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Parasitoids of earthworms of the genera *Pollenia* R.-D. and *Sarcophaga* MEIG. in the urban green of Warsaw and in some habitats of the Mazovian Lowlands

[With 7 tables, 3 maps and 33 figures in the text]

Abstract. The influence of the abiotic factors on the numbers of species, abundance, dominance structur and phenology of parasitoids of earthworms from the genera *Pollenia* and *Sarcophaga* were investigated in the town green of Warsaw and in the selected habitats of the Mazovian Plain. Also an attempt was made to determine the dependence of the abundance of the discussed group of *Diptera* on the density of their hosts and to include this community of parasitoids of earthworms to the competitive group.

1. INTRODUCTION

The dipteran parasites of earthworms include not only the representatives of the genera *Pollenia* and *Sarcophaga* discussed in the present paper but also four species of the family *Calliphoridae*, namely *Onesia austriaca* VILLENEUVE, *O. sepulcralis* (MEIGEN), *Bellardia obsoleta* (MEIGEN), *B. pruinosa* (ENDERLEIN) and probably also *B. agilis* (MEIGEN). All these species occur over the entire territory of Poland, but they have not been considered in the present paper because they are not as numerous as dipterans of the genera *Pollenia* and *Sarcophaga*.

So far, parasitic dipterans of the genera *Pollenia* and *Sarcophaga* have been recorded in three species of earthworms, namely *Allolobophora calliginosa* (SAV.), *All. chlorotica* (SAV.) and *All. rosea* (SAV.).

Unlike their hosts, parasitoids of earthworms have not been sufficiently studied in Poland[1].

[1] The author's attention was drawn to this question while studying the material collected in to yellow Moericke's traps in Warsaw lawns. This was first mentioned in papers published in 1977 and 1979.

The southern part of Poland is a relatively best studied area thanks to the studies of Bobek (1890, 1893, 1894), Grzegorzek (1873), Loew (1870), Nowicki (1873), Pawłowicz 1939a, b) and Draber-Mońko (1971, 1973a, b, 1977, 1978, 1979). The Baltic Coast, the Mazurian Lake District and the Pomeranian Lake District have been studied by Brischke (1885), Czwalina (1893), Karl (1937), Speiser (1900) and Piątkowski (1972). A few data from the Western Sudeten Mountains and from the Wielkopolska–Kujawy Lowland are found in the papers by Riedel (1930, 1934). Some information about these dipterans from Ciechocinek, Warsaw and its vicinity and from Ojców is given in Sznabl's work (1881). Karczewski's studies (1961a,b, 1967a,b, 1982) provide information about the occurrence of these parasitoids in the Małopolska Upland. There are no data on the occurrence of the dipterans discussed in the Trzebnickie Hills. The Świętokrzyskie Mountains have been studied by Myślicka (1968) and Karczewski (1982) and the Mazovian Lowlands by Draber-Mońko (1981a,b,c,d), but in the other regions of the country there have been no special studies of the parasitoids discussed. Information about them can only be found in studies of all dipterans of the group *Calyptrata* or in lists including the entire *Diptera*.

The other data on the distribution of dipterans of the genus *Pollenia* in Poland in areas not yet studied are based on materials collected by various research workers of the Institute of Zoology PAS in Warsaw, mainly by the author, during 30 years (about 10,000 specimens).

The information on the occurrence of dipterans of the genus *Sarcophaga* is based mainly on the study by Draber-Mońko (1973a) and supplemented by data from more recent studies of the Mazovian Lowlands (Draber-Mońko 1981a,b).

Significance of earthworms for the biology of the soil is well known. According to Tischler (1971), the problem was noticed first by Hensen (1877) and Darwin (1883). In their basic and conceptionally rich papers, the essential problems connected with the impact of earthworms on plough-land are either discussed or at least mentioned. Tischler (1971) reports that in the soils of arable land in the temperate zone 1 ha is on average inhabited by 1–4 million individuals (a minimum of 1 million and a maximum of 19 million individuals have been recorded).

In farming, the role of earthworms is considered to be positive and therefore it can be assumed that parasitic dipterans, which limit the abundance of their hosts, play a negative role in the environment.

The present paper is an attempt to study dipterans from the genera *Pollenia* and *Sarcophaga* – parasitoids of earthworms – and the objectives are as follows:

1. To establish the species composition of parasitoids of Mazovia and Warsaw against a background of the fauna of these dipterans recorded from Poland;

2. To establish the influence of abiotic factors (such as atmospheric precipitation, air temperature) on the abundance of parasitoids;

3. To establish the impact of urbanisation on the abundance of these dipterans;

4. To study the domination structure and abundance of these dipterans in different types of habitats (urban, suburban and country ones);

5. To study the phenology of these parasitoids;

6. A zoogeographic analysis of the host-parasite system.

2. METHODS AND THE STUDY AREA

Imagines were the only material for the study because it was too difficult (both methodically and taxonomically) to collect and determine the preimaginal developmental stages.

Materials for the present study were collected mainly by means of a modified method of Moericke's traps (MOERICKE 1951; BAŃKOWSKA, GARBARCZYK 1981) suspended in tree crowns[1].

Studied were successive samples collected continuously throughout the vegetative season, most frequently from April to November, at various time intervals

Map 1. Study sites in the Mazovian Lowlands. 1 — Hamernia, 2 — Radziejowice, park, 3 — Wola Mrokowska, 4 — Młochów, 5 — the Kampinoska Forest (Łomna), 6 — Warsaw.

[1] In two sites this method was supplemented by traps placed on the ground (control sites: the park in Radziejowice and a lawn in the centre of the city, at Wilcza Street near the Institute of Zoology PAS). In other sites traps were destroyed.

from 5 to 20 days. Most of the material (41,014 specimens) used for the quantitative study was collected by means of this method.

In the Mazovian Lowlands, quantitative materials were collected from 1976 to 1978 and in Warsaw from 1974 to 1978, mainly into yellow Moerick's traps.

The present study is based first of all on the material collected in the Mazovian Lowlands in the following localities: Hamernia (Jaktorowska Forest), Wola Mrokowska, Młochów, Radziejowice — park, and Łomna (Kampinoska Forest) (Map 1), and also in Warsaw, within the administrative boundries of the city: Ursynów, Jelonki, Białołęka Dworska, Bielany and the allotment gardens along Żwirko and Wigura Street, in the urban parks: Łazienki, the park at the Cemetery of Soviet Soldiers, the Saxon Garden and the Praski Park, the estate green of Wierzbno and Stawki (Muranów-Północ), in the back-yard green in the centre of Warsaw in Wilcza Street and in Koszykowa Street and in the isolated street side green in Konstytucja Square (Map 2).

Map 2. Warsaw. a — the centre, b — the boundary of the centre, c — the outskirts, d — the boundary of the outskirts, e — the administrative boundary of Warsaw. 1 — Ursynów, 2 — Jelonki, 3 — allotment gardens (Og. Działk.), 4 — Bielany, 5 — Białołęka Dworska, 6 — the Cemetery Mausoleum of Soviet Soldiers, 7 — Łazienki, 8 — the Praski Park, 9 — the Saxon Garden, 10 — Wierzbno, 11 — Stawki, 12 — Koszykowa Street, 13 — Konstytucja Square (MDM), 14 — Wilcza Street.

Quantitative investigations were carried out in the Mazovian Lowlands within a 50-kilometre radius from Warsaw, most of the rural (natural) habitats studied were situated in the Rawska Uplands (*Tilio-Carpinetum* and carr habitats) and in the Kampinoska Forest (moist coniferous and mixed coniferous forests).

Characteristics of the areas studied

Rural areas

Hamernia near Żyrardów, a linden-oak-hornbeam forest (*Tilio-Carpinetum*). The study site was situated in the complex of the Radziejowickie forests (an area of 250 ha), a part of the former Jaktorowska Forest. The age of the tree stand from 40 to 75 years. It is a shady

forest with dense tree crowns (Włoczewski 1968). Soils brown, acid, formed from loamy, light sands, moist, of medium depth, occurring on light, very sandy loam. Mull-type humus (Bańkowska, Garbarczyk 1981).

Hamernia, an ash-alder carr (*Circaeo-Alnetum*). It occupies a part of the bottom of the Pisia–Gągolina River valley, forming a belt of about 3.5 ha (700 m long, up to 100 m wide). It is surrounded by a mixed coniferous forest. Soils brown, moist, acid, formed from heavy loamy sands, of medium depth, occurring on loams or loose sands. Thickness of humus (mull-type) — 10 to 30 cm. Tree stand of partly offshoot character, formed mainly by 30-40-year-old *Alnus glutinosa*. Undergrowth: separate *Quercus robur* and *Fraxinus excelsior*. Herb layer (on average — 50% of the area) formed by: *Frangula alnus*, *Picea excelsa*, *Alnus glutinosa*, *Populus tremula* and others (Bańkowska, Garbarczyk 1981).

The manor park at Radziejowice is situated at the southwestern border of the Warsaw Valley at the edge of the Rawska Uplands, on the River Pisia–Gągolina, a right confluent of the River Bzura. On the eastern side, a protective belt of forests isolates the park from the Warsaw–Katowice motor-way. The park covers an area of about 4 ha and is situated in an afforested territory, but in its immediate vicinity are fields. These forests are remains of the former Jaktorowska Forest. The area occupied by the park has probably been managed at least since the beginning of the sixteenth century, and the palace was already there. At present the area of the park is too moist. The park was once intersected by a system of drainage canals but now they are silted and filled up. Meadows and lawns constitute a considerable part of the park which is subject to intensive cultivation processes such as mowing, weeding, raking of litter, and planting of flowers or even vegetables (Stefaniak, Orzeł, typescript).

The manor park in Młochów is on a housing estate. Młochów is a small estate on the River Utrata, it is entirely surrounded by with fields and the Młochowskie Forests stretch 5 km from the estate. The park was founded in the first half of XIX century. Now it is completely neglected and penetrated intensively by the local people and domestic animals. The area of the park is moist, even swampy at places. Lawns and meadows occupy a small area but trees and shrubbery constitute a fairly dense mass shading the area (Skibińska, manuscript).

A village garden at Wola Mrokowska, a village situated along a Warsaw–Cracow road. The garden lies among fields. The study site was in the part near the farm buildings. There are a few young limes (*Tilia cordata*) and plenty of ornamental bushes there. Most of the area was given to vegetables and herbaceous plants. Not far from the garden is a meadow with a mixture of fodder plants and it is usually mown three times during the season. There is an orchard several hundred metres from the garden (Skibińska, manuscript).

Łomna — forest (Kampinoska Forest). Mixed coniferous forest (*Pino-Quercetum*). The study site was in the eastern part of the Kampinoska Forest, close to the station of the Institute of Zoology, PAS, at Łomna. The *Pino-Quercetum* forest covers 2.5 ha. The 65 to 75-year-old tree stand consists of *Quercus robur*, *Betula verrucosa*, *Betula pubescens*, *Pinus silvestris*. The density of tree crowns fairly loose or loose (Włoczewski 1968). Poorly podsolized soils, from poorly loamy sands, on loose sands of water accumulation. Moder or mull type humus (Bańkowska, Garbarczyk 1981).

Łomna — forest (Kampinoska Forest). A moist coniferous forest (*Peucedano-Pinetum*). The study site was in a dune area, in the eastern part of the Kampinoska Forest, near Łomna. The 70 to 80-year-old tree stand consists of *Pinus silvestris* with some *Betula verrucosa* and *Quercus robur*. The density of tree crowns fairly loose or loose (Włoczewski 1968). The soil podsolized, from loose sands, moist. Mull-type humus (Bańkowska, Garbarczyk 1981).

Suburban areas

Białołęka Dworska is on the outskirts of the district Praga-Północ, 14 km from the centre of Warsaw (Map 2). The area of the estate is situated on an accumulation terrace of the Vistula. The terrace is formed by stratified Vistula muds, consisting of sandy loams and loamy sands. With the exception of brown soils, all the soils at Białołęka Dworska are characterized by a highly acid reaction in surface layers and acid in deeper layers. The entire area of Białołęka Dworska has been greatly disturbed as a result of long management. Most of the territory is occupied by fields and gardens and poorer soils have been afforested.

Four habitats most typical of the area have been distinguished at Białołęka Dworska: linden-oak-hornbeam forest, carr, mixed coniferous forest and moist coniferous forest[1].

The linden-oak-hornbeam habitat (*Tilio-Carpinetum*). The study site was in a tree covered area of 0.4 ha adjacent to agrocoenoses. The trees at various ages, with crowns not very dense. The tree stand in cludes *Tilia cordata*, *Quercus robur* and *Carpinus betulus*. Soil brown, poorly acid and humid. A considerable number of anthropophytes was recorded among herbaceous plants (Bańkowska, Garbarczyk 1981; Roo-Zielińska 1981).

The carr habitat (*Circaeo-Alnetum*). The study site of 0.4 ha was in the valley of a former stream, surrounded by arable land. The carr forests that once grew in the valley of Jabłonna have been cut down almost completely and at present the areas are utilized in farming. The soils in the valley of the stream are fairly rich, humus or marsh of peat origin. The level of groundwater is fairly high in relation to the other soils. Two study sites were situated in this habitat. Material for the present paper was collected in site No IV, a community of black alder about 35 years old (Bańkowska, Garbarczyk 1981).

The mixed coniferous forest (*Pino-Quercetum*) habitat. The study site of 3 ha was in a tree stand dominated by *Pinus silvestris*, *Betula verrucosa* and *Quercus robur*, and aged about 30. Some oaks (120–150 years old) grow at the edge of the tree stands. Birches occur in congeneric aggregations. A fairly large number of anthropophytes was recorded in the area studied which was adjacent to farm buildings and infields. Soils not rich, formed from light loamy sands, rusty podsolized and podsolized (Bańkowska, Garbarczyk 1981; Roo-Zielińska 1981).

The moist coniferous forest (*Peucedano-Pinetum*) habitat. The study site was in a dune stretch in a 30-year-old pine tree stand (apart from *Pinus silvestris* there was a small admixture of *Betula verrucosa* and *Quercus robur*). The tree stand is 3 km long and 1 km wide. Soils podsolized, formed from dune sands, characterized by low sorption capacity and high acidification. There occur plant communities typical of dry, sandy and warm sites, *Nardetalia* communities and moors. In comparison with other suburban habitats, this habitat was characterized by the lowest percentage of anthrophytes (Bańkowska, Garbarczyk 1981).

The park in Ursynów. It is an old manor park of over 5 ha situated on the southern outskirts of the city, on the upper Vistula terrace, in a large complex among orchards and fields. Trees of local and foreign origin. In comparison with all the other suburban areas, this site was characterized by the lowest lead index. The study site was characterized by a high percentage of open areas (lawns) with trees in double rows and clusters.

Plant cover of the type of a moist pasture with the alliance *Cynosurion*. Loamy soils (Nowakowski 1981).

Bielany. A suburban forest (now a reserve) covering 130.4 ha on Vistula terraces. The accumulation terrace is dominated by a *Tilio-Carpinetum* forest, sometimes inclined towards a derivative *Pino-Quercetum* forest, and a secondary *Potentillo albae-Quercetum* forest also

[1] Under the impact of anthropopressure these habitats have been greatly changed.

occurs there. A *Querco-Carpinetum alnetosum* forest and a *Fraxineto-Ulnetum* forest occur on the alluvial terrace. In this area predominant are brown and podsolized soils and soils with no distinct profile, ruined by ditches and an admixture of foreign material (rubble and rubbish) (Nowakowski 1981).

Urban areas

The allotment gardens (Ogr. Działk.) situated along Żwirko and Wigura Street cover 45 ha. They are adjacent to the park at the Cemetery of Soviet Soldiers and to recreation areas (Pola Mokotowskie).

The green of Warsaw was studied in four types of areas, namely in parks, the green of housing estates, backyard green and streetside green.

Parks

Each of the areas studied represents a different type of an urban park. They differ in age, size and situation and are similar due to the type of exploitation and the character of management.

Łazienki. The biggest Warsaw park covering 86 ha. The park was founded in the first half of the eighteenth century, over the territory of a forest complex (Jazdów). In the immediate vicinity of the park there is a slightly different type of urban green, such as a recreation area (Agrykola) and the Botanical Garden. Trees of local and foreign origin. The vegetation of the park is rich and its structure varied. On lawns there grows vegetation from the alliance *Cynosurion* and only on the lower terrace there occur communities close to the vegetation of a moist meadow with the alliance *Arrhenatherion*. Soils loamy or loam-sandy, in part marsh soils, mechanically transformed, seldom strewed soils.

The Saxon Garden (Ogr. Saski). The oldest public park in Warsaw, founded in 1713. In comparison with the other urban parks studied, this one has a rather small area of nearly 16 ha. It was greatly devastated during the World War II, but later partly reconstructed Soils strewed, with a lot of rubble, greatly contaminated by lead. Lawn vegetation similar to the community of a moist pasture from the alliance *Cynosurion*. The Saxon Garden has no contact with any other green because it is entirely surrounded by high density housing.

The park at the Cemetery-Mausoleum of Soviet Soldiers (CMZR) covers an area of 20.5 ha but it is a part of a fairly big complex of urban green occupying an area of 80 ha. It is a new park, founded in 1949–1950 on former arable land. Very fine sandy soils and loamy soils, mechanically transformed. Lawn vegetation from the alliance *Cynosurion*. The park adjoins other types of urban green such as allotment gardens and recreation areas (Pola Mokotowskie).

The Praski Park. It was founded in 1865 and since 1928 it has been within a park complex including the Zoological Garden. It was the only study site in the right-bank part of Warsaw. The western part of the Park with its old tree stand is situated in a carr habitat and the eastern part, included only after 1948, is probably situated in a *Pino-Quercetum* habitat. Soils mostly of strewed character. The areas studied occupied about 2.000 m^2 (Nowakowski 1981).

Housing estate green

The housing estate Wierzbno was built between 1960 and 1965 on former fields and areas with detached houses. The estate is loosely built over. The area of the estate green constitutes 42.5 % in relation to the built over ground. Most frequently, on this estate lawns occupy an area of 500–700 m^2. *Tilia cordata* dominates among trees, lawn vegetation from the alliance *Cynosurion*. Soil rich, sandy-loamy but its top layer was destroyed while the estate was being

built. The estate green was developed successively, partly on a new, several-centimetre-deep layer of humus transported there. The study site was near a kindergarten, in an area lined with separate lindens. The area is adjacent to a school playground, also lined with separate lindens.

The estate Muranów-Północ (Stawki). The estate was built between 1960 and 1965, in an area covered with rubble. It is a loosely built over estate. The estate green covers 43.2 % of the entire area of the estate but it is divided into small plots of usually about 200 m^2. Maple (*Acer campestris*) dominates among trees, lawn vegetation from the alliance *Cynosurion*. The estate green was set up several times both because it did not grow very well and also because it was destroyed by the inhabitants. The study site was in Stawki Street. It was a small lawn of about 200 m^2, with separate lindens. A municipal garden is near by.

Backyard green

A down-town backyard at 64 Wilcza Street. A lawn with bushes covering an area of about 200 m^2, weed-grown, mown very seldom, surrounded by densely built over areas. In the nearby backyards there are small lawns with separate trees and bushes. Not very far away there is a garden with vegetables and herbaceous plants.

A down-town backyard at 49 Koszykowa Street. A lawn of about 300 m^2 with separate lindens. The backyard is surrounded by areas built over very densely (it resembles a well) and therefore it is very dark.

Isolated streetside green

Konstytucja Square (MDM). A row of lindens (*Tilia cordata*) growing along the street on small patches of soil between flagstones. The trees are isolated from any bigger complexes of urban green. Densely built over areas surround the square and separate trees grow in nearby backyards.

3. CHARACTERISTICS OF DIPTERANS PARASITIZING EARTHWORMS

3.1. Species composition of the dipterans of the genus *Pollenia* and *Sarcophaga* in the Mazovian Lowlands against a background of the fauna of these dipterans recorded from Poland

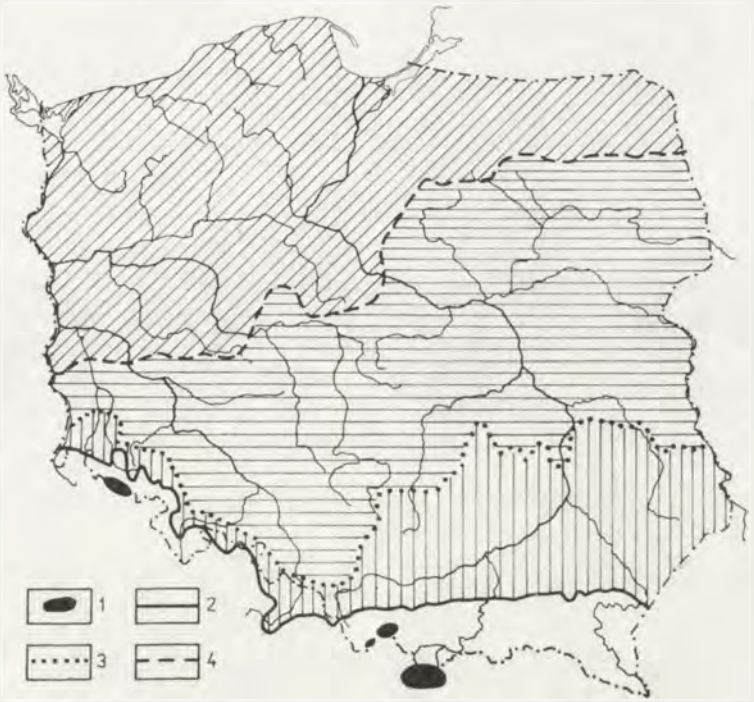
21 species of the genus *Pollenia* have been recorded from the Palaearctic, and 12 species from Poland (Table I). The most, i.e. 11 species in each, were recorded in the Pieniny Mountains and in the Mazovian Lowland. Five species were recorded in each of the following areas: the Baltic Coast, the Pomeranian Lake District and Wielkopolska–Kujawy lowland. Other regions of Poland have been studied very poorly and therefore the number of species recorded there is insignificant.

In the rural areas of Mazovia there were recorded 11 species and within the administrative boundries of Warsaw — 9 species, with two — *P. dasypoda* and *P. pectinata* collected only in Warsaw parks (Draber-Mońko 1981).

The greatest number of species of *Diptera* of the genus *Pollenia* was recorded in southern Poland and up to the limit of the last glaciation (Map 3).

From the Palaearctic there have been recorded 21 species of the genus *Sarcophaga* (Lehrer 1973), from Poland 7 species (Table I). The most, i. e. 6 species, were recorded in the Pomeranian Lake District, in the Bieszczady Mountains and in the Pieniny Mountains. Five species were recorded in the Baltic Coast,

in the Mazovian Lowlands, in the Białowieska Forest and in the Małopolska Upland. Four species were recorded in the Wielkopolska–Kujawy Plain and in Lower Silesia. Three species were recorded in each of the following areas: the



Map 3. Limits of the glaciations in Poland (after J. KOSTROWICKI simplified). 1 — the mountain glaciation, 2 — the limit of the maximum range of the Cracovian glaciation, 3 — the limit of the area covered by the Central-Polish glaciation, 4 — the limit of the area covered by the Baltic glaciation.

Pomeranian Lake District, Podlasie, the Krakowsko-Wieluńska Upland, the Lubelska Upland, the Western Sudeten Mountains, the Western Beskides Mountains, the Nowy Targ Valley and the Tatras. Only two species of *Diptera* of the genus *Sarcophaga* were recorded in other regions of the country. The various numbers of species in particular regions are a resultant both of the degree to which the Polish fauna has been studied and of the differences in the composition of the Polish fauna.

Five species of dipterans of the genus *Sarcophaga* were recorded in the rural areas of Mazovia and within the administrative boundries of Warsaw (DRABER-MOŃKO 1981).

3.2. Zoogeographic analysis of the fauna of the dipteran community parasitizing earthworms

Basing on the established geographic distribution of the community of *Diptera* of the genus *Pollenia*, the species occurring in the habitats studied have been into the following zoogeographic elements: Holarctic, Palaearctic, Euro-Si-

berian, Submediterranean and European (Fig. 1). The criteria of the zoogeographic division follow the principles worked out by the Centre of Faunistic Specification of the Institute of Zoology PAS (Czechowski, Mikołajczyk 1980). Particular species have been included into particular elements on the basis of data on their distribution, published mainly in papers by the following authors: Grunin (1970, 1975), Kano (1968), Lehrer (1972), Mihaly (1979) and Zumpt (1956).

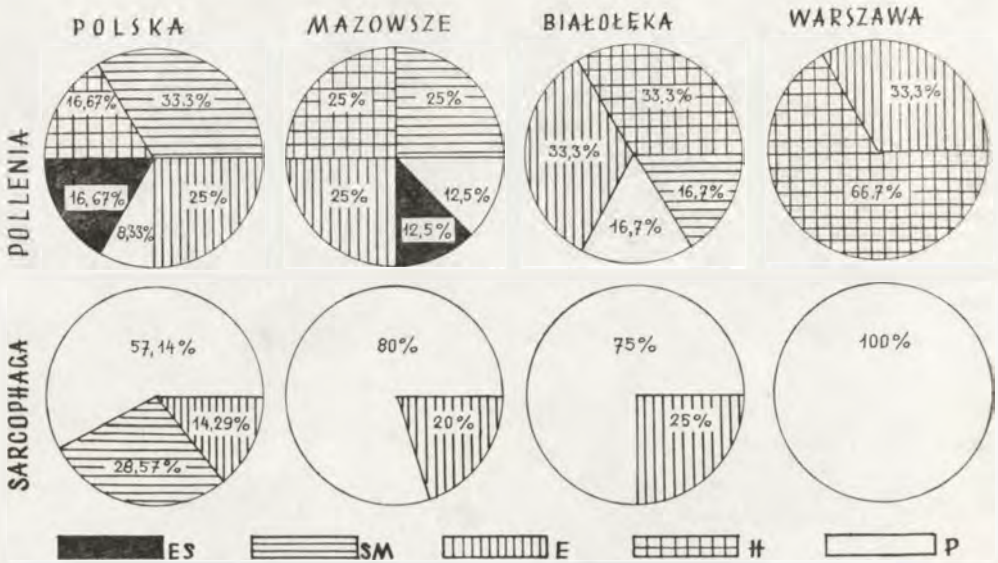


Fig. 1. Percentage share of the zoogeographic elements in the fauna of the parasitic dipterans of the genera *Pollenia* and *Sarcophaga* in Poland, the Mazovian Lowlands, Białołęka Dworska and Warsaw (based on the number of species). ES — Euro-Siberian, SM — Submediterranean, E — European, H — Holarctic, P — Palaearctic.

If the zoogeographic analysis of the *Diptera* of the genus *Pollenia* is based on the number of species (Fig. 1), it appears that in Poland the Submediterranean and European elements are the richest in species. In Mazovia the percentage shares of three elements (Holarctic, European and Submediterranean) are the same — 25%, but two others (Palaearctic and Euro-Siberian) are smaller by a half. In Białołęka Dworska the percentage share of the Holarctic and European elements is the same, but of two others (Palaearctic and Submediterranean) is smaller by a half.

The zoogeographic analysis based on the abundances of representatives of particular elements gives an entirely different picture (Fig. 2).

Since the author has no quantitative material collected over the whole territory of Poland, the generalization about the abundance of *P. rudis* — a species wide-spread in the Holarctic — has been based on data collected in the following

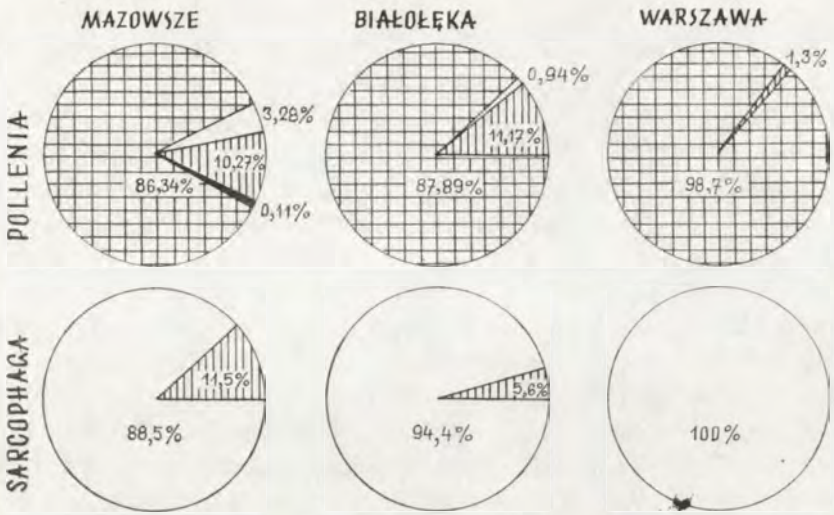


Fig. 2. Percentage share of the zoogeographic elements in the fauna of the parasitic dipterans of the genera *Pollenia* and *Sarcophaga* in the Mazovian Lowlands (Hamernia, Radziejowice and the Kampinoska Forest), Białołęka Dworska and Warsaw obtained on the basis of the species abundance. The other items as in Fig. 1.

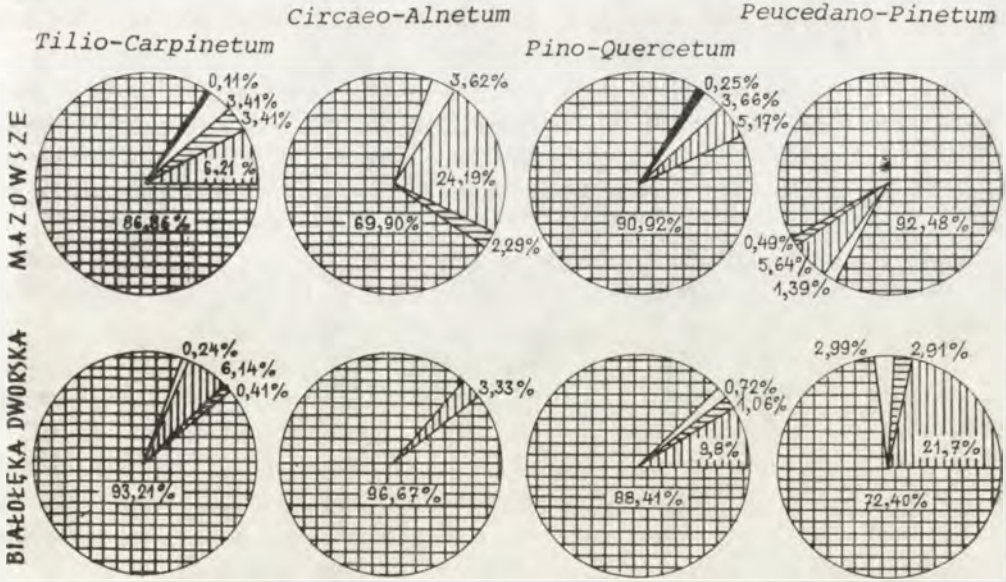


Fig. 3. Percentage share of the zoogeographic elements in the fauna of the parasitic dipterans of the genus *Pollenia* in the habitats of Białołęka Dworska on a background of the non-urbanized habitats of Mazovia, presented on the basis of the species abundance. The other items as in Fig. 1.

regions of the country: the Isle of Wolin, the Białowieska Forest, the Małopolska Upland, the Świętokrzyskie Mountains, the Bieszczady Mountains and the Pieniny Mountains. In the above six regions, the most abundant was the species *P. rudis*, collected in similar numbers in the rest of the country, and thus it can be assumed that the Holarctic element distinctly dominates among the dipteran species of the genus *Pollenia*. It was also the most abundant in all the rural habitats of the Mazovian Lowland, in Białołęka Dworska and Warsaw (Figs 2, 3).

In the Mazovian Lowland, in four selected rural (natural) habitats and in the respective habitats in Białołęka Dworska the Holarctic element was the most abundant. In rural habitats the percentage share of this element was the lowest in a carr habitat and the highest in a moist coniferous forest, thus entirely opposite to the respective, deformed habitats in Białołęka Dworska. The European in rural element habitats was the most abundant in a carr habitat and the least abundant in a moist coniferous forest, thus the reverse of the respective suburban, deformed habitats of Białołęka Dworska. The abundance of the other elements was very small (Fig. 3). In Warsaw, the Holarctic element was the most abundant and the percentage share of the European element was insignificant (Fig. 2). All the above zoogeographic elements were recorded in rural habitats, but species constituting the Euro-Siberian element had been eliminated from deformed habitats.

Both in the rural and in the suburban zones, the European element was represented by the greatest number of species but their abundance was very low in comparison with that of species representing the Holarctic element.

In all the habitats studied, the Holarctic element is the most abundant one. The species belonging to this element has the highest abundance percentage, both in their abundance in natural, rural habitats and in deformed habitats as well. In urban green, increasing anthropogenic pressure is accompanied by an increase in the percentage of the Holarctic element.

Three zoogeographic elements: Palaearctic, European and Submediterranean have been distinguished in the material collected (Fig. 1). The basis for this was provided by an analysis of the zoogeographic ranges of particular species of the genus *Sarcophaga*. Particular species were included into the particular elements on the basis of data on their distribution published in papers of the following authors: Kano (1967), Lehrer (1963, 1973) and Rohdendorf (1959, 1970).

The zoogeographic analysis of the dipterans of the genus *Sarcophaga* based on the number of species constituting the particular elements reveals that in Poland predominant were the Palaearctic and Submediterranean elements while the percentage of the European element was smaller by a half.

In the rural habitats of Mazovia and Białołęka Dworska, the Palaearctic element was the richest in species while the percentage share of the species of the genus *Sarcophaga* which constitute the European element was three times smaller.

The green of the housing estates and of the centre of Warsaw was entered only by species belonging to the Palaearctic element (Fig. 1).

The zoogeographic analysis based on the percentage shares of the representatives of particular elements provides an entirely different picture (Fig. 2). In various rural habitats of Poland (just as in the analysis of the species of the genus *Pollenia*, this generalization is based on the material collected in six regions of the country), species constituting the Palaearctic element prodominated, and the European element was represented fairly numerously, but the percentage of the Submediterranean element was extremely low.

In the Mazovian Lowlands, in the four selected rural (natural) habitats and in the respective habitats of Białołęka Dworska, the Palaearctic element was the most abundant. In rural habitats, the percentage share of this element was the lowest in a carr habitat and the highest in a lime-oak-hornbeam forest. In suburban deformed habitats, the percentage share of the Palaearctic element was the highest in a carr habitat, thus being the reverse of the situation in a respective rural habitat, and it was the lowest in a mixed coniferous forest.

The green of the housing estates and of the centre of Warsaw was entered only by the Palaearctic element (Fig. 2).

Dipteran species of the genus *Sarcophaga* constituting the Palaearctic and European elements occurred in all the rural habitats studied in the Mazovian Lowlands and in the suburban habitats of Warsaw. No species belonging to the European element were recorded in the urban green of Warsaw (Figs 2, 4).

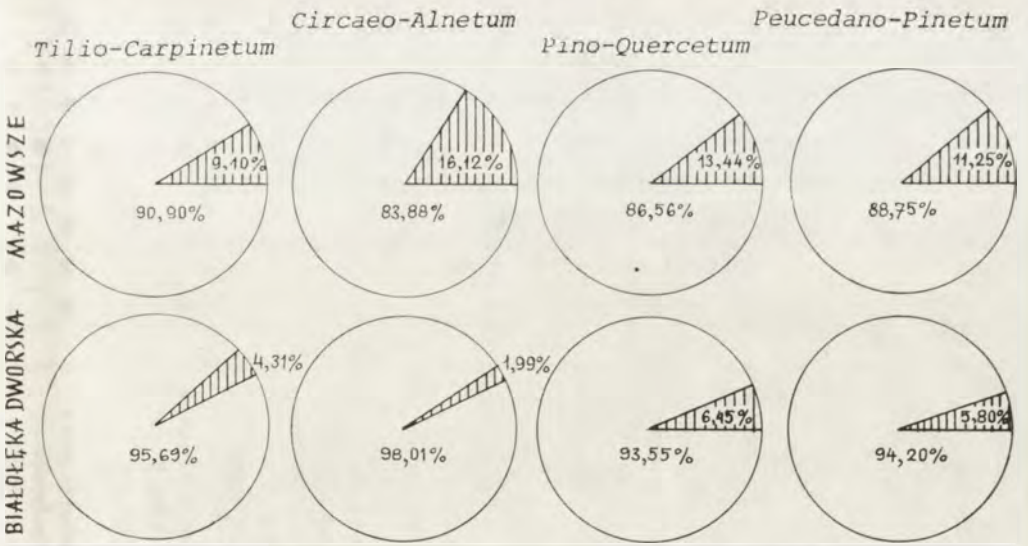


Fig. 4. Percentage share of the zoogeographic elements in the fauna of the parasitic dipterans of the genus *Sarcophaga* in the habitats of Białołęka Dworska on a background of the non-urbanized habitats of Mazovia, presented on the basis of the species abundance. The other items as in Fig. 1.

Table I. List and the distribution in Poland of the dipteran species of the genera *Pollenia* and *Sarcophaga*, parasitoids of earthworms, and the distribution of two host species recorded from Poland

● Verified data
○ Unverified data

		The Baltic Sea	The Baltic Coast	The Pomeranian Lake District	The Mazurian Lake District	The Wielkopolska-Kujawska Plain	The Mazovian Lowlands	Podlasie	The Białowieska Forest	Lower Silesia	The Trzebnickie Hills	Upper Silesia	The Krakowska-Wieluńska Upland	The Małopolska Upland	The Świętokrzyskie Mountains	The Lubelska Upland	Roztocze	The Sandomierska Lowlands	The Western Sudeten Mountains	The Eastern Sudeten Mountains	The Western Beskidy Mountains	The Nowotarska Valley	The Eastern Beskidy Mountains	The Bieszczady Mountains	The Pieniny Mountains	The Tatra Mountains		*Tilio-Carpinetum*	*Circaeo-Alnetum*	*Pino-Quercetum*	*Peucedano-Pinetum*
1	*Pollenia atramentaria* (Meig.)		●	●		●	●	●	●	●			●	●	●	●				●					●	●					●
2	*Pollenia dasypoda* (Portsch.)						●							○	●									●	●			●			
3	*Pollenia griseotomentosa* (Jacentk.)									●				●											●						
4	*Pollenia intermedia* Macq.					●	●	●	●	●			○	●	●				●	●	●	●		●	●	●		●	●	●	●
5	*Pollenia mayeri* Jacentk.		●				●																					●	●	●	●
6	*Pollenia pallida* Rohd.						●																	●	●						
7	*Pollenia pectinata* Grunin						●																		●			●		●	
8	*Pollenia rudis* (Fabr.)		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●
9	*Pollenia vagabunda* (Meig.)			●			●		●															●	●			●	●	●	●

10	*Pollenia varia* (MEIG.)	●	●		●	●	●	●			○	●	●	●	●			●		●		●	●	●			●	●	●	●			
11	*Pollenia vera* JACENTK.					●		●			●	○	●	●	○					●			●	●			●						
12	*Pollenia vespillo* (FABR.)	●	●	○	●	●	●	●	●		●	○	●	●	●					●		●	●	●	●		●	●	●	●			
1	*Sarcophaga carnaria* (L.)	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●		●	●	●	●			
2	*Sarcophaga dolosa* LEHRER	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●	●	●	○	●	●	○	●	●	●		●	●	●	●			
3	*Sarcophaga jupalnica* LEHRER		●					●																									
4	*Sarcophaga lehmani* MÜLL	●	●	●	●	●	●	●	●		○	●	●		●					●			●	●	●		●	●	●	●			
5	*Sarcophaga moldavica* ROHD																																
6	*Sarcophaga schultzi* MÜLL	●	●			●		●	●														●	●							●		
7	*Sarcophaga subvicina* ROHD.	●	●		●	●							●	●				●			●		●	●			●	●	●	●			
1	*Allolobophora chlorotica* (SAW.)	●	●	●	●	●	●	●	●	●	○	●	●	●	●			●	●	●	●			●			●	●					
2	*Allolobophora caliginosa* (SAW.)	●	●	●	●	●	●	●	●	●	○	●	●	●	●		●	●	●	●	●	●	●	●	●		●	●	●	●			

In habitats subject to strong anthropogenic pressure, the dipterans included into both taxocenes demonstrated an increase in the percentage share of the elements with wide geographic ranges and a decrease or complete elimination of the percentage shares of the elements with small ranges. Differences in the percentage shares of the elements with wide and narrow geographic ranges were most distinct in a suburban, deformed carr habitat as compared with a respective rural habitat also situated in the Mazovian Lowlands.

3.3. An attempt at explaining the origin of the two taxocenes based on the geographic distribution of particular species and on the origin of the hosts

The lower the geographic latitude, the greater is the number of earthworm species (Plisko 1965) and a similar phenomenon can be applied to the dipterans of the genus *Pollenia*. Two species of *Diptera* of the genus *Pollenia* have been recorded from Norway and four from Sweden. In northern Poland there have been recorded five species, but in central and southern Poland — 12 species (Table I). 12 species have been found in Czechoslovakia and 13 in Hungary. As far as earthworm species are concenred, the greatest number — 45 — has been recorded also in Hungary (Plisko 1973).

The available data on the distribution of the dipteran species of the genus *Pollenia* in Poland (Table I) indicate that the richest specific composition can be found in southern Poland (the mountain ranges — Pieniny and Bieszczady, and partly the Małopolska Lowland and the Lubelska Lowland) and also in the plains of central Poland (part of the Wielkopolska-Kujawy Plain, the Mazovian Lowland, Podlasie, the Białowieska Forest). This fact is most probably connected with successive glaciations reaching our country. This is clearly illustrated on the map of glaciations (Kostrowicki 1968, Map 3). Areas not reached by glaciations or those situated beyond the limit of the maximum Cracovian glaciation or the Baltic glaciation are characterized by the greatest number of earthworm species of the family *Lumbricidae* (Plisko 1965) and of the dipterans of the genus *Pollenia* parasitizing them (Table I). Some authors believe that the 'cradle' of the family *Lumbricidae* probably lies in the mountain ranges belonging to the Alpino-Carpathian-Himalayan system, together with the remains the Hercynian folding connected with them (Michaelsen 1903, Černosvitov 1935, Pop 1949, Plisko 1965, 1973).

The assumption that an increase in the number of earthworm species is connected with an increase in the number of species of their parasitoids applies only to the dipterans of the genus *Pollenia* which are specific parasitoids of *Lumbricidae*. The dipterans of the genus *Sarcophaga*, being non-specific parasites of earthworms, do not demonstrate any such correlation. They adapted to parasitizing *Lumbricidae* much later than the dipterans of the genus *Pollenia*, this being indicated by the range of their occurrence distinctly limited mainly to Europe, and in some species to the Palaearctic. The Earthworms of the genus *Allolobophora* known as hosts of the dipterans under discussion are widely distri-

buted in the Holarctic (and man has been the agent responsible for their accidental introduction on continents and islands situated beyond the original territory of the whole family). The most abundant species of the genus *Pollenia* known as parasites of these earthworms are also widely spread in the Holarctic, while the dipterans of the genus *Sarcophaga* have a considerably smaller range of occurrence.

3.4. Phenology of the dipterans parasitizing earthworms

The phenology of the dipterans of the genus *Pollenia* and *Sarcophaga* is different even though during certain periods they occur together.

Imagines of the genus *Pollenia* occur throughout the year but the greatest

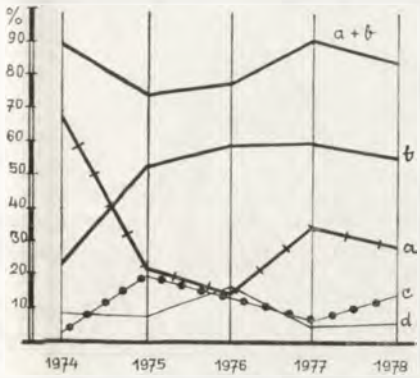


Fig. 5. Relative abundance of parasitic *Calyptrata* (in % of the total abundance of parasitic *Calyptrata*) during the five-year investigations on the fauna of Warsaw, a + b — total earthworm parasitoids, a — dipterans of the genus *Pollenia*, b — dipterans of the genus *Sarcophaga*, c — parasites of snails, d — parasites of insects.

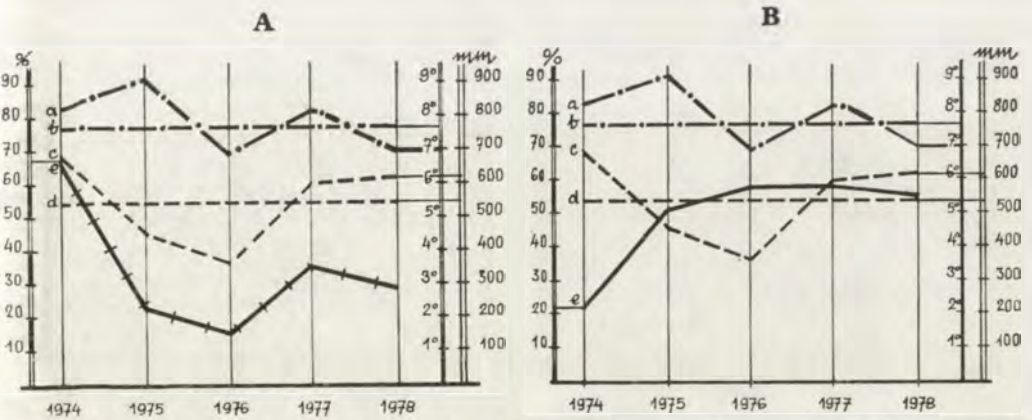


Fig. 6. Dependence of the relative abundance of the dipterans of the genus *Pollenia* (in % of the total abundance of parasitic *Calyptrata*) on the mean annual air temperature and on the mean annual rainfall during the five-year investigations on the fauna of Warsaw, a — mean annual air temperature, b — mean, many years, annual air temperature in °C (norm), c — mean, annual sums of rainfall, d — mean, many years, annual amounts of rainfall in mm (standard) measured at the station Warsaw-Okęcie (just like the air temperature), e — abundance of the dipterans of the genus *Pollenia* (A) and *Sarcophaga* (B).

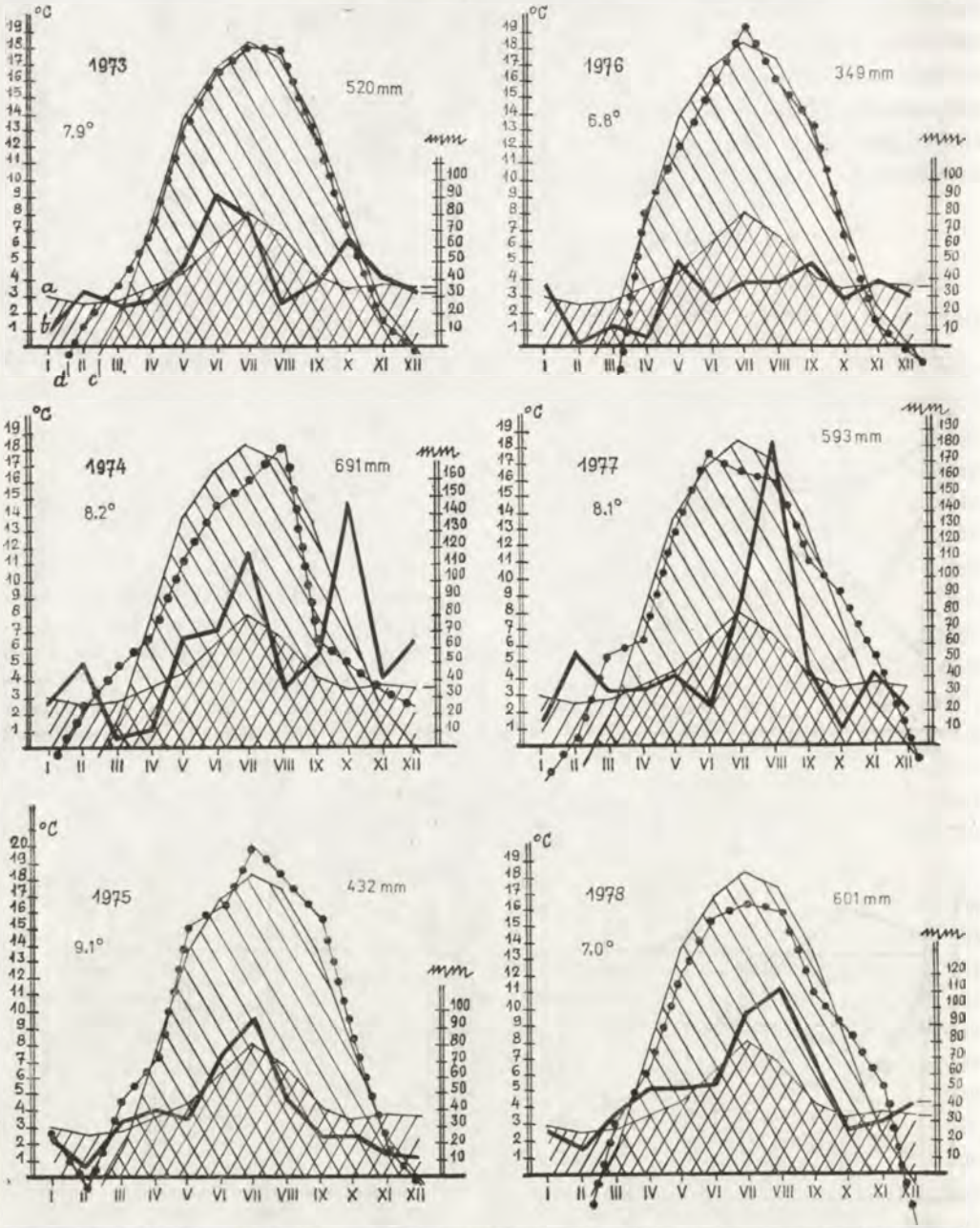


Fig. 7. Monthly and annual mean amount of rainfall in mm and the mean monthly air temperature in °C measured at the station Warsaw-Okęcie in years 1973–1978, a — mean, many years (1891–1960), monthly sum of rainfall, b — mean monthly amount of rainfall, c — mean, many years' (1891–1960), monthly air temperature, d — mean monthly air temperature. 7,9°; 8,2°; 9,1°; 6,8°; 8,1°; 7,0° — mean annual air temperature, 520 mm, 691 mm, 432 mm, 349 mm, 593 mm, 601 mm — mean annual sums of rainfall.

Table II. Abundance of the earthworm parasitoids of the genera *Pollenia* and *Sarcophaga* in particular sites during the five-year investigations on the fauna of Warsaw. The numerals indicate the number of individuals caught into a Moericke's trap within 24 hours

Genera	Warsaw											
	Bielany	The park in Ursynów	The allotment gardens	The Cemetery-Mausoleum of Soviet Soldiers	Praski Park	Łazienki	Saxon Garden	The housing estate Wierzbno	The estate Muranów-Północ (Stawki)	Wileza Street	Koszykowa Street	Konstytucja Square
1974												
Pollenia		3.622	1.701			1.070	0.688			0.059		
Sarcophaga		0.284	0.959			0.099	0.155			0.003		
1975												
Pollenia		1.336	0.529		0.120	0.101	0.063					0.031
Sarcophaga		0.510	1.006		1.081	0.455	0.469					0.008
1976												
Pollenia						0.049		0.305	0.120	0.365	0.160	0.080
Sarcophaga						0.400		4.430	0.470	0.297	0.192	0.097
1977												
Pollenia	0.181		0.417	0.291				0.255	0.235	0.014	0.008	0.006
Sarcophaga	0.521		0.653	0.493				0.573	0.177	0.019	0.015	0.003
1978												
Pollenia			1.218	0.424		0.1020	0.297			0.057		0.088
Sarcophaga			2.114	0.600		0.4281	0.475	.		0.137		0.033
Mean abundance												
Pollenia		2.479	0.966	0.357		0.3305	0.349	0.280	0.178	0.124	0.084	0.051
Sarcophaga		0.397	1.183	0.546		0.3455	0.366	2.502	0.324	0.114	0.104	0.035

numbers were caught during two, and sometimes three periods of the vegetative season: in early spring, in summer and in autumn (Figs 10–13).

Imagines of the genus *Sarcophaga* appear in late spring, are most numerous in summer, but only under exceptional weather conditions they were caught in great numbers also in autumn (this happens when it is cool and wet, i. e. when September follows an unusually cold August with the total of monthly rainfall three times higher than the average (Figs 7, 13). These dipterans are usually most abundant in August, only occasionally in July (Figs 10, 11, 13).

In the warm and rainy year 1974, in Warsaw (Fig. 7), the first material

was collected only in July and therefore no data are available on the abundance of the dipterans under discussion during the spring and early summer. The spesies of the genus *Pollenia* reached their highest abundance in September and those of the genus *Sarcophaga* in August.

In the warm and dry year 1975, in Warsaw (Fig. 7), the dipterans of both genera occurred fairly numerously during the summer months, but the maximum abundance for the species of the genus *Sarcophaga* occurred in August, while the dipterans of the genus *Pollenia* were most numerous in September.

In the cool and very dry year 1976, in Warsaw (Fig. 7), the highest abundance of the species of the genus *Sarcophaga* was recorded in August and that of the dipterans of the genus *Pollenia* in September. In Białołęka Dworska (on the outskirts of Warsaw) both genera were most numerous in August (Fig. 12) but in the Kampinoska Forest the abundance maximum for the dipteras of the genus *Pollenia* occurred in September (Fig. 11).

In the warm and rainy year 1977, in Warsaw (Fig. 7), the dipterans of both genera were numerous during the summer months, but the abundance maximum for the dipterans of the genus *Pollenia* occurred in July and that for the dipterans

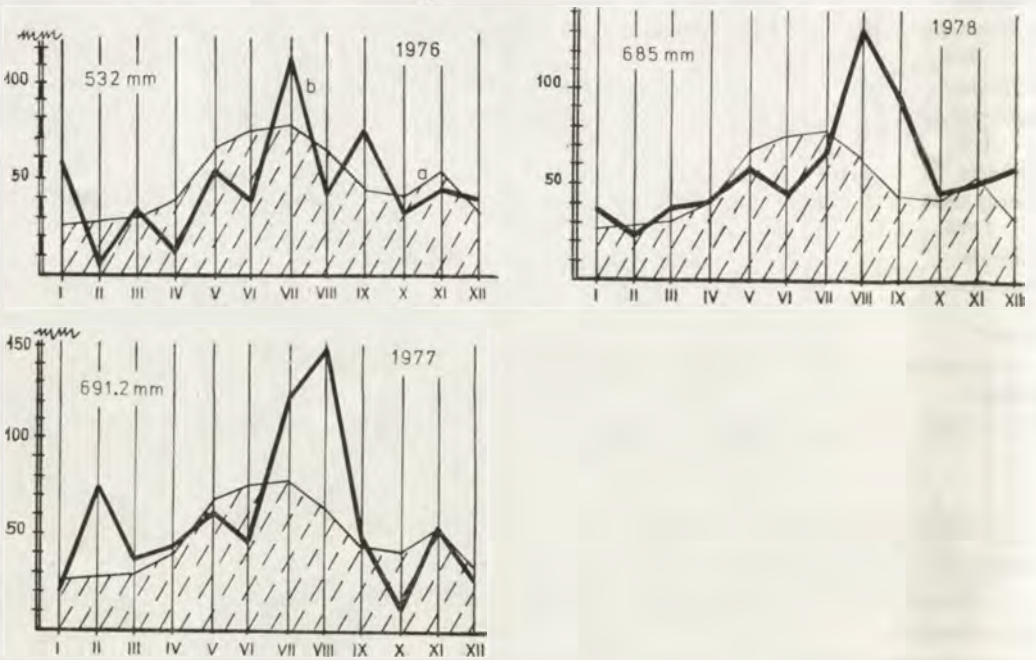


Fig. 8. Monthly and annual mean amount of rainfall in mm measured at the station Mszczonów in years' 1976–1978, a – (601 mm) mean many years' (1959–1973), monthly sum of rainfall, b – mean monthly amount of rainfall. 532 mm, 691,2 mm, 685 mm – mean annual sums of rainfall.

of the genus *Sarcophaga* in August (Fig. 12). In the Kampinoska Forest, the species of both genera were most numerous in July (Fig. 11).

In the cool and rainy year 1978, in Warsaw (Fig. 7), in Białołęka Dworska, Hamernia and Radziejowice (Fig. 8) the species belonging to both genera were most abundant in August. Moreover, in the carr at Hamernia (Fig. 10) the dipte-

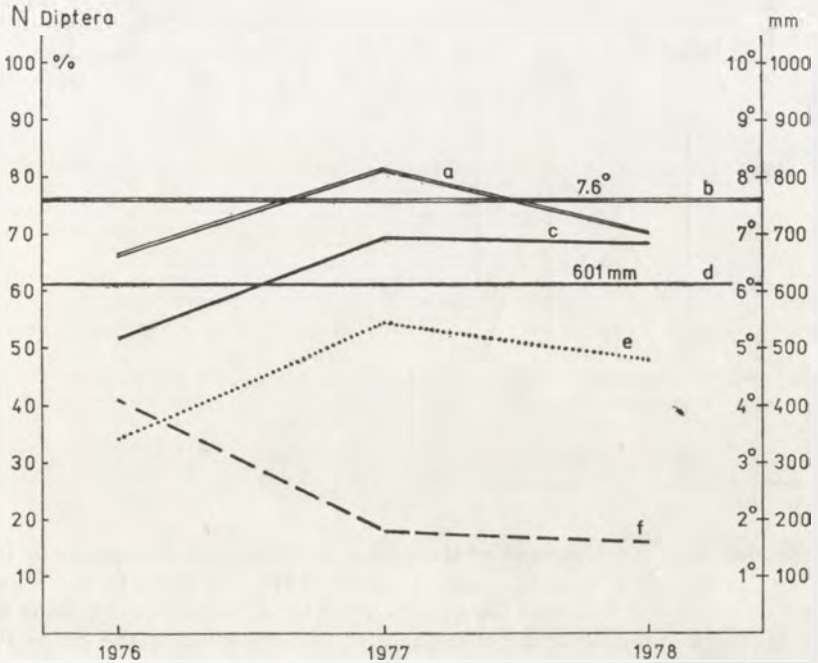


Fig. 9. Dependence of the relative abundance of the dipterans of the genera *Pollenia* and *Sarcophaga* (in % of the total abundance of parasitic *Calyptrata*) on the mean annual air temperature and on the mean annual rainfall during the three-years investigations on the fauna in the *Tilio-Carpinetum* forest at Hamernia, a — mean annual air temperature, b — mean, many years', annual air temperatures in °C (norm) measured at the station Warsaw-Okęcie, c — mean, annual sums of rainfall, d — mean, many years' (1959–1973), annual amounts of rainfall in mm (standard) measured at the station Mszczonów, e — abundance of the dipterans of the genus *Sarcophaga*, f — abundance of the dipterans of the genus *Pollenia*.

rans of the genus *Pollenia* were caught in equally great numbers both in October and in August (Fig. 10). A list of materials on earthworms (Pilipiuk 1981) collected in 1978 in the park at the Cemetery Mausoleum of Soviet Soldiers confirms an earlier hypothesis that an increase in the abundance of earthworms depends on the season, and the same was recorded for their parasites of the genera *Pollenia* and *Sarcophaga*.

In the park at the Cemetery Mausoleum of Soviet Soldiers (a study site closest

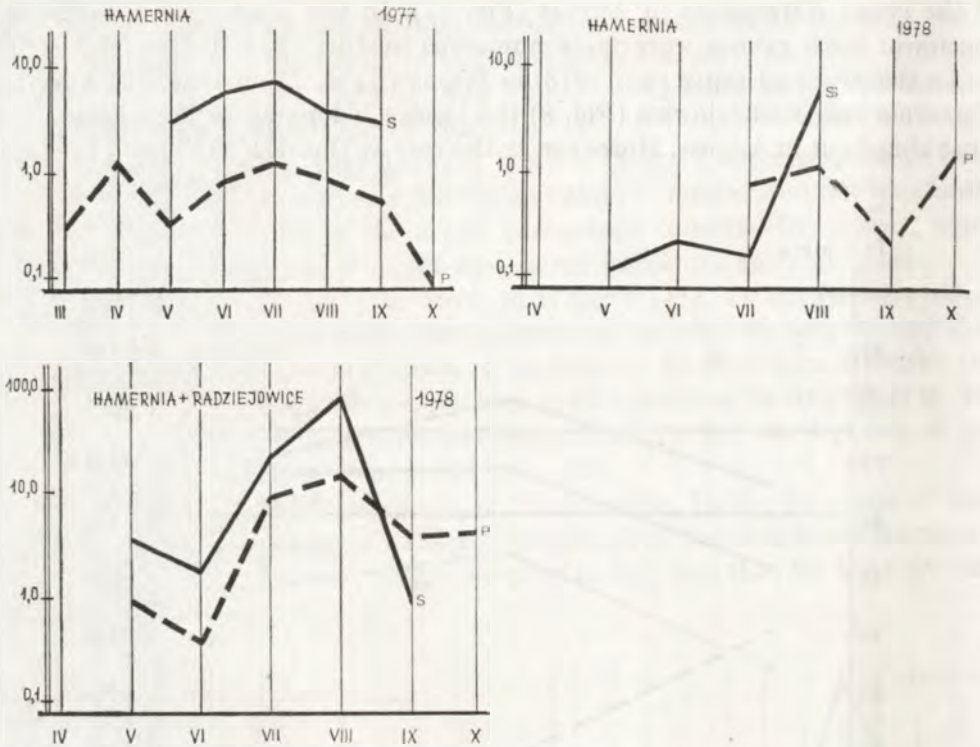


Fig. 10. Abundance of the dipterans of the genera *Pollenia* and *Sarcophaga* in the carr at Hamernia and in the park at Radziejowice in years' 1977 and 1978. In the Figures 10–13 and 15 the continuous line indicates the abundance of the dipterans of the genus *Sarcophaga* and the broken line indicates the abundance of the dipterans of the genus *Pollenia*.

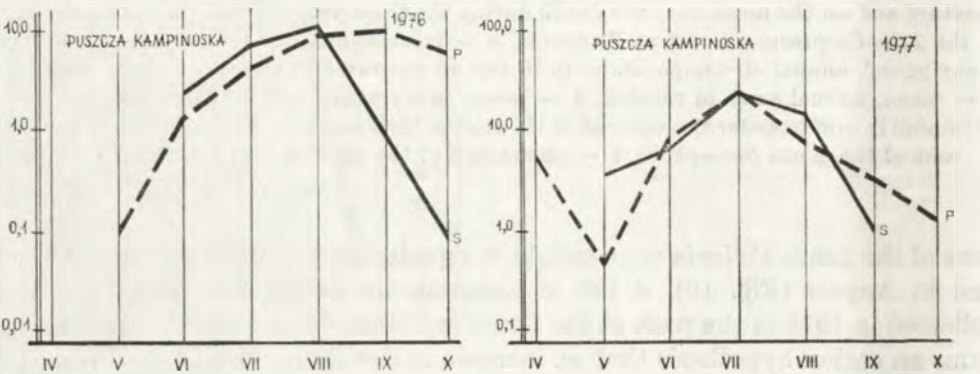


Fig. 11. Abundance of the dipterans of the genera *Pollenia* and *Sarcophaga* in the coniferous forests of the Kampinoska Forest in 1976 and 1977. The other items as Fig. in 10.

to the station of the Institute of Meteorology and Water Economics, Warsaw-Okęcie) in 1975, the highest abundance of the dipterans of both genera studied was recorded in July, but the month was exceptionally rainy and warm (Fig. 7).

In the *Tilio-Carpinetum* forest at Hamernia in 1977 and 1978, similar weather conditions were in August (Fig. 8), i. e. during that month rainfalls were more than twice higher than the standard (an eighty-year mean) for the nearest station of IMWE at Mszczonów (Fig. 8). Unfortunately, no air temperature measur-

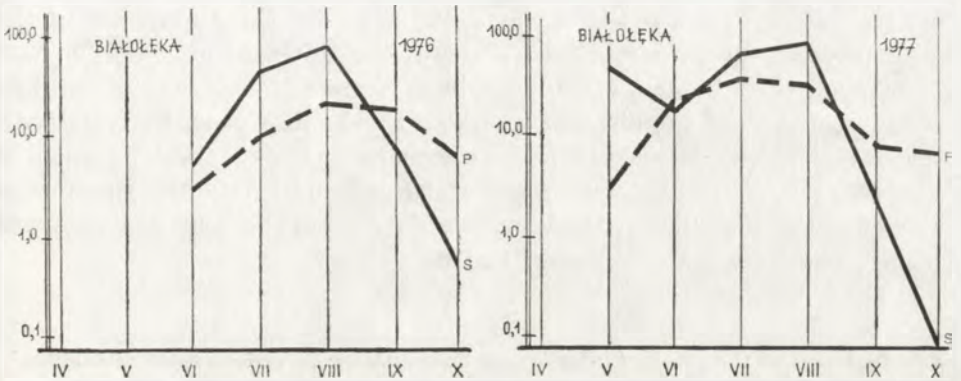


Fig. 12. Abundance of the dipterans of the genera *Pollenia* and *Sarcophaga* in Białołęka Dworska in 1976 and 1977. The other items as in Fig. 10.

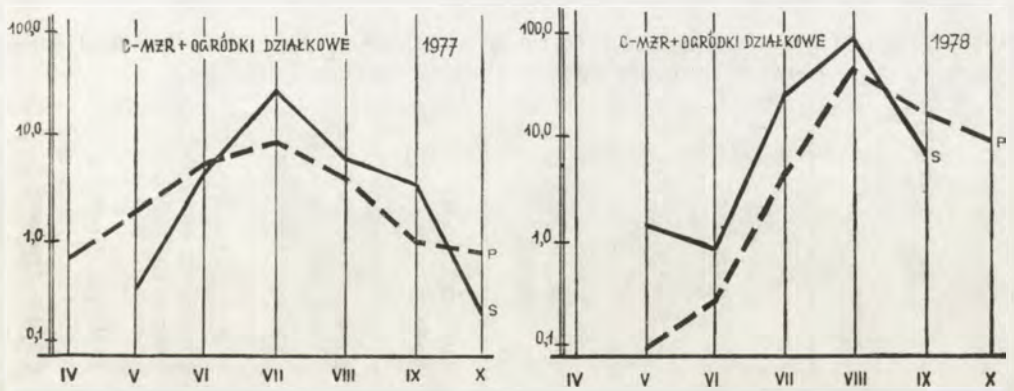


Fig. 13. Abundance of the dipterans of the genera *Pollenia* and *Sarcophaga* in the allotment Gardens and in the Cemetery Mausoleum of Soviet Soldiers in 1977 and 1978. The other items as in Fig. 10.

ements were made at that station but on the basis of data from the station Warsaw-Okęcie (Fig. 7) it can be assumed that during that month the temperature was close to the average. In can be assumed that the dipterans of both genera reach their maximum abundance in that particular summer month which

is exceptionally rainy and normally or exceptionally warm (as was the case in 1975 in the park at the Cemetery of Soviet Soldiers and in the *Tilio-Carpinetum* forest at Hamernia).

An analysis of materials collected during five years has revealed that the phenology of the dipterans under discussion parasitizing earthworms changes in response to the weather conditions in a given year. The dipterans of the genera *Pollenia* and *Sarcophaga* reach their highest abundance in the summer months. For parasitoids of the genus *Pollenia* the highest abundances were recorded in warm and rainy years while in a warm but dry year the abundance of these dipterans decreased considerably. In Warsaw, the dipterans of the genus *Sarcophaga* reached their highest abundance in dry years irrespective of the mean annual temperature of the air, and in a warm and rainy year. In Warsaw, the parasitoid community reached its highest abundance in exceptionally warm and rainy years (Fig. 5). In Warsaw, in deformed and rural habitats, these parasitoids reached their maximum abundance in July when the year had been warm and rainy, and in August in a cool and rainy year.

3.5. Dipterans of the genera *Pollenia* and *Sarcophaga* in various types of habitats

A great number of species of the genus *Pollenia* was recorded in the Mazovian Lowlands (Table I). However, the habitats studied differed in the number of species recorded there and in their abundance. The greatest numbers of species

Table III. Abundance of the species of earthworm parasitoids of genera *Pollenia* and *Sarcophaga* in different habitats of the Mazovian Lowlands

Genera	Hamernia (*Tilio-Carpinetum* and *Circaeo-Alnetum*)	The village garden at Wola Mrokowska	The manor park in Młochów	The manor park in Radziejowice	Kampinoska Forest (*Pino-Quercetum* and *Peucedano-Pinetum*)	Białołęka Dworska (*Pino-Quercetum* and *Peucedano-Pinetum*)	Białołęka Dworska (*Tilio-Carpinetum* and *Circaeo-Alnetum*)
1976							
Pollenia	2.454	1.188	0.438		1.234	1.159	1.247
Sarcophaga	1.818	1.573	0.581		0.827	2.408	2.395
1977							
Pollenia	0.895	1.989	0.616	0.352	1.396	0.829	1.412
Sarcophaga	3.077	0.582	0.472	0.300	1.2968	2.791	1.515
1978							
Pollenia	0.519			0.141			
Sarcophaga	1.247			0.691			

were found in different rural *Tilio-Carpinetum* habitats (in the manor park at Radziejowice and in the village park at Młochów). In the other natural and deformed habitats the numbers of species recorded were smaller. For three habitats (natural and deformed): moist coniferous forests in the Kampinoska Forest and Białołęka Dworska and the carr at Hamernia there were recorded five common species of the genus *Pollenia* (Tables III, IV). In rural habitats there was an additional species — *P. vespillo* and in a deformed habitat — *P. atramentaria*.

The smallest number of species of the genus *Pollenia* was recorded in the carr in Białołęka Dworska (Table VI), this habitat being greatly deformed in comparison with the natural carr at Hamernia which is rich in the number of species of the genus *Pollenia*. The greatest abundance of the dipterans discussed was recorded in the carr at Hamernia and in the *Tilio-Carpinetum* forest in Białołęka Dworska. The same number of species with a similar mean abundance was recorded in the moist coniferous forests of the Kampinoska Forest and Białołęka Dworska.

Table IV. Comparison of the abundance of the dipteran species of the genera *Pollenia* and *Sarcophaga* in different habitats in the Mazovian Lowlands.

Genera	*Tilio-Carpinetum*					*Circaeo-Alnetum*		*Pino-Quercetum*		*Peucedano-Pinetum*	
	Hamernia	The village garden at Wola Mrokowska	The manor park in Młochów	The manor park in Radziejowice	Białołęka Dworska	Hamernia	Białołęka Dworska	Kampinoska Forest	Białołęka Dworska	Kampinoska Forest	Białołęka Dworska
1976											
Pollenia	0.859	1.188	0.438		0.717	1.594	0.530	0.768	0.555	0.466	0.605
Sarcophaga	0.804	1.247	0.581		1.932	1.008	0.463	0.472	0.988	0.356	1.420
1977											
Pollenia	0.436	1.989	0.616	0.352	1.325	0.459	0.087	0.826	0.455	0.569	0.375
Sarcophaga	1.511	0.582	0.472	0.300	1.227	1.566	0.288	0.967	1.308	0.330	1.483
1978											
Pollenia	0.520			0.141							
Sarcophaga	1.247			0.690							

The investigated carrs and *Tilio-Carpinetum* forests of the Mazovian Lowland, both the natural and the deformed ones, constitute most suitable habitats for the dipterans of the genus *Pollenia*. This has been confirmed by studied on hosts

of these dipterans (PILIPIUK 1981). The highest number of species of earthworms was recorded in the *Tilio-Carpinetum* forest at Hamernia and the greatest density of earthworms — 54 individuals per 1 m² — was recorded in the *Tilio-Carpinetum* forest in Białołęka Dworska (PILIPIUK 1981). The species *Allolobophora calliginosa* and *All. rosea* known as hosts of the dipterans under discussion constituted over a half of the total density of earthworms in a linden-oak hornbeam forest habitat (PILIPIUK 1981). In the carr in Białołęka Dworska, *All. calliginosa* and *All. rosea* constituted an insignificant percentage of all earthworms and in the forests of the Kampinoska Forest. *All. rosea* was the only recorded host of these dipterans (PLISKO 1969). Therefore, it can be assumed that the dipterans of the genus *Pollenia* parasitize not only the three species mentioned above but also some other earthworms.

In Warsaw, the study sites were situated in four types of urban green: parks, estate green, backyard green and isolated street-side green in the centre of the city. Six species of dipterans of the genus *Pollenia* were recorded in the urban parks, regardless of their size and situation. The highest abundance of the parasites was recorded in the parks closest to the administrative boundaries of Warsaw and it gradually decreased towards the centre of the city (the Saxon Garden) (Figs 14, 15; Tables II, VI).

Only one or two species occurred in the green of the housing estates, and two species of dipterans of the genus *Pollenia* were recorded in the green of down-town backyards (one species in each study site). The abundance of these dipterans demonstrated a tendency similar to that recorded in the parks.

In the centre of the city, in Konstytucja Square, one or two species of the genus *Pollenia* were recorded (in rainy and warm years), but the abundance of these dipterans was insignificant (Table II).

Five species of dipterans of the genus *Sarcophaga* were recorded in the Mazovian Lowlands (Table I). Four species of the genus *Sarcophaga* occurred in all the investigated natural habitats of the Mazovian Lowlands. The moist coniferous forest in the Kampinoska Forest where one specimen of *S. schultzi* had been caught was an exception. The abundance of the dipterans of the genus *Sarcophaga* varied in the habitats studied. The highest abundance was recorded in the carr and in the linden-oak-hornbeam forest at Hamernia and in the linden-oak-hornbeam forest and other types of forests in Białołęka Dworska. The lowest abundance of the dipterans of the genus *Sarcophaga* was recorded in the carr in Białołęka Dworska and in a moist coniferous forest in the Kampinoska Forest (Table VII).

In all the parks studied in Warsaw, the same four species of dipterans of the genus *Sarcophaga* were recorded but their abundance decreased towards the centre of the city (Figs 14, 15; Tables V, VI).

In the estate green, the same four species were recorded in great numbers in Wierzbno but in Stawki there were only two species (*S. lehmani* and *S. carnaria*) with very low abundances (Table II).

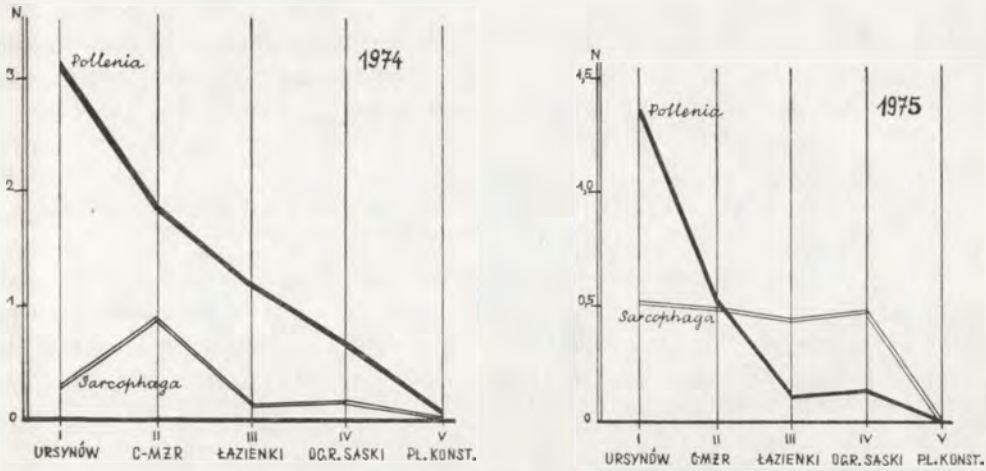


Fig. 14. Abundance of the dipterans of the genera *Pollenia* and *Sarcophaga* in the Warsaw parks and in the centre of the city in 1974 and 1975.

In the backyard green in Koszykowa Street, only two species (also found in the estate green) were recorded and their abundance was minimal and a similar abundance of the dipterans of the genus *Sarcophaga* was recorded in Wilcza Street. However, in the years 1976–1978, under weather conditions most favou-

Table V. Comparison of the abundance of the community of earthworm parasitoids of the genera *Pollenia* and *Sarcophaga* in different habitats in the Mazovian Lowlands.

Years	*Tilio-Carpinetum*					*Circaeo-Alnetum*		*Pino-Quercetum*		*Peucedano-Pinetum*	
	Hamernia	The village garden at Wola Mrokowska	The manor park in Młochów	The manor park in Radziejowice	Białołęka Dworska	Hamernia	Białołęka Dworska	Kampinoska Forest	Białołęka Dworska	Kampinoska Forest	Białołęka Dworska
1976	1.663	2.761	1.029		2.849	2.602	0.993	1.240	1.543	0.821	2.025
1977	1.946	2.570	1.088	0.653	2.552	2.026	0.375	1.793	1.763	0.899	1.858
1978				0.832							

rable to these dipterans, all four species of the genus *Sarcophaga* were caught into Moericke's traps placed in the grass.

In Konstytucja Square (the Marszałkowska Residence District) *S. carnaria* was the only species recorded and its abundance was very small (Tables II, VII).

The dipterans of the genera *Pollenia* and *Sarcophaga* demonstated a tendency to decrease the number of species and their abundance in the transect from the outskirts of the city towards its centre. Only the urban parks and the estate

green adjacent to gardens retained a number of species similar to that in rural habitats. In the centre of the city, both in the estate green and in Konstytucja Square the abundance recorded was lower than in the rural habitats or even those situated on the outskirts of the city (Figs 14, 15; Tables IV–VI).

4. THE INFLUENCE OF RAINFALL AND AIR TEMPERATURE ON THE NUMBER OF SPECIES AND THE ABUNDANCE OF DIPTERANS PARASITIZING EARTHWORMS

Soil moisture is considerably influenced by rainfall and air temperature. Adequate soil moisture is a factor particularly important in the life of earthworms. If the water content in soil drops below 30% of its volume for a longer period of time, then species of the genus *Allolobophora* pass into dormant stages (Bal-

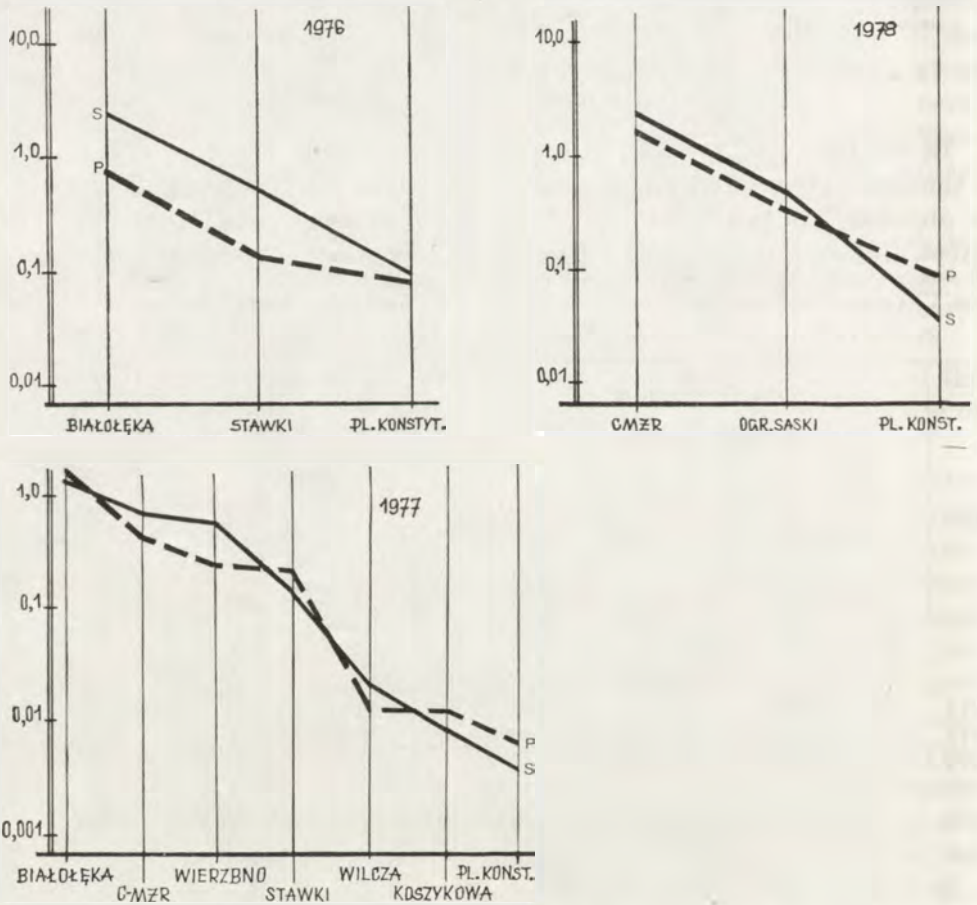


Fig. 15. Abundance of the dipterans of the genera *Pollenia* and *Sarcophaga* in different sites in Warsaw from 1976 to 1978. The continuous line indicates the abundance of the dipterans of the genus *Sarcophaga* and the broken line indicates the abundance of the dipterans of the genus *Pollenia*.

TZER 1956) and the abundance of the entire earthworm fauna decreases (ZUCK 1951). The species *All. chlorotica* is the most sensitive to soil desiccation and *All. caliginosa* tolerates drought much better (ZICI 1958a,b); both these species of earthworms are well-known hosts of the dipterans under discussion (GRUNIN 1970, LEHRER 1972).

A temperature of over 22°C and autumn ground frost in open areas are also unfavourable to earthworms. In both cases they react in a similar way – they hide deeper in the soil (TISCHLER 1971).

In Warsaw, the abundance of the dipterans of the genus *Pollenia*, specific parasites of earthworms, depends to a large extent on two abiotic factors, namely on rainfall and on air temperature (this is illustrated in Fig. 6). No similar tendency has been recorded in other parasitic dipterans within the group *Calyptrata* (Fig. 5) collected in Warsaw during a five-year period.

The dipterans of the genus *Pollenia* were most numerous in 1974, a year characterized by a higher mean annual air temperature (Fig. 7) and rainfall considerably exceeding the average (Figs 6, 7). That year followed two successive warm and wet winters (Fig. 7) and one wet autumn which is a season very important to the development of earthworms. The mild winters were favourable to the survival of the hosts and of the dipterans of the genus *Pollenia* wintering as imagines.

The lowest abundance of the dipterans studied was recorded in 1976 which was cool and dry (Fig. 7), thus particularly unfavourable to the hosts of these parasites. Moreover, in 1976 a dry spring followed a frosty winter and some authors (LARSEN 1949a) consider such a situation to be especially harmful to earthworms.

A positive change in only one abiotic factor does not influence an increase in the abundance of the dipterans of the genus *Pollenia* (Fig. 6) because in a rainy but cool year the abundance of the parasitic dipterans of the genus *Pollenia* did not increase. Such a configuration of weather conditions (rainfall and air temperature) occurred in 1978, a rainy but cool year (Fig. 6). The abundance of the dipterans of the genus *Pollenia* decreased then, when compared with 1977 which was rainy and warm (similar to 1974, but to a smaller degree) (Figs 6, 7).

Among the dipterans of the genus *Pollenia*, the greatest number of species and the highest abundance were recorded in the suburban park in Ursynów and in the urban parks in 1974, also in the suburban park in Bielany in 1977 and in the park at the Cemetery of Soviet Soldiers in 1978 (all the years were rainy).

In Warsaw, the abundance of the dipterans of the genus *Sarcophaga* did not seem to depend on abiotic factors because no graeter changes were recorded during three successive years (both in warm, dry years, in warm rainy years, and in cool rainy ones). The low abundance of the dipterans of the genus *Sarcophaga* in 1974 could have been due to the weather conditions of that warm and wet winter which were unfavourable to the suvrival of pupae of these dipterans. Only a small number of the dipterans of the genus under discussion managed

Table VI. Comparison of the abundance and the number of species of the dipterans of the genus *Pollenia* during the two-year investigations in Warsaw and in rural habitats, and the total number of species and the mean abundance. *n* — number of species, *N* — species abundance

	Hamernia				Kampinoska Forest					
	Tilio-Carpinetum		*Circaeo-Alnetum*		*Pino-Quercetum*		*Peucedano-Pinetum*			
	n	*N*	*n*	*N*	*n*	*N*	*n*	*N*		
Rural habitats of Mazovia	5	0.859	5	1.594	5	0.768	6	0.482	1976	
	6	0.436	5	0.450	6	0.826	6	0.569	1977	
	7	0.648	6	1.027	6	0.797	6	0.526	Total number of species	Mean abundance
	Białołęka Dworska									
	Tilio-Carpinetum		*Circaeo-Alnetum*		*Pino-Quercetum*		*Peucedano-Pinetum*			
	n	*N*	*n*	*N*	*n*	*N*	*n*	*N*		
Suburban habitats	3	0.717	3	0.530	3	0.555	5	0.605	1976	
	5	1.325	1	0.087	5	0.455	5	0.375	1977	
	5	1.021	3	0.309	5	0.505	6	0.490	Total number of species	Mean abundance

Urban habitats	Warsaw									
	Urban parks		Housing estate green		The centre					
					Backyard green		Konstytucja Square			
	n	*N*	*n*	*N*	*n*	*N*	*n*	*N*		
	3	0.049	1	0.212	1	0.263	1	0.080	1976	
	2	0.417	2	0.245	1	0.011	1	0.006	1977	
	3	0.233	2	0.229	2	0.137	1	0.043	Total number of species	Mean abundance

to survive the winter. These, faced with an overwhelming abundance of the dipterans of the genus *Pollenia*, were probably unable to compensate in 1974 for the losses of the previous winter and therefore they became dominated by the dipterans of the competitive genus.

It must be pointed out that an entirely opposite phenomenon was recorded in the linden-oak-hornbeam forest at Hamernia, a habitat similar to that in which Warsaw had been founded. In that rural habitat, during three successive years, the abundance of the dipterans of the genus *Sarcophaga* seemed to depend clearly on rainfall and air temperature, just the reverse of what was recorded

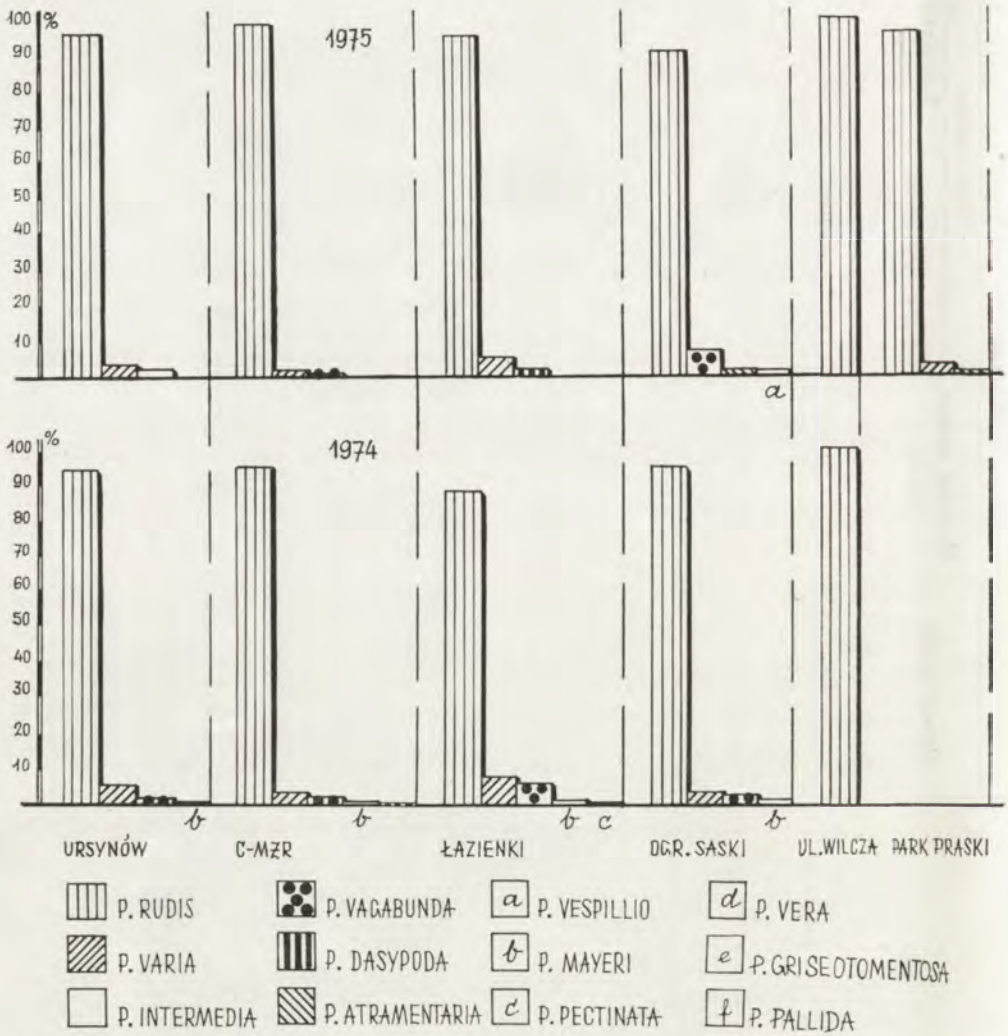


Fig. 16. Dominance structure of the dipterans of the genus *Pollenia* in particular sites in Warsaw from 1974 to 1975.

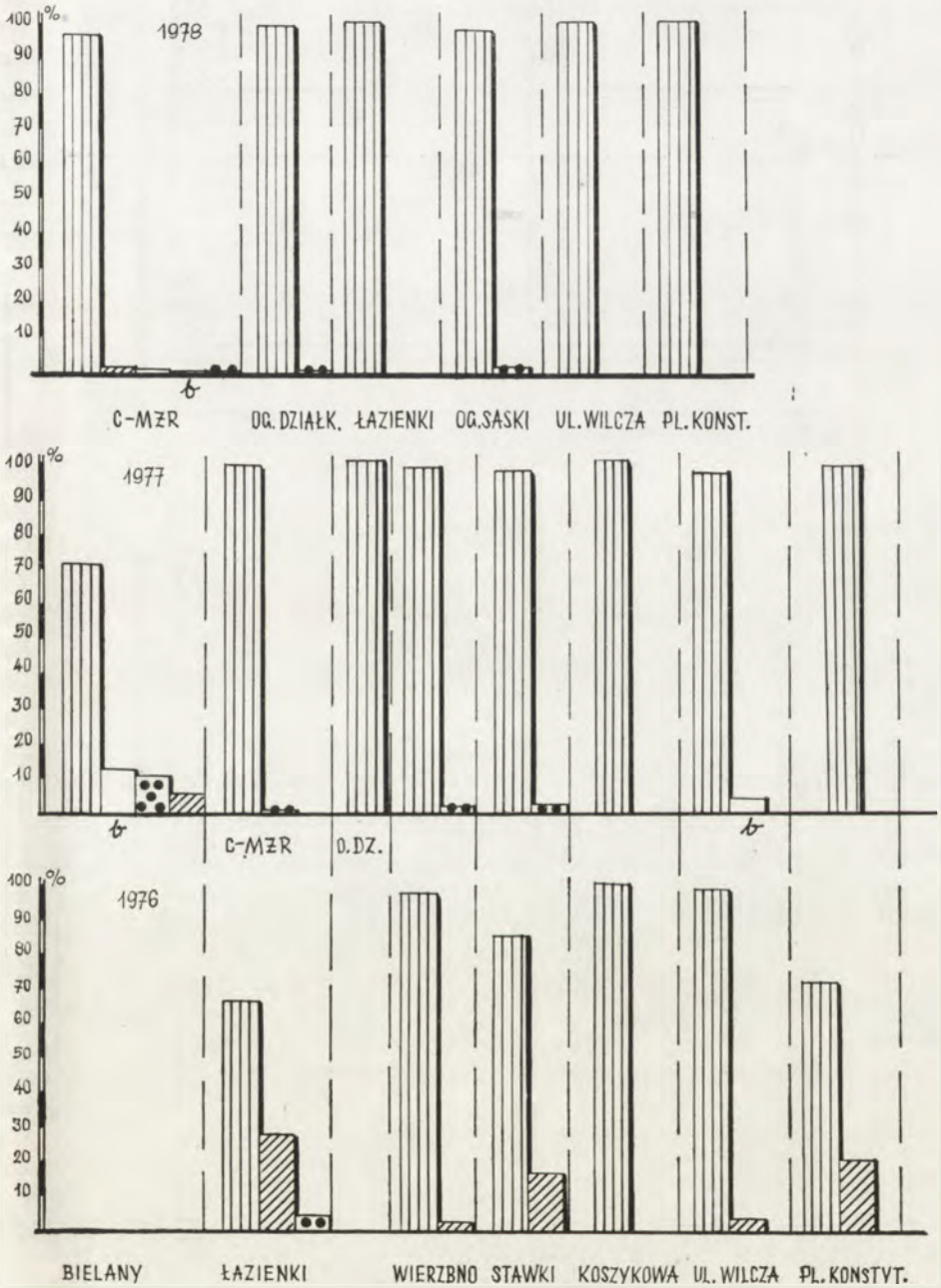


Fig. 17. Dominance structure of the dipterans of the genus *Pollenia* in particular sites in Warsaw from 1976 to 1978. The other items as in Fig. 16.

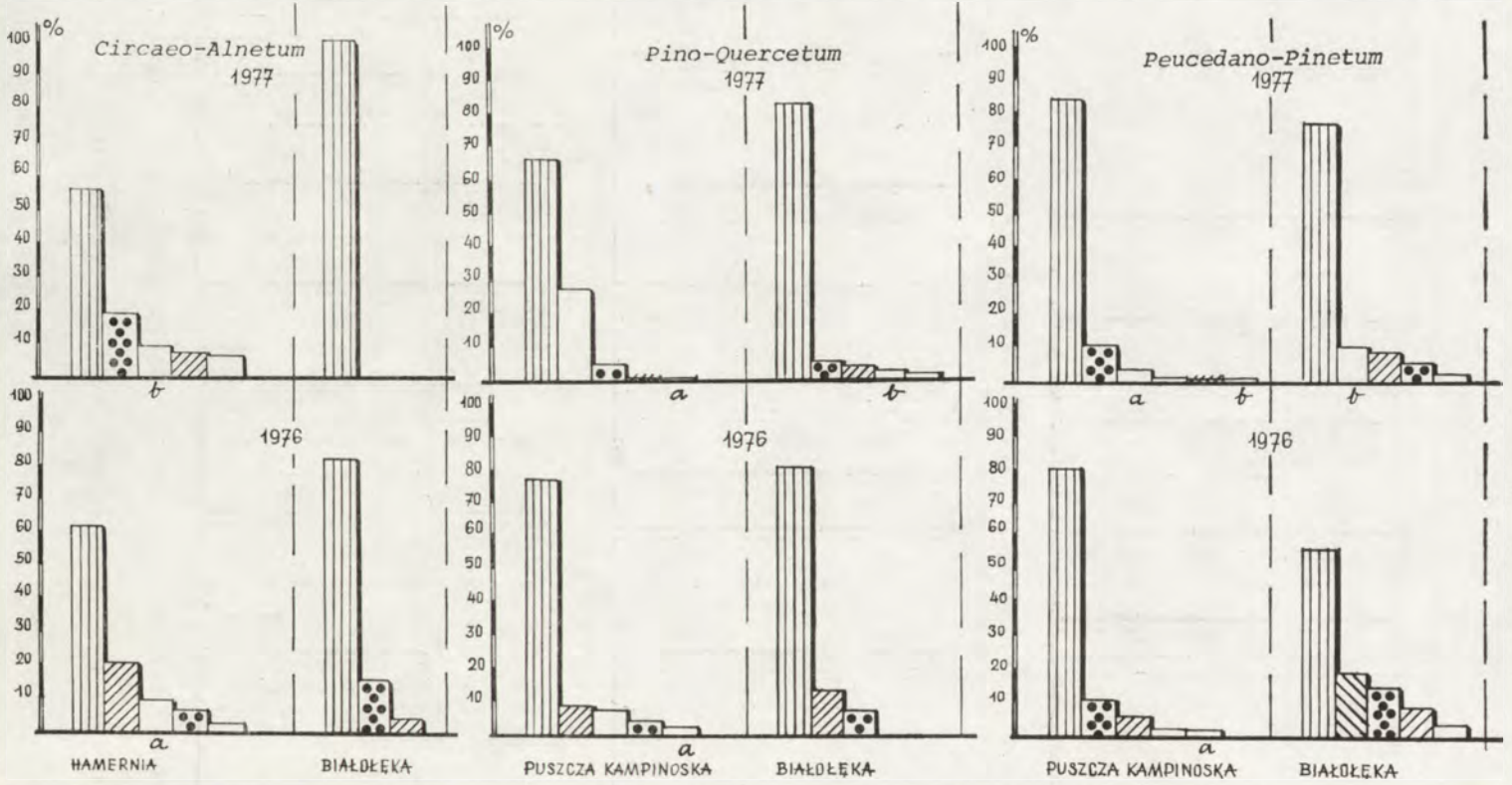


Fig. 18. Dominance structure of the dipterans of the genus *Pollenia* in three habitats in Białołęka Dworska and in respective rural habitats in the Mazovian Lowland. The other items as in Fig. 16.

in the dipterans of the genus *Pollenia* (Fig. 9). In 1976 only, there was recorded a considerable percentage share of the dipterans of both genera, but it must be pointed out that in Warsaw the year 1976 was exceptionally dry and in the vicinity of the capital the deficit of rainfall was smaller than in the city (Figs 7, 8). In the other years (Figs 8, 9), the percentage share of the dipterans of the genus *Pollenia* was, in the rural habitats, significantly lower than that of the genus *Sarcophaga*. The opinion that the dipterans of the genus *Sarcophaga* dominate in habitats under smaller anthropogenic impact has been confirmed by studies in the Pieniny Mountains and in linden-oak-hornbeam forest habitats in Mazovia (DRABER-MOŃKO 1978, 1979).

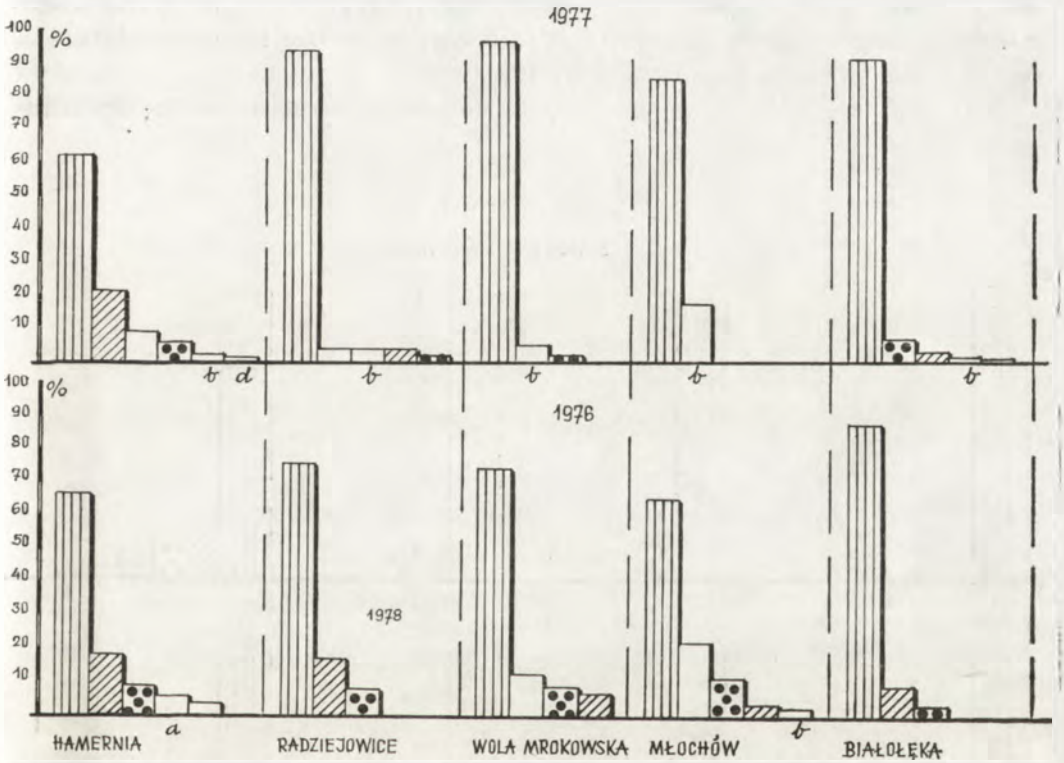


Fig. 19. Dominance structure of the dipterans of the genus *Pollenia* in the *Tilio-Carpinetum* forest in Białołęka Dworska and in the rural *Tilio-Carpinetum* habitats of the Mazovian Lowland in 1976 and 1977 (in the park at Radziejowice, the material was collected in 1977 and 1978). The other items as in Fig. 16.

5. CHANGES IN THE DOMINANCE STRUCTURE OF THE DIPTERANS OF THE GENERA *POLLENIA* AND *SARCOPHAGA* ACCORDING TO THE MEAN ANNUAL RAINFALL AND THE MEAN ANNUAL AIR TEMPERATURE

In all the investigated habitats of Poland, of the Mazovian Lowlands and the urban green of Warsaw, the same species — *Pollenia rudis* was the eudominant within the taxocene *Pollenia* (Figs 16–21). In natural habitats, the community

of the dipterans of the genus *Pollenia* did not demonstrate any significant changes in the number of species, the abundance and dominance structure in various types of habitats connected with different weather conditions in particular years (Figs 18, 19).

In the linden-oak-hornbeam forest habitats of the Mazovian Lowlands, the dominance structure of the dipterans of the genus *Pollenia* was varied but most frequently *P. varia* and *P. vagabunda* were the subdominant species.

In rural habitats (the deformed ones at Młochów and Wola Mrokowska), in the cool and dry year 1976, thus under conditions particularly unfavourable to the development of the hosts of these dipterans the dominance structure of representatives of the genus *Pollenia* was slightly reshaped. The sequence of the subdominants changed and *P. intermedia* — an accessary species in other habitats — replaced the first subdominant (Fig. 19).

In certain disturbed rural habitats, the dominance structure of the dipterans

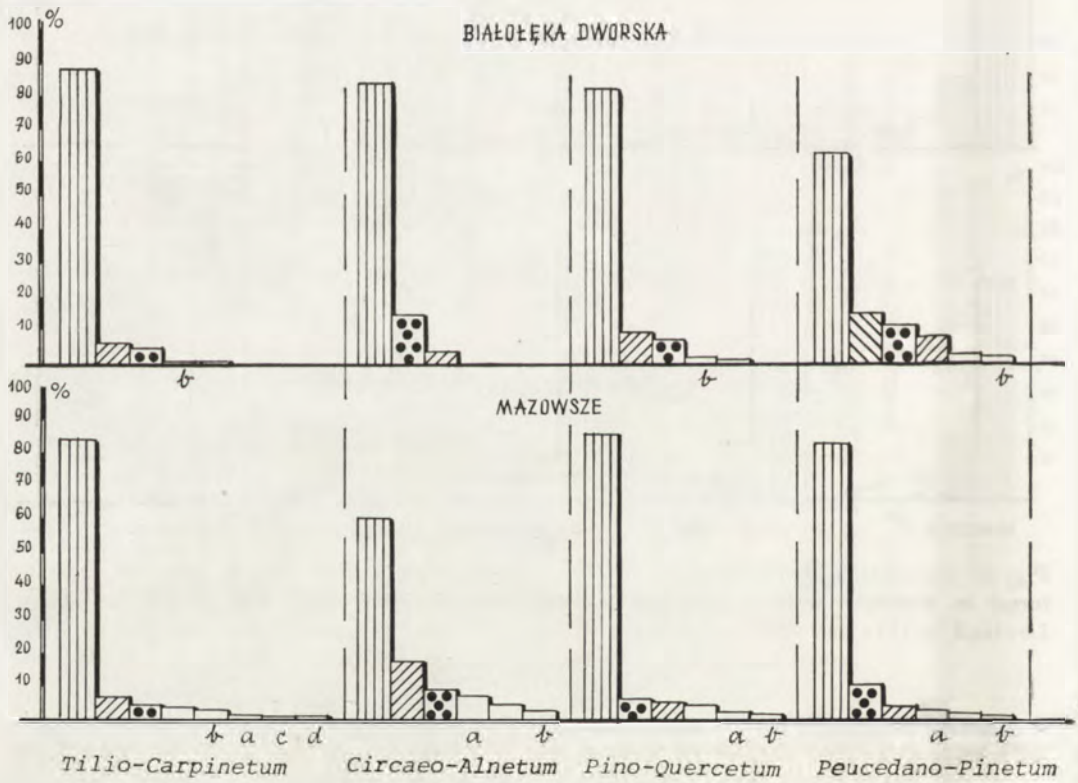


Fig. 20. Dominance structure of the dipterans of the genus *Pollenia* in the habitats of Białołęka Dworska and in respective rural habitats in the Mazovian Lowland (based on two-year means). The other items as in Fig. 16.

of the genus *Pollenia* depended to a small degree on the weather conditions in a given year.

In the *Tilio-Carpinetum* habitat in Białołęka Dworska, in the cool and dry year 1976, the dominance structure of the community of dipterans of the genus *Pollenia* was similar to the dominance structure of these dipterans in the natural habitat at Hamernia, the sequence of the subdominants was also similar in both habitats but the number of species and their percentage shares were different and the abundance of the community was slightly lower in Białołęka Dworska (Fig. 19). In the same habitat in Białołęka Dworska, in the warm and rainy year 1977, the dominance structure of the community of dipterans of the taxocene under discussion was different from that in the previous year.

In the carr in Białołęka Dworska, in the cool and dry year 1976, the number of species, their abundance and the dominance structure of the community of dipterans of the genus *Pollenia* differed distinctly when compared with the same

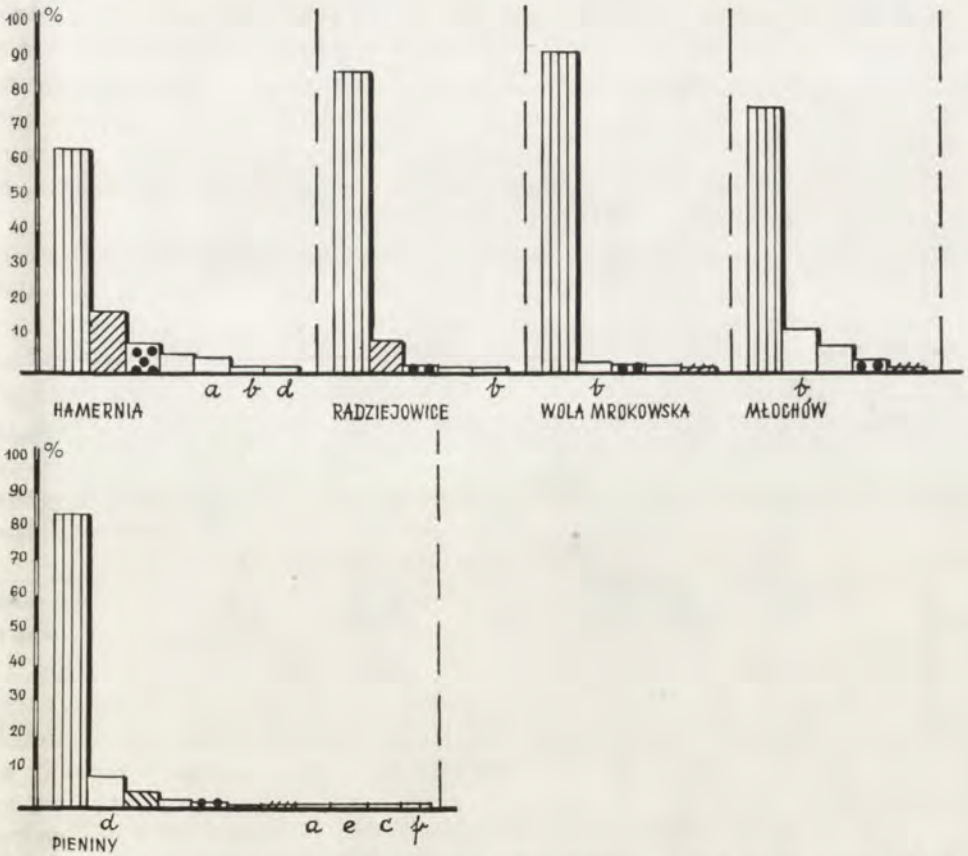


Fig. 21. Dominance structure of the dipterans of the genus *Pollenia* in various *Tilio-Carpinetum* forests in the Mazovian Lowland (based on two-year means) and in the Pieniny Mountains (all the habitats together). The other items as in Fig. 16.

for the community of these dipterans in a natural habitat (Fig. 18). In the following year, the differences were even greater because only the dominant was recorded in the deformed carr (Fig. 18).

In the coniferous forest habitats of Białołęka Dworska, in two successive years (1976 and 1977), the differences in the dominance structure of the community of dipterans of the genus *Pollenia* were smaller than in the *Tilio-Carpinetum* and carr habitats, even in comparison with the communities of respective natural habitats. These differences were mainly in the sequence of the subdominants and their percentage share. The community of dipterans of the genus *Pollenia* from coniferous forest habitats seemed to be less dependent on weather conditions (Figs 18–20).

In the *Tilio-Carpinetum* habitats of the Mazovian Lowlands, the dominance structure of the community of dipterans of the genus *Pollenia* seemed to be most similar in the natural *Tilio-Carpinetum* forest at Hamernia and in the community of these dipterans in the park at Radziejowice (data based on the mean abundances from two successive years). The structure of the community of dipterans of the genus *Pollenia* in the park at Młochów was similar to the structure of the community of these dipterans in the village garden at Wola Mrokowska (Fig. 21).

In the Pieniny Mountains, in natural habitats[1] different from those selected in Mazovia, the subdominant recorded was *P. vera*, a species whose occurrence in Mazovia was recorded in the linden-oak-hornbeam forest at Hamernia, but only occasionally and in small numbers (Fig. 21).

In the urban green of Warsaw, just as in the linden-oak-hornbeam forest habitats of Mazovia, the same species: *P. varia* and *P. vagabunda* were the subdominants during rainy years (1974, 1977 and 1978).

In the suburban park in Ursynów and in the large parks, i. e. Łazienki and that at the Cemetery Mausoleum of Soviet Soldiers the dominance structure of the taxocene under discussion was similar during several years. At least one common subdominant was recorded there and usually two or three species occurred there repeatedly during successive years (Figs 16, 17). In the small downtown park, the Saxon Garden, only one subdominant *P. vagabunda* occurred repeatedly during the three years of investigations (Figs 16, 17).

The domination structure of the dipterans of the genus *Pollenia* in the estate green (Wierzbno, Muranów) was not stabilized, a different subdominant was recorded in each of the two successive years of investigations (1976, 1977) (Fig. 17).

In the habitats under strong urban pressure (the green of down-town backyards and the isolated street-side green in Konstytucja Square), the community of dipterans of the genus *Pollenia* was practically non-existent because it was

[1] In the Pieniny Mountains the following habitats were investigated a Carpathian beech wood, a stenothermal beech wood, a stenothermal fir wood, a Carpathian alder wood, a Pieniny meadow, a meadow with *Veratrum lobelianum* and *Laserpitum latifolium*, *Dendranthemo-Seslerietum* grass, xerothermic grass, a dry pasture and a *Valeriano-Caricetum* flavae marsh (Pancer-Kotejowa, Zarzycki 1976).

represented only by the dominant species (Figs 16, 17), only exceptionally in 1976 and 1977, in the down-town backyard in Wilcza Street, more than one species occurred but it was each year a different one.

As the above analysis shows, the dominance structure of dipterans of the genus *Pollenia* in the habitats under considerable anthropogenic pressure was not stabilized, and the more a habitat had been deformed the greater is the dependence of the domination structure upon weather conditions. In the urban green

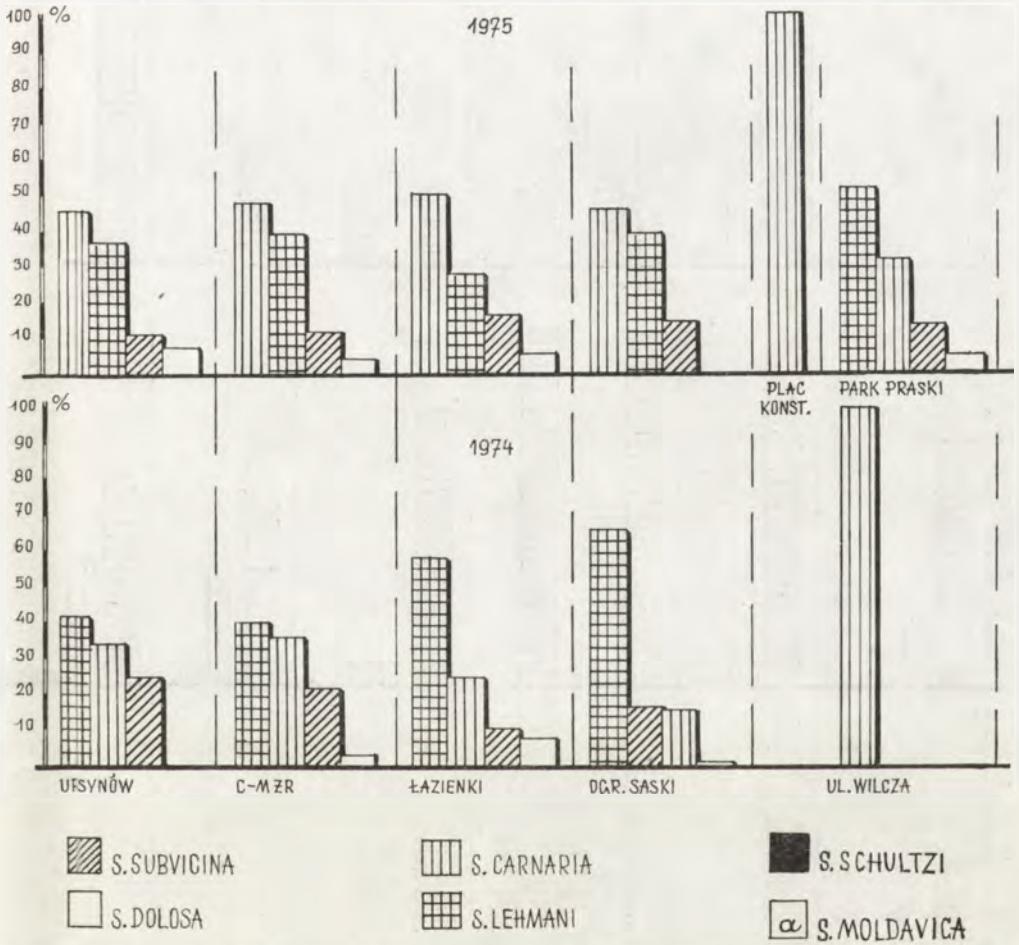


Fig. 22. Dominance structure of the dipterans of the genus *Sarcophaga* in particular sites in Warsaw in 1974 and 1975.

of Warsaw, the dominance structure, the number of species and their abundance within the taxocene *Pollenia* were varied and clearly dependent on the abiotic factors in particular years (Figs 16, 17). Moreover, the stability of the dominance structure of the taxocene under discussion depended on the size of the area studied.

Within the taxocene *Sarcophaga*, the species *Sarcophaga carnaria* dominated in all the natural habitats (Fig. 24). The same species was also the dominant in most of the study sites in rural (deformed) habitats.

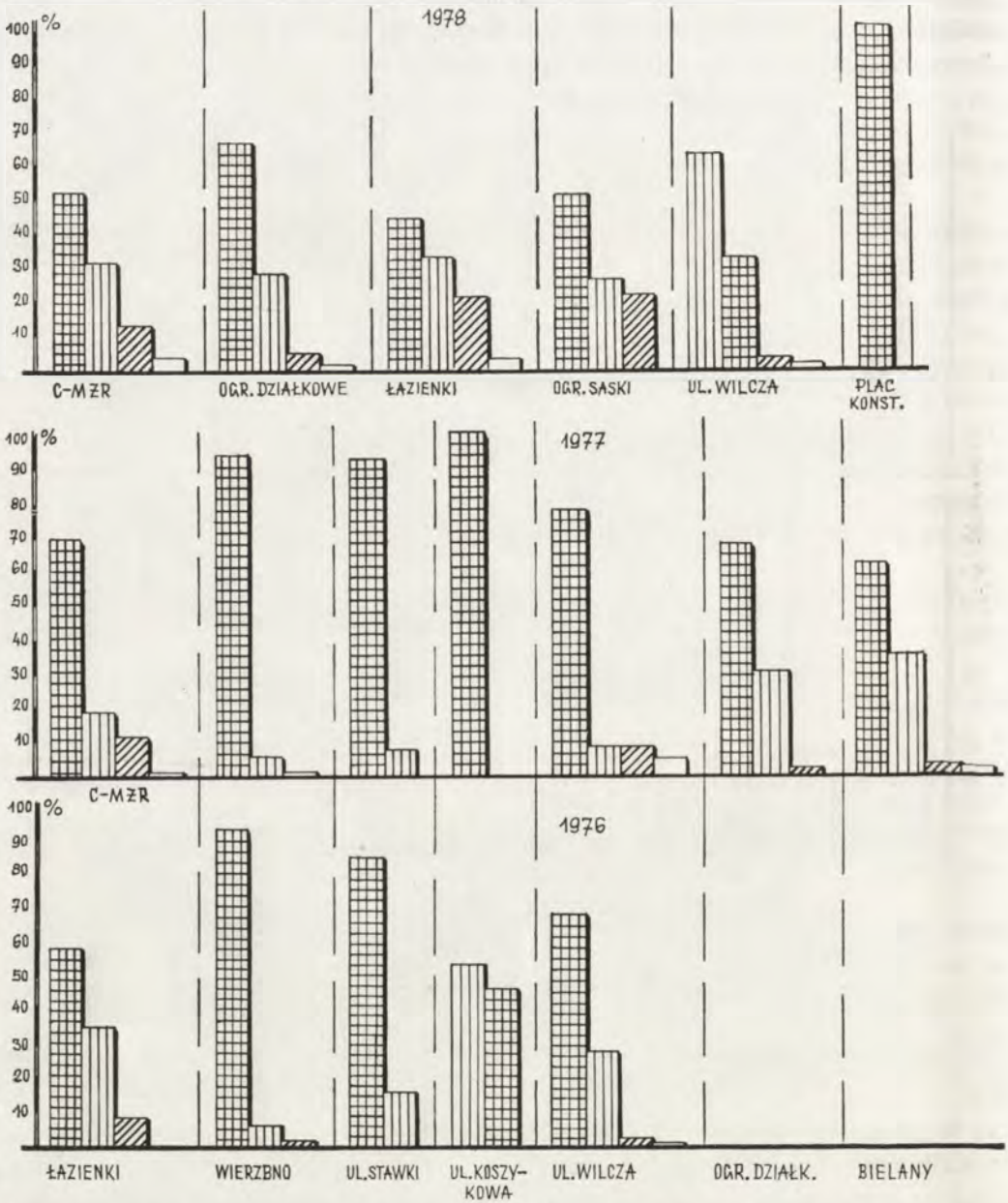


Fig. 23. Dominance structure of the dipterans of the genus *Sarcophaga* in particular sites in Warsaw from 1976 to 1978. The other items as in Fig. 22.

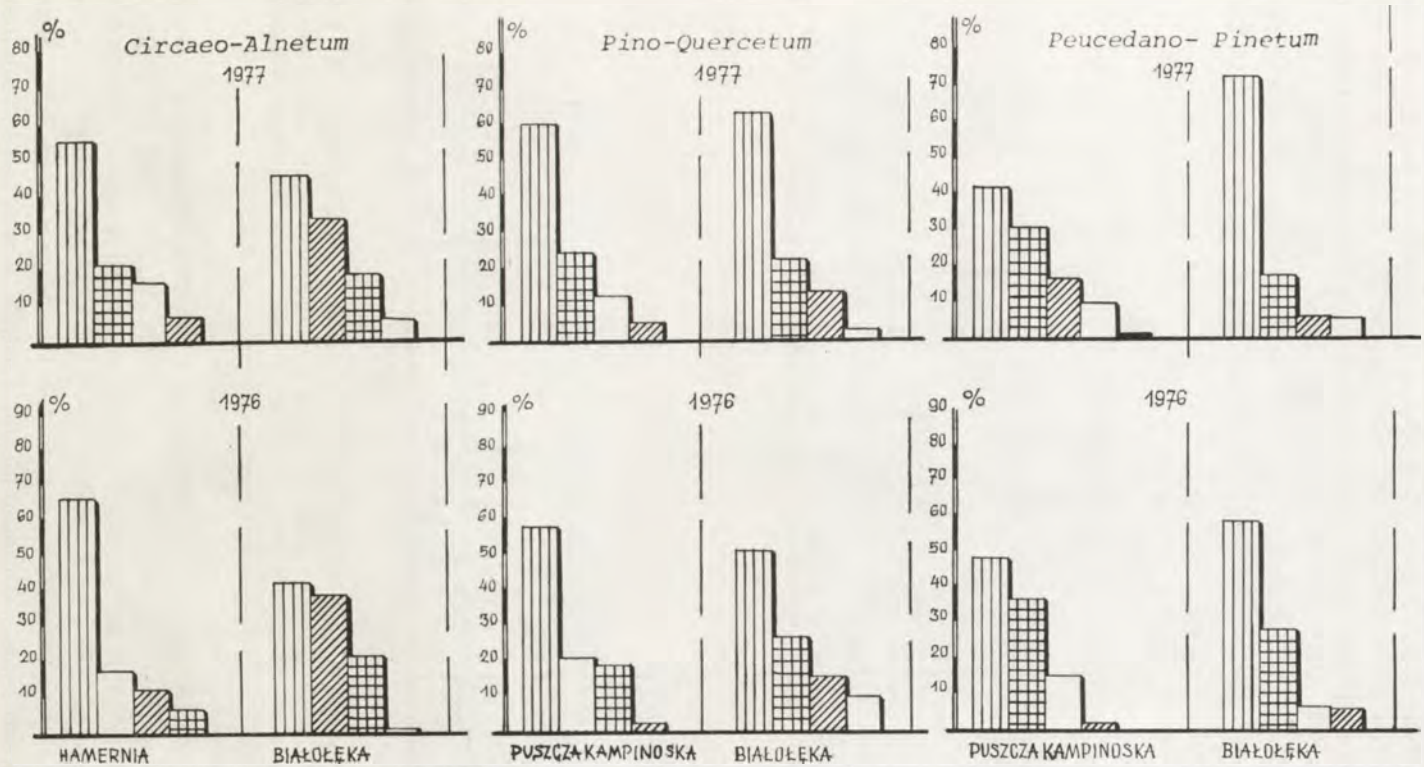


Fig. 24. Dominance structure of the dipterans of the genus *Sarcophaga* in three habitats of Białołęka Dworska and in the respective rural habitats of the Mazovian Lowland in 1976 and 1977. The other items as in Fig. 22.

In the natural habitats, the community of dipterans of the genus *Sarcophaga* demonstrated no greater changes in the number of species, the abundance and dominance structure in various types of habitats which would be connected with different weather conditions in particular years (Figs 24, 25).

In the linden-oak-hornbeam forest the habitats of the Mazovian Lowlands, the dominance structure of dipterans of the genus *Sarcophaga* was varied but

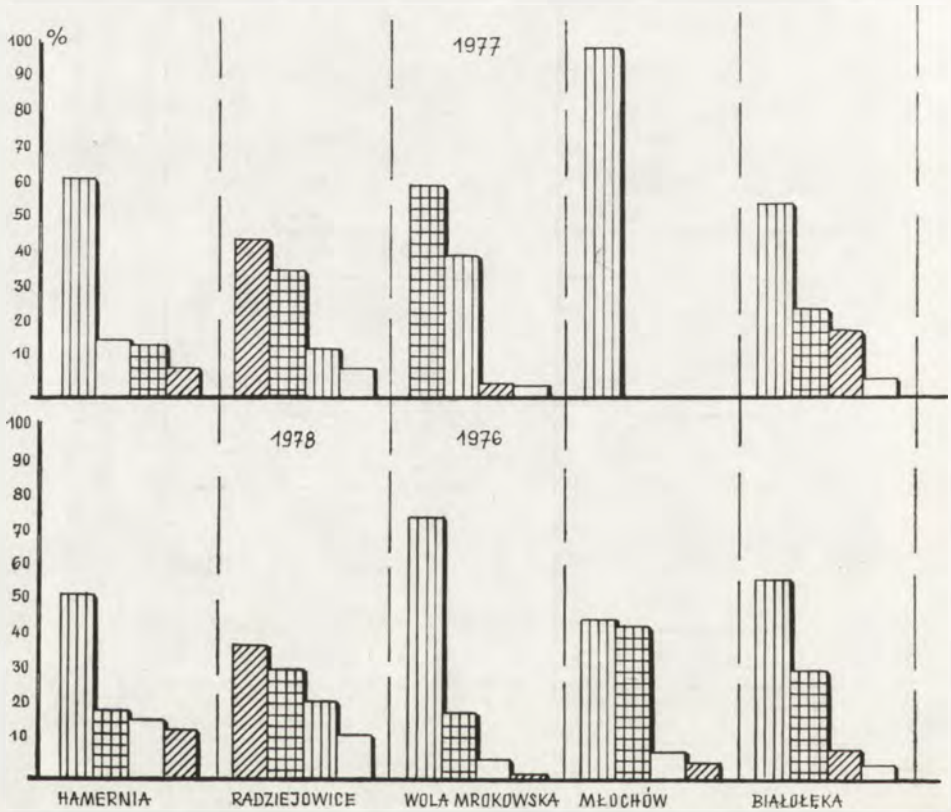


Fig. 25. Dominance structure of the dipterans of the genus *Sarcophaga* in the *Tilio-Carpinetum* forest in Białołęka Dworska and the rural *Tilio-Carpinetum* habitats in the Mazovian Lowlands in 1976 and 1977 (in the park at Radziejowice, the material was collected in 1977 and 1978). The other items as in Fig. 22.

most frequently the species *S. lehmani* was the subdominant. *S. carnaria* was the dominant in the majority of the study sites (Fig. 25). Only in the park at Radziejowice, the dominant recorded during two years of investigations (1977 and 1978) was *S. subvicina* — an accessary species or the second subdominant in other rural deformed habitats. Moreover, in the village garden at Wola Mrokowska in 1977, *S. lehmani* was the dominant and *S. carnaria* was the subdominant, thus entirely reverse to the situation in the same study area in the previous year

(Fig. 25). In the same year, in the village park at Młochów only the dominant *S. carnaria* was recorded.

In the communities of dipterans of the genus *Sarcophaga* of the suburban deformed habitats in Białołęka Dworska, unlike the above taxocene, there was not recorded any dependence between the number of species, their abundance and dominance structure in various habitats and the weather conditions prevai-

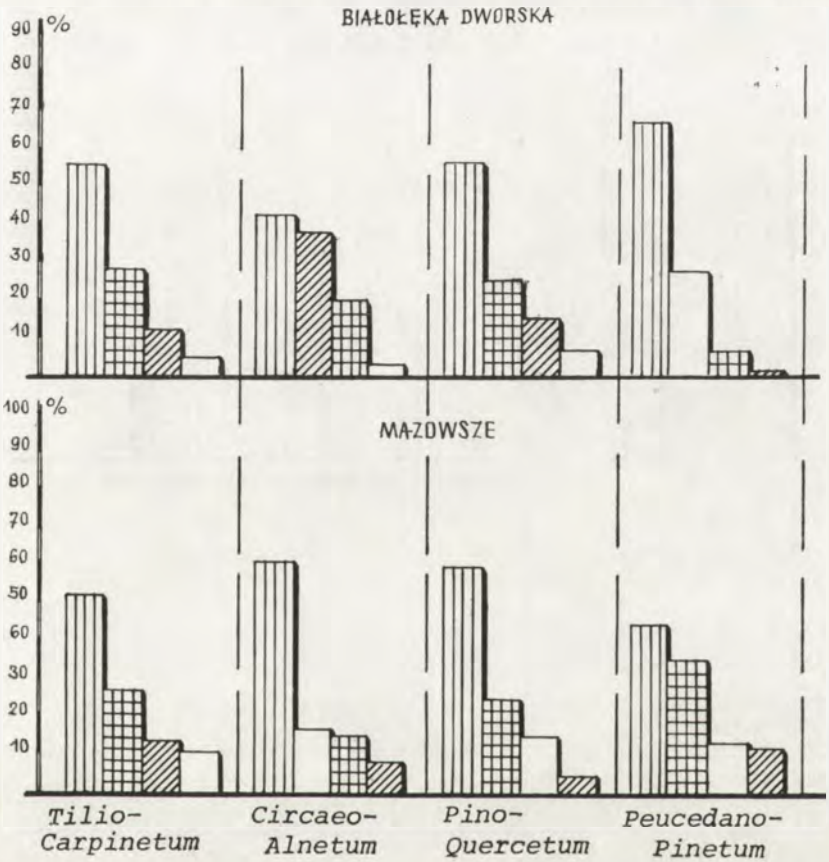


Fig. 26. Dominance structure of the dipterans of the genus *Sarcophaga* in the habitats of Białołęka Dworska and in the respective rural habitats of the Mazovian Lowlands (based on two-year means). The other items as in Fig. 22.

ling in a given year. On the other hand, in the communities of dipterans within the taxocene *Sarcophaga* MEIG. of the suburban deformed habitats as compared to those of the natural habitats there were recorded changes in the percentage shares of certain species which meants a restructuring of the dominance structure.

In the *Tilio-Carpinetum* habitat in Białołęka Dworska, in the cool and dry year 1976, the dominance structure of the dipterans of the genus *Sarcophaga* was similar to the dominance structure of these dipterans in the natural habitat

at Hamernia, the sequence of the first subdominants the same, but the sequence of the second and third subdominants was different due to a change in their percentage shares (Fig. 24). Similar changes were recorded in the sequence of the subdominants in the same habitat in the warm and rainy year 1977, but in a deformed habitat the percentage share of the dominant species was different, i. e. higher (Fig. 24).

In the carr habitat in Białołęka Dworska, in the cool and very dry year 1976 and also in the warm and rainy year 1977, the dominance structure of the community of dipterans of the genus *Sarcophaga* was stabilized. However, in com-

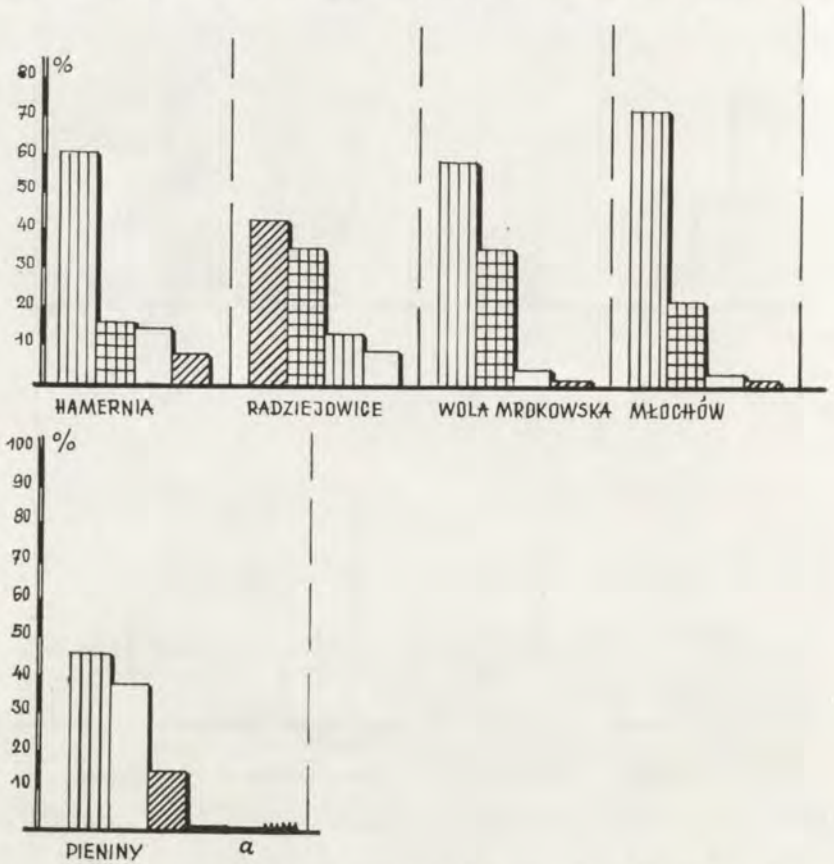


Fig. 27. Dominance structure of the dipterans of the genus *Sarcophaga* in various *Tilio-Carpinetum* forest in the Mazovian Lowland (based on two-year data) and in the Pieniny Mountains (all the habitats together). The other items as in Fig. 22.

parison with the community of these dipterans in a natural habitat, the dominance structure was different because in the natural habitat the sequence of the subdominants was different in successive years, and the percentage shares of particular species were different, too (Fig. 24).

In the mixed coniferous forest habitat in Białołęka Dworska during two successive years (1976 and 1977), the dominance structure of the communities

of dipterans of the genus *Sarcophaga* compared with the community of these dipterans in a respective natural habitat demonstrated differences of a character similar to the character of differences recorded in carr and linden-oak-hornbeam forest habitats. These differences were mainly in the sequence of the subdominants and their percentage shares. The community of dipterans of the genus *Sarcophaga* in the moist coniferous forest habitat in Białołęka Dworska was compared with the community of these dipterans in a respective natural habitat and the differences were not as significant as those found in a comparison between the communities of these dipterans in a mixed coniferous forest.

Unlike the communities of the above habitats, in a moist coniferous forest habitat the community of dipterans of the genus *Sarcophaga* seemed less dependent on the influence of weather conditions and the dominance structure of these communities seemed to be more stabilized.

The dominance structure of the community of dipterans of the genus *Sarcophaga* in two linden-oak-hornbeam forest habitats in the Mazovian Lowland (Wola Mrokowska and Młochów) was very similar to that of the community of these dipterans in the natural linden-oak-hornbeam forest at Hamernia (data based on the mean abundances from two successive years) (Fig. 27). The dominance structure of the community of dipterans of the genus *Sarcophaga* in the park at Radziejowice differed distinctly from the dominance structure in the other *Tilio-Carpinetum* habitats investigated (Fig. 27).

In the Pieniny Mountains in habitats different from those selected in the Mazovian Lowland, the species *S. carnaria* was the dominant and *S. dolosa* and *S. subvicina* were the subdominants, the other three species of the genus *Sarcophaga* were recorded in minimum numbers (Fig. 27).

In the urban green of Warsaw, the dominance structure, the number of species and their abundance in the taxocene *Sarcophaga* varied and seemed, just like the same within the taxocene *Pollenia*, to be dependent on the weather conditions in a given year (Figs 22, 23).

In the warm and dry year 1975, in most of the areas studied in the urban green of Warsaw, the species *S. carnaria* was the dominant and *S. lehmani* was the subdominant. The community of dipterans of the genus under discussion in the Praski Park was an exception (Fig. 22). During the remaining four years of the studies similar weather conditions did not occur again (Fig. 7). During those years, the dominance structure of the dipterans under discussion in the urban green of Warsaw was different, too (Figs 22, 23), namely the species *S. lehmani* dominated in the majority of the areas and *S. carnaria* was usually the subdominant there.

In the old and big urban park Łazienki, the dominance structure of the dipterans of the genus *Sarcophaga* was similar in 1974, 1976 and 1978. A similar dominance structure of the species of the same genus was recorded in the community of dipterans of the genus *Sarcophaga* in the park at the Cemetery Mausoleum of Soviet Soldiers in 1974, 1977 and 1978, in the community of these dipte-

rans in the Praski Park in 1975, in the suburban forest in Bielany in 1977, in the communities of flesh-flies in the allotment gardens in 1978, and in the community *Sarcophagidae* of the down-town backyard in Wilcza Street from 1976–1978.

It the small down-town park, the Saxon Garden, the species composition of the community of *Sarcophagidae* did not demonstrate any significant changes during three years of the studies, but the dominance structure of the species was different each year (Figs 22, 23).

In the estate green there was fairly stable dominance structure of the community *Sarcophagidae*. During the years 1976 and 1977 there were recorded no greater changes in the species composition, two common dominant species and the third accessory species recorded on the estate Wierzbno were different each year.

In the habitat under strong urban pressure, namely in the isolated street-side green, only one species was recorded and each year it was a different one.

It follows from the above analysis that in certain study sites in the urban green of Warsaw the dominance structure of the dipterans of the genus *Sarcophaga* was stabilized.

S. carnaria was the most common species of the genus *Sarcophaga* and it dominated in the majority of non-urban sites (Figs 24–27). The park at Radziejowice was an exception because the dominant recorded there was *S. subvicina* — an accessory species or the second subdominant in the other natural habitats. In the carr in Białołęka Dworska, this species was the subdominant in two successive years (1976 and 1977) and the second subdominant in Łazienki and the Saxon Garden in 1978 (Fig. 23). It seems very probable that a humid habitat and a relatively low temperature is preferred by this species. Such conditions were recorded in Warsaw in 1978 and in Białołęka Dworska in two previous years (Fig. 24). In the Pieniny Mountains, the species was very abundant on areas without trees and it was most numerous in a meadow with *Veratrum lobelianum* and *Laserpitium latifolium* at the foot of Trzy Korony Mountain (Draber-Mońko 1978). In the natural habitats of the Mazovian Lowland, the subdominant recorded was usually *S. lehmani*, but sometimes *S. dolosa* equalled or exceeded it in abundance. This was particularly the case in the carr and the linden-oak-hornbeam forest at Hamernia or in the coniferous forest habitats in the Kampinoska Forest.

In Warsaw, in the parks, in the estate green and the centre of the city, *S. lehmani* was the dominant (Figs 22, 23). Only exceptionally in 1975, *S. carnaria* — the dominant species in the natural habitats of Mazovia, was also the most abundant in the urban green of Warsaw. The species dominated in the centre of the capital, in the estate green and in the urban parks, except the Praski Park which retained the dominance structure recorded in the parks during four years (Fig. 22). In some years (1974, 1975), *S. carnaria* sometimes dominated in the centre of Warsaw in habitats that had been distinctly deformed (Figs 22, 23). The fauna of the city centre is probably to a large extent carried with the winds

from the surrounding areas, occasionally even over great distances. This assumption does not refer only to the dipterans of the two genera under discussion, but it is based on studied on several families of dipterans.

S. lehmani is probably a species succeeding most frequently in a competition with the species *S. carnaria* under urban conditions. Some authors (VERVES 1973) consider *S. lehmani* to be a steppe species and as such it would find suitable conditions for the development in over-dried urban habitats.

6. INTERRELATIONS BETWEEN THE ABUNDANCE OF OBLIGATORY PARASITOIDS OF EARTHWORMS OF THE GENUS *POLLENIA* AND THE DENSITY OF THEIR HOSTS

The density of earthworms expressed in the number of individuals per 1 m^2, probably connected with soil fertility and soil reaction, was different in particular study sites.

The only available data from natural habitats are those on the density of hosts of the dipterans under discussion recorded in the *Tilio-Carpinetum* forest in the Jaktorowska Forest. A relatively low density of earthworms — 28 individuals per 1 m^2 — was recorded in that habitat. The relative abundance index for the dipterans of the genus *Pollenia* was insignificant, too (Table IV).

In the suburban disturbed habitats of Białołęka Dworska, the the highest density of earthworms was recorded in the *Tilio-Carpinetum* forest and the lowest in a pine forest. The situation was probably due to a difference in the food supply in both habitats. A poor supply of food in the form of litter decomposing with difficulty and the acid reaction of the soil in coniferous forests influences the abundance of earthworms unfavourably (GÓRNY 1975). The linden-oak-hornbeam forest in Białołęka Dworska is situated on brown soil with a fairly high pH of about 6. *All. caliginosa* and *All. rosea* belong to the group of species living at the deeper layers of soil and preferring a soil reaction close to neutral (PILIPIUK 1981). In the podsolized soil of a pine forest, in the lower layers of the soil pH is about 5 and probably this makes possible the occurrence of *All. caliginosa*, a species that does not tolerate an acid habitat with pH below 5 (EDWARDS, LOFTY 1972). In both of the above mentioned habitats, *All. caliginosa* dominated in the *Tilio-Carpinetum* and pine forests while in the carr *Dendrobena octaedra* was the dominant and *All. caliginosa* was the accessory species[1]. Maybe that is why in the carr habitat the abundance of the parasitoids of the genus *Pollenia* was low, too.

In three suburban deformed habitats in Białołęka Dworska, the relative abundiance index for the dipterans of the genus *Pollenia* was correlated with the densty of earthworms (Fig. 29).

[1] The data on the abundance of earthworms in Białołęka Dworska have been obtained from PILIPIUK (1981) and those from Warsaw from K. JOPKIEWICZ (Unpublished data).

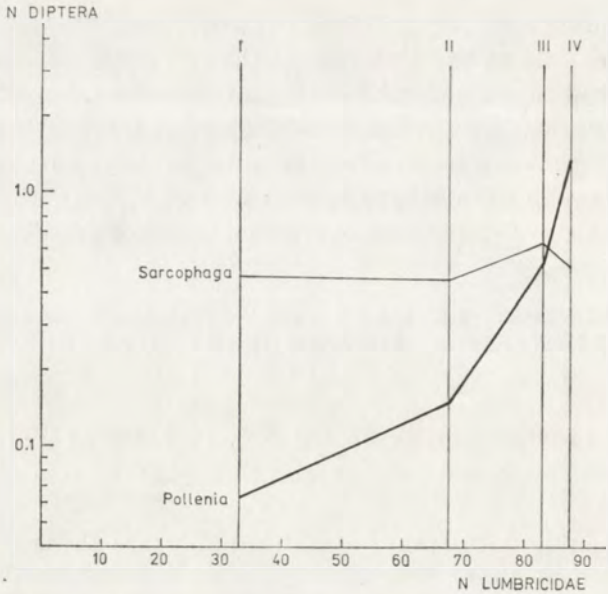


Fig. 28. Abundance of the dipterans of the genera *Pollenia* and *Sarcophaga* and the density of earthworms in Warsaw in 1975. I — The Saxon Garden, II — Łazienki, III — The Cemetery-Mausoleum of Soviet Soldiers, IV — The park in Ursynów.

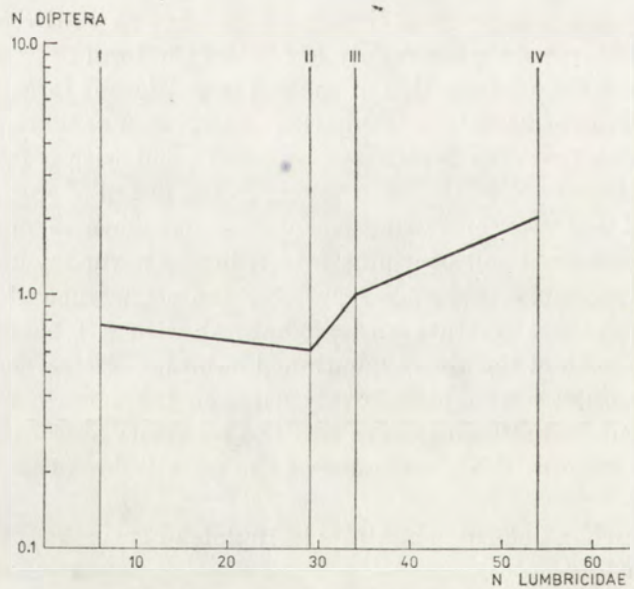


Fig. 29. Mean abundance of the dipterans collected from 1976 to 1977 in different habitats of Białołęka Dworska and the mean density of the earthworms collected at the same time and in the same habitats. I — *Peucedano-Pinetum*, II — *Circaeo-Alnetum*, III — *Pino-Quercetum*, IV — *Tilio-Carpinetum*.

In a deformed suburban *Tilio-Carpinetum* habitat, both the density of the hosts and the relative abundance index for their parasitoids were twice as high as those in a natural habitat.

In the urban green of Warsaw in 1975, a correlation between the density of parasitoids and the abundance of their hosts was also recorded (Fig. 28).

On the basis of the above data it can be assumed that in some of the deformed habitats studied and in the urban green of Warsaw, under particular weather conditions, there occurs a dependence between the density of hosts and the abundance of their parasitoids.

7. DIPTERANS OF THE GENERA *POLLENIA* AND *SARCOPHAGA* AS A COMPETITIVE COMMUNITY

It seems that the dipterans under discussion can be considered a competitive community because they constitute a group of species occupying a similar niche in the biocoenosis. In the larval stage they utilize the same food substrata (earthworms) and they have similar enemies (predatory hymenopterans of the family *Sphecidae* among others) (Skibińska 1981).

At the same time, the species included into the composition of this community differ in their position in the systematics (they are included into two different families of dipterans), in the extent of their tolerance of various factors influencing their habitats (i. e. rainfall and air temperature), in the morphophysiological characteristics and the type of reproduction (oviparity in the dipterans of the genus *Pollenia* and viviparity in the representatives of the genus *Sarcophaga*), and in the types of feeding in their larvae — polyphagy in larvae of the dipterans of the genus *Sarcophaga* (facultative parasites of earthworms and saprophages) and oligophagy in larvae of the dipterans of the genus *Pollenia* (obligatory parasites of earthworms).

The number of species parasitizing earthworms differed considerably from the theoretical value[1] (which for the Mazovian Lowland is 16 species) and it is much lower. The number of species included into the composition of the community of parasitoids of earthworms was much bigger in the national parks (Figs 21, 27; Tables VI, VII) and in non-urban areas (Figs 18–21) than in the urban green of Warsaw (Figs 16, 17, 22, 23; Tables V–VII). In extreme cases, some communities were reduced to one or two species. In the urban green in Konstytucja Square, only *Pollenia rudis* and *Sarcophaga carnaria* were left of the community of the dipterans parasitizing earthworms (Figs 22, 23; Tables VI, VII).

In the non-urbanised areas of the Mazovian Lowlands, in natural habitats, the number of dipteran species forming the competitive community of parasitoids of earthworms was constant — 9 species — and it did not depend on wea-

[1] The number of species recorded so far in a given area.

Table VII. Comparison of the abundance and the number of species of the dipterans of the genus *Sarcophaga* during the two-year investigations in Warsaw and in rural habitats, and the total number of species and the maen abundance. *n* — number of species, *N* — abundance

	Hamernia				Kampinoska Forest					
	Tilio-Carpinetum		*Circaeo-Alnetum*		*Pino-Quercetum*		*Peucedano-Pinetum*			
	n	*N*	*n*	*N*	*n*	*N*	*n*	*N*		
Rural habitats of Mazovia	4	0.804	4	1.014	4	0.491	4	0.355	1976	
	4	1.511	4	1.566	4	0.966	5	0.330	1977	
	4	1.157	4	1.290	4	0.729	5	0.343	Total number of species	Mean abundance
	Białołęka Dworska									
	Tilio-Carpinetum		*Circaeo-Alnetum*		*Pino-Quercetum*		*Peucedano-Pinetum*			
	n	*N*	*n*	*N*	*n*	*N*	*n*	*N*		
Suburban habitats	4	1.932	4	0.463	4	0.988	4	1.420	1976	
	4	1.227	4	0.288	4	1.291	4	1.483	1977	
	4	1.580	4	0.375	4	1.139	4	1.452	Total number of species	Mean abundance

Urban habitats	Warsaw									
	Urban parks		Housing estate green		The centre					
					Backyard green		Konstytucja Square			
	n	*N*	*n*	*N*	*n*	*N*	*n*	*N*		
	3	0.400	3	2.450	2	0.244	1	0.097	1976	
	4	0.653	3	0.375	1	0.017	1	0.003	1977	
	4	0.526	3	1.413	2	0.131	1	0.050	Total number of species	Mean abundance

ther conditions (air temperature and rainfall) whereas in rural deformed habitats, the number of species in this community was smaller and depending on the air temperature and rainfall of a given year.

Competitive phenomena are a universal factor operating within communities. They result from the relationships between species and from the fact that their antagonistic interests coincide. These relationships determine the occurrence of phenomena regulating the abundance within a community by establishing dependences and proportions between species. The ability to maintain a stable level of abundance of a particular trophic element in a given habitat is one of the characteristic features of a competitive community. The total abundance of a community is usually unaltered (Trojan 1980). This phenomenon could easily be observed while studying the abundance of the community of the dipterans

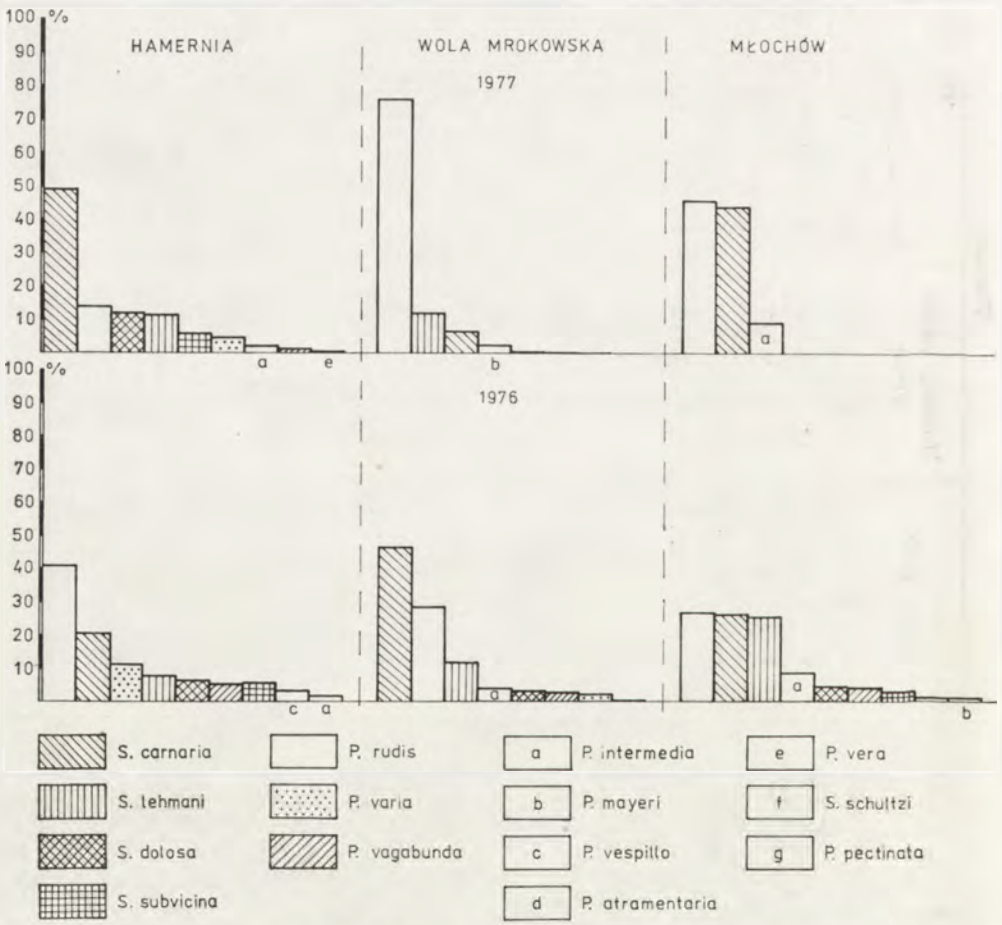


Fig. 30. Dominance structure of the competitive community of the dipterans of the genera *Pollenia* and *Sarcophaga*, parasitizing earthworms, in the *Tilio-Carpinetum* habitats of the Mazovian Lowland in 1976 and 1977.

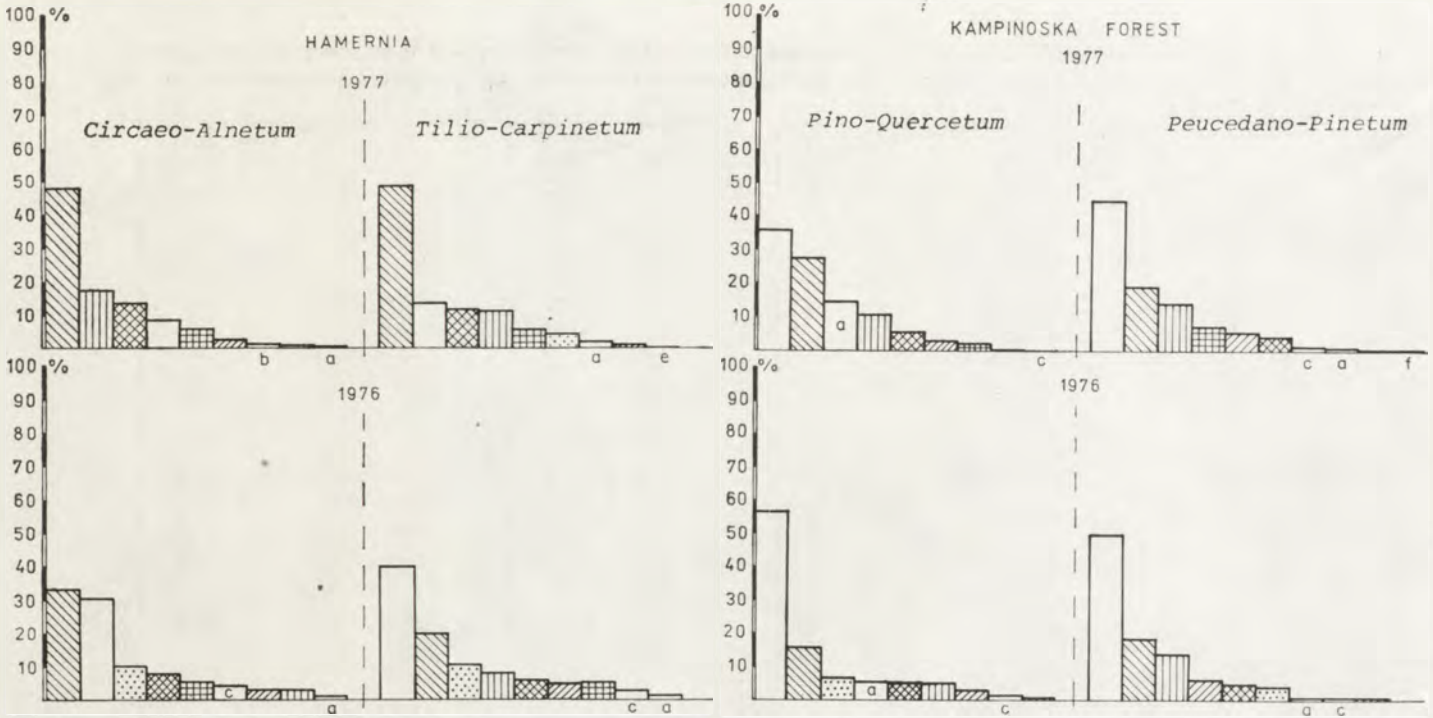


Fig. 31. Dominance structure of the competitive community of the dipterans of the genera *Pollenia* and *Sarcophaga* parasitizing earthworms, in non-urban (natural) habitats in the Kampinoska Forest (mixed coniferous forest and moist coniferous forest) and in (the Jaktorowska Forest) Hamernia (*Tilio-Carpinetum* forest and carr) in 1976 and 1977. The other items as in Fig. 30.

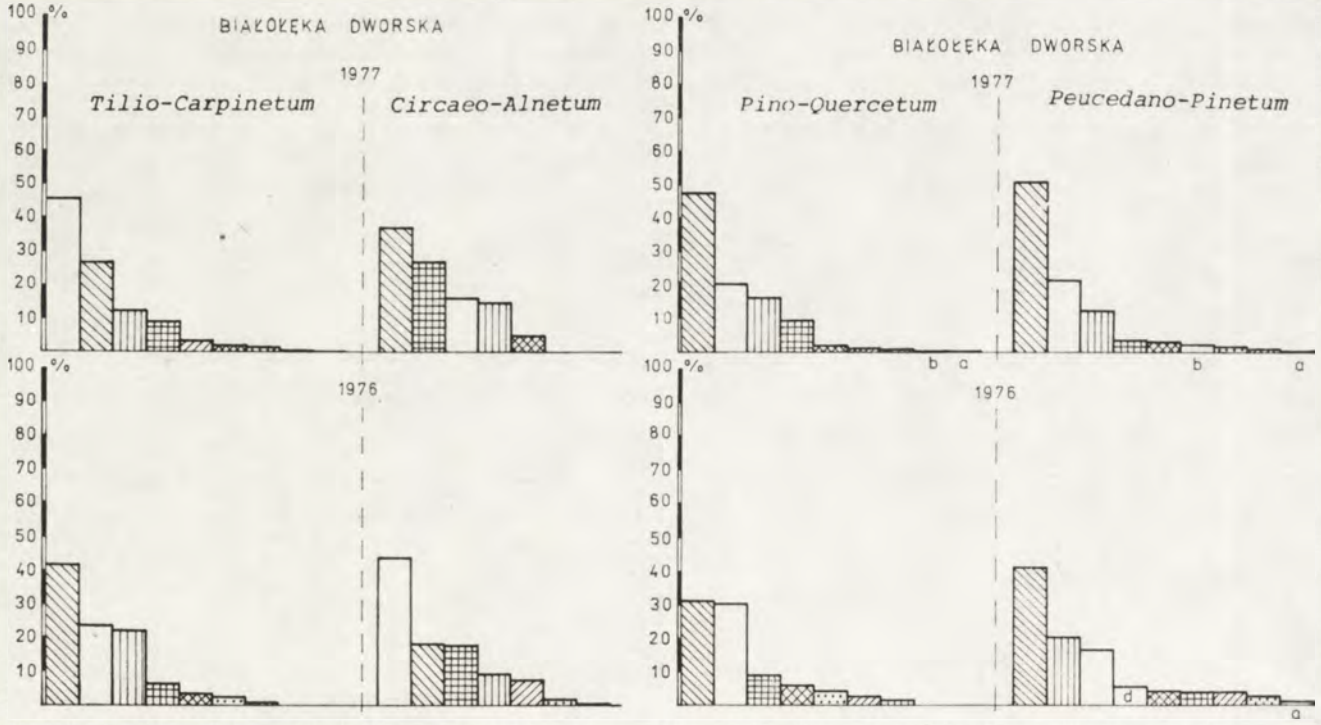


Fig. 32. Dominance structure of the competitive community of the dipterans of the genera *Pollenia* and *Sarcophaga* parasitizing earthworms in the habitats of Białołęka Dworska in 1976 and 1977. The other items as in Fig. 30.

parasitizing earthworms in the Kampinoska Forest national park and in the non-urbanised and suburban areas of the Mazovian Lowland from 1976 to 1978 (Table V). In the urban green of Warsaw, this phenomenon was not so obvious (Table II). The abundance of dipterans included into the composition of a competitive community of urban habitats depends largely on the weather conditions in a given year (Fig. 7).

The quantitative structure of a community of dipterans parasitizing earthworms depends on changes taking place in the habitat with regard to the thermal conditions of the habitat and to the soil moisture connected with cloudiness and rainfall. Most probably, changes in these two abiotic factors result in a reaction within the competitive community which consists in rebuilding the quantitative proportions (Figs 16–27). The dominant species pass to the group of subdominants or accessory species and vice versa. Transfers in the structure of the com-

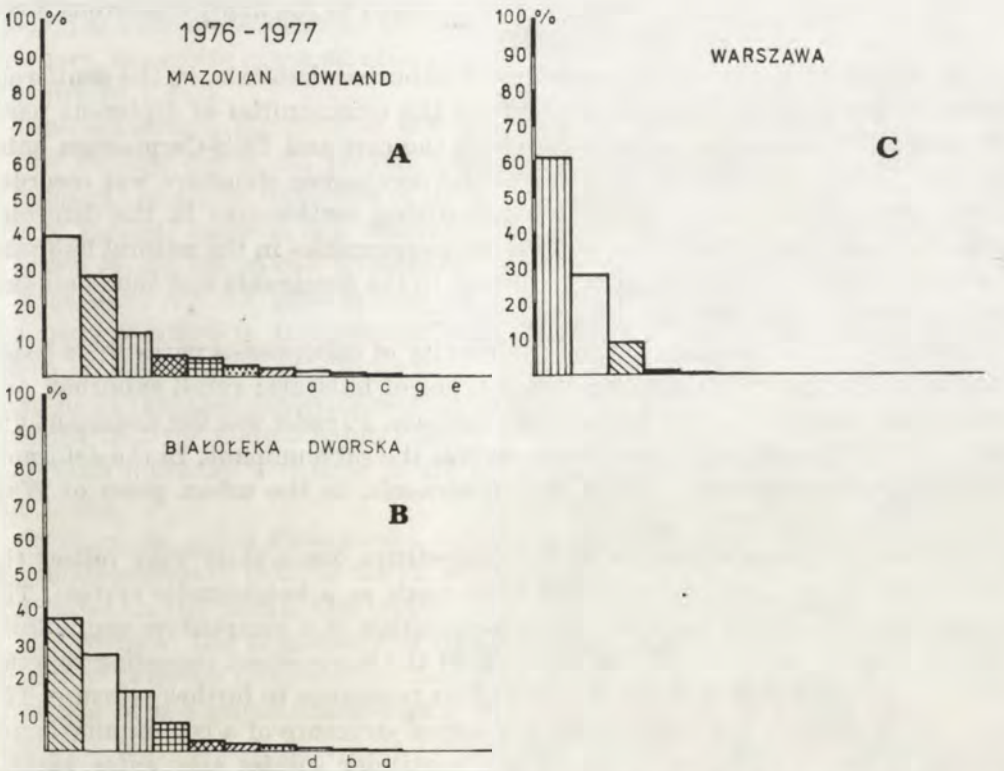


Fig. 33. Dominance structure of the competitive community of the dipterans of the genera *Pollenia* and *Sarcophaga* parasitizing earthworms, in various types of habitats: A — rural habitats in the Mazovian Lowlands, B — suburban habitats (Białołęka Dworska), C — urban habitats (Warsaw). The other items as in Fig. 30.

petitive community may reflect the compensatory function of the biocoenosis as a homeostatic system (TROJAN 1980).

In the linden-oak-hornbeam forest habitats of the Mazovian Lowland, the structure of the competitive community of the dipterans parasitizing earthworms was diverse but most frequently (in the greatest number of the study sites in the years 1976 and 1977) the species *Pollenia rudis* was the dominant and *Sarcophaga carnaria* or some other species of the genus *Sarcophaga* was the subdominant. In the investigated linden-oak-hornbeam forest habitats of the Mazovian Lowlands, the most stabilized dominance structure was recorded in the village park at Młochów. During two years of investigations, the dominant and the two subdominants were the same (Fig. 30). In the other rural (natural) habitats, the communities of parasitoids of earthworms did not demonstrate any significant changes in the dominance structure (in the carr and coniferous forest habitats) connected with different weather conditions prevailing in particular years (1976 and 1977) (Fig. 31). The most stabilized dominance structure of the community of dipterans parasitizing earthworms was recorded in the moist coniferous forest in the Kampinoska Forest (Fig. 31).

In 1976 and 1977, within the deformed suburban habitats, in the coniferous forest habitats the dominance structure of the communities of dipterans parasitizing earthworms was stabilized while in the carr and *Tilio-Carpinetum* habitats it varied (Fig. 32). A rebuilding of the dominance structure was recorded when the communities of dipterans parasitizing earthworms in the deformed suburban habitats were compared with the communities in the natural habitats. The rebuilding consisted mainly in a change in the dominants and subdominants and in their percentage shares (Figs 31, 32).

The dominance structure of the community of earthworms parasitoids based on the mean two-year data from three types of habitats: rural, suburban and urban was varied (Fig. 33). In the rural habitats, *P. rudis* was the dominant but in the other types of habitats this species was the subdominant. In the deformed habitats, the dominant recorded was *S. carnaria*, in the urban green of Warsaw — *S. lehmani*.

The shifts in the structure of the competitive community may reflect the influence of the organisation of the biocoenosis as a homeostatic system. The phenomenon of restricting the species composition of a competitive community is important in an estimation of the state of the homeostasis regarding functioning of the organisation of the system and its resistance to further pressure. The position of particular species in the dominance structure of a community is not stable. In different types of ecosystems, particular species may enter various dominance classes. Quite frequently, the dominant species of one ecosystem passes into the group of accessory or influent species in a different ecosystem. This phenomenon indicates the universality of competitive communities which, by means of a simple change in the quantitative proportions between species, may

adapt their internal organisation to the conditions under which the community can function in various types of ecosystems (TROJAN 1980).

CONCLUSION

Palaeogeographic and climatic changes and terrain topography have played a significant part in the process of forming the species composition of the *Lumbricidae* in Poland and they have also influenced the species composition of the dipterans of the genus *Pollenia* — obligatory parasitoids of earthworms. The greatest number of species of the genus *Pollenia* occurs in southern and central Poland, to the limit of the last Baltic glaciation. The dipterans of the genus *Sarcophaga* demonstrate no such relation ships.

In the Mazovian Lowlands, the Holarctic element is clearly the dominant among the investigated dipterans of the genus *Pollenia*, both in Białołęka Dworska and on the ouskirts of Warsaw and in the centre of the city. A similar situation has been recorded in the other regions of the country. In the genus *Sarcophaga*, the Palaearctic element has been the dominant in the Mazovian Lowlands However, the estate green and the centre of Warsaw are reached by the Palaearctic elements only.

The dominance structure of the dipterans under discussion depends largely on the weather conditions prevailing in a given year. The same species *P. rudis* dominates among the dipterans of the genus *Pollenia* in all the investigated habitats of Poland, Mazovia and Warsaw. Both in Mazovia and on the outskirts of Warsaw in the linden-oak-hornbeam forest habitats, two species *P. varia* and *P. vagabunda* are the most frequent subdominants. A similar species structure has been recorded in the parks in Warsaw. In the other rural, suburban and urban habitats, different species have been recorded as the subdominants. An analysis of the quantitative material on the dipterans of the genus *Pollenia* has revealed that the more a habitat has been disturbed by man, the more weather conditions influence a change in the quantitative proportions of the species of this genus.

Within the genus *Sarcophaga*, *S. carnaria* is the dominant and *S. lehmani* the subdominant in most of the rural habitats of Mazovia. However, *S. lehmani* dominates in the parks, the estate green and the centre of Warsaw.

In Warsaw, the abundance of the dipterans of the genus *Pollenia* depends on rainfall and air temperature. No such dependence has been recorded in the dipterans of the genus *Sarcophaga* in Warsaw because the abundance of these dipterans did not change during three successive years when the weather conditions were different (warm and dry, warm and rainy, cool and rainy). However, in the rural natural habitats, the abundance of the dipterans of the genus *Sarcophaga* seems to depend on both abiotic factors (quite contrary to the abundance of the dipterans of the genus *Pollenia*). On the basis of observations in various

sites in the *Tilio-Carpinetum* habitats of Mazovia and different habitats in the Pieniny Mountains it has been found that in habitats under small anthropogenic pressure usually the dominant dipterans are those of the genus *Sarcophaga*.

The linden-oak-hornbeam forests of Mazovia are the most suitable habitats for the dipterans of the genus *Pollenia*. This opinion has been confirmed by the results of investigations on the hosts of these dipterans. The same number of species of the dipterans of the genus *Pollenia* occurs in the urban parks, regardless of their size and situation, but the abundance of the species decreases toward the centre of the city. In the estate and streetside green there is no constant number of species and their abundance is generally insignificant.

The same number of species (from four to five) of the genus *Sarcophaga* usually occurs on the outskirts of Warsaw, in the parks and various types of the green of the rural habitats of Mazovia. In the most urbanised down-town sites (Konstytucja Square) the number of species has been distinctly reduced; only one species — *S. carnaria* has been recorded there.

In the urban green of Warsaw, the highest number of species and the highest abundance have been recorded in areas situated near the administrative boundaries of the city, but they decrease toward the centre.

The dipterans of the genera *Pollenia* and *Sarcophaga* have a different phenology although during some periods they occur simultaneously. The dipterans of the genus *Pollenia* winter as imagines and are caught in the greatest numbers during two, and sometimes three seasons, in spring, summer and winter. Imagines of the genus *Sarcophaga* appear in late spring, they are usually most numerous in August, sometimes even in July. An analysis of the material collected during the five-year period has revealed that the phenology of parasitoids of earthworms changes depending on the weather conditions in a given year. Imagines of both genera are caught in the greatest numbers in the summer months. The density of earthworms in the surface layer of the soil, where they can be accessible to parasitic dipterans, also depends on the abiotic factors conditioned by the seasons.

The materials collected in Białołęka Dworska and in the urban green of Warsaw confirm the hypothesis that the abundance of the dipterans of the genus *Pollenia* depends on the density of their hosts.

It seems that the dipterans under discussion can be considered a competitive community because they constitute one group of species occupying a similar niche in the biocoenosis, in the larval stage they utilize the same food substrata (earthworms) and have similar enemies. In the rural areas of Mazovia, in particular habitats, this community is characterised by constant abundance of individuals and a constant number of species. The dominance structure of the community of the parasitoids of earthworms based on mean, two-year data from three types of habitats: rural, suburban and urban is varied. The most stabilized dominance structure of the community of these dipterans has been recorded in the moist coniferous forest in the Kampinoska Forest.

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STRESZCZENIE

[Tytuł: Parazytoidy dżdżownic z rodzaju *Pollenia* R.-D. i *Sarcophaga* MEIG. zieleni miejskiej Warszawy oraz niektórych środowisk Niziny Mazowieckiej].

W Polsce stwierdzono 12 gatunków muchówek z rodzaju *Pollenia* — obligatoryjnych parazytoidów dżdżownic oraz 7 gatunków z rodzaju *Sarcophaga* — fakultatywnych parazytoidów dżdżownic. Najwięcej gatunków z rodzaju *Pollenia* występuje w południowej oraz środkowej Polsce, po granicę ostatniego zlodowacenia bałtyckiego, u muchówek z rodzaju *Sarcophaga* nie stwierdzono podobnej zależności.

W rodzaju *Pollenia* na Nizinie Mazowieckiej dominuje zdecydowanie element holarktyczny i to zarówno w środowiskach niezurbanizowanych, jak i na peryferiach Warszawy oraz w jej centrum. Analogiczną sytuację stwierdzono również w pozostałych regionach naszego kraju. W zieleni miejskiej wraz z nasilającą się presją antropogeniczną, wzrasta również udział liczebności elementu holarktycznego. W rodzaju *Sarcophaga* na Nizinie Mazowieckiej dominuje element palearktyczny. Natomiast do zieleni osiedlowej i centrum Warszawy wnikają tylko elementy palearktyczne.

Struktura dominacji omawianych muchówek jest w znacznym stopniu uzależniona od warunków atmosferycznych panujących w danym roku. Wśród muchówek z rodzaju *Pollenia* we wszystkich badanych środowiskach Polski, Mazowsza oraz Warszawy, dominuje ten sam gatunek *P. rudis*. W środowiskach grądowych zarówno na Mazowszu, jak i na peryferiach Warszawy subdominantami były najczęściej dwa gatunki *P. varia* i *P. vagabunda*. Podobną strukturę gatunkową stwierdzono również w parkach miejskich w Warszawie. W pozostałych środowiskach niezurbanizowanych oraz w podmiejskich i miejskich, subdominantami bywają różne gatunki. Analiza materiałów ilościowych muchówek z rodzaju *Pollenia* wykazała, że im bardziej środowisko jest zmienione przez człowieka, tym bardziej warunki atmosferyczne wpływają na zmianę stosunków ilościowych gatunków z tego rodzaju, stabilność struktury dominacji omawianego taksocenu uzależniona jest prócz tego od wielkości powierzchni badanego obiektu.

W rodzaju *Sarcophaga* w większości środowisk pozamiejskich Mazowsza dominuje *S. carnaria*, a subdominantem jest *S. lehmani*. Natomiast w parkach miejskich, zieleni osiedlowej i w centrum Warszawy najczęściej dominuje *S. lehmani*.

Liczebność muchówek z rodzaju *Pollenia* jest uzależniona na terenie Warszawy od opadów atmosferycznych i temperatury powietrza, a mianowicie liczebność tych parazytoidów wzrasta w latach ponad normę ciepłych i deszczowych. Podobnej zależności nie stwierdzono w Warszawie u muchówek z rodzaju *Sarcophaga*, gdyż liczebność tych muchówek nie ulega większym zmianom w ciągu kolejnych trzech lat o odmiennych warunkach atmosferycznych. Natomiast w pozamiejskich środowiskach naturalnych liczebność muchówek z rodzaju *Sarcophaga* wydaje się być uzależniona od obu czynników abiotycznych. Na podstawie

obserwacji różnych stanowisk naturalnych na Nizinie Mazowieckiej oraz różnych środowisk w Pieninach stwierdzono, że w środowiskach o niewielkich wpływach antropogenicznych dominują zwykle muchówki z rodzaju *Sarcophaga*.

Grądy Mazowsza są najodpowiedniejszymi środowiskami dla muchówek z rodzaju *Pollenia*. Potwierdzają to również wyniki badań nad żywicielami tych muchówek.

W parkach miejskich niezależnie od ich wielkości i usytuowania, występuje ta sama liczba gatunków muchówek z rodzaju *Pollenia*, natomiast ich liczebność zmniejsza się w kierunku ku centrum miasta. W zieleni osiedlowej oraz przyjezdniowej nie ma stałej liczby gatunków, a liczebność ich jest na ogół niewielka.

Na peryferiach Warszawy, w parkach i różnych typach zieleni środowisk pozamiejskich Mazowsza występuje ta sama liczba gatunków (od czterech do pięciu) z rodzaju *Sarcophaga*. W najbardziej zurbanizowanych terenach śródmiejskich (Plac Konstytucji) liczba gatunków wyraźnie ulega redukcji, stwierdzono tu tylko jeden gatunek — *S. carnaria*.

Wśród muchówek zaliczanych do rodzaju *Pollenia* i *Sarcophaga* w zieleni miejskiej Warszawy można zaobserwować także tendencję do zmniejszania liczby gatunków oraz ich liczebności w transekcie od peryferii miasta do jego centrum.

Muchówki z rodzaju *Pollenia* i *Sarcophaga* mają odmienną fenologię chociaż w pewnych okresach występują jednocześnie. Muchówki z rodzaju *Pollenia* zimują jako formy dorosłe, a najczęściej odławiane są w dwu, a niekiedy w trzech okresach, wiosną, latem i jesienią. Formy dorosłe z rodzaju *Sarcophaga* pojawiają się późną wiosną zwykle najliczniejsze są w sierpniu, a niekiedy już w lipcu. Analiza materiałów z pięciu lat wykazała, że fenologia parazytoidów dżdżownic zmienia się zależnie od warunków atmosferycznych panujących w danym roku. Postacie dorosłe z obu rodzajów najliczniej odławiane są w miesiącach letnich. Zagęszczenie dżdżownic w warstwie powierzchniowej gleby, gdzie one mogą być dostępne dla pasożytniczych muchówek jest również zależne od czynników abiotycznych (temperatury powietrza i opadów atmosferycznych) uwarunkowanych przez pory roku.

Materiały zebrane w Białołęce Dworskiej oraz zieleni miejskiej Warszawy potwierdzają przypuszczenie o zależności liczebności muchówek z rodzaju *Pollenia* od zagęszczenia ich żywicieli.

Wydaje się, że omawiane muchówki można uważać za zespół konkurencyjny, ponieważ stanowią one grupę gatunków zajmujących podobną niszę w biocenozie, wykorzystują one w stadium larwalnym te same substraty pokarmowe (dżdżownice) oraz mają podobnych wrogów. Zespół ten na terenach niezurbanizowanych na Mazowszu w poszczególnych środowiskach charakteryzuje stała liczebność osobników oraz liczba gatunków. Struktura dominacji zgrupowania parazytoidów dżdżownic trzech typów środowisk: pozamiejskich, podmiejskich i miejskich jest zróżnicowana. Najbardziej ustabilizowaną strukturę dominacyjną zespołu tych muchówek stwierdzono w borze świeżym w Puszczy Kampinoskiej.

РЕЗЮМЕ

[Заглавие: Паразитоиды лумбрицид из родов *Pollenia* R.-D. и *Sarcophaga* MEIG. городских зеленых насаждений Варшавы и некоторых битопов Мазовецкой низменности]

Из Польши известно 12 видов двукрылых из рода *Pollenia* — облигатных паразитоидов лумбрицид и 7 видов из рода *Sarcophaga* — факультативных паразитоидов лумбрицид. Больше всего видов из рода *Pollenia* встречается в южной и центральной части страны, до границы последнего, Балтийского оледенения; в отношении видов из рода *Sarcophaga* не отмечено такой зависимости.

В роде *Pollenia* на Мазовецкой низменности четко доминируют голарктические виды и то как в неурбанизированных биотопах, так и в пригородах Варшавы и в центре города. Такая самая ситуация отмечается также и в других регионах страны. В городских зеленых насаждениях параллельно с ростом урбанизационного пресса возрастает содержание голарктического элемента. В роде *Sarcophaga* на Мазовецкой низменности доминируют палеарктические виды. А в городскую зелень и центр Варшавы проникают только палеарктические виды.

Структура доминации рассматриваемых двукрылых в значительной степени зависит от метеорологических условий, господствующих в данном году. Среди мух из рода *Pollenia* во всех исследованных биотопах Польши, Мазовии, а также Варшавы доминирует один и тот же вид — *P. rudis*. В биотопах груда как на Мазовецкой низменности, так и на периферии Варшавй субдоминантами чаще всего были два вида — *P. varia* и *P. vagabunda*. Сходная структура видового состава была констатирована также в городских парках Варшавы. В остальных биотопах как неурбанизированных, так и пригородных и городских субдоминантами бывают разные виды. Анализ количественных материалов мух из рода *Pollenia* показал, что чем больше изменена среда в результате человеческой деятельности, тем больше атмосферные условия влияют на количественное соотношение видов в этом роде; стабильность структуры доминации обсуждаемого рода зависит также от величины площади исследуемого объекта.

В роде *Sarcophaga* в большинстве неурбанизированных биотопов Мазовии доминирует *S. carnaria*, а субдоминантным является *S. lehmani*. В городских парках, зелени жилых районов и в центре Варшавы чаще всего доминирует *S. lehmani*.

Численность мух из рода *Pollenia* зависит на территории Варшавы от атмосферных осадков и температуры воздуха, а именно численность этих паразитоидов возрастает в годах, в которых количество осадков и температура воздуха превышает норму. У видов из рода *Sarcophaga* не отмечено в Варшаве такой зависимости, поскольку численность этих мух не подвержена заметным изменениям на протяжении трех лет, отличающихся атмосферными условиями. В природных биотопах вне города численность мух из рода *Sarcophaga*, по-видимому, зависит от обоих абиотических факторов. Наблюдения, проведенные в различных природных биотопах на Мазовецкой низменности, а также в Пенинах свидетельствуют о том, что при

незначительном влиянии антропогенного фактора обычно доминируют мухи из рода *Sarcophaga*.

Груды Мазовецкой низменности являются наиболее соответствующими биотопами для видов из рода *Pollenia*. Подтверждается это также результатами исследований над хозяевами этих мух.

В городских парках независимо от их величины и положения число видов из рода *Pollenia* одинаково, но их численность снижается по направлению к центру города. В зелени жилых кварталов и произрастающей вдоль проезжих дорог число видов непостояно, а их численность обычно низкая.

На периферии Варшавы, в парках и в разного типа зелени внегородских биотопов Мазовии встречается одно и то же число видов (4–5) из рода *Sarcophaga*. В наиболее застроенных городских кварталах центра Варшавы (Площадь Конституции) был констатирован только один вид — *S. carnaria*.

По отношению обоих рассматриваемых родов наблюдается также тенденция снижения числа видов и их численности в трансекте от периферии города к его центру.

Мухи из рода *Pollenia* и *Sarcophaga* различаются по своей фенологии, хотя в определенные периоды встречаются одновременно. Виды *Pollenia* зимуют в стадии имаго, а ловятся чаще всего в двух, иногда трех периодах, весной, летом и осенью. Имаго *Sarcophaga* появляются под конец весны, наиболее многочислены в августе, а иногда уже в июле. Анализ материалов, собранных на протяжении пяти лет показал, что фенология паразитоидов лумбрицид изменяется в зависимости от метеорологических условий, господствующих в данном году. Стадии имаго обоих видов наиболее многочисленно отлавливаются в летние месяцы. Плотность лумбрицид в верхнем слое почвы, где они могут быть доступны для паразитических двукрылых также зависит от абиотических факторов (температура воздуха и атмосферные осадки), обуславливаемых временами года.

Материалы, собранные в Бялоленке-Дворской и городской зелени в Варшаве подтверждают предположение, что численность мух из рода *Pollenia* зависит от плотности их хозяев.

По-видимому, рассматриваемые двукрылые можно считать конкурентным сообществом, поскольку они составляют группу видов, занимающих сходную нишу в биоценозе, в личиночной стадии используют один и тот же субстрат для питания личинок (лумбрициды), имеют сходных врагов. Это сообщество на неурбанизированных территориях Мазовецкой низменности в пределах отдельных биотопов характеризует постоянная численность особей и число видов. Структура доминации сообщества паразитоидов лумбрицид различна в трех типах среды: внегородских биотопах, пригородных и городских. Наиболее стабильная структура доминации сообщества этих двукрылых была констатирована в свежем боре в Кампиносской пуще.

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