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Landscape type and species richness and composition of Arthropoda
Part I. Agricultural landscape

Elżbieta Cichocka, Magdalena Lubiarz

Department of Nature Preservation, The John Paul II Catholic University of Lublin
Konstantynów 1H, 20-708 Lublin, Poland

Abstract

The study contains a review of indirect factors affecting the number of Arthropod species, as well as the abundance and bionomy of the particular species in the agricultural environment, mainly taking true bugs (Hemiptera) as an example. Among such indirect factors influencing the Arthropods there should be counted a widely understood human activity and the environmental pollution it entails, soil cultivation and application of plant protecting chemicals and fertilizers, establishment of monocultures, forest clearing and introduction of alien species. The influence exercised by all these factors is not homogenous, and the consequences of human activity in the sphere of natural environment are difficult to predict.

The man-made agricultural landscape undergoes constant modifications, sometimes very significant ones (e.g. major cultivations, destruction of balks and mid-field clumps of trees, lack of crop rotation) which entail a serious restructuring of the species composition of Arthropods present in a given habitat. What will the agricultural landscape look like in the future if in many places it already has a degraded character at present?

Introduction

The following study provides a review of factors influencing the number of Arthropod species, as well as species abundance and bionomy of particular species during the vegetation season, taking Hemiptera and some other Arthropods as an example. Changes taking place in the occurrence of Arthropods have been associated with alterations taking place in various types of anthropogenic landscapes.

The landscape studies are subject to a terminological mayhem, especially as far as landscape classification is concerned. The synthetic nature of landscape makes it a subject of interest to many fields of research. While attempting to establish a landscape typology, various researchers point out various features, which from their point of view are the most relevant ones. For this reason there can be encountered varying, but still appropriate, typologies and classifications of landscape (PLIT, 2007).

In the present study the following types of anthropogenic landscape have been differentiated:

- agricultural landscape,
- city landscape,
- devastated landscape.

The biodiversity of various landscape types is shaping itself in various ways. It has been proved that the more serious the landscape distortions are and the more pressure is exercised over plants present in the landscape, the lower is the species diversity of Arthropods inhabiting the plants in question (CHUDZICKA, 1979; CZECHOWSKA *et al.*, 1979; RYCHLIK, 1979; CICHOCKA *et al.*, 1990; KROPCZYŃSKA-LINKIEWICZ *et al.*, 1990; CICHOCKA & GOSZCZYŃSKI, 1991; CICHOCKA *et al.*, 1998).

The species composition and abundance of Arthropods depends on a number of direct and indirect factors. The direct factors include climate conditions and the activity of natural enemies (predators and parasitoids), as well as parasitic fungi. As far as the influence of weather in vegetation season is concerned with reference to the limitation of phytophage abundance, many observations have been made and there are a number of publications on the subject, so this topic is not going to be the focus of the present discussion.

Among the factors indirectly influencing Arthropods there ought to be counted a widely understood human activity and the environmental pollution it entails, soil cultivation, application of artificial fertilizers and pesticides, monoculture implementation, forest clearing, transfer of alien species into new areas or disappearance of some plant communities as a result of human activity. The influence of indirect factors is more complicated and less known. It quite frequently takes place through changes evoked in host plants by human activity which alters natural environment (air, soil and water pollution, chemistrization of agriculture). Thus, the influence of such factors is most strikingly visible in various types of anthropogenic landscape: agricultural landscape, city landscape or devastated landscape. It is so, since an anthropogenic environment creates new living conditions for Arthropods.

It ought to be remembered that the state of a plant depends on the abundance of phytophags, and the phytophags, especially ones of the stinging-sucking kind, affect the physiology and the content of many ingredients in the plant's tissues (GOSZCZYŃSKI & CICHOCKA, 1997). Whether the results of phytophags feeding on plants and shrubs are of permanent character and to what extent, we do not know exactly. According to CIEPIELA (1995), during the contact of an Arthropod with a plant there takes place a mutual interaction affecting the metabolism of both organisms. Many changes are activated in plant tissues and there can be observed an increase in the biosynthesis of aromatic compounds. This increase is accompanied by an increased activity of PAL (phenylalanine ammonia-lyase) and TAL (tyrosine-ammonia-lyase). Furthermore, in the inhabited plant tissues there takes place a concentration of phenylopropene acids which have an antibiotic effect on the feeding Arthropods. Apart from that, the intensification of oxidation processes in a plant may lead to an increased degradation of substances indispensable for the proper growth and development of an insect. Moreover, it frequently happens that the increase of enzyme activity in a plant caused by the pest feeding on it is a result of enzymatic protein synthesis that causes an additional rise in the level of secondary metabolites, which were absent or occurred in a low concentration before the Arthropod began to feed on the plant. Thus, the activation of metabolic processes in the tissues of inhabited plants decreases their nutritional value. In the saliva of aphids there has been observed the presence of enzymes that cause changes in plant metabolism and are also used by aphids to imbibe nourishment (URBAŃSKA & NIRAZ, 1984). In all probability these enzymes facilitate the penetration of stilettos into plant tissues and damage the tissues. Together with their saliva aphids inject in the plant also toxins, hormones and viruses. According to KIEŁKIEWICZ *et al.* (2010), the feeding of stinging-sucking Arthropods activates diversified signal routes which results in the biosynthesis of regulatory compounds (salicylic acid, jasmonic acid, abscisic acid, etylene, auxins), overproduction of reactive oxygen forms and nitrogen oxide, and an increased activity of many enzymatic proteins associated with the biosynthesis of secondary metabolites and pathogenesis-related (PR) proteins. Whether the results of phytophags feeding on trees and shrubs have a permanent effect and to what extent we do not exactly know. Neither do we know what is the reaction of other stinging-sucking Arthropods to these plants as a source of their nutrition. Does it affect their demographic parameters? Environmental pollution has a bad effect on the flora, which reacts to it also with changes in its chemical composition, which further affects the invertebrates feeding on the plants. The results of such influences are difficult to predict.

In the agricultural landscape, city landscape or devastated landscape, the natural environment, and via the environment also the herbivorous Arthropoda, are also influenced by global warming. An important factor influencing changes in the species composition of plants and animals is also the transfer of alien species.

Global warming

According to forecasts, until the year 2100 the temperature may rise by 1.8 – 4°C. The present climate system has to tolerate changes amounting to 1 – 2°C (Dobrzańska *et al.*, 2008). The rise of temperature is a determining factor for the bionomy of a majority of species and certainly even now it is possible to observe some significant changes.

Global warming is responsible for the appearance in Europe of species originating from a warmer climate. Horse chestnut leaf miner (*Cameraria ohridella*) came into Europe probably from Turkey and presently has reached Sweden, destroying (mining) mainly the foliage of white horse chestnut. There have also been observed individual appearances of other leaf miner species (on a caragana and a linden). However, it is worth considering whether this was due to a global warming or rather to the occurrence of several warm years in a row. As for the 2009/2010 winter, it rather did not explicitly indicate the global warming.

Many native arthropod species can give a larger number of generations or increase the fertility of females. Global warming may also cause a development or a disappearance of the currently common species, or an appearance of entirely new species and breeds of harmful phytophags (Lipa, 1998). Therefore, it seems important to monitor the presence and abundance of herbivores in various environments all over the country. In Poland, a complex system of monitoring biological diversity has not been implemented yet, although for a number of years there have been attempts at developing it (Olszak, 1998; Skibińska & Chudzicka, 2000).

For instance, climate changes are responsible for enriching the species composition of aphids in Poland (Szelegiewicz, 1978A; Harrington, 2002; Ruszkowska, 2002). Polymorphism, migrations and parthenogenesis, as well as the possibility of developing anholocyclic forms (without the sexual cycle in their development) are rare phenomena in aphids. They make them capable of adaptation, rapid multiplication and survival in the face of a threat (Ruszkowska, 2002). Climate and nourishment are among the most important factors in natural environment which condition the life cycles of aphids (Ruszkowska, 2009). As a result of a definite climate warming in Poland there have developed anholocyclic forms of some aphid species. Having for many years conducted studies on grain aphids in Greater Poland, RUSZKOWSKA (1987, 1988, 2002) concluds that there have taken place significant changes in the life cycle of *Rhopalosiphum padi*. They refer to the change in the times of mass occurrence, the way of plant colonization, proportions in the appearance of sexual morphs, and the inhabiting of winter crop in the autumn. Another factor alongside the rise of temperature which limits the genetic diversity of this aphid species is its inability to complete the holocyclic development because of the limited occurrence of males in their population. According to RUSZKOWSKA'S (2009) study, the warming of climate is responsible for the prolonged period of giving birth by gynoparae in the autumn, under dry conditions, when the leaves fall earlier together with oviparae, and thus still more unfertilized eggs of the aphids species in question remain on the primary host. The warming of climate also prolongs the period of egg laying by oviparae in many aphid species.

In Alaska, bark beetles attacking spruces used to have one generation per year and their numbers did not threaten the numerous spruce trees growing in the area. At present, as is supposed by researchers, the warming of climate allows for the development of two generations of bark beetles in the spruce trunks and their enormous abundance causes mass dying of these trees (http://archive.greenpeace.org/climate/arctic99/reports/forests.html).

Xerothermic grasslands, endangered by human activity, are becoming impoverished floristically, which means that the species inhabiting this type of habitat are also endangered. According to OSIADACZ (2009), who has analyzed the Polish aphidofauna characteristic of xerothermic habitats, the valuable, rare and even endangered Polish species include 16 species of the genus *Aphis*, 2 species of the genus *Brachycaudus* and 2 species of the genus *Uroleucon*. The species mentioned by the author are monoecious and mostly monophagous. Inhabiting exclusively dry habitats is their common feature; they are characteristic only of xerothermic grasslands. This type of habitat is endangered both in Poland and in Europe. Apart from the presence of their favoured host plant for these aphids also such factors are important as the ground acidity and its structure (the soil has to be compact). Some species (e.g. *Brachycaudus divaricate*), which had earlier been recorded in warmer climate (Turkmenia, Turkey, Iran, Crimea), were recorded in Poland in 2003 and a year later also in Lithuania (RAKAUSKAS & CICHOCKA, 2005). It is difficult to specify how they reached this part of Europe. Many aphid species are going to spend mild winters in the form of apterous viviparae. Such a situation has been observed by GOSZCZYŃSKI in 2009 on chives in a field (unpublished data). The observed individuals represented the genus *Myzus*, and were able to survive temperatures as low as -6^{o}C. CICHOCKA & JAŚKIEWICZ (2003), as well as LUBIARZ (unpublished data) have discovered that the period of laying eggs by aphids can be prolonged even until the first days of December. DURAK (2009) discovered that the period of appearance of *Cinara juniperi* on host plants could be prolonged even until the end of December. The number of species of some Arthropods (e.g. aphids) is associated with their long phylogenetic development (280 millions of years), which gave them time to develop various forms facilitating an adaptation to the environment (DIXON, 1998). According to KARG & BAŁAZY (2009) the climate warming (milder winters, dry and warm summers) is responsible for the fact that in grain crops the general insect biomass is increasing, and there is also an increase in the average body weight of insects, while at the same time the species diversity is decreasing. The biomass increase is due to the increase in the share of thermophilous species, including the invasive ones characterized by a large body weight.

Transfer of alien species

„A BOOK OF ALIEN INVASISVE SPECIES IN POLISH FAUNA" („KSIĘGA GATUNKÓW OBCYCH INWAZYJNYCH W FAUNIE POLSKI," 2008) provides the following definition of an alien species: it is a species or a lower taxon introduced (transferred) intentionally or accidentally by man beyond the range where it occurs or used to occur in the past, including parts, gametes, seeds or eggs, thank to which it may live and multiply. An alien invasive species is one which poses a threat to the local biological diversity and/or human economic activity if introduced intentionally or accidentally.

All living organisms (both plants and animals) under new environmental conditions affect the biodiversity and may cause much confusion in a new environment (NAWROT, 2009). Well known examples include raccoons, American minks, the fish called round goby, horse chestnut leaf miners, western flower thrips and tobacco whiteflies. According to GENOVESI & SCALERA (2007), insects constitute 28% of species accidentally introduced in Europe.

Harmonia axyridis, an Asian species of lady beetle, was recorded in Poland for the first time in 2006 (PRZEWOŹNY *et al.*, 2007). Its appearance in Europe is due to carefree behaviour of man, as this species of lady beetle has been often intentionally introduced beyond its natural range of occurrence, so that it would contribute to diminishing the aphid population. At present it can be encountered in considerably large numbers in many regions of Poland, where it contributes to diminishing the number of native lady beetle species (http://www.cbe-pan.pl/harmonia/inwazja.htm).

The insect species accidentally introduced with plants anywhere in the world may become acclimatized in some country and develop large populations. The production of decorative plants in Africa and their sale to Europe is conducive to such occurrences. Many decorative plants are produced also in other parts of the world and then sold in European markets. In spite of phytosanitary controls many arthropod species have been accidentally introduced. Among these there can be listed the tobacco whitefly *Bemisia tabaci* and western flower thrips *Frankliniella occidentalis*. In the Netherlands there have accidentally been introduced 4 species of scale insects of the genus *Pulvinaria* (JANSEN, 1996), which settled on trees and decorative shrubs. Among the alien species accidentally introduced in Poland there is the Colorado potato beetle (*Leptinotarsa decemlineata*), and lately introduced corn rootworm (*Diobrotica virgifera*). OLBRECHTOVA (2007) recorded in Czech Republic the presence of the aphid *Cinara curvipes*, a species accidentally brought from America. It can be encountered in the USA, Canada and Mexico, where it inhabits the species of the genus *Abies*. In Czech Republic it has been found in city parks and gardens, where it inhabits branches and trunks of *Abies concolor* in great numbers. The aphid *Uroleucon pseudoambrosiae* appeared in great numbers on lettuce in the proximity of the Warsaw Okęcie airport only in the vegetation season and did not survive winter (CICHOCKA & GOSZCZYŃSKI, 1978). According to ŁABANOWSKI & SOIKA (2006), two species of scale insects, namely *Unaspis euronymi* and *Chlorpulvinaria floccifera*, are often accidentally brought to Poland with plants imported from the Netherlands.

Agricultural landscape

An agricultural landscape is understood as the kind of environment where a large-scale agricultural activity is conducted. Major crops are a dominating element of the agricultural landscape. More and more frequently balks and mid-field clumps of trees are disappearing. Shortening and simplification of crop rotation practices is a cause of a serious soil degradation (GÓRNY, 1992; WYRZYKOWSKA, 2008). An important factor is also the application of artificial fertilizers and plant protection chemicals, which contribute to polluting the soil as well as ground water and surface water. Frequently the so-called luxurious quantities of fertilizers are applied, i.e. the amounts significantly exceeding the nutritional needs of plants. As a result of such an activity the plants accumulate excessive amounts of ingredients and still large quantities of ingredients which have not been used up by plants stay in the soil (OSTROWSKA & PORĘBSKA, 2002). According to many authors, many species of plants and animals could be protected by a modification of the methods of usable plants cultivation and allowing for the presence of water holes or mid-field tree clumps, and thus the biodiversity of the agricultural landscape might be retained (BALDOCK *et al.*, 1993; PIMENTEL *et al.*, 1993; RYSZKOWSKI, 1995; STRIVASTAVA *et al.*, 1996; STANIAK, 2009; WOŁEJKO, 2009). However, such activities have not been frequently observed in the Polish agricultural landscape so far.

In the course of establishing cultivated fields, man modifies soil (often using agricultural machinery), introduces monocultures, fertilizes the soil with organic and mineral fertilizers, applies pesticides (fungicides, insecticides and herbicides). Each of these activities exercises influence over plants, and via the plants over the Arthropods, their bionomy, dynamics of their abundance and their species composition. Furthermore, greenhouses are built to produce vegetables and decorative plants, palm houses are built for tropical plants, and mushroom-growing cellars are built to grow champignons. All these artificial habitats provide new conditions for development and survival of winter by Arthropods.

By clearing forests, man limits the living space of numerous animals, and by introducing many-hectare agricultural cultivations may cause a plague multiplication of some species (e.g. Colorado potato beetle). Ploughing pastures and applying increasing quantities of nitrogen fertilizers in order to increase the productivity of fields in many countries has lead to increasing the nitrogen content in soils, and also in ground and surface waters, which affects plants (O'NEILL, 1998). Introducing the cultivation of new plant varieties and even new plants (e.g. triticale) is conducive to the multiplication of many herbivorous Arthropods. According to many authors (RUSZKOWSKA, 1978; KOLBE, 1969; RAUTAAPAA, 1972) the introduction of high yielding wheat has contributed to mass appearances of aphids in grains, because aphids breed most intensely on plants strongly fertilized with nitrogen fertilizers.

Human activity in the environment clearly affects the abundance of organisms and the number of species (BOCZEK, 1998). Any chemical interferences in agrocenoses, e.g. mineral fertilization or application of pesticides, have undesirable ecological consequences (KELM *et al.*, 1986). According to GARNIS *et al.* (2009), in chemically protected crops the species diversity of predatory mites (Phytoseiidae) is rather low, and the domineering species is *Typhlodromus pyri*. It suggests that the species is more immune to some plant protection chemicals than other representatives of the genus *Typhlodromus*. The application of herbicides, which affect the quality of proteins in plants, is conducive to the development of grain aphid populations (WITCHRUP *et al.*, 1985; FELKI 1988; RUSZKOWSKA, 1999). Moreover, herbicides have an unfavourable effect on plant physiology, as they are responsible for lowering the intensity of photosynthesis (RALPH, 2000), and affecting the content of amino acids, proteins and saccharides (SAWICKA, 2004; MAGNE *et al.*, 2006). The research conducted by CZERNIEWICZA & SEMPRUCHA (2009) showed that the application of the herbicide Chwastox D 179 SL in winter triticale crop lowered the content of all 15 investigated amino acids and the abundance of grain aphids was lower than in control until the wax maturity stage, when the abundance of aphids became slightly higher than in control. Such herbicides as Chwastox D 179 SL and Aminopielik D 450 SL increased the mortality of grain aphids, while the power of the produced effect depended on the chemical used and the dose applied (KRZYŻANOWSKI *et al.*, 2007). A number of conducted researches (CISZEWSKA, 1977; ZWOLIŃSKA-ŚNIATAŁOWA, 1980) confirm that the application of herbicides increase the presence of general nitrogen, proteins and amino acids in plants, and also causes a considerable change of proportions in their egzogenic and endogenic groups. Furthermore, there has also been discovered an increase of the sugar content in the roots of sugar beetroots, changes in the composition of fatty acids in rape seeds, and a drop in the carotene content in carrot roots. Apart from that, the plants treated with herbicides contained more iron, magnesium, potassium, phosphorus and zinc, while the content of calcium and molybdenum diminished.

The increase of nitrogen and amino acid content is probably the reason for intensified fertility of aphids which entails a growth in their abundance (KELM *et al.*, 1986). Similar results have been observed after the application of a mixture of chemical weed and fungus killers on winter rape. The chemical weed killers limit the abundance of parasitic Hymenoptera in crops.

Not only the diminishing forestation but also wasteland cultivation lead to the occurrence of changes in the fauna. Insects are especially strongly affected by these processes. Agro-technological methods of soil treatment (scarification, vapour extraction, moisturizing) result in modifications to soil fauna. In the untilled land there follow mass appearances of the maggots of *Hylemyia* genus, crane flies, carrion beetles, some carabids and click beetles (BOCZEK, 1998). First ploughing destroys the *Haplothrips tritici* and Hessian flies, as it causes a higher abundance of the carabids. The plough and plate harrow destroy grubs and wireworms, and hamper their development. Also plant fertilization has an enormous influence on insect abundance (BOCZEK, 1998). Application of manure results in higher abundance of maggots of Hylemyia genus, carrot flies, European mole crickets and march flies. However, together with manure there are introduced to the soil some predatory nematodes and mites, hence mass appearances of herbivorous mites are rare in the fields fertilized with manure.

Intense nitrogen fertilization is conducive to luxuriant development of vegetative parts of plants which delays the development of generative parts, increasing the fertility, and thus also the abundance, of mites, aphids and scale insects. Phosphorus and potassium have the opposite effect. Using these elements for fertilization results in the development of mechanical tissues and accelerates the maturing of plants, which makes it difficult for the nematodes and stinging-sucking Arthropods to feed. Shortages of microelements (e.g. Zn, Mg, Fe) lower the fertility rates and prolong the life cycles of insects. A cultivated field usually constitutes a large acreage of a single species, and the regionalization of crops and specialization of production are additionally conducive to the multiplication of some groups of herbivores, which become pests.

Improvement of grain achieved by introducing new varieties of wheat increased the abundance of thrips and wheat midges. Moreover, it has been observed that a close proximity of specific cultivations resulted in mass appearances of certain Arthropods in the crops. For instance, woolly aphids settle on the roots of carrots and lettuce in greater numbers if there are poplars growing next to them (Goszczyński & Cichocka, 1997) and the frit fly is more abundant on grains neighbouring with pastures and wasteland (Boczek, 1998). The implementation of a water-butt rinses spider mites, aphids and flea beetles off plants, but it is conducive to the development of leaf nematodes. An enormous influence over Arthropods is exercised by the pesticides utilized in agriculture. Application of chemistry in agriculture (herbicides, fungicides, insecticides, fertilization) has a strong influence on aphid bionomy and also on their developing new forms (Leszczyński *et al.*, 1985; Ruszkowska, 1988; Giebel *et al.*, 1998). As for the sowing of honey plants in orchards, it increases the parasitizing of insects in orchards. Zoocides destroy not only herbivores, but also their parasitoids and predators. Their application usually does not kill 100% of insects and mites. It is survived by some individuals which leads to developing immune breeds. For several decades there has been observed in Poland an increase in the abundance of grain aphids (Ruszkowska, 1999; Zwolińska-Śniatałowa, 1984). This is due to the change in the implemented types of cultivation, i.e. the implementation of monocultures in large acreages, absence of crop rotation, introduction of high yielding breeds which require strong fertilization and applying plant protection chemicals. All these factors are conducive to the appearance of numerous aphid populations (Ferro, 1987; Ruszkowska, 1999). And this is so although until the 1980s the economic significance of aphids was not even considered. The application of herbicides, which influence the quality of proteins in plants is conducive to the increasing abundance of aphid populations in grain (Witchrup *et al.*, 1985; Felkl, 1988). Also the application of pesticides limiting the abundance of grain aphids may bring results opposite to the intended ones. Pesticides destroy also the natural enemies of aphids and therefore the abundance of herbivores is growing uncontrollably. What is more, pesticides may also affect the metabolism of host plants. Once they have been applied, plants may tend to accumulate larger amounts of metabolites which facilitate the development of aphids (Risch, 1987) or change the quality of produced proteins (Zwolińska-Śniatałowa, 1984). Already in 1969 in the USA there was observed an increase in the abundance of aphids in grains after the application of an insecticide containing carbaryl (Root & Skelsey, 1969).

Both landscape structure and agriculture intensification are important factors shaping trophic associations in agroecosystems (Hawro & Ceryngier, 2009). There has been discovered a positive correlation between landscape complexity and the total number of primary parasitoids and the number of mummified aphids. On the other hand, it has not been proved that together with the increasing landscape diversification there also increases species diversity of aphids (on winter wheat) and their parasitoides.

Kelm & Fostiak (2009) discovered that on potatoes that were ecologically cultivated (without applying any pesticides) there were 22% more aphids than on potatoes protected by chemicals. Apart from that, the application on whey in ecological fields was conducive to more intense aphid multiplication. In ecological fields aphids were under the strong pressure of predators, which were far more abundant there than in the chemically protected fields. The above authors also observed that a draught evoking water stress of plants reduced the abundance of aphids.

The intensification of agriculture and impoverishment of landscape diversification in the surroundings of cultivated fields affect the abundance of many arthropod species (Ceryngier & Hawro, 2009). Together with growing landscape diversification in the surroundings of cultivated fields there also grows the abundance of *Rhopalosiphum padi* and *Metopolophium dirhodum* while the abundance of *Sitobion avenae* does not change, and neither does the abundance of natural enemies of aphids.

As for the carabids, they are less numerous in the fields where winter wheat is intensely cultivated, both with reference to species abundance and species richness. The kind of pre-sowing grain cultivation may affect the abundance of aphids on winter triticale (Sempruch *et al.*, 2007). Replacing tillage with a rototiller or cultivator resulted in an increase of the number of grain aphids.

The increase in numbers of agrophags may be accompanied by the decrease in the numbers of useful fauna. Volkmar *et al.* (2003) observed a lowered abundance of spiders belonging to the family Lycosidae and beetles belonging to the families Carabidae and Staphylinidae.

At certain time intervals the populations of herbivorous Arthropods develop dramatically. Such a mass appearance is called gradation (Joyce, 1983). As yet little is known about the reasons of gradation occurrence and its mechanisms. According to Wellings & Dixon (1987), major factors evoking gradations of grain aphids are connected with long-lasting weather conditions favourable for the development of their population. On the other hand, cool springs facilitate aphid gradations since they hamper the development of their natural enemies, who are more sensitive to lower temperatures.

Greenhouses are associated, first and foremost, with agricultural landscape. Their existence provides an opportunity for year-round development and surviving winter to many native arthropod species (spider mites, scale insects, aphids, thrips, some flies), but there can also feed in them some tropical species, which would have no chances of development in a temperate climate. The species living in greenhouses have shorter life cycles, often higher fertility rates and an ability to create numerous populations. In spring and in summer they may migrate from the greenhouses to the fields. Another problem are the arthropod species accidentally brought to greenhouses with plants grown there, which presently inhabit greenhouses and palm houses (CICHOCKA, 1992). CICHOCKA (1992) has declared 28 aphid species from Polish greenhouses. Some of them developed on vegetables and decorative plants grown in greenhouses, others appeared accidentally. For instance, *Rhopalosiphon padi* inhabited the wheat grown from individual seeds found in straw bales used in cucumber cultivation, while *Cinara pinea* inhabited dwarf pines brought into the greenhouse in containers and used for interior decoration. On decorative plants ACHREMOWICZ *et al.* (1986) recorded the presence of 29 aphid species. Some of them can be found in the open air in Poland. Thus, by building greenhouses and palm houses man provides aphids with an opportunity for development. Aphids can survive winter in the greenhouse and leave it in spring, increasing aphid abundance in the field. A majority of aphids found in greenhouses can spend winter there, and some species (e.g. *Apis gossypii*) develop only in greenhouses, which they can leave in summer only to return in September. It has been discovered that also such species as *Brachycaudus cardui* and *B. helichrysi*, as well as *Brevicoryne brassicae*, spend winters in greenhouses, even though they used to be counted among species spending winter in the field (CICHOCKA, 1992). The above discussed situation certainly contributes to higher abundance of aphids in the open air during the vegetation season. What is more, aphids can spend winters not only in greenhouses but also in the stored tubers and rhizomes (cabbages, carrots, parsley, potatoes) (CICHOCKA, 1998).

In greenhouses there can be encountered herbivorous mites, whiteflies, scale insects, thrips, and also predatory mites (Phytoseiidae) intentionally introduced in the greenhouses in order to decrease the abundance of the above mentioned species, as well as flower bugs (Anthocoridae) and parasitoids of aphids (Aphidiidae, Braconidae). Some herbivorous species are unable to spend winter outside a greenhouse, but from spring to autumn they may leave the greenhouse and in comparatively large numbers inhabit many plants in the field.

What is more, together with cultivated plants a new whitefly species, namely *Bemisia tabaci*, has been accidentally brought to greenhouses (GOSZCZYŃSKI & CICHOCKA, 1992). In Poland this thermophilous species can develop only in greenhouses and palm houses. Furthermore, out of 185 scale insect species encountered in Poland as many as 44 species (23.8% of the fauna) are greenhouse species (ŁAGOWSKA & GOLAN, 2005).

Conclusions

Arthropods are a significant component of biocenoses, as they inhabit all types of environments. Many of them feed on plants, but at the same time constitute nourishment of predatory Arthropods, as well as birds and mammals (e.g. squirrels lick honeydew out of galases together with aphids). The whole chain of relationships consists of such links as: host plant – herbivorous Arthropod – predator, and functions correctly as long as man does not interfere with its equilibrium. However, it is difficult to find a landscape nowadays characterized by the absence of human interference.

Agricultural landscape is a type of landscape which has been created by man and is being shaped and modified by man. It is a complex landscape, in which there function many interdependencies significantly affected by human activity. The state of plants in agricultural landscape is shaped by a variety of factors, which cause fluctuations in species composition and abundance of Arthropods. The following issues ought to be taken into consideration:

1. Soil cultivation results in a modification of environment, which entails modifications in species composition of plants and animals. The surroundings of cultivated fields influence the species composition of Arthropods inhabiting the fields. The species composition of Arthropods is not the same when the fields are surrounded by wasteland or meadows, as it is when the fields are surrounded by forests.
2. Major crops have the character of monocultures, which increases the nutritional acreage of herbivorous species associated with the cultivated plant species. Also due to a destruction of balks and mid-field clumps of trees the environment becomes impoverished, its biodiversity is decreasing. And this happens even though it has been proved that such environments as balks constitute reservoirs of many species considered by man to be useful.
3. As a result of soil cultivation the structure of soil becomes damaged, and the application of plant protecting chemicals and artificial fertilizers, being a common practice nowadays, results in chemistrization of cultivated areas. These phenomena cause a drop in the numbers of organisms which decompose the dead soil organic matter, such as bacteria, Protozoa, nematodes, earthworms and others. Moreover, the chemistrization also leads to a domination of some species of herbivorous Arthropods and a disappearance of others. And among some mites or insects there develop breeds immune to insecticides, such as e.g. *Typhlodromus pyri* or *Aphis gossypi.*
4. With many plant species destroyed by man as weeds there are associated some Arthropods. For instance, on nettles there live predatory mites or caterpillars of brush-footed butterflies.
5. When new plant species begin to be cultivated, new herbivorous animals appear. A spectacular example is corn and the Arthropods which inhabit this plant.

6. The transfer of alien species can take place via means of transportation, as happened in the case of the aphid *Uroleucon pseudoambrosiae*, found in Poland on lettuce in the neighbourhood of Okęcie airport. Furthermore, many species which constitute an important element of various environments, also agricultural ones, have been brought there as a result of human activity, for example as was the case with the Asian lady beetle *Harmonia axyridis* intentionally introduced in Europe as a species useful in a biological fight. Nowadays this species of lady beetle is also present in large numbers in Poland, where it is responsible for a drop in the numbers of native lady beetle species.

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Typ krajobrazu a liczebność i skład gatunkowy stawonogów część I. krajobraz rolniczy

Streszczenie

Praca zawiera przegląd czynników pośrednich wpływających na liczbę gatunków stawonogów oraz liczebność i bionomię poszczególnych gatunków w krajobrazie rolniczym, głównie na przykładzie pluskwiaków (Hemiptera). Do czynników pośrednich wpływających na stawonogi zaliczyć należy szeroko pojmowaną działalność człowieka i związane z nią skażanie środowiska, uprawę roli oraz stosowanie środków ochrony roślin i nawozów, zakładanie monokultur, wycinanie lasów czy przenoszenie obcych gatunków. Wpływ tych wszystkich czynników nie jest jednorodny, a konsekwencje jakie pociąga za sobą działalność człowieka w środowisku naturalnym trudno przewidzieć.

Krajobraz rolniczy stworzony przez człowieka stale podlega przekształceniom, niekiedy tak znacznym (uprawy wielkoobszarowe, niszczenie miedz i zadrzewnień śródpolnych, brak płodozmianu), że następuje silna przebudowa składu gatunkowego stawonogów tam występujących. Jak w przyszłości będzie wyglądał krajobraz rolniczy, jeżeli dziś w wielu miejscach ma on już charakter zdegradowany?