ANNALS OF THE UPPER SILESIAN MUSEUM IN BYTOM
ENTOMOLOGY
Vol. **28 (online 006)**: 1–28 ISSN 0867-1966, eISSN 2544-039X (online) Bytom, 05.12.2019

Marcin Walczak[1], Mariola Chruściel[2], Joanna Trela[3], Klaudia Sojka[4], Aleksander Herczek[5]

Planthopper and leafhopper fauna (Hemiptera: Fulgoromorpha et Cicadomorpha) at selected post-mining dumping grounds in Southern Poland

http://doi.org/10.5281/zenodo.3564181

Faculty of Natural Sciences, University of Silesia, Bankowa Str. 9, 40-007 Katowice, Poland

[1] e-mail: marcin.walczak@us.edu.pl; [2] mariola.pniok@gmail.com; [3] joanna.m.trela@us.edu.pl (corresponding author); [4] klaudia.sojka.tg@gmail.com; [5] aleksander.herczek@us.edu.pl

Abstract: The paper presents the results of the study on species diversity and characteristics of planthopper and leafhopper fauna (Hemiptera: Fulgoromorpha et Cicadomorpha) inhabiting selected post-mining dumping grounds in Mysłowice in Southern Poland. The research was conducted in 2014 on several sites located on waste heaps with various levels of insolation and humidity. During the study 79 species were collected. The paper presents the results of ecological analyses complemented by a qualitative analysis performed based on the indices of species diversity.

Key words: insects communities, zoocenological analyses, dominant species, seasonal dynamics of abundance, ecology, distribution, synanthropy, post-industrial areas, biodiversity in degraded environments, anthropopressure, natural succession.

INTRODUCTION

Planthoppers and leafhoppers (Hemiptera: Fulgoromorpha et Cicadomorpha) are phytophagous insects which are highly related to their host plants, and most of them are trophically specialized as mono- or oligophagous (Nickel 2003), so most of them are attached to the specific plant associations, where they form multispecies communities. The term **community**, applied in this study, was introduced by Ramensky (1952), and further developed by Łuczak and Wierzbowska (1981), who defined it as all species co-occurring in a particular habitat or in its particular layer, belonging to a particular systematic group. Such a group is studied by a zoologist-specialist who concentrates on its own structural features such as the number of species and their abundance. Pawlikowski (1985) developed a very similar concept in his study devoted to bee communities (Hymenoptera, Apoidea). He defined a community as a group of species constantly present in the habitat (by direct relationship) and occurring temporarily (through migration or host alternation) with weakly recognized internal interrelationships. Analyses of hopper communities are very useful for urban ecology research, because of their distinct reaction to anthropogenic pressure - in general, the closer the urban agglomerations the more intense insects' reaction (Chudzicka & Skibińska 1998). The study of seasonal variations in the structure of hopper communities allows to record the rate of changes occurring in urban and industrial areas (Gębicki 1979). This is why planthoppers and leafhoppers are considered important bioindicators, useful in determining the degree of anthropopression in various habitats. They are even regarded as a model group of insects in the environmental monitoring (Chudzicka 1979, 1981, Klimaszewski *et al*. 1980a, 1980b, Gębicki 1983, Nickel & Hildebrandt 2003). In spite of this, hopper communities of post-mining dumping grounds are poorly researched and little information on this subject could be found (Denno & Roderick 1991). We could only find an interesting information on planthopper and leafhopper fauna of brownfields as general post-industrial areas regardless of origin (Biedermann 2002, Strauss & Biedermann 2006, Sanders *et al.* 2008).

So far in Poland there has been published just one paper devoted specifically to planthopper and leafhopper communities living around post-industrial dumping grounds in Ruda Śląska and Mikołów (Simon & Szwedo 2005). Additionally, some information related to hopper communities on waste heaps was found in a study conducted around Częstochowa (Walczak *et al.* 2014). Most of the research done on post-industrial dumping grounds is still unpublished in manuscripts of master theses (Ruda 1981, Taszakowska 1985, Zimoń 1986, Gibas 2015, Mielimonka 2015).

Studies conducted on the mining waste heaps of Mysłowice were undertaken due to insufficient knowledge of planthopper and leafhopper communities inhabiting post-industrial dumping grounds. The paper describes the structure of insect communities and their population dynamics on the area of selected heaps. The results are also supplemented with chorological, ecological, zoocoenological and qualitative analyses conducted based on the indices of species diversity.

MATERIAL AND METHODS

Study site

Mysłowice is a city which covers the area of 6557 hectares, and it is adjacent to Katowice. It is located in the southern Poland (Fig. 1), within the Silesian Upland (Kondracki 2002), and the region of Upper Silesia according to the regionalization system adopted in the *Catalogue of Polish Fauna* (Burakowski *et al.* 1973). Mysłowice lies within the Upper Silesia basin, and its Precambrian foundation of the geological structure is covered with the Upper Carbon, Triassic, Palaeogene, Neogene and Quaternary deposits. From an economic point of view, the most important are the Upper Carbon formations (Gilewska 1972).

Vegetation around the study area has changed during the long period of economic exploitation, especially mining. However, many valuable natural sites have been preserved. The local flora has been impoverished by settlements, development of communication, industry and the storage of post-industrial wastes. The waste heaps remain a threat to the natural environment, but they also form specific niches for habitat of a number of species and shape the landscape of the city (Czylok *et al*. 2002).

Characteristics of the study plots

The research was conducted in Mysłowice (Wesoła district) on post-mining dumps, or adjacent areas of the Mysłowice-Wesoła Coal Mine, on 5 selected research plots (Fig. 2). Each plot measured ca. 120 m². Nomenclature of the vascular plant species by Mirek *et* *al.* (2002). Information on the origin of heaps was obtained with an agreement of the Coal Holding in Katowice and using the data of the Coal Mine Mysłowice-Wesoła.

Plot 1. Surroundings of Spacerowa Street [N50°11'39", E19°05'19"; UTM: CA66]. Dumping ground was probably formed between 1960 and 1980. The site is located within the landscape complex 'Ruberg' in the Przywra Valey. The heap is covered by shrub associations, transforming into a forest association, formed in ruderal stand with the dominance of *Betula pendula* in the stand, and an admixture of *Populus tremula* and *Padus serotina* in the undergrowth. Undergrowth is dominated by *Elymus repens* with a few less numerous species of grasses (Tokarska-Guzik *et al.* 2012).

Plot 2. Surroundings of Piastów Śląskich Street [N50°11'11", E19°06'38"; UTM: CA66]. Until the end of the 1970s, there was functioning a brickyard and a municipal waste dump. In the 1990s, the reclamation of the liquidated landfill with the use of waste rock, slag and sewage sludge of Coal Mine Mysłowice-Wesoła was conducted. The studies were carried out on well sunlit grassland on the southern slope of the heap. *Festuca ovina* and *Lotus corniculatus* dominate there, also with an invasive *Solidago canadensis* (Tokarska-Guzik *et al.* 2012).

Plot 3. Adjacent to plot number 2 [N50°11'13", E19°06'34"; UTM: CA66]. The plot was located in the central part of the heap. It is a grassland complex dominated by *Festuca ovina* and *Festuca rubra*, accompanied by *Lotus corniculatus* (Tokarska-Guzik *et al.* 2012).

Plot 4. Surroundings of Piastów Śląskich Street [N50°10'32", E19°05'43"; UTM: CA66]. It is a terrain of waste disposal of Coal Mine Mysłowice-Wesoła, with the area of 23 hectares. From the 1950s to the end of the 1980s waste rocks were deposited here. The study was conducted in the initial grassland complex, with the dominance of *Calamagrostis epigejos*, and a significant share of *Lotus corniculatus*, *Tussilago farfara*, *Echium vulgare*, *Melilotus* sp., and *Phragmites communis*. There were several tree seedlings: *Pinus sylvestris* and *Betula* sp. (Tokarska-Guzik *et al.* 2012).

Plot 5. The research site was located at a retention reservoir receiving rainwater and melting waters from the area of the heap. It is settled near the plot 4 [N50°10'38", E19°06'13"; UTM: CA66]. Water from this reservoir flows down the draining ditch of the heap area to the Ławecki Stream. Near the ditch, there is also located a coal mud settler. Insects were collected in a rush association with the predominance of *Typha latifolia* and *Equisetum fluviatile*, which were accompanied by invasive Nearctic: *Padus avium* and *Solidago canadensis* (Tokarska-Guzik *et al.* 2012).

The study was conducted from May to September 2014. Insects were collected at 2-week intervals, using an entomological sweep net, according to the commonly used methodology for this type of study (Gębicki *et al.* 1977, Klimaszewski *et al.* 1980a, 1980b, Stewart 2002). At the appointed terms, on each plot, 4 samples were collected – where a single sample mean 25 strikes with the entomological sweep net. It is common knowledge that hopper species diversity is related to the variety of flora species present in the local area (Witkowski 1970). This is why, in accordance with the research on the minimum size of representative area done by Kimsa (1986), our research adopted the plot size of 120 m^2. A research site of this size usually contains sufficient diversity of plant species to be considered representative.

Most of the collected material was identified with the following keys: Ossiannilsson (1978, 1981, 1983), Holzinger *et al.* (2003) and Biedermann & Niedringhaus (2004). In some cases, specialised papers on particular genera were applied: *Muellerianella* Wagner, 1963 (Booij 1981), *Ribautodelphax* Wagner, 1963 (Bieman 1987), *Aphrodes* Curtis, 1833 (Tišečkin 1998), *Forcipata* DeLong & Caldwell, 1936 (Gniezdilov 2000), *Eupteryx* Curtis, 1833 (Le Quesne 1974), *Zygina* Fieber, 1866 (Dworakowska 1970a), *Arboridia* Zachvatkin, 1946 (Dworakowska 1970b), *Balclutha* Kirkaldy, 1900 (Knight 1987), *Macrosteles* Fieber, 1866 (Gajewski 1961), *Doratura* J. Sahlberg, 1871 (Dworakowska 1968b), *Fieberiella* Signoret, 1880 (Dlabola 1965), *Rhopalopyx* Ribaut, 1939 (Dmitriev 1999), *Elymana* DeLong, 1936 (Dworakowska 1968a) and *Arthaldeus* Ribaut, 1947 (Remane 1960).

Determination of collected species was based on external morphology, but we also used the microscopic preparations of sound and male apparatus. The material was prepared according to the Knight procedure (1965). Systematics and nomenclature were used following Gębicki *et al*. (2013).

The collected specimens are deposited in the collection of the Institute of Biology, Biotechnology and Environmental Protection, Faculty of Natural Sciences, University of Silesia in Katowice.

Analysis

The dominance index (*D*), constancy index (*C*) and fidelity index (*W*) (after Kasprzak & Niedbała 1981) were calculated in order to determine the species diversity in studied communities. Based on the values received by applying the dominance index (*D*) equation the following five classes of dominance have been distinguished: superdominants – more than 30% of all collected individuals on investigated plot; dominants – from 20.01% to 30.00%; subdominants – from 7.51% to 20.00%; accessory classes: recedents – from 2.51% to 7.50%; subrecedents – less than 2.51%. Based on the values of constancy index (*C*) the following four classes of constancy of occurrence have been distinguished: 1^{st} class (euconstant species) – from 75.01% to 100%; 2^{nd} class (constant species) – from 50.01% to 75.00%; 3^{rd} class (accesoric species) – from 25% to 50.00%; 4^{th} class (accident species) – less than 25%. The values of fidelity index (*W*) were divided into four main categories used in many studies that discuss planthopper communities. Four fidelity classes were distinguished: differential species – *W* from 95.01% to 100.00%; characteristic species – *W* from 50.01% to 95.00% – accompanying species – *W* below 50%; accidental species – species only accidentally encountered in a given plant community, showing no strong association with it (after: Walczak *et al.* 2014, Musik *et al.* 2018).

The following coefficients were applied: Shannon-Weaver's *H'* and Brillouin's $\hat{H}$ (Shannon & Weaver 1949 and Brillouin 1962 after: Trojan 1992). Cluster analysis and PCA were performed for determining the similarity of studied communities (after: Walczak *et al.* 2014).

The aim of ecological analysis was to indicate the share of particular ecological elements in the planthopper fauna of the studied region. Various environmental factors induce the changes in animal communities and constantly modify them (Trojan 1992). The planthoppers and leafhoppers are a group which reflects the interrelationships within a biocoenosis in an astonishing way (Nickel 2003). The research on such relations in various insect taxa helped to explain how ecosystems function, what processes maintain the homeostasis and what factors trigger the response to stress (Szujecki 1998).

In the ecological analysis the following factors were taken into account: humidity (hygrophilous, mesohigrophilous and xerophilous species), insolation (heliophilous, mesoheliophilous and skiophilous species), trophic relations (1-degree and 2-degree monophagous, 1-degree and 2-degree oligophagous and polyphagous), the overwintering stages (wintering in the egg, nymphal or adult stage), number of generations during the year (species with one generation during a year – univoltine; two generation – bivoltine) and environmental connections of the tested insects – their life strategy (eurytopic, oligotopic and stenotopic species). In terms of humidity requirements and insolation, the criteria proposed by Czechowski and Mikołajczyk (1981). Information on the trophic requirements and relations with their host plants follows Nickel (2003) and Świerczewski (2007), the overwintering stage and the number of generations during the year was accepted after Nickel and Remane (2002), while the strength of relationship of a species with its habitat follows Achtzinger and Nickel (1997) and Nickel and Hildebrandt (2003).

RESULTS

During the research a total of 2913 planthopper and leafhopper specimens was recorded and determined into 79 species. 114 larvae individuals. The detailed results are presented in tables at the end of the paper. Suborder Fulgoromorpha was represented by 2 families: Delphacidae and Tettrigometridae, and Cicadomorpha was represented by 3 families: Aphrophoridae, Membracidae and Cicadellidae. Over 2/3 (54 sp.) collected taxa belong to Cicadellidae. Single female from Delphacidae and 2 males from *Macropsis* sp. could not be identified.

In gathered material were recorded species rare in Poland like: *Paraliburnia adela*, *Tettigometra impressopunctata*, *Ebarrius cognatus* and *Metalimnus steini*.

The most numerous in the whole material was *Stenocranus major* (1297 specimens – 45.44% share; Fig. 6h). Also abundant were populations of *Cicadella viridis* (234 specimens – 8.2% share), *Jassargus flori* (4.77%), *Balclutha calamagrostis* (3.92%), *Neophilaenus lineatus* (3.75%), *Neophilaenus minor* (3.36%) and *Balclutha punctata* (2.59%). Mentioned species represent dominant (above 20% share) and subdominant (7,5%-20% share) species in planthopper communities (Kasprzak & Niedbała 1981, Walczak *et al.* 2014). *Stenocranus major* and *Cicadella viridis* dominated in moist environment on plot 5, and were the most numerous at the end of the August and early September. *Neophilaenus lineatus*, *Jassargus flori* and *Balclutha punctata* dominated in forest association on plot 1, and the largest increase in their population was observed in July and August. Mesophilous and xerophilous dominants like *Balclutha calamagrostis* and *Neophilaenus minor* were the most numerous on the insolated plots 2 and 4. The population dynamics chart of both species had its peaks twice: at the end of the spring and in summer (Fig. 3., Tab. 3).

As many as 28 species were represented only by 1 single specimen. The share of unidentified larvae in the total material was 3.99%.

Indices of species diversity and evenness

The values of Shannon-Weaver's species diversity index *H'*, calculated on the basis of the natural logarithm (log e), on the examined plots ranged between 0.603 and 2.794. The Brillouin's diversity index $\hat{H}$ ranged between 0.589 and 2.545. The highest values of these indices were obtained in planthopper community on plot 3, and the lowest in case of plot 5 (Tab. 1).

Similarity of communities on study plots

The hierarchical tree (Fig. 4) revealed the highest degree of similarity between communities on plots 2 and 3, and located close to them community on plot 4. The outer group for this cluster is the community on plot 1. It has also been shown, that the community on plot 5 has to be treated separately.

The results achieved by principal components analysis (PCA) has mostly confirmed what the agglomeration analysis revealed. Thanks to this method, we obtained the graphic view of group constituted of communities from plots 2, 3 and 4. Planthopper communities associated with plots 1 and 5 were scattered separated (Fig. 5).

Ecological analysis

In total collected material, in term of the environmental humidity, the largest share belong to mesohigrophilous (60.98%), and in the case of insolation to mesoheliophilous species (59.76%) (Tab. 2).

Taking into account trophic relations the percentage share of individual groups were almost equal. Monophagous species dominated slightly (36.59%), second were oligophagous species (34.15%), while the lowest proportion belongs to polyphagous (24.39%).

Species with only one generation per year formed 52.44% of the total, and that with more than two generations formed a group of 43.90%. The most abundant were species overwintering in the stage of egg (62.20%), while the least were the ones overwintering as imago (14.63%). In terms of life strategy, species with eurytopic and oligotopic range had the highest share (37.80%), while stenotopic species (20.73%) were less common. Undetermined adults and larvae have been classified as unknown. The results obtained during the above analysis for individual plots were placed in Tab. 2.

A review of rare and interesting species of planthoppers and leafhoppers (* – new species for the Upper Silesia region):

1. *Paraliburnia adela* (Flor, 1861)* (Fig. 6a) – Plot 5: 18.08.2014, 1♂, 1♀; species known almost from all over the Europe (Nast 1987) and Kazakhstan (Nast 1972). Inhabits *Phalaris arundinacea* (Nickel & Remane 2002). In Poland new to the region of Upper Silesia, previous known only from the Pomeranian Lake District, Mazovian Lowland (Smreczyński 1954, Gębicki *et al.* 2013) and Kraków-Wieluń Upland (Walczak 2014, Walczak *et al.* 2014, 2016).

2. *Stictocephala bisonia* Kopp et Yonke, 1977 (Fig. 6b) – Plot 4: 30.08.2014, 1♂ (data published: Walczak *et al*. 2018); Nearctic species invasive in Poland. For 100 years it has been spreading in Europe and other parts of the world, sometimes causing significant damage to crops (Seliak 2004, Lauterer *et al.* 2011). In Poland, recorded a few years ago (Świerczewski & Stroiński 2011), currently known from about 90 positions and from almost the entire area, with the exception of the east border of the country and some regions in the south (Walczak *et al.* 2018).

3. *Macrosteles sardus* Ribaut, 1948 (Fig. 6c) – Plot 4: 18.08.2014, 1♂; Species occur in the middle Europe and Kazakhstan (Nast 1972). The host plant of this species remains unknown (Nickel & Remane 2002). In Poland recorded only in the region of Kraków-Wieluń Upland and Upper Silesia (Świerczewski & Walczak 2011, Musik *et al*. 2018).

4. *Allygus modestus* Scott, 1876 (Fig. 6d) – Plot 1: 20.06.2014, 1♂, 04.07.2014, 2♀♀; Occour almoust all over the Europe (Nast 1987, Söderman *et al.* 2009), and also in Marocco and Tunisia (Nast 1972). In Poland recorded on the Baltic Coast, Wielkopolsko-Kujawska Lowland (Nast 1976), Kraków-Wieluń Upland (Walczak *et al.* 2014, 2016), Małopolska Upland, Lubelska Upland (Gębicki *et al.* 2013), and lately also Upper Silesia (Musik *et al.* 2018).

5. *Metalimnus steini* (Fieber, 1869) (Fig. 6e) – Plot 3: 18.08.2014, 1♀; The species is present in Europe, Caucasus and Primorsky Krai (Nast 1972). Monophagous on *Carex hirta*

(Nickel & Remane 2002). In Poland known from the region of Upper Silesia (Świerczewski & Walczak 2011, Musik *et al.* 2018, Junkiert & Gorczyca 2019), Kraków-Wieluń Upland (Świerczewski & Walczak 2011) and Małopolska Upland (Gębicki *et al.* 2013).

6. *Ebarrius cognatus* (Fieber, 1869) (Fig. 6f) – Plot 3: 20.06.2014, 3♀♀, 30.08.2014, 1♂; Occours almost all over the Europe, Asia Minor and Transcaucasia (Nast 1972). Monophagous on *Festuca* sp. (Nickel & Remane 2002). In Poland recorded in Upper Silesia, Kraków-Wieluń Upland, Western Beskidy Mountains and Pieniny Mountains (Gębicki *et al.* 2013).

7. *Arthaldeus arenarius* Remane, 1960 (Fig. 6g) – Plot 4: 21.06.2014, 1♂; Present in Cenral Europe and in the South Russia (Nast 1972). Monophagous *Calamagrostis epigejos* (Nickel & Remane 2002). In Poland known from Upper Silesia, Kraków-Wieluń Upland, Małopolska Upland, Sandomierska Lowland (Gębicki *et al.* 2013, Walczak *et al.* 2014, 2016), and lately recorded also on the Baltic Coast (Stroiński *et al.* 2018).

DISCUSSION

The post-industrial dumping grounds are heavily degraded areas, where various types of waste materials are stored, after the mining industry or metallurgical treatment. They include waste rocks, shale, slag and ash. Until recently, waste heaps and other dumping grounds have occupied an area of 3204.4 ha of the former Katowice Province. Nearly 77.3% of them were minefields, and only 21.8% were found at the ironworks (Piontek 1980). The largest number of mining sites is located in the Rybnik Coal District and the Upper Silesian Industrial District (Chorzów, Bytom and Ruda Śląska). The largest heaps are located in Bytom, Tarnowskie Góry, Piekary Śląskie and Szopienice district in Katowice. The age of the oldest coal heaps does not exceed 250 years, and their formation is related to the development of coal mining. Their composition includes material in different states of fragmentation (Mazaraki 1956a, 1956b). Despite their degradation effect, most of the Upper Silesian heaps are covered by the specific phytocoenoses, that have grown as a result of deliberate reclamation or spontaneous succession. There are also some Europe-wide unique ecosystems (Rostański 2000).

Around the world a very few articles on the entomofauna of post-industrial dumping grounds were published. Well was studied the process of soil entomofauna growing on the reclaimed heaps of brown coal mines in the vicinity of Görlitz, Leipzig (Dunger 1968) and Kiel (Neumann 1971). In Germany also urban brownfields as general post-industrial areas were investigated in case of being a temporary habitats for phytophagous insects, and to know community structure and life strategies of leafhoppers during the process of natural succession (Biedermann 2002, Strauss & Biedermann 2006). In Poland, there has been only one article published so far, which is a comprehensive study of post-industrial dumping grounds in the area of Ruda Śląska and Mikołów (Simon & Szwedo 2005). Additionally, the fauna of the Barbara heap in Częstochowa was described in the monograph devoted to planthopper and leafhopper communities in Częstochowa (Walczak *et al*. 2014). Other groups of Hemiptera which were objectives of a study on wastelands were aphids in the area coal and zinc mines in Upper Silesia (Czylok *et al*. 1991) and scale insects on post-industrial dumping grounds in Ruda Śląska (Kalandyk-Kołodziejczyk *et al.* 2011).

The results of these studies indicate that the dumping grounds became attractive niches for living and development of many insects, including planthoppers and the latter are present there in a large number of species and specimens (Simon & Szwedo 2005, Walczak *et al.* 2014). Many of the species are often associated with xerothermic habitats, some are native to Asian or European Steppes, or to various Mediterranean environments, so they favour the specific and sometimes extreme physical and chemical conditions (Simon & Szwedo 2005). Researchers believe that due to the disappearance of some natural biotopes, many species of planthoppers and leafhoppers move to brownfields as dumps and other suitable habitats. Moreover urban areas tend to have a higher biodiversity than their agricultural surroundings. This might be due to high habitat diversity and a wide range of environmental conditions found in urban habitats (Rebele 1994, Strauss & Biedermann 2006) The existing case studies on leafhoppers clearly demonstrate the effects of area and isolation on distribution and density in fragmented habitats. A set of hypotheses is available to explain these static patterns. However, that kind of studies give only an idea of the importance of dynamic spatial processes. In particular, studies on the dynamics of the distribution (extinction and colonisation) in the habitat patches would be required in order to enhance our knowledge of spatial processes (e.g. turnover rates) at the regional scale (Biedermann 2002).

On dumping grounds in Mysłowice total of 79 planthopper and leafhopper species was recorded and represented by over 2913 specimens. It constitutes 14.58% of Polish cicadofauna. In other studies, conducted under similar conditions, with a similar number of research sites (from 5 to 7) by Ruda (1981), Gibas (2015) and Mielimonka (2015) were obtained similar results (2574 individuals and 77 species; 3338 and 84; and 907 and 50 respectively). Simon and Szwedo (2005) were able to capture as much as 110 different species, but they set up 16 sites. The number of specimens they collected was around 2900 but the overall specimen per site ratio was similar to the studies with fewer sites.

The highest number of species and specimens was recorded on plot 1: 36 species (within two undetermined specimens from Delphacidae and *Macropsis* and larvae) and 492 specimens. This site had the richest phytocenosis – a rare forest association with grassy undergrowth and numerous glades and clearings in the crown of trees, at an advanced stage of succession. Morning shade and afternoon insolation provided moderate humidity for the undergrowth and allowed proper development of many plants, which brought about a significant variety of planthopper species. This community was dominated by *Jassargus flori*, *Balclutha punctata* and *Neophilaenus lineatus*, often found on heavily overgrown meadows and the edges of forests (Chudzicka 1981, Walczak *et al.* 2014).

Plots 2, 3 and 4 were dominated by grasslands. The communities had from 25 to 31 species (200-436 specimens) – a little less than plot 1. Cluster analysis (Fig. 2), and PCA (Fig. 3) showed that in terms of species composition the most similar were communities on plots 2 and 3. The species common to both sites are the species with xerothermic preferences, feeding on *Festuca*, which have been mostly found in the grasslands of Częstochowa Jura (Świerczewski & Wojciechowski 2009) and Błędowska Desert (Jasińska 1980, Musik *et al.* 2018).

The hopper community on plot 5 stands out as the site with the least number of collected species (only 16) but the highest number of specimens – as much as 1562. The plot was set up close to a retention pond, which collects precipitation and ice melting water, with poor rush overgrowth which is very different from other plant communities on heaps. This affected the composition of species and number of specimen present on the site. The dominant species was *Stenocranus major* (1288 specimens, Fig. 4h) probably due to a lack of competition. An increase in its population was observed from the beginning of August. The species overwinters as imago and produces one generation per season (Gębicki *et al.* 2013). No adult specimens of the species were recorded during the spring, so it can be assumed that not many survive winter. Only a few larvae were collected, as they stay hidden close to the roots of plants (Nickel 2003) The host plant of *S. major* – *Phalaris arundinaceae* was not found on the study plot, which questions the idea of the monophagous character of this species. A similar community located around dumping grounds was previously studied by Simon and Szwedo (2005), who also found *S. major* as a dominant species with a similar share of higro- and mesohigrophilous species.

Dominant and subdominant species like: *Cicadella viridis*, *Neophilaenus lineatus*, *Neophilaenus minor*, *Balclutha calamagrostis*, *Balclutha punctata* and *Jassargus flori* most strongly affected the population dynamics of planthopper and leafhopper fauna on study plots (Tab. 3). Their populations were the most numerous at the mid- and late summer (Fig. 3). Those periods were in accordance with the ecology and the behaviour of those species, and confirm observations made from other regions of Poland (Chudzicka 1981, Klimaszewski *et al.* 1980a, 1980b, Gębicki 1983, Simon & Szwedo 2005, Walczak *et al.* 2014, 2016, Musik *et al.* 2018).

The study plots had a majority of species with a wide range of ecological tolerance (eurytopic) and mesohigrophilous, heliophilous and xerophilous species, which was the same fauna characteristic found previously in disturbed habitats by Denno and Roderick (1991). In total collected material monophagous species were most common (36.59%), oligophagous were a little less numerous (34.15%), with least numerous polyphagous species (24.39%). The number of species on each plot varied, however the monophagous constituted a significant group (Tab. 2).

According to Prestige (1982), unstable environments in the process of plant succession are characterized by the predominance of polyphagous species; whereas stable environments are characterized by a greater share of species with the stronger ties between them and a host plant than the habitat. The research conducted on planthoppers and leafhoppers inhabiting the waste heaps in Mysłowice did not prove this assumption. The high rate of monophagous species in the collected material may indicate that the waste heaps have the majority of species with stronger ties to the host plant that the habitat even though the heaps mostly should belong to disturbed habitats. This was confirmed by Simon and Szwedo (2005), who found on many plots in the area of Ruda Śląska and Mikołów predominance of monophagous species over other ecological groups of planthoppers. It is possible, that some species choose a host plant regardless of the environmental conditions and processes taking place in the ecosystem, this is why there is a large number of hoppers (including monophagous) found in urban areas (Walczak 2005, Walczak *et al.* 2014).

We could also conclude that due to the age of many Silesian heaps (Mazaraki 1956a, 1956b), they may be, at least in some cases, more stable habitats than commonly accepted. We should also underline, that in our climate zone, according to the research carried out on this group of insect in Germany, polyphagous hopper species represent only about 14%, while monophagous account for 38% of total cicadofauna (Nickel 2003). For this reason, the high rate of monophagous species on the waste heaps, significantly higher than polyphagous – should not be surprising. There are also findings of other studies which contradicts the above results, where on some dumping grounds in the Upper Silesia the prevalent species were oligophagous or even polyphagous rather than the monophagous (Ruda 1981, Gibas 2015 and Mielimonka 2015).

It is believed that the dominance of species hibernating in the egg stage indicates a balance in the environment, and the dominance of forms wintering in the stage of nymphs and imago suggest the disturbances in the environment (Waloff 1980, Hollier *et al*. 1994). In turn Brown and Southwood (1987) have shown in theire studdies that the dominance of species with more generations per year can indicate the early stages of the plant succession in the environment. In Mysłowice most species hibernate in the egg stage (62.20%), and the less in the imago stage (14.63%) (Table 2). There also on all sites predominated univoltine species, with the share of 52.44%. This may indicate that the research plots were established on heaps in habitats with a relatively stable character.

The study on communities living on post-mining dumping grounds in Mysłowice confirmed the results of the research conducted by Simon and Szwedo (2005), who reported that species diversity of a planthopper and leafhopper communities depends mostly on the richness of flora in the area, with indirect effect of the nature of the site, in particular its humidity and insolation. The reasons of high species diversity on waste heaps can also be the same as in large urban areas. It has been proven, that groups of herbivorous invertebrates living in cities are mostly composed of the trophic chains of the sucking phytophagous insects (Hemiptera), which replace insect with biting and chewing mouthparts, such as butterfly larvae, beetles and sawflies (Pisarski & Trojan 1976, Chudzicka 1979, 1990). The leaf blade keeps most of the impurities on its surface so that the concentration of toxic substances in the plant tissue is smaller. That's why sucking insects (planthoppers and other Hemiptera) and leaf miners (larvae of some butterflies) have a better tolerance for such conditions (Chudzicka 1990). Due to the lack of competition, the species living in the most heavily contaminated part of the habitat occur in high density, as confirmed by Pisarski and Trojan (1976), which indicates that in some sites Hemiptera species accounted for 88% of the overall insect fauna.

Research indicate that waste heaps are valuable biotopes for many species of hoppers. Many rare species make them their home, including: *Trigonocranus emmeae*, *Pentastiridius beieri*, *Macrosteles maculosus*, *Psammotettix dubius* or *P. poecilus* (Simon & Szwedo 2005, Walczak *et al*. 2014, Gibas 2015, Mielimonka 2015) and the same species were found on waste heaps in Mysłowice additionally there were recorded also species like *Delphacodes venosus*, *Paraliburnia adela*, *Macrosteles sardus*, *Allygus modestus*, *Metalimnus steini*, *Ebarrius cognatus* and *Arthaldeus arenarius*. We can assume that the waste heaps of Upper Silesia are a refuge area for a number of hopper species, with large groups of specimen, who create stable hopper populations.

The study explored communities living on 5 different sites and revealed that the insects form highly diversified communities. It contributes to raising the knowledge about the planthopper and leafhopper communities living on post-mining dumping grounds, by bringing a lot of new information, and confirming conclusions reached by the previous researchers. Primarily that due to mosaic character this kind of areas have higher biodiversity than agricultural surroundings, and they can create a suitable niche for species (Biedermann 2002, Strauss & Biedermann 2006). The results indicate the need to conduct further studies on communities of insects living in post-mining dumping grounds or other unexplored post-industrial environments.

SUMMARY AND CONCULUSIONS

– As a result of research conducted on post-mining dumping areas of Mysłowice 79 species were found, which constitutes 14.58% of the Polish fauna of planthoppers and leafhoppers (Gębicki *et al.* 2013).

– There were found representatives of 3 families within Cicadomorpha (1480 specimens) and 2 families within Fulgoromorpha (1319 specimens). The most numerous was the family Cicadellidae (54 species), and the most abundant was *Stenocranus major* from Delphacidae (1288 individuals).

– The richest in terms of the number of species was plot 1 (36 species), the least species were collected on plot 5 (16 species).

– In the studied material some rare species were found: *Paraliburnia adela*, *Macrosteles sardus*, *Allygus modestus*, *Metalimnus steini*, *Ebarrius cognatus* and *Arthaldeus arenarius*.

– The most abundant were: *Stenocranus major*, *Cicadella viridis*, *Jassargus flori*, *Balclutha calamagrostis*, *Balclutha punctata*, *Neophilaenus minor*, *Neophilaenus lineatus*, *Neophilaenus campestris*, *Kosswigianella exigua*, *Psammotettix confinis* and *Philaenus spumarius*. On the other hand some species were representet only by one single speciment: *Delphacodes venosus*, *Macrosteles sardus*, *Metalimnus steini*, *Psammotettix poecilus*, *Arthaldeus arenarius* and invasive *Stictocephala bisonia*.

– The degree of similarity of the discussed communities was based on a hierarchical tree performed using the Ward method, as well as on the analysis of the main components (PCA). The highest degree of similarity was observed between the communities on plot 2 and 3, while the community on the plot 5 differed the most. The analysis with the use of the species diversity indices (Shannon-Weaver *H'* and Brillouin $\hat{H}$) confirmed the previous results.

– All collected species were classified into 13 chorological elements. European and Transpalearctic species predominated in the material. The less share belong to Nearctic, South European, West European and round Mediterranean (all of them were represented only by one single specimen) (Tab. 2).

– In terms of the ecological analysis the biggest share belong to mesohelophilous, mosohigrophilous, monophagous, eurytopic species and to those with one generation per year and overwintering in the stage of egg (Tab. 2).

– No species belonging to the first class of constancy were found, second-class representatives appeared on four plots.

– Superdominant species were observed on 2 plots – plot 4 (*Balclutha calamagrostis*) and plot 5 (*Stenocranus major*). The greatest species diversity was noted on plot 1, overgrown by the mosaic of forest and meadow communities.

– The conclusions of Denno and Roderick (1991), who in disturbed environments observed the advantage of taxa with a broad ecological valence were confirmed. But the results of research on the Mysłowice heaps did not confirm the earlier conclusions of Prestidge (1982), Brown and Southwood (1987), Waloff (1980) and Hollier *et al.* (1994). According to them, in the disturbed and degraded environments predominate poliphagous species (Prestige 1982), which have many generations in season (Brown & Southwood 1987) and wintering in the nymph or imago stage (Waloff 1980, Hollier *et al.* 1994). Meanwhile, the Mysłowice heaps were dominated by monophagous species with one-generation per year and wintering in the egg stage. This may indicate that the research plots were established on heaps in habitats with a relatively stable character.

However, it should be noted, that the ecological groups the most numerous on the heaps in Mysłowice occur most often in the majority of biotopes in this part of Europe (Nickel 2003).

ACKNOWLEDGMENTS

The authors would like to thank our colleagues from the Institute of Biology, Biotechnology and Environmental Protection, Faculty of Natural Sciences, University of Silesia: PhD Agnieszka Nawrocka and PhD Wojciech Szczepański for their help in maintaining the statistical analyses. We also like to thank PhD Łukasz Depa for valuable comments and suggestions on the previous version of the manuscript, and PhD Łukasz Junkiert for photographs and figure.

REFERENCES

ACHTZIGER R., NICKEL H. 1997. Zikaden als Bioindikatoren für naturschutzfachliche Erfolgskontrollen im Feuchtgrünland. *Beiträge zur Zikadenkunde* 1: 3–16.

BIEDERMANN R. 2002. Leafhoppers (Homoptera, Auchenorrhyncha) in fragmented habitats. *Denisia 04*, *zugleich Kataloge des OÖ. Landesmuseums*, *Neue Folge* 176: 523–553.

BIEDERMANN R., NIEDRINGHAUS R. 2004. Die Zikaden Deutschlands. Bestimmungstafeln für alle Arten. Wissenschaftlich Akademischer Buchvertrieb-Fründ, Scheeßel: 409 pp.

BIEMAN C.F.M. den 1987. Host plant relations in the planthopper genus *Ribautodelphax* (Homoptera, Delphacidae). *Ecological Entomology* 12: 16–172.

BOOIJ C.J.H. 1981. Biosystematics of the *Muellerianella* complex (Homoptera, Delphacidae), taxonomy, morphology and distribution. *Netherlands Journal of Zoology* 31(3): 572–595.

BROWN V.K., SOUTHWOOD T.R.E. 1987. Secondary succession: patterns & strategies, In: GRAY A.J., CRAWLEY M.J., EDWARDS P.J. (Eds.), Colonization, successionand stability. Oxford: Blackwell Scientific Publications: 315–337.

BURAKOWSKI B., MROCZKOWSKI M., STEFAŃSKA J. 1973. Chrząszcze Coleoptera. Biegaczowate – Carabidae, cz. 1. *Katalog fauny Polski* 23(2): 1–232.

CHUDZICKA E. 1979. Wpływ struktury zieleni miejskiej na skład gatunkowy i liczebność fitofagów koron (na przykładzie *Tilia* sp.), In: Warunki rozwoju drzew i ich fauny w Warszawie. Materiały konferencji naukowo-technicznej z 28 stycznia 1978r. Wydawnictwo PAN, Wrocław-Warszawa- Kraków-Gdańsk: 74–83.

CHUDZICKA E. 1981. Piewiki (Auchenorrhyncha), In: Zoocenologiczne podstawy kształtowania środowiska przyrodniczego osiedla mieszkaniowego Białołęka Dworska w Warszawie. I. Skład gatunkowy i struktura fauny terenu projektowanego osiedla mieszkaniowego. *Fragmenta Faunistica* 11: 175–191.

CHUDZICKA E. 1990. Impact of the structure of urban green and of environment pollution on arthropods. *Fragmenta Faunistica* 34: 17–35.

CHUDZICKA E., SKIBIŃSKA E. 1998. Diversity of reactions of insect communities as a response to anthropogenic pressure. *Memorabilia zoologica* 51: 13–30.

CZECHOWSKI W., MIKOŁAJCZYK W. 1981. Methods for the study of urban fauna. *Memorabilia Zoologica* 34: 49–58.

CZYLOK A., GĄDEK B., TYC A. 2002. Przyroda Mysłowic. Przewodnik przyrodniczy po mieście Mysłowice. Mysłowice, Centrum Informacji Miejskiej: 135 pp.

CZYLOK A., GORCZYCA J., HAŁAJ R., KLIMASZEWSKI S.M., WOJCIECHOWSKI W. 1991. Fauna mszyc (Homoptera, Aphidoidea) zwałowisk odpadów węglowych i cynkowych województwa katowickiego. *Acta biologica silesiana* 18(35): 108–117.

DENNO R.F., RODERICK G.K. 1991. Influence of path, size, vegetation structure and host plant architecture on the diversity, abundance and life history styles of sap-feeding herbivores, In: BELL S.S., MCCOY E.D., MUSHINSKY H.R. (Eds.), Habitat Structure: the Physical Arrangement of object in Space. Chapmann et Hall, New York: 169–196.

DLABOLA J. 1965. Zoogeographische Arten-gliederung der Gattung *Fieberiella* SIGN. (Homoptera, Auchenorrhyncha). *Acta entomologica Bohemoslovaca* 62(6): 428–442.

DMITRIEV D.A. 1999 Obzor vidov roda *Rhopalopyx* RIBAUT, 1939 (Homoptera, Cicadellidae). *Entomologičeskoe Obozrenie* 78: 610–624.

DUNGER W. 1968. Die Entwicklung der Bodenfauna auf rekultivierten Kippen und Halden des Braun-Kohlentagebaus. Ein Beitrag zurpedozoologischen Standortsdiagnose. *Abhandlungen und Berichte des Naturkunde Museums Görlitz* 43(2): 1–256.

DWORAKOWSKA I. 1968a. Notes on the genus *Elymana* DELONG (Homoptera, Cicadellidae). *Bulletin de l'Académie Polonaise des Sciences. Serie des sciences biologiques* 16: 233–238.

DWORAKOWSKA I. 1968b. Materiały do znajomości krajowych gatunków z rodzaju *Doratura* J. SHLB. (Homoptera, Cicadellidae). *Annales Zoologici* 25: 381–401.

DWORAKOWSKA I. 1970a. On the genus *Zygina* FIEB. and *Hypericiella* sgen. n. (Auchenorrhyncha, Cicadellidae, Typhlocybinae). *Bulletin de l'Académie Polonaise des Sciences. Serie des sciences biologiques* 18: 559–567.

DWORAKOWSKA I. 1970b On the genus *Arboridia* ZACHV. (Auchenorrhyncha, Cicadellidae, Typhlocybinae). *Bulletin de l'Académie Polonaise des Sciences. Serie des sciences biologiques* 18: 607–615.

GAJEWSKI A. 1961. Krajowe gatunki z rodzaju *Macrosteles* FIEB. (Homoptera, Jassidae). *Fragmenta Faunistica* 9: 87–196.

GĘBICKI C. 1979. Charakterystyka zgrupowań piewików (Homoptera, Auchenorrhyncha) wybranych środowisk rejonu huty „Katowice". *Acta Biologica. Prace Naukowe Uniwersytetu Śląskiego* 7: 29–44.

GĘBICKI C. 1983. Zgrupowania piewików (Homoptera, Auchenorrhyncha) w borach i grądach okolic Pińczowa. *Acta Biologica. Prace Naukowe Uniwersytetu Śląskiego* 13: 83–97.

GĘBICKI C., GŁOWACKA E., KARWAŃSKA J., KLIMASZEWSKI S.M., WOJCIECHOWSKI W. 1977. Zgrupowania piewików, mszyc i koliszków (Homoptera: Auchenorrhyncha, Aphidodea i Psyllodea) wybranych środowisk rejonu huty „Katowice". *Acta Biologica. Prace Naukowe Uniwersytetu Śląskiego* 4: 95–122.

Gębicki C., Świerczewski D., Szwedo J. 2013. Planthoppers and Leafhoppers of Poland (Hemiptera: Fulgoromorpha et Cicadomorpha). Systematics, Check-list, Bionomy. The Monograph. *Annals of the Upper Silesian Museum, Entomology* 21–22: 1–245.

Gibas M. 2015. Cykadofauna wybranych zwałowisk województwa śląskiego. MSc thesis. Faculty of Biology and Environmental Protection, Silesian University, Katowice, manuscript.

Gilewska S. 1972. Wyżyny Śląsko-Małopolskie, In: Klimaszewski M. (Ed), Geomorfologia Polski, Tom I. Państwowe Wydawnictwo Naukowe, Warszawa: 232–339.

Gniezdilov V.M. 2000. On the Palearctic species of the genus *Forcipata* DeLong et Caldwell (Homoptera: Cicadellidae, Typhlocybinae). *Zoosystematica Rossica* 8: 283–286.

Hollier J.A., Brown V.K., Edward-Jones G. 1994. Successional leafhoppers assemblages: Pattern and process. *Ecological Research* 9: 185–191.

Holzinger W.E., Kammerlander I., Nickel H. 2003. The Auchenorrhyncha of Central Europe. Vol. 1: Fulgoromorpha, Cicadomorpha, excl. Cicadellidae. Brill, Leiden-Boston: 672 pp.

Jasińska J. 1980. Piewiki (Homoptera, Auchenorrhyncha) Pustyni Błędowskiej. *Acta Biologica*. *Prace Naukowe Uniwersytetu Śląskiego* 8: 40–49.

Junkiert Ł., Gorczyca J. 2019. Zgrupowania piewików (Hemiptera: Fulgoromorpha et Cicadomorpha) wybranych zbiorowisk roślinnych Parku Krajobrazowego Cysterskie Kompozycje Krajobrazowe Rud Wielkich. *Monographs of the Upper Silesian Museum in Bytom* 12: 1–xxx. [in press]

Kalandyk-Kołodziejczyk M., Simon E., Herczek A. 2011. Scale insects (Coccoidea, Hemiptera) of the postindustrial wastelands of Ruda Śląska (Poland), In: Indykiewicz P., Jerzak L., Böhner J., Kavanagh B. (Eds.), Urban fauna. *Studies of animal biology*, *ecology and conservation in European cities* 97–104.

Kasprzak K., Niedbała W. 1981. Wskaźniki biocenotyczne stosowane przy porządkowaniu i analizie danych w badaniach ilościowych, In: Górny M., Grüm L. (Eds.), Metody stosowane w zoologii gleby. Państwowe Wydawnictwo Naukowe Warszawa: 379–416.

Kimsa T. 1986. Problem powierzchni reprezentatywnej fitocenozy na przykładzie runa wybranych zbiorowisk leśnych Roztoczańskiego Parku Narodowego. *Prace Naukowe Uniwersytetu Śląskiego w Katowicach* 817: 1–74.

Klimaszewski S.M., Wojciechowski W., Gębicki C., Czylok A., Jasińska J., Głowacka E. 1980a. Zgrupowania owadów ssących (Homoptera i Heteroptera) zbiorowisk trawiastych i zielnych w rejonie huty „Katowice". *Acta Biologica*. *Prace Naukowe Uniwersytetu Śląskiego* 8: 9–21.

Klimaszewski S.M., Wojciechowski W., Czylok A., Gębicki C., Herczek A., Jasińska J. 1980b. Zgrupowania wybranych grup pluskwiaków równoskrzydłych (Homoptera) i różnoskrzydłych (Heteroptera) w lasach rejonu huty „Katowice". *Acta Biologica*. *Prace Naukowe Uniwersytetu Śląskiego* 8: 22–39.

Knight W.J. 1965. Techniques for use in the identification of leafhoppers (Homoptera: Cicadellidae). *Entomologist's Gazette* 16: 129–136.

Knight W.J. 1987. Leafhoppers of the grass-feeding genus *Balclutha* (Homoptera, Cicadellidae) in the Pacific region. *Journal of Natural History* 21: 1173–1224.

Kondracki J. 2002. Geografia regionalna Polski. Wydawnictwo Naukowe PWN. Warszawa: 441 pp.

Lauterer P., Malenovský I., Špryňar P. 2011. Invasion of the treehopper Stictocephala bisonia (Hemiptera: Cicadomorpha: Membracidae) in the Czech Republic: current distribution and first records from Bohemia. *Klapalekiana* 47: 67–73.

Le Quesne W.J. 1974. *Eupteryx origani* Zakhvatkin (Hem., Cicadellidae) new to Britain and related species. *Entomologist's Monthly Magazine* 109: 203–206.

Łuczak J., Wierzbowska T. 1981. Metody analizy zoocenologicznej, In: Górny M., Grüm L. (Eds), Metody stosowane w zoologii gleby. PWN, Warszawa: 417–436.

Mazaraki I. 1956a. Zwały powstałe z odpadów hut żelaza i wytyczne ich zagospodarowania, In: Szafer W. (Ed.), Komitet dla spraw Górnośląskiego Okręgu Przemysłowego, przy Prezydium PAN, *Komisja Biologicznego Zagospodarowania Nieużytków Poprzemysłowych* 1: 117–121.

Mazaraki I. 1956b. Nieużytki przylegające do zakładu Huty „Florian" w Świętochłowicach. Materiały dokumentacyjne do rozdziału VI, In: Szafer W. (Ed.), Komitet dla spraw Górnośląskiego Okręgu Przemysłowego, przy Prezydium PAN, *Komisja Biologicznego Zagospodarowania Nieużytków Poprzemysłowych* 1: 122–127.

Mielimonka K. 2015. Cykadofauna zwałowisk węglowych w powiecie rybnickim. MSc thesis. Faculty of Biology and Environmental Protection, Silesian University, Katowice, manuscript.

Mirek Z., Piękoś-Mirkowa H., Zając A., Zając M. 2002. Flowering plants and pteridophytes of Poland. A checklist. Krytyczna lista roślin naczyniowych Polski. Instytut Botaniki im. Szafera PAN, Kraków: 442 pp.

Musik K., Walczak M., Kalandyk-Kołodziejczyk M., Wojciechowski W. 2018. Planthopper and leafhopper communities (Hemiptera: Fulgoromorpha et Cicadomorpha) of selected plant associations of Garb Tarnogórski. *Monographs of the Upper Silesian Museum* 7: 1–244.

Nast J. 1972. Palaearctic Auchenorrhyncha (Homoptera). An annotated check list. Polish Scientific Publishers, Warszawa: 550 pp.

Nast J. 1976. Piewiki. Auchenorrhyncha (Cicadodea). *Katalog fauny Polski* 25 XXI(1). Państwowe Wydawnictwo Naukowe, Warszawa: 256 pp.

Nast J. 1987. The Auchenorrhyncha (Homoptera) of Europe. *Annales Zoologici* 40(15): 535–66.

Neumann U. 1971. Die Sukzession der Bodenfauna (Carabidae (Coleoptera), Diplopoda und Isopoda) in den forstlich rekultivierten Gebieten des Rheinischen Braunkohlenreviers. *Pedobiologia* 11: 193–226.

Nickel H. 2003. The Leafhoppers and Planthoppers of Germany (Hemiptera, Auchenorrhyncha): Patterns and strategies in a highly diverse group of phytophagous insects. Pensoft Publishers, Sofia-Moscow: 460 pp.

Nickel H., Hildebrandt J. 2003. Auchenorrhyncha communities as indicators of disturbance in grasslands (Insecta, Hemiptera) – a case study from the Elbe flood plains (northern Germany). *Agriculture*, *Ecosystems and Environment* 98: 183–199.

Nickel H., Remane R. 2002. Artenliste der Zikaden Deutschlands, mit Angabe von Nährpflanzen, Nahrungsbreite, Lebenszyklus, Areal und Gefährdung (Hemiptera, Fulgoromorpha et Cicadomorpha). *Beiträge zur Zikadenkunde* 5: 27–54.

Ossiannilsson F. 1978. The Auchenorrhyncha (Homoptera) of Fennoscandia and Denmark. *Fauna Entomologica Scandinavica* 7(1): 1–222.

Ossiannilsson F. 1981. The Auchenorrhyncha (Homoptera) of Fennoscandia and Denmark. *Fauna Entomologica Scandinavica* 7(2): 223–593.

Ossiannilsson F. 1983. The Auchenorrhyncha (Homoptera) of Fennoscandia and Denmark. *Fauna Entomologica Scandinavica* 7(3): 594–979.

Pawlikowski T. 1985. Zgrupowania dzikich pszczołowatych (Hymenoptera, Apoidea) na kserotermicznych siedliskach wydmowych Kotliny Toruńskiej. S*tudia Societatis Scientiarum Torunensis*, *Sectio E Zoologia* 10(4): 1–57.

Piontek F. 1980. Organizacja i funkcjonowanie procesów ochrony środowiska na szczeblu centralnym i regionalnym. Polska Akademia Nauk. Instytut Podstaw Inżynierii Środowiska. Zakład Narodowy im. Ossolińskich, Wrocław, 24: 1–122.

Pisarski B., Trojan P. 1976. Wpływ urbanizacji na entomofaunę, In: Sander H. (Ed.), Entomologia a ochrona środowiska. Wydawnictwo Naukowe PWN, Warszawa: 19–25.

Prestige R.A. 1982. Zagad Instar duration, adult consumption, oviposition and nitrogen utilization efficiencies of leafhoppers feeding on different quality food (Auchenorrhyncha: Homoptera). *Ecological Entomology* 7: 91–101.

Ramensky L. 1952 O niekotorych pryncypialnych polozeniach sowriemiennoj geobotaniki. *Botanicheskii Zhurnal* 37(2): 215–232.

Rebele F. 1994. Urban ecology and special features of urbanecosystems. *Global Ecology et Biogeography Letters* 4: 173–187.

Remane R. 1960. Zur Kenntnis der Gattung *Arthaldeus* Ribaut (Hom. Cicadina, Cicadellidae). *Mitteilungen der Müncher Entomologischen Gesellschaft* 50: 72–82.

Rostański A. 2000. Trawy spontanicznie zasiedlające nieużytki poprzemysłowe w aglomeracji katowickiej. *Łąkarstwo w Polsce* 3: 141–150.

Ruda B. 1981. Piewiki (Auchenorrhyncha) hałd okolic Bytomia. MSc thesis. Faculty of Biology and Environmental Protection, Silesian University, Katowice, manuscript.

Sanders D., Nickel H., Grützner T., Platner Ch. 2008. Habitat structure mediates top–down effects of spiders and ants on herbivores. *Basic and Applied Ecology* 9:152–160.

Seljak G. 2004. Contribution to the knowledge of planthoppers and leafhoppers of Slovenia (Hemiptera: Auchenorrhyncha). *Acta Entomologica Slovenica* 12(2): 189–216.

Simon E., Szwedo J. 2005. Zgrupowania piewików na hałdach kopalnianych Rudy Śląskiej i Mikołowa (Hemiptera: Fulgoromorpha et Cicadomorpha). *Acta entomologica silesiana* 12–13: 79–144.

Smreczyński S. 1954. Materiały do fauny pluskwiaków (Hemiptera) Polski. *Fragmenta Faunistica* 7: 1–146.

Söderman G., Gillerfors G., Endrestöl A. 2009. An annotated catalogue of the Auchenorrhyncha of Northern Europe (Insecta, Hemiptera: Fulgoromorpha et Cicadomorpha). *Cicadina* 10: 33–69.

Stewart A.J. 2002. Techniques for sampling Auchenorrhyncha in grasslands. *Denisia 4*(*N.F.*): 491–512.

Strauss B., Biedermann R. 2006. Urban brownfields as temporary habitats: driving forces for the diversity of phytophagous insects. *Ecography* 29: 928–940.

Stroiński A., Błaszczyk J., Świerczewski D. 2018. New records of planthoppers and leafhoppers from northern Poland (Hemiptera: Fulgoromorpha et Cicadomorpha). *Acta entomologica silesiana* 26: 45–56.

Szujecki A. 1998. Przegląd osiągnięć ekologii owadów lądowych w Polsce. *Wiadomości entomologiczne* 17: 79–136.

Świerczewski D. 2007. A food plant study of the Auchenorrhyncha of the Częstochowa upland, southern Poland (Insecta, Hemiptera). *Beiträge zur Zikadenkunde* 9: 15–22.

Świerczewski D., Stroiński A. 2011. The first record of the Nearctic treehopper *Stictocephala bisonia* in Poland (Hemiptera: Cicadomorpha: Membracidae) with some comments on this potential pest. *Polish Journal of Entomology* 80(1): 13–22.

Świerczewski D., Walczak M. 2011. New records of leafhopper for Poland (Hemiptera: Cicadomorpha). *Polish Journal of Entomology* 80(2): 291–298.

Świerczewski D., Wojciechowski W. 2009. Leafhopper communities of the sandy and limestone grasslands of the Częstochowa Upland (southern Poland). The Monograph. *Annals of the Upper Silesian Museum in Bytom*, *Natural History* 20: 1–152.

Taszakowska J. 1985. Piewiki (Homoptera: Auchenorrhyncha) zwałowisk okolic Rudy Śląskiej. MSc thesis. Faculty of Biology and Environmental Protection, Silesian University, Katowice, manuscript.

Tišečkin D.Ju. 1998. Akustičeskie signaly i morfologičeskie osobennosti cikadok gruppy *Aphrodes bicinctus* (Homoptera, Cicadellidae) iz evropejskoj časti Rossii. *Zoologičeskij Žurna* 77: 669–676.

Tokarska–Guzik B., Dajdok Z., Zając M., Zając M., Urbisz A., Danielewicz W., Hołdyński Cz. 2012. Rośliny obcego pochodzenia w Polsce ze szczególnym uwzględnieniem gatunków inwazyjnych. Generalna Dyrekcja Ochrony Środowiska, Warszawa: 196 pp.

Trojan P. 1992. Analiza struktury fauny. *Memorabilia Zoologica* 47: 1–120.

Walczak M. 2005. Piewiki (Hemiptera: Auchenorrhyncha) zieleni miejskiej Sosnowca. *Acta entomologica silesiana* 12–13: 145–154.

Walczak M. 2014. Rare planthopper species (Hemiptera, Fulgoromorpha) of the family Delphacidae (Leach, 1815) in the area of Częstochowa, In: Indykiewicz P., Böhner J. (Eds), Urban fauna. Animal, Man, and the City – Interactions and Relationships: 97–104.

Walczak M., Gębicki C., Wojciechowski W., Świerczewski D. 2016. The fauna of planthoppers and leafhoppers (Hemiptera: Fulgoromorpha et Cicadomorpha) in the city of Częstochowa (southern Poland). *Annals of the Upper Silesian Museum in Bytom*, *Entomology* 24–25: 1–193.

Walczak M., Wojciechowski W., Depa Ł. 2014. The communities of Planthoppers and Leafhoppers (Hemiptera: Fulgoromorpha et Cicadomorpha) inhabiting selected plant associations in Częstochowa city and its buffer zone. The Monograph. *Annals of the Upper Silesian Museum*, *Entomology* 23: 1–301.

Walczak M., Brożek J., Junkiert Ł., Kalandyk-Kołodziejczyk M., Musik K., Kaszyca N., Łazuka A., Gierlasiński G. 2018. *Stictocephala bisonia* Kopp et Yonke, 1977 (Hemiptera: Cicadomorpha, Membracidae) in Poland. *Annals of the Upper Silesian Museum in Bytom*, *Entomology* 27(online 010): 1–13.

Waloff N. 1980. Studies on grassland leafhoppres (Auchenorrhyncha: Homoptera) and their natural enemies. *Advances in Ecological Research* 11: 81–215.

Witkowski Z. 1970. Zagadnienia różnorodności gatunkowej w badaniach biocenotycznych. *Wiadomości ekologiczne* 16(2): 117–132.

Zimoń I. 1986. Zgrupowania zoocenotyczne piewików (Auchenorrhyncha) zbiorowisk inicjalnych na hałdach. MSc thesis. Faculty of Biology and Environmental Protection, Silesian University, Katowice, manuscript.

Fig. 1. The localization of Mysłowice (study plots) in Poland.

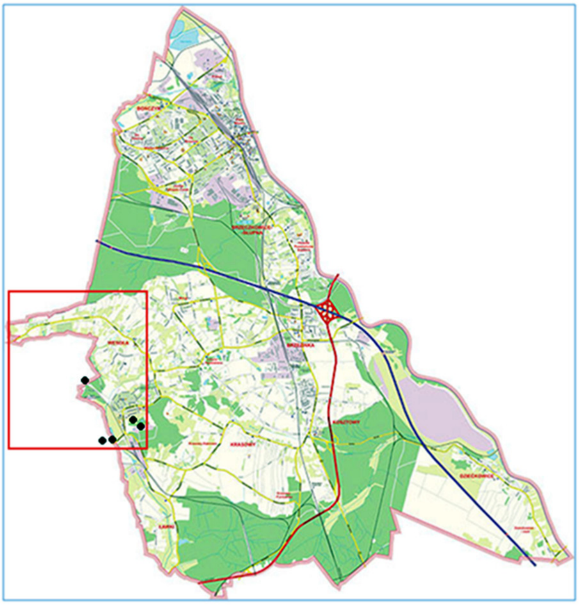

Fig. 2. The localization of study plots in Mysłowice.

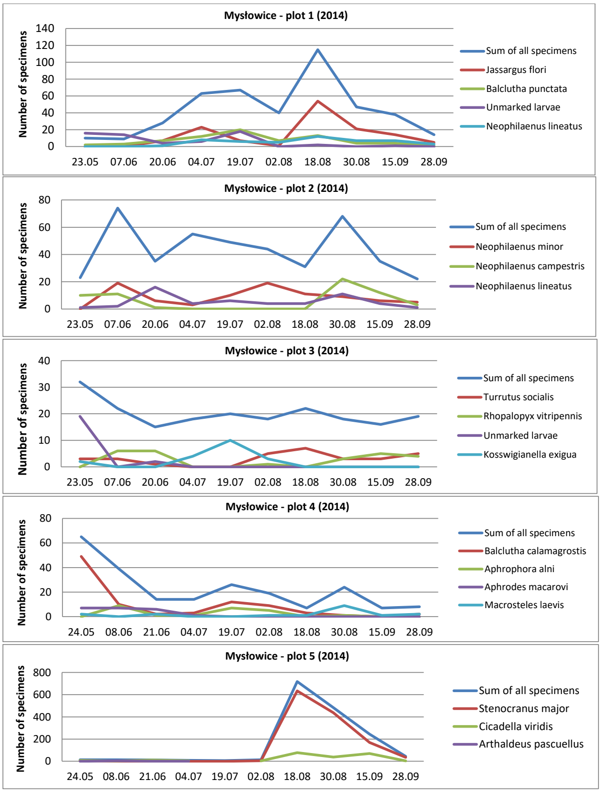

Fig. 3. The dominant species population dynamics charts.

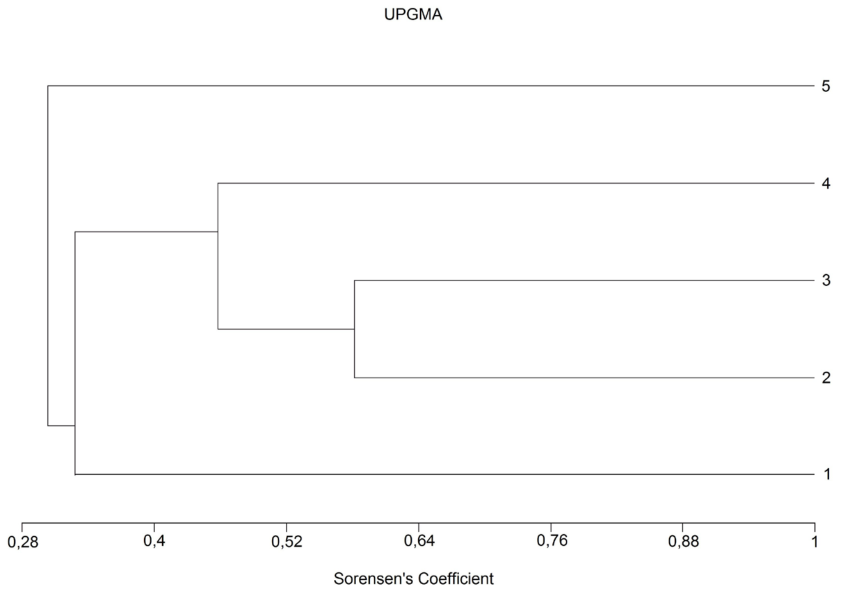

Fig. 4. Dendrogram of Euclidean distances of community similarities based on the calculation of the number of individuals of all species; Ward's method.

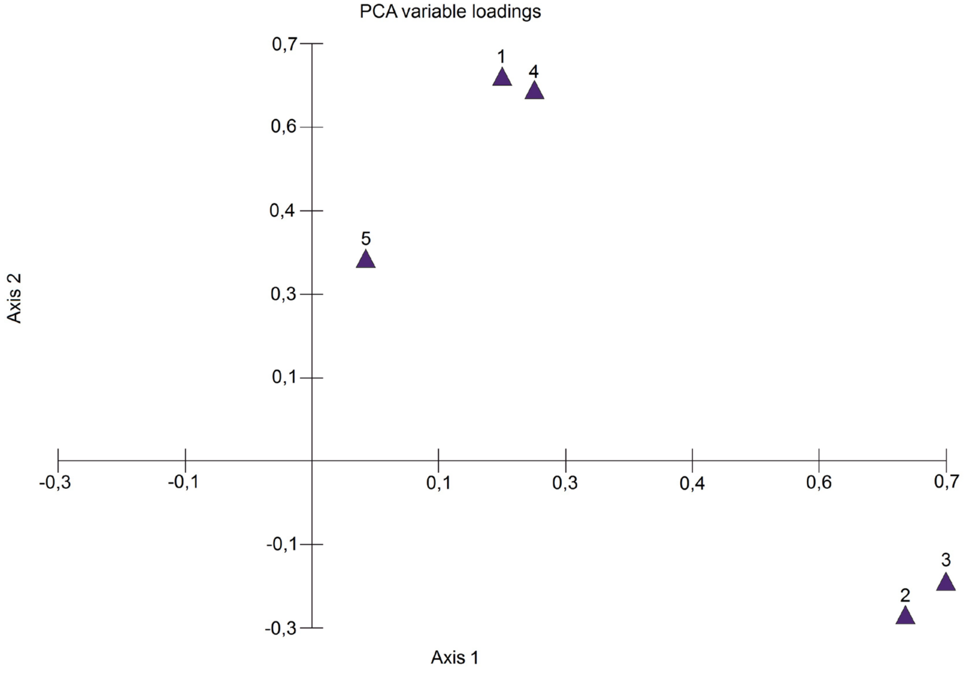

Fig. 5. Principal Components Analysis (PCA) based on the calculation of the number of individuals of all species.

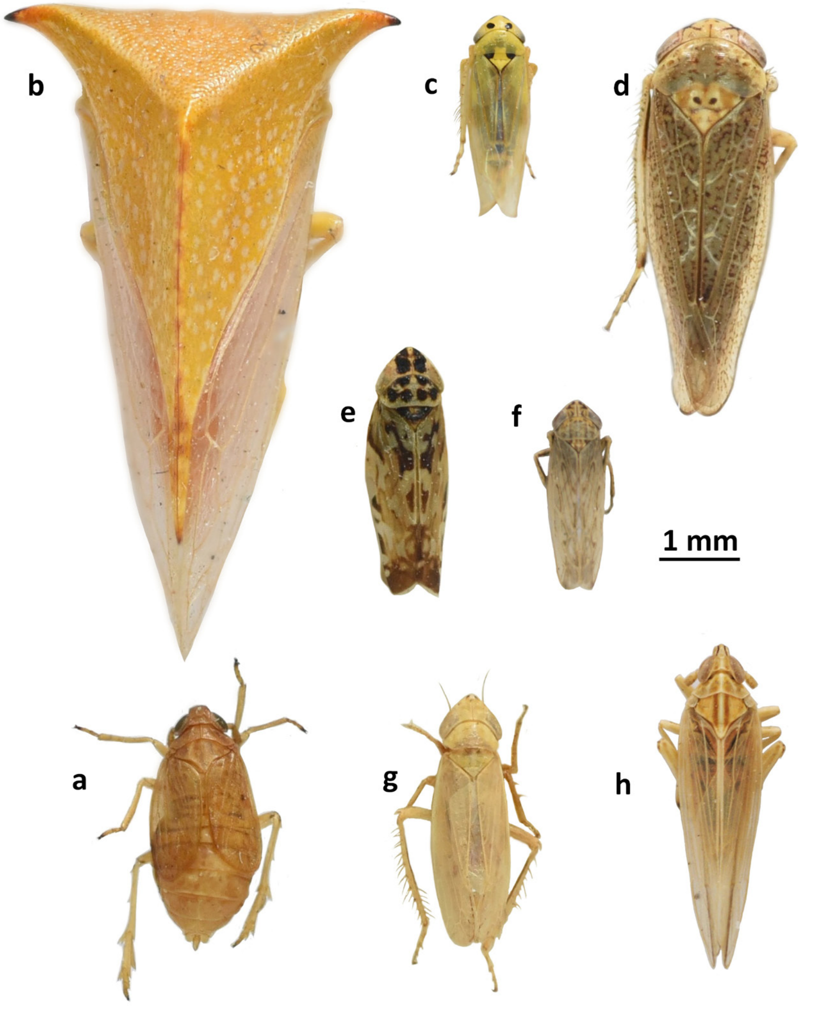

Fig. 6. Rare and interesting species of planthoppers and leafhoppers collected at selected post-mining dumping grounds in Southern Poland: **a** – *Paraliburnia adela* (Flor, 1861), **b** – *Stictocephala bisonia* Kopp et Yonke, 1977, **c** – *Macrosteles sardus* Ribaut, 1948, **d** – *Allygus modestus* Scott, 1876, **e** – *Metalimnus steini* (Fieber, 1869), **f** – *Ebarrius cognatus* (Fieber, 1869), **g** – *Arthaldeus arenarius* Remane, 1960, **h** – *Stenocranus major* (Kirschbaum, 1868).

Tab. 1. The values of the of Shannon-Weaver's *H'* and Brillouin's *Ĥ* species diversity indices in studied communities: Shannon-Weaver's *H'* and Brillouin's *Ĥ*.

Plot	*H'*	*Ĥ*	Number of specimens
1	2,453	2,324	36
2	2,289	2,193	25
3	2,794	2,545	31
4	2,15	1,959	30
5	0,603	0,589	16

Tab. 2. The share of particular ecological elements on research plots 1–5, and in the total collected material (N – sum of the element).

Ecological element	Plots										Total	
	1		2		3		4		5			
	N	%	N	%	N	%	N	%	N	%	N	%
HUMIDITY												
higrophilous	5	12,82	0	0.00	0	0.00	1	3.23	3	17.65	9	10.98
mesohigrophilous	30	76.92	17	65.38	20	62.50	23	74.19	13	76.47	50	60.98
xerophilous	1	2.56	9	34.62	11	34.38	6	19.35	0	0.00	20	24.39
unknown	3	7.69	1	3.85	1	3.13	1	3.23	1	5.88	3	3.66
INSOLATION												
heliophilous	3	7.69	13	50.00	17	53.13	12	38.71	2	11.76	30	36.59
mesoheliophilous	33	84.62	12	46.15	14	43.75	18	58.06	14	82.35	49	59.76
unknown	3	7.69	1	3.85	1	3.13	1	3.23	1	5.88	3	3.66
TROPHIC RELATIONS												
1st degree monophagous	5	12.82	6	23.08	7	21.88	5	16.13	3	17.65	26	66.67
2nd degree monophagous	6	15.38	5	19.23	3	9.38	3	9.68	4	23.53	21	54.85
monophagous in total	11	28.21	11	42.31	10	31.25	8	25.81	7	41.18	30	36.59
1st degree oligophagous	9	23.08	6	23.08	11	34.38	10	32.26	3	17.65	39	100
2nd degree oligophagous	2	5.13	1	3.85	2	6.25	1	3.23	0	0.00	6	15.38
oligophagous in total	11	28.21	7	26.92	13	40.63	11	35.48	3	17.65	20	24.39
polyphagous	14	35.90	7	26.92	8	25.00	10	32.26	6	35.29	20	24.39
unknown	3	7.69	1	3.85	1	3.13	2	6.45	1	5.88	4	4.88
OVERWINTERING												
egg	20	51.28	16	61.54	20	62.50	23	74.19	9	52.94	51	62.20
nymph	9	23.08	7	26.92	4	12.50	1	3.23	3	17.65	16	19.51
imago	7	17.95	2	7.69	5	15.63	6	19.35	4	23.53	12	14.63
unknown	3	7.69	1	3.85	1	3.13	1	3.23	1	5.88	3	3.66

Ecological element	Plots										Total	
	1		2		3		4		5			
	N	%	N	%	N	%	N	%	N	%	N	%
GENERATIONS PER YEAR												
univoltine	24	61.54	12	46.15	16	50.00	17	54.84	10	58.82	43	52.44
bivoltine	12	30.77	13	50.00	15	46.88	13	41.94	6	35.29	36	43.90
unknown	3	7.69	1	3.85	1	3.13	1	3.23	1	5.88	3	3.66
LIFE STRATEGY												
eurytopic	21	53.85	12	46.15	16	50.00	11	35.48	8	47.06	31	37.80
stenotopic	4	10.26	5	19.23	6	18.75	3	9.68	3	17.65	17	20.73
oligotopic	11	28.21	8	30.77	9	28.13	16	51.61	5	29.41	31	37.80
unknown	3	7.69	1	3.85	1	3.13	1	3.23	1	5.88	3	3.66

Tab. 3. The values of the of species diversity and evenness indices: dominance *D*, constancy of occurrence *C* and fidelity *W* (calculated for each plot and for the total collected material. The table includes also the number of specimens collected on each study plot (L), the total number of collected specimens (Total) and the percentage share of all species collected throughout the study.

Species	**Plots**																				**Total**	
	1				**2**				**3**				**4**				**5**					
	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	**=**	**%**
FULGOROMORPHA																						
Delphacide																						
Stenocranus fuscovittatus (Stål, 1858)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.45	12.5	100	7	7	0.25
Stenocranus major (Kirschbaum, 1868)	0.2	2.5	0.08	1	0.46	5	0.15	2	0.5	2.5	0.08	1	2.24	10	0.39	5	82.46	60	99.31	1288	1297	45.44
Stenocranus minutus (Fabricius, 1787)	0.2	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Eurysula lurida (Fieber, 1866)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	2.5	100	1	1	0.04
Laodelphax striatellus (Fallén, 1806)	0.2	2.5	20	1	0.46	5	40	2	1	5	40	2	-	-	-	-	-	-	-	-	5	0.18
Paraliburnia adela (Flor, 1861)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13	5	100	2	2	0.07
Hyledelphax elegantula (Boheman, 1847)	0.2	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Mirabella albifrons (Fieber, 1879)	0.81	10	100	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0.14
Delphacodes venosus (Germar, 1830)	-	-	-	-	-	-	-	-	-	-	-	-	0.45	2.5	100	1	-	-	-	-	1	0.04

Species	Plots																				Total	
	1				2				3				4				5					
	D%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	=	%
Muellerianella brevipennis (Boheman, 1847)	0.2	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Muellerianella fairmairei (Perris, 1857)	2.64	12.5	100	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	0.46
Acanthodelphax spinosa (Fieber, 1866)	-	-	-	-	0.23	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Dicranotropis hamata (Boheman, 1847)	1.83	12.5	90	9	0.23	2.5	10	1	-	-	-	-	-	-	-	-	-	-	-	-	10	0.35
Kosswigianella exigua (Boheman, 1847)	-	-	-	-	9.4	15	68	41	9.5	25	32	19	-	-	-	-	-	-	-	-	60	2.10
Xanthodelphax straminea (Stål, 1858)	0.2	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Javesella dubia (Kirschbaum, 1868)	5.89	25	100	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	1.02
Javesella pellucida (Fabricius, 1794)	1.42	12.5	41	7	0.23	2.5	6	1	0.5	2.5	6	1	0.45	2.5	6	1	0.45	12.5	41	7	17	0.60
Ribautodelphax albostriata (Fieber, 1866)	-	-	-	-	0.23	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
female Delphacidae sp.	0.2	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Tettrigometridae																						
Tettigometra impressopunctata Dufour, 1846	-	-	-		-	-	-		1.5	7.5	100	3	-	-	-		-	-	-		3	0.11

Species	Plots																				Total	
	1				2				3				4				5					
	D%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	=	%
CICADOMORPHA																						
Aphrophoridae																						
Aphrophora alni (Fallén, 1805)	1.83	20	24	9	0.23	2.5	3	1	1.5	7.5	8	3	10.76	20	63	24	0.06	2.5	3	1	38	1.33
Philaenus spumarius (Linnaeus, 1758)	5.49	37.5	51	27	4.82	22.5	40	1	0.5	2.5	2	1	0.45	2.5	2	1	0.19	7.5	6	3	33	1.16
Neophilaenus campestris (Fallén, 1805)	-	-	-	-	13.53	42.5	88	59	3	10	9	6	0.9	2.5	3	2	-	-	-	-	67	2.35
Neophilaenus lineatus (Linnaeus, 1758)	9.96	50	45	49	12.16	55	49	53	1.5	7.5	3	3	1.35	7.5	3	2	-	-	-	-	107	3.75
Neophilaenus minor (Kirschbaum, 1868)	-	-	-	-	20.18	60	92	88	4	5	8	8	-	-	-	-	-	-	-	-	96	3.36
Lepyronia coleoptrata (Linnaeus, 1758)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	2.5	100	1	1	0.04
Membracidae																						
Stictocephala bisonia Kopp et Yonke, 1977	-	-	-	-	-	-	-	-	-	-	-	-	0.45	2.5	100	1	-	-	-	-	1	0.04
Cicadellidae																						
Macropsis sp.	0.41	5	100	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.07
Megophthalmus scanicus (Fallén,1806)	0.2	2.5	33	1	-	-	-	-	0.5	2.5	33	1	0.45	2.5	33	1	-	-	-	-	3	0.11
Anaceratagalia ribauti (Ossiannilsson, 1938)	-	-	-	-	0.92	10	22	4	6	25	67	-	0.9	5	11	2	-	-	-	-	6	0.21

Species	Plots																				Total	
	1				2				3				4				5					
	D%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	=	%
Tremulicerus tremulae (Estlund, 1796)	0.2	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Cicadella viridis (Linnaeus, 1758)	0.2	2.5	0.4	1	0.69	7.5	1.3	3	-	-	-	-	4.93	12.5	5	11	14.02	67.5	94	219	234	8.20
Forcipata forcipata (Flor, 1861)	0.2	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Zygina hyperici (Herrich-Schäffer, 1836)	-	-	-	-	0.23	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Empoasca pteridis (Dahlbom, 1850)	-	-	-	-	-	-	-	-	0.5	2.5	20	1	1.35	7.5	60	3	0.06	2.5	20	1	5	0.18
Empoasca vitis (Göethe, 1875)	1.02	2.5	100	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	0.18
Chlorita paolii (Ossiannilsson, 1939)	-	-	-	-	-	-	-	-	-	-	-	-	0.9	5	100	2	-	-	-	-	2	0.07
Eupteryx vittata (Linnaeus, 1758)	0.2	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Aphrodes bicincta (Schrank, 1776)	0.41	5	67	2	-	-	-	-	0.5	2.5	33	1	-	-	-	-	-	-	-	-	3	0.11
Aphrodes makarovi Zachvatkin, 1948	0.41	2.5	9	2	-	-	-	-	-	-	-	-	9.42	17.5	91	21	-	-	-	-	2	0.07
Anoscopus albifrons (Linnaeus, 1758)	0.2	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Fieberiella septentrionalis Wagner, 1963	-	-	-	-	-	-	-	-	-	-	-	-	0.45	2.5	100	1	-	-	-	-	1	0.04

Species	Plots																				Total	
	1				2				3				4				5					
	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	**=**	**%**
Neoaliturus fenestratus (Herrich-Schaffer, 1834)	-	-	-	-	-	-	-	-	-	-	-	-	2.24	12.5	100	5	-	-	-	-	5	0.18
Balclutha calamagrostis Ossiannilsson, 1961	2.64	17.5	12	13	-	-	-	-	3	12.5	5	6	40.81	52.5	81	91	0.13	5	2	2	112	3.92
Balclutha punctata (Fabricius, 1775)	14.84	65	99	73	-	-	-	-	-	-	-	-	-	-	-	-	0.6	2.5	1	1	74	2.59
Macrosteles laevis Ribaut, 1927	-	-	-	-	2.06	17.5	26	9	4	12.5	23	8	8.07	20	51	18	-	-	-	-	35	1.23
Macrosteles maculosus (Then, 1897)	-	-	-	-	-	-	-	-	-	-	-	-	2.69	5	100	6	-	-	-	-	6	0.21
Macrosteles sardus Ribaut, 1948	-	-	-	-	-	-	-	-	-	-	-	-	0.45	2.5	100	1	-	-	-	-	1	0.04
Allygus mixtus (Fabricius, 1794)	0.41	5	100	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.07
Allygus modestus Scott, 1876	0.61	5	100	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0.11
Allygidius commutatus (Fieber, 1872)	0.2	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Rhytistylus proceps (Kirchbaum, 1868)	-	-	-	-	7.57	32.5	75	33	5.5	15	25	11	-	-	-	-	-	-	-	-	44	1.54
Speudotettix subfusculus (Fallén, 1806)	1.22	10	100	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	0.21

Species	Plots																				Total	
	1				2				3				4				5					
	D%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	=	%
Hesium domino (Reuter, 1880)	0.41	5	100	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.07
Thamnotettix confinis Zetterstedt, 1828	0.61	7.5	100	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0.11
Athysanus argentarius Metcalf, 1955	-	-	-	-	-	-	-	-	-	-	-	-	0.45	2.5	50	1	0.6	2.5	50	1	2	0.07
Euscelis distinguendus (Kirschbaum, 1858)	-	-	-	-	-	-	-	-	-	-	-	-	0.9	5	100	2	-	-	-	-	2	0.07
Euscelis incisus (Kirschbaum, 1858)	-	-	-	-	-	-	-	-	1	5	100	2	-	-	-	-	-	-	-	-	2	0.07
Cicadula quadrinotata (Fabricius, 1794)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.26	10	100	4	4	0.14
Rhopalopyx vitripennis (Flor, 1861)	-	-	-	-	8.72	32.5	60	38	12.5	40	40	25	-	-	-	-	-	-	-	-	63	2.21
Mocydia crocea (Herrich-Schäffer, 1837)	1.02	12.5	71	5	-	-	-	-	0.5	2.5	14	1	0.45	2.5	14	1	-	-	-	-	7	0.25
Mocydiopsis attenuata (Germar, 1821)	3.05	17.5	100	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	0.35
Eupelix cuspidata (Fabricius, 1775)	-	-	-	-	0.23	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Doratura stylata (Boheman, 1847)	-	-	-	-	2.29	17.5	83	10	1	5	17	2	-	-	-	-	-	-	-	-	12	0.42

Species	Plots																				Total	
	1				2				3				4				5					
	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	***D*%**	***C*%**	***W*%**	**L**	**=**	**%**
Deltocephalus pulicaris (Fallén, 1806)	0.2	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Metalimnus steini (Fieber, 1869)	-	-	-	-	-	-	-	-	0.5	2.5	100	1	-	-	-	-	-	-	-	-	1	0.04
Arocephalus languidus (Flor, 1861)	-	-	-	-	-	-	-	-	0.5	2.5	100	1	-	-	-	-	-	-	-	-	1	0.04
Arocephalus longiceps (Kirschbaum, 1868)	-	-	-	-	-	-	-	-	-	-	-	-	0.45	2.5	100	1	-	-	-	-	1	0.04
Arocephalus punctum (Flor, 1861)	-	-	-	-	0.23	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Psammotettix alienus (Dahlbom, 1850)	-	-	-	-	-	-	-	-	1	5	100	2	-	-	-	-	-	-	-	-	2	0.07
Psammotettix confinis (Dahlbom, 1850)	-	-	-	-	9.86	40	77	43	5.5	22.5	20	11	0.9	2.5	4	2	-	-	-	-	56	1.96
Psammotettix poecilus (Flor, 1861)	-	-	-	-	-	-	-	-	-	-	-	-	0.45	2.5	100	1	-	-	-	-	1	0.04
Ebarrius cognatus (Fieber, 1869)	-	-	-	-	-	-	-	-	2	5	100	4	-	-	-	-	-	-	-	-	4	0.14
Errastunus ocellaris (Fallén, 1806)	0.81	10	33	4	-	-	-	-	1	5	17	2	2.69	10	50	6	-	-	-	-	12	0.42
Turrutus socialis (Flor, 1861)	-	-	-	-	0.23	2.5	3	1	15	40	97	30	-	-	-	-	-	-	-	-	31	1.09
Jassargus pseudocellaris (Flor, 1861)	-	-	-	-	-	-	-	-	0.5	2.5	100	1	-	-	-	-	-	-	-	-	1	0.04

Species	Plots																				Total	
	1				2				3				4				5					
	D%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	*D*%	*C*%	*W*%	L	=	%
Jassargus flori (Fieber, 1869)	26.83	60	97	132	0.23	2.5	0.7	1	0.5	2.5	0.7	1	0.9	5	1.4	2	-	-	-	-	136	4.77
Verdanus abdominalis (Fabricius, 1803)	-	-	-	-	0.23	2.5	100	1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
Arthaldeus arenarius Remane, 1960	-	-	-	-	-	-	-	-	-	-	-	-	0.9	5	100	2	-	-	-	-	2	0.07
Arthaldeus pascuellus (Fallén, 1826)	-	-	-	-	-	-	-	-	4.5	10	43	9	0.45	2.5	4.8	1	0.7	22.5	52.4	11	21	0.74
Erzaleus metrius (Flor, 1861)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	7.5	100	4	4	0.14
larvae	12.40	42.5	54	61	4.36	20	17	19	10.5	10	18.4	21	1.79	12.5	3.5	4	0.58	17.5	7.9	9	114	3.99

Accepted: 26 November 2019; published: 5 December 2019