphids. It is known from the literature that in the Soviet Union, in Central Asia, a related species, *Eumerus sogdianus*, is an important pest of the carrot grown for seed [38]. It seems useful to pay attention to these two species of the genus *Eumerus*, and to recognize their actual harmfulness to root crops in Poland.

Studying the fauna of agrocoenoses, the process of advancing synantrophization of many species can be most easily observed. This refers not only to aphidophagous syrphids living in crops or phytophagous crop pests, but also to groups having little chance to adapt to the environmental conditions transformed by man. Among aquatic saprophages, in addition to *Eristalis tenax* known as a synanthropic species for a long time, also *E. arbustorum* should be mentioned. It reproduces in a similar way and is only a little less abundant. Among terrestrial saprophages, a coprophagous species, *Syritta pipiens*, is most abundant in agrocoenoses. Its larvae can live in both livestock manure and semiliquid, decaying plant material. Recently the abundance of a forest species, *Xylota segnis*, largely increased near farm buildings, as its larvae have adapted themselves to life in compost and even in silos with silage for cattle.

COENOSES SUBJECTED TO INDUSTRIAL PRESSURE

The study carried out in the areas of industrial plants and sulphur mines are of preliminary character, and they covered only one growing season. The material was collected only by means of yellow Moerick's traps, thus it is not comparable with the data obtained by means of sampling per time unit. With this respect it is difficult to draw many conclusions from the obtained material, and, in particular, to analyse structural changes in syrphid communities as a result of industrial pollution.

Nevertheless, some regularities common to all industrial centres under study can be distinguished: the number of syrphid species and their abundance decreased with lowering distance to the source of pollution.

Most industrial plants under study are located in the agricultural landscape and surrounded by crop fields. Only the nitrogen plant in Puławy adjoins a forest. The structure of syrphid communities in control plots, more distant from the source of pollution, is rather typical of crop fields. In the heavy polluted areas there are so few species and individuals that it is not possible to analyse structure.

In the cement plant "Nowiny" near Kielce, where the fall of dust exceeds 1150 tons per km^2 per year, the abundance of syrphids is very low (Fig. 97) and only 6 species are present. At Posłowice, in the plot located 4 km from the plant, 10 species were caught and their abundance also tended to increase. At a distance of 6 km (at Dyminy) there were

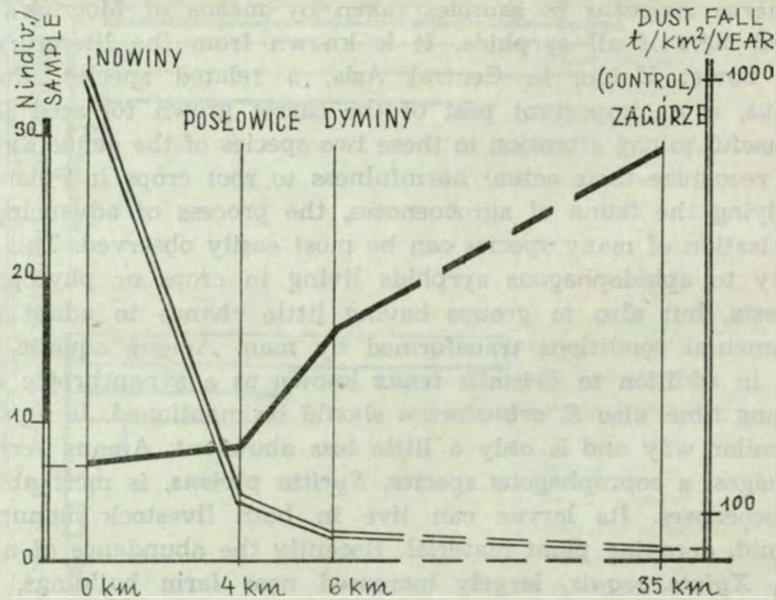


Fig. 97. Changes in syrphid abundance along the gradient of pollution with dust from the cement plant „Nowiny" near Kielce.

13 species and their abundance was still higher. They were dominated by the species characteristic of crop fields, such as *Eumerus strigatus, Sphaerophoria scripta, Pipizella varipes,* or *Melanostoma mellinum.*

The study plots subjected to the emissions from the nitrogen plant in Puławy also formed a gradient. In the area of the plant itself only 9 syrphid species were recorded. Both their low abundance and the species composition show that they are casual visitors from neighbouring crops. A very interesting situation is observed on the areas originally covered with forests, then degraded by emissions, deforested and finally reclaimed as agriculturally used area. Samples were taken in artificially watered plots. They were located in close vicinity to the plant, nevertheless syrphids were abundant there and 16 species were recorded, that is, not less than in the crop fields distant from the source of pollution. The structure of the syrphid community occurring in intensely reclaimed areas was similar to that in the crop fields at Osiny, located at a distance of 7 km (Fig. 98).

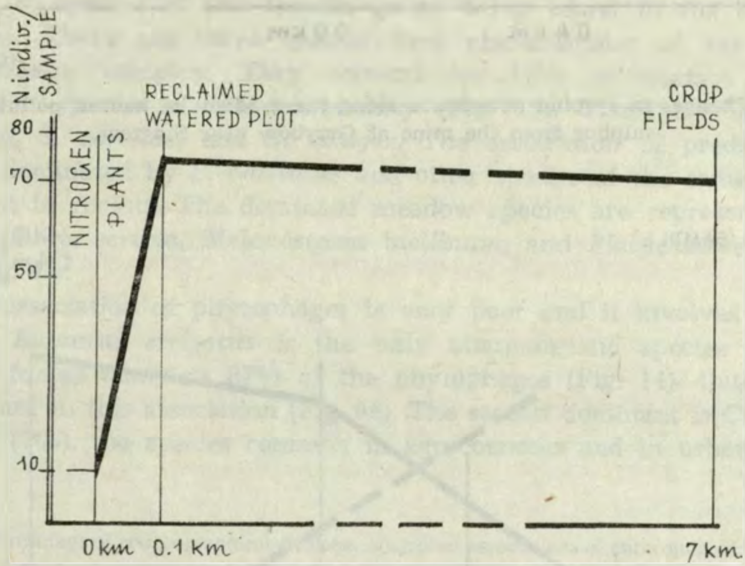


Fig. 98. Abundance of syrphids in the area of the nitrogen plant in Puławy, in reclaimed watered plots, and in crop fields at a distance of 7 km from the plant.

Sulphur mining is also very burdening to the environment. The excavation itself and the storing of sulphur affect the whole living world. Like in the two preceding cases, the syrphid community occurring in the centre of pollution has no structure, the number of species and their abundance being low. The relationship between the abundance of syrphids and the distance to the source of pollution is illustrated for the sulphur mine at Grzybów (Fig. 99), where samples were taken along the gradient from the mine to a control plot 16 km.

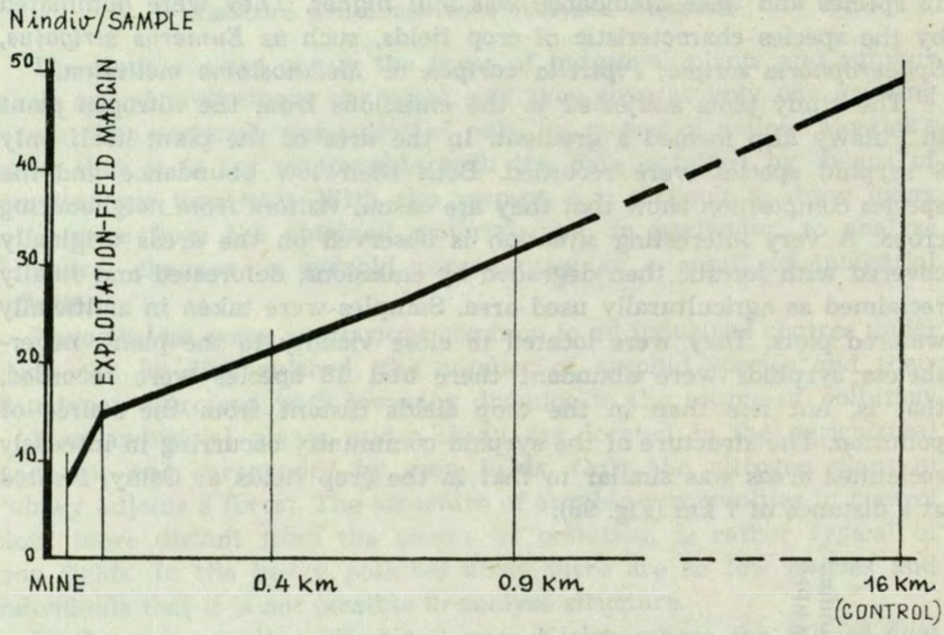


Fig. 99. Changes in syrphid abundance along the gradient of habitat pollution with sulphur from the mine at Grzybów near Staszów.

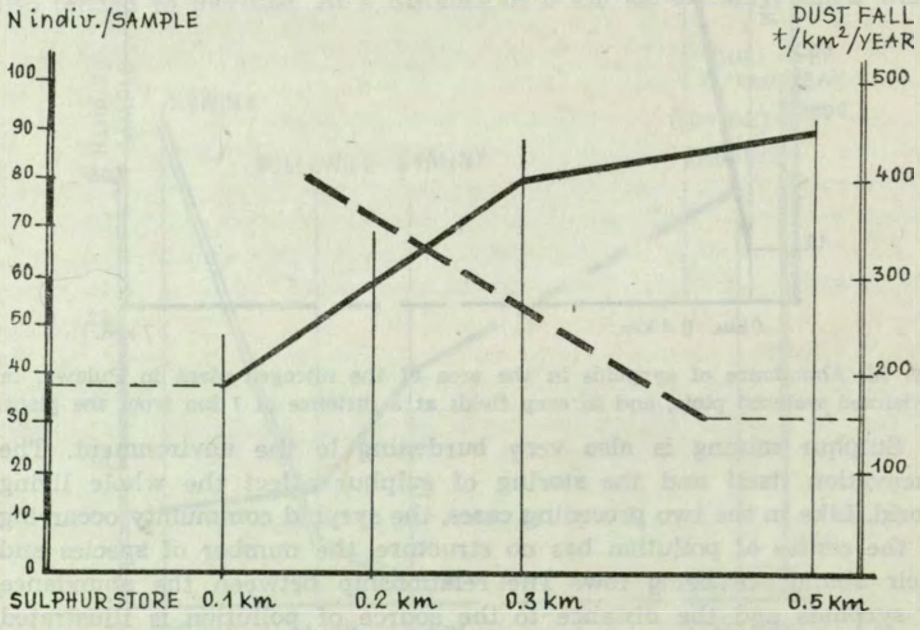


Fig. 100. Changes in syrphid abundance along the gradient of habitat pollution with sulphur dust from the store at Dobrów.

Similar results were obtained in the area surrounding the store of dust sulphur at Dobrów (Fig. 100). The number of syrphids increased with distance to the centre of the store.

These fragmentary observations cannot be extended on to other branches of industry and mining; however, it may be suggested that industrial pollution disturbs the structure of syrphids communities and their abundance everywhere.

COMPARATIVE ANALYSIS OF THE SYRPHID FAUNA OF ANTHROPOGENIC HABITATS

Syrphid communities of anthropogenic ecosystems involve mostly expansive species, with a high ecological tolerance, forming a specific complex. Both in agrocoenoses and urbicoenoses the species composition and, in particular, community structure, are very similar. It was possible to distinguish there 5 characteristic species common to the two coenoses. They account for 45% of the community (Fig. 3).

The most abundant community of anthropogenic habitats are zoophages, 35 species of this trophic group being found in the material collected. There are three species here characteristic of the whole anthropogenic complex. They account for 41% in relation to the companion species of this community (Fig. 13). These are *Syrphus balteatus, S. corollae,* and *S. luniger*. The association of predators is largely dominated by *S. balteatus* and other species of the same genus, abundant in forests. The dominant meadow species are represented by *Sphaerophoria scripta, Melanostoma mellinum,* and *Platycheirus clypeatus* (Fig. 93).

The association of phytophages is very poor and it involves only 7 species. *Eumerus strigatus* is the only characteristic species and it account for as many as 87% of the phytophages (Fig. 14), thus being a dominant in this association (Fig. 94). The second dominant is *Cheilosia vernalis* (7%), the species common in agrocoenoses and in urban green areas.

Table 10. Percentage of zoogeographical elements in syrphid associations of anthropogenic coenoses

Trophic groups \ Zoogeographical elements	Cosmopolitan	Holarctic	Palaearctic	Euro-Siberian	European	Boreal	Mountain	Submediterranean
Zoophages	1.5	45.0	19.0	22.0	11.0	—	—	1.5
Phytophages	—	43.0	14.0	43·0	—	—	—	—
Terrestrial saprophages	—	22.0	33.5	33.5	11.0	—	—	—
Aquatic saprophages	5.0	28.5	28.5	24.0	14.0	—	—	—
Total	2.0	40.0	22.0	24.0	11.0	—	—	—

The association of terrestrial saprophages is also poorly represented. Similarly, only 7 species were recorded in it and none of them was characteristic. The association is dominated by hemisynanthropic species such as *Syritta pipiens* and *Xylota segnis* (Fig. 95).

The association of aquatic saprophages is much more abundant. It consists of 22 species, including one characteristic — *Eristalis tenax* (Fig. 19). It is the first dominant of this association and accounts for 45% of the total number of individuals (Fig. 96). Among the other dominants, two species such as *Helophilus pendulus* (22%) and *E. arbustorum* (19%) should be mentioned. They are largely synanthropized.

It should be added that syrphid communities of anthropogenic habitats include many species with very large geographical ranges. They are dominated by the Holarctic element (40%), and the Palaearctic and Euro-Siberian elements are also rather abundant (Tab. 10). The other elements are scarce or they were not found in the material collected.

CONCLUSIONS

Dipterans of the family *Syrphidae* inhabiting various landscapes of Poland form 8 major communities. Each of them consists of four associations differing in food habits of larvae. These are associations of zoophages, phytophages, terrestrial saprophages and aquatic saprophages.

The diversity of syrphid associations is mainly related to food supply (fertility) of the habitat, and its humidity. Both these factors limit the occurrence of, particularly, saprophagous and phytophagous syrphids. Predatory syrphids are least dependent on habitat conditions. They can find food almost everywhere, even in the ecosystems largely transformed by man. That is why under heavy anthropogenic pressure the proportion of predatory species rapidly increases, as compared with other association (Figs 72—74).

The species composition of syrphids in the ecosystems under study is rather largely diversified (Fig. 1). The index of similarity S varies from 22 to 75%. This indicates that some species are common to all syrphid communities. In this material 25 such common species were distinguished. They form the bulk of all communities and inhabit the landscapes of Poland from the Tatra mountains to the Baltic coast (Tab. 11).

The group of the species common to all communities consists of syrphids with very large geographical ranges. As many as 68% are Holarctic species. Two of them, *Eristalis tenax* and *Syrphus balteatus* have also been carried to other zoogeographical regions. The Palaearctic species account for 28%. Only 4 species are Euro-Siberian. Moreover, these species show a very high ecological tolerance, 72% being eurytopic species and 28% polytopic. In this group of species, phytophages account for 8 %, terrestrial saprophages for 8%, aquatic saprophages for 20%, and predators for as many as 64%. Most of these species are highly expansive. They colonize new habitats, frequently largely transformed by man. Many of them are very abundant, particularly in anthropogenic coenoses. All syrphids considered as hemisynanthropic species are members of this group, and their proportion reaches 75%. Also the species characteristic of anthropogenic coenoses, such as *Eristalis tenax*, *Syrphus balteatus*, *S. corollae*, *S. luniger*, and *Eumerus strigatus*, are represented here. These species alone can be used as an index of the degree of anthropogenic pressure on the environment. *Eristalis tenax* is particularly important here as it is an indicator of the sanitary state of human settlements.

The proportion of the species common to all syrphid communities markedly increases in coenoses poor in species, such as coniferous forests, moors or anthropogenic habitats (Fig. 101). They reach a highest proportion of 86% in urbi- and agrocoenoses.

Recently, an intense synanthropization of many syrphid species can be observed. This is the case not only of aphidophages and aquatic saprophages related to *Eristalis tenax*, but also of phytophages and terrestrial saprophages, which being threatened with shrinking of the habitats occupied by them so far, colonize the terrains transformed by man. *Xylota segnis* can be quoted here as an example. This species appears more and more frequently near human settlements. It has been shown that its larvae became adapted to the compost in gardens, and recently they have been found even in silos with silage for cattle.

Man-made environmental changes have also an effect on the structure of syrphid communities. With an increasing anthropogenic pressure some syrphid species are eliminated, and the species successfully adapted to new conditions often have no competitors so their numbers increase to a level exceeding that under natural conditions (Figs 29 and 94). The number of species drops and at the same time the abundance of dominant species increases. Predators are able to maintain their numbers at an unchanged level for some time. But when the barriers of ecological tolerance of the association are exceeded, the abundance of dominants drops. In extreme situations the association disappears and scarce syrphids met in such habitats are visitors from adjacent areas. Such examples are provided in the areas closely surrounding industrial plants and in heavily polluted large urban areas.

In addition, the study shows that all syrphids abundant in coenoses largely transformed by man, have large ecological amplitudes, that is, they are typical eurytopic species. Most often they are polyphagous, less frequently oligophagous. They usually have large geographical

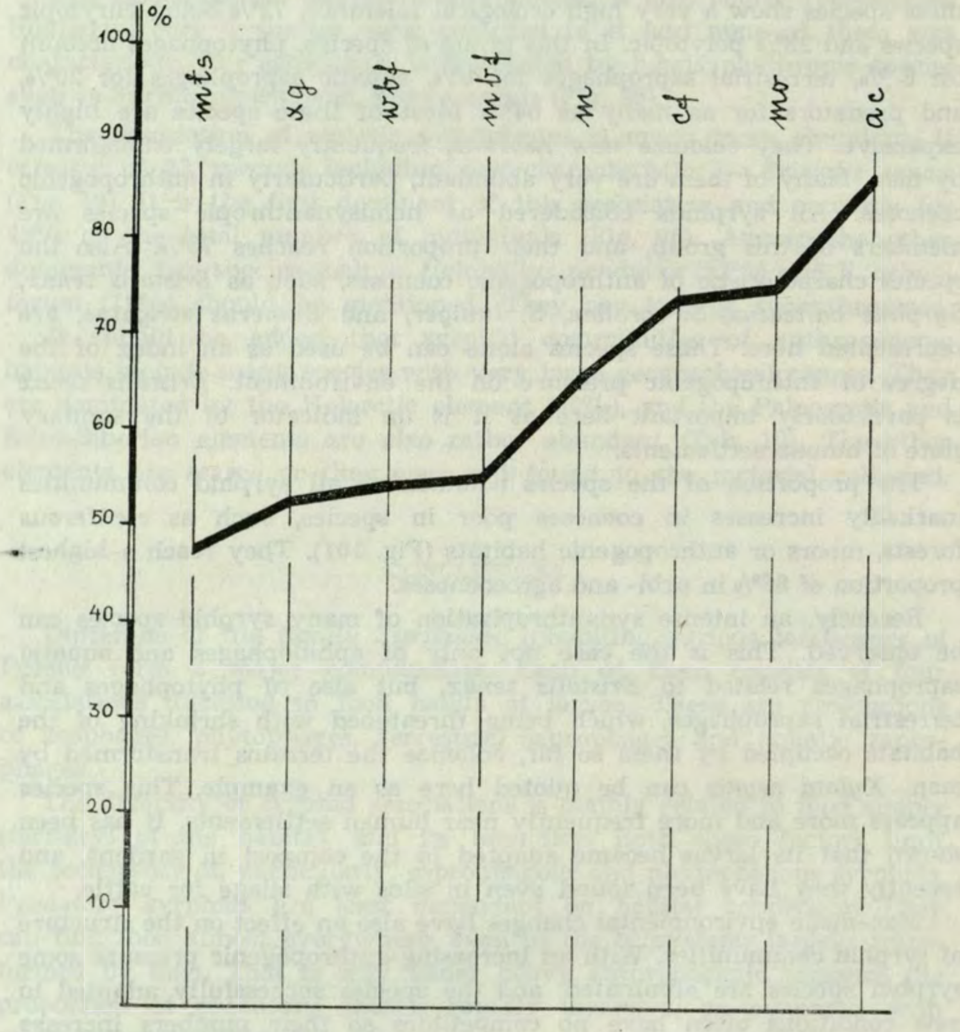


Fig. 101. Proportions of 25 syrphid species common to all syrphid communities distinguished in the landscape of Poland.

mts — mountains, xg — xerothermal grasslands, wf — wet forests, mf — moist forests, m — meadows, cf — coniferous forests, mo — moors, ac — anthropogenic coenoses.

ranges covering almost the whole Palaearctic, frequently even the Holarctic, and they can be cosmopolitan species. Many of them have a high reproductive rate and can produce two or three generations a year, which also accounts for an increase in their numbers in anthropogenic coenoses.

The comparative analysis of the dominance structure of particular syrphid communities does not yield univocal results. Generally, the dominance structure of syrphid associations with a high species diversity is characterized by gently decreasing proportions from one species to another. Frequently, as it is the case of mesophilous forests, there are no distinct dominants. But in syrphid communities poor in species, like those occurring in moors or pine forests, the percentage contribution of particular species is highly diversified. Usually there one or two dominants much more abundant than the other species.

Zoogeographical characteristics of syrphids show that there are significant differences in their fauna between particular habitat types and between syrphid associations in each of them.

Zoophages are zoogeographically the most uniform group. In all the habitat types under study they maintain the same dominance sequence from the Holarctic, through Euro-Siberian, to Palaearctic species. Also aquatic saprophages are little diversified, he sequence of Euro-Siberian—Palaearctic—Holarctic species being most frequent for them. Terrestrial saprophages represent an intermediate type, usually with Euro-Siberian species on the first position and varying zoogeographical elements on the second and the third positions. Phytophages are shown to be the most diversified group since different zoogeographical elements dominate them, depending on the habitat type.

This result indicates that particular trophic groups of syrphids occurring in Poland differ in their origin and history.

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ZGRUPOWANIA MUCHÓWEK Z RODZINY *SYRPHIDAE* NATURALNYCH I ANTROPOGENICZNYCH ŚRODOWISK POLSKI

STRESZCZENIE

W opracowaniu podjęto próbę wyróżnienia zespołów naturalnie istniejących w przyrodzie, za punkt wyjścia przyjmując ich powiązania z warunkami środowiska.

Każde siedlisko jest zamieszkałe przez cztery współistniejące obok siebie zespoły *Syrphidae* — różniące się sposobem odżywiania larw: zoofagi, fitofagi, saprofagi lądowe i saprofagi wodne. Wyodrębniono 8 zgrupowań tych zespołów w krajobrazie Polski (fig. 3). Zespół taki jest jednostką powtarzalną (w naszej strefie klimatycznej), ma określoną strukturę i skład gatunkowy, posiada ponadto gatunki charakterystyczne.

Fauna *Syrphidae* każdego z badanych typów siedliskowych została zanalizowana pod kątem: a) podobieństwa składu gatunkowego, b) struktury dominacji badanych gatunków, c) stopnia przywiązania do całokształtu warunków siedliskowych, d) struktury fagizmu i e) struktury zoogeograficznej.

Zgrupowanie *Syrphidae* gór wykazuje dużą odrębność w stosunku do zgrupowań *Syrphidae* na niżu. Występują tu aż 42 gatunki charakterystyczne, w tym 14 wyłącznych. *Syrphidae* zasiedlające poszczególne piętra górskie wykazują stosunkowo małe różnice w składzie gatunkowym, mają wiele gatunków wspólnych, co przy braku gatunków charakterystycznych, wskazuje na istnienie jednego, dużego zgrupowania górskich *Syrphidae*.

Obszary niżowe Polski są zasiedlane przez pozostałe 7 zgrupowań *Syrphidae*

W ekosystemach trawiastych występują zgrupowania *Syrphidae* zespołów łąkowych (fig. 29—32), muraw kserotermicznych (fig. 35—38) i torfowisk (fig. 41—44). W ekosystemach leśnych istnieją zgrupowania zespołów *Syrphidae borów* (fig. 65—68), lasów świeżych (fig. 57—60) i lasów wilgotnych (fig. 49—52).

Zgrupowania *Syrphidae* różnych siedlisk, będących pod wyraźnym wpływem hemerobii, stanowią jeden zespół cenoz antropogenicznych. Mimo pewnych różnic w strukturze i składzie gatunkowym wykazują one dużo cech wspólnych. Stwierdzono, że pod wpływem destrukcyjnego oddziaływania człowieka na środowisko, zachodzą daleko idące zmiany w strukturze zespołów *Syrphidae*. Wyraźnemu ograniczeniu ulega liczba gatunków, wyeliminowane zostają gatunki o mniejszej tolerancji ekologicznej. Zachodzą zmiany w samej strukturze zespołu: często następuje gwałtowny wzrost liczebności jednego lub kilku dominantów, przy równoczesnym ograniczeniu liczebności pozostałych gatunków zespołu. Przewagę uzyskują gatunki o dużej plastyczności ekologicznej — eurytopowe i politopowe. Charakteryzują się one także szerokimi zasięgami geograficznymi — palearktycznym, a często holarktycznym (tab. 10). Są to gatunki przeważnie polifagiczne i wykazujące dużą zdolność reprodukcyjną — przy sprzyjających warunkach osiągają one do trzech pokoleń w ciągu roku.

W miarę rosnącej presji antropogenicznej zmieniają się proporcje w obrębie czterech współistniejących obok siebie zespołów *Syrphidae* — zwiększa się wyraźnie liczebność zespołu drapieżców, a ograniczeniu ulegają pozostałe zespoły, zwłaszcza saprofagów lądowych i fitofagów (fig. 72—74).

СООБЩЕСТВА ДВУКРЫЛЫХ ИЗ СЕНЕЙСТВА ЖУРЧАЛОК *SYRPHIDAE* ПРИРОДНЫХ И АНТРОПОГЕННЫХ БИОТОПОВ ПОЛЬШИ

РЕЗЮМЕ

В работе произведена попытка выделения существующих естественно в природе сообществ *Syrphidae*, исходя из их приуроченности к биотопам.

Анализ количественного материала показал, что эти двукрылые, заселяющие различные ландшафты Польши, образовывают 8 основных группировок, каждая из которых состоит из четырёх сообществ журчалок, которые различаются по фагизму личинок. Выделены зоофаги, фитофаги, сапрофаги наземные и сапрофаги водяные. Дифференциация сообществ журчалок связана с богатством биотопа, а также его влажностью. Оба эти фактора особенно ограничивают распространение двукрылых-сапрофагов и фитофагов.

Констатировано сильное действие антропогенно пресса на характер структуры сообществ журчалок. Как в урби-, так и в агроценозах наблюдалось снижение количества видов при одновременном росте численности доминантов. Это обычно виды отличающиеся большой экологической пластичностью (эвритопные), преимущественно полифагические, имеющие широкий географический ареал. Многие из них характеризуются высокой плодовитостью и несколькими поколениями на протяжении года. Кроме того чётко увеличивается численность сообщества хищников, а ограничивается численность остальных трёх сообществ.

Table 11. Occurrence and abundance of syrphids in typical ecosystems and landscape zones of Poland
+++ - very abundant, ++ - abundant, + - present.
The species common to all habitats are marked with x.

Species	Alpine zone	Upper montane zone	Lower montane zone	Submontane zone	Wet meadows	Moist meadows	Xerothermal grasslands	Moors	Carrs	Alder swamps	Oak-hornbeam forests	Pomeranian beech forests	Mixed forests	Pine forests	Agrocoenoses	Urbicoenoses
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. *Cheilosia gagatea* LOEW		+	++	+												
2. *Cheilosia coerulescens* (MEIGEN)		+	+	++							+	+				
3. *Cheilosia canicularis* (PANZER)	++	++	+++	+++		+			+			+				
4. *Cheilosia personata* LOEW	+	+	++	+							+	+				
5. *Cheilosia nasutula* BECKER	+	+	+	+												
6. *Cheilosia montana* EGGER			+													
7. *Cheilosia rhynchops* EGGER	+	+	+	+							+					
8. *Cheilosia sahlbergi* BECKER	+	+	+													
9. *Cheilosia variabilis* (PANZER)	+	+	+	+	+	+				+	+	+	+			
10. *Cheilosia gigantea* (ZETTERSTEDT)	+	+	+	+						+		+				
11. *Cheilosia barbata* LOEW		+	+	++		+			+							
12. *Cheilosia bergenstammi* BECKER		+	+	+	+	+					+	+				
13. *Cheilosia chloris* (MEIGEN)		+	+	+	+	++					+					
14. *Cheilosia cynocephala* LOEW		+	+	+		+					+	+				
15. *Cheilosia illustrata* (HARRIS)	+	+	++	++		+						+				
16. *Cheilosia impressa* LOEW	+	+	+	+	+	+			+			+		+		
17. *Cheilosia pagana* (MEIGEN)		+	+	+	+	++	+		+		+	+	+	+		

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
18. *Cheilosia vicina* ZETTERSTEDT		+	++	+		+		+		+	+		+			
19. *Cheilosia vernalis* (FALLEN) x	+	+	+	++	+++	+++	+	+++	++	+	++	++	++	+	++	+
20. *Cheilosia vulpina* (MEIGEN)		+	+	+	+	+			+		+					
21. *Cheilosia rufimana* BECKER	+	+	+	+		+			+			+				
22. *Cheilosia carbonaria* EGGER	+	+	+	+							+	+				
23. *Cheilosia conops* BECKER			+	+							+					
24. *Cheilosia zetterstedti* BECKER	+	+	+	+	+	+	+				+		+		+	
25. *Cheilosia flavipes* (PANZER)			+	+	+	+	+				+					
26. *Cheilosia morio* (ZETTERSTEDT)			+	+									+			
27. *Cheilosia albitarsis* (MEIGEN)			+	++	+	+		++	++	+++	+++	++	+	+	+	+
28. *Cheilosia pubera* (ZETTERSTEDT)	+	+	+	+	+	+			+		+					
30. *Cheilosia lenis* BECKER			+	+												
31. *Cheilosia nigripes* (MEIGEN)	+		+	+							+					
32. *Cheilosia chrysocoma* (MEIGEN)			+													
33. *Cheilosia langhofferi* BECKER			+						+							
34. *Cheilosia melanura* BECKER	+	+	+	+							+					
35. *Cheilosia omissa* BECKER	+		+	+												
36. *Cheilosia albipila* MEIGEN		+	+	+					+			+				
37. *Cheilosia longula* (ZETTERSTEDT)			+	+								+				
38. *Cheilosia soror* (ZETTERSTEDT)			+	+	+	+					+	+	+			
39. *Cheilosia scutellata* (FALLEN)			+	+	+	+		+	+		+	+	+	+		
40. *Cheilosia ruralis* (MEIGEN)			+	++	++	+++	++	++	++		++	+	+			
41. *Cheilosia pascuorum* BECKER			+	+					+		+					
42. *Cheilosia mutabilis* (FALLEN)			+	+	+	+					+		+			
43. *Cheilosia grossa* (FALLEN)			+	+					+			+				
44. *Cheilosia intonsa* LOEW			+	+												

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
45. *Cheilosia curvinervis* BECKER				+							+					
46. *Cheilosia insignis* LOEW				+							+					
47. *Cheilosia melanopa* ZETTERSTEDT				+		+										
48. *Cheilosia pallipes* LOEW				+	+											
49. *Cheilosia frontalis* LOEW				+	+						+	+				
50. *Cheilosia deresa* LOEW				+												
51. *Cheilosia maculata* (FALLEN)				+												
52. *Cheilosia brachysoma* EGGER				+	+											
53. *Cheilosia latifacies* LOEW				+							+					
54. *Cheilosia velutina* LOEW				+	+	+			+		+		+			
55. *Cheilosia grisella* BECKER				+												
56. *Cheilosia fasciata* SCHINER											+					
57. *Cheilosia honesta* RONDANI				+												
58. *Cheilosia scanica* RHINGDAHL				+							+			+		
59. *Cheilosia semifasciata* BECKER											+					
60. *Cheilosia antiqua* (MEIGEN)			+	+			+				+	+				
61. *Cheilosia fraterna* (MEIGEN)					+	+										
62. *Merodon equestris* (FABRICIUS)	+	+	+	+		+	+								+	+
63. *Merodon aeneus* MEIGEN			+	+		+	+									
64. *Merodon constans* (ROSSI)			+	+			+									
65. *Merodon ruficornis* MEIGEN			+	+												
66. *Merodon funestus* (FABRICIUS)		+	+	+												
67. *Merodon spinipes* (FABRICIUS)						+	++				+					
68. *Merodon rufus* MEIGEN							+									
69. *Eumerus strigatus* (FALLEN) x		+	+	+	++	++	+	+	+	+	+	+	+	+	+++	++
70. *Eumerus sabulonum* (FABRICIUS)			+	+		+	+									

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
71. *Eumerus annulatus* (PANZER)			+	+		+	+									
72. *Eumerus flavitarsis* ZETTERSTEDT			+	+		+										
73. *Eumerus ovatus* LOEW							+							+		
74. *Eumerus ornatus* MEIGEN			+	+												
75. *Eumerus tricolor* MEIGEN						+	+				+					
76. *Eumerus tuberculatus* RONDANI				+		+									+	+
77. *Pipiza bimaculata* MEIGEN	+	+	+	+	+	+			+			+			+	+
78. *Pipiza carbonaria* MEIGEN	+	+	+			+								+		+
79. *Pipiza austriaca* MEIGEN			+	+	+	+	+									
80. *Pipiza lugubris* (FABRICIUS)			+	+	+	+			+		+		+		+	+
81. *Pipiza noctiluca* (LINNAEUS)		+	+	+	+	+			+			+	+	+		+
82. *Pipiza festiva* MEIGEN					+	+			+	+	+					+
83. *Pipiza quadrimaculata* (PANZER)	+	+	+	+	+	+			+	+						
84. *Platycheirus peltatus* (MEIGEN) x	+	+	+	+	+	++	+	+	+	+	+	+	+	+	++	+
85. *Platycheirus scutatus* (MEIGEN)	+	+	+	+	+	+			+		+	+		+	+	+
86. *Platycheirus albimanus* (FABRICIUS) x	+	+	+	++	++	++	+	+	++	+	+	+	+	+	++	+
87. *Platycheirus podagratus* (ZETTERSTEDT)	+	+	+	+	+	+									+	
88. *Platycheirus immarginatus* (ZETTERSTEDT)		+	+	+		+			+		+		+	+		
89. *Platycheirus fulviventris* (MACQUART)					+	+	+		+					+		
90. *Platycheirus angustatus* (ZETTERSTEDT)	+	+	+	+	+	+			+			+	+		+	+
91. *Platycheirus clypeatus* (MEIGEN) x	+	+	+	++	++	+++	++	+	+	++	+	+	+	+	+++	++
92. *Platycheirus melanopsis* LOEW		+	+	+												
93. *Platycheirus manicatus* (MEIGEN)	+	+	+	+		+	+									
94. *Platycheirus tarsalis* (SCHUMMEL)			+	+												
95. *Platycheirus latimanus* WHALBERG			+	+												
96. *Platycheirus perpallidus* VERRALL			+	+												

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
97. *Xanthogramma pedisequum* (HARRIS)			+	+	+	+	+		+	+	+		+	+		+
98. *Xanthogramma citrofasciatum* (DEGEER)			+	+	+	+	+			+	+					
99. *Heringia heringii* (ZETTERSTEDT)					+	+					+					+
100. *Parapenium flavitarse* (MEIGEN)						+				+	+				+	+
101. *Psilota atra* (FALLÉN)			+		+	+										
102. *Pipizella varipes* (MEIGEN) x	+	+	+	+	++	+++	++	+	+	+	+	+	+	+	+++	++
103. *Pipizella virens* (FABRICIUS)					+	+	+		+		+				+	
104. *Neocnemodon latitarsis* EGGER			+	+		+	+				+	+				
105. *Neocnemodon fulvimanus* (ZETTERSTEDT)											+	+	+		+	
106. *Neocnemodon pubescens* DELUSCHI-PSCHORN-WALCHER						+					+					
107. *Neocnemodon vitripennis* (MEIGEN)			+	+	+	+					+	+	+	+	+	
108. *Paragus tibialis* (FALLÉN)			+	+	+	+	+	+	+		+	+			+	
109. *Paragus albifrons* (FALLÉN)					+	+					+					
110. *Paragus bicolor* (FABRICIUS)					+	+	++	+		+	+					
111. *Didea alneti* (FALLÉN)	+	+	++							+	+					
112. *Didea fasciata* MACQUART	+	+	+	+		+		+	+	+	+					+
113. *Didea intermedia* LOEW			+	+					+		+	+	+	++		+
114. *Ischyrosyrphus glaucius* (LINNAEUS)	+	+	++	+++	+	+				+					+	
115. *Ischyrosyrphus laternarius* (MÜLLER)		+	+	+		+			+	+						
116. *Scaeva pyrastri* (LINNAEUS) x	+	+	+	+	+	+	+	+	+	+	+	+	+	+	++	+
117. *Scaeva selenitica* (MEIGEN)	+	+	+	+	+	+	+		+		+	+	+	+	+	+
118. *Erizona syrphoides* (FALLÉN)	+	+	++	++								+				
119. *Leucozona lucorum* (LINNAEUS)	+	+	+	+		+			+			+				
120. *Sphaerophoria scripta* (LINNAEUS) x	+	+	++	+++	+++	+++	+++	++	+	+	+	++	+	+	+++	+
121. *Sphaerophoria menthastri* (LINNAEUS) x	+	+	+	+	++	++	++	+	+	+	+	+	+	+	++	+
122. *Sphaerophoria rueppelli* (WIEDEMANN)			+	+	+	+	+			+	+				++	+

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
123. *Sphaerophoria picta* (MEIGEN)	+	+	+	+		+	+	+	+		+	+	+		+	+
124. *Sphaerophoria dubia* (ZETTERSTEDT)	+	+	+	+		+	+									
125. *Sphaerophoria philanthus* (MEIGEN)					+	+			+		+		+	+		
126. *Pyrophaena rosarum* (FABRICIUS)			+	+	++	+		+	++							+
127. *Pyrophaena granditarsa* (FORSTER)			+	+	++	+		+	+							+
128. *Olbiosyrphus laetus* (FABRICIUS)			+	+												
129. *Xanthandrus comtus* (HARRIS)	+	+	+	+		+	+				+	+	+	+		+
130. *Melanostoma mellinum* (LINNAEUS) x	+	+	++	+++	+++	+++	++	+	++	+	++	+	+	+	+++	++
131. *Melanostoma scalarae* (FABRICIUS)		+	+	+	+	++	+		+	+	++	+	+		+	
132. *Melanostoma ambiguum* (FALLEN)		+	+	+		+	+								+	+
133. *Melangyna quadrimaculata* (VERRALL)				+							+	+				
134. *Baccha elongata* (FABRICIUS)			+	+		+	+		+		+	+	+	+		+
135. *Baccha obscuripennis* MEIGEN			+	+		+							+			+
136. *Doros conopseus* (FABRICIUS)			+	+												
137. *Spathiogaster ambulans* (FABRICIUS)	+	+	+	+												
138. *Triglyphus primus* LOEW						+	+			+			+			+
139. *Syrphus albostriatus* (FALLEN)			+	+	+	+	+		+		+	+	+	+	+	+
140. *Syrphus venustus* MEIGEN x	+	+	+	+	+	+	+	+	+	+	++	++	++	+	+	+
141. *Syrphus hilaris* (ZETTERSTEDT)	+	+	+	+		+			+			+		+		
142. *Syrphus annulipes* (ZETTERSTEDT)		+	+	+	+	+	+			+	+	+	+	+		+
143. *Syrphus lunulatus* MEIGEN		+	+	+	+		+						+	+		
144. *Syrphus macularis* (ZETTERSTEDT)			+	+									+			
145. *Syrphus tricinctus* (FALLEN)	+	+	+	+	+	+			+	+	++	+	+	+	+	+
146. *Syrphus friuliensis* VAN DER GOOT	+	++	++	+												
147. *Syrphus torvus* OSTEN-SACKEN x	+	+	++	++	+	+	+	+	+	+	++	++	++	+	++	++
148. *Syrphus bifasciatus* FABRICIUS			+	+	+	+			+		++	++			+	+

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
149. *Syrphus balteatus* (DEGEER) x	+	++	++	++	++	++	+	+++	++	++	++	+++	++	+++	+++	+++
150. *Syrphus cinctus* (FALLEN)			+	+	+	+			+		+		+			+
151. *Syrphus cinctellus* (ZETTERSTEDT)	+	+	+	+	+	+			+	+	+	+	+	+	+	+
152. *Syrphus auricollis* MEIGEN			+	++	+	+			+	+			+	+	+	+
153. *Syrphus malinellus* COLLIN			+	+	+		+				+	+				
154. *Syrphus annulatus* (ZETTERSTEDT)	+	+	+	++		+	+	+	+	+		+				
155. *Syrphus vittiger* (ZETTERSTEDT)		+	+	+			+		+		+	+	+	+	+	
156. *Syrphus lineola* (ZETTERSTEDT)	+	+	+	+	+	+		+	+	+	+		+		+	
157. *Syrphus diaphanus* (ZETTERSTEDT)			+	+		+										
158. *Syrphus grossularius* MEIGEN	+	+	+	+	+	+					+	+	+	+		
159. *Syrphus melanostoma* (ZETTERSTEDT)			+	+	+	+	+				+					
160. *Syrphus ochrostoma* (ZETTERSTEDT)			+	+	+			+			+					
161. *Syrphus nigritarsis* (ZETTERSTEDT)								+								
162. *Syrphus nitidicollis* MEIGEN			+	+	+	+			+	+	+	+		+	+	
163. *Syrphus ribesii* (LINNAEUS) x	++	++	++	++	+	+	+	+	+	+	++	++	++	++	+++	++
164. *Syrphus vitripennis* MEIGEN x	++	++	++	+++	+	++	++	+	++	+	+++	+++	+++	++	+++	+++
165. *Syrphus braueri* EGGER			+	+	+	+					+					
166. *Syrphus nitens* (ZETTERSTEDT)	+	+	+	+	+	+	+			+				+	+	
167. *Syrphus latifasciatus* MACQUART	+	+	+	+	+	+	+	+			+	+			+	+
168. *Syrphus corollae* FABRICIUS x	+	+	+	+	+	++	++	++	+	+	++	+	++	+++	+++	+++
169. *Syrphus lapponicus* (ZETTERSTEDT)	+	+	+	+		+	+			+	+	+		+		+
170. *Syrphus lundbeckii* (SCOT-RYEN)						+						+				
171. *Syrphus luniger* MEIGEN x	+	+	+	+	+	+	+	+	+	+	+	+	+	+	++	+
172. *Syrphus euchromus* KOWARZ											+				+	
173. *Syrphus triangulifer* (ZETTERSTEDT)											+				+	+
174. *Syrphus guttatus* (FALLEN)						+					+					+

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
175. *Syrphus umbellatarum* FABRICIUS			+	+	+	+	+		+		+	+			+	+
176. *Syrphus compositarum* VERRALL	+	+	+	+		+	+			+	+					+
177. *Syrphus labiatarum* VERRALL			+	+		+										
178. *Syrphus lasiophthalmus* (ZETTERSTEDT)			+	+		+	+				+		+		+	
179. *Syrphus barbifrons* (FALLEN)		+	+	+	+											
180. *Syrphus punctulatus* VERRALL		+	+	+				+			+	+				
181. *Chamaesyrphus scaevoides* (FALLEN)		+	+	+			+									
182. *Pelecocera tricincta* MEIGEN							+									
183. *Chrysotoxum bicinctum* (LINNAEUS) x	+	+	+	++	++	++	+	+	+	+	+	+	+	+	+	+
184. *Chrysotoxum arcuatum* (LINNAEUS)	+	+	++	++	+	+	+			+		+		+		+
185. *Chrysotoxum cautum* (HARRIS)						+	+				+					
186. *Chrysotoxum fasciolatum* (DEGEER)	+	++	++	+		+	++		+	+		+				
187. *Chrysotoxum festivum* (LINNAEUS)	+	+	+	+	+	++	++		+	+	+	+	+	+	+	+
188. *Chrysotoxum elegans* LOEW			+	+			+									
189. *Chrysotoxum lineare* (ZETTERSTEDT)					+	+					+					
190. *Chrysotoxum intermedium* MEIGEN			+	+			+									
191. *Chrysotoxum octomaculatum* CURTIS			+		+	+		+			+					
192. *Chrysotoxum vernale* LOEW	+	+	+	+	+	++	++			+	++	+	+	+	+	
193. *Volucella bombylans* (LINNAEUS)	+	+	++	++	+	+	+	+	+		+	+	+	+		+
194. *Volucella zonaria* PODA			+	+		+							+			+
195. *Volucella inanis* (LINNAEUS)		+	+	+	+	+				+	+	+	+			
196. *Volucella pellucens* (LINNAEUS)	+	++	++	+	+	+		+	+	+	+	+	+	+		
197. *Microdon devius* (LINNAEUS)			+	+	+	+	+	+	+	+	++	+	+			
198. *Microdon mutabilis* (LINNAEUS)			+	+	+	+	+	+		+	+	+				
199. *Microdon latifrons* LOEW						+					+					
200. *Microdon eggeri* MIK			+	+												

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
201. *Sphegina verecunda* COLLIN			+	+												
202. *Sphegina kimakowiczi* STROBL			+	+								+				
203. *Sphegina latifrons* EGGER			+	+												
204. *Sphegina clunipes* (FALLEN)		+	+	+		+	+				+	+			+	
205. *Sphegina sibirica* STACKELBERG			+	+												
206. *Neoascia interrupta* (MEIGEN)				+								+				
207. *Neoascia aenea* (MEIGEN)	+	+	+	+	+	+			+			+				
208. *Neoascia floralis* (MEIGEN)			+	+	+	+				+				+		
209. *Neoascia dispar* (MEIGEN)		+	+	++	++	++		+	+			+	+			+
210. *Neoascia geniculata* (MEIGEN)					+					+						
211. *Neoascia obliqua* COE				+												
212. *Neoascia podagrica* (FABRICIUS)			+++	+++	++	+			+	+				+	+	+
213. *Criorhina berberina* (FABRICIUS)	+	+	+	+				+	+		+	+		+		
214. *Criorhina berberina* var. *oxyacanthae* (MEIGEN)		+	+	+				+			+	+				
215. *Criorhina asilica* (FALLEN)				+				+			+	+				
216. *Criorhina pachymera* EGGER												+				
217. *Criorhina floccosa* (MEIGEN)													+			
218. *Criorhina ranunculi* (PANZER)													+			
219. *Pocota apiformis* (SCHRANK)											+	+				
220. *Spilomyia diophthalma* (LINNAEUS)			+								+	+	+			
221. *Spilomyia manicata* (RONDANI)											+					
222. *Spilomyia saltuum* (FABRICIUS)				+								+				
223. *Temnostoma apiforme* (FABRICIUS)								+		+	+	+				
224. *Temnostoma bombylans* (FABRICIUS)	+	+	+	+	+			+	+	+	+	+	+			
225. *Temnostoma vespiforme* (LINNAEUS)	+	+	+	+	+			+	+	++	+	+	+			
226. *Calliprobola speciosa* (ROSSI)	+	+														

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
227. *Tropidia scita* (HARRIS)			+	+	++	+				+		+				
228. *Cynorrhina fallax* (LINNAEUS)	+	+	++					+	+			+				
229. *Ferdinandea cuprea* (SCOPOLI)			+	+				+		+	+	+	+			
230. *Myolepta luteola* (GMELIN)			+	+				+	+		+	+	+			
231. *Myolepta vara* (PANZER)				+								+				
232. *Leiota ruficornis* (ZETTERSTEDT)		+	+	+							+		+			
233. *Syritta pipiens* (LINNAEUS) x	+	+	+	++	++	+++	+++	++	++	++	+	+	+	++	+++	++
234. *Rhingia rostrata* (LINNAEUS)	+	+	+	+	+	+			++	++	+	+	+		+	
235. *Rhingia campestris* MEIGEN		+	+	+	+	+			+	++	+	+			+	+
236. *Brachyopa bicolor* (FALLEN)				+												
237. *Brachyopa conica* (PANZER)		+	+	+		+	+					+				
238. *Brachyopa dorsata* ZETTERSTEDT				+									+			
239. *Hammerschmidtia ferruginea* (FALLEN)			+			+		+				+				
240. *Callicera aenea* (FABRICIUS)	+	+	+													
241. *Cerioides conopsoides* (LINNAEUS)				+				+	++	+	+	+		+		
242. *Cerioides subsessilis* (ILLIGER)									+	+	+					
243. *Brachypalpus angustatus* EGGER			+													
244. *Brachypalpus bimaculatus* (MACQUART)			+	+					+	+	++	+	+		+	
245. *Brachypalpus chrysites* EGGER			+	+							+	+				
246. *Brachypalpus valgus* (PANZER)			+	+							+	+				
247. *Xylota segnis* (LINNAEUS) x	+	++	++	+++	+	+	+	+	++	++	+	+	+	+	+	+
248. *Xylota tarda* MEIGEN			+	+					+		+	+				
249. *Xylota pigra* (FABRICIUS)											+	+				
250. *Xylota lenta* MEIGEN		+	+	+				+		+	+	+				
251. *Xylota ignava* (PANZER)	+	+	+	+					+	+	+			+		
252. *Xylota abiens* MEIGEN			+							+						

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
253. *Xylota xanthocnema* COLLIN			+	++				+		+						
254. *Xylota sylvarum* (LINNAEUS)		+	++	++	+	+		+	+	++	++	+	+			
255. *Xylota nemorum* (FABRICIUS)					+	+		+	+	++	+	+	+			
256. *Xylota florum* (FABRICIUS)		+	+	+	+	+	+	+	+	+	+	+	+	+	+	
257. *Xylota femorata* (LINNAEUS)	+	+	+	+				+				+				+
258. *Xylota curvipes* LOEW									+	+	+					
259. *Xylota caeruleiventris* ZETTERSTEDT									+							
260. *Xylota rufipes* LOEW									+	+						
261. *Sericomyia silentis* HARRIS	+	+	+	+				+			+	+	+	+		
262. *Sericomyia lappona* (LINNAEUS)	+	+	++	+				+			+	+	+			
263. *Arctophila fulva* HARRIS		+	+	+				+	+			+	+			
264. *Arctophila bombiformis* (FALLEN)	+	+	+	+					+							
265. *Mallota cimbiciformis* (FALLEN)											+	+	+			
266. *Mallota fuciformis* (FABRICIUS)											+	+				
267. *Mallota megiliformis* (FALLEN)											+		+			
268. *Mallota tricolor* LOEW											+					
269. *Eristalis abusivus* COLLIN			+	+	+	+				+	+					
270. *Eristalis arbustorum* (LINNAEUS) x	+	++	++	++	++	++	+	++	+++	+++	+	+	+	+	+++	+++
271. *Eristalis alpinus* (PANZER)	+	++	++	+	+	+				+	+	+				
272. *Eristalis anthophorinus* (FALLEN)									+	+						
273. *Eristalis cryptarum* (FABRICIUS)			+		+			+		+						
274. *Eristalis oestraceus* (LINNAEUS)									+	+						
275. *Eristalis intricarius* LINNAEUS)			+	+	+	+		+	++	+	++	+	+	+	+	+
276. *Eristalis jugorum* EGGER	+	+	+	+												
277. *Eristalis rupium* FABRICIUS	+	+	++	+	+	+	+	+	+	+	+	+	+	+	+	+
278. *Eristalis pertinax* (SCOPOLI)	+	+	+	+	+	+			+	+	+	+	+	+		+

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
279. *Eristalis pratorum* MEIGEN		+	+	+		+			+	++	+	+	+			
280. *Eristalis nemorum* (LINNAEUS) x	+	+	++	+	++	+	+	+	++	++	+	+	+	+	+	+
281. *Eristalis horticola* (DEGEER)	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+
282. *Eristalis vitripennis* STROBL			+	+	+	+		+	+			+	+			
283. *Eristalis tenax* (LINNAEUS) x	++	++	++	+++	++	++	+	+++	+++	+++	+	+	++	++	+++	+++
284. *Lathyrophtalmus aeneus* (SCOPOLI)			+	+	+	+		+	+	+	+	+		+	+	+
285. *Eristalinus sepulcralis* (LINNAEUS)			+	+	++	+		+	+	++	++	+	+	+	+	+
286. *Myiatropa florea* (LINNAEUS) x	+	+	++	++	+	+	+	·	+	++	++	++	++	++	+	+
287. *Eurinomyia frutetorum* (FABRICIUS)			+	+	++	+	+	·	++	+	+	+			+	
288. *Eurinomyia versicolor* (FABRICIUS)					++	+			++	+		+		+	+	
289. *Eurinomyia consimilis* (MALM)					+				+	+	+					
290. *Eurinomyia lineata* (FABRICIUS)					+	+			+	+		+				+
291. *Eurinomyia transfuga* (LINNAEUS)									+							
292. *Eurinomyia lunulata* (MEIGEN)					+	+		+	+	+				+	+	
293. *Helophilus pendulus* (LINNAEUS) x	+	++	++	+++	+++	++	+	++	+++	+++	+	++	++	++	+++	+++
294. *Helophilus trivittatus* (FABRICIUS)	+	+	+	++	++	+	+	+	+++	+++	+	+	+	+	+	++
295. *Helophilus hybridus* LOEW					+	+		+	+	+						+
296. *Helophilus affinis* W HALBERG					+			+		+		+				+
297. *Helophilus bottnicus* WHALBERG								+								
298. *Orthoneura plumbago* LOEW										+						
299. *Orthoneura nobilis* (FALLEN)	+		+	+		+	+			+		+			+	
300. *Orthoneura elegans* (MEIGEN)					+											
301. *Orthoneura geniculata* MEIGEN					+	+										
302. *Orthoneura intermedia* LUNDBECK					+	+						+		·		
303. *Chrysogaster brevicornis* LOEW	+		+		+											
304. *Chrysogaster chalybeata* MEIGEN			+	+	+	+	+		+		+	+				

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
305. *Chrysogaster solstitialis* (FALLEN)	+	+	+	+	++	+		+		+	+	+	+			
306. *Chrysogaster viduata* (LINNAEUS)			++	++	+++	++	+	+	++	++	+			+	+	
307. *Chrysogaster macq arti* LOEW						+										
308. *Liogaster metallina* (FABRICIUS)	+	+	+	+	++	+			+					+		+
309. *Liogaster splendida* (MEIGEN)					+	+										

FLY COMMUNITIES OF THE FAMILY *SYRPHIDAE* IN NATURAL AND ANTHROPOGENIC HABITATS OF POLAND

CONTENTS

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PL ISSN 0076-6372
ISBN 83-04-00555-7