LEAFHOPPER COMMUNITIES
(HEMIPTERA: FULGOROMORPHA ET CICADOMORPHA)
OF THE SANDY AND LIMESTONE GRASSLANDS
OF THE CZĘSTOCHOWA UPLAND (SOUTHERN POLAND)

The Monograph

ZGRUPOWANIA PIEWIKÓW
(HEMIPTERA: FULGOROMORPHA ET CICADOMORPHA)
MURAW NAPIASKOWYCH
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WYŻYNY CZĘSTOCHOWSKIEJ (POŁUDNIOWA POLSKA)

Monografia

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Dariusz Świerczewski, Wacław Wojciechowski

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Abstract.

The paper presents the results of investigations into the composition, structure and dynamics of the leafhopper communities of sandy and limestone grasslands in the area of the Częstochowa Upland (Wyżyna Częstochowska), southern Poland; UTM CB72 and CB73.

Leafhoppers (Hemiptera: Fulgoromorpha et Cicadomorpha) represent a group of insect herbivores which feed on plant sap and the contents of mesophyll cells, thus ecologically forming a homogenous group known also as 'Auchenorrhyncha'. They form a most important component of the phytophagous fauna of temperate grasslands, with the density of adults at times exceeding 100–200 individuals per m^2. A number of leafhopper species are vectors of plant diseases, but in Poland on the whole, they are not considered as serious agricultural pests. So far 515 species of leafhoppers have been recorded in Poland, which constitutes about 30% of the European fauna of this group.

The research was carried out in the northern part of the Częstochowa Upland, near the villages of Olsztyn and Mstów. This area is characterized by Upper Jurrasic limestone formations surrounded by valleys filled with Pleistocene sands. The variety of habitats and plant assemblages have a big impact on the rich and diverse fauna of this region. The study covered two types of grassland ecosystems – the first being steppe-like on limestone hills and the second being on sandy soils in depressions. Both are considered to be rare and endangered in Poland. Steppe-like limestone grasslands occur in the Jurrasic limestone area stretching from Kraków to Częstochowa (Wyżyna Krakowsko-Częstochowska) and known as the Polish Jura. They belongs to the xerothermic vegetation of *Festuco-Brometea* class which covers plant assemblages connected with extremely warm, dry places under more continental climatic conditions. Their diversified flora is characterized by many rare and relic species, which have their northern range limits in central Europe. Sandy (psammophilous) grasslands of *Koelerio glaucae-Corynephoretea canescentis* class represent pioneer plant assemblages on inland, oligotrophic and acidic sands. They are part of secondary recreative succession as seminatural secondary communities for pine forests.

Five of the eleven plots chosen for examination represented sandy grasslands: *Spergulo vernalis-Corynephoretum* and *Diantho-Armerietum elongatae*. The other six plots were classified as limestone grasslands: *Festucetum pallentis, Sileno-Phleetum* and *Adonido-Brachypodietum pinnati*. Quantitative insect sampling was carried out every two weeks from the beginning of May till October in the years 2001 to 2003 (plots 1, 3–9, 11) and 2002 to 2004 (plots 2 and 10). A standard sweep net was used to collect the individual leafhoppers.

During the field-work, a total of 112 leafhopper species were collected from investigated plant assemblages with 102 typical grassland species. The number of recorded species per site varied from 34 for *Spergulo vernalis-Corynephoretum* (site 2) up to 52 for *Diantho-Armerietum elongatae* (site 4). Moreover, the characteristic leafhopper community was described for each vegetation in terms of such parameters as dominance, frequency and fidelity. The dominants for particular leafhopper communities were as follow: of *Spergulo vernalis-Corynephoretum* grassland – *Neophilaenus minor, Doratura exilis* and *Psammotetix excisus,* of *Diantho-Armerietum elongatae – Chlorita paolii, Neoaliturus fenestratus* and *Turrutus socialis,* of *Festucetum pallentis – Erythria aureola* and *Emelyanoviana mollicula,* of *Sileno-Phleetum –*

Acanthodelphax spinosa, Arocephalus languidus and *T. socialis,* of *Adonido-Brachypodietum pinnati – Adarrus multinotatus*.

Additionally, statistical analysis, such as Cluster Analysis and Principal Components Analysis, supported the identified differences between the leafhopper communities inhabiting particular plant assemblages. However, the community of *Sileno-Phleetum* shares features of the fauna of both sandy and limestone grasslands. This is in line with the botanical composition of that plant assemblage, which is a mixture of flora inhabiting both type of substrates. Regarding the index of species diversity, the community associated with *Diantho-Armerietum elongatae* grassland was found to have the highest value.

Chorological analysis indicates that species with a wide disribution, i.e. Eurosiberian, European and Transpalaearctic, form the most numerous groups. The aim of the ecological analysis was to characterize the particular Auchenorrhyncha communities in terms of such factors as moisture, insolation, host plant specialization and voltinism. Xerophilous elements were the most abundant in the leafhopper communities linked to sandy grassland *Spergulo vernalis-Corynephoretum* and limestone grassland *Festucetum pallentis*. The highest ratio of monophagous species was recorded for the leafhopper community associated with the sandy grassland *Spergulo vernalis-Corynephoretum,* which probably reflects the simple structure of this floral assemblage.

Summarizing, the described communities have a particular composition and structure and so may be useful in monitoring the biotic conditions of endangered grassland ecosystems.

Key words: Hemiptera, Fulgoromorpha, Cicadomorpha, leafhopper communities, grasslands, Częstochowa Upland, Poland

1. INTRODUCTION

Leafhoppers are a group of insect herbivores which feed on plant sap and the contents of mesophyll cells. Until the mid-90's, the group scientifically named Auchenorrhyncha was treated as monophyletic and regarded as a suborder within the Homoptera order. However, work using molecular techniques (Campbell *et al.*, 1995; Sorensen *et al.*, 1995) together with traditional morphological analysis (Bourgoin, 1986a & 1986b) revealed that Auchenorrhyncha, in fact, consists of two separate developmental linkages: Fulgoromorpha (closer to Heteroptera) and Cicadomorpha. Both groups are now regarded as suborders of Hemiptera alongside Heteroptera and Sternorrhyncha (aphids, scales, whiteflies, lerps and their relatives). On the other hand, some morphological (Yoshizawa & Saigusa, 2001) and anatomical (Szklarzewicz *et al.*, 2007) studies support the monophyly of the Auchenorrhyncha. Whether the term 'Auchenorrhyncha' is accepted as a valid group phylogenetically or not, it is still practical from an ecological point of view to assemble a group of plant-sucking insects.

The position of the rostrum is diagnostic of this group (Dolling, 1991). It arises at the back of the head, in contact with the anterior margin of the prosternum. It is not displaced between anterior coxae, as in Sternorrhyncha, nor is there a bridge of cuticle behind it, closing the head capsule posteriorly, as in Heteroptera.

As mentioned above, nearly all leafhoppers feed on vascular plants, mainly on their stems, leaves and underground parts. Several taxa live on ferns and there is only one record of briophagy in this group of insects (Wheeler, 2003). Phloem sap is their usual food but some families like Cicadidae, Cercopidae and some Cicadellidae utilize xylem sap instead, and most Typhlocybinae cicadellids feed on the content of mesophyll cells.

Most Auchenorrhyncha lay their eggs in slits in plant tissue, often in rows (Dolling, 1991). However, Tettigometride and Issidae deposit their eggs on the substrate, using a plate-like ovipositor, and Cixiidae insert them into the soil. There are five nymphal instars in most families but more in Cicadidae.

Natural enemies include insect predators and parasitoids (Waloff, 1980), but leafhoppers are also food for some vertebrates like birds and shrews in agro ecosystems.

Representatives of all families of Auchenorrhyncha are known to produce sounds by vibrating the tymbals – a pair of plates at the base of the abdomen (Claridge, 1985). The airborne signals of male cicadas are loud and easily recognizable but the sounds of tiny leafhoppers are inaudible to the human ear under normal conditions. Their vibrations are transmitted through the substrate and play an important role in mate-selection by the females.

According to Nickel and Hildebrandt (2003), leafhoppers form an important component of the phytophagous fauna of temperate grasslands and are a useful tool to monitor the biotic conditions of these habitats because: i) the numerous species occur in high population densities, ii) being primary consumers they interact with both plants and predators, iii) they show specific life strategies and occupy specific spatial and temporal niches, iv) they respond rapidly to the management regime and v) whole assemblages can be described quickly by sampling several times a year. The majority of leafhopper fauna form mono- and oligophagous species.

A total of 515 species of leafhoppers have been recorded on Polish territory so far, which constitutes about 30% of European leafhopper fauna (Nast & Chudzicka, 1990; Świerczewski & Gębicki, 2002; Świerczewski & Gębicki, 2003). The Kraków-Częstochowa Upland, with the Częstochowa upland as one of its mesoregions, is an area of Poland where information on leafhopper fauna has been quite well documented. However, most of the 339 reported species have been recorded in the southern part of the region – the surroundings of Kraków and Ojców (Szwedo 2001), and there are only a few reports from the Częstochowa region (Dobosz, 1986; Lis, 1988; Świerczewski, 2004; Świerczewski & Gębicki, 2004).

Up to the present, thorough studies on leafhopper communities in Poland have focused mainly on deciduous and coniferous forests (Klimaszewski *et al.*, 1980; Gębicki, 1983), peat-bogs (Szwedo *et al.*, 1998), and meadows and pastures (Andrzejewska, 1965; 1991; 1999) but rarely on sandy and xerothermic grasslands (including those formed on limestone bedrock).

The Częstochowa Upland is characterized by rich vascular flora and differentiated vegetation and spectacular wildlife, which were the main reasons behind the project to establish a Jurrasic National Park here (Hereźniak, 2004). Moreover, some parts of the Upland were registered as sites of the Natura 2000 network (www.natura2000.mos.gov.pl).

The sandy and limestone grasslands of this area are of special interest as they occur on isolated stands and are becoming rarer and rarer not only in Poland but across Central Europe. Insects are the dominant group of invertebrates inhabiting these phyocenoses, with many rare species recorded in localities far from the main range (Mazur & Kubisz, 2000). So far entomological research into the sandy and limestone grasslands of the Częstochowa Upland has covered orthopteroid insects (Liana, 1976; Warchałowska-Śliwa *et al.*, 1992), butterflies and moths (Skalski, 1992a, 1992b; Nowacki & Wąsala, 2006), thrips (Pokuta, 2001) and selected groups of beetles, dipterans and hymenopterans (Celary, 1992; Mazur *et al.*, 1998; Klasa, 2004). In respect of hemipterans, only communities of aphids (Hałaj & Wojciechowski, 1996) and mirids (Gorczyca, 1994) were described but there is no data on leafhoppers.

Taking this into consideration, it was necessary to conduct a survey in order to determine the zoocenological structures of leafhoppers on selected grasslands of the Częstochowa Upland.

The main aims behind the work were:

- to determine the leafhopper species composition on selected sandy and limestone grasslands of the Częstochowa Upland
- to describe leafhopper communities associated with selected grasslands with respect to such parameters as dominance, frequency and fidelity

- to investigate the seasonal abundance changes in dominant and subdominant species
- to characterize the leafhopper fauna in terms of chorology and ecological parameters

The term which is the most often used in quantitative faunistic investigations is 'taxocen'. According to CHODOROWSKI (1960), it is a community of organisms belonging to the same systematic level and sharing a particular habitat with a similar annual dominance structure. However, TROJAN (1992) believes that in zoocenological investigations the only unit which fulfills the criteria of ecological homogeneity is the competitive assemblage. This means a group of species with similar ecological preferences, sharing the same time and space, utilizing the same food and possessing common enemies.

Leafhoppers as primary consumers possess the same trophic requirements but the internal interactions within a multispecies community are not well understood. This is why in this work the term 'community' has been adopted to indicate a group of leafhopper species found in a particular habitat, including species constantly inhabiting the environment together with those that appear temporarily because of food plant alteration or migration from another habitat. The above term was used in the same way in recently published papers concerning rove beetles (Coleoptera: Staphylinidae) (SMOLEŃSKI, 2000) and bees (Hymenoptera: Apoidea) (CIERZNIAK, 2003).

2. OVERVIEW OF THE RESEARCH ON GRASSLAND LEAFHOPPERS IN POLAND AND CENTRAL EUROPE

The first data reporting leafhoppers on the present-day territory of Poland was given by Weigel (Weigel, 1806 after Nast, 1976b), who mentioned 19 species in Silesia – a former province of the Kingdom of Prussia. Since then over 250 papers have been published concerning the leafhopper fauna of the country. Most of them are check-lists of the species from a particular area with a short note on their habitat, the collecting time and the number of specimens. Analyzing such data we can make a preliminary list of the species connected with sandy and limestone habitats and give their ecological characteristic in brief. Unfortunately, there is only scarce data on the host plants of the bulk of the leafhopper fauna in Poland.

The papers presented below, which relate to the territory of Poland and its neighbouring countries, refer in whole or in part to the characteristics of leafhopper communities on sandy and xerothermic grassland both in qualitative and quantitative terms. Few of them support the view that there is still a need for scientific research on this particular subject.

Leafhopper fauna on sandy grasslands of the *Koelerio glaucae-Corynephoretea canescentis* class

The first paper on the leafhopper fauna of the sandy inland habitats of the Błędowska Desert was published by Jasińska (1980). The main plant assemblage of the area was *Spergulo vernalis-Corynephoretum* with dominating grasses such as *Corynephorus canescens* and *Koeleria glauca* and isolated stands of willows – *Salix rosmarinifolia* and *Salix acutifolia*. Ninety-one species were reported from the area of investigation with two dominat species feeding monophagously on willows – *Macropsis impura* and *Sagatus punctifrons*. The subdominants were represented by species trophically associated with the herb layer – *Muirodelphax aubei, Neophilaenus exclamationis, Neophilaenus minor, Zyginidia viaduensis, Doratura exilis, Psammotettix nodosus* and *Jassargus flori*.

Gębicki *et al.* (1982), investigating the leafhopper fauna of the Biebrza River Basin, recorded 32 leafhopper species from psammophilous grasslands with 5 species associated exclusively with this type of vegetation –*Muirodelphax aubei, Macropsidius sahlbergi, Anaceratagallia ribauti, Doratura homophyla* and *Arocephalus languidus*.

Szwedo, in 1992–1995, undertook research on leafhopper communities in the degraded, post-mining habitats of sand-pit excavations near Jaworzno and Bukowno in the Upper Silesia region (Szwedo, 1997). Several plots represented psammophilous grasslands in different stages of succession. The initial plant assemblage with *Corynephorus canescens* was inhabited by 24 leafhopper species with eudominant *Psammotettix axcisus* and subdominat *Psammotettix alienus*. The characteristic species of the community were *Psammotettix excisus, Neoaliturus haematoceps* and *Ebarrius cognatus*. Some investigated plots were identified as initial psammophilous grassland with *Corynephorus canescens* and *Sedum acre*. The characteristic species of the leafhopper community associated with the aforementioned vegetation were *Neoaliturus haematoceps, Neoaliturus fenestratus* and *Macrosteles maculosus*. In contrast, the characteristic species of the community inhabiting rich psammophilous grassland were two cicadellids – *Dortura impudica* and *Mocuellus collinus*.

Bednarczyk and Gębicki (1998), in their faunistic paper on leafhoppers collected in the surroundings of Janów Lubelski, investigated two areas covered with sandy grasslands. They discovered 32 leafhopper species in the psammophilous grassland of *Festuco-Sedetalia* order, but did not associate those species only with this type of vegetation. The second type of investigated psammophilous grassland was *Spergulo-Corynephoretum* with 41 leafhopper species reported, among which *Ribautodelphax pallens, Doratura exilis* and *Erzaleus metrius* are worth mentioning.

Leafhopper fauna on xerothermic grasslands of the *Festuco-Brometea* class

The first research on leafhoppers of xerothermic vegetation dates back to the 50's of XX century and was carried out by scientists from the National Zoological Museum in Warsaw in the area of the Nida River Valley (Małopolska Upland). The goal of the investigation was to discover the invertebrate fauna of the area and one of the important results was a description of a relict, isolated population of the cicada *Cicadetta podolica* (Kostrowicki & Nast, 1952).

In 1979 and 1981 Gębicki carried out advanced research in the same area covering six plots representing xerothermic grasslands of *Thalictro-Salvietum pratensis* and *Inuletum ensifoliae* of *Cirsio-Brachypodion pinnati* alliance (Gębicki, 1987). He recorded 98 leafhopper species. The *Thalictro-Salvietum pratensis* leafhopper community was characterized by three differentiating species – *Doratura concors, Doratura horvathi* and *Cicadetta podolica*. Two species – *Adarrus bellevoyei* and *Arboridia potentillae* were identified as differentiating for *Inulietum ensifoliae* leafhopper community.

The only survey concerning leafhopper fauna from one type of limestone grassland (*Festucetalia valesiacae*) on the Częstochowa Upland is that of Lis (1988) carried out in 1986 and 1987 near Pilica in the southern part of the region. She described quite a rich leafhopper community of the *Festucetalia valesiacae* order with 52 species and a large group of xerothermophilous taxa including *Zygina hyperici, Rhopalopyx preyssleri, Psammotettix cephalotes, Adarrus multinotatus, Hephathus nanus, Utecha trivia* and *Muirodelphax aubei*.

Szwedo (1992) in his paper describing the leafhopper fauna of the Ojców National Park characterised Auchenorrhyncha fauna associated with three xerothermic phytocenoses of *Festuco-Brometea* class. The *Origano-Brachypodietum pinnati* plant assemblage was inhabited by 53 leafhopper species with such species as *Xanthodelphax stramineus, Utecha trivia, Cercopis sanguinolenta, Zygina hyperici, Psammotettix cephalotes* and a species of *Cicadetta montana* complex as typical for this vegetation. He collected 12 leafhopper species from the *Kelerio-Festucetum sulcatae* grassland but only 7 species from the rocky grassland *Festucetum pallentis*.

Chudzicka and Stroiński (2000), analysing the work of Nast (1976a), made a comparison of leafhopper fauna associated with different environments in the Pieniny Mountains. They characterized the leafhopper communities of two xerothermic plant assemblages – steepe-like grassland *Origano-Brachypodietum laserpitietosum* and mountain grassland *Dendranthemo-Seslerietum*. The latter is an endemic phytocenosis of the central Pieniny Mts and shares the features of both high-mountain limestone grasslands (*Seslerietea variae* class) and xerothermic upland rocky grasslands (*Festuco-Brometea* class) (Matuszkiewicz, 2001). The Auchenorrhyncha fauna of the afore-mentioned plant assemblages was similar for the most abundand termophilous species such as *Cercopis sanguinolenta, Eupelix cuspidata, Emelyanoviana mollicula, Zyginidia mocsaryi, Elymana sulphurella* and *Diplocolenus bohemani*. The rare species reported from these plant assemblages were *Chlorionidea flava* – known only in this region of Poland and *Erythria montandoni* – typhlocybid species occuring in warm and sunny habitats in the Polish mountains.

In countries bordering Poland, the most comprehensive work concerning the leafhopper communities of warm and dry grasslands was done by Schiemenz (1969, 1971, 1973) in the eastern part of Germany (former German Democratic Republic). The survey covered 70 places representing different types of psammophilous and xerothermic vegetation. The results of the investigation were published as the characteristics of Auchenorrhyncha communities in terms of dominance, constancy, phenology and ecological valency. At present some of these places are being re-researched by Schuch (Schuch *et al.*, 2009). Other studies from Eastern Germany were done by Witsack (1997, 1999) mainly in the region of Sachsen-Anhalt.

In the Czech Republic, the first survey concerning the subject was undertaken by Lang (1945) on the steppe-like vegetation formed on the serpentinite bedrock of the Mohelno Nature Reserve (western Moravia). According to the author, one third of the 59 species recorded can be classified as xerothermophilous. Recently Malenovsky (2007) carried out long-term studies (2001–2005) on leafhopper communities of calcareous vegetation in the area of the White Carpathians Biosphere Reserve (south-eastern Moravia). He discovered that the management regime, such as mowing and grazing, influenced the structure of the Auchenorrhyncha communities, and identified the species associated with both types of agricultural activity.

There are only two reports on leafhopper fauna of steppe-like vegetation from Slovakia. Musil (1958) in his work carried out in southern Slovakia in the surroundings of such towns as Nitra, Zlaté Moravce, Košice, Sobotište and Spišské Podhradie recorded 115 leafhopper species with a large group of xerothermophilous taxa associated with steppe-like grasslands. In addition, Okáli (1960), exploring habitats in the vicinity of Bratislava, described the leafhopper communities of steppe-like grassland and forest-steppe vegetation.

In Ukraine, Logvinenko researched the Auchenorrhyncha fauna of xerothermic vegetation in the Ukrainian part of the Carpathians, Transcarpathia and the Ukrainian

Polesia (Logvinenko, 1961; 1964). In both papers, the author gives a short characteristic of the insect communities together with a list of the species recorded.

Borodin (2004), in his checklist of the Auchenorrhyncha of Belarus, gives the moisture requirements for all species recorded in the country including those classified as xerophilous, which prefer dry grasslands, steppes and dry pine forests.

3. STUDY AREA

According to the system of Universal Transverse Mercator (UTM), applied in studies of faunistic data and accepted by the Centre of Faunistic Documenting of the Museum and Institute of Zoology of the Polish Academy of Sciences (PAN), the area of investigation lies in squares CB 72 and CB 73 (Fig. 1).

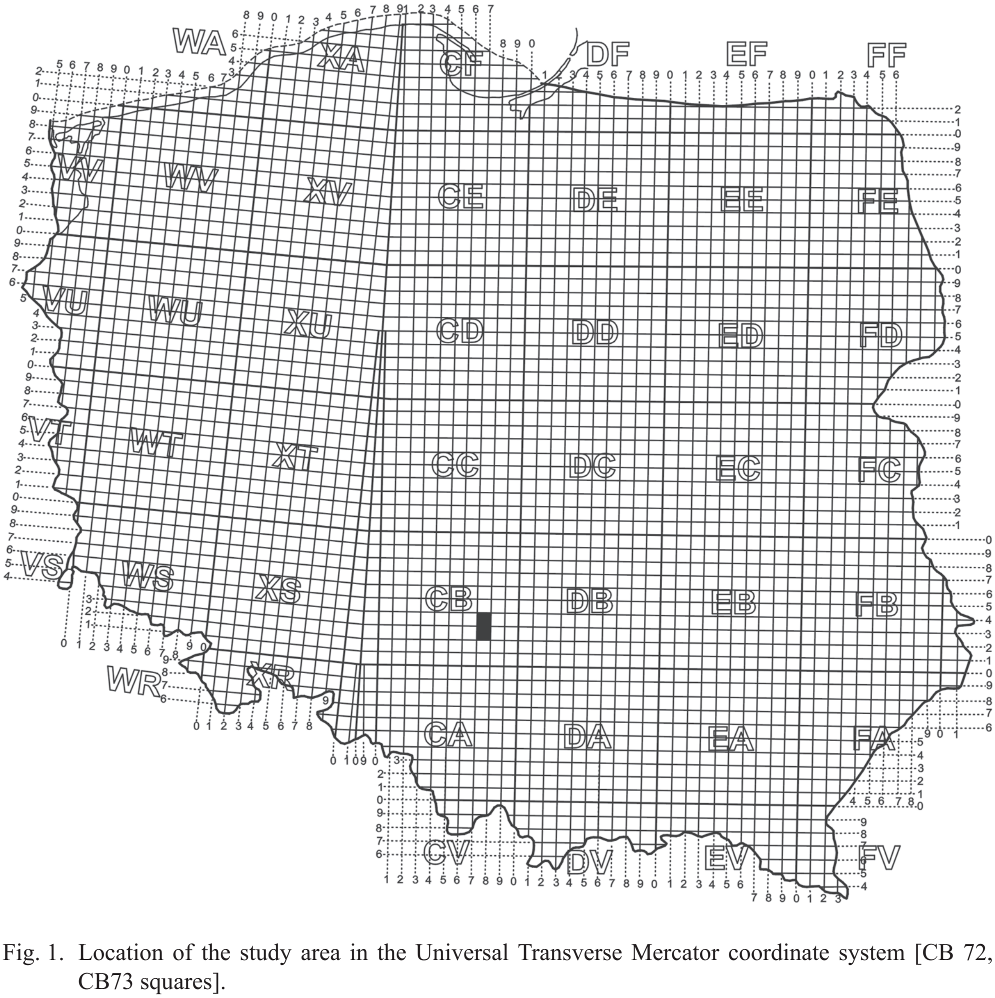


Fig. 1. Location of the study area in the Universal Transverse Mercator coordinate system [CB 72, CB73 squares].

According to the physicogeographical regionalisation of Poland (Kondracki, 2000), the study area is located in the northern part of the Częstochowa Upland, within the Eagles' Nests Landscape Park. The study sites were located in two places – to the south-east of the village of Olsztyn and to the east of the village Mstów near Częstochowa (Fig. 2).

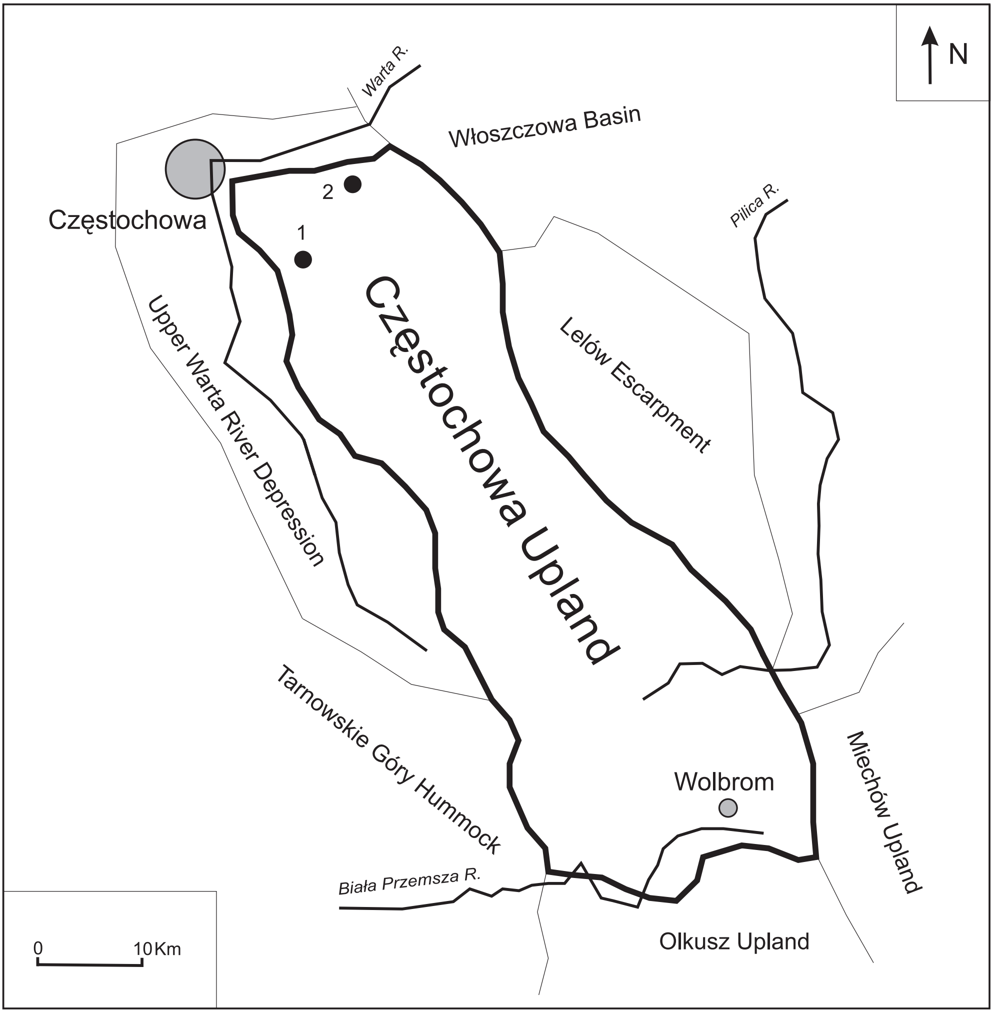


Fig. 2. Location of the study area within the Częstochowa Upland and in relation to neighbouring geographical units (1 – Olsztyn plots, 2 – Mstów plots).

The Częstochowa Upland (341.31) is one of 4 mesoregions, together with the Olkusz Upland, Krzeszowice Ditch and Tenczyn Hummock, within the macroregion of the Cracow-Częstochowska Upland (341.3) of the subprovince of the Silesian-Cracow Upland (341). It stretches between the gorge of the River Warta near Częstochowa up to

Mstów in the north and the so-called Wolbrom Gateway and the Biała Przemsza River valley to the south, occupying an area of about 1300 sq. km. From the west, this area borders the depression of the Upper Warta, with which it forms a 70 metre high cuesta, whereas to the east it adjoins the Włoszczowa Basin, Lelów Escarpment and Miechów Upland. The upland lies within the borders of the Silesian Province (Silesian Voivodeship).

In respect of geobotany, it is the Central Region of the Cracow-Wieluń Upland (Szafer, 1977).

Geological structure, relief and soil cover

In respect of geology, the area of the Częstochowa Upland belongs to the Silesian-Cracow monocline, which borders the Upper Silesian Depression to the west, the Sub-Carpathian Depression to the south and the Miechów basin to the east. It is possible to distinguish three main structural horizons in the geological structure of this area: 1) the folded deposits of the Palaeozoic substratum, 2) a plate of sedimentary Mesozoic rocks, 3) a cover of Cainozoic deposits (Kleczkowski, 1972).

The Palaeozoic element was made by the Małopolski block, which came into the Silesian-Cracow Upland from the area of the present-day Black Sea. It is built of metamorphic rocks, which are nowadays found on the surface in the surroundings of Dobruja (Romania) (Tyc, 2001).

The Mesozoic formation predominating in the area under discussion is represented by differently shaped limestones of the Upper Jurassic period (the Malm), which vary in respect of lithology – platy, massive and laminated. They originated about 150 million years ago from the skeletons of sponges, cephalopods, echinoderms and blue-green algae (Cyanobacteria), which in the deeper-shelf marine environments formed carbonate structures called bioherms. A detailed stratigraphic analysis of carbonate structures has been carrried out for the Olsztyńskie Skałki (Olsztyn rocks), belonging to the Olsztyn-Mirów range. The substratum of Olsztyńskie Skałki is built of sponge limestones with marly intercalations, which, towards the top, merge into platy limestones with numerous sponges (Trammer, 1989). The roof part of these limestones belongs to the Bifurcatus Zone. Above the platy limestones the sequence of massive limestones begins, within which the boundary between the Bifurcatus and Bimammatum Zones runs (Matyja & Wierzbowski, 1992).

The valleys between the limestone hills are filled with the Cainozoic-Quaternary deposits of the South Polish Glaciations and to the north of the region – also the Oder Glaciation (Lewandowski, 1994). The sandy covers, which have undergone multiple re-deposition, are of different ages and have a polygenetic character. They are made of aeolian, fluvioperiglacial and fluvioglacial sands and gravels. They occur in valley bottoms, on slopes and within flat watershed surfaces. Additional characteristic elements are numerous dunes, which occur at the bottom of dry valleys as well as in watershed areas.

The Częstochowa Upland presents a rather level surface, though in some places slightly folded (Gilewska, 1972). The warm and humid climate and the Tertiary tectonics have had a very important influence on the development of the relief of the

Częstochowa Jurassic Highland Chain. In this period, karst phenomena predominated and as a result the higher horizon of the Upland underwent damage and the Palaeogenic planation surface, i.e. Jurassic hilltops with an average height of about 450 m a.s.l., was formed. Only more resistant fragments of limestone remained in the form of so-called rocky remnants above the surface. On the top of many karst hillocks the picturesque ruins of Medieval and Renaissance defensive castles can be seen (Eagle Nests' Route, Route of Jurassic fortresses).

In the southern part, groups of rocky remnants called mogotes or inselbergs predominate (Rocks of Ryczów, Kroczyce or Podlesice) with characteristic wider basements (Polichtówna, 1962). They are built of resistant mass limestones and proper rocky limestone, which today exhibit different stages of deterioration: the best preserved are in the form of dome mountains, then there are complexes of rocky forms – dense or loose, then individual rocks, hummocks and finally, the last developmental stage, detrital elevations. The highest point of the Upland occurs near the village of Ogrodzieniec – 502.2 m a.s.l. The next stage in the relief development of this area was the formation of valley landforms, characterized by basin-like widenings, narrow sections and broken courses resulting from the direction of fissures.

In the northern part of the Upland, karst hills (Gorzkowskie, Sokole and Towarne Hills) with numerous rocks and vertical and horizontal caves stretch from Gorzków up to the neighbourhood of Olsztyn.The limestone remnants here have a distinctly shaped character, occurring as isolated crags with nearly vertical walls (Szaflarski, 1955; Czeppe, 1972).

Karst processes occurring within the layer of rocky massifs are responsible for the formation of numerous caves in the area. Three hundred and thirty-six caves have been recorded on the terrain of the Częstochowa Upland, although their number is surely larger (Szelerewicz & Górny, 1986).

The type of rocky substratum and terrain relief clearly determine the variety of soils and consequently habitat conditions on the Częstochowa Upland (Kobylecka, 1981). In terrain depressions, where a thick layer of sandy deposits occurs, different types of podzols originated – typical podzolic soils and iron podzols. Sandy or sandy-loamy fluvial soils and sandy half-bog-gley soils also ocurr but to a much lesser extent. Different subtypes of sandy brown soils and pararendzinas occur together with locally found lessive soils on slopes and hilltops formed from the Jurassic limestones. The common feature of these types of soils is their high permeability, which accounts for the permanent water deficiency in the soil body.

Climate

When considering the agricultural-climatic provinces identified by Gumiński (1948), the Częstochowa Upland belongs to the Częstochowa-Kielce Province within the central part of the climatic zone. According to the division of Poland into climatic regions by Romer (1949), the Częstochowa Upland lies within the area of climate of the Central Uplands within the borders of the Silesian-Cracow

Region. Woś (1989) classified the area discussed as part of the Western Małopolska climatic zone.

On the basis of the data taken from the Institute of Meteorology and Water Management's (IMGW) station in Częstochowa, selected weather elements during the period of investigation are characterized below (Table 1).

Table 1. Characteristic of selected weather parameters in the years 2001–2004 – Meteorological station of IMGW in Częstochowa (50°49'N/19°06'E; 293 m. a.s.l.).

Year	Month												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Monthly average air temperature (°C)													Annual average
2001	-0.8	-0.3	2.5	7.4	14.4	14.7	19.4	19.1	11.5	11.4	1.7	-4.4	8.05
2002	-1.4	3.3	4.5	8.3	17.1	17.6	20.3	20.1	12.6	7.0	4.9	-4.8	9.12
2003	-3.0	-4.7	2.3	7.2	15.9	19.0	19.6	19.6	13.9	4.9	5.4	0.2	8.35
2004	-4.7	-0.4	2.9	8.8	12.3	16.3	18.1	18.9	13.5	10.2	3.7	0.5	8.34
Monthly sum of precipitation (mm)													Annual sum
2001	25.8	28.1	51.8	97.7	110.8	96.8	192.1	55.4	159.4	14.4	39.2	26.8	898.3
2002	28.8	50.2	22.6	30.3	98.7	97.2	98.0	43.8	67.0	71.8	35.7	17.6	661.7
2003	28.7	7.2	18.9	39.1	62.2	41.1	78.7	37.9	38.4	79.5	19.0	44.8	495.5
2004	35.5	63.4	54.9	45.0	45.8	76.9	74.8	55.4	28.6	31.7	56.5	16.0	584.5
Monthly number of days with snow cover													Annual number
2001	6	15	12	2	–	–	–	–	–	–	8	29	72
2002	24	6	2	–	–	–	–	–	–	–	–	23	55
2003	15	25	3	4	–	–	–	–	–	–	–	13	60
2004	31	23	17	–	–	–	–	–	–	–	6	5	82

In the period 2001–2004, average annual air temperatures fluctuated from 8.05°C (2001) up to 9.12°C (2002). When compared to the long-term average of 7.7°C (Słowicki, 1978) these seasons had thermal conditions which were higher than average. The mean January temperature during the four years was -2.5°C, whereas the average temperature of the warmest month, August, was 19.4°C. Total annual precipitation within the period of investigation ranged from 495.5 mm (2003) up to 893.3 mm (2001) with the long-term average being 680 mm (Słowicki, 1978). The highest precipitation was in July with the average over the four years amounting to 110.9 mm. The largest number of days with snow cover occurred in 2004 (82), the lowest in 2002 (55).

Winter in the area under discussion lasts about 100–110 days. Snow cover lasts for between 60–80 days (Słowicki, 1974). The length of the vegetation period (with average 24 hour temperatures above 5°C) is from 190 days to 210 days, and is about 2 weeks shorter in comparison with neighbouring areas (Michalik, 1974).

In the area of the Częstochowa Upland, winds from a western and south-western direction prevail. The average annual wind velocity is 2.4 m/s. The greatest number of cloudy days in the Częstochowa region occurs in December (18 days) whereas the fewest is in May (8 days) (SŁOWICKI, 1978).

Hydrological conditions

A watershed of the first order runs through the area of Częstochowa Upland between the catchments of the Vistula and Oder rivers. The northern part of the Upland is drained by the Warta together with its tributary – the Wiercica (the Oder catchment), the central part is drained by the Pilica together with its tributaries – the Białka and the Krztynia, whereas the southern part is drained by the Biała Przemsza and the Szreniawa (the Vistula catchment). The rivers are characterized by a ground-snow-rain type of supply with a distinct (50–70%) predomination of ground supply from springs and as a result of the cutting of water-bearing horizons by river channels as well (DYNOWSKA, 1983). The river net within the Częstochowa Upland, in comparison to the Cracow Upland or Wieluń Upland, is sparser (0.11 km/km^2), which indicates the predominance of water infiltration over surface flow and the significant supply of underground waters. These waters fill karst fissures and chambers, creating one common water table, which occurs at a depth of even up to 100 m within hilltops. Natural water reservoirs are not found in the area, the majority of them having an anthropogenic character, playing the role of farm ponds.

Springs are distributed irregularly in the area of the Częstochowa Upland; large, effective springs prevail and are concentrated in the river valleys (DYNOWSKA, 1983). Numerous springs are connected with the cuesta, running along the western border of the Częstochowa Upland and are the source of all the right-side tributaries of the Upper Warta and some tributaries of the Przemsza River. The springs in the area vary considerably in terms of their character and form of outflow.

Flora and vegetation

The first floristic paper on the Częstochowa Upland was written by KARO (1881), who listed 777 species of vascular plants collected mainly in the surroundings of Częstochowa. Moreover, SOKOŁOWSKI (1928) published one of the earliest phytosociological papers in Poland from this region, which dealt with the variety of beech forests resulting from the varied exposure of limestone hill slopes. In the last few decades, interest in this area has significantly increased, which is illustrated by the higher number of floristic and phytosociological papers published by such authors as BŁASZCZYK (1949), HEREŹNIAK, KRASOWSKA and ŁAWRYNOWICZ (1970, 1973), CELIŃSKI and WIKA (1975, 1978), BABCZYŃSKA (1978), BABCZYŃSKA-SENDEK (1998), HEREŹNIAK (1983, 1993), MRÓZ and MAJCHRZAK (2003). A comprehensive work on this subject, a checklist of vascular plants of the Kraków-Częstochowa Upland, was recently published (URBISZ, 2004).

It is estimated that the flora of the vascular plants of the Częstochowa Upland comprises over 1000 taxa (Skalski, 1995; Hereźniak, 2002) with a group of 30 southern species which reach the northern limit of their range here. Some examples are plants which can be found in xerothermic vegetation such as *Cerasus fruticosa, Nonea pulla, Erysimum odoratum* and *Staphylea pinnata*. Two endemic species should be also mentioned here – *Galium cracoviense*, which occurs on two limestone hills near the village of Olsztyn and *Cochlearia polonica*, which can be found in karst springs near the village of Złoty Potok.

Not only the flora but also the vegetation of the region is rich and varied, represented by at least 250 plant assemblages (Hereźniak, 1996) representing different types of forests, grasslands, meadows and those types associated with cultivated fields. Among them the most interesting are two woodland phytocenoses *Dentario enneaphylidis-Fagetum* and *Carici-Fagetum* as well as the sandy and limestone grasslands.

Both the flora and vegetation are under a strong anthropogenic influence which covers the exploitation of minerals, degradation of ground and surface waters, air and soil pollution and tourism (Babczyńska-Sendek *et al.*, 1992). As a result 42 plant species have already become extinct and 246 taxa are in danger of extinction (Hereźniak, 2002). Regarding the sandy and limestone grasslands, the main dangers are the establishment of sand-pits and limestone quarries and the natural succession towards shrubs and forests connected with the cessation of traditional grazing.

4. STUDY PLOTS

The experimental, permanent study plots are stands of sandy grasslands of *Koelerio glaucae-Corynephoretea canescentis* class and limestone grasslands of *Festuco-Brometea* class. Habitat features (altitude, exposure, slope angle) and a description of vegetation (herb and moss-lichen cover, height, list of recorded plant species with an abundance rank) for particular plots are presented in Table 2.

Table 2. Characteristics of the investigated plots. Numbers and symbols in the alphabetical list of plant species as per the Braun-Blanquet plant cover scale.

Habitat parameters	Plot										
	1	2	3	4	5	6	7	8	9	10	11
	Spergulo-Cor.		*Diantho-Arm.*			*Festucetum pall.*		*Sileno-Phl.*		*Adonido-Brach.*	
Date of investigations	15.07	15.07	15.07	15.07	15.07	20.07	20.07	20.07	20.07	28.07	28.07
Area of investigation (m^2)	100	100	100	100	100	100	100	100	100	100	100
Altitude (m. a.s.l.)	318	317	315	305	306	340	335	325	307	285	277
Exposure	NW	SE	–	SW	W	SE	S	NE	S	S	SW
Slope angle (°)	3	6	–	4	3,5	40	20	5	7	20	10
Average height of herb layer (cm)	26	26	45	60	48	33	36	46	48	40	47
Herb layer cover (%)	50	60	80	80	80	70	70	90	90	95	100
Moss-lichen cover (%)	10	30	30	10	30	40	50	10	25	10	10

Plant species	Plot										
	1	2	3	4	5	6	7	8	9	10	11
Achillea millefolium			+	+	+	+	+	+	+		
Acinos arvensis						+	+	+			
Agrimonia eupatoria										1	1
Agrostis gigantea					+						
Agrostis capillaris								1	1		
Allium montanum			r			+	1		+		
Anemone sylvestris										+	+
Anthericum ramosum						2	4	+		1	+
Anthoxanthum odoratum			2	1	1			+	+		
Anthyllis vulneraria							+	1	1	+	+
Armeria maritima			2	2	1			+	+		
Arrhenatherum elatius				+				+	+	+	+
Artemisia campestris	+	+	1	2	1			+	+		
Asperula cynanchica						+	1	2	2	+	+
Asplenium ruta-muraria						+	+				
Avenula pubescens								+			
Berteroa incana				+	+						
Betonica officinalis											+
Brachypodium pinnatum										3	3

Plant species	Plot										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
	Spergulo-Cor.		*Diantho-Arm.*			*Festucetum pall.*		*Sileno-Phl.*		*Adonido-Brach.*	
Briza media								+			+
Calamagrostis epigejos								+			
Campanula persicifolia											+
Campanula rapunculoides										+	
Campanula rotundifolia						r	+				
Carex caryophyllea			1					1	+		
Carex flacca											+
Carex hirta			+	+	+						
Carlina acaulis										+	+
Carlina onopordifolia										r	
Carlina vulgaris								+	+	+	+
Centaurea jacea										+	
Centaurea scabiosa										+	+
Centaurea stoebe	r	r		+	+	+	+	+	+	+	
Cerastium arvense				+	+			+			
Chamaecytisus ratisbonensis											+
Cirsium acaule										+	+
Clinopodium vulgare							1				
Convolvulus arvensis				+	+						+
Coronilla varia				+	+	+	+	+		+	
Corynephorus canescens	3	4	2	2	1						
Cotoneaster integerrimus						r					
Crataegus sp.			r						r		
Dactylis glomerata					+				+		
Daucus carota										+	+
Deschampsia flexuosa			+		+						
Dianthus cartusianorum			2	+		1					
Dianthus deltoides				+	1						
Echium vulgare							+		+		
Elymus repens	+										
Erigeron acris				+	1						
Erysimum odoratum						+	+				
Euphorbia cyparissias				1	1	1	1	1	1	1	1
Euphrasia stricta						+			+		
Festuca ovina (s. l.)			1	+	+	+		2	+		
Festuca pallens							1				
Fragaria viridis						1	1	1	1	1	+

Plant species	Plot										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
	Spergulo-Cor.		*Diantho-Arm.*			*Festucetum pall.*		*Sileno-Phl.*		*Adonido-Brach.*	
Galium cracoviense							+				
Galium boreale										+	+
Galium mollugo						+	+	+			
Galium verum										1	1
Geranium sanguineum							+				
Helianthemum nummularium						+	+	+		+	+
Helichrysum arenarium				1	+						
Hieracium pilosella	+	+	3	4	4	+	+	1	2		
Hypericum perforatum	+	+	+	1	+	+	+	+	+		
Inula ensifolia										+	+
Jasione montana	+	+	1	+	+						
Jovibarba sobolifera			1			1	1		+		
Juniperus communis		r				r	r	+	+		
Knautia arvensis			+							+	+
Lathyrus pratensis											+
Leontodon hispidus			+	+	+			+	+		
Leucanthemum vulgare											+
Libanotis pyrenaica						1	1				
Linum catharticum								+		+	+
Lotus corniculatus									+	+	
Luzula campestris			+		+			+	+		
Medicago falcata										+	+
Medicago lupulina						+		+			
Melampyrum nemorosum										1	
Onobrychis viciifolia											+
Orobanche sp.											+
Phleum phleoides				2	1	1	1	1	1		
Pimpinella saxifraga					+			+			
Pinus silvestris			r	r		r	r	r	r		
Plantago lanceolata			+		+			+	+	+	
Plantago media										+	1
Poa angustifolia			+	+	2	+	+	3	2	+	+
Poa compressa						+			+		
Poa pratensis				1		1			+		
Polygala vulgaris						+				+	
Potentilla arenaria						1	2		2		
Potentilla argentea			+	+				+	+		

Plant species	Plot										
	1	2	3	4	5	6	7	8	9	10	11
	Spergulo-Cor.		*Diantho-Arm.*			*Festucetum pall.*		*Sileno-Phl.*		*Adonido-Brach.*	
Primula veris											+
Ranunculus bulbosus										+	+
Rhamnus cathartica						r	r	r			
Rumex acetosa				+	+				+		
Rumex acetosella			1	1	+			+			
Salvia pratensis										2	2
Sanguisorba minor					+	+	+	+	+	+	+
Scabiosa ochroleuca			+	+	1	+	+	1	1	+	+
Scleranthus perennis	+	+	+		+						
Sedum acre					1	+					
Sedum sexangulare						1	+	1	+		
Senecio jacobea				+	+			+	+	+	+
Seseli annuum								+			
Silene nutans						+					
Silene otites			1	1	+	+		+	+		
Silene vulgaris							+		+		
Spergula vernalis	+	1									
Stachys recta						+	1				
Teesdalea nudicaulis	+	1	+	+							
Thalictrum minus								+			
Thymus pulegioides					2	1	1	1	1		
Thymus serpyllum			+	+	+						
Tragopogon pratensis									+		
Trifolium arvense			+	1	1			+			
Trifolium campestre					1			+			
Trifolium pratense					+			+			+
Trifolium repens					+						
Verbascum lychnitis			+			+	+	+	+		
Veronica chamaedrys											+
Veronica spicata			+	+	+	+	+	+	1		
Vicia hirsuta				+							
Vincetoxicum hirundinaria						1	+	+	+	+	
Viola sp.						+	+	+	+		
Number of species	**10**	**10**	**32**	**37**	**43**	**44**	**40**	**53**	**47**	**38**	**41**

The *Koelerio glaucae-Corynephoretea canescentis* class represents lowland, initial grasslands of inland lime-poor sandy dunes (Fig. 3). They are typical of free-draining sands and gravels in Western, Central and partly Northern and Eastern Europe. The vegetation mainly consist of acidophilous and xerophilous narrow-leaf grasses, rosette plants, therophytes and succulents together with bryophytes and photophilous lichens. The floristics of the plant assemblages belonging to this class are influenced by both the oceanic and continental climate (Brzeg & Rakowski, 1997).

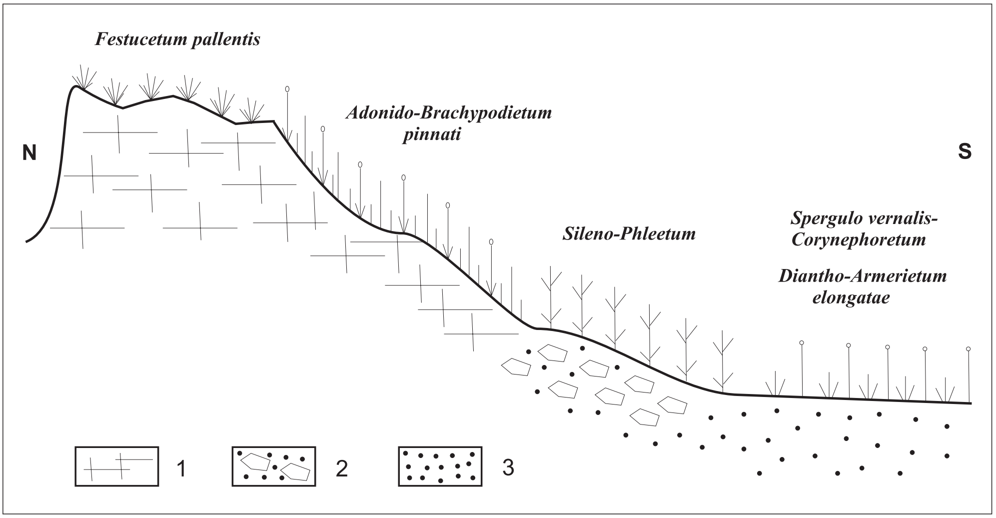


Fig. 3. Occurrence of the investigated plant assemblages in respect to the exposure, slope angle and the type of bedrock (1 – limestone rock, 2 – limestone rock gravel mixed with sand, 3 – sand).

In the northern part of the Częstochowa Upland two plant assemblages of the class – *Spergulo vernalis-Corynephoretum* and *Diantho-Armerietum elongatae* were identified (Babczyńska, 1978) with the following classification:

Class: *Koelerio glaucae-Corynephoretea canescentis* Klika in Klika et Novak 1941
Ordo: *Corynephoretalia canescentis* R.Tx. 1937
Alliance: *Corynephorion canescentis* Klika 1934
Assemblage: *Spergulo vernalis-Corynephoretum* (R.Tx. 1928) Libb. 1933
Alliance: *Vicio lathyroidis-Potentillion argenteae* Brzeg in Brzeg et M. Wojt. 1996
Assemblage: *Diantho-Armerietum elongatae* Krausch 1959

The *Festuco-Brometea* class covers xerothermic grasslands confined in Poland to base soils of limestone or gypsum underlying bedrocks, and specific microclimatic conditions typical for the dry, warm west-exposed sides of hills, river valleys and ravines (Fig. 3). The structure of the assemblage depends greatly on the level of precipitation and the intensity of sunlight. The most extreme places are inhabited by sparse vegetation of tussocky and highly xeromorphic grasses. In contrast, the areas where wetter conditions prevail are characterized by dense grassland cover with dominating mesomorphic grasses and sedges with occasional patches of forbs, which, when flowering, give the vegetation a colourful perspective (Medwecka-Kornaś & Kornaś, 1977).

In Poland, this kind of vegetation occurs in regions where the influence of the continental climate dominates. These are mainly the southern and eastern areas of the country (Śląsk-Kraków upland, Małopolska upland, Lubelska upland, Roztocze) with several stands in the Lower Wisła and Odra valleys. However, most of the xerothermic grasslands in our climatic zone are not climax ecosystems. They are usually of anthropogenic origin, so grazing, cutting and controlled burning prevent the progression of the vegetation to scrub or woodland (Wysocki & Sikorski, 2000; Michalik, 1990).

Five plant assemblages belonging to the class were identified in the northern part of the Częstochowa Upland (Babczyńska, 1978). Three of these were chosen for investigation and their classification is as follows:

Class: *Festuco-Brometea* Br. Bl. et R.Tx. 1943
Ordo: *Festucetalia valesiacae* Br.-Bl. et R.Tx. 1943
Alliance: *Seslerio-Festucion duriusculae* Klika (1931) 1948
Assemblage: *Festucetum pallentis* (Kozł. 1928) Kornaś 1950
Alliance: *Phleion boehmeri* Głowacki 1975
Assemblage: *Sileno-Phleetum* Głowacki 1975
Alliance: *Cirsio-Brachypodion pinnati* Hadač et Klika 1944 em. Krausch 1961
Assemblage: *Adonido-Brachypodietum pinnati* (Libb. 1933) Krausch 1960

Plot 1

An inland sandy dune located to the east of Zamek Hill, where the nature landscape reserve 'Olsztyńskie Skały' is to be established (Hereźniak, 1992)

Plot 2

An inland sandy dune located to the east of the Bliskie Lipówki Hills, near a young pine forest

Floristic description

The vegetation on the above two plots was classified as psammophilous grassland ***Spergulo vernalis-Corynephoretum*.** In Poland, this phytocenosis is restricted to the free-draining, acidic, low humus soils of sandy, inland dunes. It can be also found in places which were previously occupied by a poorer variation of the scots pine forest *Pineto-Vaccinietum myrtilli* (Kornaś, 1957; Czyżewska, 1997). On the area under investigation the above mentioned plant assemblage inhabits glaciofluvial sands at the bottom of the valleys between limestone hills. The herb cover on the investigated plots was not higher than 60%, the moss-lichen cover was 10% (plot 1) and 30% (plot 2).

Xerophilous grass *Corynephorus canescens* was dominant, forming isolated groups which gave the vegetation quite a tussocky character. Between the tussocks there were small carpets of *Hieracium pilosella* together with the species characteristic for the assemblage – *Spergula vernalis* and *Teesdalea nudicaulis*. Other plants occasionally present were *Scleranthus perennis*, *Centaurea stoebe*, *Artemisia campestris* and *Hypericum perforatum*.

Plot 3

An inland sandy dune located to the south-east of Zamek Hill where the nature landscape reserve 'Olsztyńskie Skały' is to be established (Hereźniak, 1992)

Plot 4

Abandoned cultivated area on sandy soil between Bliskie Lipówki Hill and Brodło (Biakło) Hill

Plot 5

Abandoned cultivated area on sandy soil west of Brodło (Biakło) Hill

Floristic description

The vegetation on the above three plots was classified as psammophilous grassland ***Diantho-Armerietum elongatae*.** This plant assemblage follows *Spergulo vernalis-Corynephoretum* in the pine forest succession on inland, sandy areas. It inhabits similar biotopes as the previously mentioned assemblage but prefers places where the soil profile is better developed and fixed by initial vegetation (Babczyńska, 1978). The herb layer cover on the investigated plots reached 80%, the moss-lichen cover ranged from 10% to 30%.

Anthoxanthum odoratum, *Festuca ovina*, *Phleum phleoides* and *Corynephorum canescens* are all common and all are abundant. Together with tall forbs such as *Artemisia campestris* and *Dianthus carthusianorum* they form a 20–40 cm high canopy. Quite frequently there are also small amounts of *Dianthus deltoides* and *Armeria maritima* – two species characteristic for the assemblage. Among shorter species *Helichrysum arenarium* and *Rumex acetosella* are significant. The ground layer is mainly formed by a carpet of *Hieracium pilossella* and *Thymus serpyllum*, their companions, *Sedum acre* and *Thymus pulegioides*, were also present on plot 5.

Plot 6

The upper part of the steep south-eastern slope of Bliskie Lipówki Hill.

Plot 7

The upper part of the steep southern slope of Brodło Hill.

Floristic description

The vegetation on the above two plots was classified as limestone rocky grassland ***Festucetum pallentis.*** It was first described on the limestone hills near Olsztyn by KOZŁOWSKA (1928) and re-researched by BABCZYŃSKA (1978). This pioneer phytocenosis is very local and restricted to the steep slopes of limestone hills, where the thin rendzina soil occurs only in shallow depresions formed during the weathering of the rock. The structure of the underlying limestone bedrock influences the physiognomy of the vegetation, which consists of vascular plants forming irregularly distributed patches. The herb cover on the investigated plots was about 70%, the moss-lichen cover 40% on plot 6 and 50% on plot 7.

Although the assemblage has a three-layer structure, the layers are not well separated. *Potentilla arenaria*, *Jovibarba sobolifera* and *Thymus pulegioides* dominated in the lowest (ground) layer, where *Galium cracoviense* and *Sedum acre* were occasionally also present. Apart from the above mentioned, there was an understorey of *Festuca pallens* (plot 7) and *Festuca ovina* (plot 6) together with higher amounts of *Anthericum ramosum*, *Allium montanum*, *Asperula cynanchica*, *Vincetoxicum hirundinaria* and *Stachys recta*. These were overtopped by tall, flowering dicotyledons such as *Erysimum odoratum*, *Scabiosa ochroleuca* and *Libanotis pyrenaica*.

While both of the described plots represented the *Festucetum pallentis sempervivetosum* variant, plot 6 had the poorer plant composition due to the lack of *Festuca pallens* grass.

Plot 8

Brodło foothill with northern exposure.

Plot 9

Brodło foothill with southern exposure.

Floristic description

The vegetation on the above two plots was classified as limestone grassland ***Sileno-Phleetum*** described for the first time by GŁOWACKI (1975) on an area of the Trzebnickie Hills in south-western Poland. In the surroundings of Olsztyn, it has a transitional character between psammophilous and limestone grasslands (BABCZYŃSKA, 1978) and occurs on gentle slopes in places where sand is mixed with limestone rock rubble. The herb cover on the investigated plots reached 90%, the moss-lichen cover was 10% on plot 8 and 25% on plot 9.

Three grasses, *Poa angustifolia*, *Agrostis capillaris* and *Phleum phleoides,* were very common and of high cover in the described assemblage. The last grass is the characteristic species of the assemblage and the alliance, together with small amounts of *Acinos arvensis* and *Silene otites,* which also made a constant and prominent contribution.

The representatives of *Festuco-Brometea* class played a predominant role in the vegetation including such forbs as *Scabiosa ochroleuca*, *Anthyllis vulneraria*, *Asperula cynanchica*, *Euphorbia cyparissias* and *Veronica spicata* which formed a canopy over the patches of *Thymus pulegioides* and *Sedum sexangulare*.

Plot 10

The south-facing slope of Na Wale Hill near the village of Mstów, where the nature steppe reserve 'Murawa na Górze Wał' is to be established (Hereźniak, 1992), is surrounded by deciduous forest, thermophilous shrubs and meadow; the hill is located in a bend of the the Warta river

Plot 11

The south-western side of a ravine on the outskirts of Mstów where the nature steppe reserve 'Małuski Jar' is to be established (Hereźniak, 1992); bordering a deciduous forest, thermophilous shrubs and apple orchards

Floristic description

The vegetation on the above two plots was classified as limestone grassland ***Adonido-Brachypodietum pinnati.*** In the surroundings of Mstów, this plant assemblage is confined to highly insolated places with southern and western exposures where the rendzinas derived from the limestone parent material have a thick humus layer (Hereźniak *et al.*, 1970). This plant assemblage takes much of its structural and floristic character from traditional grazing and when released from this it can be choked with dead leaf litter (as in plot 11).

Although the floristics of the phytocenosis was quite rich, the mesoxerophilous grass *Brachypodium pinnatum* played the dominant role and was joined by smaller amounts of tall forbs such as *Salvia pratensis*, *Scabiosa ochroleuca* and *Inula ensifolia*. Among shorter herbs *Galium verum*, *Medicago falcata* and *Coronilla varia* were frequent and generally of medium cover. The ground layer consisted of the fairly commonly found *Euphorbia cyparissias*, *Fragaria viridis*, *Asperula cynanchica* and the less common *Carlina acaulis* and *Carlina onopordifolia* (plot 10). The characteristic species of the asssemblage were *Anthyllis vulneraria*, *Plantago media* and *Anemone sylvestris*.

5. MATERIAL AND METHODS

Sampling regime and sampling technique

The quantitative studies lasted over a three-year period, on 9 plots in the years 2001–2003 and on 2 plots in the years 2002–2004, with a similar annual schedule. Insects were collected at regular intervals from the beginning of May till October, generally every fortnight, by use of a standard circular sweep-net (30 cm in diameter). A transect across the plot was taken and invertebrates were sampled at four equidistant points with 100 sweeps in total covering the length of the field. If the field was a square, the transect was laid out in a shape resembling the letter 'X'. Samples were taken on windless, sunny days usually between 11 am and 2 pm.

The vegetation on the plots was surveyed within 10 x 10 m quadrats in the first year of the investigation. This included plant cover estimation according to the Braun-Blanquet scale (Braun-Blanquet, 1964) and, on the basis of this, plant assemblage identification was made. Botanical nomenclature has been adopted from Mirek *et al.* (2002), while geobotanical nomenclature follows that of Matuszkiewicz (2001).

Sampling processing and species identification

The invertebrates were collected alive with an aspirator connected to a glass tube and then transferred to a container containing a cotton pad moistened with small amounts of killing liquid (ethyl acetate). The specimens were stored in glass tubes before being arranged into a drawer collection, which is now housed in the Department of Ecology and Nature Conservation of Jan Długosz University of Częstochowa.

The adult Auchenorrhyncha were identified to the species level using keys covering the fauna of the country or region published by Dlabola (1954), Logvinenko (1975), Ossiannilsson (1978, 1981, 1983), Holzinger *et al.* (2003), Biedermann and Niedringhaus (2004) and particular papers referring to such genera as *Ribautodelphax* (Bieman, 1987), *Aphrodes* (Tishechkin, 1998), *Forcipata* (Gnezdilov, 2000), *Eupteryx* (Le Quesne, 1974), *Macrosteles* (Gajewski, 1961), *Doratura* (Dworakowska, 1968a), *Fieberiella* (Dlabola, 1965), *Rhopalopyx* (Dmitriev, 1999), *Elymana* (Dworakowska, 1968b), *Laburrus* (Tishechkin, 2002), *Euscelis* (Remane, 1967) and *Arthaldeus* (Remane, 1960).

In order to identify Auchenorrhyncha species it was necessary to remove the genital segment, which was then macerated in 10% KOH in line with the procedure described by Knight (1965). The genital capsule was opened to facilitate viewing of the genital structures and particular parts were examined in a drop of glycerine on a microscope slide. It was also necessary to detach the male song apparatus for some difficult genera (e.g. *Macrosteles*).

The systematic list of Auchenorrhyncha presented in this study has been adopted from Nast and Chudzicka (1990).

Analysis

Dominance

To examine the dominance structure of communities, the index of dominance (D) was used:

$$D = \frac{n}{N} \times 100\% \qquad (1)$$

where:

n – number of individuals of the species

N – number of individuals of all species of the community

Four classes of species were distinguished according to the index of dominance (D) and their proportions were as follows:

- eudominant – over 30.0%
- dominant – from 20.1% to 30.0%
- subdominant – from 10.1% to 20.0%
- recedent – from 5.1% to 10.0%
- subrecedent – up to 5.0%

Frequency

The frequency formula (F) proposed by TISCHLER (1949) was used to assess the occurrence of species in samples from a given plot. It is measured as:

$$F = \frac{p}{P} \times 100 \qquad (2)$$

where:

p – number of samples containing a particular species

P – number of all samples

Frequency classes were distinguished according to the frequency values and were as follows:

- frequency class I – over 75.1%
- frequency class II – from 50.1% to 75.0%
- frequency class III – from 25.1% to 50.0%
- frequency class IV – up to 25.0%

Q index

In order to clarify the dominance structure, the Q index was calculated by combining the frequency (F) with dominance (D) to obtain the geometric mean.

$$Q = \sqrt{F \times D} \qquad (3)$$

Fidelity

The fidelity formula (W) expressed quantitatively was used to identify characteristic (preferential) species of particular habitats:

$$W = \frac{a}{b} \times 100 \quad (4)$$

where:

a – abundance of a particular species in a particular habitat

b – total abundance of the species in all the habitats

Species with a value W not lower than 51% were regarded as characteristic (preferential) for a particular community.

Species diversity

The diversity of communities was measured according to the following indices:

■ The Shannon-Weaver index of real species diversity H' (Shannon & Weaver, 1949). This index assesses the structure of fauna in respect to the species richness and the evenness of the abundance distribution between particular species (Trojan, 1992, 1994):

$$H' = -\sum_{i=1}^{S} p_i \log p_i \quad (5)$$

where:

p_i – the abundance of i-th species to total abundance of the community consisting of S species

The potential diversity of communities (H_{max}), which is also a maximum value of the index H', equals log$S$. The Pielou's index (J) – eveness – was used to determine the degree to which potential diversity was realized by particular communities (Trojan, 1992)

$$J = \frac{100H'}{H_{\max}} \quad (6)$$

where:

H' – real species diversity (as in 5)

H_{max} – potential species diversity

■ Brillouin's species diversity index ($\hat{H}$)

Pielou (1974) emphasizes that the Shannon-Weaver index is not appropriate for faunistic samples, which are finite sets for a known number of species. The formula proposed by Brillouin (1962) is more useful:

$$\hat{H} = \frac{1}{N}\log\left(\frac{N!}{n_1!n_2!n_3!...n_S!}\right) \quad (7)$$

where:

N – number of all specimens in the sample

n_S – number of specimens of a particular species in a sample

- Simpson's species diversity index *(I)*

To calculate Simpson's species diversity index (Simpson, 1949), the probe species diversity index proposed by Pielou (1975) was used:

$$I' = 1 - \sum_{i=1}^{S}\left[\frac{n_i(n_i - 1)}{N(N-1)}\right] \quad (8)$$

where:

n_i – number of specimens of the i-species in a sample

N – the overall number of specimens in a sample

To estimate the maximum probe species diversity index in a particular community the following formula was used:

$$I_p = 1 - \frac{S\{\overline{n_i}(\overline{n_i} - 1)\}}{N(N-1)} \approx 1 - \frac{1}{S} \quad (9)$$

symbols as in 8

In order to estimate the deviation of the real state of the community from the potential one, the following equation was used:

$$dI = \frac{I'}{I_p}100\% \quad (10)$$

where:

I' – probe species diversity index

I_p – potential species diversity index

Statistics

Correlations between vegetation parameters and the abundance of leafhoppers were calculated using the Pearson correlation test (Program STATISTICA).

Comparisons between leafhopper communities among the plots were made using Euclidean distance. The data were log (n+1) transformed. The resemblance matrices were then analyzed in a hierarchical cluster analysis (Program STATISTICA), employing Ward's method.

Additionally, principal component analysis (PCA) was conducted to assess the relative similarity across the various sites (Program MVSP-3.1).

Chorology

Chorological analysis was done to estimate the percentage ratio of particular chorological elements in relation to the species set recorded from the whole area under investigation as well as the species sets associated with the surveyed grasslands. However, in respect of the latter, only those species recorded on all the plots representing the same type of plant assemblage were taken into consideration. The criteria of zoogeographic classification are in line with those proposed by Nickel and Remane (2002) which reflect the close relationship of leafhopper species with the main vegetational formations. The term 'species range' is defined here as an area covering the dispersion centre and having the highest density of natural origin sites; less densely populated ones located in the peripheral regions within the range are of less importance. Each species was classified as one of the following 11 range elements:

- European – European deciduous forest zone
- Northern European – North European tundra and bog region
- Western European – western European heath and coastal region
- Southern European – southern parts of the European deciduous forest zone
- Kazakh – central Asian steppes; in central Europe confined to dry and sunny habitats
- Siberian – Siberian taiga zone; in central Europe confined to cool habitats
- Eurosiberian – coniferous and deciduous forest zones of Siberia and Europe
- Western Palaearctic – western or south western parts of the Palaearctic
- Transpalaearctic – throughout the Palaearctic or large parts of it
- Mediterranean – the area of the Mediterranean Sea basin
- Holarctic – throughout the northern continents of the world

Ecology

The aim of the ecological analysis was to assess the percentage ratio of particular ecological elements in relation to the species sets associated with the surveyed grasslands. Although similar to the chorological analysis, only those species recorded on all the plots representing the same type of plant assemblage were taken into consideration.

Particular leafhopper species were classified according to the following ecological requirements: moisture, insolation, host plant specialization, voltinism and overwintering stage. The classification was mainly based on the authors' investigations and data from numerous papers concerning the leafhopper fauna of Poland. However, in some cases (diet width, overwintering stage) they were supplemented with findings from Germany (Nickel, 2003).

In respect of the moisture requirements the following elements were distinguished:

- hygrophilous – species preferring moist or damp habitats
- mesohygrophilous – species found in habitats with different moisture levels
- xerophilous – species of dry environments

Regarding the insolation preferences the following elements were distinguished:

- heliophilous – species of open areas requiring great light intensity
- mesoheliophilous – species occurring in sunny places but also occasionally shade-tolerant
- skiophilous – shade-seeking species, often under a dense tree canopy

The range of food specialization involved the following groups:

- polyphagous – species utilizing a wide range of plant families
- oligophagous – species utilizing no more than 5 plant families
- monophagous – species utilizing 1 plant species or 1 plant genus

In respect of the number of annual generations, the following criteria were considered:

- univoltine species – one generation per year (1)
- bivoltine species – two generations per year (2)

Regarding overwintering, the following stages were taken into consideration:

- egg
- nymph
- adult

All calculations were made using software belonging to the Department of Ecology and Nature Conservation of Jan Długosz University of Częstochowa (MS OFFICE) and the Faculty of Biology and Environmental Protection of the University of Silesia in Katowice (STATISTICA, MVSP ver. 3.1).

6. RESULTS

6.1. General results

Overall, 396 samples, containing 19 411 adults representing 112 species were taken in the study (Table 3).

Table 3. Leafhopper species recorded on the study plots.

Leafhopper species	Plot											Sum
	1	2	3	4	5	6	7	8	9	10	11	
	Spergulo-Cor.		*Diantho-Arm.*			*Festucetum pall.*		*Sileno-Phl.*		*Adonido-Brach.*		
Cixius nervosus							2				1	3
Tachycixius pilosus											2	2
Kelisia guttula											24	24
Kelisia guttulifera				1								1
Anakelisia perspicillata							1	12			1	14
Stenocranus major				5		2	1	6	4	12	40	70
Eurysa lineata						11						11
Metropis inermis								1				1
Chloriona vasconica			1									1
Megadelphax sordidula	2		3	1	2	1	1	45	2	1	16	74
Laodelphax striatella	4	7	9	20	7	3	7	5	13	3	4	82
Hyledelphax elegantula										1	1	2
Mirabella albifrons								1				1
Muirodelphax aubei	20	195	4	5	2							226
Acanthodelphax spinosa				1	27			227	20		1	276
Dicranotropis hamata							1					1
Kosswigianella exigua	2	9	11	10	9		2	65	101		4	213
Criomorphus albomarginatus								4				4
Javesella pellucida	4		10	35	8	3	4	37	58	2	7	168
Ribautodelphax albostriata				55	6	5		179	8		43	296
Ribautodelphax angulosa	16		8		8							32
Ribautodelphax collina	14	19	233	71	94	2		94	67			594
Ribautodelphax pungens										13	12	25
Tettigometra atra			5									5
Tettigometra impressopunctata						2						2
Cercopis sanguinolenta					1			1	1	1	2	6
Neophilaenus campestris				1			1					2
Neophilaenus exclamationis		3	2	2	1					2		10
Neophilaenus lineatus								1	1			2

Leafhopper species	Plot											Sum
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
	Spergulo-Cor.		*Diantho-Arm.*			*Festucetum pall.*		*Sileno-Phl.*		*Adonido-Brach.*		
Neophilaenus minor	232	333	49	17	2		3					636
Aphrophora alni								1		26	74	101
Philaenus spumarius					2		11	1		2		16
Centrotus cornutus						1						1
Utecha trivia			1	1		3		14		12	3	34
Utecha lugens	2		1							2		5
Megophthalmus scanicus				5	5			2	2			14
Agallia brachyptera											2	2
Anaceratagallia ribauti	11	10	16	45	19		16		1			118
Anaceratagallia venosa		29	127	34	41	126	3			1		361
Eupelix cuspidata	1	2		2	2							7
Aphrodes bicincta	1	1	13	14	8	12	9	5	4	5	4	76
Aphrodes makarovi		1	5	2		2		2		2		14
Planaphrodes trifasciata	1				1	1						3
Anoscopus albifrons								1				1
Anoscopus flavostriatus											1	1
Cicadella viridis											2	2
Erythria aureola	1				42	245	150	2	99	1		540
Emelyanoviana mollicula			3		1	236	265	40	51	78	39	713
Dikraneura variata			2					7	2			11
Micantulina stigmatipennis						30	1		2			33
Wagneriala incisa							1					1
Forcipata citrinella			1	1			2	15	26	1	1	47
Empoasca affinis							2					2
Empoasca pteridis		5	7	8	5	63	231	10	12	24	10	375
Empoasca vitis							2					2
Austroasca vittata						1						1
Chlorita paolii	21	7	66	311	214	54	1	10	71	10		765
Linnavuoriana decempunctata										1		1
Linnavuoriana sexmaculata		1										1
Eupteryx atropunctata			1		1		2	1			1	6
Eupteryx notata	2	2	10	65	51	8	3	25	20		3	189
Eupteryx stachydearum							1					1
Eupteryx tenella						5						5
Zygina flammigera							4				1	5
Zygina hyperici		3		31	11	12	33	18	26		6	140
Zygina ordinaria							2					2

Leafhopper species	Plot											Sum
	1	2	3	4	5	6	7	8	9	10	11	
	Spergulo-Cor.		*Diantho-Arm.*			*Festucetum pall.*		*Sileno-Phl.*		*Adonido-Brach.*		
Zygina rubrovittata						1						1
Neoaliturus fenestratus	9	42	277	149	286	20	15		6			804
Balclutha calamagrostis			3	1	1	4	3	10	7	3	7	39
Balclutha punctata									1			1
Macrosteles laevis	684	404	179	95	178	10	21	13	55	21	17	1677
Macrosteles quadripunctulatus	1				3							4
Macrosteles sexnotatus	6		1									7
Deltocephalus pulicaris								1				1
Recilia coronifera											3	3
Doratura exilis	194	68	81	14	1	1	2				1	362
Doratura homophyla	8	6	54	25	11							104
Doratura impudica		2	8	13								23
Doratura stylata	8	7	42	168	162	2	2	174	66	7	11	649
Fieberiella septentrionalis						15	69					84
Allygus communis							1				1	2
Graphocraerus ventralis		2	1	19	4			4				30
Hardya tenuis	1	1								1		3
Rhopalopyx preyssleri						1		35			11	47
Rhopalopyx vitripennis	5	11	25	7	15		5	1	48		1	118
Elymana sulphurella			4	7	5			5	1	3	30	55
Cicadula flori											1	1
Cicadula persimilis	1			3	7				2	1		14
Cicadula quadrinotata				7								7
Mocydiopsis parvicauda									1		1	2
Athysanus argentarius											11	11
Athysanus quadrum											1	1
Ophiola decumana			1									1
Ophiola transversa			4	3	6							13
Laburrus impictifrons	2	7		40	24							73
Euscelis distinguendus	1	7	12	5	4						1	30
Euscelis incisus			5	3	5							13
Arocephalus languidus	1		3	244	84	383	106	30	323	1	1	1176
Arocephalus longiceps		2	1	1		33			1	42	7	87
Psammotettix alienus	151	204	98	51	39		5		13	6	1	568
Psammotettix cephalotes	19	9	451	98	87			8	1		6	679
Psammotettix confinis	103	81	46	24	36	1		3	13	2	2	311
Psammotettix excisus	1220	1760	174	3	47	9			2	1		3216

Leafhopper species	Plot											Sum
	1	2	3	4	5	6	7	8	9	10	11	
	Spergulo-Cor.		Diantho-Arm.			Festucetum pall.		Sileno-Phl.		Adonido-Brach.		
Psammotettix nodosus	15	8	255	4	41				1			324
Ebarrius cognatus							2					2
Adarrus multinotatus										259	239	498
Errastunus ocellaris			3		3			5	1	1	11	24
Turrutus socialis	5	19	144	483	213	158	85	514	138	4		1763
Jassargus pseudocellaris			1	4				11	10			26
Verdanus abdominalis								1				1
Arthaldeus pascuellus				3				4				7
Mocuellus collinus	12		13	133	9				1		1	169
Number of adults	2780	3267	2474	2350	1841	1466	1078	1651	1282	552	670	19411
Number of nymphs	122	158	308	317	190	162	147	255	100	125	118	2002
Number of species	36	34	50	52	50	36	41	46	42	35	49	

Regarding abundance, the highest percentage ratio was reached by *Psammotettix excisus* (16.57%), the second and third place gained *Turrutus socialis* (9.08%) and *Macrosteles laevis* (8.64%), respectively. At the same time, 49 species (43.36%) were represented by less than 10 individuals. The highest number of leafhopper specimens (3267) was collected on plot 2 (*Spergulo vernalis-Corynephoretum*), the lowest on plot 10 (*Adonido-Brachypodietum pinnati*) – 552 (Table 4). The highest number of species (52) was reported from plot 4 (*Diantho-Armerietum elongatae*), the lowest number of species (34) from plot 2 (*Spergulo vernalis-Corynephoretum*). The number of collected nymphs ranged from 100 individuals on plot 9 (*Sileno-Phleetum*) to 317 on plot 4 (*Diantho-Armerietum elongatae*). Additionally, there was a positive correlation between: 1) the species richness of the Auchenorrhyncha fauna and the number of recorded plant species from the vegetation quadrats (Fig. 4) and 2) the number of Auchenorrhyncha species and the average vegetation height (Fig. 5).

Table 4. Number of leafhopper adults collected on particular plots in all three investigating seasons.

Year	Plot											Total
	1	2	3	4	5	6	7	8	9	10	11	
2001	407	–	294	409	461	389	378	409	376	–	260	3383
2002	1870	2232	1503	986	919	415	408	757	469	221	160	9940
2003	503	594	677	955	461	662	292	485	437	64	250	5380
2004	–	441	–	–	–	–	–	–	–	267	–	708

Finally, carrying out the investigation during the full growing season also made it possible to follow phenological changes in the Auchenorrhyncha fauna in particular plant assemblages.

Fig 4. The relationship between Auchenorrhyncha species richness and plant species richness ($y = 0.16x + 23.21$; $r = 0.31$; $P < 0.005$).

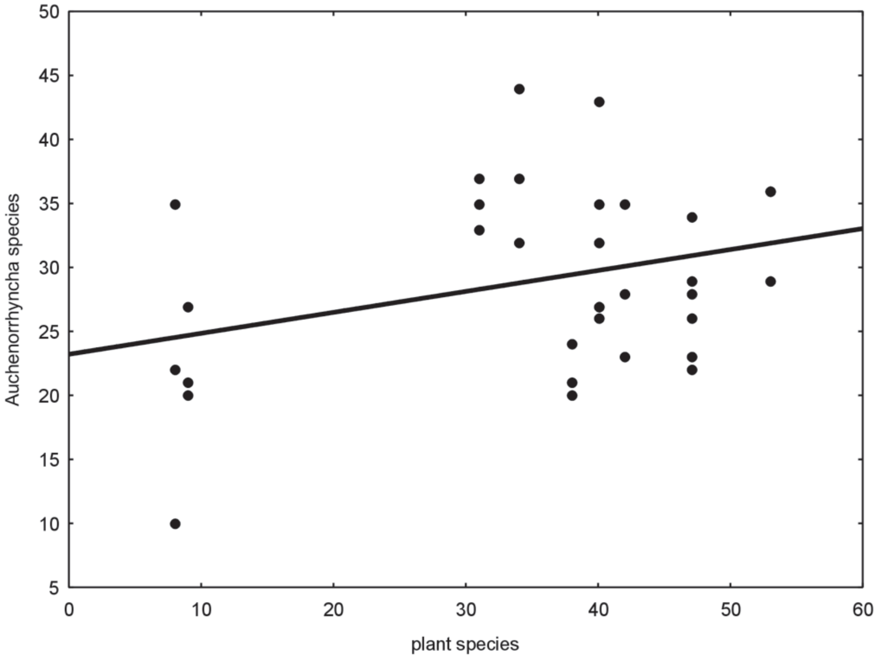
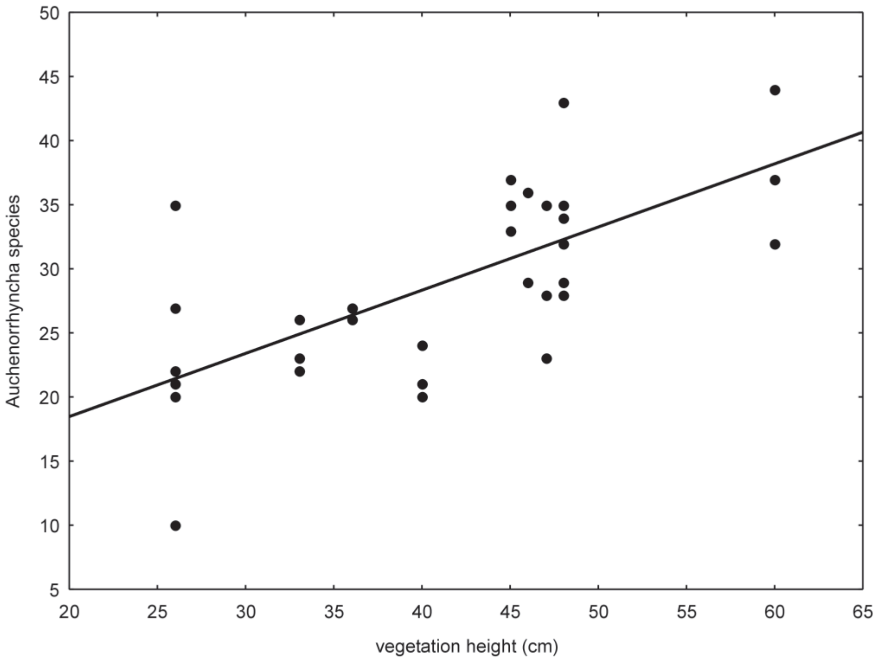


Fig 5. The relationship between the number of Auchenorrhyncha species and the mean vegetation height ($y = 0.49x + 18.61$; $r = 0.67$; $P < 0.005$).



6.2. Leafhopper community linked to psammophilous grassland *Spergulo vernalis-Corynephoretum*

Plot 1

Overall, 2780 Auchenorrhyncha adults belonging to 36 species and 122 nymphs were collected on plot 1 in the years 2001–2003 (Table 3, Table 4).

The eudominant species during all three growing seasons was *Psammotettix excisus* (62.41%, 37.86%, 51.29%) (Annex 1). *Doratura exilis* subdominated in 2001 (17.20%) and 2003 (10.74%). *Macrosteles laevis* was eudominat in 2002 (35.08%) and *Naeophilaenus minor* was ranked as dominant in 2003 (21.67%).

Two species were in the I-st frequency class in 2001 – *Psammotettix excisus* (100.00%) and *Neophilaenus minor* (77.78%). In 2002, *Psammotettix excisus* (91.67%) and *Macrosteles laevis* (83.33%) made the I-st frequency class, while the following were classified in the II-nd frequency class: *Neophilaenus minor* (75.00%), *Psammotettix alienus* (58.33%) and *Psammotettix confinis* (58.33%). In 2003, only *Psammotettix excisus* (81.82%) was in the I-st frequency class, and two species, *Neophilaenus minor* (72.73%) and *Macrosteles laevis* (54.55%), were in the II-nd frequency class.

The highest values of the Q index were obtained by *Psammotettix excisus* (79.00, 58.91, 64.78) on plot 1 in all three seasons.

The occurence dynamic of dominants on plot 1 was as follow (Annex 12): *Psammotettix excisus* had two dominance peaks – the first in June and the second in the first half of August; *Doratura exilis* peaked at the beginning of July; *Macrosteles laevis* and *Neophilaenus minor* had only one dominance maximum – at the beginning of October and in the middle of June respectively.

Plot 2

Overall, 3267 Auchenorrhyncha adults belonging to 34 species and 158 nymphs were collected on plot 2 in the years 2002–2004 (Table 3, Table 4).

Psammotettix excisus achieved the status of eudominant in all three seasons (56.99, 47.81, 46.26%) (Annex 2). *Neophilaenus minor* fulfilled the criteria of subdominant in 2003 (16.50%) and was classified as eudominant in 2004 (41.95%). *Macrosteles laevis* was listed as subdominant in 2002 (17.38%), as was *Psammotettix alienus* in 2003 (12.79%).

Two species were in the I-st frequency class over a three-season period – *Neophilaenus minor* (81.82, 80.00, 81.82%) and *Psammotettix excisus* (100.00, 90.00, 90.91%). In 2002, *Macrosteles laevis* also achieved this rank (81.82%).

The highest value of the Q index on plot 2 in all three seasons was obtained by *Psammotettix excisus* (75.49, 65.60, 64.85).

The occurence dynamic of dominants on plot 2 was as follow (Annex 13): *Psammotettix excisus* had two dominance peaks – the first in the middle of June, the second at the turn of August and September; *Neophilaenus minor* had one dominance maximum at the beginning of July (2003) and September (2004); *Macrosteles laevis* and *Psammotettix alienus* peaked only once during the three-year period – at the beginning of October.

Description of the community

The leafhopper community associated with psammophilous grassland *Spergulo vernalis-Corynephoretum* was described on the basis of research carried out on plots 1 and 2. Altogether, 45 leafhopper species were recorded with 25 taxa common to both sites. The core of the community are two dominants in the I-st frequency class – *Psammotettix excisus* and *Neophilaenus minor*, other species were classified in lower ranks. The charcteristic species of the community were *Neophilaenus minor* and *Psammotettix excisus* – both with high fidelity and trophically linked to *Corynephorus canescens* (Annex 23).

In spring, community fauna is formed mainly by *Psammotettix excisus* (1^{st} gen.) and *Neophilaenus minor*. Early summer fauna consists of *Doratura exilis* and *Macrosteles laevis* (1^{st} gen.), late summer of *Psammotettix confinis* and *P. excisus* (2^{nd} gen.). Two species – *Macrosteles laevis* (2^{nd} gen.) and *Psammotettix alienus* dominate in Autumn.

The highest number of specimens was collected in June (101–192) and at the beginning of August (103–363). The highest number of species (10–12) was observed in July and September.

6.3. Leafhopper community linked to psammophilous grassland *Diantho-Armerietum elongatae*

Plot 3

Overall, 2474 Auchenorrhyncha adults belonging to 50 species and 308 nymphs were collected on plot 3 in the years 2001–2003 (Table 3, Table 4).

Psammotettix cephalotes was classified as dominant in 2002 (23.35%) and as subdominant in 2003 (11.52%) (Annex 3). *Psammotettix excisus* achieved the status of subdominant only in the 2001 season (15.31%). In 2002, *Ribautodelphax collina* (14.77%) and *Psammotettix nodosus* (12.44%) fulfilled the same criteria. *Neoaliturus fenestratus* was classified as dominant in the 2003 season (27.77%).

In 2001, two species were classified in the I-st frequency class – *Neophilaenus minor* and *Psammotettix excisus* (88.89%). Four species achieved this class in 2002 – *Psammotettix cephalotes*, *Psammotettix excisus*, *Psammotettix nodosus* and *Mocuellus collinus* (83.33%), but, in 2003, only *Neoaliturus fenestratus* (81.82%) made the I-st frequency class.

The highest values of the Q index were obtained by *Neoaliturus fenestratus* (47.67), *Psammotettix cephalotes* (44.11) and *Psammotettix excisus* (36.89).

The occurence dynamic of dominants on plot 3 was as follow (Annex 14): *Psammotettix cephalotes* had two dominance maxima – the first at the beginning of

June, the second in the middle of August; *Psammotettix excisus* also had two dominance peaks – at the beginning of July and September; *Ribautodelphax collina* dominated at the beginning of May and July; *Psammotettix nodosus* peaked at the beginning of June and in August; *Neoaliturus fenestratus* had dominance peaks in the middle of June and at the beginning of October.

Plot 4

Overall, 2350 Auchenorrhyncha adults belonging to 52 species and 317 nymphs were collected on plot 4 in the years 2001–2003 (Table 3, Table 4).

Turrutus socialis fulfilled the criteria of subdominant (10.76%) in 2001, but was listed as dominant in the 2002 (24.95%) and 2003 seasons (20.21%) (Annex 4). The typhlocybid species *Chlorita paolii* became a dominant in 2001 (24.21%), but was regarded as subdominant (13.93%) in 2003. *Neoaliturus fenestratus* and *Arocephalus languidus* achieved the status of a subdominant only in one season (10.51% – 2001, 16.86% – 2003 respectively).

Only *Turrutus socialis* (88.89, 91.67, 81.82%) was in the I-st frequency class in all three seasons. *Chlorita paolii* was in the same class in 2001 (100.00%) and 2003 (90.91%). *Eupteryx notata* was classified in the I-st frequency class in 2001 (88.89%) and *Arocephalus languidus* in 2003 (81.82%).

The highest values of the Q index were obtained by *Chlorita paolii* (49.20), *Turutus socialis* (47.82) and *Arocephalus languidus* (37.14).

The occurence dynamic of dominants on plot 4 was as follow (Annex 15): *Turrutus socialis* had two dominance peaks – the first in June, the second at the beginning of September; *Chlorita paolii* had two dominance maxima – the first in the middle of June (2001) and at the beginning of June (2003), the second at the beginning of August (2001) and in the middle of September (2003); *Arocephalus languidus* peaked at the beginning of June and in the middle of August.

Plot 5

Overall, 1841 Auchenorrhyncha adults belonging to 50 species and 190 nymphs were collected on plot 5 in the years 2001–2003 (Table 3, Table 4).

Neoaliturus fenestratus had the status of a dominant in 2001 (26.25%) and a subdominant in 2002 (10.23%) and 2003 (15.40%) (Annex 5). *Chlorita paolii* fulfilled the criteria for a dominant in 2001 (22.56%), but was listed as a subdominant (15.84%) in 2003. *Turrutus socialis* was a subdominant in 2002 (15.67%) and 2003 (11.06%). The species which had a subdominance grade in only one season were *Macrosteles laevis* (18.17%) and *Doratura stylata* (15.18%).

In 2001, *Chlorita paolii* was the only species to appear in the I-st frequency class (88.89%). In 2002, *Arocephalus languidus* and *Psammotettix cephalotes* (83.33%) were in this class but, in 2003, only *Turrutus socialis* was classified in the I-st frequency class.

The highest values of the Q index were obtained by *Chlorita paolii* (44.78), *Neoaliturus fenestratus* (41.83), *Macrosteles laevis* (34.81) and *Turrutus socialis* (34.28).

The occurence dynamic of dominants on plot 5 was as follow (Annex 16): *Neoaliturus fenestratus* dominated in June and at the beginning of October; *Chlorita paolii* peaked in the middle of May (2003)/June (2001) and at the beginning of August (2001)/September (2003); *Turrutus socialis* had two dominance maxima – the first in June, the second at the turn of August and September; *Macrosteles laevis* had its only maximum at the beginning of October; *Doratura stylata* reached its dominance maximum at the beginning of July.

Description of the community

The leafhopper community associated with psammophilous grassland *Diantho-Armerietum elongatae* was described on the basis of research carried out on plots 3, 4 and 5. Altogether, 67 leafhopper species were recorded with 34 taxa common to all three sites. The core of the community is formed by dominants in the I-st or II-nd frequency classes – *Chlorita paolii*, *Neoaliturus fenestratus* and *Turrutus socialis*. Several species such as *Kelisia guttulifera*, *Chloriona vasconica*, *Tettigometra atra*, *Cicadula quadrionotata* and *Ophiola decumana* did appear in this type of vegetation, but in small numbers and only on one plot. Since they did not show a close trophic relation with the plants, they were regarded as accidental in this type of plant assemblage. The only exception could be *Tettigometra atra* – a termophilous species associated with ant nests. The characteristic species of the community were *Chlorita paolii* and *Laburrus impictifrons* – trophically associated with *Artemisia campestris* – together with *Eupteryx notata* and *Neoaliturus fenestratus* which feed on *Hieracium pilosella* (Annex 23).

Early spring fauna is represented mostly by delphacid species with *Ribautodelphax albostriata* and *R. collina* in highest abundance. Late spring fauna is characterised by 1st generations of *Anaceratagallia venosa*, *Chlorita paolii*, *Eupteryx notata*, *Arocephalus languidus*, *Psammotettix cephalotes*, *P. excisus*, *P. nodosus*, *Turrutus socialis* and *Mocuellus collinus*. Summer is typical for the 2nd generations of *Ribautodelphax albostriata*, *R. collina*, *Chlorita paolii*, *Doratura homophyla*, *Psammotettix cephalotes*, *P. excisus* and *P. nodosus* and 1st generations of *Macrosteles laevis*, *Doratura exilis*, *D. impudica* and *D. stylata*. Autumn fauna is formed mainly by the 2nd generations of *Anaceratagallia ribauti*, *Eupteryx notata*, *Neoaliturus fenestratus*, *Macrosteles laevis*, *Arocephalus languidus*, *Psammotettix alienus*, *Turutus socialis* and *Mocuellus collinus*.

6.4. Leafhopper community linked to limestone rocky grassland *Festucetum pallentis*

Plot 6

Overall, 1466 Auchenorrhyncha adults belonging to 36 species and 162 nymphs were collected on plot 6 in the years 2001–2003 (Table 3, Table 4).

Erythria aureola was a subdominant in the 2001 (13.37%) and 2002 (13.25%) seasons, but achieved the status of a dominant (20.85%) in the 2003 season (Annex 6). *Arocephalus languidus* was classified as a subdominant in 2001 (11.83%) and as a eudominant in 2002 and 2003 (30.84% and 31.57% respectively). *Emelyanoviana mollicula* fulfilled the criteria of eudominant in 2001 (33.93%) and was listed as a dominant in 2002 (16.63%). *Turrutus socialis* was regarded as a subdominant in 2002 (13.25%) and 2003 (13.75%).

Only *Erythria aureoli* was in the I-st frequency class in all three seasons (100.00, 88.89, 81.82). In 2001 and 2002, two other species were also in this classs – *Emelyanoviana mollicula* (88.89, 100.00%) and *Arocephalus languidus* (77.78, 88.89%). *Turrutus socialis* belonged to the I-st frequency class in 2002 and 2003 (88.89, 90.91%).

The highest values of the Q index were obtained by *Emelyanoviana mollicula* (54.92), *Arocephalus languidus* (52.36) and *Erythria aureola* (41.30).

The occurence dynamic of dominants on plot 6 was as follow (Annex 17): *Erythria aureola* had two dominance maxima – the first in June, the second at the turn of August and September; *Arocephalus languidus* peaked twice during the growing season – firstly in June, secondly at the beginning of September; *Emelyanoviana mollicula* dominated in June and at the turn of August and September; *Turrutus socialis* achieved dominance peaks at the beginning of June and September.

Plot 7

Overall, 1078 Auchenorrhyncha adults belonging to 41 species and 147 nymphs were collected on plot 7 in the years 2001–2003 (Table 3, Table 4).

Emelyanoviana mollicula was an eudominant in 2001 (30.42%), a dominant in 2002 (28.68%) and a subdominant in 2003 (11.30%) (Annex 7). *Erythria aureola* was classified as a subdominant (12.99%) in the 2002 season and had the status of a dominant (22.26%) in the 2003 season. *Empoasca pteridis* was listed as a dominant in 2001 (28.84%) and 2002 (23.53%). Two species fulfilled the criteria for a subdominant only in one season (2003) – *Arocephalus languidus* (15.75%) and *Turrutus socialis* (16.44%).

In 2001, two species made the I-st frequency class – *Emelyanoviana mollicula* (90.91%) and *Fieberiella septentrionalis* (90.91%). Four species fulfilled the criteria for the I-st frequency class in 2002 – *Erythria aureola* (88.89%), *Emelyanoviana mollicula* (100.00%), *Arocephalus languidus* (88.89%) and *Turrutus socialis* (88.89%). This same rank was held by *Erythria aureola* (81.82%) and *Turrutus socialis* (90.91%) in the 2003 season.

The highest values of the Q index were obtained by *Emelyanoviana mollicula* (53.55), *Empoasca pteridis* (42.84) and *Erythtria aureola* (42.68).

The occurence dynamic of dominants on plot 7 was as follow (Annex 18): *Emelyanoviana mollicula* had its dominance maxima in the middle of May and at the beginning of September; *Erythria aureola* peaked twice during the growing season – in June and at the beginning of September; *Empoasca pteridis* had its highest abundance peak at the turn of August and September; *Arocephalus languidus* and *Turrutus socialis* were most abundant in June and at the beginning of September.

Description of the community

The leafhopper community associated with rocky limestone grassland *Festucetum pallentis* was described on the basis of the research carried out on plots 6 and 7. Altogether, 56 leafhopper species were recorded with 21 taxa common to both sites. The basis of the community was formed by two typhlocybid dominants in the I-st frequency class – *Erythria aureola* and *Emelyanoviana mollicula*. The species which were reported only from this community were *Eurysa lineata*, *Dicranotropis hamata*, *Tettigometra impressopunctata*, *Centrotus cornutus*, *Wagneriala incisa*, *Empoasca affinis*, *Empoasca vitis*, *Austroasca vittata*, *Eupteryx stachydearum*, *Eupteryx tenella*, *Zygina ordinaria*, *Zygina rubrovittata*, *Fieberiella septentrionalis* and *Ebarrius cognatus*, but apart from *Fieberiella septentrionalis*, they were collected in small numbers and only on one plot. As such they were regarded as accidental in this type of vegetation with the exception of *Tettigometra impressopunctata*, *Wagneriala incisa* and *Ebarrius cognatus,* which prefer dry and warm habitats on limestone bedrock. The characteristic species of the community are *Erythria aureola* and *Emelyanoviana mollicula* trophically associated with the representatives of the mint family (Lamiaceae), *Micantulina stigmatipennis* feeding monophagously on *Verbascum lychnitis* and *Fiebriella septentrionalis* which here utilizes *Vincetoxicum hirundinaria* (Annex 23).

Spring fauna of the community is characterized by the first peak of abundance of *Turrutus socialis* and *Arocephalus languidus* species together with the 1st generations of *Erythria aureola*, *Emelyanoviana mollicula* and *Micantulina stigmatipennis*. Late summer is the beginning of the 2nd generations of several species which reach their highest abundance levels during the autumn. These are: *E. aureola*, *E. mollicula*, *A. languidus* and *T. socialis*.

6.5. Leafhopper community linked to limestone grassland *Sileno-Phleetum*

Plot 8

Overall, 1651 Auchenorrhyncha adults belonging to 46 species and 255 nymphs were collected on plot 8 in the years 2001–2003 (Table 3, Table 4).

Turrutus socialis had the status of a dominant in 2001 (27.38%), but was classified as an eudominant in 2002 and 2003 (30.25 and 35.67% respectively) (Annex 8). *Acanthodelphax spinosa* was a dominant in the 2002 season (20.08%) and fulfilled the criteria for a subdominant in 2003 (12.99%). The species which subdominated or dominated in only one year were *Megadelphax sordidula* (2001 – 10.76%), *Ribautodelphax albostriata* (2002 – 14.80%) and *Doratura stylata* (2003 – 20.62%).

Turrutus socialis (88.89, 81.82, 81.82%) was in the I-st frequency class in all three seasons. In contrast, *Emelyanoviana mollicula* fulfilled the same criteria only in 2001 (100.00%).

The highest values of the Q index were obtained by *Turrutus socialis* (49.34, 49.75, 54.02) and *Acanthodelphax spinosa* (35.75).

The occurrence dynamic of dominants on plot 8 was as follow (Annex 19): *Turrutus socialis* had two dominance peaks – the first in June and the second much higher peak at the turn of August and September; *Acanthodelphax spinosa* peaked in May and at the beginning of August; *Megadelphax sordidula* reached its only abundance maximum in the middle of August; *Ribautodelphax albostriata* had two abundance peaks – the first at the beginning of May, the second in July; *Doratura stylata* had one abundance maximum in the middle of July.

Plot 9

Overall, 1282 Auchenorrhyncha adults belonging to 42 species and 100 nymphs were collected on plot 9 in the years 2001–2003 (Table 3, Table 4).

Arocephalus languidus was classified as subdominant in 2001 (14.89%), but had the status of a dominant in 2002 (20.90%) and an eudominant in 2003 (38.67%) (Annex 9). *Turrutus socialis* was listed as a subdominant in the 2001 (11.17%) and 2003 seasons (13.04%). The species which subdominated only in one season were *Javesella pellucida* (2001 – 12.50%), *Erythria aureola* (2001 – 10.90%) and *Macrosteles laevis* (2002 – 10.87%).

Turrutus socialis was in the I-st frequency class in the seasons 2001 and 2002 (90.00, 100.00% respectively). In 2002, *Erythria aureola* (77.78%) and *Macrosteles laevis* (77.78%) were in this class but, in 2003, only *Arocephalus languidus* fulfilled the criteria for the I-st frequency class (81.82%).

The highest values of the Q index were obtained by *Arocephalus languidus* (32.29, 37.32, 56.25), *Turrutus socialis* (31.71, 30.80) and *Macrosteles laevis* (29.08).

The occurence dynamic of dominants on plot 9 was as follow (Annex 20): *Arocephalus languidus* had two abundance peaks – the first in the middle of June, and a second much higher peak at the beginning of September; *Turrutus socialis* had its highest abundance in June and at the turn of August and September; *Javesella pellucida* peaked only once at the beginning of August; *Erythria aureola* had two abundance maxima – in the middle of June and at the beginning of September; *Macrosteles laevis* had its maximum at the beginning of October.

Description of the community

The leafhopper community associated with limestone grassland *Sileno-Phleetum* was described on the basis of the research carried out on plots 8 and 9. Altogether, 61 leafhopper species were recorded with 31 taxa common to both sites. The basis of the community on both sites was formed by *Turrutus socialis* – a dominant in the I-st frequency class – and *Acanthodelphax spinosa* (plot 8) and *Arocephalus languidus* (plot 9). The species reported only from this vegetation were *Metropis inermis*, *Mirabella albifrons*, *Criomorphus albomarginatus*, *Neophilaenus lineatus*, *Anoscopus albifrons*, *Balclutha punctata*, *Deltocephalus pulicaris* and *Verdanus abdominalis*. Since these species were collected as single specimens and only on one plot they were regarded as not associated with the vegetation. The only exception might be *Metropis inermis* which prefers sunny and warm places. The characteristic species of the community are *Acanthodelphax spinosa* (plot 8) and *Kosswigianella exigua* (plot 9) – both with a high fidelity value and trophically associated with *Festuca ovina* (Annex 23).

Early spring fauna is formed by delphacids, as shown by the first peaks of abundance of *Acanthodelphax spinosa*, *Javesella pellucida*, *Ribautodelphax albostriata* and *R. collina*. Late spring is characterised by the high abundance of 1st generations of *Arocephalus languidus* and *Turrutus socialis*. Summer is the time for the second generation of delphacids. The 2nd generation of the Typhlocybinae and Deltocephaline species is characteristic for Autumn fauna.

6.6. Leafhopper community linked to limestone grassland *Adonido-Brachypodietum pinnati*

Plot 10

Overall, 552 Auchenorrhyncha adults belonging to 35 species and 125 nymphs were collected on plot 10 in the years 2002–2004 (Table 3, Table 4).

Adarrus multinotatus fulfilled the criteria for a dominant in 2002 (28.96%) and 2003 (28.13%), but achieved the status of an eudominant in 2004 (66.29%) (Annex 10). *Emelyanoviana mollicula* was classified as a subdominant in the 2002 (19.91%) and 2004 seasons (11.24%). *Arocephalus longiceps* had the same dominance grade in 2002 (13.12%) and 2003 (14.06%).

Adarrus multinotatus was in the I-st frequency class in two seasons, 2002 and 2004 (87.50 and 81.82 respectively). *Macrosteles laevis* had the same frequency grade in 2002 (87.50%).

The highest values of the Q index were obtained by *Adarrus multinotatus* in all three seasons (50.34, 40.50, 73.65).

The occurrence dynamic of dominants on plot 10 was as follow (Annex 21): *Adarrus multinotatus* had two abundance peaks – the first at the beginning of June, and a second much higher peak in September; *Emelyanoviana mollicula* also peaked twice during the growing season – in the middle of May and at the beginning of September (2004)/October (2002); *Arocephalus longiceps* had its only abundance maximum in the middle of August.

Plot 11

Overall, 670 Auchenorrhyncha adults belonging to 49 species and 118 nymphs were collected on plot 11 in the years 2001–2003 (Table 3, Table 4).

Adarrus multinotatus was a dominant in 2001 (23.85%) and 2002 (23.13%), but had the status of an eudominant in 2003 (56.00%) (Annex 11). The species which subdominated in only one season were *Ribautodelphax albostriata* (2001 – 14.23%), *Stenocranus major* (2002 – 11.25%), *Elymana sulphurella* (2002 – 10.63%) and *Aphrophora alni* (2003 – 15.60%).

In 2001, only *Adarrus multinotatus* (88.89%) was in the I-st frequency class, while three other species belonged to the II-nd frequency class – *Megadelphax sordidula* (66.67%), *Ribautodelphax albostriata* (55.56%) and *Emelyanoviana mollicula* (66.67%). In 2002, *Adarrus multinotatus* fulfilled the criteria for the II-nd frequency class (75.00%) together with *Emelyanoviana mollicula* (75.00%) and *Elymana sulphurella* (75.00%). In 2003, *Adarrus multinotatus* was the only species in the II-nd frequency class (72.73%).

The highest values of the Q index were obtained by *Adarrus multinotatus* (46.04, 41.65, 63.82).

The occurrence dynamic of dominants on plot 11 was as follow (Annex 22): *Adarrus multinotatus* had two abundance maxima – the first in the middle of June, and a second much higher peak in September; *Ribautodelphax albostriata* also peaked twice during the growing season – the first in June, the second at the beginning of August; *Stenocranus major* reached its only maximum at the beginning of October; *Elymana sulphurella* had two dominance peaks – the first at the beginning of July, the second in September; *Aphrophora alni* had its only maximum in the middle of June.

Description of the community

The leafhopper community associated with limestone grassland *Adonido-Brachypodietum pinnati* was described on the basis of the research carried out on plots 10 and 11. Altogether, 61 leafhopper species were recorded with 23 taxa common to both sites. The basis of the community on both sites was *Adarrus multinotatus* – a dominant species in the I-st or II-nd frequency class. The species reported only from this vegetation were *Tachycixius pilosus*, *Kelisia guttula*, *Hyledelphax elegantula*, *Ribautodelphax pungens*, *Agallia brachyptera*, *Anoscopus flavostriatus*, *Cicadella viridis*, *Linnavuoriana decempunctata*, *Recilia coronifera*, *Cicadula flori*, *Athysanus argentarius*, *Athysanus quadrum* and *Adarrus multinotatus*. Two of them – *Ribautodelphax pungens* and *Adarrus multinotatus* – can be regarded as the characteristic species of this community since they had maximal fidelity and both live monophagously on the main component of the phytocenosis – the grass species *Brachypodium pinnatum*. The others were collected as single specimens and only on one plot, and because of this they were classified as not associated with the vegetation (Annex 23).

The spring fauna of the community is characterised by the 1st generation of delphacids together with the first peak of abundance of *Adarrus multinotatus*. Summer sees the appearance of *Aphrophora alni*, *Utecha trivia*, *Elymana sulphurella* and *Athysanus argentarius*. The appearance of the 2nd generation of *A. multinotatus* is typical for the Autumn period.

6.7. Species diversity

The Shannon-Weaver index of species diversity (H') for identified leafhopper communities on sandy and limestone grasslands ranged from 0.75 to 1.30 with maximum values 1.54–1.72 (Table 5). The lowest value (0.75) was calculated for the community associated with sandy grassland *Spergulo vernalis-Corynephoretum* on plot 2, the highest (1.30) for the leafhopper community linked to a *Diantho-Armerietum elongatae* sward on plot 5. The potential diversity (Pielou's eveness index) was lowest (48.38%) for the community on plot 2 and highest (75.96%) for the community on plot 5.

Similarly, the Brillouin's and Simpson's diversity indices had their lowest and highest values on the above mentioned plots (0.74 and 0.68 for plot 2, 1.27 and 0.93 for plot 5 respectively) (Table 5, Table 6). The observed species diversity of the leafhopper community linked to sandy grassland on plot 2 was lower by about 30% and on plot 5 by only about 5% in respect of the potential one.

Table 5. Shannon-Weaver, Pielou's and Brillouin's diversity indices for leafhopper communities on particular plots (H' – real species diversity, H_{max} – potential species diversity).

Plot	Shannon-Weaver index		Pielou's index J	Brillouin's index $\hat{H}$
	H'	H_{max}		
1	0.77	1.57	49.23	0.76
2	0.75	1.54	48.38	0.74
3	1.24	1.71	72.56	1.22
4	1.26	1.72	73.36	1.24
5	1.30	1.71	75.96	1.27
6	1.00	1.56	64.45	0.98
7	1.00	1.62	62.16	0.98
8	1.10	1.66	65.25	1.06
9	1.19	1.63	72.67	1.16
10	0.91	1.54	58.68	0.86
11	1.14	1.69	67.33	1.09

Table 6. Simpson's diversity index for leafhopper communities on particular plots.

Plot	Shannon-Weaver index			
	Probe species diversity I'	Potential species diversity I_p	Deviation of the real state of the community from the potential one dI	Species diversity lower than the potential one by x %
1	0.73	0.97	75.10	24.90
2	0.68	0.97	69.54	30.46
3	0.91	0.98	93.54	6.46
4	0.91	0.98	92.88	7.12
5	0.93	0.98	94.58	5.41
6	0.85	0.97	87.91	12.09
7	0.85	0.98	87.39	12.61
8	0.85	0.98	87.25	12.75
9	0.89	0.98	91.76	8.24
10	0.75	0.97	76.94	23.06
11	0.84	0.98	86.15	13.85

6.8. Similarities between the plots

Cluster analysis revealed four clusters – faunistic groups – concerning the number of individuals in all the collected species (Fig. 6):

- the first group encompasses communities associated with psammophilous grassland *Spergulo vernalis-Corynephoretum* (plots 1 and 2)
- the second group encompasses communities associated with psammophilous grassland *Diantho-Armerietum elongatae* (plots 3, 4 and 5) and the community linked to limestone grassland *Sileno-Phleetum* (plot 8)
- the third group encompasses communities associated with rocky limestone grassland *Festucetum pallentis* (plots 6 and 7) and the community linked to limestone grassland *Sileno-Phleetum* (plot 9)
- the fourth group encompasses communities associated with limestone grassland *Adonido-Brachypodietum pinnati* (plots 10 and 11)

The only difference between the dendrograms is when the plots are clustered on the basis of the dominants plot 3, representing a leafhopper community of *Diantho-Armerietum* grassland, belonged to the cluster of limestone grasslands leafhopper communities (Fig. 7).

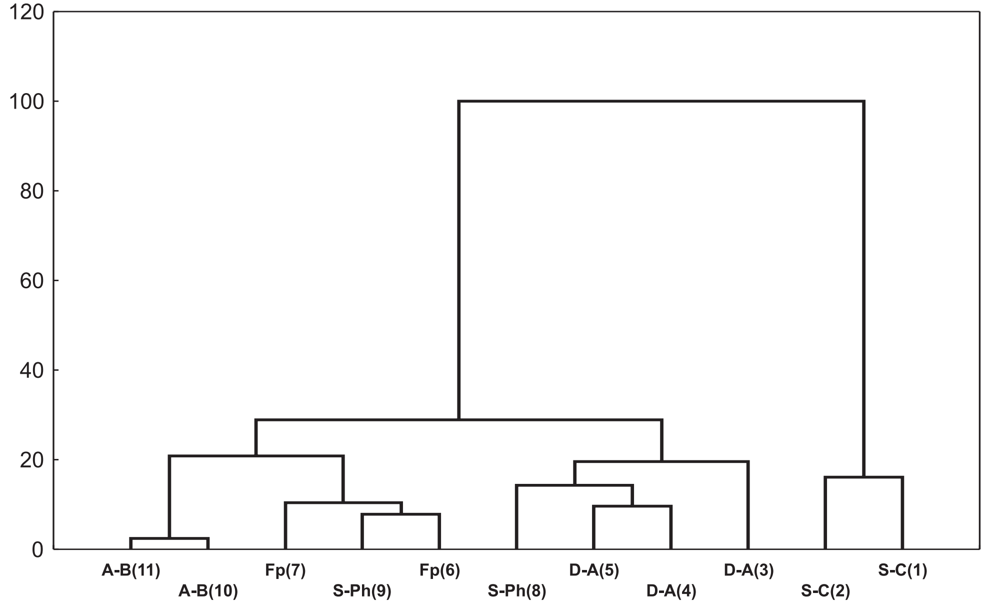


Fig. 6. Cluster analysis of community data from the study plots – the number of individuals of all species (Euclidean distance, Ward's method).
Abbreviations of communities as follows: A-B – *Adonido-Brachypodietum pinnati*; Fp – *Festucetum pallentis*; S-Ph – *Sileno-Phleetum*; D-A – *Diantho-Armerietum elongatae*; S-C – *Spergulo vernalis-Corynephoretum*. Number of plot in brackets.

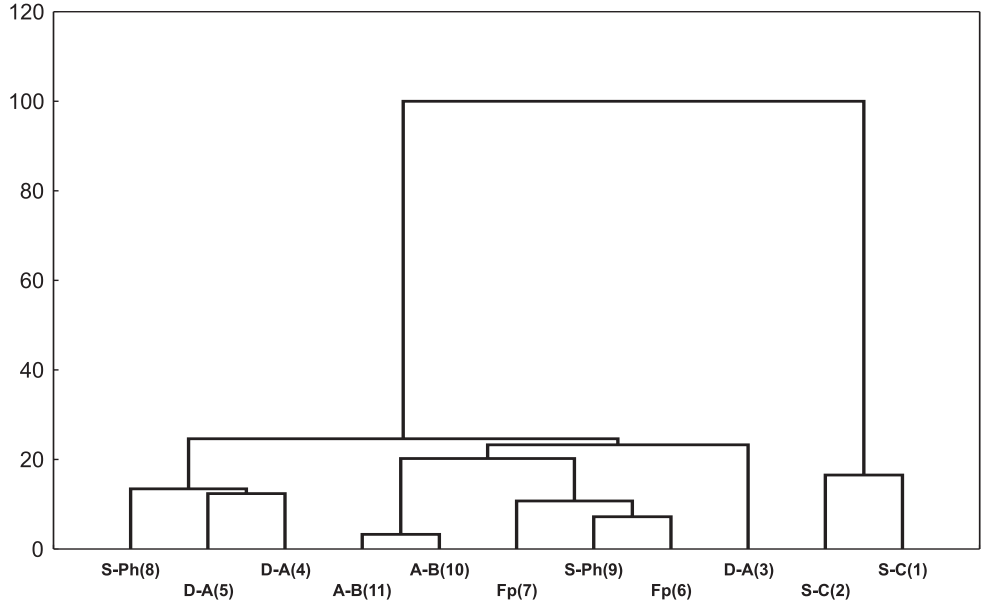
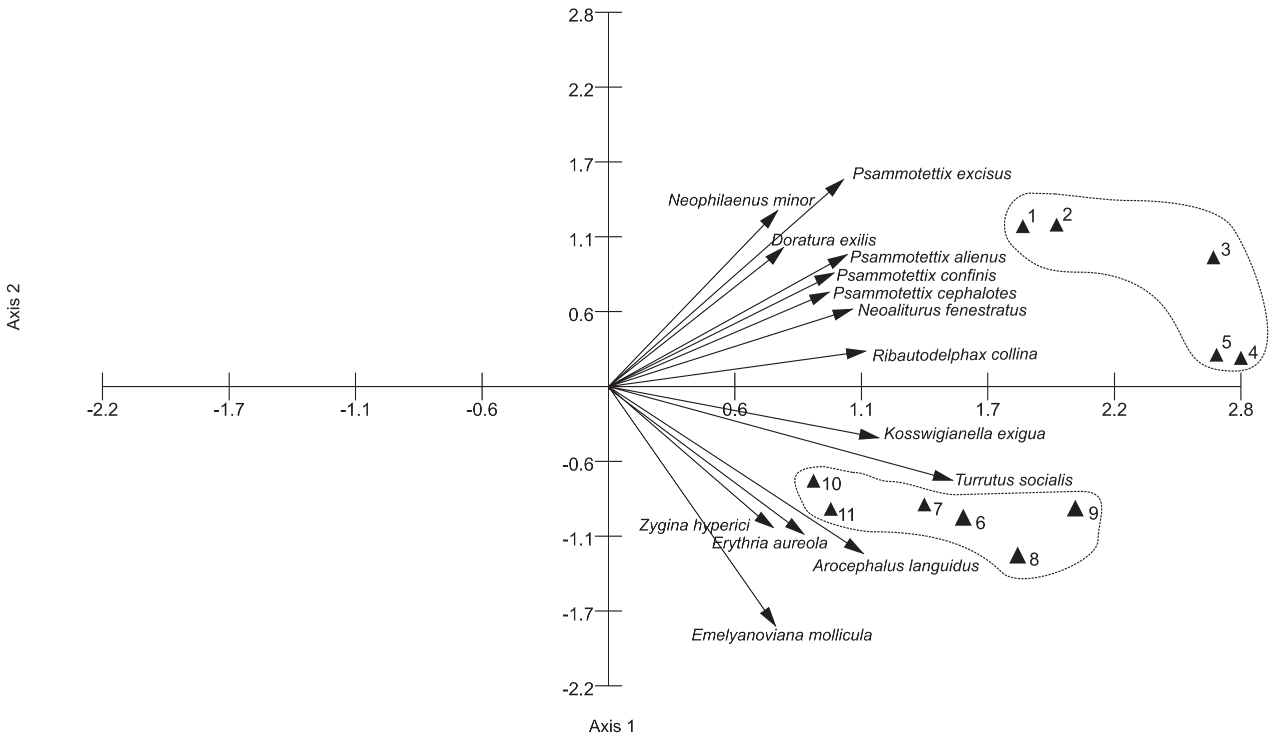


Fig. 7. Cluster analysis of community data from the study plots – the number of individuals of the dominants (Euclidean distance, Ward's method). Abbreviations as in Fig. 6.

Fig. 8. Principal Component Analysis (PCA) of Auchenorrhyncha communities.



Vector scaling: 5,31

eigenvalue axis 1: 43,701; eigenvalue axis 2: 9,415

PCA ordination grouped the plots into four sets (Fig. 8). Leafhopper communities of *Spergulo vernalis-Corynephoretum* grassland (plots 1 and 2) form the first cluster which is situated near plots 3, 4 and 5, which belong to the second group representing leafhopper communities of *Diantho-Armerietum elongatae*. They are both ordinated in the upper section of axis 1 and the positive part of axis 2. The third group consists of the leafhopper communities of *Festucetum pallentis* (plots 6 and 7) and *Sileno-Phleetum* (plots 8 and 9). Finally, leafhopper communities of *Adonido-Brachypodietum pinnati* form the last group. They are both ordinated in the lower part of axis 1 and the positive part of axis 2.

Species indicating communities of sandy grasslands (clusters 1 and 2) are *Neophilaenus minor*, *Psammotettix excisus*, *Doratura exilis*, *Psammotettix alienus*, *Psammotettix confinis*, *Psammotettix cephalotes*, *Neoaliturus fenestratus* and *Ribautodelphax collina*. The group of species indicating the communities of limestone grasslands (clusters 3 and 4) are *Kosswigianella exigua*, *Turrutus socialis*, *Arocephalus languidus*, *Erythria aureola*, *Zygina hyperici* and *Emelyanoviana mollicula*.

6.9. Weather conditions and changes in leafhoppers abundance

The warmest collecting season, with a thermally optimal spring and summer, was 2002, with an annual average temperature of 9.12 °C (Table 1, page 18). On eight of the eleven plots investigated, the highest number of individuals was caught in three investigating seasons (Table 4, page 39). It can also be seen that the first and second generations of some dominants appeared apparently earlier, for example *Psammotettix excisus* on plot 1 (Annex 12), *Turrutus socialis* on plot 5 (Annex 16) and 8 (Annex 19), *Emelyanoviana mollicula* and *Erythria aureola* on plot 7 (Annex 18).

Comparing leafhopper abundance in relation to the amount of precipitation (Table 1), the relationship between the moisture level and the number of individual leafhoppers is noticeable. Of the three compared seasons, the most favorable was again that of 2002 with an annual total of 661.7 mm, similar to the long-term average, and producing the highest number of specimens (9940) (Table 4). Neither the wettest year of 2001 nor the driest of 2003 supported leafhopper population growth.

6.10. Chorology

The species representing the most wide-ranging elements form the major group: Eurosiberian (23.89%), European (20.35%), Transpalaearctic (16.81%) and Western Palaearctic (13.27%) (Table 7, Fig. 9). Those species with a narrow distribution are less numerous: Kazakh (7.08%), Mediterranean (5.31%), Northern-, Western- and Southern European (1.77, 0.88, 0.88% respectively)

In the leafhopper community of *Spergulo vernalis-Corynephoretum* grassland the highest percentage ratio was obtained by two elements – Transpalaearctic (23.08%) and European (19.23%), followed by Kazakh with a slightly lower one (15.38%) (Table 7, Fig. 10).

Table 7. The ratio of chorological elements in the leafhopper fauna of all investigated plots and in particular leafhopper communities (N – number of leafhopper species).

Chorological element	*All plots*		*Spergulo-Corynephoretum*		*Diantho-Armerietum*		*Festucetum pallentis*		*Sileno-Phleetum*		*Adonido-Brachypodietum*	
	N	%	N	%	N	%	N	%	N	%	N	%
European	23	20.35	5	19.23	5	14.29	1	4.76	5	16.13	2	8.70
Northern European	2	1.77	–	–	1	2.86	1	4.76	2	6.45	1	4.35
Western European	1	0.88	1	3.85	1	2.86	–	–	–	–	–	–
Southern European	1	0.88	–	–	–	–	–	–	–	–	–	–
Kazakh	8	7.08	4	15.38	4	11.43	4	19.05	3	9.68	1	4.35
Siberian	4	3.54	–	–	–	–	–	–	1	3.23	1	4.35
Eurosiberian	27	23.89	3	11.54	8	22.86	4	19.05	2	6.45	3	13.04
Western Palaearctic	15	13.27	3	11.54	4	11.43	6	28.57	5	16.13	4	17.39
Transpalaearctic	19	16.81	6	23.08	8	22.86	4	19.05	7	22.58	6	26.09
Meditterranean	6	5.31	–	–	–	–	–	–	2	6.45	2	8.70
Holarctic	6	5.31	3	11.54	3	8.57	1	4.76	4	12.90	3	13.04

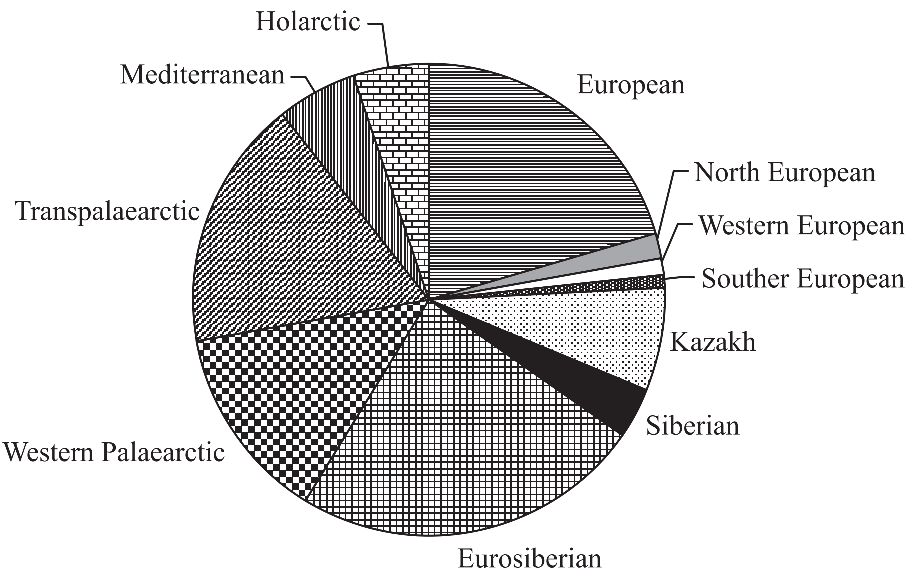


Fig. 9. The ratio of chorological elements in the group of Auchenorrhyncha from all the investigated plots.

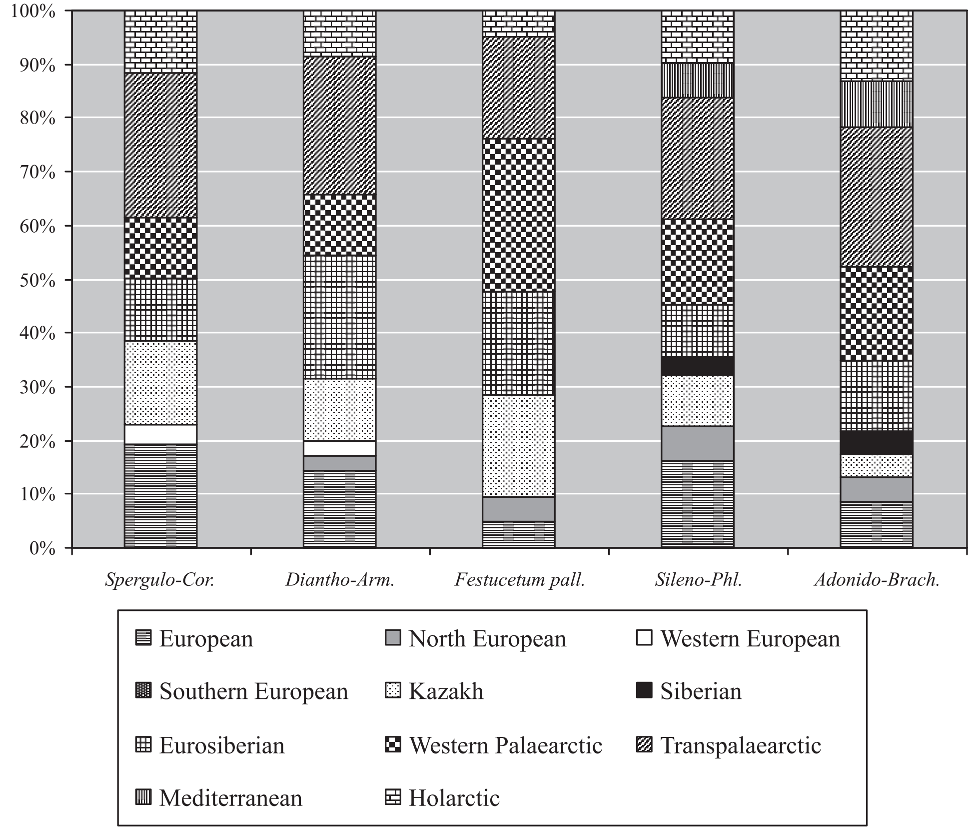


Fig. 10. The ratio of chorological elements in the Auchenorrhyncha communities associated with particular plant assemblages.

The Auchenorrhyncha community of *Diantho-Armerietum elongatae* was characterized by the highest ratio of Transpalaearctic (22.86%), Eurosiberian (22.86%) and European (14.29%) elements, followed by Kazakh and Western Palaearctic (11.43%).

In the leafhopper community associated with rocky limestone grassland *Festucetum pallentis,* Western Palaearctic element (28.57%) had the highest percentage ratio. Three elements – Kazakh, Eurosiberian and Transpalaearctic – shared the same value of 19.05%.

The Auchenorrhyncha community of *Sileno-Phleetum* was characterized by the dominance of three elements – Transpalaearctic (22.58%), European (16.13%) and Western Palaearctic (16.13%); the lowest percentage was recorded for Siberian element (3.23%).

In the leafhopper community of *Adonido-Brachypodietum pinnati,* the species of Transpalearctic (26.09%), Western Palaearctic (17.39%), Eurosiberian (13.04%) and Holarctic (13.04%) elements had the highest percentage ratio.

The Northern European element was noted in all leafhopper communities except those associated with *Spergulo vernalis-Corynephoretum* and is represented by *Balclutha calamagrostis* and *Jassargus pseudocellaris*.

The Western European element appeared only in communities of psammophilous grasslands and is represented by *Psammotettix excisus*.

The Southern European element – *Wagneriala incisa* – was reported only on plot 7 in the Auchenorrhyncha community of *Festucetum pallentis*.

The Kazakh element in the recorded set of species is represented by 8 species (7.08%): *Metropis inermis*, *Austroasca vittata*, *Chlorita paolii*, *Eupteryx notata*, *Doratura exilis*, *Doratura impudica*, *Laburrus impictifrons* and *Arocephalus languidus*. It achieved the highest share in the leafhopper communities of *Festucetum pallentis* (19.05%) and *Spergulo vernalis-Corynephoretum* (15.38%).

The Siberian element (3.54%) was represented by four species recorded on the investigated plots: *Forcipata citrinella*, *Empoasca affinis*, *Linnavuoriana decempunctata* and *Athysanus quadrum*. However, only the first species appeared in both the *Sileno-Phleetum* and *Adonido-Brachypodietum* leafhopper communities.

The Mediterranean element was represented by 6 species (5.31%): *Tettigometra impressopunctata*, *Cercopis sanguinolenta*, *Neophilaenus campestris*, *Utecha trivia*, *Utecha lugens* and *Megophthalmus scanicus*. They appeared with a low ratio in the Auchenorrhyncha community of *Sileno-Phleetum* (6.45%, 2 species – *Cercopis sanguinolenta*, *Megophthalmus scanicus*) and *Adonido-Brachypodietum pinnati* (8.70%, 2 species – *Cercopis sanguinolenta*, *Utecha trivia*).

The Holarctic element appeared in all five identified communities with a percentage ratio from 4.76% to 13.04%.

6.11. Ecology

Considering preferences for moisture, higrophilous species appeared with a small percentage ratio in all the leafhopper communities associated with xerothermic grasslands: *Adonido-Brachypodietum pinnati* (8.70%), *Sileno-Phleetum* (6.45%) and *Festucetum pallentis* (4.76%) (Fig. 11). The mesohygrophilous element had the highest ratio in the community of *Adonido-Brachypodietum pinnati* (69.57%). Xerophilous species dominated in the community of sandy grassland *Spergulo vernalis-Corynephoretum* (69.23%) and *Festucetum pallentis* (57.14%) on rocky limestone grassland.

Regarding insolation, the heliophilous element dominated in all the identified leafhopper communities, but achieved the highest percentage ratio in the leafhopper community associated with sandy grassland *Spergulo vernalis-Corynephoretum* (80.77%) and the leafhopper community of rocky limestone grassland *Festucetum pallentis* (76.19%) (Fig. 12). The mesoheliophilous element had the highest ratio in the community of *Adonido-Brachypodietum pinnati* (47.83%) and that of *Sileno-Phleetum* (38.71%).

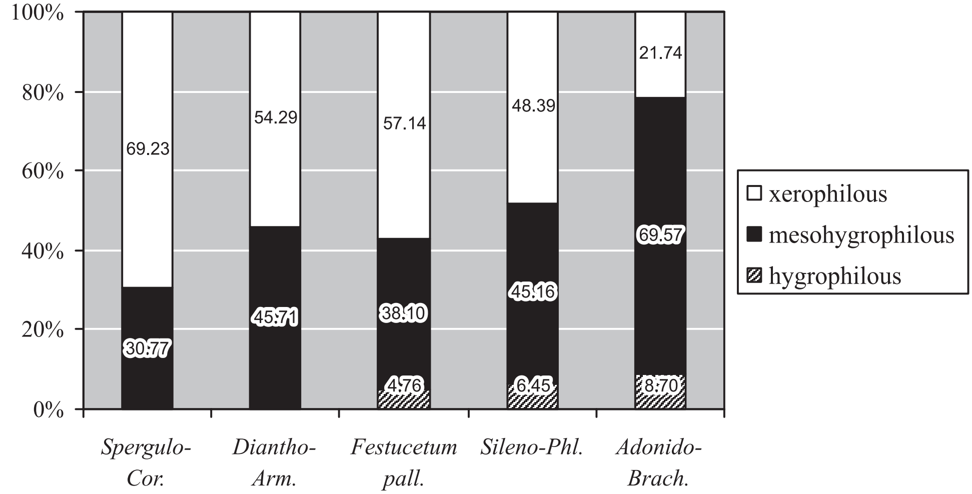


Fig. 11. The ratio of ecological elements – moisture – in the Auchenorrhyncha communities associated with particular plant assemblages.

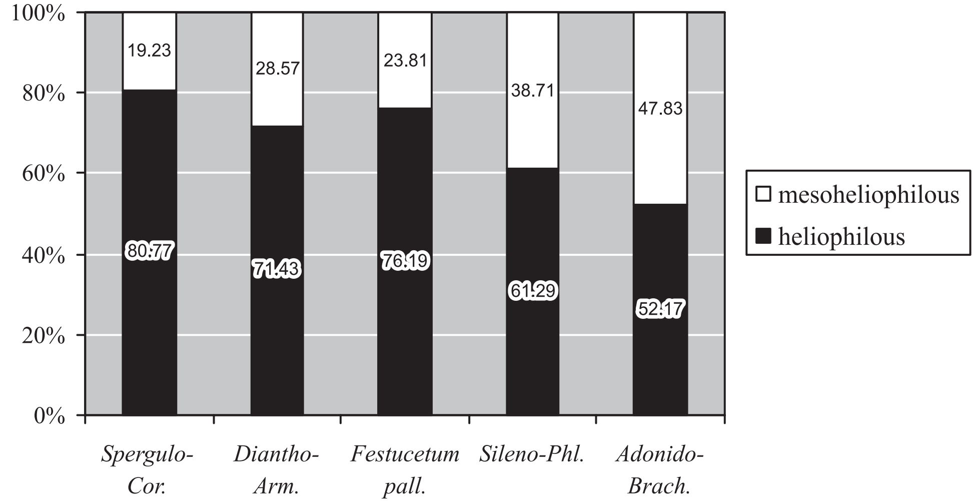


Fig. 12. The ratio of ecological elements – insolation – in the Auchenorrhyncha communities associated with particular plant assemblages.

Regarding the trophic structure, it can be seen that polyphagous species had the highest percentage ratio in the leafhopper community associated with limestone grassland *Adonido-Brachypodietum pinnati* (26.09%) (Fig. 13). Oligophagous species showed a similar ratio in all leafhopper communities in a range from 42.86 to 51.43%.

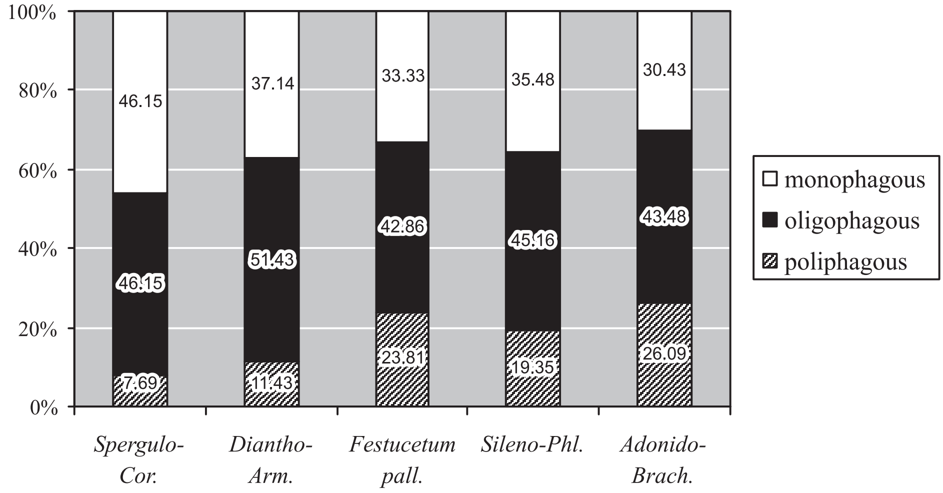


Fig. 13. The ratio of ecological elements – diet width – in the Auchenorrhyncha communities associated with particular plant assemblages.

Monophagous species dominated in the community of *Spergulo vernalis-Corynephoretum* (46.15%). Fifty nine leafhopper species prefer the representatives of Poaceae as food plants (Fig. 14).

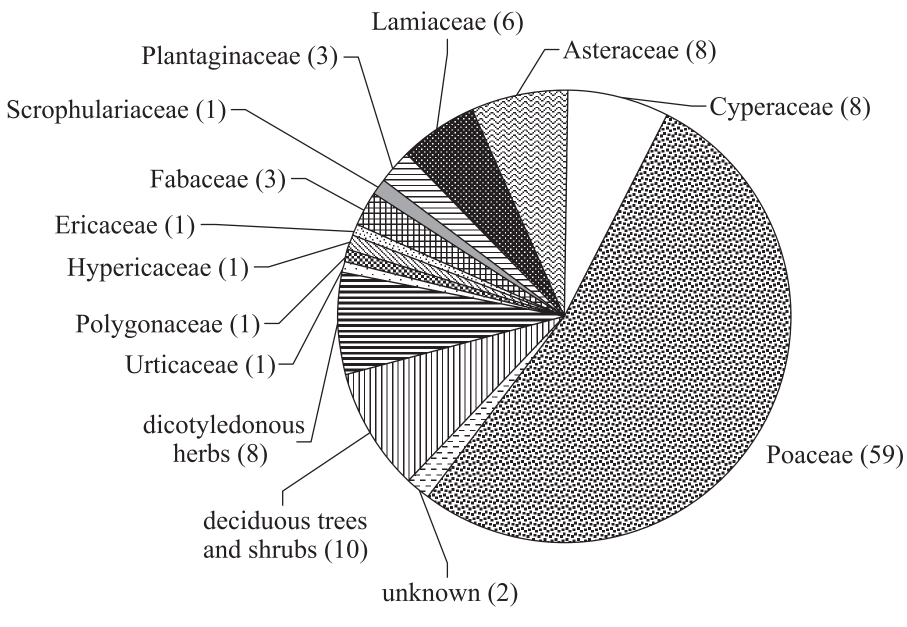


Fig. 14. Numbers of Auchenorrhyncha species on particular plant families.

Throughout the investigation into leafhopper communities, bivoltine species dominate with a ratio ranging from 65.22% to 74.19% (Fig. 15). Similarly, forms hibernating as eggs had the highest ratio in all Auchenorrhyncha communities (from 60.87% to 71.43%) (Fig. 16). Species surviving as nymphs were the most numerous in the communities of *Adonido-Brachypodietum pinnati* (26.09%) and *Sileno-Phleetum* (25.81%). Leafhoppers overwintering as adults were of minor importance.

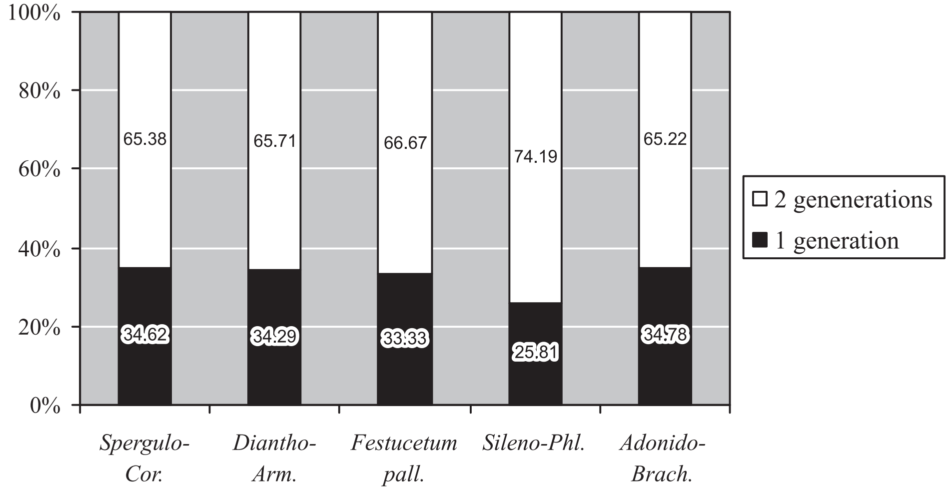


Fig. 15. The ratio of ecological elements – number of annual generations – in the Auchenorrhyncha communities associated with particular plant assemblages.

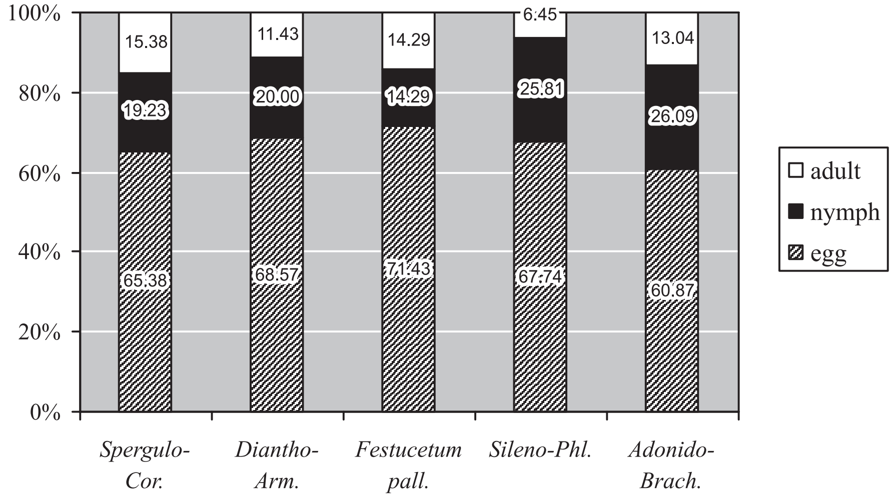


Fig. 16. The ratio of ecological elements – overwintering stage – in the Auchenorrhyncha communities associated with particular plant assemblages.

For the stenotopic leafhopper species associated with psammophilous grasslands the following can be listed: *Muirodelphax aubei*, *Ribautodelphax angulosa*, *Ribautodelphax collina*, *Tettigometra atra*, *Neophilaenus minor*, *Austroasca vittata*, *Chlorita paolii*, *Neoaliturus fenestratus*, *Doratura exilis*, *Doratura impudica*, *Rhopalopyx preyssleri*, *Rhopalopyx vitripennis*, *Laburrus impictifrons*, *Psammotettix cephalotes* and *Psammotettix excisus*. Among the stenotopic leafhopper species associated with xerothermic limestone grasslands the following can be listed: *Anakelisia perspicillata*, *Metropis inermis*, *Acanthodelphax spinosa*, *Kosswigianella exigua*, *Ribautodelphax pungens*, *Tettigometra impressopunctata*, *Utecha lugens*, *Utecha trivia*, *Erythria aureola*, *Emelyanoviana mollicula*, *Micantulina stgmatipennis*, *Wagneriala incisa*, *Arocephalus languidus* and *Adarrus multinotatus*.

7. REVIEW OF SPECIES

A list of species recorded from the investigated area is given below. Each species is characterized by 7 parameters. Chorological element and diet width comes from the annotated check list of Auchennorhyncha in Germany published by Nickel and Remane (2002). Moisture and insolation are based on the available data published in papers on the territory of Poland. The source of information on food plants, occurrence of adults and number of generation are our own observations (published or unpublished marked with *), otherwise they were taken with some modifications from the monographic work of Nickel (2003). The overwintering stage comes exclusively from the latter.

Subordo: Fulgoromorpha Evans, 1946
Family: Cixiidae Spinola, 1839

Cixius nervosus (Linnaeus, 1758)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous
Food plant: various deciduous shrubs and trees
Occurrence of adults: 2V–2IX (from the 2nd half of May until the 2nd half of September)
Number of generations/Overwintering stage: 1/ nymph

Tachycixius pilosus (Olivier, 1791)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous
Food plant: various deciduous shrubs and trees
Occurrence of adults: 2IV–2VII
Number of generations/Overwintering stage: 1/ nymph

Family: Delphacidae Leach, 1815

Kelisia guttula (Germar, 1818)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Carex flacca*
Occurrence of adults: 2VIII–1X*
Number of generations/Overwintering stage: 1/ egg

Kelisia guttulifera (Kirschbaum, 1868)

Chorological element: European
Ecological elements
moisture: hygrophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Carex sylvatica*, *Carex remota* and others
Occurrence of adults: 2VII–2X, females frequently until IV/V
Number of generations/Overwintering stage: 1/ adult?

Anakelisia perspicillata (Boheman, 1845)

Chorological element: Eurosiberian
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Carex flacca*, *Carex pilulifera*
Occurrence of adults: 1VIII–2IX*
Number of generations/Overwintering stage: 1*/ egg
Note: rare species in Poland, associated with dry meadows and xerothermic grasslands (Świerczewski & Gębicki, 2004)

Stenocranus major (Kirschbaum, 1868)

Chorological element: Western Palaearctic
Ecological elements
moisture: hygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: According to Nickel (2003), *Phalaris arundinacea* is the host plant, however in autumn the species is locally extremely abundant and may also be found in stands of other grasses but apparently without breeding; in the investigated area it was collected from *Arrhenatherum elatius*, *Brachypodium pinnatum* and *Calamagrostis epigejos* (Świerczewski, 2007)
Occurrence of adults: 2VIII–2VI
Number of generations/Overwintering stage: 1/ adult

Eurysa lineata (Perris, 1857)

Chorological element: Western Palaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: Poaceae
Occurrence of adults: 1V-2VII
Number of generations/Overwintering stage: 1/ nymph

Metropis inermis W. Wagner, 1939

Chorological element: Kazakh
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Festuca ovina* species group
Occurrence of adults: 1V–2VI
Number of generations/Overwintering stage: 1/ nymph
Note: rare species in Poland, associated with steppe-like habitats (Świerczewski & Gębicki, 2004)

Chloriona vasconica Ribaut, 1934

Chorological element: European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Phragmites australis*
Occurrence of adults: 2V–1VII
Number of generations/Overwintering stage: 1/ nymph

Megadelphax sordidula (Stål, 1853)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: *Arrhenatherum elatius* (Świerczewski, 2007)
Occurrence of adults: V, 2VII–2VIII*
Number of generations/Overwintering stage: 2*/ nymph

Laodelphax striatella (Fallén, 1826)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous?

Food plant: Poaceae, Cyperaceae?, Juncaceae?
Occurrence of adults: V, 1VII–2VIII*
Number of generations/Overwintering stage: 2*/ nymph

Hyledelphax elegantula (Boheman, 1847)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: heliophilous
diet width: oligophagous
Food plant: Poaceae
Occurrence of adults: 2IV–2IX
Number of generations/Overwintering stage: 2/ nymph

Mirabella albifrons (Fieber, 1879)

Chorological element: Eurosiberian?
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: *Calamagrostis epigejos* (Świerczewski, 2007)
Occurrence of adults: 1IV–2IX
Number of generations/Overwintering stage: 2/ nymph

Muirodelphax aubei (Perris, 1857)

Chorological element: Western Palaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Poa pratensis*?
Occurrence of adults: V, 1VII–1VIII*
Number of generations/Overwintering stage: 2*/ nymph

Acanthodelphax spinosa (Fieber, 1866)

Chorological element: European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Festuca ovina* species group (Świerczewski, 2007), *Festuca rubra* (Nickel, 2003)
Occurrence of adults: V, 1VII–2VIII*
Number of generations/Overwintering stage: 2*/ nymph

Dicranotropis hamata (Boheman, 1847)

Chorological element: Transpalaearctic?
Ecological elements

moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous

Food plant: Poaceae
Occurrence of adults: 1IV–2X
Number of generations/Overwintering stage: 2/ nymph

Kosswigianella exigua (Boheman, 1847)

Chorological element: European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous

Food plant: *Festuca ovina* species group (Świerczewski, 2007)
Occurrence of adults: V, 2VI–1VIII*
Number of generations/Overwintering stage: 2*/ nymph

Criomorphus albomarginatus Curtis, 1833

Chorological element: European
Ecological elements
moisture: hygrophilous
insolation: mesoheliophilous
diet width: oligophagous

Food plant: Poaceae
Occurrence of adults: 1V–2VII
Number of generations/Overwintering stage: 1/ nymph

Javesella pellucida (Fabricius, 1794)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous

Food plant: *Arrhenatherum elatius* (Świerczewski, 2007); Poaceae, Ceparaceae?, Juncaceae? (Nickel, 2003)
Occurrence of adults: V, 1VII–1VIII*
Number of generations/Overwintering stage: 2*/ nymph

Ribautodelphax albostriata (Fieber, 1866)

Chorological element: Western Palaearctic
Ecological elements
moisture: mesohygrophilous
insolation: heliophilous
diet width: monophagous

Food plant: *Poa pratensis*
Occurrence of adults: 1V–1VI, 1VII–1VIII*
Number of generations/Overwintering stage: 2*/ nymph

Ribautodelphax angulosa (Ribaut, 1953)

Chorological element: European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Anthoxanthum odoratum* (Świerczewski, 2007)
Occurrence of adults: 1V–2VIII
Number of generations/Overwintering stage: 2/ nymph

Ribautodelphax collina (Boheman, 1847)

Chorological element: European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Agrostis capillaris* (Świerczewski, 2007)
Occurrence of adults: V, 1VII–1VIII*
Number of generations/Overwintering stage: 2*/ nymph

Ribautodelphax pungens (Ribaut, 1953)

Chorological element: European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Brachypodium pinnatum* (Świerczewski, 2007)
Occurrence of adults: 2V–2VI, 1VIII–1IX*
Number of generations/Overwintering stage: 2*/ nymph
Note: rare species in Poland, associated with grasslands on limestone bedrock (Świerczewski & Gębicki, 2004)

Family: Tettigometridae Germar, 1821

Tettigometra atra Hagenbach, 1825

Chorological element: Western Palaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: polyphagous?
Food plant: ?
Occurrence of adults: 2VIII–1V*
Number of generations/Overwintering stage: 1*/ adult

Tettigometra impressopunctata Dufour, 1846

Chorological element: Mediterranean

Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: polyphagous?
Food plant: ?
Occurrence of adults: 1VIII–1VI
Number of generations/Overwintering stage: 1/ adult

Suborder: Cicadomorpha EVANS, 1946
Family: Cercopidae LEACH, 1815

Cercopis sanguinolenta (SCOPOLI, 1763)

Chorological element: Mediterranean
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: polyphagous
Food plant: *Galium mollugo* (ŚWIERCZEWSKI, 2007); various grasses and dicotyledonous herbs (NICKEL, 2003)
Occurrence of adults: 1V–2VI*
Number of generations/Overwintering stage: 1*/ nymph

Neophilaenus campestris (FALLÉN, 1805)

Chorological element: Mediterranean
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Dactylis glomerata* (ŚWIERCZEWSKI, 2007); Poaceae (NICKEL, 2003)
Occurrence of adults: 2V–1X
Number of generations/Overwintering stage: 1/ egg

Neophilaenus exclamationis (THUNBERG, 1784)

Chorological element: European
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous
Food plant: *Festuca ovina*, *Deschampsia flexuosa* and other grasses
Occurrence of adults: 2VII–2IX*
Number of generations/Overwintering stage: 1*/ egg

Neophilaenus lineatus (LINNAEUS, 1758)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous

insolation: mesoheliophilous
diet width: polyphagous
Food plant: Poaceae, Cyperaceae, Juncaceae
Occurrence of adults: 1VI–1XI
Number of generations/Overwintering stage: 1/ egg

Neophilaenus minor (Kirschbaum, 1868)

Chorological element: Western Palaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Corynephorus canescens* (Świerczewski, 2007); *Festuca ovina*, *Koeleria glauca* and other species of fine-leaved grasses (Nickel, 2003)
Occurrence of adults: 2VI–2X*
Number of generations/Overwintering stage: 1*/ egg

Aphrophora alni (Fallén, 1805)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous
Food plant: adults on deciduous shrubs and trees, nymphs on various herbaceous plants
Occurrence of adults: 2VI–1IX*
Number of generations/Overwintering stage: 1*/ egg

Philaenus spumarius (Linnaeus, 1758)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous
Food plant: mainly on dicotyledonous herbs but also on grasses, ferns and dwarf shrubs
Occurrence of adults: 2V–1XI
Number of generations/Overwintering stage: 1/ egg

Family: Membracidae Rafinesque, 1815

Centrotus cornutus (Linnaeus, 1758)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous
Food plant: low-growing woody plants

Occurrence of adults: 1V–1VIII
Number of generations/Overwintering stage: 1/ nymph (3rd and 5th instar)

Family: Ulopidae Le Peletier et Serville, 1825

Utecha trivia (Germar, 1821)

Chorological element: Mediterranean
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous?
Food plant: *Echium*?, *Plantago*?
Occurrence of adults: 2VII–V
Number of generations/Overwintering stage: 1/ adults (females)

Utecha lugens (Germar, 1821)

Chorological element: Mediterranean
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous?
Food plant: *Echium*?, *Plantago*?
Occurrence of adults: 2VII–V?
Number of generations/Overwintering stage: 1/ adults (females)?

Family: Cicadellidae Latreille, 1825
Subfamily: Megophthalminae Kirkaldy, 1906

Megophthalmus scanicus (Fallén, 1806)

Chorological element: Mediterranean
Ecological elements
moisture: mesohygrophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Trifolium arvense* (Świerczewski, 2007); Fabaceae (Nickel, 2003)
Occurrence of adults: 2VI–2X
Number of generations/Overwintering stage: 1/ egg

Subfamily: Agalliinae Kirkaldy, 1901

Agallia brachyptera (Boheman, 1847)

Chorological element: Western Palaearctic
Ecological elements
moisture: hygrophilous

insolation: mesoheliophilous
diet width: oligophagous

Food plant: Fabaceae, Asteraceae
Occurrence of adults: 1VII–2X
Number of generations/Overwintering stage: 1/ eggs in secondary parapause terminated by cold

Anaceratagallia ribauti (Ossiannilsson, 1938)

Chorological element: Western Palaearctic
Ecological elements
moisture: mesohygrophilous
insolation: heliophilous
diet width: oligophagous

Food plant: *Trifolium arvense* (Świerczewski, 2007); *Plantago lanceolata*, *P. major*, Fabaceae, Lamiaceae (Nickel, 2003)
Occurrence of adults: 2VII–1VI*
Number of generations/Overwintering stage: 1*/ adult

Anaceratagallia venosa (Geoffroy, 1785)

Chorological element: Eurosiberian
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous

Food plant: *Lotus corniculatus*, *Hippocrepis comosa*, *Thymus*
Occurrence of adults: 1VI–1X*
Number of generations/Overwintering stage: 1*/ eggs in secondary parapause terminated by cold

Subfamily: Dorycephalinae Oman, 1943

Eupelix cuspidata (Fabricius, 1775)

Chorological element: Transpalaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous

Food plant: *Festuca ovina*, *F. rubra*?
Occurrence of adults: I–XII
Number of generations/Overwintering stage: 1/nymph, adult

Subfamily: Aphrodinae Haupt, 1927

Aphrodes bicincta (Schrank, 1776))

Chorological element: Eurosiberian

Ecological elements

moisture: mesohygrophilous
insolation: heliophilous
diet width: oligophagous

Food plant: *Trifolium arvense* (Świerczewski, 2007); Fabaceae (Nickel, 2003)
Occurrence of adults: 2VI–1IX*
Number of generations/Overwintering stage: 1*/ egg

Aphrodes makarovi Zachvatkin, 1948

Chorological element: European
Ecological elements

moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous

Food plant: *Taraxacum*, *Cirsium*, *Urtica dioica*, *Rumex*
Occurrence of adults: 2VI–2X
Number of generations/Overwintering stage: 1/ egg

Planaphrodes trifasciata (Geoffroy, 1785)

Chorological element: Eurosiberian
Ecological elements

moisture: mesohygrophilous
insolation: heliophilous
diet width: monophagous

Food plant: *Thymus serpyllum* (Świerczewski, 2007); *Thymus*, *Calluna* (Nickel, 2003)
Occurrence of adults: 2VI–2X
Number of generations/Overwintering stage: 1/ egg

Anoscopus albifrons (Linnaeus, 1758)

Chorological element: European
Ecological elements

moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous

Food plant: Poaceae
Occurrence of adults: 2VI–2X
Number of generations/Overwintering stage: 1/ egg

Anoscopus flavostriatus (Donovan, 1799)

Chorological element: Eurosiberian
Ecological elements

moisture: hygrophilous
insolation: mesoheliophilous
diet width: oligophagous

Food plant: Poaceae
Occurrence of adults: 1VII–1XI
Number of generations/Overwintering stage: 1/ egg

Subfamily: Cicadellinae Latreille, 1825

Cicadella viridis (Linnaeus, 1758)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous
Food plant: *Juncus*, Cyperaceae, Poaceae, dicotyledons?
Occurrence of adults: 1VII–X
Number of generations/Overwintering stage: 1/egg

Subfamily: Typhlocybinae Kirschbaum, 1868
Tribe: Dikraneurini Mc Atee, 1926

Erythria aureola (Fallén, 1806)

Chorological element: European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Thymus pulegioides* (Świerczewski, 2007); *Calluna vulgaris*, *Thymus* (Nickel, 2003)
Occurrence of adults: 2V–2VI, 1VIII–1X*
Number of generations/Overwintering stage: 2*/egg

Emelyanoviana mollicula (Boheman, 1845)

Chorological element: Western Palaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Clinopodium vulgare*, *Salvia pratensis*, *Stachys recta* (Świerczewski, 2007); various Lamiaceae, *Verbascum* (Nickel, 2003)
Occurrence of adults: 2V–1VI, 1VIII–1X*
Number of generations/Overwintering stage: 2*/ egg (occasionally also adults)

Dikraneura variata Hardy, 1850

Chorological element: Holarctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous
Food plant: *Deschampsia flexuosa*, *Festuca*
Occurrence of adults: 1VI–1VII, 2IX–1X*
Number of generations/Overwintering stage: 2*/egg

Micantulina stigmatipennis (Mulsant et Rey, 1855)

Chorological element: Western Palaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Verbascum lychnitis* (Świerczewski, 2007, Nickel, 2003)
Occurrence of adults: 2V–2VI, 2VIII–2IX*
Number of generations/Overwintering stage: 2*/egg
Note: rare species in Poland, found in dry and sunny places (Świerczewski & Gębicki, 2004)

Wagneriala incisa (Then, 1897)

Chorological element: Southern European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous?
Food plant: *Carex montana*?
Occurrence of adults: VII–2VIII
Number of generations/Overwintering stage: 1?/egg
Note: rare species in Poland (Świerczewski & Gębicki, 2004)

Forcipata citrinella (Zetterstedt, 1828)

Chorological element: Siberian
Ecological elements
moisture: hygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: low-growing species of *Carex*
Occurrence of adults: 2V–2X
Number of generations/Overwintering stage: 2/ egg

Tribe: Empoascini Distant, 1908

Empoasca affinis Nast, 1937

Chorological element: Siberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous
Food plant: deciduous shrubs and trees
Occurrence of adults: According to Nickel (2003) the males occur 2VII–1XI, females probably survive winter and can be found until V/VI
Number of generations/Overwintering stage: 1?/ adult (females)?

Empoasca pteridis (Dahlbom, 1850)

Chorological element: Western Palaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous
Food plant: dicotyledonous herbs including cultivated potato
Occurrence of adults: ?, 2VII–2X*
Number of generations/Overwintering stage: According to Nickel (2003) this species gives probably 2 generations per year thus in the investigated ecosystems the individuals of the second generation were only collected/ egg?

Empoasca vitis (Göthe, 1875)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous
Food plant: deciduous woody plants
Occurrence of adults: 1VII–V
Number of generations/Overwintering stage: 1/ adult

Austroasca vittata (Lethierry, 1884)

Chorological element: Kazakh
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: mainly *Artemisia absinthium*, occasionally also on *A. maritima* in inland saltmarshes
Occurrence of adults: 2V–1X
Number of generations/Overwintering stage: 2/ egg

Chlorita paolii (Ossiannilsson, 1939)

Chorological element: Kazakh
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Artemisia campestris* (Świerczewski, 2007); *Achillea millefolium*, *Artemisia* (Nickel, 2003)
Occurrence of adults: 1V–2VI, 2VII–2X*
Number of generations/Overwintering stage: 2*/egg

Tribe: Typhlocybini Kirschbaum, 1868

Linnavuoriana decempunctata (Fallén, 1806)

Chorological element: Siberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: *Betula pendula*, *B. pubescens*
Occurrence of adults: 1VIII–VI
Number of generations/Overwintering stage: 1/ adult

Linnavuoriana sexmaculata (Hardy, 1850)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: hairy-leaved species of willows; usually in high frequency on *Salix viminalis*, less frequently on *S. cinerea*, *S. caprea*, *S. aurita* and *S. alba*
Occurrence of adults: 2 VII–X
Number of generations/Overwintering stage: 1/ egg

Eupteryx atropunctata (Goeze, 1778)

Chorological element: European
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous
Food plant: mainly Lamiaceae but also other dicotyledonous herbs
Occurrence of adults: V–2X
Number of generations/Overwintering stage: 2/ egg

Eupteryx notata Curtis, 1837

Chorological element: Kazakh
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Hieracium pilosella* (Świerczewski, 2007); *Hieracium pilosella* and *Leontodon hispidus*, also reported from *Prunella*, *Thymus* and *Hypochaeris* (Nickel, 2003)
Occurrence of adults: 1VI–1VII, 1IX–2X*
Number of generations/Overwintering stage: 2*/ egg

Eupteryx stachydearum (Hardy, 1850)

Chorological element: European
Ecological elements

moisture: hygrophilous
insolation: skiophilous
diet width: oligophagous

Food plant: *Stachys sylvatica*, *Lamium galeobdolon* and other species of Lamiaceae
Occurrence of adults: V–2X
Number of generations/Overwintering stage: 2/ egg

Eupteryx tenella (Fallén, 1806)

Chorological element: European
Ecological elements
moisture: mesohygrophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Achillea millefolium*
Occurrence of adults: 1V–2X
Number of generations/Overwintering stage: 2/ egg

Tribe: Erythroneurini Young, 1952

Zygina flammigera (Geoffroy, 1785)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous
Food plant: various woody plants of Rosaceae, mainly *Prunus*, *Malus*, *Crataegus* and *Sorbus*
Occurrence of adults: VII–1VI
Number of generations/Overwintering stage: 1/ adult

Zygina hyperici (Herrich-Schäffer, 1836)

Chorological element: Western Palaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Hypericum perforatum* (Świerczewski, 2007; Nickel, 2003)
Occurrence of adults: 2V–1VI, 2VIII–1X*
Number of generations/Overwintering stage: 2*/ egg

Zygina ordinaria (Ribaut, 1936)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: monophagous

Food plant: narrow-leaved species of willows, notably *Salix alba*, *S. triandra*, *S. viminalis*, *S. fragilis*, *S. purpurea*, *S. repens* and *S. pentandra*
Occurrence of adults: VII–2V
Number of generations/Overwintering stage: 1/ adult

Zygina rubrovittata (LETHIERRY, 1869)

Chorological element: European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Calluna vulgaris*
Occurrence of adults: I–XII
Number of generations/Overwintering stage: 2?/ adult

Subfamily: Deltocephalinae FIEBER, 1869
Tribe: Opsiini EMELJANOV, 1962

Neoaliturus fenestratus (HERRICH-SCHÄFFER, 1834)

Chorological element: Transpalaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous?
Food plant: *Hieracium pilosella* (ŚWIERCZEWSKI, 2007); in Germany mainly collected from *Leontodon* spp. (NICKEL, 2003)
Occurrence of adults: 2VI–1VII, 2VIII–V*
Number of generations/Overwintering stage: 2*/ adult

Tribe: Macrostelini KIRKALDY, 1906

Balclutha calamagrostis OSSIANNILSSON, 1961

Chorological element: Northern European
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: *Calamagrostis epigejos* (ŚWIERCZEWSKI, 2007), ocasionally also on *C. pseudophragmites* (NICKEL, 2003)
Occurrence of adults: 1X–2VI*
Number of generations/Overwintering stage: 1*/ adult

Balclutha punctata (FABRICIUS, 1775)

Chorological element: Holarctic
Ecological elements

moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous

Food plant: Poaceae (Nickel, 2003)
Occurrence of adults: 2VII–2VI*
Number of generations/Overwintering stage: 1*/ adult

Macrosteles laevis (Ribaut, 1927)

Chorological element: Holarctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous

Food plant: Poaceae, Juncaceae, Cyperaceae and dicotyledonous herbs
Occurrence of adults: 2VI–1VIII, 2IX–2X*
Number of generations/Overwintering stage: 2*/ egg

Macrosteles quadripunctulatus (Kirschbaum, 1868)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous?

Food plant: *Setaria*?, *Panicum*?, dicotyledons?
Occurrence of adults: 2V–1X
Number of generations/Overwintering stage: 2/ egg

Macrosteles sexnotatus (Fallén, 1806)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous

Food plant: Poaceae, Cyperaceae and probably also dicotyledonous herbs
Occurrence of adults: 2V–2X
Number of generations/Overwintering stage: 2/ egg

Tribe: Deltocephalini Fieber, 1869

Deltocephalus pulicaris (Fallén, 1806)

Chorological element: Holarctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous

Food plant: Poaceae

Occurrence of adults: V–2X
Number of generations/Overwintering stage: 2/ egg

Recilia coronifer (Marshall, 1866)

Chorological element: Eurosiberian
Ecological elements
moisture: hygrophilous
insolation: mesoheliophilous
diet width: oligophagous
Food plant: *Holcus mollis*, less frequently *Molinia caerulea*
Occurrence of adults: 2VI–X
Number of generations/Overwintering stage: 1/ egg

Tribe: Doraturini Ribaut, 1952

Doratura exilis Horváth, 1903

Chorological element: Kazakh
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: grey-leaved subspecies of *Festuca ovina*
Occurrence of adults: 2VI–2VIII*
Number of generations/Overwintering stage: 1*/ egg

Doratura homophyla (Flor, 1861)

Chorological element: Transpalaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: Poaceae
Occurrence of adults: VI, 2VII–2IX*
Number of generations/Overwintering stage: 2*/ egg

Doratura impudica Horváth, 1897

Chorological element: Kazakh
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Calamagrostis epigejos*
Occurrence of adults: 2VI–2VII*
Number of generations/Overwintering stage: 1*/ egg

Doratura stylata (Boheman, 1847)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Festuca ovina* species group (Świerczewski, 2007); also *Festuca rubra*, *Agrostis capillaris* and additional species of fine-leaved grasses (Nickel, 2003)
Occurrence of adults: 1VI–1VIII*
Number of generations/Overwintering stage: 1*/ egg

Tribe: Fieberiellini W. Wagner, 1951

Fieberiella septentrionalis W. Wagner, 1963

Chorological element: Western Palaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: polyphagous
Food plant: *Vincetoxicum hirundinaria* (Świerczewski, 2007); woody plants, usually *Prunus spinosa* and *Rosa* species but also found on *Ligustrum vulgare*, *Rubus*, *Rhododendron*, *Cotoneaster*, *Solidago canadensis* and *S. gigantea* (Nickel, 2003)
Occurrence of adults: 1VII–2X*
Number of generations/Overwintering stage: 1*/egg

Tribe: Athysanini Van Duzee, 1892

Allygus communis (Ferrari, 1882)

Chorological element: European
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: polyphagous
Food plant: *Quercus* and *Betula* for adults, grasses and dicotyledons for nymphs
Occurrence of adults: VI–X
Number of generations/Overwintering stage: 1/ egg

Graphocraerus ventralis (Fallén, 1806)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Festuca ovina* species group (Świerczewski, 2007); *Anthoxanthum odoratum*, *Poa pratensis* and other grasses (Nickel, 2003)

Occurrence of adults: 1VI–1VII*
Number of generations/Overwintering stage: 1*/ egg

Hardya tenuis (Germar, 1821)

Chorological element: European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Festuca ovina*, *Poa nemoralis*, *Agrostis capillaris* and other grasses
Occurrence of adults: VII–X, females occasionally until VI
Number of generations/Overwintering stage: 1/ adult?

Rhopalopyx preyssleri (Herrich-Schäffer, 1838)

Chorological element: Eurosiberian
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Festuca ovina* species group (Świerczewski, 2007), however in Germany this species lives exclusively on *Poa angustifolia* (Nickel, 2003)
Occurrence of adults: 1VII–1IX*
Number of generations/Overwintering stage: 1*/ egg

Rhopalopyx vitripennis (Flor, 1861)

Chorological element: Transpalaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Festuca ovina* species group (Świerczewski, 2007); fine-leaved species of *Festuca ovina*, perhaps also *F. rubra* (Nickel, 2003)
Occurrence of adults: VI, 1IX–1X*
Number of generations/Overwintering stage: 2*/ egg

Elymana sulphurella (Zetterstedt, 1828)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous
Food plant: Poaceae
Occurrence of adults: 1VII–1IX*
Number of generations/Overwintering stage: 1*/ egg

Cicadula flori (J. Sahlberg, 1871)

Chorological element: Eurosiberian

Ecological elements
moisture: hygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: *Carex acuta*, perhaps also *C. acutiformis* and other tall sedges
Occurrence of adults: 2VI–2X
Number of generations/Overwintering stage: 2/ egg

Cicadula persimilis (Edwards, 1920)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: *Dactylis glomerata* (Świerczewski, 2007; Nickel, 2003)
Occurrence of adults: VI, 1VIII–2X*
Number of generations/Overwintering stage: 2*/ egg

Cicadula quadrinotata (Fabricius, 1794)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: various species of *Carex*
Occurrence of adults: 1VI–2X
Number of generations/Overwintering stage: 2/ egg

Mocydiopsis parvicauda Ribaut, 1939

Chorological element: European
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: *Agrostis capillaris*
Occurrence of adults: 2VII–IV
Number of generations/Overwintering stage: 1/ adult

Athysanus argentarius Metcalf, 1955

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous
Food plant: *Arrhenatherum elatius*, *Calamagrostis epigejos*, *Dactylis glomerata* (Świerczewski, 2007); various tall grasses (Nickel, 2003)
Occurrence of adults: 1VII–1IX*

Number of generations/Overwintering stage: 1*/ egg

Athysanus quadrum Boheman, 1845

Chorological element: Siberian
Ecological elements
moisture: hygrophilous
insolation: mesoheliophilous
diet width: monophagous?
Food plant: *Lathyrus*?, *Inula*?, *Filipendula*?
Occurrence of adults: 1VII–X
Number of generations/Overwintering stage: 1/ egg

Ophiola decumana (Kontkanen, 1949)

Chorological element: Eurosiberian
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Polygonum aviculare*, *Rumex acetosella* and probably other dicotyledonous herbs
Occurrence of adults: 2V–1X
Number of generations/Overwintering stage: 2/ egg

Ophiola transversa (Fallén, 1826)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: monophagous
Food plant: *Achillea millefolium*
Occurrence of adults: 2VI–2VIII*
Number of generations/Overwintering stage: 1*/ egg

Laburrus impictifrons (Boheman, 1852)

Chorological element: Kazakh
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Artemisia campestris* (Świerczewski, 2007; Nickel, 2003)
Occurrence of adults: 1VII–1X*
Number of generations/Overwintering stage: 1*/ egg

Euscelis distinguendus (Kirschbaum, 1858)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: heliophilous

diet width: oligophagous
Food plant: Asteraceae
Occurrence of adults: 2V–2VIII*
Number of generations/Overwintering stage: 1*/ egg

Euscelis incisus (Kirschbaum, 1858)

Chorological element: Transpalaearctic
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: various species of Fabaceae and Poaceae
Occurrence of adults: 2III–XI
Number of generations/Overwintering stage: 2/ 3rd and 4th instar nymphs and eggs

Tribe: Paralimnini Distant, 1908

Arocephalus languidus (Flor, 1861)

Chorological element: Kazakh
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Phleum phleoides* (Świerczewski, 2007); *Sesleria*, *Stipa*, *Koeleria* and other grasses (Nickel, 2003)
Occurrence of adults: VI, 1VIII–2X*
Number of generations/Overwintering stage: 2*/ egg

Arocephalus longiceps (Kirschbaum, 1868)

Chorological element: European
Ecological elements
moisture: mesohygrophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Holcus mollis*, *H. lanatus*, *Bromus erectus* and other species of Poaceae
Occurrence of adults: 2V–1VI, 1VIII–1X*
Number of generations/Overwintering stage: 2*/ egg

Psammotettix alienus (Dahlbom, 1850)

Chorological element: Holarctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous
Food plant: *Corynephorus canescens*, *Phleum phleoides* (Świerczewski, 2007); various grasses (Nickel, 2003)

Occurrence of adults: 2V–1VII, 1VIII–2X*
Number of generations/Overwintering stage: 2*/ egg

Psammotettix cephalotes (Herrich-Schäffer, 1834)

Chorological element: European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Briza media*
Occurrence of adults: VI, 1VII–2X*
Number of generations/Overwintering stage: 2*/ egg

Psammotettix confinis (Dahlbom, 1850)

Chorological element: Holarctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous
Food plant: *Corynephorus canescens*, *Festuca ovina* species group (Świerczewski, 2007) and other various grasses (Nickel, 2003)
Occurrence of adults: VI, 2VIII–1X*
Number of generations/Overwintering stage: 2*/ egg

Psammotettix excisus (Matsumura, 1906)

Chorological element: Western European
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: monophagous
Food plant: *Corynephorus canescens* (Świerczewski, 2007)
Occurrence of adults: 2V–1VII, 1VIII–2X*
Number of generations/Overwintering stage: 2*/ egg

Psammotettix nodosus (Ribaut, 1925)

Chorological element: European
Ecological elements
moisture: xerophilous
insolation: mesoheliophilous
diet width: oligophagous
Food plant: low-growing grasses, often *Festuca ovina*
Occurrence of adults: VI, 2VII–2X *
Number of generations/Overwintering stage: 2*/ egg

Ebarrius cognatus (Fieber, 1869)

Chorological element: European
Ecological elements

moisture: mesohygrophilous
insolation: heliophilous
diet width: monophagous?

Food plant: various *Festuca* species?
Occurrence of adults: VII–2IX *
Number of generations/Overwintering stage: 1*/ egg
Note: rare species in Poland, prefering dry grasslands on limestone bedrock (Świerczewski & Gębicki, 2003)

Adarrus multinotatus (Boheman, 1847)

Chorological element: Western Palaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: monophagous

Food plant: *Brachypodium pinnatum* (Świerczewski, 2007; Nickel, 2003)
Occurrence of adults: 2V–2VI, 2VIII–2X*
Number of generations/Overwintering stage: 2*/ egg

Errastunus ocellaris (Fallén, 1806)

Chorological element: Transpalaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous

Food plant: *Calamagrostis epigejos*, *Festuca ovina* species group (Świerczewski, 2007); various, usually taller-growing grasses (Nickel, 2003)
Occurrence of adults: VI, 2VII–2X*
Number of generations/Overwintering stage: 2*/ egg

Turrutus socialis (Flor, 1861)

Chorological element: Eurosiberian
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous

Food plant: *Arrhenatherum elatius*, *Festuca ovina* species group (Świerczewski, 2007); *Festuca rubra*, *Bromus erectus*, *Nardus stricta* and other grasses (Nickel, 2003)
Occurrence of adults: 2V–2VI, 2VII–2X*
Number of generations/Overwintering stage: 2*/ egg

Jassargus pseudocellaris (Flor, 1861)

Chorological element: Northern European
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous

Food plant: *Festuca rubra*, *Agrostis capillaris* and other grasses
Occurrence of adults: 1VI–1VII, 2VIII–1X*
Number of generations/Overwintering stage: 2*/ egg

Verdanus abdominalis (Fabricius, 1803)

Chorological element: Western Palaearctic
Ecological elements
moisture: mesohygrophilous
insolation: mesoheliophilous
diet width: oligophagous
Food plant: *Holcus lanatus* and other Poaceae
Occurrence of adults: in the lowlands mainly V–VIII, at higher altitudes VII–1X
Number of generations/Overwintering stage: 1/ egg

Arthaldeus pascuellus (Fallén, 1826)

Chorological element: Eurosiberian
Ecological elements
moisture: mesohygrophilous
insolation: heliophilous
diet width: oligophagous
Food plant: Poacae
Occurrence of adults: V–2X
Number of generations/Overwintering stage: 2/ egg

Mocuellus collinus (Boheman, 1850)

Chorological element: Eurosiberian
Ecological elements
moisture: xerophilous
insolation: heliophilous
diet width: oligophagous
Food plant: *Arrhenatherum elatius*, *Festuca ovina* species group (Świerczewski, 2007); also *Elymus repens*, *Poa compressa* and other grasses (Nickel, 2003)
Occurrence of adults: 1VI–1VII, 2VIII–1X*
Number of generations/Overwintering stage: 2*/ egg

8. DISCUSSION AND CONCLUSIONS

Research concerning the structure of animal communities is basic to our understanding of ecological concepts (Petrusewicz, 1966). The pattern showing how organisms of a particular population are distributed within the area they occupied is not only important for the population itself but also for the populations of other species which share the same habitat. The organization of individuals in a population is an important factor influencing the life processes of other populations in the biocenosis.

As a complete description of the biocenosis structure appears impossible, fragmentary studies focused on a particular set of species belonging to the ecosystem have been undertaken (Trojan, 1992). This represents a model of interactions within a biocenosis. In this work, leafhoppers were chosen as representative organisms for grassland ecosystems and this group of insects was thoroughly investigated. They dominate in grassland phytocenoses and, as primary consumers, well reflect changes to the whole ecosystem.

The research was carried out on 11 plots representing different types of sandy and limestone grasslands typical for the area of the Częstochowa Upland. The established plots were not managed, which means they were not cut or grazed and, consequently, not fertilized. This is associated with the restructuring of agriculture which began in Poland at the beginning of the 1990's. One of the side effects of the changes has been a steady increase in the uncultivated land area as a result of the decreasing profitability of production.

It was very important to eliminate anthropogenic factors such as grazing and hay- and silage-making as numerous studies have shown that these farming methods, by changing the plant communities, markedly influence the structure of leafhopper communities. Both intensive grazing and cutting reduce the number of species and individuals (Morris, 1971, 1973, 1979, 1981) which is associated with a decrease in the vegetation complexity parameters such as plant species richness, vegetation height and vegetation heterogeneity (Kruess & Tscharntke, 2002). Fertilizer application, as was proved by Andrzejewska (1976), while resulting in an increase in general plant biomass, caused an increase in individual insects on the one hand but on the other hand led to the simplification of the structure of the leafhopper community.

Agreement has yet to be reached on which techniques can be relied upon to collect the full range of leafhopper species from grassland vegetation (Stewart, 2002). Two classic techniques are sweep-netting and pitfall-trapping, but recently the efficiency of the suction method has been emphasized (Wilson *et al.*, 1993). In this work, sweep-netting was employed as it is still the most common way of sampling field layer arthropods. Its main advantages are a simple, easy to use portable sweep net, that large numbers of insects can be collected and that extensive areas of ground can be covered (Stewart, 2002). On the downside, it is not appropriate if vegetation is wet, flattened or very short. Payne (1981) and Törmälä (1982) point out that when using a sweep net in high vegetation only the insects occupying the middle and upper herb layer are collected, excluding those living on the lower parts, the litter layer and the surface of the soil. The herb layer of the investigated plant communities in the area of the Częstochowa Upland have an average height of 30–40 cm and can be fully explored with the use of a sweep net, making it possible to follow quantitative and qualitative changes in leafhopper fauna during the growing season. However, NOVOTNÝ (1992) reported that some leafhopper species, especially from Agallinae and Aphrodinae subfamilies, are soil- and litter-dwelling arthropods so future works should be supplemented with a pitfall-trapping method.

The number of samples which should be taken from a particular habitat depends on the scope of the survey. According to KAMITANI (2002), if we want to assess only the species richness, it is enough to explore the habitat six times in the vegetation season but the timing has to be estimated experimentally. In an earlier work, KAMITANI and URANO (2000) concluded that the optimal number of strokes for collecting the maximum number of species should be 720. In contrast, 100 strokes per sample is a minimum in quantitative studies (KONTKANEN, 1950). In our investigations, 36 samples were taken on each plot which constituted about 3600 strokes indicating that this number is sufficient to obtain a nearly maximal number of species. Not only the number of samples but also the time of sampling is important. SCHIEMENZ (1969) proved that around noon is the optimal daytime period for collecting the maximum number of species of leafhoppers and individual leafhoppers.

The identified Auchenorrhyncha communities associated with the investigated grasslands were characterized by such parameters as dominance, frequency and fidelity. As was suggested by SCHIEMENZ (1969), dominants with a high frequency better characterize the community than characteristic species and can be called the 'principal species'. In this work, this would be the species which achieved a high Q index value. Using principal species for the characteristics of leafhopper communities is practical as they are easily caught in particular phytocenoses, which cannot always be said of less abundant characteristic taxa. Thus, in our investigations, when identifying the characteristic species we took not only the fidelity value but also the dominance and frequency values into consideration.

Between 35 and 37 leafhopper species were reported for the communities associated with psammophilous grassland *Spergulo vernalis-Corynephoretum* in the area of the Częstochowa Upland. SZWEDO (1997) noted 10–24 species for the communities linked to similar phytocenoses in Jaworzno-Szczakowa, BEDNARCZYK and GĘBICKI (1998) reported 41 species in the vicinity of Janów Lubelski, and GĘBICKI *et al.* (1982) collected 32 taxa in the area of the Biebrza Basin. The above listings are interesting in light of the comparison made by WITSACK (1997) in Germany. He stated that the above mentioned sandy grassland was characterized by much richer leafhopper fauna in the Harz Foreland (more than 25 species) than in the area of the Elbe and the Havel rivers interfluve (8–19 species). The same comparison can also be made in Poland by comparing the data from the upland areas (Częstochowa upland, Lublin upland) with those from the lowlands (the Biebrza Basin). The small number of species caught in the sand-pit excavation of Jaworzno-Szczakowa can be explained by the strong anthropogenic pressure on the habitats occurring there.

Considering the dominant species, the eudominant status of *Psammotettix excisus* in the leafhopper community of *Spergulo vernalis-Corynephoretum* is in line with the observations of Szwedo (1997) from Poland and Schiemenz (1969) and Witsack (1997) from Germany. In the contribution of Schiemenz, the second of the dominants feeding on *Corynephorus canescens* – *Neophilaenus minor* belonged to the principal species but in the above mentioned works of Szwedo and Witsack it was classified as an accessory species. The characteristic species of this community were the two dominants described above – *Neophilaenus minor* and *Psammotettix excisus*, both regarded by Schiemenz as principal species of the community.

The leafhopper communities associated with *Diantho-Armerietum elongatae* grassland consisted of 51–53 species. The principal species of the community were *Chlorita paolii*, *Turrutus socialis* and *Neoaliturus fenestratus*. The characteristic species of the community included *Chlorita paolii* and *Laburrus impictifrons* feeding monophagously on *Artemisia campestris* and *Eupteryx notata* and *Neoaliturus fenestratus* – both trophically associated with *Hieracium pilosella*. In the work of Schiemenz (1969) from eastern Germany, *Chlorita paolii* was the principal species of psammophilous grasslands with *Festuca ovina* and *Koeleria pyramidata,* while *Turrutus socialis* was a dominant in xerothermic grasslands with *Stipa* species.

The plant assemblge of *Festucetum pallentis* was inhabited by leafhopper communities of 36–42 species. The principal species covered two Typhlocybinae leafhoppers – *Erythria aureola* and *Emelyanoviana mollicula* feeding on representatives of Lamiaceae. They were both also regarded as characteristic species together with *Micantulina stigmatipennis* – monophgous insect on *Verbascum lychnitis*, and *Fieberiella septentrionalis* living on *Vincetoxicum hirundinaria*. Szwedo (1992), carrying out his research on similar phytocenosis in Ojców National Park, recorded only 7 species, without identifying characteristic taxa. Witsack (1999) described the leafhopper community of xerothermic limestone grassland with *Festuca pallens* from central Germany (Unstrut-Triasland). It consisted of 24 leafhopper species with three dominants: *Kelisia haupti*, *Emelyanoviana mollicula* and *Erythria aureola*. So, the structure of dominants is similar to that described by the authors of this investigation on the Częstochowa Upland.

A leafhopper community of xerothermic grassland *Sileno-Phleetum* was described for the first time. It was built of 43–46 species and the principal species were *Acanthodelphax spinosa*, *Arocephalus languidus* and *Turrutus socialis*. Moreover, *Acanthodelphax spinosa* and *Kosswigianella exigua* were regarded as the characteristic species of the community. Cluster analysis showed that the community shares features of the *Diantho-Armerietum elongatae* and *Festucetum pallentis* leafhopper communities. This probably reflects the intermediate phytosociological position of this plant assemblage between sandy and limestone grasslands (Babczyńska, 1978).

The leafhopper communities linked to xerothermic limestone grassland *Adonido-Brachypodietum pinnati* were composed of 35 and 49 species. The principal species of the community was *Adarrus multinotatus* which was also regarded, together with *Ribautodelphax pungens,* as the characteristic species – both feeding monophagously on *Brachypodium pinnnatum*. A similar community was described in the above mentioned work of Schiemenz (1969) on grassland where *Brachypodium pinnatum* formed the bulk of the cover. The highest domination and frequency were achieved by two species – *Adarrus multinotatus* and *Mocydia crocea*. Another survey from Germany (Witsack, 1999) carried out in similar phytocenosis reported three dominants – *Eupteryx notata*, *Psammotettix cephalotes* and *Ribautodelphax pungens*. According to Gębicki (1987), *Adarrrus multinotatus* was also the dominant in a community of *Thalictrum-Salvietum pratensis* grassland in an area in the vicinity of Pińczów in Poland.

According to the results obtained from the Częstochowa Upland and those of other authors (e.g. Brown *et al.*, 1992), a wide range of abiotic (temperature, moisture, soil conditions, human management) and biotic (vegetation architecture, foodplant species requirements, competition and natural enemies) constraints are involved in determining the composition of leafhopper communities.

Taking into consideration the plant species and structure of the grasslands which hosted the identified leafhopper communities, there was a positive correlation between the number of Auchenorrhyncha species and the average vegetation height on the one hand and the plant species richness on the other. Maczey (2004) made a similar finding for leafhopper communities on chalk grasslands in southern England, and Cherrill and Rushton (1993) for Auchenorrhyncha fauna of moorland and acidic vegetation. However, Brown *et al.* (1992) and Stinson and Brown (1983) suggested that plant architecture is more important in determining the species composition of leafhopper communities. For example, Cook (1996) described a species rich leafhopper community on grassland dominated by *Brachypodium pinnatum*. Similarly, Huusela-Veistola and Vasarainen (2000) discovered that, although the plant species number in perennial grass strips decreased markedly during succession, changes in the species richness of leafhoppers were not significant. Lawton (1983) claims that it is impossible to say to what extent the insect community is influenced by the habitat complexity and plant species richness as these two factors are inextricably linked. Andrzejewska (1979) stressed that high vegetation with a multilayer structure provides better conditions for forming rich Auchenorrhyncha communities than grassland simplified by cutting or grazing. Moreover, Hollier *et al.* (1994), investigating the response of leafhopper communities to the succession of plant assemblages, observed that the structure of individual grass species is also important as they become more tussocky as succession proceeds. It is clear that the calculated diversity indices for particular leafhopper communities simply reflect the differentiated, internal architecture of psammophilous and limestone vegetation on the Częstochowa Upland. The highest values were obtained for the Auchenorrhyncha communities of the multilayer *Diantho-Armerietum elongatae* grassland, the lowest values for the simple plant assemblage of *Spergulo vernalis-Corynephoretum*.

Interestingly, herbivorous insects can modulate the structure and dynamics of the plant assemblages as well (Gibson *et al.*, 1987; Jung *et al.*, 2000; Coupe & Cahill, 2003). Feeding on preferential plant species, they change the competition pattern within phytocenosis and allow the growth of those which are unaffected. The effects of insect herbivory during the early successional stages is a reduction in the height of annual grasses and short-lived perennials and an increase in the height of perennial herbs.

Fifty nine of the 112 species collected are trophically associated with grasses. In Central Europe almost 50% of Auchenorhyncha species feed on graminoids (Poaceae, Cyperaceae and Juncaceae) even though they are rather a minor group among European flora (Nickel, 2003). Morover, although the graminoids are poor in secondary compounds (alkaloids, terpenoids, phenols, etc.), the degree of host specifity is still high. Additionally, the high silica content in grasses, which is a defence against chewing insects, does not hamper leafhoppers as they obtain liquid food using their sucking mouthparts (McNaughton *et al.*, 1985).

The leafhopper-grass association depends mainly on the food requirements of the insects (Prestidge and McNeill, 1983). Synchronization of the insect life history with an appropriate food quality results in high ovipositional rates, which ensure rapid increases in population (Hill, 1982; Prestidge, 1982a). This was shown for *Dicranotropis hamata* and *Errastunus ocellaris,* both of which breed on *Holcus mollis,* which responded positively in development and reproductive output to the artificial addition of nitrogen fertilizer on experimental plots (Prestidge, 1982b). The type of grass can also be important as was shown for Auchenorrhyncha by Morris (1990), who found that species richness, equitability and diversity were higher on a coarse sward than on a fine-leaved one.

An additional survey on Auchenorrhyncha food plants on the Częstochowa Upland carried out over a 3-year period revealed that the most diverse leafhopper guild, one consisting of 10 species, was found on the grass *Festuca ovina* (Świerczewski, 2007). Guilds associated with *Arrhenatherum elatius*, *Calamagrostis epigejos* and *Dactylis glomerata* were less diverse (5 species, respectively). Tscharntke and Greiler (1995) mentioned that annual-perennial dichotomy meant shoot length and the abundance of grasses significantly influenced the number of major groups of phytophagous insects per grass species. Shoot length presumably correlates with the heterogenity of the food supply and allows specialization on plant parts. Food abundance offers the leafhoppers the possibility of a quick transfer to another food source, if the first one diminshes.

An important factor influencing the abundance fluctuationts of leafhoppers is migration to and from other environments. In temporary habitats, this is often associated with the density-dependent higher production of macropters in winged dimorphic species, which is a response to frequent habitat deterioration (Novotný, 1994). An example can be cereal fields where the current Auchenorrhyncha fauna probably originated from grassland habitats, but the link between the two habitats has not diminished completely and some species appear temporarily in both. Raatikainen and Vasarainen (1976) listed *Javesella pellucida*, *Megadelphax sordidula*, *Macrosteles cristatus* and *Macrosteles laevis* as the dominants of oatfields in Finland. In our study, *Macrosteles leavis* appeared with high abundance in autumn (October), after the harvest and the ploughing in of stubble, probably being on migration routes to places where eggs are deposited. In contrast, the individuals of *Javesella pellucida* and *Megadelphax sordidula* have already been recorded in high numbers in August. According to the results obtained by Waloff (1973), it can be suggested that they represent the second generation which colonizes grasses for breeding and produces nymphs which are the hibernating stage of these species and move on to crop fields in spring. Raatikainen (1972) distinguished three groups according to their ability to disperse: (1) non-fliers, crawling in the field layer, (2) fliers, travelling in the field layer or immediately above it, and (3) migrants covering a distance of a kilometre or more. Similarly, Andrzejewska (1991) showed that immigration from neighbouring habitats is mainly responsible for the creation of leafhopper communities on newly established meadows.

It was thought for some time that multispecies leafhopper communities existed because they properly use the environment in time and space and because there is no direct competition among the species inhabiting the same plant (Waloff, 1980). Andrzejewska (1964, 1965), in her pioneering works on leafhopper communities on meadows, revealed that species forms inhabit particular layers of the plant assemblage, nymphs are found at the base of the stems whereas adults occupy higher areas of the phytocenoses. Waloff (1979) analysing the seasonal occurrence of the adults of five species associated with the grass *Holcus mollis – Dicranotropis hamata*, *Errastunus ocellaris*, *Diplocolenus bensoni*, *Elymana sulphurella* and *Recilia coronifer* proved that potential competition for oviposition sites is reduced by segregation over time. Moreover, Thompson (1978) showed that these species have a characteristic pattern for the vertical distribution of their eggs depending on the availability of plant tissue. Similarly, we observed alternating waves of abundance of delphacids and cicadellids in the leafhopper communities on the Częstochowa Upland. The first peak of bundance of delphacids was noticed in May, and of cicadellids in June. The second generation of delphacids appeared in July and that of cicadellids in August-September.

However, Denno *et al.* (1995) in their review paper resurrected the importance of interspecific competition as a force affecting the distribution, abundance, and community structure of phytophagous insects. This viewpoint was partly based on the earlier investigation of Denno and Roderick (1992) who demonstrated interspecific competition for two sympatric species, *Prokelisia marginata* and *Prokelisia dolus*, feeding monophagously on the grass *Spartina alterniflora* along the Atlantic Coast. The interspecific interactions were asymmetric, with *P. dolus* having a far greater influence on the wing form of *P. marginata*. Thus, under more crowded conditions, fully winged migratory forms were produced, which resulted in emigration to new habitats and decreased population growth.

In our study, aphids can be regarded as the main competitors of leafhoppers because in the area of the investigation they are represented by a wide set of species, often occurring in high abundance (Hałaj & Wojciechowski, 1996). Alla *et al.* (2001a) showed that under laboratory conditions an increase in aphid numbers caused a lengthening of the development duration and increased mortality of leafhopper nymphs. Additionally, in the presence of aphids, the leafhoppers moved towards the upper part of the plant. Further research (Alla *et al.*, 2001b) demonstrated that this effect was due to chemical components contained in the extract of aphids, which deter feeding and oviposition in leafhopper females. Taking into account the previous work of GREENWAY *et al.* (1978), it can be assumed that long-chain fatty acids play an important role here, with dodecanoic acid predominant. Similarly, the laboratory experiments of TOMLIN and SEARS (1992) suggested that the potato leafhopper *Empoasca fabae* can be affected by biochemical compounds found in the excrement of the potato beetle *Leptinotarsa decemlineata*.

The main predators of leafhoppers are spiders (Linyphiidae), Opiliones, Nabidae and Coleoptera: Coccinellidae, Carabidae and Staphylinidae (DÖBEL & DENNO, 1994; WALOFF, 1980). PĘTAL *et al.* (1971) also added ants to the list – *Myrmica scabrinoidis* and *Mirmica ruginoidis*, which were seen carrying leafhoppers to their nests on a number of occasions. Regarding the developmental stages, the most common predators of nymphs are ants and epigeal spiders, whereas the adults form a high percentage of the diet of web-spinning spiders (KAJAK, 1971; WALOFF, 1980).

In natural grassland ecosystems predation is the main factor regulating the abundance of leafhoppers (ANDRZEJEWSKA, 1971). However, the prey-predator interaction can be modified by antagonistic interactions among invertebrate predators such as intraguild predation and cannibalism. FINKE and DENNO (2003) and DENNO *et al.* (2004) showed that the presence of intraguild predation relaxes natural enemy impacts on leafhopper populations. However, structurally complex vegetation can moderate this phenomenon by providing a refuge for predators, thereby enhancing the suppression of prey (FINKE & DENNO, 2002).

The common parasitoids of the nymphal and adult stages of the Auchenorrhyncha are hymenopterans of the Mymaridae and Dryinidae families, dipterans representing the Pipunculidae family and the Strepsiptera (WALOFF & JERVIS, 1987). Mymaridae develop endoparasitically in the leafhopper eggs, while others are parasitic on nymphs and adults. WALOFF (1975) gave an account of the dynamic of the leafhoppers and parasitoids complex in an area of acidic grassland in southern England. Thirty species of parasitoids were bred out comprising 16 pipunculids, 2 Strepsiptera, 11 Dryinidae and one hyperparasite of the latter. The most abundant leafhopper species within the study area, *Psammotettix confinis* was attacked by nine pipunculid and six dryinid species. Considering the most common representatives of Cicadellidae such as *Psammotettix confinis*, *Arthaldeus pascuellus* and *Jassargus pseudocellaris*, the attacks by dryinids tend to be heavier on the first host generations and those of pipunculids on the second annual host generations. Dryinidae also possess predatory features as they kill many potential hosts before they find the one which is appropriate for ovipositing. Most parasitoid species which attack grassland leafhoppers are polyphagous or oligophagous, their host specifity generally extending to the family or subfamily levels of the hosts. Their main role in the ecosystem is to stabilize the populations of the most abundant leafhopper species (WALOFF & THOMPSON, 1980).

Our observation that leafhoppers were most abundant in the warmest collecting season is consistent with the findings of other authors. Raatikainen investigating the biology of *Dicranotropis hamata* and *Megadelphax sordidula* reached the conclusion that weather factors seem to affect strongly the abundance of the species as they apparently increased in numbers in years with high temperature and dry weather (Raatikainen & Vasarainen, 1964; Raatikainen, 1970). Raupach *et al.* (2002) revealed in laboratory experiments the significant influence of various temperature regimes on the egg and larval development of *Empoasca decipiens* – an important pest of plants cultivated in fields and greenhouses. They found that the largest number of larvae emerged at 24°C, in contrast to 15°C when the development time was three times longer. The shortest larval development time was noted at 30°C.

The specific thermal conditions of the investigated grasslands meant that, in all leafhopper communities, species with two generations achieved the highest percentage ratios. Considering the hibernation stage, the highest ratios were recorded for species surviving the winter as eggs, but the percentage of those overwintering as nymphs and adults was also noticeable. Comparing the above results with those of Schiemenz (1973) from Germany it can be concluded that they are characteristic for the leafhopper fauna of psammophilous and xerothermic grasslands of Central Europe. In the paper, Schiemenz also gave data for meso- and hygrophilous meadows, whose leafhopper fauna is characterized by a high ratio of monovoltine species and a lower number of those hibernating as nymphs and adults.

We discovered that the season with an annual sum of precipitation similar to the long-term average was the most favourable. However, it has been suggested that drought supports an increase in the abundance of herbivorous insects. When plants experience water stress, the protein metabolism and the amino acid synthesis are impaired and existing proteins are hydrolyzed resulting in increased levels of the free amino acids (Hsiao, 1973). As the availability of nitrogen is a limiting factor in development of phytophagous insects, White (1969, 1976, 1984) pointed out in several papers that during stress plants become a better source of food for invertebrate herbivores, which leads to population outbreaks (plant-stress hypothesis). Prestidge and McNeill (1983) claim that this phenomenon may suggest that grassland leafhoppers select host grasses according to their leaf nitrogen levels. In contrast to this, Huberty and Denno (2004) provided evidence that many phytophagous insects, especially sap feeders, are adversely affected by continuous water stress. To explain the observed outbreaks of phytophagous insects on water-stressed plants in nature, they proposed that bouts of stress and the recovery of turgor allow sap-feeders to benefit from stress-induced increases in plant nitrogen (pulsed stress hypothesis). Moreover, Masters *et al.* (1998) investigating the influence of wetter and drier summers on the numbers of Auchenorrhyncha, showed that although summer droughts caused a decrease in vegetation cover, this did not lead to a corresponding decrease in the abundance of leafhoppers. At the same time, supplemented summer rainfall also led to a large increase in the number of insects.

The Auchenorrhyncha communities described are characterized by a higher ratio of heliophilous than mezoheliophilous species, which is typical for fauna associated with sunny grassland habitats of southern-facing limestone slopes. Claridge *et al.* (1981) observed that the distribution of three leafhopper species *Eupteryx urticae*, *Eupteryx aurata* and *Ribautiana ulmi* was different on shaded and unshaded plants.

Leafhopper species which prefer sun leaves have longer stylets than those piercing shade leaves, which reflects the morphological structure of the leaves. The sun leaves have a thicker epidermis and palisade mesophyll and they also tend to possess more intercellular spaces in the spongy mesophyll. Moreover, there were significantly more tannins in the sun than in the shade leaves.

Soil conditions may not only influence the Auchenorrrhyncha by determining the species composistion of the vegetation, but also by causing spatial variation in 'host quality' within plant species (Cherill & Rushton, 1993). Comparing sandy and limestone habitats, the main difference is soil pH – acidic for sandy soils and alkaline for limestone ones. Additionally, both types support different microclimatic conditions. Sand grains accumulate higher amounts of warmth than limestone rock, but in contrast to the latter they lose it quite quickly during the nocturnal period. Thus, typical xerothermic species prefer limestone grasslands, even though their food plants also occur in sandy plant assemblages (Mazur, 2001).

It is worth mentioning briefly the origin of the leafhopper fauna of grassland ecosystems in Poland. Before the Neolithic tribes settled here (about 6500 years ago), the country was a 90% woodland area. The primeval forests of Central Europe had an undergrowth rich in grasses (Bengtsson *et al.*, 2000) and this was probably the first platform of adaptive radiation for leafhoppers in an environment of different grass species. The next step was to occupy the forest openings and gaps which appeared as a result of unselective and fairly intense grazing by large megaherbivores. Finally, humans played an important role in changing the landscape composition. Meadows and pastures maintained by domestic grazers were a new source of diverse ecological niches (Nickel, 2003). Deforestation also resulted in the expansion of heliophilous plants, including those of steppe origin, which survived in isolated forest enclaves as relicts of a previously widely distributed steppe (Bredenkamp *et al.*, 2002). These were rocky, gravelly and sandy arid areas resulting from periglacial conditions where steppe vegetation could remain and then disperse. The appearance of forestless corridors made it possible for xerothermic insects to migrate northwards and inhabit dry and warm places. The origin of xerothermophilous fauna in Central Europe is still under discussion. It is thought to be rather an inflow in the Holocene epoch than a relict remnant from the Pleistocene glacial-interglacial period (Mazur, 2001). The xerothermophilous fauna of the Kraków-Częstochowa Upland was formed by migration from two directions (Szeptycki & Warchałowska-Śliwa, 1992). The first route ran from the areas of the Black Sea via the Podolian and Małopolska uplands. The second had its origin in the area of the Pannonian Plain (Great and Little Hungarian Plains) and ran via the Moravian Gate and the Silesian upland. The Podolian route was used by leafhopper species representing the Kazakh element, the Moravian route by those which migrated from southern parts of Central Europe and areas bordering on the Mediterranean Sea.

Taking into account the factors involved in forming leafhopper communities, it is easy to see the dominating influence of the species diversity of plant assemblage on the number of leafhoppers, whereas the abundance of a particular species depends on weather conditions and the presence of competitors, predators and parasitoids. The characteristic species for the identified insect communities are mainly monophagous, feeding on typical species of particular plant phytocenoses. Generally speaking, the more diversified the plant assemblages are, the greater the number of individual phytophagous fauna inhabiting them is.

Leafhopper relationships within the ecosystem can be considered at different levels. Species inhabiting particular plants combine into microcommunities which when associated together form the community level. It is also possible to distinguish a higher rank – a range of communities linked to the phytosocilogical class. PCA analysis supports this view, splitting the leafhopper communities into two groups – the first representing communities associated with plant assemblages of the *Koelerio glaucae-Corynephoretea canescentis* class and the second with assemblages of the *Festuco-Brometea* class.

As mentioned in Chapter 2, there is still a lack of papers on Auchenorrhyncha based on several years of research in the Polish literature. This monograph partly fills this gap, but to show the general mechanism governing the formation of leafhopper communities, comparative studies on other grassland plant assemblages are necessary.

Summarizing, the following conclusions can be drawn from our research work:

1. The investigation into leafhopper communities on the psammophilous and limestone grasslands of the Częstochowa Upland is one of only a few comprehensive studies dedicated to this group of insects in Poland.

2. One hundred and twelve species were recorded from the investigated plots, which constitutes 22% of Polish Auchenorrhyncha fauna. Several species are rare in Poland – known only in a few locations or not recorded at all for several decades.

3. Taking into account such parameters as dominance, frequency and fidelity and on the basis of chorological and ecological analysis, the leafhopper communities of sandy grasslands *Spergulo vernalis-Corynephoretum* and *Diantho-Armerietum elongatae* and xerothermic, limestone grasslands *Festucetum pallentis*, *Sileno-Phleetum* and *Adonido-Brachypodietum pinnati* were identified.

4. Plant species richness and vegetation complexity determine the diversity of the leafhopper communities. Moreover, the occurrence of specific characteristic species, mostly monophagous, denotes the natural character of the investigated habitats.

5. The leafhopper community associated with psammophilous grassland *Spergulo vernalis-Corynephoretum* was characterized by the presence of two dominants –

Neophilaneus minor and *Psammotettix excisus*. These species, trophically linked to the grass *Corynephorus canescens*, were also the characteristic species of the community. The xerophilous (73.08%) and heliophilous (80.77%) elements had the highest ratios in the community together with monophagous species (46.15%).

6. The leafhopper community linked to psammophilous grassland *Diantho-Armerietum elongatae* was characterized by the presence of three dominants – *Chlorita paolii*, *Neoaliturus fenestratus* and *Turrutus socialis*. The characteristic species of the community were *Chlorita paolii* and *Laburrus impictifrons* trophically associated with *Artemisia campestris* and *Eupteryx notata* and *Neoaliturus fenestratus* both utilizing *Hieracium pilosella*. Oligophagous species (51.43%) had the highest ratio in the community together with xerophilous (57.14%) and heliophilous elements (71.43%).

7. The leafhopper community linked to rocky limestone grassland *Festucetum pallentis* was characterized by the presence of two dominants – *Erythria aureola* and *Emelyanoviana mollicula*. The characteristic species of the community were the previously mentioned two dominants trophically associated with Lamiaceae together with *Micantulina stigmatipennis* feeding monophagously on *Verbascum lychnitis* and *Fieberiella septentrionalis* utilizing *Vincetoxicum hirundinaria*. The Kazakh element (19.05%) had the highest ratio in the community together with the xerophilous (61.90%) and heliophilous (76.19%) species.

8. The leafhopper community associated with limestone grassland *Adonido-Brachypodietum pinnati* was characterized by the presence of only one dominant species – *Adarrus multinotatus*. The characteristic species of this community were *Ribautodelphax pungens* and *Adarrus multinotatus* – both feeding monophagously on the grass *Brachypodium pinnatum*. The community was characterized by the highest ratio of poliphagous species (26.09%) and those forms hibernating as nymphs (26.09%).

9. The community of *Sileno-Phleetum* grassland had a transitional character between the community of *Diantho-Armerietum elongatae* sandy grassland and the community of *Festucetum pallentis* limestone grassland.

10. The leafhopper communities were characterized by quantitative (species abundance) and qualitative (species richness) changes within the growing season. The abundance maxima of leafhoppers were recorded at the turn of June and July and at the turn of August and September.

11. On the basis of the chorological analysis, it was shown that the leafhoppers representing Transpalaearctic, Eurosiberian and European elements were the most abundant in the Auchenorrhyncha fauna of the investigated area.

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STRESZCZENIE

Piewiki (Fulgoromorpha Ev. et Cicadomorpha Ev. = Auchenorrhyncha Dum.) należą do grupy fitofagów ssących z rzędu pluskwiaków (Hemiptera). Są ważnym składnikiem sieci troficznych większości ekosystemów lądowych, w których tworzą bogate i charakterystyczne gatunkowo zgrupowania o złożonej strukturze i dynamice liczebności występowania. Z tego względu są także wartościowym narzędziem do oceny stanu i zmian środowiska przyrodniczego. Znaczną część piewików stanowią mono- i oligofagi, związane przede wszystkim z różnymi gatunkami roślin nasiennych, kilkanaście gatunków żyje na paprotnikach, stwierdzono także przypadek briofagii w tej grupie owadów.

Z terenu Polski wykazano dotychczas 515 gatunków piewików, co stanowi około 30% europejskiej cykadofauny. Wyżyna Krakowsko-Wieluńska, która obejmuje obszar Wyżyny Częstochowskiej, należy do regionów Polski dobrze poznanych pod względem składu gatunkowego fauny piewików. Jednak większość z 339 gatunków została wykazana z części południowej Wyżyny – okolic Krakowa i Ojcowa, niewiele jest natomiast doniesień z obszaru samej Wyżyny Częstochowskiej. Dotychczasowe kompleksowe badania nad składem i strukturą zgrupowań piewików w Polsce koncentrowały się na zbiorowiskach lasów liściastych i borowych, torfowiskach, łąkach i pastwiskach różnego typu, jednak w niewielkim stopniu na fitocenozach murawowych.

Wyżyna Częstochowska charakteryzuje się bogatą florą naczyniową oraz dużym zróżnicowaniem zbiorowisk roślinnych, a o unikalnych walorach przyrodniczych tego obszaru świadczy projekt utworzenia Jurajskiego Parku Narodowego.

Szczególnie cenne są murawy napiaskowe (psammofilne) i kserotermiczne murawy nawapienne tego terenu, które w skali kraju należą do zbiorowisk coraz rzadszych, występujących tylko na nielicznych, izolowanych stanowiskach. W powyższych fitocenozach spotkać można wiele rzadkich gatunków owadów, które są grupą dominującą w tych ekosystemach. Często są to gatunki reliktowe, na stanowiskach znacznie oddalonych od obszaru zwartego zasięgu. Do tej pory badania entomofauny muraw psammofilnych i kserotermicznych Wyżyny Częstochowskiej dotyczyły prostoskrzydłych (Orthoptera), motyli (Lepidoptera), wybranych grup chrząszczy (Coleoptera), muchówek (Diptera), błonkówek (Hymenoptera) oraz wciornastków (Thysanoptera). Z pluskwiaków (Hemiptera) opracowano tylko mszyce (Aphidinea) i tasznikowate (Heteroptera: Miridae), brak natomiast danych dotyczących piewików.

Wydawało się więc celowe podjęcie próby scharakteryzowania struktur zooceno-tycznych właśnie piewików w zbiorowiskach murawowych Wyżyny Częstochowskiej, a głównym celem pracy było: 1) określenie składu gatunkowego piewików wybranych muraw piaskowych i kserotermicznych Wyżyny Częstochowskiej, 2) wyróżnienie zgrupowań piewików związanych z wybranymi zbiorowiskami murawowymi na podstawie ich struktury dominacji oraz stopnia powiązania z tymi zbiorowiskami roślinnymi, 3) zbadanie dynamiki zmian sezonowych piewików na przykładzie dominantów i subdominantów w badanych zbiorowiskach murawowych, 4) przeprowadzenie analizy chorologicznej i ekologicznej badanej grupy owadów.

Obszar badań położony był w północnej części Wyżyny Częstochowskiej, na terenie Parku Krajobrazowego Orlich Gniazd. Stanowiska badawcze zlokalizowane były w dwóch miejscach – na południowy wschód od miejscowości Olsztyn oraz na wschód od miejscowości Mstów koło Częstochowy.

Zgodnie z regionalizacją fizycznogeograficzną Polski Wyżyna Częstochowska jest jednym z 4 mezoregionów, wraz z Wyżyną Olkuską, Rowem Krzeszowickim i Garbem Tenczyńskim, w obrębie makroregionu Wyżyny Krakowsko-Częstochowskiej podprowincji Wyżyny Śląsko-Krakowskiej. Rozciąga się między przełomową doliną Warty od Częstochowy po Mstów na północy, a tzw. Bramą Wolbromską i doliną Białej Przemszy na południu, zajmując powierzchnię około 1300 km^2. Obszar ten od zachodu góruje nad Obniżeniem Górnej Warty, ku któremu opada kilkudziesięciometrowym progiem (kuestą), od wschodu natomiast przylega do Niecki Włoszczowskiej, Progu Lelowskiego i Wyżyny Miechowskiej. Biorąc pod uwagę podział administracyjny Polski, Wyżyna leży w granicach województwa śląskiego.

Obszar Wyżyny (Jury) Częstochowskiej pod względem geologicznym należy do monokliny śląsko-krakowskiej, która graniczy od zachodu z zapadliskiem górnośląskim, od południa z zapadliskiem przedkarpackim, a od wschodu z niecką miechowską. W profilu geologicznym obszaru wyróżnić można trzy główne piętra strukturalne: 1) sfałdowane utwory podłoża paleozoicznego, 2) płytę osadowych skał mezozoicznych, 3) pokrywowe utwory kenozoiczne.

Formację mezozoiczną, dominującą na omawianym obszarze, reprezentują różnie litologicznie wykształcone wapienie górnej jury (malm); są to wapienie płytowe, skaliste i uławicone. Na rozwój rzeźby Jury Częstochowskiej bardzo ważny wpływ miał ciepły i wilgotny klimat oraz tektonika trzeciorzędu. W tym okresie dominowały zjawiska krasowe, w wyniku których zniszczeniu uległ wyższy poziom Wyżyny i powstała paleogeńska powierzchnia zrównania, czyli wierzchowina jurajska, o wysokości średniej ok. 450 m n.p.m. Ponad powierzchnią pozostały tylko bardziej odporne fragmenty wapieni w postaci tak zwanych skalnych ostańców. Doliny pomiędzy wzgórzami wapiennymi wypełniają kenozoiczne osady czwartorzędowe zlodowacenia południowopolskiego, a na północy regionu także zlodowacenia Odry. Pokrywy piaszczyste, które uległy wielokrotnej redepozycji, mają charakter poligenetyczny i różnowiekowy. Składają się na nie piaski eoliczne, piaski fluwioperyglacjalne oraz piaski i żwiry fluwioglacjalne. Występują one w dnach dolinek, na stokach, jak i w obrębie płaskich powierzchni wododziałowych.

Na florę Wyżyny Częstochowskiej składa się ponad 1000 gatunków roślin naczyniowych. Znaczna jest grupa gatunków południowych, bo aż 30, z takimi przedstawicielami elementu pontyjskiego jak wisienka stepowa (*Cerasus fruticosa*), zapłonka brunatna (*Nonea pulla*), pszonak pannoński (*Erysimum odoratum*) czy kłokoczka południowa (*Staphylea pinnata*). Na szczególną uwagę zasługują przede wszystkim dwa gatunki endemiczne: przytulia krakowska (*Galium cracoviense*) w Olsztynie oraz warzucha polska (*Cochlearia polonica*) na zastępczym stanowisku w Złotym Potoku a także kilka gatunków reliktowych, między innymi skalnica gronkowa (*Saxifraga paniculata*) i kozłek trójlistkowy (*Valeriana tripteris*). Istnienie

247 gatunków jest zagrożone, a 91 taksonów to rośliny podlegające ochronie ścisłej. Szacuje się, że liczba dobrze zdefiniowanych zespołów roślinnych na omawianym obszarze wynosi co najmniej 250. Reprezentują one zbiorowiska leśno-zaroślowe, muraw kserotermicznych, piaskowych i naskalnych, łąk oraz pól uprawnych (segetalne). Do najbardziej zróżnicowanych należą zespoły buczyn i muraw kserotermicznych. Najcenniejsze naturalne zespoły leśne to żyzna buczyna sudecka *Dentario enneaphyllidis-Fagetum* i ciepłolubna buczyna storczykowa *Carici-Fagetum*. Głównym czynnikiem zagrażającym szacie roślinnej jest silna antropopresja, na którą składa się eksploatacja kopalin, zakłócenie układów hydrologicznych, zanieczyszczenia atmosfery i gleby oraz coraz bardziej rozwijająca się turystyka.

Powierzchnie badawcze, w liczbie 11, wyznaczone zostały w reprezentatywnych płatach muraw napiaskowych z klasy *Koelerio glaucae-Corynephoretea canescentis* i kserotermicznych muraw nawapiennych z klasy *Festuco-Brometea*.

Klasa *Koelerio glaucae-Corynephoretea canescentis* obejmuje europejskie, niżowe pionierskie murawy piaszczysk bezwapiennych. Zbiorowiska te występują na przepuszczalnych piaskach i żwirach i są rozpowszechnione w Europie zachodniej, środkowej, częściowo północnej i wschodniej. Ich fitocenozy budują głównie acido- i kserofilne wąskolistne trawy, rośliny rozetkowe, terofity oraz sukulenty, a także mchy i światłolubne porosty. Zbiorowiska omawianej klasy, ze względu na swój zasięg, podlegają zarówno wpływom klimatu atlantyckiego, jak i kontynentalnego. Badania prowadzono w dwóch zbiorowiskach roślinnych należących do tej klasy – *Spergulo vernalis-Corynephoretum* (powierzchnia 1 i 2) i *Diantho-Armerietum elongatae* (powierzchnia 3, 4 i 5).

Klasa *Festuco-Brometea* obejmuje zbiorowiska ciepłolubnych muraw wykształcających się na glebach zasadowych, zasobnych w węglan wapnia, w miejscach o specyficznych warunkach mikroklimatycznych – wysokiej temperaturze powietrza i gleby. Są to najczęściej suche, słoneczne zbocza wzgórz, dolin rzecznych i wąwozów, zwłaszcza o wystawie południowej, rzadziej wschodniej czy zachodniej. W Polsce typowe płaty muraw kserotermicznych, często o charakterze reliktowym, występują w regionach o wyraźnych cechach klimatu kontynentalnego. Są to Wyżyna Małopolska, Wyżyna Lubelska, Śląsk, okolice Przemyśla, a na północy kraju rejon dolnej Wisły i dolnej Odry. Jednak znaczna część muraw z wyżej wymienionych regionów oraz z innych obszarów Polski ma najczęściej charakter wtórnych zbiorowisk antropogenicznych powstałych po zniszczeniu ciepłolubnych zarośli czy lasów i utrzymujących się dzięki gospodarce rolnej. Badania prowadzono w trzech zbiorowiskach roślinnych należących do tej klasy: *Festucetum pallentis* (powierzchnia 6 i 7), *Sileno-Phleetum* (powierzchnia 8 i 9) i *Adonido-Brachypodietum pinnati* (powierzchnia 10 i 11).

Próby ilościowe pobierano na 11 powierzchniach badawczych, z tym jednak, że na 9 powierzchniach w latach 2001–2003, a na 2 powierzchniach w latach 2002–2004, w sezonach wegetacyjnych, od początku maja do połowy października w odstępach dwutygodniowych. Próby pobierano w dni suche i słoneczne, przy braku lub niewielkim wietrze, między godziną 11.00 a 14.00. W sumie na 11 powierzchniach badawczych pobrano 396 prób ilościowych – 36 na każdej powierzchni. Materiał zbierano za pomocą standardowego czerpaka entomologicznego (Ø = 30 cm), przyjmując za pojedynczą próbę 25 uderzeń w czterech transektach (4 x 25 = 100). Owady odławiano z czerpaka przy pomocy ekshaustora, a w niektórych przypadkach cały zebrany materiał przesypywano do plastikowego worka ze środkiem usypiającym i segregowano w laboratorium.

Analizując zebrany materiał posłużono się zwykle używanymi wskaźnikami analitycznymi i syntetycznymi tj. dominacja, stałość, wskaźnik Q i wierność. Przeprowadzono także analizę wskaźników umożliwiających wnioskowanie o różnorodności gatunkowej obserwowanych zgrupowań (wskaźniki różnorodności gatunkowej Shannona-Weavera, Brillouina i Simpsona). Podobieństwo zgrupowań na poszczególnych powierzchniach określono metodą aglomeracji oraz analizy głównych składowych (PCA).

Analizę chorologiczną przeprowadzono w celu określenia procentowego udziału poszczególnych elementów zasięgowych w faunie piewików wykazanej z terenu badań jak i zasiedlającej poszczególne zbiorowiska murawowe. Każdy gatunek zaklasyfikowano do jednego z następujących elementów chorologicznych: europejskiego, północnoeuropejskiego, zachodnioeuropejskiego, południowoeuropejskiego, kazachskiego, syberyjskiego, eurosyberyjskiego, zachodniopalearktycznego, transpalearktycznego i mediterrańskiego. Analizę ekologiczną przeprowadzono w celu określenia procentowego udziału poszczególnych elementów ekologicznych w faunie piewików zasiedlających badane zbiorowiska roślinne. Określono preferencje odnośnie takich parametrów środowiska jak wilgotność i nasłonecznienie, scharakteryzowano związki troficzne oraz podano liczbę pokoleń i stadium zimujące.

Na wyznaczonych 11 powierzchniach badawczych w ciągu trzech sezonów wegetacyjnych w badaniach ilościowych wykonano 396 prób, w których zebrano łącznie, w latach 2001–2004, 19 411 osobników piewików należących do 112 gatunków.

Zgrupowanie piewików związane z murawą psammofilną *Sperguło vernalis-Corynephoretum* badane było na powierzchni 1 i 2. Na obu powierzchniach stwierdzono 45 gatunków piewików, z których 25 było wspólnych dla obu powierzchni. Ilościowo trzon zgrupowania tworzą dwa dominanty z pierwszym stopniem stałości – *Neophilaenus minor* i *Psammotettix excisus*. Do gatunków charakterystycznych dla tego zgrupowania zaliczono *Neophilaenus minor* i *Psammotettix excisus* – oba z wysokim stopniem wierności i troficznie związane ze szczotlichą siwą (*Corynephorus canescens*).

Zgrupowanie piewików związane z murawą psammofilną *Diantho-Armerietum elongatae* badane było na powierzchni 3, 4 i 5. Na badanych powierzchniach odnotowano 67 gatunków, z których 34 były wspólne dla wszystkich trzech powierzchni. Ilościowo trzon zgrupowania tworzą dominanty z pierwszym, bądź drugim stopniem stałości – *Chlorita paolii*, *Neoaliturus fenestratus* i *Turrutus socialis*. Do gatunków charakterystycznych dla badanego zgrupowania, z wysokim stopniem wierności, zaliczono *Chlorita paolii* i *Laburrus impictifrons* – gatunki monofagiczne na bylicy polnej (*Artemisia campestris*) oraz *Eupteryx notata* i *Neoaliturus fenestratus* – troficznie związane z jastrzębcem kosmaczkiem (*Hieracium pilosella*).

Zgrupowanie piewików związane z naskalną murawą kserotermiczną *Festucetum pallentis* badane było na powierzchni 6 i 7. W ciągu sezonów 2001–2003 odnotowano 56 gatunków piewików, z których 21 było wspólnych dla obu powierzchni badawczych. Ilościowo trzon zgrupowania tworzą dwa dominanty z pierwszym stopniem stałości – *Erythria aureola* i *Emelyanoviana mollicula*. Jako gatunki charakterystyczne dla tego zgrupowania, z wysokim stopniem wierności, wyróżniono: *Erythria aureola* i *Emelyanoviana mollicula* troficznie związane z jasnotowatymi (Lamiacae), *Micantulina stigmatipennis* – monofag na dziewannie firletkowej (*Verbascum lychnitis*) i *Fieberiella septentrionalis* – żerujący na ciemiężyku białokwiatowym (*Vincetoxicum hirundinaria*).

Zgrupowanie piewików związane z murawą kserotermiczną *Sileno-Phleetum* badane było na powierzchniach 8 i 9. Na badanych powierzchniach odnotowano 61 gatunki piewików, z których 31 było wspólnych dla obu powierzchni. Ilościowo trzon zgrupowania na obu powierzchniach tworzy *Turrutus socialis* – dominant z pierwszym stopniem stałości oraz *Acanthodelphax spinosa* (pow. 8) i *Arocephalus languidus* (pow. 9). Do gatunków charakterystycznych dla tego zgrupowania zaliczono *Acanthodelphax spinosa* (pow. 8) i *Kosswigianella exigua* (pow. 9).

Zgrupowanie piewików związane z murawą kserotermiczną *Adonido-Brachypodietum pinnati* badane było na powierzchni 10 i 11. W ciągu trzech sezonów odnotowano 61 gatunków, z których 23 były wspólne dla obu powierzchni. Ilościowo trzon zgrupowania tworzy dominant z pierwszym bądź drugim stopniem stałości – *Adarrus multinotatus*. Za gatunki wyróżniające zgrupowanie związane z badanym zbiorowiskiem murawowym uznano *Ribautodelphax pungens* i *Adarrus multinotatus* – monofagi na kłosownicy pierzastej (*Brachypodium pinnatum*).

Wskaźnik ogólnej różnorodności gatunkowej Shannona-Weavera dla wyznaczonych zgrupowań piewików muraw psammofilnych i kserotermicznych Wyżyny Częstochowskiej zawiera się w granicach 0,75–1,30, przy wartościach maksymalnych 1,54–1,72. Najniższa wartość wskaźnika (0,75) wystąpiła w zgrupowaniu związanym z murawą napiaskową *Spergulo vernalis-Corynephoretum* na powierzchni 2, natomiast wartość najwyższą (1,30) odnotowano dla zgrupowania związanego z murawą psammofilną *Diantho-Armerietum elongatae* na powierzchni 5. Podobnie, wskaźniki Brillouina i Simpsona osiągnęły najniższe i najwyższe wartości na powyższych powierzchniach.

Zastosowanie metody aglomeracyjnej pozwoliło na wyodrębnienie na terenie badań czterech grup faunistycznych, zarówno w przypadku analizy ilości osobników wszystkich zebranych gatunków jak również, gdy pod uwagę wzięto wyłącznie liczbę osobników gatunków dominujących. Zastosowana metoda analizy głównych składowych (PCA) uporządkowała zgrupowania na poszczególnych powierzchniach w dwa kręgi zgrupowań, każdy reprezentowany przez dwie grupy faunistyczne. Pierwszy krąg tworzą zgrupowania związane z murawami piaskowymi, natomiast drugi zgrupowania zasiedlające murawy kserotermiczne.

Najliczniej na całym terenie badań reprezentowane są gatunki należące do elementów o szerokim rozprzestrzenieniu – eurosyberyjskiego (23,89%), europejskiego

(20,35%), transpalearktycznego (16,81%) i zachodniopalearktycznego (13,27%). Znacznie mniejszy udział mają elementy o węższym rozprzestrzenieniu: kazachski (7,08%), mediterrański (5,31%), północnoeuropejski (1,77%), zachodnioeuropejski (0,88%) i południowoeuropejski (0,88%).

Element południowoeuropejski odnotowano tylko na powierzchni 7 (murawa naskalna *Festucetum pallentis*) i reprezentowany jest przez *Wagneriala incisa*. Element kazachski w zebranym materiale reprezentowany jest przez 8 gatunków: *Metropis inermis*, *Austroasca vittata*, *Chlorita paolii*, *Eupteryx notata*, *Doratura exilis*, *Doratura impudica*, *Laburrus impictifrons* i *Arocephalus languidus*. Największy udział tego elementu odnotowano w zgrupowaniu związanym z naskalaną murawą kserotermiczną *Festucetum pallentis* (19,05%) i murawą psammofilną *Spergulo vernalis-Corynephoretum* (15,38%). Element mediterrański w całości zebranego materiału reprezentowany jest z udziałem 5,31% przez sześć gatunków: *Tettigometra impressopunctata*, *Cercopis sanguinolenta*, *Neophilaenus campestris*, *Utecha trivia*, *Utecha lugens* i *Megophthalmus scanicus*. Element ten pojawił się z niewielkim udziałem w zgrupowaniu związanym z murawą kserotermiczną *Sileno-Phleetum* (6,45%; 2 gatunki – *Cercopis sanguinolenta*, *Megophthalmus scanicus*) i murawą kserotermiczną *Adonido-Brachypodietum pinnati* (8,70%; 2 gatunki – *Cercopis sanguinolenta*, *Utecha trivia*).

Odnośnie wymagań względem wilgotności środowiska, gatunki higrofilne wystąpiły z niewielkim udziałem w zgrupowaniach związanych z murawami kserotermicznymi: *Adonido-Brachypodietum pinnati* (8,70%), *Sileno-Phleetum* (6,45%) i *Festucetum pallentis* (4,76%). Element mezohigrofilny osiągnął największy udział w zgrupowaniu związanym z murawą kserotermiczną *Adonido-Brachypodietum pinnati* (69.57%). Element kserofilny dominował w zgrupowaniu związanym z murawą psammofilną *Spergulo vernalis-Corynephoretum* (69,23%) oraz zgrupowaniu zasiedlającym naskalną murawę kserotermiczną *Festucetum pallentis* (57,14%).

Element heliofilny osiągnął największy udział w zgrupowaniu związanym z murawą napiaskową *Spergulo vernalis-Corynephoretum* (80,77%) oraz zgrupowaniu związanym z naskalną murawą kserotermiczną *Festucetum pallentis* (76,19%). Większy udział elementu mezoheliofilnego odnotowano w dwóch zgrupowaniach – związanym z murawą kserotermiczną *Adonido-Brachypodietum pinnati* (47,83%) oraz murawą kserotermiczną *Sileno-Phleetum* (38,71%).

Analizując strukturę troficzną stwierdzono, że gatunki polifagiczne miały największy udział w zgrupowaniu piewików związanym z murawą kserotermiczną *Adonido-Brachypodietum pinnati* (26,09%). Gatunki oligofagiczne miały podobny udział we wszystkich zgrupowaniach, w zakresie od 42,86% do 51,43%. Monofagi osiągnęły największy udział procentowy w zgrupowaniu związanym z murawą napiaskową *Spergulo vernalis-Corynephoretum* (46,15%). Najwięcej gatunków piewików wykazanych z terenu badań troficznie związanych jest z trawami (Poaceae) – 59 gatunków.

We wszystkich analizowanych zgrupowaniach cykadofauny muraw dominują gatunki biwoltynne, a ich udział jest dość wyrównany i wynosi od 65,22% do 74,19%. Wśród gatunków piewików występujących w poszczególnych zgrupowaniach najczęstsze są formy zimujące w stadium jaja (od 60,87% do 71,43%). Gatunki hibernujące jako nimfy miały największy udział w zgrupowaniu związanym z murawą kserotermiczną *Adonido-Brachypodietum pinnati* (26,09%) oraz murawą kserotermiczną *Sileno-Phleetum* (25,81%). Najmniejszy udział ilościowy we wszystkich zgrupowaniach miały piewiki zimujące jako formy dorosłe.

Biorąc pod uwagę czynniki kształtujące zgrupowania piewików, zauważyć można dominujący wpływ zróżnicowania zespołu roślinnego na liczbę gatunków piewików, natomiast obfitość występowania poszczególnych gatunków zależy głównie od warunków pogodowych w danym sezonie, jak również obecności konkurentów, drapieżników czy parazytoidów. Gatunki wyróżniające czy charakterystyczne dla zgrupowania piewików związanego z daną fitocenozą to przede wszystkim monofagi żerujące na specyficznych gatunkach roślin. Tak więc, im badane zbiorowiska roślinne są bardziej zróżnicowane, tym większa odrębność zasiedlającej je fauny badanych fitofagów.

Powiązania gatunków piewików w obrębie biocenozy mogą być rozpatrywane na różnych poziomach. Gatunki współzasiedlające poszczególne rośliny tworzą „mikrozgrupowania", które w obrębie zespołu roślinnego składają się na zgrupowanie. Można również pokusić się o wyróżnienie jednostki o wyższej randze, czyli kręgu zgrupowań związanego z określoną klasą fitosocjologiczną. Pomocna okazuje się tutaj analiza PCA, której wyniki pozwoliły na wydzielenie zgrupowań związanych z klasą muraw psammofilnych *Koelerio glaucae-Corynephoretea canescentis* oraz z klasą muraw kserotermicznych *Festuco-Brometea* oraz wyodrębnienie gatunków, które można przyjąć za charakterystyczne dla tych dwóch kręgów zgrupowań.

Interesującą kwestią jest pochodzenie fauny piewików zbiorowisk trawiastych, w tym także muraw piaskowych i kserotermicznych. Przed pojawieniem się plemion neolitycznych (ok. 6500 lat temu) obszar Polski w 90% pokryty był lasem. Pierwotne lasy liściaste Europy Środkowej zawierały podszyt bogaty w różne gatunki traw i to prawdopodobnie był obszar pierwotnej radiacji i adaptacji piewików do tej grupy roślin. Następny etap to zasiedlanie niewielkich trawiastych terenów otwartych, które utrzymywały się głównie dzięki obecności dużych roślinożerców. Wkroczenie człowieka i przekształcenie znacznych obszarów leśnych w łąki i pastwiska dało jeszcze większą możliwość do zajmowania nowych nisz ekologicznych.

Wylesienia powodowały także ekspansję roślin heliofilnych, w tym także stepowych, które pierwotnie zasiedlały izolowane siedliska na szczytach wapiennych i gipsowych wzgórz oraz urwiste zbocza dolin rzecznych. Powstanie bezleśnych korytarzy umożliwiło, szczególnie owadom kserotermofilnym, migrację ku północy i zasiedlanie suchych i ciepłych biotopów. Pochodzenie fauny kserotermofilnej w Europie Środkowej jest wciąż jeszcze sprawą dyskusyjną. W większym stopniu uznaje się ją za napływową w okresie holocenu, niż reliktową z plejstoceńskiego okresu glacjalno-interglacjalnego. Fauna kserotermofilna Wyżyny Krakowsko-Częstochowskiej kształtowana była przez migrację owadów z dwóch kierunków. Pierwszy prowadził wzdłuż Podola i Wyżyny Małopolskiej z obszarów stepowych nad Morzem Czarnym, drugi przez Bramę Morawską i Wyżynę Śląską z terenu Kotliny Pannońskiej (Nizina Węgierska). Podolski szlak migracyjny wykorzystywały prawdopodobnie gatunki piewików reprezentujące element kazachski (8 na terenie badań), natomiast szlak morawski gatunki zaliczone do elementu mediterrańskiego (6 na terenie badań).

Podsumowując:

- zastosowanie takich parametrów jak dominacja, stałość i wierność oraz analiza chorologiczna i ekologiczna pozwoliło na wyodrębnienie zgrupowań piewików związanych z murawami psammofilnymi *Spergulo vernalis-Corynephoretum* i *Diantho-Armerietum elongatae* oraz kserotermicznymi murawami nawapiennymi *Festucetum pallentis*, *Sileno-Phleetum* i *Adonido-Brachypodietum pinnati*;
- zgrupowania piewików kształtowane są przez szeroki wachlarz czynników, zarówno biotycznych (struktura fitocenozy, wartości odżywcze roślin, obecność konkurentów, drapieżników i parazytoidów), jak i abiotycznych (temperatura, opady, typ podłoża, gospodarka człowieka);
- struktura przestrzenna zespołów murawowych oraz liczba gatunków roślin determinuje bogactwo gatunkowe związanych z nimi zgrupowań piewików;
- obecność swoistych gatunków charakterystycznych świadczy o naturalnym charakterze wykształcających się zgrupowań piewików;
- zróżnicowaną wewnętrzną architekturę muraw psammofilnych i kserotermicznych Wyżyny Częstochowskiej wyraźnie odzwierciedlają obliczone dla poszczególnych zgrupowań piewików wskaźniki różnorodności gatunkowej; największe wartości osiągnęły one w zgrupowaniach zasiedlających wielowarstwową murawę napiaskową *Diantho-Armerietum elongatae*, najmniejsze natomiast w zgrupowaniach związanych z prostą fitocenozą murawy szczotlichowej *Spergulo vernalis-Corynephoretum*;
- analiza chorologiczna wykazała, że najliczniej na całym terenie badań reprezentowany jest element transpalearktyczny, eurosyberyjski i europejski;
- niewielki udział gatunków polifagicznych, z przewagą oligofagów i monofagów, świadczy o stabilności siedlisk zajmowanych przez wyróżnione zgrupowania;
- korzystne warunki termiczne jakie panują w badanych zbiorowiskach murawowych powodują, iż we wszystkich zgrupowaniach największy udział mają gatunki dwupokoleniowe;
- warunki pogodowe wyraźnie wpływają na liczebność piewików – zaobserwowano znaczny wzrost liczby okazów piewików w sezonie o znacznie wyższej od przeciętnej średniej temperaturze rocznej;
- ważnym czynnikiem decydującym o fluktuacjach populacji piewików w zgrupowaniach jest migracja do i z innych środowisk;
- wyróżnione zgrupowania piewików charakteryzują się większym udziałem gatunków heliofilnych niż mezoheliofilnych, przy braku form skiofilnych co jest typowe dla fauny zasiedlającej silnie insolowane siedliska, jakimi są wykształcające się w dolinach i na południowych stokach wzgórz wapiennych zbiorowiska murawowe;
- maksimum liczebności dominantów przypada na różne okresy sezonu wegetacyjnego – zaobserwowano czasowe przesunięcie w pojawie gatunków z rodziny Delphacidae i podrodziny Deltocephalinae żerujących na trawach, realizujących w ten sposób podział zasobów pokarmowych pomiędzy grupy wykorzystujące ten sam krąg roślin żywicielskich.

ANNEXES

Annex 1. Dominance – D [%], Frequency – F [%] and Q index for Auchenorrhyncha species collected on plot 1 (*Spergulo vernalis-Corynephoretum*).

Auchenorrhyncha species	Year											
	2001				2002				2003			
	D	*F*		*Q*	*D*	*F*		*Q*	*D*	*F*		*Q*
Megadelphax sordidula	0.25	11.11	IV	1.65	–	–	–	–	0.20	9.09	IV	1.34
Laodelphax striatella	0.98	11.11	IV	3.30	–	–	–	–	–	–	–	–
Muirodelphax aubei	0.74	11.11	IV	2.86	0.91	33.33	III	5.50	–	–	–	–
Kosswigianella exigua	–	–	–	–	0.11	16.67	IV	1.33	–	–	–	–
Javesella pellucida	0.25	11.11	IV	1.65	0.16	16.67	IV	1.63	–	–	–	–
Ribautodelphax angulosa	–	–	–	–	0.80	16.67	IV	3.64	0.20	9.09	IV	1.34
Ribautodelphax collina	–	–	–	–	0.75	16.67	IV	3.53	–	–	–	–
Neophilaenus minor	4.18	77.78	I	18.02	5.67	75.00	II	20.62	21.67	72.73	II	39.70
Utecha lugens	–	–	–	–	0.05	8.33	IV	0.67	0.20	9.09	IV	1.34
Anaceratagallia ribauti	0.98	22.22	IV	4.67	0.11	16.67	IV	1.33	0.99	27.27	III	5.21
Eupelix cuspidata	0.25	11.11	IV	1.65	–	–	–	–	–	–	–	–
Aphrodes bicincta	–	–	–	–	–	–	–	–	0.20	9.09	IV	1.34
Planaphrodes trifasciata	–	–	–	–	0.05	8.33	IV	0.67	–	–	–	–
Erythria aureola	–	–	–	–	–	–	–	–	0.20	9.09	IV	1.34
Chlorita paolii	0.49	11.11	IV	2.34	0.75	33.33	III	4.99	0.99	18.18	IV	4.25
Eupteryx notata	0.49	11.11	IV	2.34	–	–	–	–	–	–	–	–
Neoaliturus fenestratus	0.25	11.11	IV	1.65	0.27	16.67	IV	2.11	0.60	27.27	III	4.04
Macrosteles laevis	4.18	44.44	III	13.62	35.08	83.33	I	54.07	2.19	54.55	II	10.92
Macrosteles quadripunctulatus	0.25	11.11	IV	1.65	–	–	–	–	–	–	–	–
Macrosteles sexnotatus	1.47	33.33	III	7.01	–	–	–	–	–	–	–	–
Doratura exilis	17.20	33.33	III	23.94	3.74	41.67	III	12.49	10.74	36.36	III	19.76
Doratura homophyla	–	–	–	–	0.21	25.00	IV	2.31	0.80	27.27	III	4.66
Doratura stylata	–	–	–	–	0.27	25.00	IV	2.58	0.60	18.18	IV	3.29
Hardya tenuis	–	–	–	–	0.05	8.33	IV	0.67	–	–	–	–
Rhopalopyx vitripennis	–	–	–	–	0.27	16.67	IV	2.11	–	–	–	–
Cicadula persimilis	–	–	–	–	–	–	–	–	0.20	9.09	IV	1.34
Laburrus impictifrons	–	–	–	–	0.11	16.67	IV	1.33	–	–	–	–
Euscelis distinguendus	–	–	–	–	–	–	–	–	0.20	9.09	IV	1.34
Arocephalus languidus	–	–	–	–	0.05	8.33	IV	0.67	–	–	–	–
Psammotettix alienus	1.72	33.33	III	7.57	5.94	58.33	II	18.61	6.56	36.36	III	15.45
Psammotettix cephalotes	0.25	11.11	IV	1.65	0.96	41.67	III	6.33	–	–	–	–
Psammotettix confinis	2.21	44.44	III	9.91	4.87	58.33	II	16.85	0.60	9.09	IV	2.33
Psammotettix excisus	62.41	100.00	I	79.00	37.86	91.67	I	58.91	51.29	81.82	I	64.78
Psammotettix nodosus	0.49	11.11	IV	2.34	0.37	16.67	IV	2.50	1.19	27.27	III	5.70
Turrutus socialis	–	–	–	–	0.21	8.33	IV	1.33	0.20	9.09	IV	1.34
Mocuellus collinus	0.98	44.44	III	6.61	0.37	41.67	III	3.95	0.20	9.09	IV	1.34

Annex 2. Dominance – D [%], Frequency – F [%] and Q index for Auchenorrhyncha species collected on plot 2 (*Spergulo vernalis-Corynephoretum*).

Auchenorrhyncha species	Year											
	2002				2003				2004			
	D	*F*		*Q*	*D*	*F*		*Q*	*D*	*F*		*Q*
Laodelphax striatella	0.09	9.09	IV	0.90	0.84	10.00	IV	2.90	–	–	–	–
Muirodelphax aubei	8.02	36.36	III	17.08	0.67	10.00	IV	2.59	2.72	18.18	IV	7.03
Kosswigianella exigua	0.36	18.18	IV	2.55	0.17	10.00	IV	1.30	–	–	–	–
Ribautodelphax collina	0.76	27.27	III	4.56	0.34	10.00	IV	1.83	–	–	–	–
Neophilaenus exclamationis	0.13	9.09	IV	1.11	–	–	–	–	–	–	–	–
Neophilaenus minor	2.24	81.82	I	13.54	16.50	80.00	I	36.33	41.95	81.82	I	58.59
Anaceratagallia ribauti	0.40	36.36	III	3.83	0.17	10.00	IV	1.30	–	–	–	–
Anaceratagallia venosa	0.90	36.36	III	5.71	1.18	30.00	III	5.95	0.45	18.18	IV	2.87
Eupelix cuspidata	0.09	18.18	IV	1.28	–	–	–	–	–	–	–	–
Aphrodes bicincta	0.04	9.09	IV	0.64	–	–	–	–	–	–	–	–
Aphrodes makarovi	0.04	9.09	IV	0.64	–	–	–	–	–	–	–	–
Empoasca pteridis	0.18	18.18	IV	1.81	0.17	10.00	IV	1.30	–	–	–	–
Chlorita paolii	0.09	9.09	IV	0.90	0.84	30.00	III	5.03	–	–	–	–
Linnavuoriana sexmaculata	0.04	9.09	IV	0.64	–	–	–	–	–	–	–	–
Eupteryx notata	0.09	9.09	IV	0.90	–	–	–	–	–	–	–	–
Zygina hyperici	0.04	9.09	IV	0.64	0.34	20.00	IV	2.59	–	–	–	–
Neoaliturus fenestratus	1.21	45.45	III	7.42	2.53	30.00	III	8.70	–	–	–	–
Macrosteles laevis	17.38	81.82	I	37.71	2.53	40.00	III	10.05	0.23	9.09	IV	1.44
Doratura exilis	1.08	36.36	III	6.25	5.89	50.00	III	17.16	2.04	27.27	III	7.46
Doratura homophyla	0.04	9.09	IV	0.64	0.84	30.00	III	5.03	–	–	–	–
Doratura impudica	0.09	18.18	IV	1.28	–	–	–	–	–	–	–	–
Doratura stylata	0.09	18.18	IV	1.28	0.84	20.00	IV	4.10	–	–	–	–
Graphocraerus ventralis	0.09	18.18	IV	1.28	–	–	–	–	–	–	–	–
Hardya tenuis	0.04	9.09	IV	0.64	–	–	–	–	–	–	–	–
Rhopalopyx vitripennis	0.45	27.27	III	3.50	–	–	–	–	0.23	9.09	IV	1.44
Laburrus impictifrons	0.18	27.27	III	2.21	0.51	20.00	IV	3.18	–	–	–	–
Euscelis distinguendus	0.18	36.36	III	2.55	0.51	20.00	IV	3.18	–	–	–	–
Arocephalus longiceps	0.09	9.09	IV	0.90	–	–	–	–	–	–	–	–
Psammotettix alienus	4.84	45.45	III	14.83	12.79	40.00	III	22.62	4.54	36.36	III	12.84
Psammotettix cephalotes	0.40	18.18	IV	2.71	–	–	–	–	–	–	–	–
Psammotettix confinis	2.42	54.55	II	11.49	3.54	40.00	III	11.89	1.36	18.18	IV	4.97
Psammotettix excisus	56.99	100.00	I	75.49	47.81	90.00	I	65.60	46.26	90.91	I	64.85
Psammotettix nodosus	0.36	45.45	III	4.04	–	–	–	–	–	–	–	–
Turrutus socialis	0.54	54.55	II	5.42	1.01	30.00	III	5.50	0.23	9.09	IV	1.44

Annex 3. Dominance – D [%], Frequency – F [%] and Q index for Auchenorrhyncha species collected on plot 3 (*Diantho-Armerietum elongatae*).

Auchenorrhyncha species	Year											
	2001				2002				2003			
	D	*F*		*Q*	*D*	*F*		*Q*	*D*	*F*		*Q*
Chloriona vasconica	0.34	11.11	IV	1.94	–	–	–	–	–	–	–	–
Megadelphax sordidula	1.02	22.22	IV	4.76	–	–	–	–	–	–	–	–
Laodelphax striatella	1.36	22.22	IV	5.50	0.27	25.00	IV	2.58	0.15	9.09	IV	1.16
Muirodelphax aubei	–	–	–	–	0.27	16.67	IV	2.11	–	–	–	–
Kosswigianella exigua	1.70	11.11	IV	4.35	0.33	25.00	IV	2.88	0.15	9.09	IV	1.16
Javesella pellucida	3.40	11.11	IV	6.15	–	–	–	–	–	–	–	–
Ribautodelphax angulosa	–	–	–	–	0.27	8.33	IV	1.49	0.59	9.09	IV	2.32
Ribautodelphax collina	3.74	44.44	III	12.90	14.77	58.33	II	29.35	–	–	–	–
Tettigometra atra	–	–	–	–	–	–	–	–	0.74	45.45	III	5.79
Neophilaenus exclamationis	0.34	11.11	IV	1.94	–	–	–	–	0.15	9.09	IV	1.16
Neophilaenus minor	5.44	88.89	I	21.99	1.66	58.33	II	9.85	1.18	45.45	III	7.33
Utecha trivia	–	–	–	–	0.07	8.33	IV	0.74	–	–	–	–
Utecha lugens	–	–	–	–	0.07	8.33	IV	0.74	–	–	–	–
Anaceratagallia ribauti	0.68	11.11	IV	2.75	0.33	16.67	IV	2.35	1.33	27.27	III	6.02
Anaceratagallia venosa	8.16	55.56	II	21.30	2.53	66.67	II	12.98	9.60	72.73	II	26.42
Aphrodes bicincta	1.02	11.11	IV	3.37	0.33	16.67	IV	2.35	0.74	27.27	III	4.49
Aphrodes makarovi	–	–	–	–	0.33	25.00	IV	2.88	–	–	–	–
Emelyanoviana mollicula	0.34	11.11	IV	1.94	0.07	8.33	IV	0.74	0.15	9.09	IV	1.16
Dikraneura variata	0.68	11.11	IV	2.75	–	–	–	–	–	–	–	–
Forcipata citrinella	0.34	11.11	IV	1.94	–	–	–	–	–	–	–	–
Empoasca pteridis	–	–	–	–	0.47	16.67	IV	2.79	–	–	–	–
Chlorita paolii	8.16	66.67	II	23.33	1.20	50.00	III	7.74	3.55	27.27	III	9.83
Eupteryx atropunctata	–	–	–	–	–	–	–	–	0.15	9.09	IV	1.16
Eupteryx notata	0.68	22.22	IV	3.89	0.20	25.00	IV	2.23	0.74	9.09	IV	2.59
Neoaliturus fenestratus	6.80	44.44	III	17.39	4.59	50.00	III	15.15	27.77	81.82	I	47.67
Balclutha calamagrostis	0.68	22.22	IV	3.89	0.07	8.33	IV	0.74	–	–	–	–
Macrosteles laevis	4.42	55.56	II	15.67	9.98	66.67	II	25.79	2.36	54.55	II	11.35
Macrosteles sexnotatus	0.34	11.11	IV	1.94	–	–	–	–	–	–	–	–
Doratura exilis	3.40	22.22	IV	8.69	4.19	41.67	III	13.22	1.18	36.36	III	6.56
Doratura homophyla	0.68	11.11	IV	2.75	2.79	58.33	II	12.77	1.48	27.27	III	6.35
Doratura impudica	1.02	22.22	IV	4.76	–	–	–	–	0.74	18.18	IV	3.66
Doratura stylata	2.72	33.33	III	9.52	1.53	25.00	IV	6.19	1.62	36.36	III	7.69
Graphocraerus ventralis	–	–	–	–	–	–	–	–	0.15	9.09	IV	1.16
Rhopalopyx vitripennis	1.02	33.33	III	5.83	1.40	41.67	III	7.63	0.15	9.09	IV	1.16
Elymana sulphurella	0.34	11.11	IV	1.94	0.20	25.00	IV	2.23	–	–	–	–
Ophiola decumana	0.34	11.11	IV	1.94	–	–	–	–	–	–	–	–
Ophiola transversa	0.34	11.11	IV	1.94	0.07	8.33	IV	0.74	0.30	18.18	IV	2.32
Euscelis distinguendus	1.02	22.22	IV	4.76	–	–	–	–	1.33	36.36	III	6.95
Euscelis incisus	–	–	–	–	0.33	16.67	IV	2.35	–	–	–	–
Arocephalus languidus	–	–	–	–	0.07	8.33	IV	0.74	0.30	9.09	IV	1.64
Arocephalus longiceps	–	–	–	–	0.07	8.33	IV	0.74	–	–	–	–
Psammotettix alienus	–	–	–	–	2.59	58.33	II	12.30	8.71	45.45	III	19.90
Psammotettix cephalotes	7.48	55.56	II	20.39	23.35	83.33	I	44.11	11.52	54.55	II	25.07
Psammotettix confinis	0.34	11.11	IV	1.94	1.20	33.33	III	6.32	3.99	45.45	III	13.46
Psammotettix excisus	15.31	88.89	I	36.89	6.45	83.33	I	23.19	4.73	54.55	II	16.06
Psammotettix nodosus	9.18	66.67	II	24.74	12.44	83.33	I	32.20	6.06	45.45	III	16.59
Errastunus ocellaris	–	–	–	–	0.20	25.00	IV	2.23	–	–	–	–
Turrutus socialis	7.14	66.67	II	21.82	4.66	66.67	II	17.62	7.83	63.64	II	22.32
Jassargus pseudocellaris	–	–	–	–	–	–	–	–	0.15	9.09	IV	1.16
Mocuellus collinus	–	–	–	–	0.67	83.33	I	7.45	0.44	27.27	III	3.48

Annex 4. Dominance – D [%], Frequency – F [%] and Q index for Auchenorrhyncha species collected on plot 4 (*Diantho-Armerietum elongatae*).

Auchenorrhyncha species	**Year**											
	2001				**2002**				**2003**			
	D	*F*		*Q*	*D*	*F*		*Q*	*D*	*F*		*Q*
Kelisia guttulifera	0.24	11.11	IV	1.65	–	–	–	–	–	–	–	–
Stenocranus major	1.22	22.22	IV	5.21	–	–	–	–	–	–	–	–
Megadelphax sordidula	–	–	–	–	–	–	–	–	0.10	9.09	IV	0.98
Laodelphax striatella	1.47	33.33	III	6.99	0.41	25.00	IV	3.18	1.05	27.27	III	5.34
Muirodelphax aubei	0.73	11.11	IV	2.85	0.20	8.33	IV	1.30	–	–	–	–
Acanthodelphax spinosa	–	–	–	–	0.10	8.33	IV	0.92	–	–	–	–
Kosswigianella exigua	0.98	11.11	IV	3.30	0.51	25.00	IV	3.56	0.10	9.09	IV	0.98
Javesella pellucida	2.69	22.22	IV	7.73	2.13	25.00	IV	7.30	0.31	9.09	IV	1.69
Ribautodelphax albostriata	0.98	33.33	III	5.71	4.36	58.33	II	15.95	0.84	27.27	III	4.78
Ribautodelphax collina	2.93	33.33	III	9.89	5.27	58.33	II	17.54	0.73	27.27	III	4.47
Neophilaenus campestris	–	–	–	–	–	–	–	–	0.10	9.09	IV	0.98
Neophilaenus exclamationis	0.24	11.11	IV	1.65	0.10	8.33	IV	0.92	–	–	–	–
Neophilaenus minor	0.24	11.11	IV	1.65	0.41	25.00	IV	3.18	1.26	36.36	III	6.76
Utecha trivia	–	–	–	–	–	–	–	–	0.10	9.09	IV	0.98
Megophthalmus scanicus	–	–	–	–	0.51	8.33	IV	2.06	–	–	–	–
Anaceratagallia ribauti	3.91	66.67	II	16.15	2.23	58.33	II	11.41	0.73	27.27	III	4.47
Anaceratagallia venosa	3.18	44.44	III	11.89	0.20	8.33	IV	1.30	1.99	54.55	II	10.42
Eupelix cuspidata	–	–	–	–	0.20	8.33	IV	1.30	–	–	–	–
Aphrodes bicincta	–	–	–	–	1.12	16.67	IV	4.31	0.31	9.09	IV	1.69
Aphrodes makarovi	–	–	–	–	0.10	8.33	IV	0.92	0.10	9.09	IV	0.98
Forcipata citrinella	0.24	11.11	IV	1.65	–	–	–	–	–	–	–	–
Empoasca pteridis	1.22	33.33	III	6.38	0.30	16.67	IV	2.25	–	–	–	–
Chlorita paolii	24.21	100.00	I	49.20	8.01	75.00	II	24.51	13.93	90.91	I	35.58
Eupteryx notata	9.05	88.89	I	28.36	2.54	33.33	III	9.19	0.31	9.09	IV	1.69
Zygina hyperici	4.65	33.33	III	12.44	1.22	33.33	III	6.37	–	–	–	–
Neoaliturus fenestratus	10.51	55.56	II	24.17	5.27	75.00	II	19.89	5.65	63.64	II	18.97
Balclutha calamagrostis	–	–	–	–	–	–	–	–	0.10	9.09	IV	0.98
Macrosteles laevis	1.22	44.44	III	7.37	8.32	66.67	II	23.55	0.84	45.45	III	6.17
Doratura exilis	0.98	22.22	IV	4.66	1.01	8.33	IV	2.91	–	–	–	–
Doratura homophyla	2.69	33.33	III	9.47	0.41	16.67	IV	2.60	1.05	27.27	III	5.34
Doratura impudica	–	–	–	–	–	–	–	–	1.36	27.27	III	6.09
Doratura stylata	5.38	44.44	III	15.46	6.09	58.33	II	18.84	9.01	54.55	II	22.16
Graphocraerus ventralis	–	–	–	–	0.30	25.00	IV	2.76	1.68	18.18	IV	5.52
Rhopalopyx vitripennis	0.24	11.11	IV	1.65	0.41	16.67	IV	2.60	0.21	18.18	IV	1.95
Elymana sulphurella	–	–	–	–	0.41	25.00	IV	3.18	0.31	18.18	IV	2.39
Cicadula persimilis	0.24	11.11	IV	1.65	0.20	16.67	IV	1.84	–	–	–	–
Cicadula quadrinotata	–	–	–	–	0.71	25.00	IV	4.21	–	–	–	–
Ophiola transversa	–	–	–	–	0.10	8.33	IV	0.92	0.21	18.18	IV	1.95
Laburrus impictifrons	2.69	55.56	II	12.22	0.71	50.00	III	5.96	2.30	54.55	II	11.21
Euscelis distinguendus	–	–	–	–	–	–	–	–	0.52	45.45	III	4.88
Euscelis incisus	–	–	–	–	0.30	16.67	IV	2.25	–	–	–	–
Arocephalus languidus	4.16	44.44	III	13.59	6.69	66.67	II	21.12	16.86	81.82	I	37.14
Arocephalus longiceps	–	–	–	–	0.10	8.33	IV	0.92	–	–	–	–
Psammotettix alienus	–	–	–	–	3.25	33.33	III	10.40	1.99	45.45	III	9.51
Psammotettix cephalotes	1.22	22.22	IV	5.21	4.46	58.33	II	16.13	5.13	45.45	III	15.27
Psammotettix confinis	0.24	11.11	IV	1.65	0.91	33.33	III	5.52	1.47	36.36	III	7.30
Psammotettix excisus	–	–	–	–	0.10	8.33	IV	0.92	0.21	18.18	IV	1.95
Psammotettix nodosus	–	–	–	–	0.20	16.67	IV	1.84	0.21	9.09	IV	1.38
Turrutus socialis	10.76	88.89	I	30.92	24.95	91.67	I	47.82	20.21	81.82	I	40.66
Jassargus pseudocellaris	–	–	–	–	0.10	8.33	IV	0.92	0.31	9.09	IV	1.69
Arthaldeus pascuellus	0.49	11.11	IV	2.33	0.10	8.33	IV	0.92	–	–	–	–
Mocuellus collinus	0.98	22.22	IV	4.66	4.97	66.67	II	18.20	8.38	72.73	II	24.68

Annex 5. Dominance – D [%], Frequency – F [%] and Q index for Auchenorrhyncha species collected on plot 5 (*Diantho-Armerietum elongatae*).

Auchenorrhyncha species	Year											
	2001				2002				2003			
	D	*F*		*Q*	*D*	*F*		*Q*	*D*	*F*		*Q*
Megadelphax sordidula	0.22	11.11	IV	1.55	0.11	8.33	IV	0.95	–	–	–	–
Laodelphax striatella	–	–	–	–	0.22	8.33	IV	1.35	1.08	9.09	IV	3.14
Muirodelphax aubei	–	–	–	–	0.22	16.67	IV	1.90	–	–	–	–
Acanthodelphax spinosa	0.65	22.22	IV	3.80	2.39	41.67	III	9.99	0.43	9.09	IV	1.99
Kosswigianella exigua	–	–	–	–	0.98	50.00	III	7.00	–	–	–	–
Javesella pellucida	1.30	11.11	IV	3.80	0.22	8.33	IV	1.35	–	–	–	–
Ribautodelphax albostriata	–	–	–	–	0.54	16.67	IV	3.01	0.22	9.09	IV	1.40
Ribautodelphax angulosa	–	–	–	–	0.76	8.33	IV	2.52	0.22	9.09	IV	1.40
Ribautodelphax collina	6.51	44.44	III	17.01	6.96	50.00	III	18.66	–	–	–	–
Cercopis sanguinolenta	–	–	–	–	0.11	8.33	IV	0.95	–	–	–	–
Neophilaenus exclamationis	–	–	–	–	0.11	8.33	IV	0.95	–	–	–	–
Neophilaenus minor	0.22	11.11	IV	1.55	0.11	8.33	IV	0.95	–	–	–	–
Philaenus spumarius	–	–	–	–	0.11	8.33	IV	0.95	0.22	9.09	IV	1.40
Megophthalmus scanicus	0.22	11.11	IV	1.55	0.44	8.33	IV	1.90	–	–	–	–
Anaceratagallia ribauti	1.08	22.22	IV	4.91	1.52	33.33	III	7.13	–	–	–	–
Anaceratagallia venosa	4.12	55.56	II	15.13	1.31	33.33	III	6.60	2.17	45.45	III	9.93
Eupelix cuspidata	–	–	–	–	–	–	–	–	0.43	18.18	IV	2.81
Aphrodes bicincta	0.65	22.22	IV	3.80	0.44	16.67	IV	2.69	0.22	9.09	IV	1.40
Planaphrodes trifasciata	–	–	–	–	0.11	8.33	IV	0.95	–	–	–	–
Erythria aureola	5.86	66.67	II	19.76	0.76	33.33	III	5.04	1.74	36.36	III	7.94
Emalyanoviana mollicula	–	–	–	–	–	–	–	–	0.22	9.09	IV	1.40
Empoasca pteridis	0.65	22.22	IV	3.80	0.22	8.33	IV	1.35	–	–	–	–
Chlorita paolii	22.56	88.89	I	44.78	4.03	58.33	II	15.33	15.84	72.73	II	33.94
Eupteryx atropunctata	–	–	–	–	–	–	–	–	0.22	9.09	IV	1.40
Eupteryx notata	7.59	66.67	II	22.50	0.65	25.00	IV	4.04	2.17	9.09	IV	4.44
Zygina hyperici	1.95	22.22	IV	6.59	–	–	–	–	0.43	18.18	IV	2.81
Neoaliturus fenestratus	26.25	66.67	II	41.83	10.23	75.00	II	27.70	15.40	72.73	II	33.47
Balclutha calamagrostis	–	–	–	–	–	–	–	–	0.22	9.09	IV	1.40
Macrosteles laevis	–	–	–	–	18.17	66.67	II	34.81	2.39	27.27	III	8.07
Macrosteles quadripunctulatus	0.65	33.33	III	4.66	–	–	–	–	–	–	–	–
Doratura exilis	0.22	11.11	IV	1.55	–	–	–	–	–	–	–	–
Doratura homophyla	0.22	11.11	IV	1.55	0.87	33.33	III	5.39	0.43	9.09	IV	1.99
Doratura stylata	2.17	44.44	III	9.82	8.92	50.00	III	21.12	15.18	45.45	III	26.27
Graphocraerus ventralis	–	–	–	–	0.22	8.33	IV	1.35	0.43	18.18	IV	2.81
Rhopalopyx vitripennis	0.43	11.11	IV	2.20	0.54	25.00	IV	3.69	1.74	18.18	IV	5.62
Elymana sulphurella	–	–	–	–	0.44	25.00	IV	3.30	0.22	9.09	IV	1.40
Cicadula persimilis	0.22	11.11	IV	1.55	0.54	16.67	IV	3.01	0.22	9.09	IV	1.40
Ophiola transversa	0.65	22.22	IV	3.80	0.22	16.67	IV	1.90	0.22	9.09	IV	1.40
Laburrus impictifrons	2.17	33.33	III	8.50	0.87	33.33	III	5.39	1.30	36.36	III	6.88
Euscelis distinguendus	0.65	33.33	III	4.66	0.11	8.33	IV	0.95	–	–	–	–
Euscelis incisus	0.22	11.11	IV	1.55	0.44	16.67	IV	2.69	–	–	–	–
Arocephalus languidus	2.60	33.33	III	9.31	4.03	83.33	I	18.32	7.59	72.73	II	23.50
Psammotettix alienus	–	–	–	–	1.63	58.33	II	9.76	5.21	36.36	III	13.76
Psammotettix cephalotes	3.25	88.89		17.01	5.66	83.33	I	21.71	4.34	54.55	II	15.38
Psammotettix confinis	0.87	33.33	III	5.38	2.61	58.33	II	12.34	1.74	36.36	III	7.94
Psammotettix excisus	–	–	–	–	4.35	50.00	III	14.75	1.52	27.27	III	6.44
Psammotettix nodosus	0.22	11.11	IV	1.55	1.96	33.33	III	8.08	4.77	36.36	III	13.17
Errastunus ocellaris	–	–	–	–	0.22	8.33	IV	1.35	0.22	9.09	IV	1.40
Turrutus socialis	3.90	66.67	II	16.13	15.67	75.00	II	34.28	11.06	81.82	I	30.09
Mocuellus collinus	1.74	55.56	II	9.82	–	–	–	–	0.22	9.09	IV	1.40

Annex 6. Dominance – D [%], Frequency – F [%] and Q index for Auchenorrhyncha species collected on plot 6 (*Festucetum pallentis*).

Auchenorrhyncha species	**Year**											
	2001				**2002**				**2003**			
	D	*F*		*Q*	*D*	*F*		*Q*	*D*	*F*		*Q*
Stenocranus major	–	–	–	–	0.48	11.11	IV	2.31	–	–	–	–
Eurysa lineata	0.51	22.22	IV	3.38	–	–	–	–	1.36	9.09	IV	3.52
Megadelphax sordidula	–	–	–	–	–	–	–	–	0.15	9.09	IV	1.17
Laodelphax striatella	0.77	22.22	IV	4.14	–	–	–	–	–	–	–	–
Javesella pellucida	0.77	11.11	IV	2.93	–	–	–	–	–	–	–	–
Ribautodelphax albostriata	0.51	11.11	IV	2.39	0.72	22.22	IV	4.01	–	–	–	–
Ribautodelphax collina	–	–	–	–	0.48	11.11	IV	2.31	–	–	–	–
Tettigometra atrata	0.51	22.22	IV	3.38	–	–	–	–	–	–	–	–
Centrotus cornutus	–	–	–	–	–	–	–	–	0.15	9.09	IV	1.17
Utecha trivia	–	–	–	–	0.24	11.11	IV	1.64	0.30	9.09	IV	1.66
Anaceratagallia venosa	9.25	55.56	II	22.67	7.95	77.78	I	24.87	8.61	72.73	II	25.02
Aphrodes bicincta	0.26	11.11	IV	1.69	0.72	22.22	IV	4.01	1.21	18.18	IV	4.69
Aphrodes makarovi	0.51	22.22	IV	3.38	–	–	–	–	–	–	–	–
Planaphrodes trifasciata	–	–	–	–	0.24	11.11	IV	1.64	–	–	–	–
Erythria aureola	13.37	100.00	I	36.56	13.25	88.89	I	34.32	20.85	81.82	I	41.30
Emelyanoviana mollicula	33.93	88.89	I	54.92	16.63	100.00	I	40.78	5.29	54.55	II	16.98
Micantulina stigmatipennis	1.54	33.33	III	7.17	2.65	55.56	II	12.13	1.96	36.36	III	8.45
Empoasca pteridis	9.51	88.89	I	29.08	3.37	44.44	III	12.24	1.81	54.55	II	9.94
Austroasca vittata	0.26	11.11	IV	1.69	–	–	–	–	–	–	–	–
Chlorita paolii	3.34	55.56	II	13.63	3.37	55.56	II	13.69	4.08	63.64	II	16.11
Eupteryx notata	1.03	33.33	III	5.85	0.72	22.22	IV	4.01	0.15	9.09	IV	1.17
Eupteryx tenella	1.03	33.33	III	5.85	–	–	–	–	0.15	9.09	IV	1.17
Zygina hyperici	2.57	55.56	II	11.95	0.48	11.11	IV	2.31	–	–	–	–
Zygina rubrovittata	–	–	–	–	0.24	11.11	IV	1.64	–	–	–	–
Neoaliturus fenestratus	3.60	77.78	I	16.73	0.24	11.11	IV	1.64	0.76	27.27	III	4.54
Balclutha calamagrostis	0.51	11.11	IV	2.39	0.24	11.11	IV	1.64	0.15	9.09	IV	1.17
Macrosteles laevis	1.03	44.44	III	6.76	1.20	33.33	III	6.34	0.15	9.09	IV	1.17
Doratura exilis	–	–	–	–	0.24	11.11	IV	1.64	–	–	–	–
Doratura stylata	–	–	–	–	0.24	11.11	IV	1.64	0.15	9.09	IV	1.17
Fieberiella septentrionalis	0.26	11.11	IV	1.69	1.45	44.44	III	8.02	1.21	36.36	III	6.63
Rhopalopyx preyssleri	–	–	–	–	–	–	–	–	0.15	9.09	IV	1.17
Arocephalus languidus	11.83	77.78	I	30.33	30.84	88.89	I	52.36	31.57	72.73	II	47.92
Arocephalus longiceps	–	–	–	–	0.24	11.11	IV	1.64	4.83	9.09	IV	6.63
Psammotettix confinis	–	–	–	–	0.24	11.11	IV	1.64	–	–	–	–
Psammotettix excisus	–	–	–	–	0.24	11.11	IV	1.64	1.21	9.09	IV	3.31
Turrutus socialis	3.08	55.56	II	13.09	13.25	88.89	I	34.32	13.75	90.91	I	35.35

Annex 7. Dominance – D [%], Frequency – F [%] and Q index for Auchenorrhyncha species collected on plot 7 (*Festucetum pallentis*).

Auchenorrhyncha species	Year											
	2001				2002				2003			
	D	*F*		*Q*	*D*	*F*		*Q*	*D*	*F*		*Q*
Cixius nervosus	0.26	9.09	IV	1.55	–	–	–	–	0.34	9.09	IV	1.76
Anakelisia perspicillata	–	–	–	–	0.25	11.11	IV	1.65	–	–	–	–
Stenocranus major	0.26	9.09	IV	1.55	–	–	–	–	–	–	–	–
Megadelphax sordidula	0.26	9.09	IV	1.55	–	–	–	–	–	–	–	–
Laodelphax striatella	0.79	27.27	III	4.65	0.74	22.22	IV	4.04	0.34	9.09	IV	1.76
Dicranotropis hamata	–	–	–	–	–	–	–	–	0.34	9.09	IV	1.76
Kosswigianella exigua	–	–	–	–	–	–	–	–	0.68	9.09	IV	2.50
Javesella pellucida	0.26	9.09	IV	1.55	0.49	11.11	IV	2.33	0.34	9.09	IV	1.76
Neophilaenus campestris	0.26	9.09	IV	1.55	–	–	–	–	–	–	–	–
Neophilaenus minor	0.26	9.09	IV	1.55	0.25	11.11	IV	1.65	0.34	9.09	IV	1.76
Philaenus spumarius	–	–	–	–	1.23	22.22	IV	5.22	2.05	36.36	III	8.64
Anaceratagallia ribauti	2.12	45.45	III	9.81	0.49	22.22	IV	3.30	2.05	27.27	III	7.49
Anaceratagallia venosa	–	–	–	–	–	–	–	–	1.03	9.09	IV	3.06
Aphrodes bicincta	0.79	27.27	III	4.65	0.25	11.11	IV	1.65	1.71	27.27	III	6.83
Erythria aureola	8.47	54.55	II	21.49	12.99	88.89	I	33.98	22.26	81.82	I	42.68
Emelyanoviana mollicula	30.42	90.91	I	52.59	28.68	100.00	I	53.55	11.30	54.55	II	24.83
Micantulina stigmatipennis	–	–	–	–	–	–	–	–	0.34	9.09	IV	1.76
Wagneriala incisa	0.26	9.09	IV	1.55	–	–	–	–	–	–	–	–
Forcipata citrinella	–	–	–	–	0.49	11.11	IV	2.33	–	–	–	–
Empoasca affinis	0.53	18.18	IV	3.10	–	–	–	–	–	–	–	–
Empoasca pteridis	28.84	63.64	II	42.84	23.53	55.56	II	36.16	8.90	54.55	II	22.04
Empoasca vitis	0.26	9.09	IV	1.55	0.25	11.11	IV	1.65	–	–	–	–
Chlorita paolii	–	–	–	–	0.25	11.11	IV	1.65	–	–	–	–
Eupteryx atropunctata	–	–	–	–	0.25	11.11	IV	1.65	0.34	9.09	IV	1.76
Eupteryx notata	0.79	18.18	IV	3.80	–	–	–	–	–	–	–	–
Eupteryx stachydearum	0.26	9.09	IV	1.55	–	–	–	–	–	–	–	–
Zygina flammigera	0.79	18.18	IV	3.80	–	–	–	–	0.34	9.09	IV	1.76
Zygina hyperici	4.23	36.36	III	12.41	2.94	44.44	III	11.43	1.71	18.18	IV	5.58
Zygina ordinaria	0.53	9.09	IV	2.19	–	–	–	–	–	–	–	–
Neoaliturus fenestratus	1.06	36.36	III	6.21	1.47	33.33	III	7.00	1.71	27.27	III	6.83
Balclutha calamagrostis	0.79	18.18	IV	3.80	–	–	–	–	–	–	–	–
Macrosteles laevis	1.06	27.27	III	5.37	3.43	44.44	III	12.35	1.03	27.27	III	5.29
Doratura exilis	–	–	–	–	0.49	11.11	IV	2.33	–	–	–	–
Doratura stylata	–	–	–	–	0.25	11.11	IV	1.65	0.34	9.09	IV	1.76
Fieberiella septentrionalis	8.47	90.91	I	27.74	3.43	55.56	II	13.81	7.88	63.64	II	22.39
Allygus communis	–	–	–	–	0.25	11.11	IV	1.65	–	–	–	–
Rhopalopyx vitripennis	0.26	9.09	IV	1.55	0.25	11.11	IV	1.65	1.03	27.27	III	5.29
Arocephalus languidus	5.29	63.64	II	18.35	9.80	88.89	I	29.52	15.75	63.64	II	31.66
Psammotettix alienus	–	–	–	–	0.49	22.22	IV	3.30	1.03	18.18	IV	4.32
Ebarrius cognatus	–	–	–	–	0.25	11.11	IV	1.65	0.34	9.09	IV	1.76
Turrutus socialis	2.38	54.55	II	11.40	6.86	88.89	I	24.70	16.44	90.91	I	38.66

Annex 8. Dominance – D [%], Frequency – F [%] and Q index for Auchenorrhyncha species collected on plot 8 (*Sileno-Phleetum*).

Auchenorrhyncha species	**Year**											
	2001				**2002**				**2003**			
	D	*F*		*Q*	*D*	*F*		*Q*	*D*	*F*		*Q*
Anakelisia perspicillata	2.20	33.33	III	8.56	0.26	18.18	IV	2.19	0.21	9.09	IV	1.37
Stenocranus major	0.73	33.33	III	4.94	0.40	9.09	IV	1.90	–	–	–	–
Metropis inermis	0.24	11.11	IV	1.65	–	–	–	–	–	–	–	–
Megadelphax sordidula	10.76	22.22	IV	15.46	0.13	9.09	IV	1.10	–	–	–	–
Laodelphax striatella	0.24	11.11	IV	1.65	0.26	18.18	IV	2.19	0.41	9.09	IV	1.94
Mirabella albifrons	–	–	–	–	–	–	–	–	0.21	9.09	IV	1.37
Acanthodelphax spinosa	2.93	44.44	III	11.42	20.08	63.64	II	35.75	12.99	54.55	II	26.62
Kosswigianella exigua	5.38	33.33	III	13.39	3.43	45.45	III	12.49	3.51	27.27	III	9.78
Criomorphus albomarginatus	–	–	–	–	0.13	9.09	IV	1.10	0.62	9.09	IV	2.37
Javesella pellucida	4.16	22.22	IV	9.61	2.38	27.27	III	8.05	0.41	9.09	IV	1.94
Ribautodelphax albostriata	7.33	33.33	III	15.64	14.80	54.55	II	28.41	7.63	45.45	III	18.62
Ribautodelphax collina	2.93	33.33	III	9.89	9.78	45.45	III	21.08	1.65	27.27	III	6.71
Cercopis sanguinolenta	–	–	–	–	0.13	9.09	IV	1.10	–	–	–	–
Neophilaenus lineatus	0.24	11.11	IV	1.65	–	–	–	–	–	–	–	–
Aphrophora alni	–	–	–	–	0.13	9.09	IV	1.10	–	–	–	–
Philaenus spumarius	0.24	11.11	IV	1.65	–	–	–	–	–	–	–	–
Utecha trivia	1.22	22.22	IV	5.21	0.53	27.27	III	3.80	1.03	27.27	III	5.30
Megophthalmus scanicus	–	–	–	–	0.26	9.09	IV	1.55	–	–	–	–
Aphrodes bicincta	0.24	11.11	IV	1.65	0.13	9.09	IV	1.10	0.62	27.27	III	4.11
Aphrodes makarovi	0.24	11.11	IV	1.65	0.13	9.09	IV	1.10	–	–	–	–
Anoscopus albifrons	0.24	11.11	IV	1.65	–	–	–	–	–	–	–	–
Erythria aureola	0.24	11.11	IV	1.65	0.13	9.09	IV	1.10	–	–	–	–
Emelyanoviana mollicula	6.36	100.00	I	25.21	1.19	45.45	III	7.35	1.03	18.18	IV	4.33
Dikraneura variata	–	–	–	–	0.13	9.09	IV	1.10	1.24	36.36	III	6.71
Forcipata citrinella	1.71	55.56	II	9.75	0.92	45.45	III	6.48	0.21	9.09	IV	1.37
Empoasca pteridis	2.20	55.56	II	11.06	–	–	–	–	0.21	9.09	IV	1.37
Chlorita paolii	1.47	33.33	III	6.99	0.40	18.18	IV	2.68	0.21	9.09	IV	1.37
Eupteryx atropunctata	0.24	11.11	IV	1.65	–	–	–	–	–	–	–	–
Eupteryx notata	3.18	55.56	II	13.29	0.79	36.36	III	5.37	1.24	27.27	III	5.81
Zygina hyperici	4.16	22.22	IV	9.61	–	–	–	–	0.21	9.09	IV	1.37
Balclutha calamagrostis	0.49	11.11	IV	2.33	0.26	18.18	IV	2.19	1.24	36.36	III	6.71
Macrosteles laevis	1.47	55.56	II	9.03	0.92	27.27	III	5.02	–	–	–	–
Deltocephalus pulicaris	–	–	–	–	0.13	9.09	IV	1.10	–	–	–	–
Doratura stylata	8.07	44.44	III	18.94	5.42	54.55	II	17.19	20.62	54.55	II	33.54
Graphocraerus ventralis	0.24	11.11	IV	1.65	0.13	9.09	IV	1.10	0.41	9.09	IV	1.94
Rhopalopyx preyssleri	1.22	33.33	III	6.38	1.85	27.27	III	7.10	3.30	45.45	III	12.25
Rhopalopyx vitripennis	–	–	–	–	–	–	–	–	0.21	9.09	IV	1.37
Elymana sulphurella	0.24	11.11	IV	1.65	0.53	27.27	III	3.80	–	–	–	–
Arocephalus languidus	0.24	11.11	IV	1.65	1.72	54.55	II	9.68	3.30	45.45	III	12.25
Psammotettix cephalotes	0.49	11.11	IV	2.33	0.26	18.18	IV	2.19	0.82	27.27	III	4.74
Psammotettix confinis	–	–	–	–	0.13	9.09	IV	1.10	0.41	9.09	IV	1.94
Errastunus ocellaris	0.49	11.11	IV	2.33	0.26	18.18	IV	2.19	0.21	9.09	IV	1.37
Turrutus socialis	27.38	88.89	I	49.34	30.25	81.82	I	49.75	35.67	81.82	I	54.02
Jassargus pseudocellaris	0.49	11.11	IV	2.33	1.06	18.18	IV	4.38	0.21	9.09	IV	1.37
Verdanus abdominalis	0.24	11.11	IV	1.65	–	–	–	–	–	–	–	–
Arthaldeus pascuellus	–	–	–	–	0.53	9.09	IV	2.19	–	–	–	–

Annex 9. Dominance – D [%], Frequency – F [%] and Q index for Auchenorrhyncha species collected on plot 9 (*Sileno-Phleetum*).

Auchenorrhyncha species	Year											
	2001				2002				2003			
	D	*F*		*Q*	*D*	*F*		*Q*	*D*	*F*		*Q*
Stenocranus major	1.06	30.00	III	5.65	–	–	–	–	–	–	–	–
Megadelphax sordidula	0.53	20.00	IV	3.26	–	–	–	–	–	–	–	–
Laodelphax striatella	1.06	10.00	IV	3.26	0.64	11.11	IV	2.67	1.37	27.27	III	6.12
Acanthodelphax spinosa	1.33	20.00	IV	5.16	1.49	33.33	III	7.05	1.83	9.09	IV	4.08
Kosswigianella exigua	7.18	40.00	III	16.95	6.61	55.56	II	19.16	9.84	36.36	III	18.92
Javesella pellucida	12.50	20.00	IV	15.81	2.35	33.33	III	8.84	–	–	–	–
Ribautodelphax albostriata	0.27	10.00	IV	1.63	1.49	33.33	III	7.05	–	–	–	–
Ribautodelphax collina	3.72	30.00	III	10.57	9.38	44.44	III	20.42	2.06	27.27	III	7.49
Cercopis sanguinolenta	–	–	–	–	–	–	–	–	0.23	9.09	IV	1.44
Neophilaenus lineatus	0.27	10.00	IV	1.63	–	–	–	–	–	–	–	–
Megophthalmus scanicus	0.27	10.00	IV	1.63	0.21	11.11	IV	1.54	–	–	–	–
Anaceratagallia ribauti	–	–	–	–	–	–	–	–	0.23	9.09	IV	1.44
Aphrodes bicincta	–	–	–	–	0.43	22.22	IV	3.08	0.46	18.18	IV	2.88
Erythria aureola	10.90	70.00	II	27.63	7.89	77.78	I	24.77	4.81	63.64	II	17.49
Emelyanoviana mollicula	4.52	70.00	II	17.79	5.33	66.67	II	18.85	2.06	45.45	III	9.68
Dikraneura variata	0.27	10.00	IV	1.63	–	–	–	–	0.23	9.09	IV	1.44
Micantulina stigmatipennis	0.27	10.00	IV	1.63	–	–	–	–	0.23	9.09	IV	1.44
Forcipata citrinella	5.05	60.00	II	17.41	1.28	44.44	III	7.54	0.23	9.09	IV	1.44
Empoasca pteridis	2.39	30.00	III	8.47	0.21	11.11	IV	1.54	0.46	9.09	IV	2.04
Chlorita paolii	6.38	70.00	II	21.14	4.05	55.56	II	15.00	6.41	72.73	II	21.59
Eupteryx notata	1.06	40.00	III	6.52	1.92	33.33	III	8.00	1.60	27.27	III	6.61
Zygina hyperici	3.99	40.00	III	12.63	2.13	22.22	IV	6.88	0.23	9.09	IV	1.44
Neoaliturus fenestratus	0.80	20.00	IV	3.99	0.21	11.11	IV	1.53	0.46	9.09	IV	2.04
Balclutha calamagrostis	0.53	20.00	IV	3.26	0.21	11.11	IV	1.54	0.92	9.09	IV	2.88
Balclutha punctata	–	–	–	–	–	–	–	–	0.23	9.09	IV	1.44
Macrosteles laevis	0.80	30.00	III	4.89	10.87	77.78	I	29.08	0.23	9.09	IV	1.44
Doratura stylata	4.79	50.00	III	15.47	5.97	44.44	III	16.29	4.58	27.27	III	11.17
Rhopalopyx vitripennis	1.86	30.00	III	7.47	2.13	55.56	II	10.88	7.09	54.55	II	19.67
Elymana sulphurella	0.27	10.00	IV	1.63	–	–	–	–	–	–	–	–
Cicadula persimilis	0.27	10.00	IV	1.63	0.21	11.11	IV	1.54	–	–	–	–
Mocydiopsis parvicauda	0.27	10.00	IV	1.63	–	–	–	–	–	–	–	–
Arocephalus languidus	14.89	70.00	II	32.29	20.90	66.67	II	37.32	38.67	81.82	I	56.25
Arocephalus longiceps	–	–	–	–	–	–	–	–	0.23	9.09	IV	1.44
Psammotettix alienus	–	–	–	–	2.13	22.22	IV	6.88	0.69	18.18	IV	3.53
Psammotettix cephalotes	–	–	–	–	0.21	11.11	IV	1.54	–	–	–	–
Psammotettix confinis	0.53	10.00	IV	2.31	1.07	33.33	III	5.96	1.37	45.45	III	7.90
Psammotettix excisus	0.27	10.00	IV	1.63	0.21	11.11	IV	1.54	–	–	–	–
Psammotettix nodosus	–	–	–	–	–	–	–	–	0.23	9.09	IV	1.44
Errastunus ocellaris	0.27	10.00	IV	1.63	–	–	–	–	–	–	–	–
Turrutus socialis	11.17	90.00	I	31.71	8.32	100.00	I	28.84	13.04	72.73	II	30.80
Jassargus pseudocellaris	–	–	–	–	2.13	44.44	III	9.73	–	–	–	–
Mocuellus collinus	0.27	10.00	IV	1.63	–	–	–	–	–	–	–	–

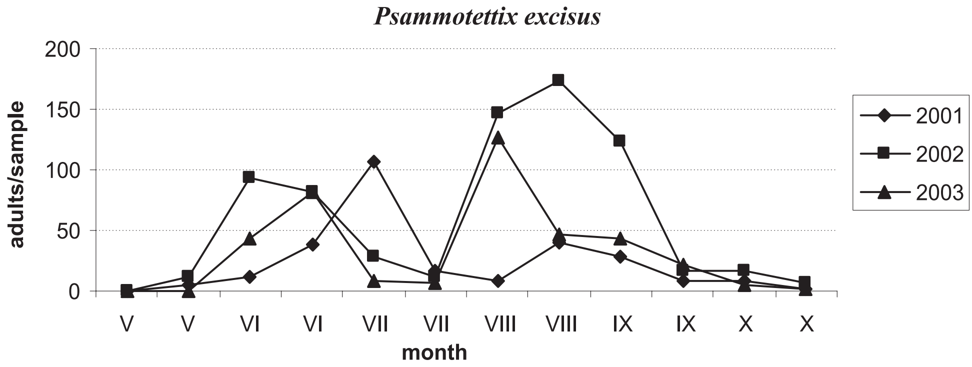
Annex 10. Dominance – D [%], Frequency – F [%] and Q index for Auchenorrhyncha species collected on plot 10 (*Adonido-Brachypodietum pinnati*).

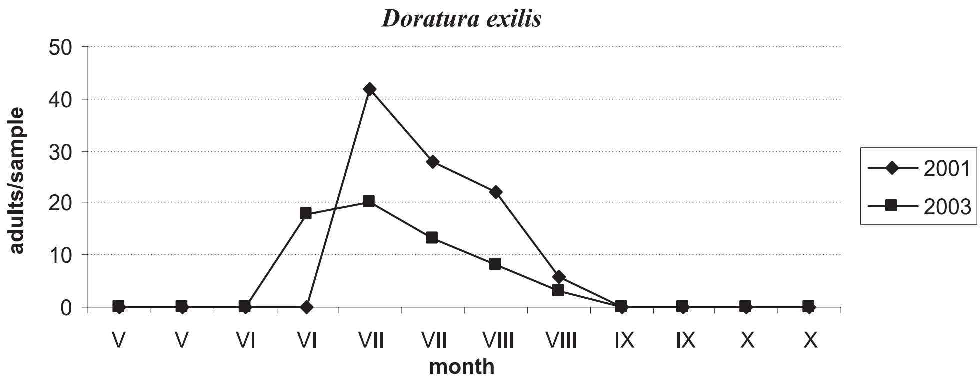
Auchenorrhyncha species	Year											
	2002				2003				2004			
	D	*F*		*Q*	*D*	*F*		*Q*	*D*	*F*		*Q*
Stenocranus major	2.71	25.00	IV	8.24	1.56	8.33	IV	3.61	1.87	18.18	IV	5.84
Megadelphax sordidula	0.45	12.50	IV	2.38	–	–	–	–	–	–	–	–
Laodelphax striatella	0.45	12.50	IV	2.38	3.13	16.67	IV	7.22	–	–	–	–
Hyledelphax elegantula	–	–	–	–	–	–	–	–	0.37	9.09	IV	1.85
Javesella pellucida	0.45	12.50	IV	2.38	–	–	–	–	0.37	9.09	IV	1.85
Ribautodelphax pungens	2.71	25.00	IV	8.24	4.69	16.67	IV	8.84	1.50	27.27	III	6.39
Cercopis sanguinolenta	–	–	–	–	–	–	–	–	0.37	9.09	IV	1.85
Neophilaenus exclamationis	0.45	12.50	IV	2.38	1.56	8.33	IV	3.61	–	–	–	–
Aphrophora alni	8.14	75.00	II	24.72	6.25	33.33	III	14.43	1.50	27.27	III	6.39
Philaenus spumarius	0.45	12.50	IV	2.38	–	–	–	–	0.37	9.09	IV	1.85
Utecha trivia	0.45	12.50	IV	2.38	–	–	–	–	4.12	9.09	IV	6.12
Utecha lugens	–	–	–	–	–	–	–	–	0.75	18.18	IV	3.69
Anaceratagallia venosa	–	–	–	–	–	–	–	–	0.37	9.09	IV	1.85
Aphrodes bicincta	0.45	12.50	IV	2.38	–	–	–	–	1.50	18.18	IV	5.22
Aphrodes makarovi	0.90	25.00	IV	4.76	–	–	–	–	–	–	–	–
Erythria aureola	–	–	–	–	1.56	8.33	IV	3.61	–	–	–	–
Emelyanoviana mollicula	19.91	62.50	II	35.28	6.25	25.00	IV	12.50	11.24	54.55	II	24.76
Forcipata citrinella	0.45	12.50	IV	2.38	–	–	–	–	–	–	–	–
Empoasca pteridis	4.52	37.50	III	13.03	9.38	33.33	III	17.68	3.00	9.09	IV	5.22
Chlorita paolii	2.26	12.50	IV	5.32	4.69	8.33	IV	6.25	0.75	18.18	IV	3.69
Linnavuoriana decempunctata	–	–	–	–	1.56	8.33	IV	3.61	–	–	–	–
Balclutha calamagrostis	0.90	25.00	IV	4.76	–	–	–	–	0.37	9.09	IV	1.85
Macrosteles laevis	9.05	87.50	I	28.14	1.56	8.33	IV	3.61	–	–	–	–
Doratura stylata	1.36	25.00	IV	5.83	–	–	–	–	1.50	27.27	III	6.39
Hardya tenuis	–	–	–	–	1.56	8.33	IV	3.61	–	–	–	–
Elymana sulphurella	–	–	–	–	1.56	8.33	IV	3.61	0.75	18.18	IV	3.69
Cicadula persimilis	–	–	–	–	1.56	8.33	IV	3.61	–	–	–	–
Arocephalus languidus	0.45	12.50	IV	2.38	–	–	–	–	–	–	–	–
Arocephalus longiceps	13.12	50.00	III	25.61	14.06	25.00	IV	18.75	1.50	27.27	III	6.39
Psammotettix alienus	0.45	12.50	IV	2.38	3.13	8.33	IV	5.10	1.12	27.27	III	5.54
Psammotettix confinis	0.45	12.50	IV	2.38	1.56	8.33	IV	3.61	–	–	–	–
Psammotettix excisus	–	–	–	–	1.56	8.33	IV	3.61	–	–	–	–
Adarrus multinotatus	28.96	87.50	I	50.34	28.13	58.33	II	40.50	66.29	81.82	I	73.65
Errastunus ocellaris	0.45	12.50	IV	2.38	–	–	–	–	–	–	–	–
Turrutus socialis	–	–	–	–	4.69	25.00	IV	10.83	0.37	9.09	IV	1.85

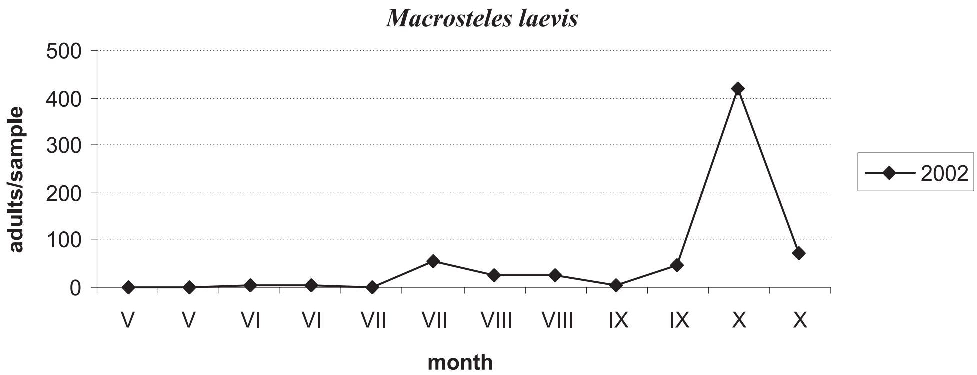
Annex 11. Dominance – D [%], Frequency – F [%] and Q index for Auchenorrhyncha species collected on plot 11 (*Adonido-Brachypodietum pinnati*).

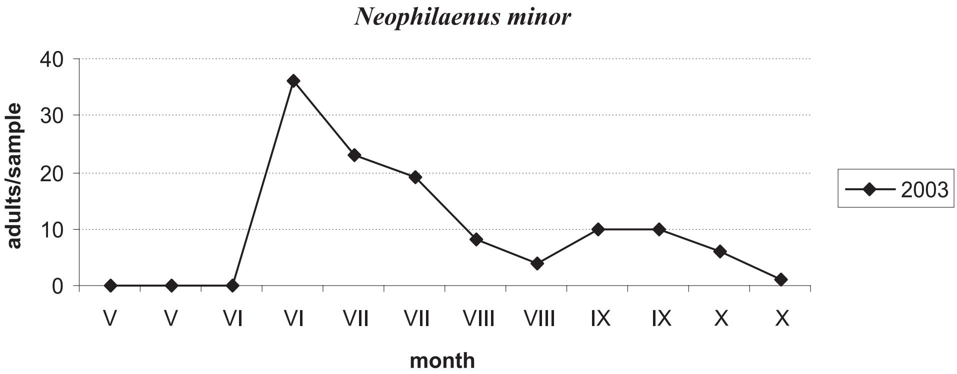
Auchenorrhyncha species	Year											
	2001				2002				2003			
	D	*F*		*Q*	*D*	*F*		*Q*	*D*	*F*		*Q*
Cixius nervosus	0.38	11.11	IV	2.07	–	–	–	–	–	–	–	–
Tachycixius pilosus	0.38	11.11	IV	2.07	–	–	–	–	0.40	9.09	IV	1.91
Kelisia guttula	7.69	44.44	III	18.49	1.25	12.50	IV	3.95	0.80	9.09	IV	2.70
Anakelisia perspicillata	–	–	–	–	–	–	–	–	0.40	9.09	IV	1.91
Stenocranus major	5.77	33.33	III	13.87	11.25	37.50	III	20.54	2.80	27.27	III	8.74
Megadelphax sordidula	5.77	66.67	II	19.61	0.63	12.50	IV	2.80	–	–	–	–
Laodelphax striatella	1.15	22.22	IV	5.06	–	–	–	–	0.40	9.09	IV	1.91
Hyledelphax elegantula	0.38	11.11	IV	2.07	–	–	–	–	–	–	–	–
Acanthodelphax spinosa	–	–	–	–	0.63	12.50	IV	2.80	–	–	–	–
Kosswigianella exigua	1.15	11.11	IV	3.58	0.63	12.50	IV	2.80	–	–	–	–
Javesella pellucida	1.92	11.11	IV	4.62	1.25	12.50	IV	3.95	–	–	–	–
Ribautodelphax albostriata	14.23	55.56	II	28.12	3.75	50.00	III	13.69	–	–	–	–
Ribautodelphax pungens	1.15	11.11	IV	3.58	–	–	–	–	3.60	18.18	IV	8.09
Cercopis sanguinolenta	–	–	–	–	0.63	12.50	IV	2.80	0.40	9.09	IV	1.91
Aphrophora alni	7.31	44.44	III	18.02	10.00	50.00	III	22.36	15.60	36.36	III	23.82
Utecha trivia	0.77	22.22	IV	4.13	0.63	12.50	IV	2.80	–	–	–	–
Agallia brachyptera	0.77	22.22	IV	4.13	–	–	–	–	–	–	–	–
Aphrodes bicincta	0.38	11.11	IV	2.07	1.88	25.00	IV	6.85	–	–	–	–
Anoscopus flavostriatus	0.38	11.11	IV	2.07	–	–	–	–	–	–	–	–
Cicadella viridis	–	–	–	–	1.25	25.00	IV	5.59	–	–	–	–
Emelyanoviana mollicula	5.38	66.67	II	18.95	6.88	75.00	II	22.71	5.60	45.45	III	15.95
Forcipata citrinella	–	–	–	–	0.63	12.50	IV	2.80	–	–	–	–
Empoasca pteridis	1.15	22.22	IV	5.06	0.63	12.50	IV	2.80	2.40	18.18	IV	6.61
Eupteryx atropunctata	–	–	–	–	–	–	–	–	0.40	9.09	IV	1.91
Eupteryx notata	1.15	33.33	III	6.20	–	–	–	–	–	–	–	–
Zygina flammigera	–	–	–	–	–	–	–	–	0.40	9.09	IV	1.91
Zygina hyperici	1.15	22.22	IV	5.06	1.88	37.50	III	8.39	–	–	–	–
Balclutha calamagrostis	0.38	11.11	IV	2.07	2.50	37.50	III	9.68	0.80	9.09	IV	2.70
Macrosteles laevis	0.38	11.11	IV	2.07	9.38	50.00	III	21.65	0.40	9.09	IV	1.91
Recilia coronifera	1.15	22.22	IV	5.06	–	–	–	–	–	–	–	–
Doratura exilis	0.38	11.11	IV	2.07	–	–	–	–	–	–	–	–
Doratura stylata	3.08	33.33	III	10.13	1.88	25.00	IV	6.85	–	–	–	–
Allygus communis	0.38	11.11	IV	2.07	–	–	–	–	–	–	–	–
Rhopalopyx preyssleri	1.54	22.22	IV	5.85	1.25	25.00	IV	5.59	2.00	18.18	IV	6.03
Rhopalopyx vitripennis	–	–	–	–	–	–	–	–	0.40	9.09	IV	1.91
Elymana sulphurella	2.31	33.33	III	8.77	10.63	75.00	II	28.23	2.80	36.36	III	10.09
Cicadula flori	–	–	–	–	–	–	–	–	0.40	9.09	IV	1.91
Mocydiopsis parvicauda	–	–	–	–	0.63	12.50	IV	2.80	–	–	–	–
Athysanus argentarius	1.92	44.44	III	9.25	3.13	37.50	III	10.83	0.40	9.09	IV	1.91
Athysanus quadrum	–	–	–	–	–	–	–	–	0.40	9.09	IV	1.91
Euscelis distinguendus	0.38	11.11	IV	2.07	–	–	–	–	–	–	–	–
Arocephalus languidus	0.38	11.11	IV	2.07	–	–	–	–	–	–	–	–
Arocephalus longiceps	–	–	–	–	1.25	12.50	IV	3.95	2.00	18.18	IV	6.03
Psammotettix alienus	–	–	–	–	0.63	12.50	IV	2.80	–	–	–	–
Psammotettix cephalotes	1.15	11.11	IV	3.58	–	–	–	–	1.20	18.18	IV	4.67
Psammotettix confinis	–	–	–	–	1.25	25.00	IV	5.59	–	–	–	–
Adarrus multinotatus	23.85	88.89	I	46.04	23.13	75.00	II	41.65	56.00	72.73	II	63.82
Errastunus ocellaris	3.85	33.33	III	11.32	0.63	12.50	IV	2.80	–	–	–	–
Mocuellus collinus	0.38	11.11	IV	2.07	–	–	–	–	–	–	–	–

Annex 12. Number of individuals of dominants taken on plot 1.

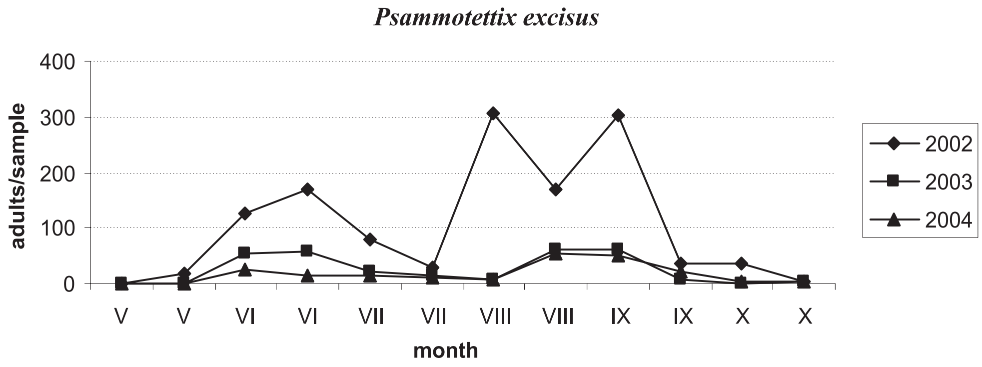


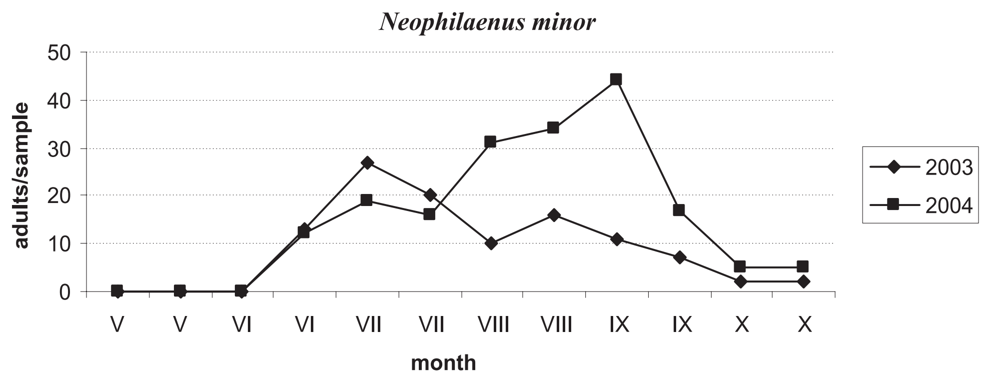


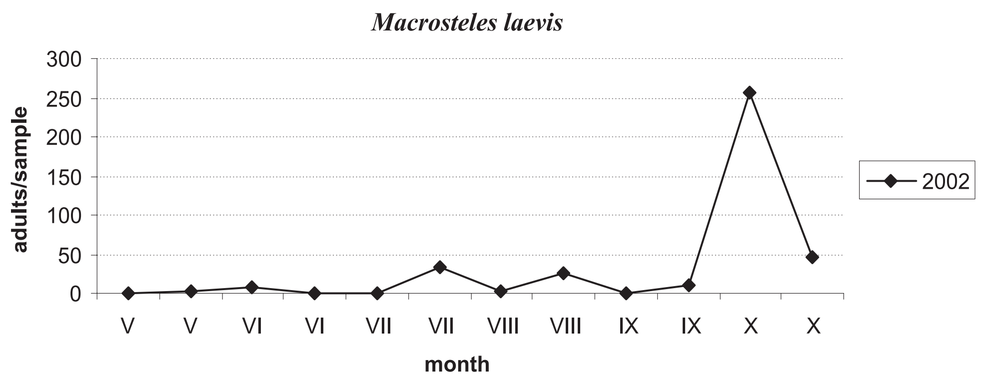


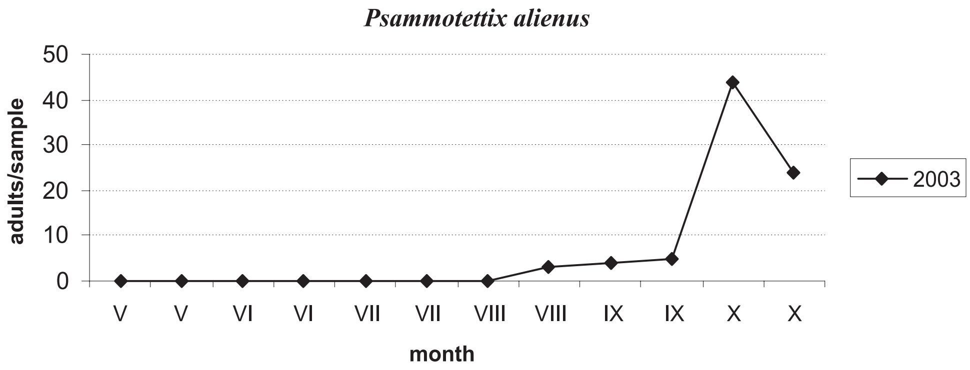

Neophilaenus minor
40
30
20
10
0
adults/sample
V V VI VI VII VII VIII VIII IX IX X X
month
2003

Annex 13. Number of individuals of dominants taken on plot 2.

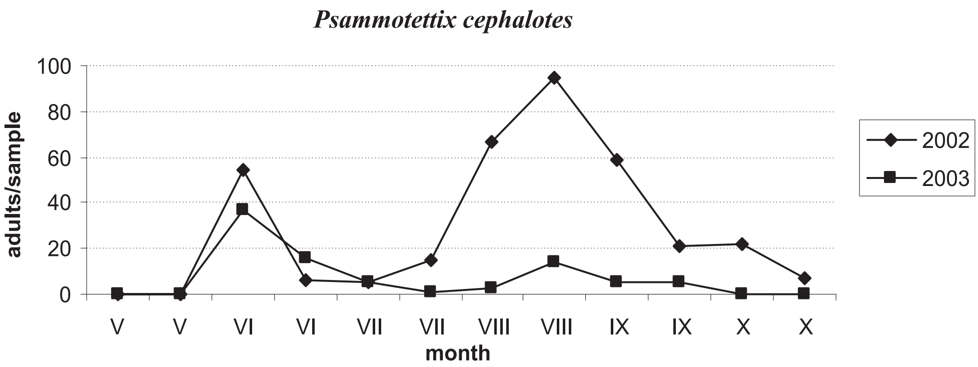


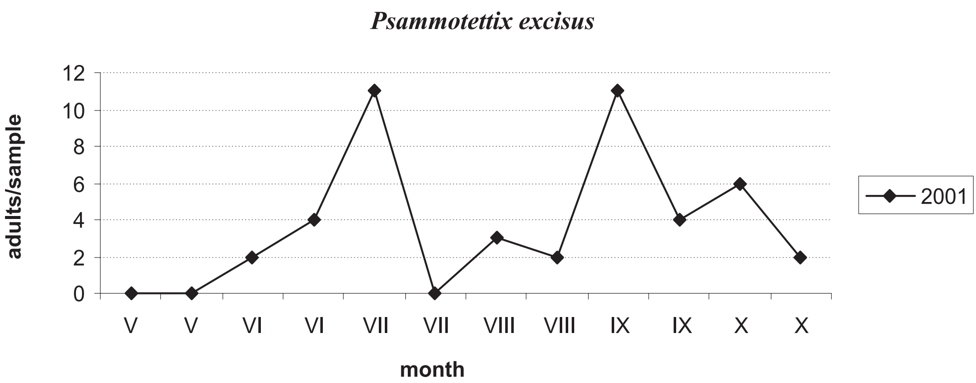


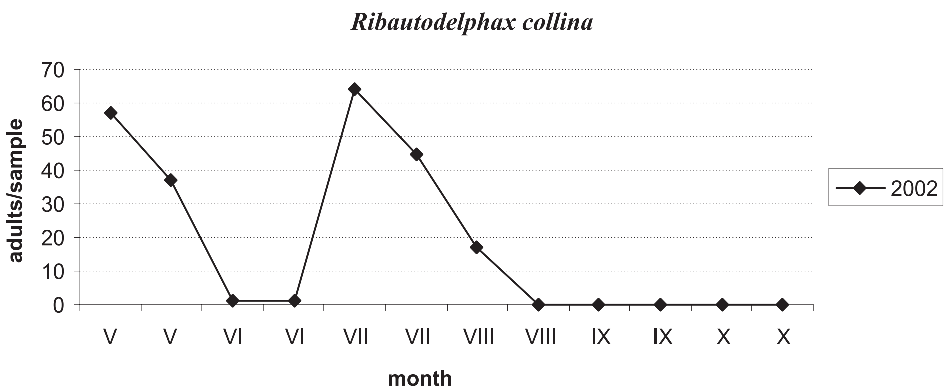


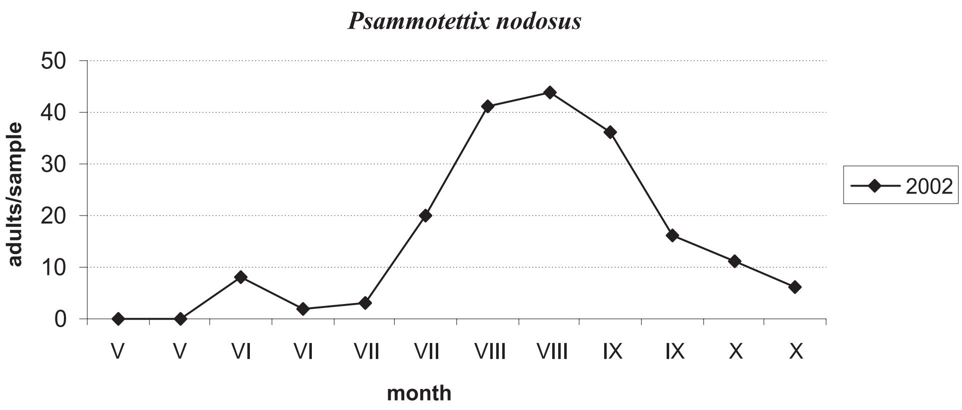

Psammotettix alienus
50
40
30
20
10
0
adults/sample
V
V
VI
VI
VII
VII
VIII
VIII
IX
IX
X
X
month
2003

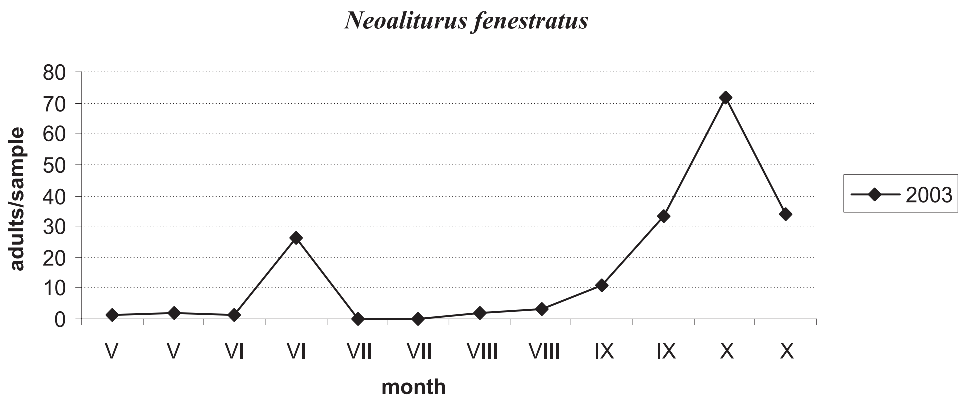
Annex 14. Number of individuals of dominants taken on plot 3.



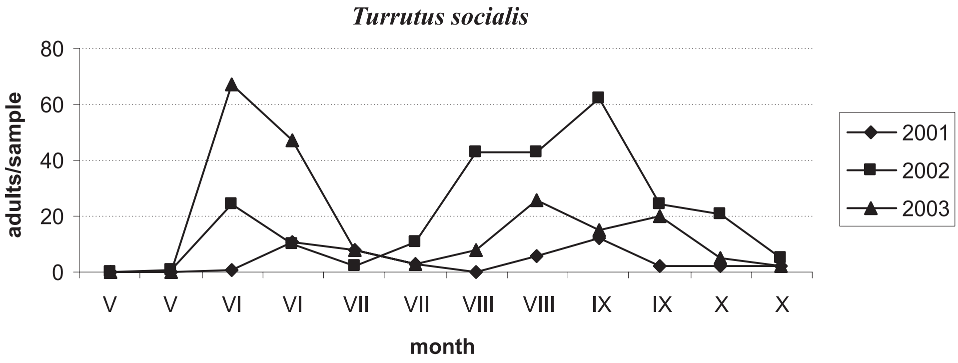


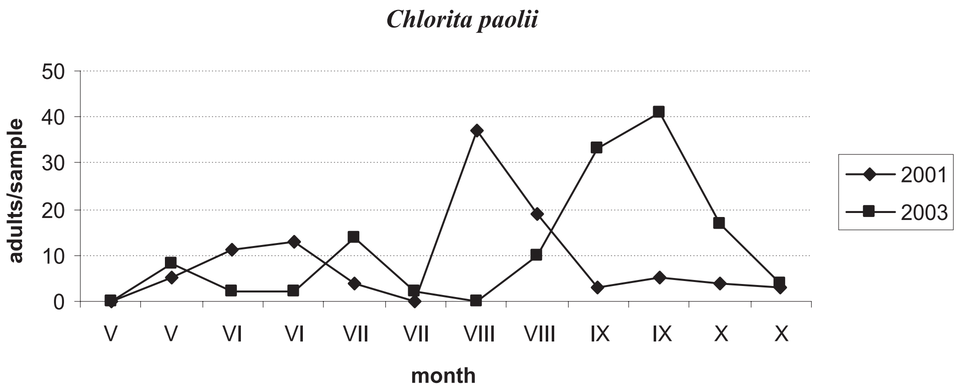


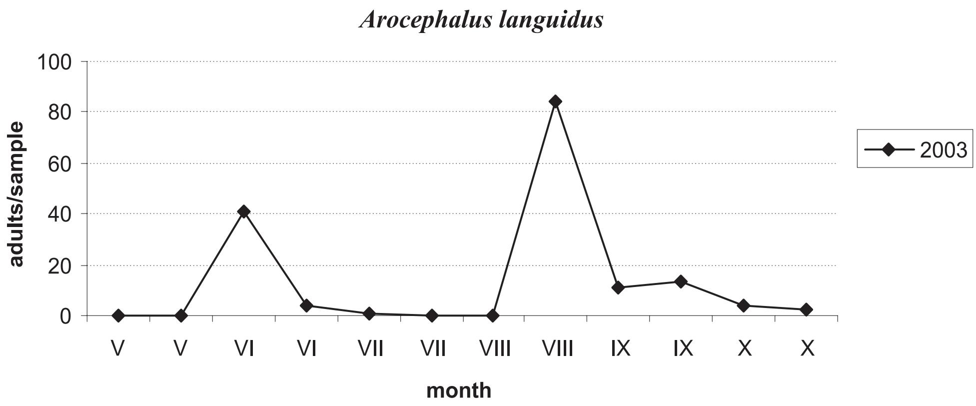

Psammotettix nodosus
adults/sample
50
40
30
20
10
0
V V VI VI VII VII VIII VIII IX IX X X
month
2002


Neoaliturus fenestratus
adults/sample
80
70
60
50
40
30
20
10
0
V V VI VI VII VII VIII VIII IX IX X X
month
2003

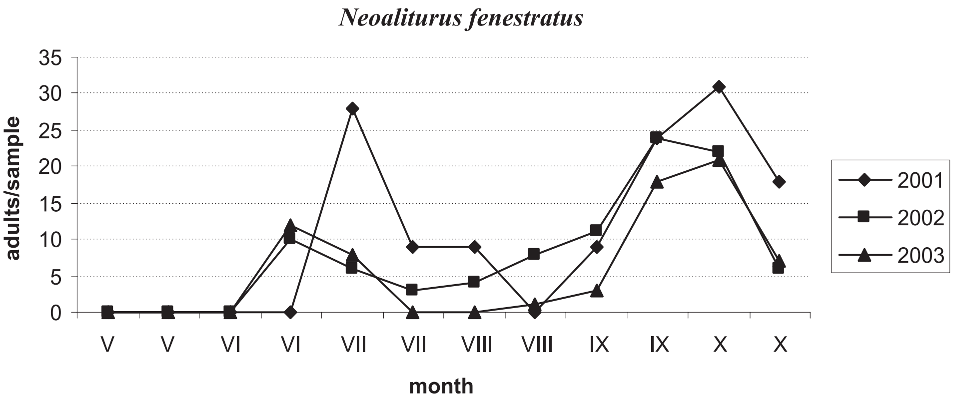
Annex 15. Number of individuals of dominants taken on plot 4.

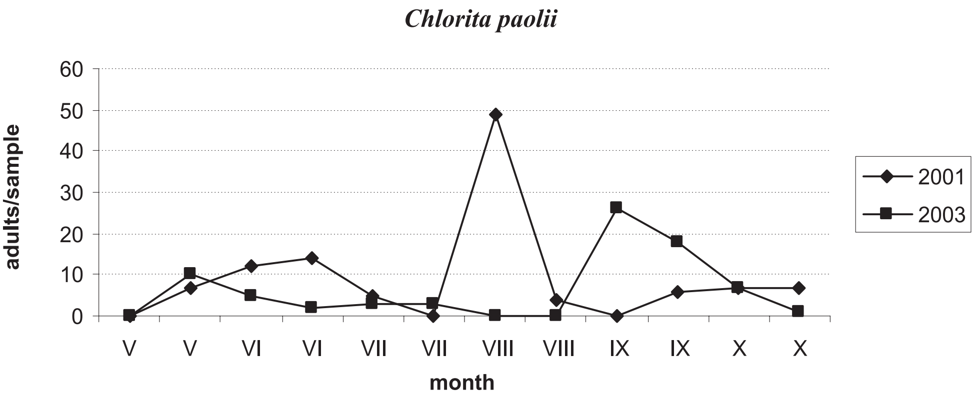


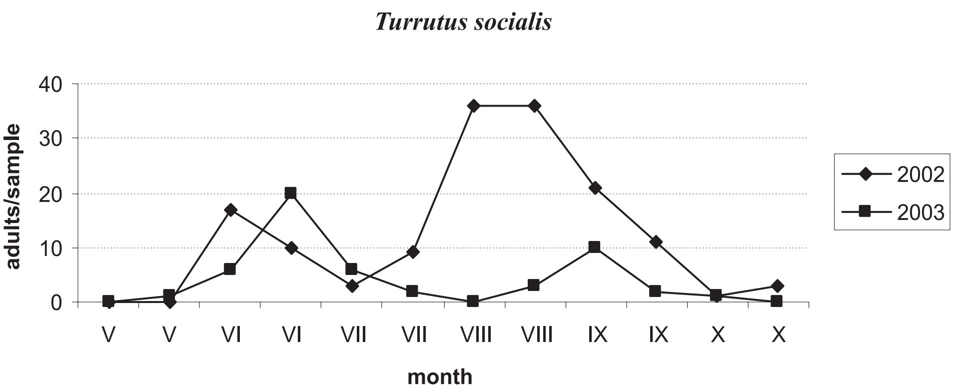




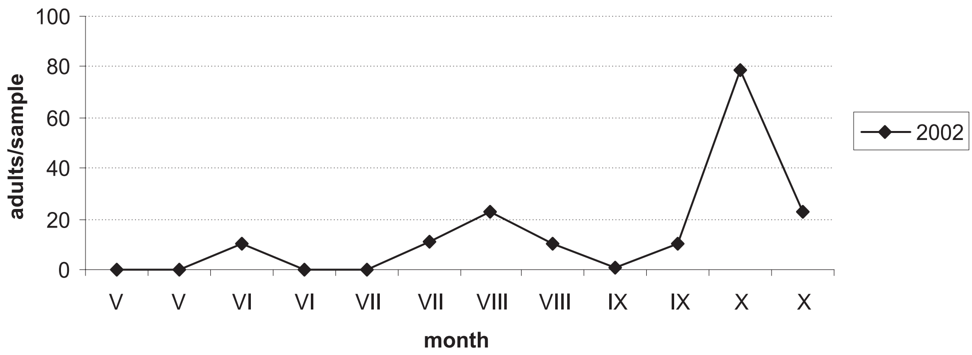
Annex 16. Number of individuals of dominants taken on plot 5.



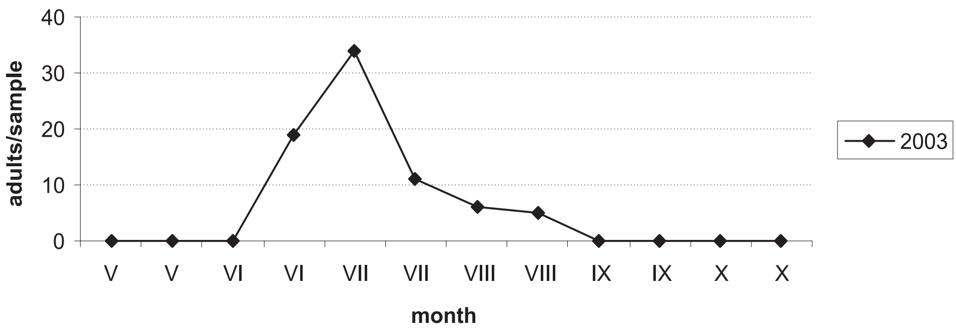




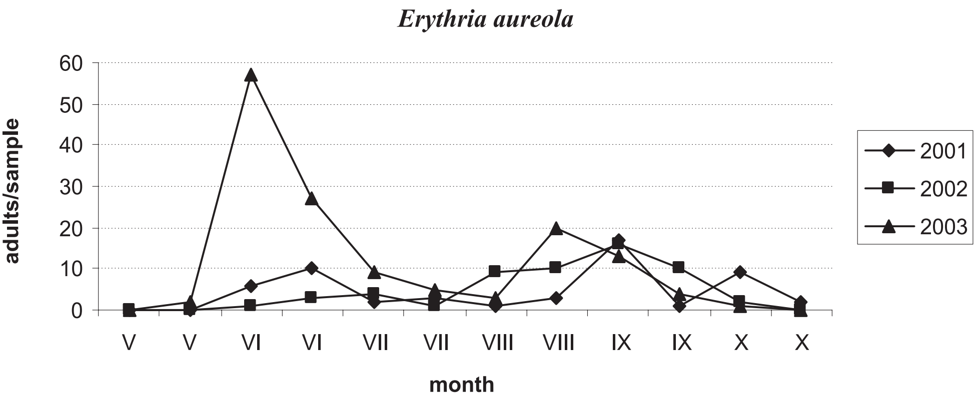
Macrosteles laevis

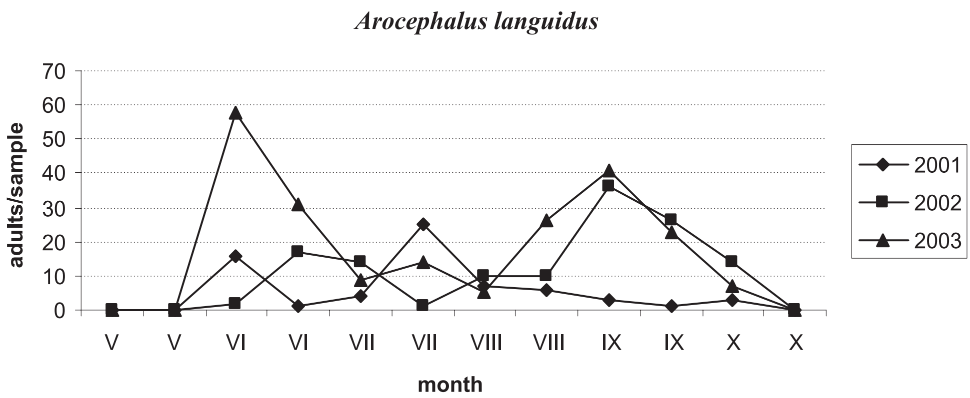


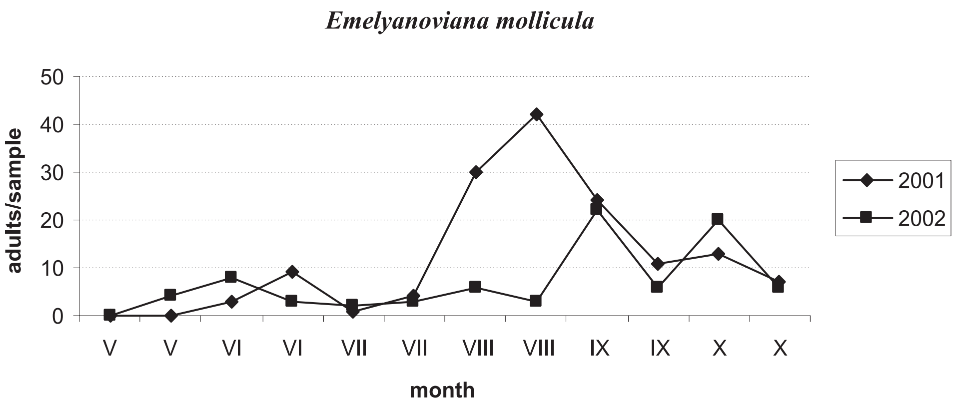
Doratura stylata

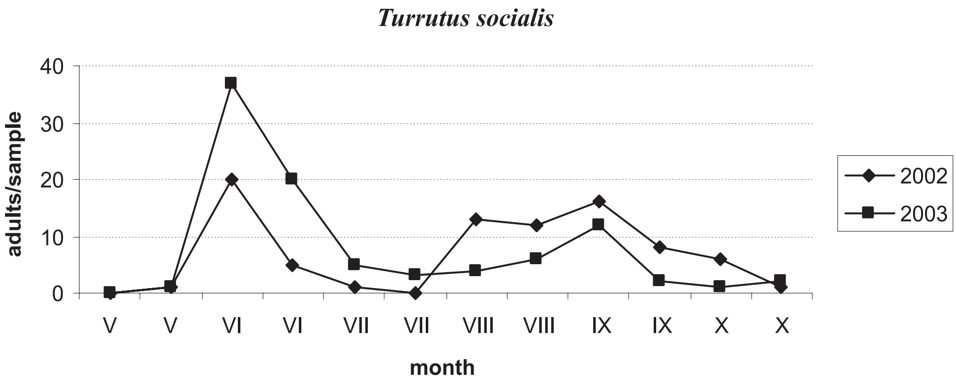


Annex 17. Number of individuals of dominants taken on plot 6.

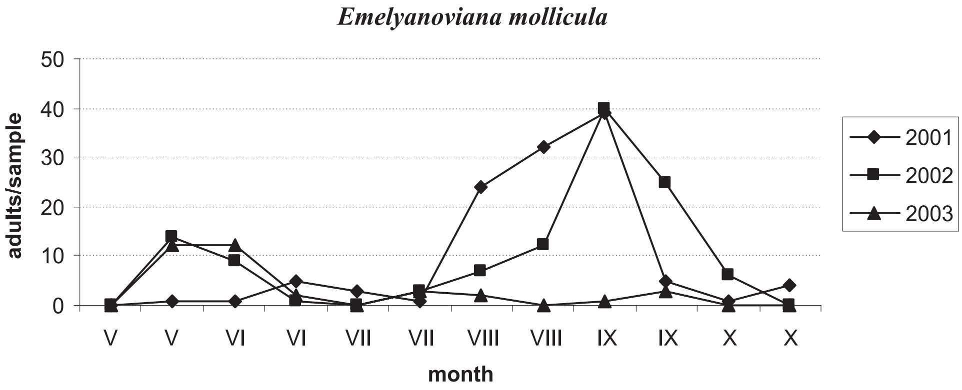


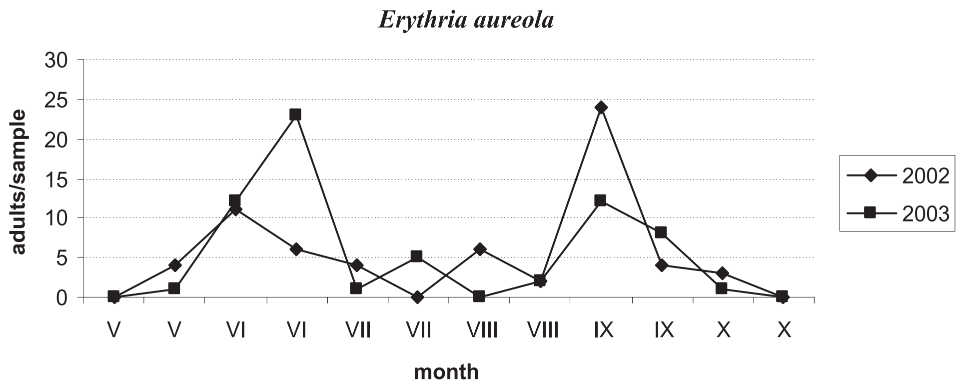


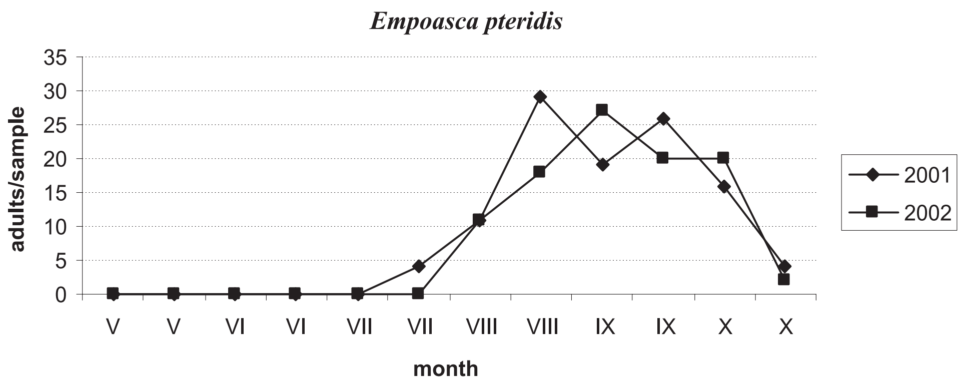


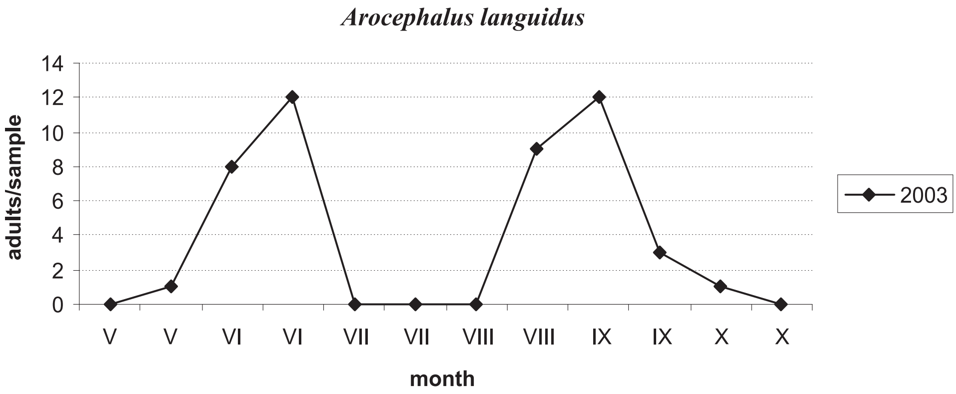

Turrutus socialis
adults/sample
40
30
20
10
0
V
V
VI
VI
VII
VII
VIII
VIII
IX
IX
X
X
month
2002
2003

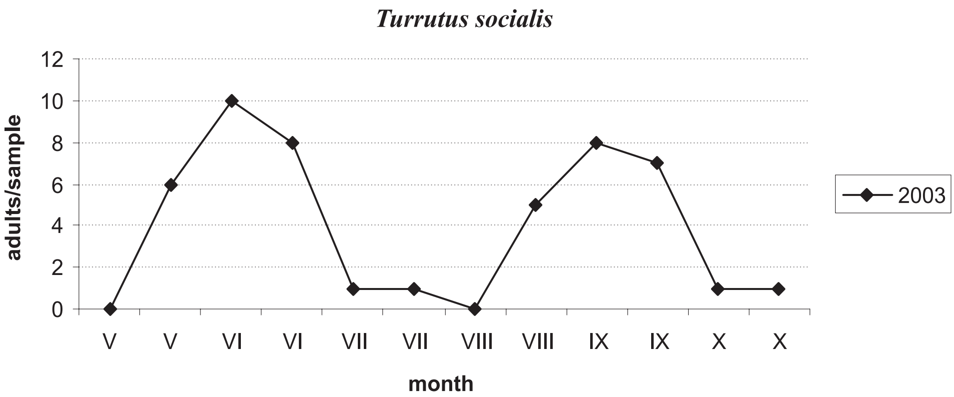
Annex 18. Number of individuals of dominants taken on plot 7.



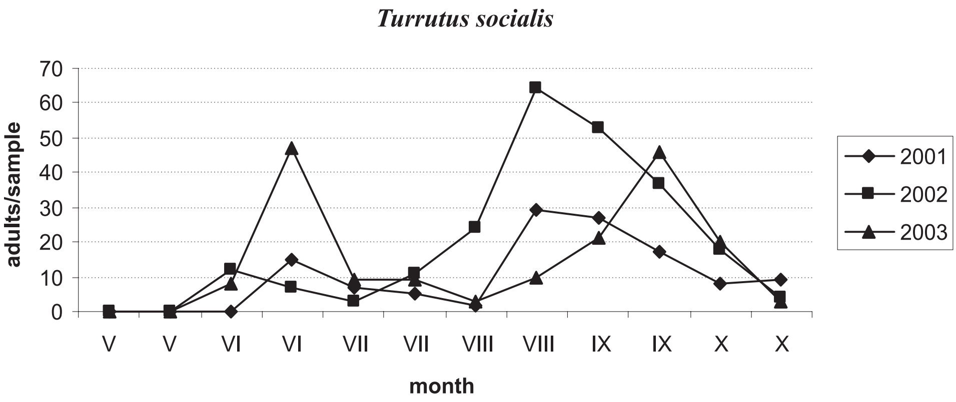


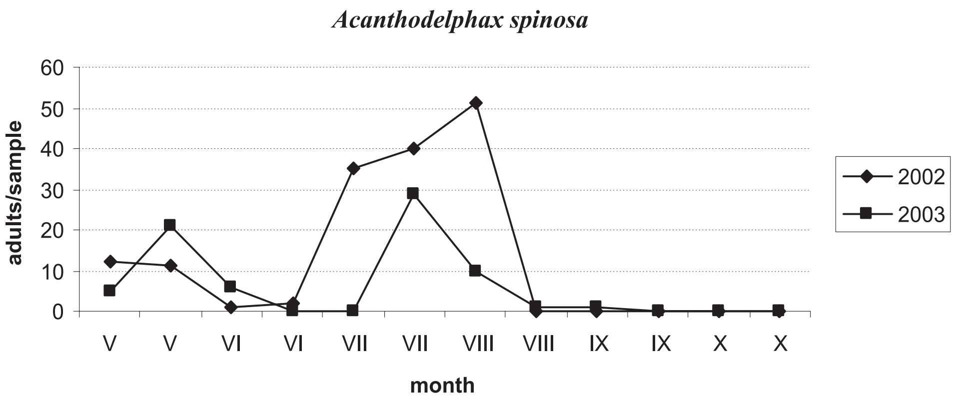


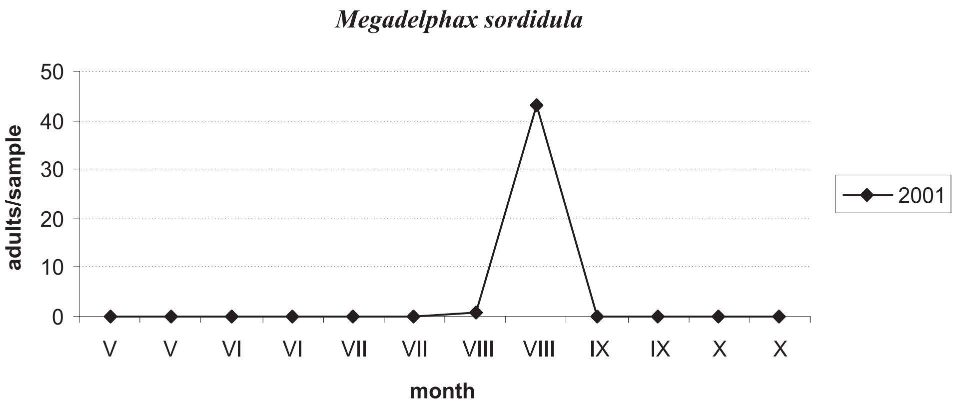

Arocephalus languidus
14
12
10
8
6
4
2
0
adults/sample
V
V
VI
VI
VII
VII
VIII
VIII
IX
IX
X
X
month
2003


Turrutus socialis
12
10
8
6
4
2
0
adults/sample
V
V
VI
VI
VII
VII
VIII
VIII
IX
IX
X
X
month
2003

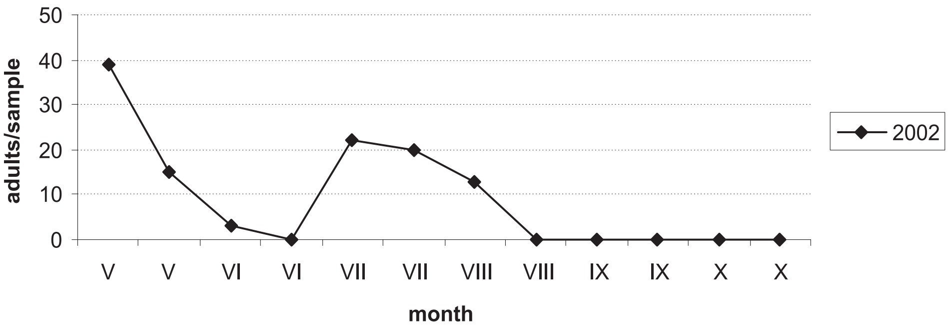
Annex 19. Number of individuals of dominants taken on plot 8.



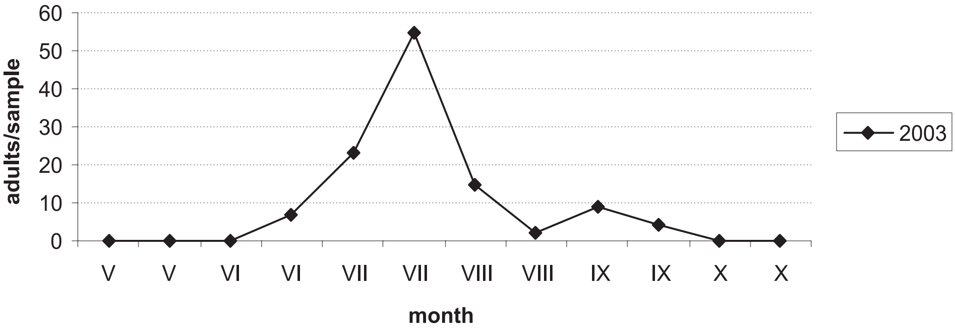




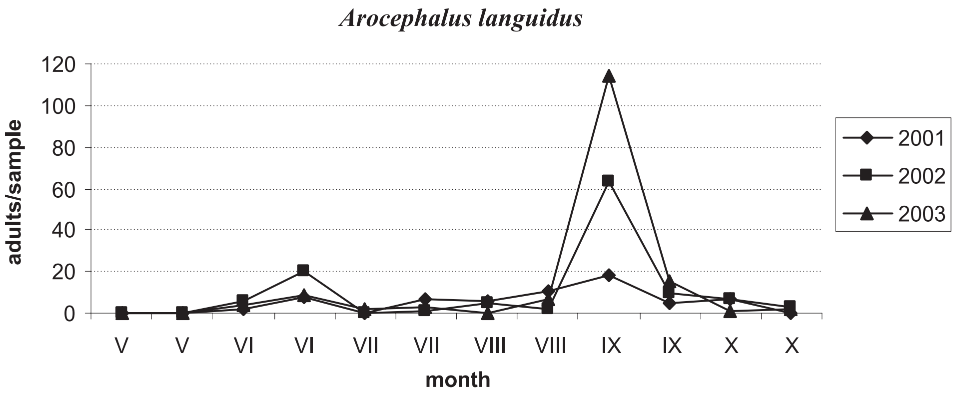
Ribautodelphax albostriata

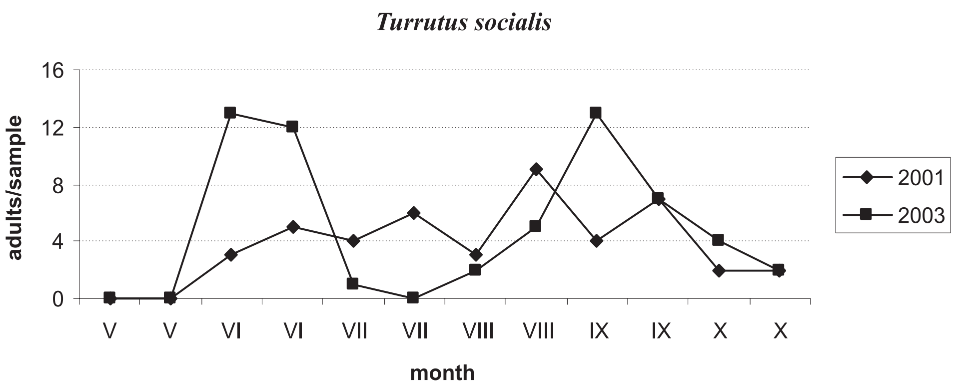


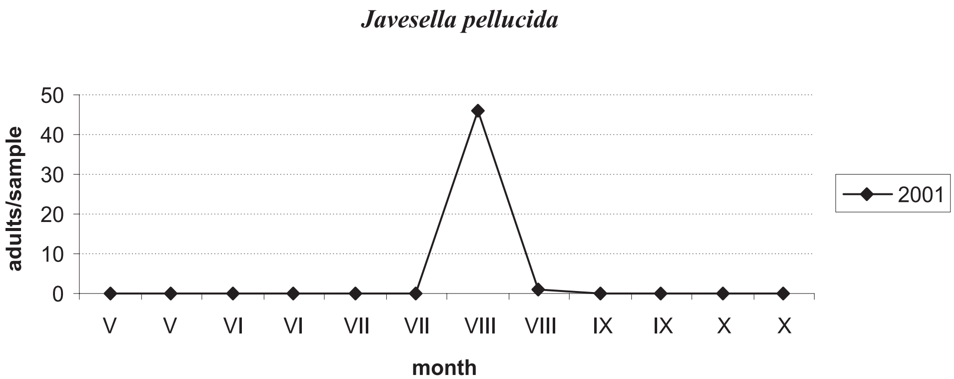
Doratura stylata



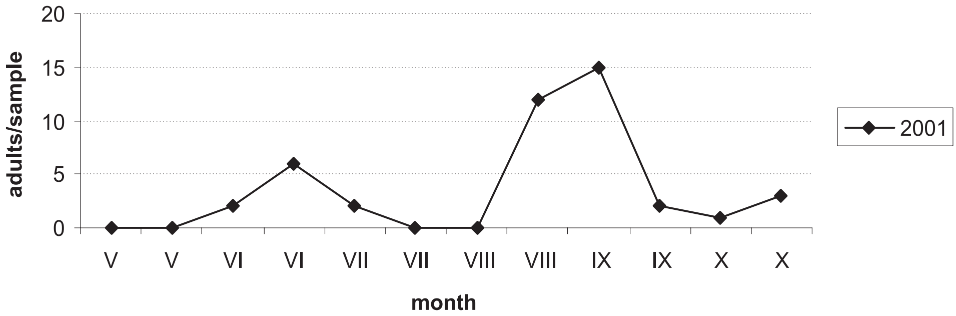
Annex 20. Number of individuals of dominants taken on plot 9.



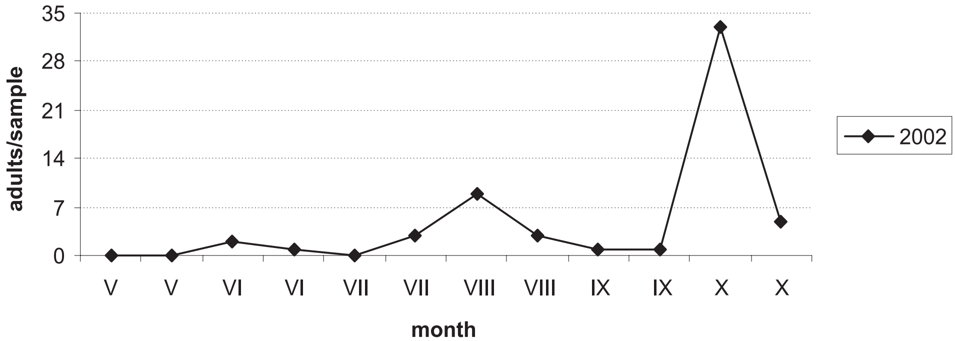




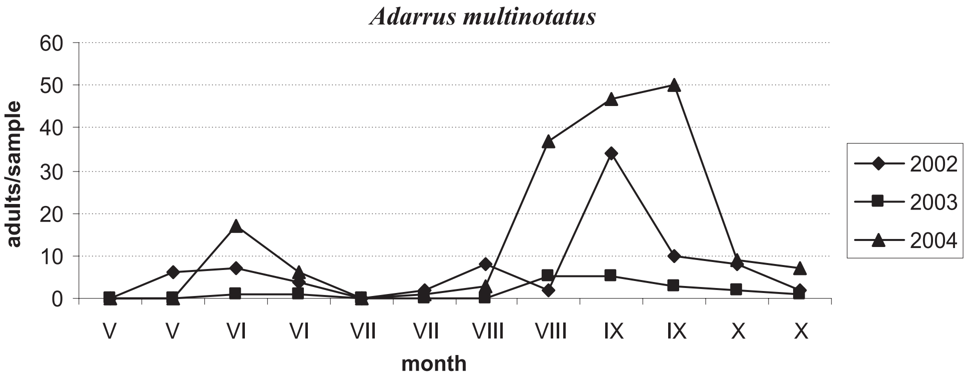
Erythria aureola

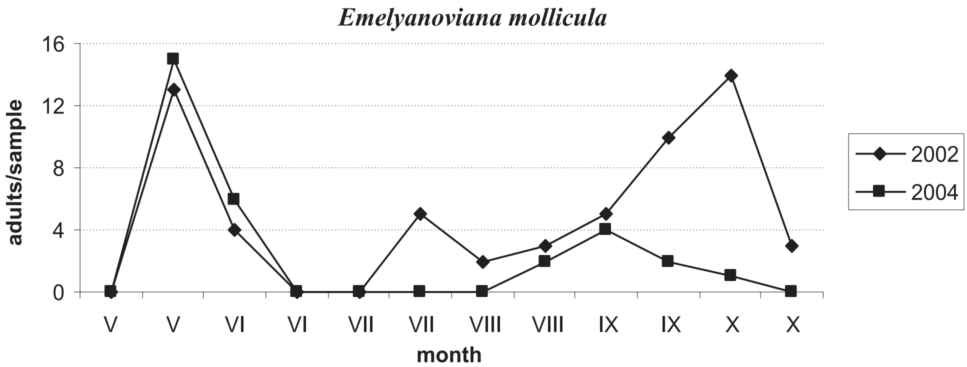


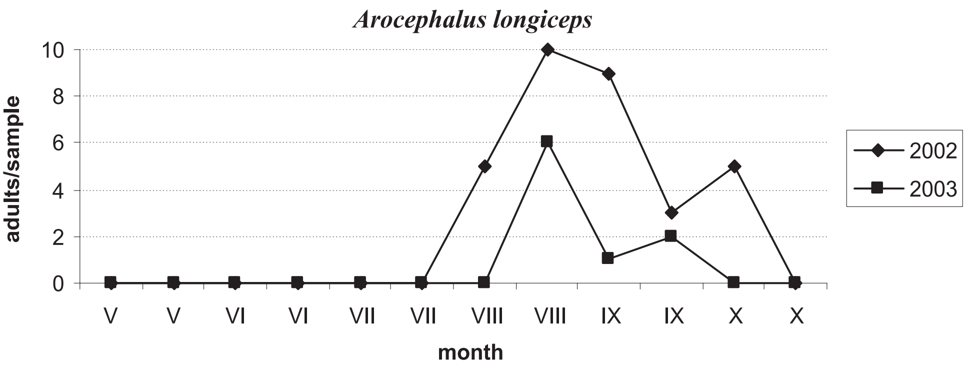
Macrosteles laevis



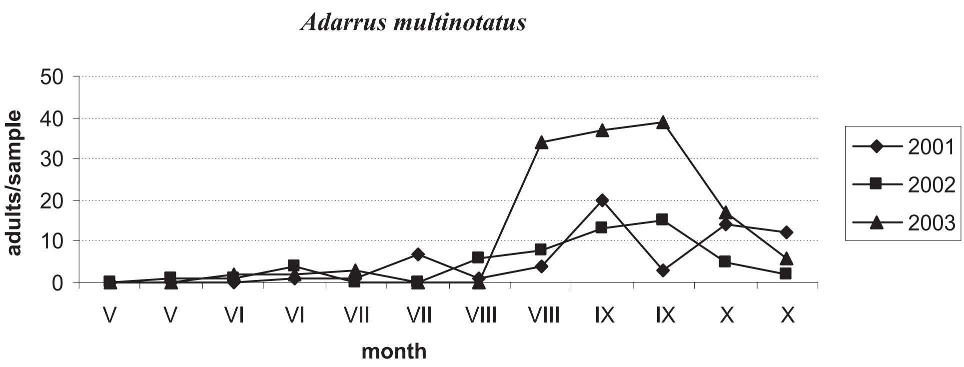
Annex 21. Number of individuals of dominants taken on plot 10.

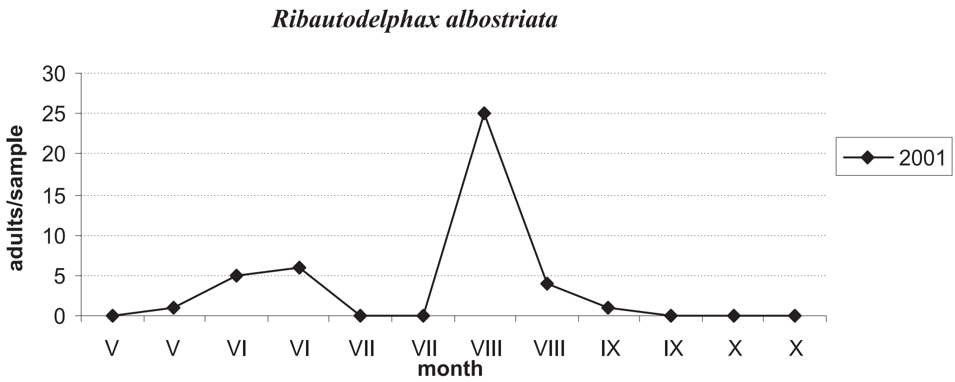


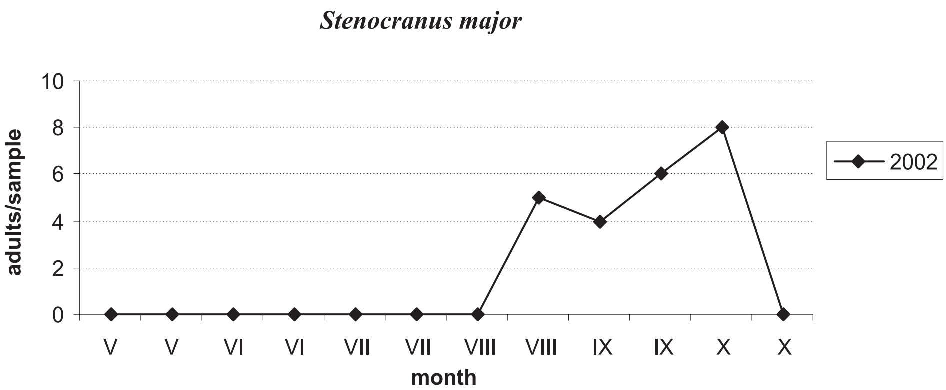




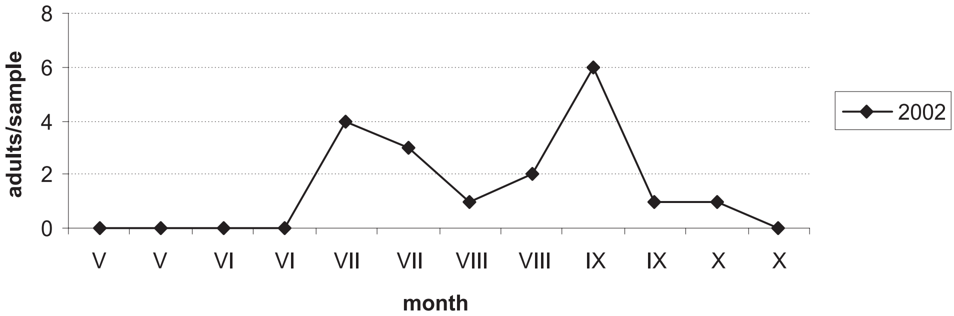
Annex 22. Number of individuals of dominants taken on plot 11.



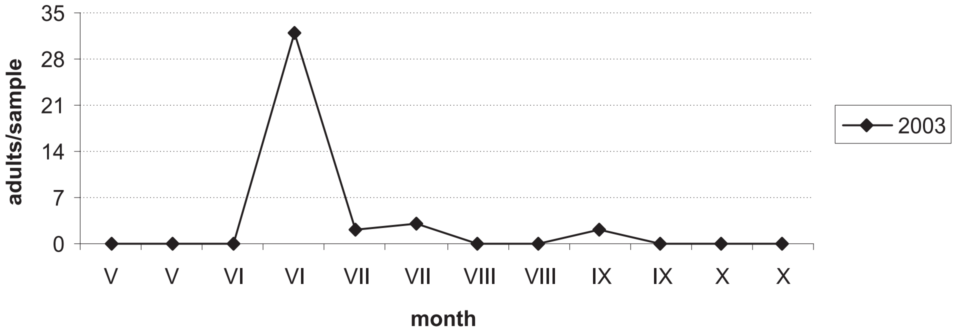




Elymana sulphurella



Aphrophora alni



Annex 23. Fidelity values for Auchenorrhyncha species recorded in investigated plant assemblages.

1	2	3	4	5	6
Auchenorrhyncha species	**Plant assemblage**				
	Spergulo vernalis-Corynephoretum	*Diantho-Armerietum elongatae*	*Festucetum pallentis*	*Sileno-Phleetum*	*Adonido-Brachypodietum pinnati*
Cixius nervosus	–	–	66.67	–	33.33
Tachycixius pilosus	–	–	–	–	100.00
Kelisia guttula	–	–	–	–	100.00
Kelisia guttulifera	–	100.00	–	–	–
Anakelisia perspicillata	–	0.00	7.14	85.71	7.14
Stenocranus major	–	7.14	4.29	14.29	74.29
Eurysa lineata	–	–	100.00	–	–
Metropis inermis	–	–	–	100.00	–
Chloriona vasconica	–	100.00	–	–	–
Megadelphax sordidula	2.70	8.11	2.70	63.51	22.97
Laodelphax striatella	13.41	43.90	12.20	21.95	8.54
Hyledelphax elegantula	–	–	–	–	100.00
Mirabella albifrons	–	–	–	100.00	–
Muirodelphax aubei	95.13	4.87	–	–	–
Acanthodelphax spinosa	–	10.14	–	89.49	0.36
Dicranotropis hamata	–	–	100.00	–	–
Kosswigianella exigua	5.16	14.08	0.94	77.93	1.88
Criomorphus albomarginatus	–	–	–	100.00	–
Javesella pellucida	2.38	31.55	4.17	56.55	5.36
Ribautodelphax albostriata	–	20.61	1.69	63.18	14.53
Ribautodelphax angulosa	50.00	50.00	–	–	–
Ribautodelphax collina	5.56	67.00	0.34	27.10	–
Ribautodelphax pungens	–	–	–	–	100.00
Tettigometra atra	–	100.00	–	–	–
Tettigometra impressopunctata	–	–	100.00	–	–
Cercopis sanguinolenta	–	16.67	–	33.33	50.00
Neophilaenus campestris	–	50.00	50.00	–	–
Neophilaenus exclamationis	30.00	50.00	–	–	20.00
Neophilaenus lineatus	–	–	–	100.00	–
Neophilaenus minor	88.84	10.69	0.47	–	–
Aphrophora alni	–	–	–	0.99	99.01
Philaenus spumarius	–	12.50	68.75	6.25	12.50
Centrotus cornutus	–	–	100.00	–	–
Utecha trivia	–	5.88	8.82	41.18	44.12
Utecha lugens	40.00	20.00	–	–	40.00
Megophthalmus scanicus	–	71.43	–	28.57	–
Agallia brachyptera	–	–	–	–	100.00
Anaceratagallia ribauti	17.80	67.80	13.56	0.85	–
Anaceratagallia venosa	8.03	55.96	35.73	–	0.28
Eupelix cuspidata	42.86	57.14	–	–	–
Aphrodes bicincta	2.63	46.05	27.63	11.84	11.84
Aphrodes makarovi	7.14	50.00	14.29	14.29	14.29
Planaphrodes trifasciata	33.33	33.33	33.33	–	–
Anoscopus albifrons	–	–	–	100.00	–
Anoscopus flavostriatus	–	–	–	–	100.00
Cicadella viridis	–	–	–	–	100.00
Erythria aureola	0.19	7.78	73.15	18.70	0.19
Emelyanoviana mollicula	–	0.56	70.27	12.76	16.41
Dikraneura variata	–	18.18	–	81.82	–

1	2	3	4	5	6
Micantulina stigmatipennis	–	–	93.94	6.06	–
Wagneriala incisa	–	–	100.00	–	–
Forcipata citrinella	–	4.26	4.26	87.23	4.26
Empoasca affinis	–	–	100.00	–	–
Empoasca pteridis	1.33	5.33	78.40	5.87	9.07
Empoasca vitis	–	–	100.00	–	–
Austroasca vittata	–	–	100.00	–	–
Chlorita paolii	3.66	77.25	7.19	10.59	1.31
Linnavuoriana decempunctata	–	–	–	–	100.00
Linnavuoriana sexmaculata	100.00	–	–	–	–
Eupteryx atropunctata	–	33.33	33.33	16.67	16.67
Eupteryx notata	2.12	66.67	5.82	23.81	1.59
Eupteryx stachydearum	–	–	100.00	–	–
Eupteryx tenella	–	–	100.00	–	–
Zygina flammigera	–	–	80.00	–	20.00
Zygina hyperici	2.14	30.00	32.14	31.43	4.29
Zygina ordinaria	–	–	100.00	–	–
Zygina rubrovittata	–	–	100.00	–	–
Neoaliturus fenestratus	6.34	88.55	4.35	0.74	–
Balclutha calamagrostis	–	12.82	17.95	43.59	25.64
Balclutha punctata	–	–	–	100.00	–
Macrosteles laevis	64.88	26.95	1.85	4.05	2.27
Macrosteles quadripunctulatus	25.00	75.00	–	–	–
Macrosteles sexnotatus	85.71	14.29	–	–	–
Deltocephalus pulicaris	–	–	–	100.00	–
Recilia coronifera	–	–	–	–	100.00
Doratura exilis	72.38	26.52	0.83	–	0.28
Doratura homophyla	13.46	86.54	–	–	–
Doratura impudica	8.70	91.30	–	–	–
Doratura stylata	2.31	57.32	0.62	36.98	2.77
Fieberiella septentrionalis	–	–	100.00	–	–
Allygus communis	–	–	50.00	–	50.00
Graphocraerus ventralis	6.67	80.00	–	13.33	–
Hardya tenuis	66.67	–	–	–	33.33
Rhopalopyx preyssleri	–	–	2.13	74.47	23.40
Rhopalopyx vitripennis	13.56	39.83	4.24	41.53	0.85
Elymana sulphurella	–	29.09	–	10.91	60.00
Cicadula flori	–	–	–	–	100.00
Cicadula persimilis	7.14	71.43	–	14.29	7.14
Cicadula quadrinotata	–	100.00	–	–	–
Mocydiopsis parvicauda	–	–	–	50.00	50.00
Athysanus argentarius	–	–	–	–	100.00
Athysanus quadrum	–	–	–	–	100.00
Ophiola decumana	–	100.00	–	–	–
Ophiola transversa	–	100.00	–	–	–
Laburrus impictifrons	12.33	87.67	–	–	–
Euscelis distinguendus	26.67	70.00	–	–	3.33
Euscelis incisus	–	100.00	–	–	–
Arocephalus languidus	0.09	28.15	41.58	30.02	0.17
Arocephalus longiceps	2.30	2.30	37.93	1.15	56.32
Psammotettix alienus	62.50	33.10	0.88	2.29	1.23
Psammotettix cephalotes	4.12	93.67	–	1.33	0.88
Psammotettix confinis	59.16	34.08	0.32	5.14	1.29
Psammotettix excisus	92.66	6.97	0.28	0.06	0.03
Psammotettix nodosus	7.10	92.59	–	0.31	–
Ebarrius cognatus	–	–	100.00	–	–
Adarrus multinotatus	–	–	–	–	100.00
Errastunus ocellaris	–	25.00	–	25.00	50.00
Turrutus socialis	1.36	47.65	13.78	36.98	0.23
Jassargus pseudocellaris	–	19.23	–	80.77	–
Verdanus abdominalis	–	–	–	100.00	–
Arthaldeus pascuellus	–	42.86	–	57.14	–
Mocuellus collinus	7.10	91.72	–	0.59	0.59

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Mulsant E., Rey A. 1844a. Histoire Naturelle des Coléopteres de France. Maison, Paris: vii + 1–196, pl. 1.

Lawrance J. F. 1982. Coleoptera. [in:] Parker S.P. (ed.). Synopsis and Classification of Living Organisms. Vol. 2, McGraw-Hill, New York: 482–553.

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