APHIDS AND OTHER HEMIPTEROUS INSECTS	VOL.17 (2011) 29–38

Alien and invasive species of oviparous aphids (Aphidomorpha: Adelgoidea, Phylloxeroidea) in Poland: characteristics and review

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ABSTRACT

The paper provides a short characteristics of oviparous aphids, discussing their classification and providing a review of the species Adelgoidea and Phylloxeroidea, encountered in Poland. It discusses the species which, by definition, meet the criteria which classify them as alien or invasive species in the fauna of Poland. Among these species there are the following: *Adelges* (*Gilletteella*) *cooleyi* (Gillette, 1907), *Dreyfusia nordmannianae* (Eckstein, 1890), *Pineus strobus* (Hartig, 1837) and *Viteus vitifoliae* (Fitch, 1885).

KEY WORDS: Aphids, Adelgoidea, Phylloxeroidea, Poland

INTRODUCTION

Every area of our planet is characterized, in the passage of time, by changes of its componential elements. It refers especially to such as a sensitive element as animate nature. As a result of the influence exercised by various factors, local flora and fauna become impoverished both in a quantitative and qualitative sense, but at the same time they are enriched by the appearance of new species. Such enrichment may take place in a natural way (e.g. in the course of speciation processes or due to the extension of ranges of already existing species), and in an artificial

way, caused by human activity such as purposeful or accidental transfer of species beyond their usual ranges. In the case of such an artificial enrichment we have to do with the introduction of elements which are alien for the local flora and fauna (Głowaciński *et al.,* 2008). What is more, if an alien species turns out to be an "invasive" one, its occurrence may constitute a threat to native biodiversity, as well as human economy. Can such phenomena be observed with respect to oviparous aphids in Poland?

MATERIAL AND METHODS

The paper provides a short characteristics of oviparous aphids, their classification and review of the species Adelgoidea and Phylloxeroidea are occurring in Poland. It discusses the species which, by definition, meet the criteria which classify them as alien or invasive species in the fauna of Poland. Authors use the definition of invasive or alien species according to "A Book of Alien Invasive Species in Polish Fauna". 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 (Głowaciński *et al.,* 2008).

Characteristics, classification and review of species

Oviparous aphids are such aphids in the case of which reproduction, in all generations, takes place solely by laying eggs, either fertilized or unfertilized. The most characteristic morphological features of such aphids include: the absence of siphs and cauda; three-segmented antennae of wingless adult morphs; abdomen of females ending in an ovipositor and if there is no ovipositor there are no cerci either; wings of reduced function, no sector radii in forewings.

In fact, since the very first attempts at classifying aphids, oviparous aphids have been differentiated as separate taxons. Already in the 1860s, Passerini (1863) classified them as a subfamily of Chermesinae. Twenty-two years later, Lichtenstein (1885) divided this group into two taxons having the rank of families (i.e. Chermesiens and Phylloxeriens – differing by virtue of the presence/absence of the ovipositor in females), and raised the rank of oviparous aphids to that of a superfamily. Several years later, Dreyfus (1889) in a way juxtaposed oviparous aphids against the remaining aphids on the basis of the criterion whether all generations are oviparous or viviparous, and in this way founded the system which, with various modifications, has been used to this day.

Nowadays, two approaches prevail with regard to aphid classification. According to the first one, two superfamilies are differentiated (Phylloxeroidea and Aphidoidea) within the suborder Sternorrhyncha of the order Hemiptera (Nieto Nafria *et al.,* 2010). According to the second one, several superfamilies are differentiated, and three among the contemporary aphids: Adelgoidea, Phylloxeroidea and Aphidoidea. Seemingly, the latter approach is better grounded, since it takes into account all paleontological data available (Heie & Wegierek, 2009ab). The system of classification of oviparous aphids is shown below. Only the species encountered in Poland are featured and in each case host plants are listed after the colon.

Order: Hemiptera Linnaeus, 1758
Suborder: Sternorrhyncha Amyot et Serville, 1843
Infraorder: Aphidomorpha Becker-Migdisova et Aizenberg, 1962
Superfamily: Adelgoidea Annand, 1928
Family: Mesozoicaphididae Heie & Pike, 1992 (†)
Family: Elektraphididae Steffan, 1968 (†)
Family: Adelgidae Annand, 1928
Subfamily: Adelginae Annand, 1928
Genus: *Adelges* Vallot, 1836
Subgenus: *Adelges* Vallot, 1836
Adelges (*Adelges*) *laricis* Vallot, 1836: *Picea* spp./*Larix* spp.
Adelges (*Adelges*) *tardus* (Dreyfus, 1888): *Picea* spp.
Subgenus: *Gilletteella* Börner, 1930
Adelges (*Gilletteella*) *cooleyi* (Gillette, 1907): *Picea* spp., *Pseudotsuga menziesii* (Mirb.) Franco
Subgenus: *Sacchiphantes* Curtis, 1844
Adelges (*Sacchiphantes*) *abietis* (Linnaeus, 1758): *Picea* spp.
Adelges (*Sacchiphantes*) *viridis* (Ratzeburg, 1843): *Picea* spp./*Larix* spp.
Genus: *Dreyfusia* Börner, 1908
Dreyfusia nordmannianae (Eckstein, 1890): *Abies* spp.
Dreyfusia piceae (Ratzeburg, 1844): *Abies* spp.
Genus: *Aphrastasia* Börner, 1909
Aphrastasia pectinatae (Cholodkovsky, 1888): *Picea* spp./*Abies* spp.
Subfamily: Pineinae Börner, 1930
Genus: *Pineus* Shimer, 1869
Pineus cembrae cembrae (Cholodkovsky, 1888): *Picea* spp./*Pinus cembra* L.
Pineus pineoides (Cholodkovsky, 1903): *Picea* spp.
Pineus pini (Ratzeburg, 1844): *Picea* spp.
Pineus strobus (Hartig, 1837): *Pinus strobus* L.
Superfamily: Phylloxeroidea Herrich-Schaeffer in Koch, 1854
Family: Phylloxeridae Herrich-Schaeffer in Koch, 1854

Subfamily: Phylloxerinae Herrich-Schaeffer in Koch, 1854
Tribus: Phylloxerini Herrich-Schaeffer in Koch, 1854
Genus: *Albertaphis* Heie, 1992 (†)
Genus: *Aphanostigma* Börner, 1909
Genus: *Foaiella* Börner, 1909
Genus: *Moritziella* Börner, 1909
Genus: *Olegia* Shaposhnikov, 1979
Genus: *Phylloxera* Boyer de Fonscolombe, 1834
Phylloxera coccinea (von Heyden, 1837): *Quercus* spp.
Phylloxera glabra (von Heyden, 1837): *Quercus* spp.
Genus: *Viteus* Shimer, 1867
Viteus vitifoliae (Fitch, 1855): *Vitis* spp.
Tribus: Acanthochermesini Börner, 1952
Genus: *Acanthochermes* Kollar, 1848
Acanthochermes quercus Kollar, 1848: *Quercus* spp.
Subfamily: Phylloxerininae Börner, 1952
Genus: *Palaeophylloxera* Heie & Peñalver, 1999 (†)
Genus: *Phylloxerina* Börner, 1908
Phylloxerina capreae Börner, 1942: *Salix* spp. (especially *Salix capreae* L.)
Phylloxerina salicis (Lichtenstein, 1884): *Salix* spp. (especially *Salix alba* L.)

So far, the total of 109 species and subspecies of contemporary oviparous aphids have been identified worldwide (Blackman & Eastop, 1994; Ghosh, 1983; Havill & Foottit, 2007). In the family Adelgidae 51 taxons have been differentiated, and 58 in the family Phylloxeridae. Out of these numbers, 24 and 18, respectively, have been reported from Europe (Binazzi, 2000; Nieto Nafria *et al.,* 2010). In Poland 12 have been reported, and 6 taxons in the rank of a species (Osiadacz & Hałaj, 2010). It should be noted, however, that due to considerable difficulties with correct identification of the taxons belonging to this group of aphids (Binazzi, 2000; Börner & Heinze, 1957; Heinze, 1962; Shaposhnikov, 1964; Steffan, 1968), it is possible that further new forms of oviparous aphids will be discovered in Poland.

Most species of oviparous aphids (except for the subgenera *Adelges* and *Sacchiphantes*, as well as *D. nordmannianae* and *P. coccinea*) are rather rare in Poland. They have been reported from few localities and few regions of Poland (Borowiak-Sobkowiak & Wilkaniec, 2010; Osiadacz & Hałaj, 2009; Szelegiewicz, 1968); they do not pose a serious threat to their host plants. Among the forms of oviparous aphids that are encountered in Poland (see the list above), only several fulfill the criteria which classify them as alien (or both alien and invasive) species (Coeur d'acier *et al.,* 2010; DAISIE, 2009; Genovesi & Scalera, 2007)

in the native fauna (Głowaciński *et al.,* 2008). Among these species there are the following:

***Adelges* (*Gilletteella*) *cooleyi* (Gillette, 1907)**

Country of origin: North America.

Europe: probably brought accidentally on the seedlings of host plants (*Picea pungens* Engelm*., Pseudotsuga* spp.) towards the end of the 19th century.

Biology: in its country of origin the species if holocylic and dioecious: it migrates from spruces (*P. pungens, Picea engelmanni* Parry ex Engelm., *Picea sitchensis* (Bong.) Carr.) onto Douglas-firs (*Pseudotsuga* spp., *Pseudotsuga macrocarpa* (Vasey) Mayr, *P. menziesii*). On spruces it forms characteristic, elongated, cone-shaped galases. There is also known an anholocyclic form which feeds solely on Douglas-fir needles and is encountered mainly in Europe, however, there has also been described a form which follows a full two-year cycle (Scotland, Germany) (Cumming, 1962; Parry & Spires, 1982; Osiadacz & Hałaj, unpublished).

Harmfulness: no serious harm caused by the feeding of the species has been observed.

***Dreyfusia nordmannianae* (Eckstein, 1890)**

Country of origin: Caucasus Mountains, Eastern Pontic Mountains and Crimea.

Europe: the species has been accidentally transferred in the middle of the 19th century on the seedlings of a Caucasian fir *Abies nordmanniana* (Steven) Spach. In Poland the species has migrated into the country from the south, mainly from the western part of the Beskidy Mountains, from where it gradually extended its range in the northerly and easterly directions. The species settled on firs in a passive way, by having the eggs and larvae carried by the wind, animals and man, together with the planting material. The species has been reported from many localities and regions of Poland, and in all probability it is now present throughout the country within the range of a European silver fir (Głowaciński *et al.,* 2008).

Biology: in its native country the species is holocyclic and dioecious with a full 2-year life cycle, migrating from a Caucasian spruce (*Picea orientalis*) (L.) onto a Caucasian fir. In Europe the species is anholocyclic: it develops solely on a European silver fir (Eichhorn, 1991).

Harmfulness: the piercings of needles result in the formation of cone-shaped galases which hinder the growth of shoots. This results in weakening of the trees, which causes deaths of branches and the tops of crowns, as well as the appearance of shrub-like formations, which additionally encourages the settlement of secondary pests on the trees, which cause further damage. The species attacks firs of all age classes, as well as seedlings in nurseries, especially in areas affected by industrial pollution. Outbreak foci appear in locations where tree stands are weakened,

poorly maintained, with numerous mechanical injuries. It is possible that because the species transfers easily, it may extend its primary and secondary distributional range (Głowaciński *et al.,* 2008).

***Pineus strobus* (Hartig, 1837)**

Country of origin: North America.

Europe: accidentally transferred at the beginning of the 20th century together with its host plant *P. strobus*.

Biology: an anholocyclic, monoecious species, feeds on the bark of a trunk and twigs (especially young ones) (Carter, 1971).

Harmfulness: no serious harm caused by this species has been observed.

***Viteus vitifoliae* (Fitch, 1885)**

Country of origin: warm zones of the western part of North America.

Europe: accidentally transferred in the 1860s on its host plants (mostly *Vitis riparia* Michx and *Vitis rupestris* Scheele). Presently it can be encountered practically in every place where vines are grown, with the exceptions of Chile in South America and Cyprus in Europe. In Poland reported for the first time from the region of Lesser Poland in 2010 (Hałaj *et al.,* 2011).

Biology: in its native country the species is holocyclic and monoecious, but it changes the locality where it feeds from the above ground organs of a plant (leaves) to the underground organs (thin roots): it is subheteroecious. In Europe, beside the holocyclic form an anholocyclic one also appears (feeding mainly on roots) and, seemingly, a majority of local populations are examples of the latter form (Hałaj *et al.,* 2011).

Harmfulness: feeding of the species results in the formation of characteristics galases on leaves and roots. A considerable number of galases appearing on thin roots (rhizoids) may disturb the water circulation system of plants and result in withering of whole plants. American vine species, due to their considerable capacity for root regeneration, tolerate such damage pretty well, but the species and varieties of vine grown in Europe have proved to be very vulnerable to the threat posed by this aphid species, which has been the reason for serious losses in European vineyards (estimated 1/5 of French vineyards have been affected and even up to 60% in Hungary). When the European vine varieties (deriving mainly from *Vitis vinifera* L.) were grafted onto the stock of mixed varieties of American vines it was believed that the problem was overcome. However, it was soon discovered that *V. vitifoliae* was a very flexible species, capable of developing local biotypes (literature lists ca. 150 genotypes) and breaking down the immunity system of its hosts (Hałaj *et al.,* 2011). The threat posed by this aphid species is still large and for this reason it is featured on EPPO Alert List as a quarantine pest (EPPO list 2A).

CONCLUSIONS

A wide majority of aphid species (Aphidomorpha) encountered in Poland are neutral with respect to the environment. From the point of view of biological diversity they play an important, well-established role in the circulation of matter and energy in ecosystems. It refers especially to ecosystems which are considerably natural (i.e. "sustained ecosystems") and not modified to a serious degree by various factors, especially ones connected with anthropopressure, resulting from human activities undertaken in connection with globalization, or even "homogenization" of life. In the case of ecosystems where the natural balance has been disturbed, there usually occur changes concerning the structure of richness and domination of species which make up biocenoses in such environments. Another change refers to the internal structure of the populations of particular species within these zoocenoses (e.g. dynamics of species richness, modifications of life cycles). There also come into being biological niches which provide an opportunity for a diffusion (often even an invasion) of species which are alien to the local fauna, including species from far located zoogeographical zones. Extreme examples of modified ecosystems include all types of artificially created monocultures (encountered in gardening, agriculture, forestry), particularly ones which cover large areas, especially if they are already degraded (Cichocka & Lubiarz, 2010). In this type of ecosystems the ecological phenomena discussed above may become very visible. As has been mentioned in recent studies (e.g.: Coeur d'acier *et al.,* 2010; Olenin & Didziulis, 2008), over eleven thousand alien species have been encountered in the recent years in Europe, while within the territory of Poland solely the number of alien agrophages exceeds 1800 (Nawrot, 2009).

Among oviparous aphids only 4 species are alien to Polish aphidofauna (*A.* (*G.*) *cooleyi*, *D. nordmannianae, P. strobus*, *V. vitifoliae*), while a tendency for invasive behavior has been observed in the case of *D. nordmanniana*, which comes from the Caucasus Mountains and is continually extending its distributional range. The same may be true, as further studies will show, about the species *V. vitifoliae* from North America, which has recently been encountered in Poland. Problems may also be caused by the native species belonging to the genus *Adelges* (*A.* (*A.*) *laricis, A.* (*A.*) *tardus, A.* (*Sacchiphantes*) *abietis, A.* (*S.*) *viridis*), which are presently frequently encountered not only in their natural forest environments, but also in "artificial" tree clumps, planted by man (Budzińska & Goszczyński, 2010). Their appearance often has the character of an invasion or an outbreak. Let it be added that the feeding of these aphids on their primary host (*Picea* spp.) leads to the development of characteristic cone-shaped galases, which may lead to shoot deformations or even the hindrance of plant growth in the case of en masse appearances.

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Obce i inwazyjne gatunki mszyc jajorodnych (Aphidomorpha: Adelgoidea, Phylloxeroidea) w Polsce – charakterystyka i przegląd

STRESZCZENIE

W pracy przedstawiono krótką charakterystykę „mszyc jajorodnych", omówiono ich klasyfikację oraz podano gatunki Adelgoidea i Phylloxeroidea występujące w Polsce. Przedstawiono gatunki, które spełniają według definicji kryteria gatunków obcych lub inwazyjnych w faunie Polski. Do gatunków tych zaliczono: *Adelges* (*Gilletteella*) *cooleyi* (Gillette, 1907), *Dreyfusia nordmannianae* (Eckstein, 1890), *Pineus strobus* (Hartig, 1837) i *Viteus vitifoliae* (Fitch, 1885).