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ORIGINAL ARTICLE

First report of the Nearctic planthopper *Metcalfa pruinosa* (Say, 1830) in Poland, its current status and potential threats (Hemiptera: Fulgoromorpha: Flatidae)

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Abstract

Metcalfa pruinosa (Say, 1830) was recorded for the first time in Poland, in the city of Warsaw. This Nearctic species of the Flatidae family was introduced into Europe in the late 1970s and has expanded its range ever since. We provide data on the first record as well as briefly characterize the insect in terms of its diagnostic features, biology and potential harm to agriculture and the environment.

Keywords: agriculture, first record, *Metcalfa pruinosa*, pest, Poland

Introduction

The Flatidae is the fourth largest family of planthoppers (suborder Fulgoromorpha), with 297 genera and 1446 species worldwide (Bourgoin 2022), found primarily in the tropics. They can be characterized by two external morphological characteristics: i) a submarginal vein, parallel to the wing margin, and a defining series of marginal cells in the apical and leading portion of the front wing and ii) the presence of wax-bearing pustules in the claval region (Bartlett *et al.* 2014). Flatids are mostly macropterous, which means that they possess a transversal row of five to six closed nodal cells, plus one complete distal row of open and closed postnodal cells. Adult wings are often covered with a dusting of wax, whereas nymphs are distinguished with flocculent wax. The family covers two subfamilies: Flatinae with fore wings, which are usually tectiform and Flatoidinae with wings held horizontally (O'Brien 2002). Adults and immature stages utilize the above-ground parts of woody and semi-woody plants (Bartlett *et al.* 2018).

In Europe Flatidae are represented by two species of *Phantia* Fieber, 1866: *Phantia michelina* Della Giustina & Remane, 1992 (France, Corsica) and *Phantia subquadrata* (Herrich-Schäffer, 1838) (southern Europe), 33 species of *Cyphopterum* Melichar, 1905 distributed in southwestern Europe and the Canary Islands and *Metcalfa pruinosa* (Say, 1830) of Nearctic origin (Hoch 2017).

Metcalfa pruinosa known as citrus flatid planthopper belongs to the family Flatidae (Fulgoromorpha) and is widely distributed in North America. The first record in Europe dates back to 1979 from Italy – region Veneto (Zangheri and Donadini 1980), where it quickly established a large population, and then spread to southern France, Slovenia and southern Austria (Giustina 1986). To date it has colonized about 15 European countries and this process is expected to continue, as has been shown by Byeon *et al.* (2018).

It is assumed that the spreading of *M. pruinosa* is due to the transport of tree and ornamental seedlings from countries where the pest is fully established. The planthopper can migrate to new localities and the natural spreading of *M. pruinosa* is ca. 50 m per year (Lauterer 2002).

Being highly polyphagous, in North America it is not of significant economic importance, doing little harm to citrus trees and some ornamentals (Mead 1969). However, in Europe this gregarious insect infests various cultivated and wild trees, shrubs and weedy plants. More than 120 species in 50 families have been reported in the United States (Wilson and Lucchi 2000), over 300 species in 78 families in Europe (Bagnoli and Lucchi 2000; Alma *et al.* 2005), and 145 species in 62 families in South Korea (Yeyeun *et al.* 2011; Kim and Kil 2014).

Materials and Methods

The discovery of *M. pruinosa* in Poland was the result of observation and collection of nymphs and adult insects. To collect individuals, the sweep-netting method was used. Specimens were identified on the basis of external characteristics as well as dissected male genitalia structures using illustrations and descriptions given by Holzinger *et al.* (2003).

Our evaluation of the damage to cultivated plants in Poland was based on a thorough survey of scientific literature describing the ability of *M. pruinosa* to transmit plant pathogens as well as a review of a list of host plants.

Host plant names and classification are after Tropicos. The name of Polish zoogeographical regions is adopted after the series of Catalogues of Polish Fauna (Burakowski *et al.* 1973).

Photos of nymphs exuvia of *M. pruinosa* and scale insect (Lecaniidae) clusters were taken using a stereomicroscope Leica MZ 16 with digital camera IC 3D (Museum and Institute of Zoology PAS, Warsaw). Photos of *M. pruinosa* terminalia were taken using a stereomicroscope Nikon SMZ 25 with digital camera Nikon Ri2 (Resource and Teaching Support Centre, Wrocław University of Environmental and Life Sciences, Wrocław).

Results

Systematics

Class Insecta Linnaeus, 1758
Order Hemiptera Linnaeus, 1758
Suborder Fulgoromorpha Evans, 1946
Superfamily Fulgoroidea Latreille, 1810
Family Flatidae Spinola, 1839
Subfamily Flatinae Spinola, 1839
Tribe Nephesini Distant, 1906
Genus *Metcalfa* Caldwell & Martorell, 1951
Species *Metcalfa pruinosa* (Say, 1830)

Morphology

The recognition of *M. pruinosa* in Poland is easy since this species is the only local representative of the family Flatidae. Therefore, it can be characterized by the following diagnostic features:

Adults. Individuals are 7–8 mm in length. The dorsal surface of the body and forewings are blackish brown (Figs 1A–E, 2A–D). The body and forewings are covered with a whitish powdery secretion making the blackish color bluish gray. A characteristic pair of dark spots is located on the basal half of each forewing. Male and female genitalia are shown in Figures 4A–D.

Nymphs. The larvae are agile and soft, surrounded by elongate filaments of white waxy exudate, sometimes covering the whole body. They are particularly long at the end of the abdomen. After removing the wax layer the larval body is white to light green, sometimes with an ochreous tinge. The same waxy secretion is deposited on leaves and shoots where the nymphs feed (Figs 3C–D). According to Wilson and McPherson (1981), there are five larval instars, differing in the size of the head capsule and wing pads. The last instar is 5–6 mm long.

Localities in Poland

The individuals of *M. pruinosa* were preliminary identified on the basis of photos and individuals collected by Teodor Smulski in Warsaw between 16th and 21st August 2021. The species was firstly observed on *Catalpa* sp., and after detailed examination and identification was regarded as the first record for Poland (Figs 2E–F).

Material examined: Mazowiecka Lowland – Warszawa UTM EC08; Białowieska Street (distance of 150 m between Budrysów and Ignańska Streets), Praga-Południe district; 52.238050, 21.091304.

August 19, 2021, 9♂♂, 3♀♀, 3 larvae (preserved in 96% ethanol), 14♂♂, 21♀♀ (as dried specimens),

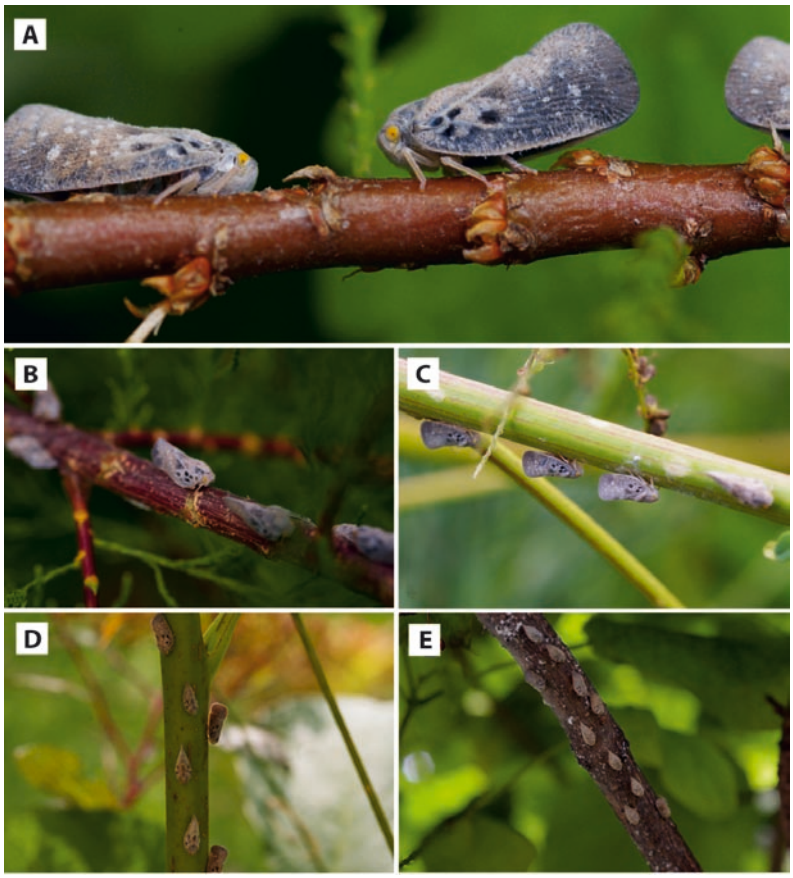

Fig. 1A–E. *Metcalfa pruinosa* – adults feeding on different plant species (Photos by Teodor Smulski, August 22, 2021)

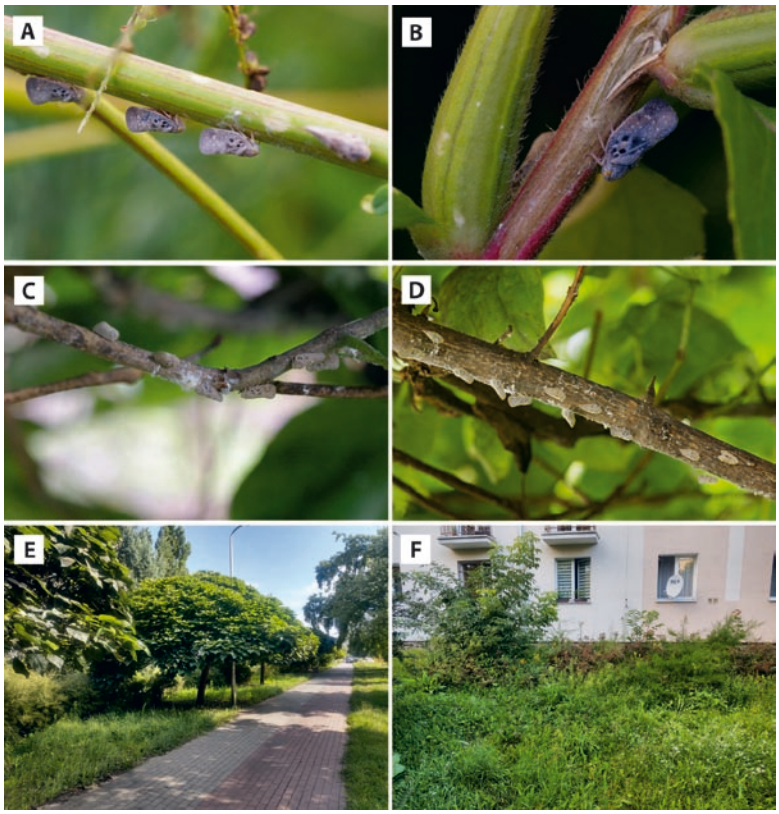

Fig. 2. *Metcalfa pruinosa* – individuals and collecting site; (A–D) – individuals on different plant species; (E–F) – collecting site: (E) – *Catalpa* trees, (F) – flowerbed with ornamental plants (Photos by Teodor Smulski, August 21, 2021)

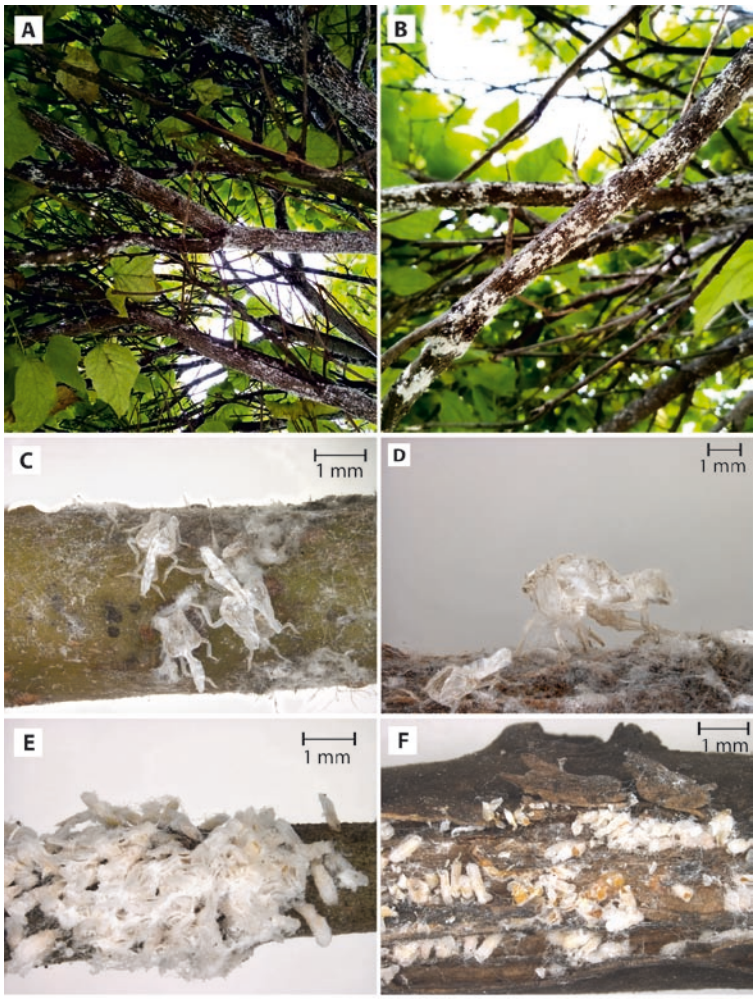

Fig. 3. *Metcalfa pruinosa* and scale insects (Lecaniidae) on *Catalpa* tree: (A–B) – twigs covered with wax filaments excreted by nymphs of *Metcalfa* and Lecaniidae; (C–D) – nymphs exuvia of *Metcalfa pruinosa*; (E–F) – cluster of Lecaniidae individuals covered with wax filaments (Photos by Adam Stroiński, September 28, 2021)

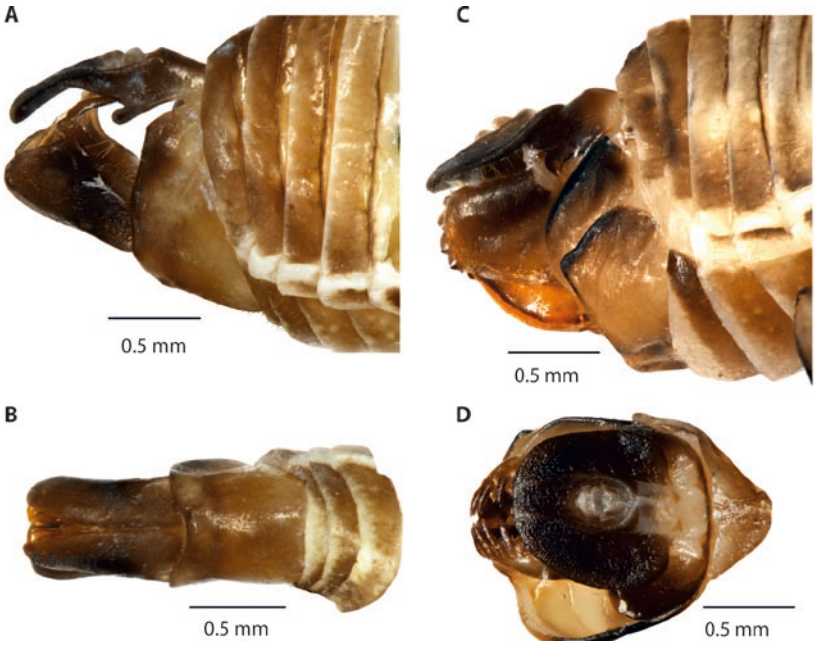

Fig. 4. *Metcalfa pruinosa* – terminalia: (A–B) – male: (A) – lateral view, (B) – ventral view; (C–D) – female: (C) – lateral view, (D) – dorsal view (Photos by Paweł Jarzembowski)

all collected by Teodor Smulski from *Catalpa* sp. and *Melilotus albus*, identified by Andrzej J. Woźnica (in AJW private collection).

September 28, 2021, 33♂♂, 28♀♀, 3 larvae (preserved in 96% ethanol and as dried specimens), all collected from various plants (Table 1) and identified by Adam Stroiński (collection of Museum and Institute of Zoology PAS).

Remark: the infestation of *Catalpa* trees by scale insects of the Lecaniidae family was also observed (Figs 3A–B, E–F).

Host plants

During the investigations 22 species were identified as host plants of *M. pruinosa* in Warsaw, which are presented in Table 1. All plants belong to angiosperms, apart from blue spruce (*Picea pungens*), which represents gymnosperms.

Bionomy

Nymphs were first observed in June, adults emerged in mid-July and survived until the end of October. This

Table 1. List of host plant species utilized by *Metcalfa pruinosa* in the locality site of Warsaw

Species	Genus	Family	Order	Superorder
Acer negundo L.	*Acer* L.	Sapindaceae Juss.	Sapindales Juss. ex Bercht. & J. Presl	Rosanae Takht.
Acer platanoides L.	*Acer* L.	Sapindaceae Juss.	Sapindales Juss. ex Bercht. & J. Presl	Rosanae Takht.
Amaranthus retroflexus L.	*Amaranthus* L.	Amaranthaceae Juss.	Caryophyllales Juss. ex Bercht. & J. Presl	Caryophyllanae Takht.
Artemisia vulgaris L.	*Artemisia* L.	Asteraceae Bercht. & J. Presl	Asterales Link	Asteranae Takht.
Berberis sp.	*Berberis* L.	Berberidaceae Juss.	Ranunculales Juss. ex Bercht. & J. Presl	Ranunculanae Takht. ex Reveal
Catalpa bignonioides Walter	*Catalpa* Scop.	Bignoniaceae Juss.	Lamiales Bromhead	Asteranae Takht.
Conyza sp.	*Conyza* Less.	Asteraceae Bercht. & J. Presl	Asterales Link	Asteranae Takht.
Cornus sp.	*Cornus* L.	Cornaceae Bercht. ex J. Presl	Cornales Link	Asteranae Takht.
Crataegus monogyna Jacq.	*Crataegus* L.	Rosaceae Juss.	Rosales Bercht. & J. Presl	Rosanae Takht.
Deutzia sp.	*Deutzia* Thunb.	Hydrangeaceae Dumort.	Cornales Link	Asteranae Takht.
Juglans regia L.	*Juglans* L.	Juglandaceae DC. ex Perleb	Fagales Engl.	Rosanae Takht.
Ligustrum vulgare L.	*Ligustrum* L.	Oleaceae Hoffmanns. & Link	Lamiales Bromhead	Asteranae Takht.
Lycium chinense Mill.	*Lycium* L.	Solanaceae Juss.	Solanales Juss. ex Bercht. & J. Presl	Asteranae Takht.
Melilotus albus Medik.	*Melilotus* (L.) Mill.	Fabaceae Lindl.	Fabales Bromhead	Rosanae Takht.
Oenothera sp.	*Oenothera* L.	Onagraceae Juss.	Myrtales Juss. ex Bercht. & J. Presl	Rosanae Takht.
Picea pungens Engelm.	*Picea* A. Dietr.	Pinaceae Spreng. ex Rudolphi	Pinales Gorozh.	–
Sambucus nigra L.	*Sambucus* L.	Viburnaceae Raf.	Dipsacales Juss. ex Bercht. & J. Presl	Asteranae Takht.
Solidago gigantea Aiton	*Solidago* L.	Asteraceae Bercht. & J. Presl	Asterales Link	Asteranae Takht.
Spiraea japonica L. f.	*Spiraea* L.	Rosaceae Juss.	Rosales Bercht. & J. Presl	Rosanae Takht.
Symphyotrichum novae-angliae (L.) G.L. Nesom	*Symphyotrichum* Nees	Asteraceae Bercht. & J. Presl	Asterales Link	Asteranae Takht.
Tamarix ramosissima Ledeb.	*Tamarix* L.	Tamaricaceae Link	Caryophyllales Juss. ex Bercht. & J. Presl	Caryophyllanae Takht.
Urtica dioica L.	*Urtica* L.	Urticaceae Juss.	Rosales Bercht. & J. Presl	Rosanae Takht.

indicates that in Poland the citrus flatid planthopper gives one generation per year and overwinters as eggs, which agrees with observations of other authors (Mead 1969; Lauterer 2002).

Discussion

The first recorded population of *M. pruinosa* in Poland seems to be persistent taking into account that several individuals were already observed by amateur entomologist Teodor Smulski in 2020 and the number of observed individuals in 2021 was quite high. All observed plants to be attacked belonged to angiosperms, with the exception of blue spruce (*Picea pungens*). Vlad and Grozea (2016) observed that conifers are rarely attacked, probably because they have needles or scale-like leaves with thick, rough and waxy epidermis. In Romania the flatid only attacked *Pinus strobus*, *Taxus baccata* and *Thuja orientalis*.

The most obvious effect of nymphs and adults sucking phloem sap is deformation and injury to shoots and twigs leading to wilt and destruction.

Moreover, this planthopper produces considerable amounts of honeydew because it lacks a filter chamber and has a midgut cellular membrane, which prevents efficient consumption of sugars (Lucchi *et al.* 1999). The excreted honeydew is often colonized by sooty moulds from several taxa, especially the family Capnodiaceae (Della Gustina and Navarro 1993). It is the most serious impairment of diverse plants by *M. pruinosa* in Europe as the honeydew and hyphae of microfungi stop transpiration. Nymphs and adults feed mainly during daylight hours, whereas local movement of nymphs and dispersal and mating of adults take place at night (Wilson and Lucchi 2007).

Another problem is that the juveniles and adults produce a significant amount of wax that covers the whole body. Wax filaments deposited on leaves and shoots destroy the aesthetic value of ornamentals in nurseries and parks. The wax protects insects against adverse abiotic (UV radiation, rain) and biotic factors (entomopathogenic fungi, parasitoid insects and predators) (Lucchi and Santini 2001). Moreover, in this species, the wax probably plays an important role in preventing individuals from becoming contaminated with honeydew, perpetually secreted by juveniles and adults, which would cover the cuticle with sticky droplets (Lucchi and Mazzoni 2004).

Because *M. pruinosa* is a typical phloem feeder, it has been proposed as a possible vector of phytoplasmas. According to the analysis of phytoplasma 16S rRNA gene sequences, several studies have documented the occurrence of aster yellows (16SrI-B), clover phyllody (16SrI-C), stolbur (16SrXII-A), elm yellows (16SrV) and apple proliferation (16SrX) phytoplasmas in the insect (Danielli *et al.* 1996; Landi *et al.* 2007).

Further experiments were carried out to assess the vector competence of this species, which showed that *M. pruinosa* was unable to transmit flavescence dorée phytoplasma (16SrV group) and clover phyllody (16SrI-C subgroup) to grapevine, broadbean (*Vicia faba*) and nettle (*Urtica dioica*) (Bressan *et al.* 2006; Trivellone *et al.* 2019). However, the recent work of Mergenthaler *et al.* (2020) based on rigorous experiments gives experimental evidence that *M. pruinosa* is a vector of AY phytoplasmas (16SrI-B subgroup) to French marigold (*Tagetes patula*). This work is not inconsistent with the previously mentioned findings because flavescence dorée (16SrV group) or clover phyllody (16SrI-C subgroup) are phylogenetically and ecologically distant phytoplasmas compared to AY phytoplasmas (16SrI-B subgroup). Another point is that all these other transmissions were attempted to laboratory experimental plants, which may explain why they did not succeed.

The ability of *M. pruinosa* to transmit the 16SrI-B group in Hungary can be of tremendous importance for the spread of AY in Poland taking into account that this phytoplasma is involved in epidemics and the AY disease cycle associated with winter oilseed rape in Poland (Zwolińska *et al.* 2019). The appearance of a polyphagous invasive planthopper, which has been shown to be a capable vector of this phytoplasma, poses a serious threat of achieving an epidemic level, and transmitting the phytoplasma from wild grassland plants surrounding agroecosystems to crops.

Donati *et al.* (2017) found the potential of *M. pruinosa*, one of the most common kiwifruit pests in Italy, to transmit bacterium *Pseudomonas syringae* pv. *actinidiae* Takikawa (Psa) from experimentally inoculated plants to healthy ones under laboratory conditions. In its native range there is usually no need for pest control apart from cases where obvious damage is observed, which is, however, uncommon (Mead 1969). Cutting twigs infested with eggs and the usage of many insecticides have been successful against the pest, however, many of them are of broad spectrum belonging to the groups of organophosphates and pyrethroids (Girolami and Mazzon 2001), and therefore they may be a substantial danger to beneficial arthropods, e.g., honeybees (*Apis mellifera* Linnaeus, 1758), which collect honeydew produced by the planthopper and utilize it to produce honey (Lucchi 1997). Moreover, the reinfestation of the treated crop with highly mobile individuals from neighboring vegetation is also possible.

The non-native parasitoid wasp *Neodryinus typhlocybae* (Ashmead, 1893) (Hymenoptera, Dryinidae) has been considered as a potential control agent since the 1980s, being the only natural enemy of *M. pruinosa*

occurring throughout its native range (Girolami and Mazzon 1999). The first specimens of *N. typhlocybae* originating from the USA (area of Connecticut) were repeatedly released in northwestern Italy in 1987 and the following years (Girolami and Camporese 1994). Apart from many parts of Italy, *N. typhlocybae* was also introduced into Croatia, France, Greece, the Netherlands, Slovenia, Spain and Switzerland (Strauss 2009, 2012). The appearance of the species in Austria, Hungary, Bulgaria and Slovakia during the last decade is associated with its natural dispersal across central Europe (Vétek *et al.* 2019). It is possible that the parasitoid will also appear in Poland if populations of its host increase significantly.

Females of *N. typhlocybae* parasitize the third, fourth and fifth nymphal stages of *M. pruinosa*, and they also prey on the nymphs. The egg of the parasitoid is inserted by the female into the intersegmental membrane below the mesothoracic wing pad of the flatid nymph. The hatching and developing of white-yellowish larva may be observed with its posterior part protruding partly from the body of the host below the wing pad, forming a thylacium. The mature larva penetrates the host body, destroys its organs, and finally leaves the host and prepares a whitish, oval, double-walled cocoon under the residues of the dead host (Guglielmino and Bückle 2003). It is important that *N. typhlocybae* attacks exclusively *M. pruinosa*, having no affinity to native European planthoppers.

Interestingly, Bocca *et al.* (2020) recently provided evidence that the species of *Oligosita collina* group (Hymenoptera, Trichogrammatidae) parasitizes eggs of *M. pruinosa* at a parasitization rate of over 40%, which is much higher than the one showed for the previously mentioned *N. typhlocybae*. The parasitization rate mainly depends on the host egg density and the abundance of plants appropriate for the oviposition. *O.* cf *collina* is probably attracted by the exudates or honeydew manufactured by the planthopper, which can perform as a contact-kairomone.

There are examples of insects and spiders, which prey on *M. pruinosa*. Kahrer *et al.* (2009) observed that *Coccinella septempunctata* Linnaeus, 1758 preys on 3rd and 4th instar larva of the planthopper. Following this, Grozea *et al.* (2015) tried to introduce biological control against this species by using Coccinellid beetles in ornamental plants in Romania. Camerini (2017) researched a spider species to provide biological control against this pest in northern Italy. The community of spiders mainly covered species belonging to Agelenidae (27.4%), Linyphiidae (26.7%) and Araneidae (15.6%), with *Agelena labyrinthica* (Clerck, 1757) and *Linyphia triangularis* (Clerck, 1757) as the most common planthopper predators. Almost all residues of *M. pruinosa* found in the webs were adults of the pest, while the predation of juvenile stages was insignificant.

Summarizing, *M. pruinosa* can pose a real danger, both for ornamental and agricultural plants (Grozea *et al.* 2011). At present, being in the settling period in the city of Warsaw, it is associated mainly with ornamental plants, however, we predict migration of the planthopper outside the city to suburbs and agricultural areas. Permanent monitoring of the species in its primary locality and neighboring areas is recommended as a preventive control measure, including visual inspections of plants in parks and allotments, especially from May to July when the wax filaments are clearly visible. It is possible that the insect will soon be recorded in other cities of Poland, if foreign, egg-infested ornamental plants are planted in parks and gardens.

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