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Host plant preference of *Metcalfa pruinosa* (Say, 1830) (Hemiptera: Flatidae) in the north of Hungary

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SUMMARY

Citrus flatid planthopper, a native insect to North America had for a long time a scarce economic importance there. However, being polyphagous made little damage on citrus trees and some ornamentals. In 1979 it was introduced to Italy where it established and spread quickly. It is now an invasive alien species continually spreading in South and Central Europe causing considerable damage in fruit crops and various ornamentals. Present study shows the results of a series of observations carried out from 2011 to 2015 at a number of habitats in north of Hungary. The pest could be found at each habitat but the hedge, the tree row, the gardens and the orchard/vineyard were the most infested. Frequency and population density of Metcalfa pruinosa *were considerable on Asteraceae, Cannabaceae, Fabaceae, Juglandaceae, Lamiaceae, Rosaceae and Sapindaceae. Typical vegetation could be functionally classified as ornamental plants, trees/shrubs, fruit plants, weeds and feral plants. Feral plants – some of them also invasive alien species – were found at each habitat. Plant species native to America were among them the most populated. As the hedgerows were neglected, and most gardens, orchards and vineyards abandoned, these are excellent conditions for the quick and long-lasting establishment of the pest as well as they may be reservoirs to infest cultivated fruit crops and ornamentals. The hedgerow was situated along a railway line. The length of similar hedges can be merely in Pest county several hundred km, which means* M. pruinosa *has plenty of opportunity for spreading along the railway and infest agricultural and ornamental cultures. On the surveyed alfalfa and maize fields, accidentally very few nymphs and adults were observed. Although, the population density of* M. pruinosa *was considerable on many hostplants, economic damage or yield losses could not be detected. Economic or significant damage was observed only on roses, raspberries and stinging nettle. This later is cultivated in Germany and Finland. The applied horticultural oil was efficient.*

Keywords: *Metcalfa pruinosa*, host plant, hedgerow, tree row, garden, orchard, vineyard

INTRODUCTION

Citrus flatid planthopper (CFP) *Metcalfa pruinosa* (Say, 1870) is native to North America from where it was accidentally introduced to Italy in 1979 (Zangheri and Donadini, 1980). After a rapid spreading in Italy it managed to get to more than 15 European countries (Strauss, 2010). Its harm is little in the USA: some fruit trees and ornamentals suffered little damage and aesthetic injury (Mead, 1969). Being polyphagous, *M. pruinosa* attacked various cultivated and wild trees, shrubs and weedy plants in Italy (Bagnali and Luccchi 2000). Sucking of nymphs can cause deformation and injury of shoots and twigs leading to wilt and destruction. Grape quality damaged considerably as a consequence of nymphs' feeding (acidity and sugar content altered) and also soybean suffered a 30-40% yield loss in Italy (Ciampolini *et al*., 1987). Grape quality decreased heavily by the honeydew production of *M. pruinosa* and the following sooty mould formation in France (Della Giustina and Navarra, 1993). Ornamentals in nurseries and parks are in danger because of the waxy filaments produced on leaves and shoots by CFP (Lauterer, 2002; Strauss, 2010). It was revealed that some *M. pruinosa* were infested with various phytoplasmas but they could not transmit them in experiments (Bressan *et al*., 2006 in Strauss, 2010).

In Europe, *M. pruinosa* has been settled in Italy, France (Della Giustina, 1986), Slovenia (Sivic, 1991 in Strauss 2010), Switzerland (Jermini *et al*., 1995), Croatia (Maceljski *et al*., 1995 in Strauss, 2010), Austria (Kahrer and Moosbeckhofer, 2003), Greece (Drosopoulos *et al*., 2004 in Strauss 2010), Spain (Pons *et al*., 2002 in Strauss, 2010), Serbia and Montenegro (Hrncic, 2003), Hungary (Orosz and Dér, 2004), Bulgaria (Tomov *et al*., 2006 in Strauss, 2010), Turkey (Karsavuran and Güçlu, 2004 in Strauss, 2010), Bosnia Herzegovina (Gotlin Culjak *et al*., 2007 in Strauss, 2010), Romania (Grozea *et al*., 2011) and was found also in Albania, Slovakia and Russia (DAISIE website, 2015). *M. pruinosa* populations found in the UK and Bohemia were successfully eradicated by insecticide treatments (C. Malumphy and P. Lauterer, personnel communication in Strauss, 2009).

In Bohemia, Austria and Romania started thorough observations and investigations to get to know its spread, host plants and control. In Austria using the CLIMEX® programme various parameters (temperature index, diapausa index, moisture index, cold, wet, dry and heat stresses) were investigated in order to find the susceptible Austrian areas and cultures and also worked on the control opportunities (Strauss, 2010).

M. pruinosa occurred in Hungary (Budapest) in 2004 but its expansion and injury have not been reported considerable. The pest was observed on feeding *Ambrosia artemisiifolia* L. in Szabolcs-Szathmár county (Lajos Szőke personnel communication, 2011), which was considered as a possible natural weed control.

The aim of this study was studying the most frequent host plants of *M. pruinosa* monitored in various habitats of Gödöllő and countryside as well as to conclude with assessing the population density to the preference of the pest.

Morphology

Mead (1969) and Lauterer (2002) gave a detailed morphological characterisation on adults and nymphs, thus here only a very brief description will be provided. Adults are 7-8 mm in length. Dorsal surface of the body and forewings are blackish brown. Body and forewings are covered with a whitish powdery secretion making the blackish colour grey-bluish. The nymphs' body is flattened and white, covered with a dense waxy substance forming long filaments at the apex. The same waxy secretion is produced on leaves and shoots where the nymphs feed. The 5th – last one – instar is 5-6 mm long. Development stage of nymphs can be distinguished by the size of head capsule and wing pads (Lauterer, 2002).

Life cycle

M. pruinosa has one generation a year and overwinters as eggs laid in the bark of damaged twigs (Mead, 1969, Lauterer 2002). In France and Austria, nymphs can hatch from May to mid July and suck phloem sup of host plants and produce a lot of honeydew. They have five growth stages. Finishing development adults emerge in August and begin laying eggs. Egg production can be maximum 90 eggs (Della Giustina, 1987; Kahrer *et al*., 2009).

Host plants

M. pruinosa is a polyphagous planthopper feeding on a great diversity of plants. Unfortunately, because of this high diversity it is difficult to prove its preference and future injury.

In the USA, CFP was found on citrus, grape fruit, orange, grape, many forest and fruit trees, shrubs and some herbs (Mead, 1969). Bagnoli and Lucchi (2000) reported more than 200 host plants from different families for *M. pruinosa* in Italy. In the Czech Republic, *M. pruinosa* slightly damaged ornamental plants like *Thuja occidentalis* L., *Juniperus communis* L., *Sorbus aucuparia* L., *Lilium* sp. and were found also on some woody species (Lauterer, 2002). In Austria (Vienna), the following host plant genera were observed: *Acer*, *Aesculus*, *Ailanthus*, *Amaranthus*, *Amelanchier*, *Amorpha*, *Arctium*, *Aronia*, *Artemisia*, *Aucuba*, *Ballota*, *Bryonia*, *Buddleja*, *Buxus*, *Calycanthus*, *Campanula*, *Canna*, *Carpinus*, *Catalpa*, *Ceratostigma*, *Cercis*, *Chaenomeles*, *Chelidonium*, *Chenopodium*, *Clematis*, *Clivia*, *Convolvulus*, *Conyza*, *Cornus*, *Corylus*, *Cotinus*, *Cotoneaster*, *Crataegus*, *Cucurbita*, *Daphne*, *Daucus*, *Deutzia*, *Dipsacus*, *Duchesnea*, *Echium*, *Epilobium*, *Epimedium*, *Erigeron*, *Euonymus*, *Fagus*, *Falcaria*, *Fallopia*, *Ficus*, *Fontanesia*, *Forsythia*, *Fraxinus*, *Galium*, *Geranium*, *Geum*, *Glechoma*, *Hedera*, *Heptacodium*, *Heracleum*, *Hibiscus*, *Hippophae*, *Humulus*, *Hydrangea*, *Hypericum*, *Jasminum*, *Juglans*, *Knautia*, *Koelreuteria*, *Kolkwitzia*, *Laburnum*, *Lamium*, *Leonurus*, *Ligustrum*, *Lonicera*, *Lycium*, *Lythrum*, *Magnolia*, *Mahonia*, *Majorana*, *Malus*, *Malva*, *Medicago*, *Mercurialis*, *Mespilus*, *Morus*, *Nerium*, *Oxalis*, *Parthenocissus*, *Paulownia*, *Pennisetum*, *Petroselinum*, *Phaseolus*, *Philadelphus*, *Physocarpus*, *Phytolacca*, *Pieris*, *Pinus*, *Plantago*, *Platanus*, *Polygonum*, *Poncirus*, *Populus*, *Potentilla*, *Prunus*, *Ptelea*, *Pyracantha*, *Pyrus*, *Quercus*, *Rhododendron*, *Rhus*, *Ribes*, *Robinia*, *Rosa*, *Rosmarinus*, *Rubus*, *Rumex*, *Salix*, *Sambucus*, *Silene*, *Sisymbrium*, *Skimmia*, *Solanum*, *Solidago*, *Sonchus*, *Sorbus*, *Spartium*, *Spiraea*, *Staphylea*, *Symphoricarpus*, *Syringa*, *Tagetes*, *Tanacetum*, *Taraxacum*, *Taxus*, *Thuja*, *Tilia*, *Triticum*, *Ulmus*, *Urtica*, *Vaccinium*, *Veronica*, *Viburnum*, *Vinca*, *Viola*, *Vitis*, *Weigela*, *Wisteria*, *Yucca*. Nymphs, adults or both of them were found on these genera (Kahrer *et al*., 2009). There was presented another study indicating that 251 plant species among them numerous horticultural and agricultural varieties were attacked either by the nymphs or imagines of the planthopper (Moosbeckhofer *et al*., 2009). In Serbia (Belgrad), *M. pruinosa* were reported on woody species in the genera: *Acer*, *Aesculus*, *Gleditchia*, *Robinia*, *Ailanthus*, *Populus*, *Platanus*, *Prunus*, *Pyrus*, *Ulmus*, *Tilia*, *Cornus*, *Fraxinus*, *Quercus* and *Thuja* (Mihajlović, 2007). In Romania, it was collected and seen on *Acer saccharinum* L., *Juglans nigra* L., *Juniperus* sp., *Thuja occidentalis* L., *Buxus sempervirens* L., *Albizia julibrissin Durazz.*, *Potentilla (Dasiphora) fruticosa* L., *Cycas revoluta* Thunb., *Vitis vinifera* L., *Atriplex hortensis* L., *Sambucus nigra* L., *Melissa officinalis* L., *Philadelphus coronaries* L., *Ligustrum vulgare* L., *Hibiscus rosa-sinensis l.* and *Rosa* sp. (Grozea *et al*., 2011). In western counties of Romania *M. pruinosa* nymphs were observed on 45 host plants species at various habitats like parks, orchard and vineyard. The most important plants were *Acer negundo* L., *Acer pseudoplatanus* L., *Acer campestre* L., *Acer platanoides* L., *Catalpa bignonioides* Walter, *Hibiscus syriacus* L., *Juglans regia* L., *Ligustrum vulgare*, *Malus domestica* L., *Prunus persica* (L.) Batsch, *Prunus armeniaca* L., *Prunus domestica* L., *Tilia cordata* Mill., and *Vitis vinifera* L. In Greece, 26 ornamental, 15 fruit, nine weed and two vegetable plant species were reported as associated with CFP. Among them there were three monocotyledonous species, each of them weeds such as *Bromus* sp., *Digitaria sanguinals* (L.) Scop. and *Setaria* sp. (Souliotis *et al*., 2008).

In Hungary, *M. pruinosa* was observed in Budapest on the following plants: *Acer* sp., *Aesculus hippocastanum* L., *Berberis* sp., *Crataegus* sp., *Hibiscus* sp., *Syringa* sp., *Ulmus* sp. (Orosz and Dér, 2004). In addition, Bozsik (2012) listed some plants on which adults and waxy secretion of *M. pruinosa* were observed: *Acer negundo* L., *Celtis occidentalis* L., *Clematis vitalba* L., *Crataegus monogyna* Jacq., *Lycium halimifolium* L., *Morus alba* L., *Prunus padus* L., *Prunus serotina* Ehrh., *Prunus spinosa* L., *Robinia pseudoacacia* L., *Rosa canina* L., *Ulmus campestris* L. and *Vitis vinifera* L.

Control of *Metcalfa pruinosa*

In its native area usually there is no need for control except in case of obvious damage which is a rarity (Mead, 1969). Cutting twigs infested with eggs or treatments with horticultural oil and insecticidal soap is enough against *M. pruinosa* (Rebek, 2009). Chlorpyriphos and imidacloprid was efficient in Austria (Kahrer and Moosbeckhofer, 2003). Fenitrothion was used successfully in the Czech Republic (Lauterer, 2002). Strauss (2009) studied control opportunities with special regard for the use of the natural enemy, *Neodryinus typhlocybae* (Ashmead, 1893) (Hymenoptera: Dryinidae) which has been released in Italy, France and Slovenia. She showed that *N. typhlocybae* attacked and parasitised only *M. pruinosa* and the native European planthoppers were saved (Strauss, 2009). Malausa *et al*. (2003) introduced *N. typhlucybae* in the south of France in 1996 to control *M. pruinusa*. The parasitoid was released in about sixty sites and after five years of the first introduction the authors evaluated the establishment and dispersal of *N. typhlucybae*. They found established populations in 51 (86%) sites.

Route of spreading

Spreading of *M. pruinosa* in Hungary could be with transported tree and ornamental seedlings from areas where the pest is established or the planthopper itself could migrate from the same localities. According to Lauterer (2002) the natural annual spreading of *M. pruinosa* is about 50 m on each direction. Grozea *et al*. (2011) thought *M. pruinosa* individuals flew in Romania (Temes County) from the neighbouring Serbia and Hungary. It means that the density of this planthopper in Hungary was estimated as high.

MATERIALS AND METHODS

The surveyed sites were found at Gödöllő and Máriabesnyő about 25 km from Budapest. Most areas at Máriabesnyő belonged to the Szent István University and localised along the railway running towards Budapest. Localities at Gödöllő were in the centre of the town and at the Blaha district. The Blaha district is an area where orchards, vineyards and vegetable gardens were found (*Table 1*).

Hedge (Máriabesnyő)
Vegetation of the area consisted of European and some adventive (with American and Asian origin) trees and bushes that created a very dense structure.

Tree row (Máriabesnyő)
A line of trees – along an alfalfa field and a field path – consisted mainly of matured trees and some saplings. The trees generally do not meet each other.

Stinging nettle spot (Máriabesnyő)
It was found at the border of a deciduous wood below the tree branches.

Backside garden (Máriabesnyő)
It contained ornamental plants, fruit trees and shrubs.

Maize field (Máriabesnyő)
The field was overgrown with weeds such as *Artemisia vulgaris*, *Ambrosia artemisiifolia*, *Cannabis sativa spontanea*, *Chenopodium album* and *Atriplex tatarica*. The weeds hampered even the moving in the field. Four times 25 corn plants were visually surveyed along a transect line. No pesticides were applied.

Alfalfa field (Máriabesnyő)
The field was overrun with weeds such as *Rumex obtusifolius*, *Agropyron repens*, *Setaria glauca*, *Senecio vulgaris* and *Lactuca serriola*. The alfalfa stand was thinned out and the weeds covered more space than the alfalfa. Captures were obtained by sweeping net (4 x 25 sweeps). The individuals captured by sweeping were taken into a freezer, then dried for a while and identified immediately. At the field no pesticides were applied.

Backside garden (Gödöllő)
It contained ornamental and fruit trees and shrubs.

Orchard and vineyard (Gödöllő)
The site was grown over with fruit trees and grapevine.

In the hedge, five shoots of randomly selected trees or bushes – or weedy plants – were observed from a 50 cm distance and the number of nymphs and adults of *M. pruinosa* was recorded (abbreviated as VO1). In case of the other habitats (except the alfalfa field), plants were examined similarly but instead of counting the pest

individuals the following approximation was used: 1 = weak infestation (< 5 nymphs or adults on a shoot part); 2 = middle infestation (5 - 10 nymphs or adults on a shoot part); 3 = strong infestation (> 10 nymphs or adults on a shoot part; abbreviated as VO2) (Kahrer *et al*., 2009).

Also the efficiency of chemical control administered at the Máriabesnyő garden was approximately assessed. A horticultural oil (Vectaphid A EC: 83% paraffin oil +17% Atplus 309 F - in a concentration of 0.5%) was applied two times in July and once in August in 2015 with a manual backpack sprayer.

Table 1

Basic data of the surveys

Site and date	Geographic position Altitude	Habitat Size	Surveying method	Surveying frequency
Máriabesnyő 2013 from early July to early October	47°36'3″ N 19°21'59″E 209 m	hedge 660 m	visual observation = VO1	weekly
Máriabesnyő 2015 from early July to early September	47°35'54″N 19°22'56″E 211 m	tree row 649 m	VO2	weekly
Máriabesnyő 2013-15 from early June to early October	47°35'37″N 19°22'59″E 196 m	stinging nettle spot 60 m2	VO2	weekly
Máriabesnyő 2011-15 from early April to early October	47°35'44″N 19°22'54″E 204 m	backside garden 680 m2	VO2	weekly
Máriabesnyő 2015 from early July to early September	47°35'51″N 19°22'29″E 207 m	maize field 2.7 ha	VO1	weekly
Máriabesnyő 2015 from early July to early September	47°35'52″N 19°22'5″E 212 m	alfalfa field 7.7 ha	sweep netting	weekly
Gödöllő 2011-15 from early April to early October	47°36'9″N 19°21'27″E 188 m	backside garden 1296 m2	VO2	weekly
Gödöllő 2011-15 from early April to early October	47°37'25″N 19°19'56″E 192 m	orchard and vineyard 2160 m2	VO2	weekly

RESULTS

Most important habitats in North America of CFP are mixed deciduous woods and open areas overgrown with bushes. Also in Italy, the pest started its spread from an open bushland (Moosbeckhofer *et al*., 2009). In Central and South Europe, similar habitats were sampled. Regarding the Czech Republic, it was found in a nursery of ornamentals (Lauterer, 2002) and in Austria, the pest was first found and sampled in gardens, parks, a city wood with ornamental and not cultivated trees and shrubs and a cemetery (Moosbeckhofer *et al*., 2009).
In Romania, similarly, parks, green areas, public gardens, an orchard, a vineyard and vegetation along the roads were observed and surveyed (Preda and Skolka, 2011; Grozea *et al*., 2015). In Greece, citrus and olive groves were investigated to monitor CFP (Souliotis *et al*., 2008). In the present study, a hedge, a tree row and various horticultural and agricultural spaces such as gardens, an orchard, a vineyard, two fields and a nettle stand were examined.

M. pruinosa individuals or their waxy secretion were observed on 57 species of 31 plant families at seven survey sites (*Table 2*). The most objective investigation was carried out at the hedge where 23 species of 14 families were associated with *M. pruinosa*. *R. pseudoacacia, P. spinosa, C. vitalba, U. campestris, P. cerasifera* were the most attacked host plants (*Table 3*). At the tree row the pest was observed on 12 plants of eight families and *R. pseudoacacia, C. occidentalis* and *A. pseudoplatanus* showed the highest pest density (*Table 4*). The vegetation of the backside garden at Máriabesnyő indicated the highest number of infested host plants. *R. idaeus, C. occidentalis, H. lupulus, R. damascena, J. regia, R. canina* and *H. helix* revealed a strong *M. pruinosa* population (*Table 5*). In the Gödöllő backside garden with 15 infested host plants *C. occidentalis, J. regia* and *R. damascena* were the most preferred plants (*Table 6*). In the Gödöllő orchard eight plants was infested and the pest was observed mainly on *C. occidentalis, R. pseudoacacia* and *A. negundo* (*Table 7*). Plants of the stinging

Table 2

Host plants associated with *Metcalfa pruinosa* at Gödöllő and environment (H = hedge, T = tree row, BB = backside garden Máriabesnyő, BG = Backside garden Gödöllő, OG = orchard, vineyard Gödöllő)

Host plant	H	T	BM	BG	OG
Acer campestre	+	+	+	+	
Acer negundo	+			+	+
Acer platanoides	+	+			
Acer pseudoplatanus		+			
Achillea colinna			+		
Alcea rosea			+		
Ailanthus altissima					
Ambrosia artemisiifolia	+				
Buxus sempervirens				+	
Caryopteris incana x Caryopteris mongholica			+		
Castanea sativa			+		
Celtis occidentalis	+	+	+	+	+
Chrysanthemum indicum			+		
Clematis vitalba	+				
Cornus sanguinea		+	+		
Cosmos bipannatus			+		
Crataegus monogyna	+		+		
Euonymus europeus	+		+		
Euonymus japonicus			+		
Euphorbia salicifolia	+				
Forsythia suspensa				+	
Fragaria vesca	+				
Fraxinus ornus		+			
Gleditsia triacanthos				+	
Hedera helix			+	+	
Helianthus tuberosus			+		
Humulus lupulus	+		+		+
Juglans regia	+	+	+	+	+
Mahonia aquifolium				+	
Malus domestica	+	+	+		
Morus nigra	+				
Nerium oleander			+		
Populus nigra		+			
Prunus cerasifera	+				
Prunus domestica			+	+	
Prunus serotina	+	+			
Prunus spinosa	+				
Philadelphus coronarius				+	
Physostegia virginiana			+		
Robinia pseudoacacia	+	+			+
Rosa canina	+	+	+	+	+
Rosa damascena			+	+	
Rubus fruticosus			+		
Rubus idaeus			+		
Salvia sclarea			+		
Sambucus nigra	+				
Solanum nigrum	+			+	
Solidago canadensis			+		+
Spirea x vanhouttei				+	
Syringa vulgaris			+		
Ulmus campestris	+				
Urtica urens			+		
Vitis vinifera			+		+
Weigela florida			+		

Table 3

Host plants and frequency of *Metcalfa pruinosa* (hedge, Máriabesnyő, 2013, + = waxy secretion found)

Plant	Number of shoots	Number of *M. pruinosa*		
		nymphs	adults	waxy rests
Acer campestre	9	-	5	+
Acer negundo	13	-	40	+
Acer platanoides	35	2	41	+
Ailanthus altissima	2	2	2	+
Ambrosia artemisiifolia	1	-	-	+
Celtis occidentalis	11	2	4	+
Clematis vitalba	99	169	36	+
Crataegus monogyna	56	4	23	+
Euonymus europeus	8	-	10	+
Euphorbia salicifolia	1	-	-	+
Fragaria vesca	1	-	1	+
Humulus lupulus	10	-	13	+
Juglans regia	2	-	4	+
Malus domestica	3	18	-	+
Morus nigra	1	-	-	+
Prunus cerasifera	60	39	66	+
Prunus serotina	11	-	5	+
Prunus spinosa	84	251	36	+
Robinia pseudo-acacia	317	1160	101	+
Rosa canina	6	-	3	+
Sambucus nigra	1	-	-	+
Solanum nigrum	1	-	-	+
Ulmus campestris	130	114	71	+

Table 4

Host plants and frequency of *Metcalfa pruinosa* (tree row, Máriabesnyő, 2015)

Plant	*M. pruinosa*		
	nymphs	adults	waxy filaments
Acer campestre	-	1	-
Acer platanoides	-	1	-
Acer pseudoplatanus	1	2	+
Celtis occidentalis	2	2	+
Cornus sanguinea	-	1	+
Fraxinus ornus	1	1	+
Juglans regia	1	1	+
Malus domestica	-	1	-
Populus nigra	-	1	+
Prunus serotina	-	1	-
Robinia pseudoacacia	1	2	+
Rosa canina	-	1	-

nettle stand were strongly infested. The average number of nymphs and adults of *M. pruinosa* varied between 30 and 100 individuals or more.

Tables 8-12 specify the host plant families classified in functional groups like ornamental plants, trees, fruit plants, weeds and feral plants. The plants studied were almost exclusively dicotyledonous species except maize. CFP was found also on maize plants. Their density was very low: some 4^{th}, 5^{th} instar nymphs and adults of *M. pruinosa* as well as some waxy secretion were observed on the leaves and stalks. The infestation on maize can be regarded as very scarce. The population density of the pest in the alfalfa field was accidental. At this field along the tree row investigated, altogether two adults were found in the net during the survey period in the late of August. On the alfalfa plants no nymphs or waxy rests were observed.

The three times applied horticultural oil at the Máriabesnyő garden allowed to decrease the planthopper's density to a tolerable level in roses and raspberries.

Table 5

Host plants and frequency of *Metcalfa pruinosa* (backside garden, Máriabesnyő, 2011-15)

Plant	*M. pruinosa*		
	nymphs	adults	waxy filaments
Acer campestre	1	2	+
Achillea colinna	-	1	-
Alcea rosea		1	-
Caryopteris incana x Caryopteris mongholica	-	1	+
Castanea sativa	1	1	+
Celtis occidentalis	2	2	+
Chrysanthemum		1	+
Cornus sanguinea	1	2	+
Cosmos bipinnatus	-	1	-
Crataegus monogyna	1	1	
Euonnymus europeus	1	1	+
Euonymus japonicus	1	1	+
Hedera helix	1	3	+
Helianthus tuberosus	-	1	-
Humulus lupulus	2	3	+
Juglans regia	2	2	+
Malus domestica	1	1	+
Nerium oleander	1	1	+
Prunus domestica	-	1	+
Physostegia virginiana	-	1	-
Rosa canina	1	2	+
Rosa damascena	2	3	+
Rubus caesius	-	1	-
Rubus idaeus	3	3	+
Salvia sclarea	-	2	+
Solidago canadensis	-	1	-
Syringa vulgaris	-	1	-
Urtica urens	-	1	+
Vitis vinifera	1	2	+
Weigela florida	-	1	-

Table 6

Host plants and frequency of *Metcalfa pruinosa* (backside garden, Gödöllő, 2011-15)

	M. pruinosa		
Plant	nymphs	adults	waxy filaments
Acer campestre	1	1	+
Acer negundo	1	1	+
Buxus sempervirens	1	1	+
Celtis occidentalis	2	3	+
Forsythia suspensa	-	1	-
Gleditsia triacanthos	-	1	+
Hedera helix	-	1	-
Juglans regia	2	2	+
Mahonia aquifolium	-	1	+
Philadelphus coronarius	-	1	+
Prunus domestica	1	1	+
Rosa canina	1	1	+
Rosa damascena	1	2	+
Solanum nigrum	-	1	-
Spirea × vanhouttei	-	1	-

Table 7

Host plants and frequency of *Metcalfa pruinosa* (orchard and vineyard, Gödöllő, 2011-15)

Plant	*M. pruinosa*		
	nymphs	adults	waxy filaments
Acer negundo	1	2	+
Celtis occidentalis	2	2	+
Humulus lupulus	1	1	+
Juglans regia	1	1	+
Robinia pseudoacacia	1	2	+
Rosa canina	-	1	-
Solidago gigantea	-	1	+
Vitis vinifera	-	1	+

Table 8

Functionally classified host plant families (hedge, Máriabesnyő, 2013)

Plant family	Trees shrubs climbers	Fruit plants	Weeds	Feral plants	Total number of species
Adoxaceae	1				1
Asteraceae			1		1
Cannabaceae	2				2
Celastraceae	1				1
Euphorbiaceae			1		1
Fabaceae	1				1
Juglandaceae		1			1
Moraceae				1	1
Ranunculaceae	1				1
Rosaceae	4	2		1	7
Sapindaceae	2			1	3
Simaroubaceae				1	1
Solanaceae			1		1
Ulmaceae	1				1
Number of species	13	3	3	4	23

Table 9

Functionally classified host plant families (tree row, Máriabesnyő, 2013)

Plant family	Trees shrubs climbers	Fruit plants	Feral plants	Total number of species
Cannabaceae	1			1
Cornaceae	1			1
Fabaceae	1			1
Juglandaceae		1		1
Oleaceae	1			1
Rosaceae	1	1	1	3
Salicaceae	1			1
Sapindaceae	3			3
Number of species	9	2	1	12

Table 10

Functionally classified host plant families (backside garden, Máriabesnyő, 2011-15)

Plant family	Ornamental plants	Trees shrubs climbers	Fruit plants	Weeds	Feral plants	Total number of species
Araliaceae		1				1
Apocynaceae	1					1
Asteraceae	2			1	2	5
Cannabaceae		2				2
Caprifoliaceae	1					1
Celastraceae	1	1				2
Cornaceae		1				1
Fagaceae			1			1
Juglandaceae			1			1
Lamiaceae	3					3
Malvaceae	1					1
Oleaceae	1					1
Rosaceae	1	3	3			7
Sapindaceae		1				1
Urticaceae				1		1
Vitaceae			1			1
Number of species	11	9	6	2	2	30

Table 11

Functionally classified host plant families (backside garden, Gödöllő, 2011-15)

Plant family	Ornamental plants	Trees shrubs climbers	Fruit plants	Weeds	Total number of species
Araliaceae		1			1
Berberidaceae	1				1
Buxaceae	1				1
Cannabaceae		1			1
Fabaceae	1				1
Hydrangeaceae	1				1
Juglandaceae			1		1
Oleaceae	1				1
Rosaceae	2	1	1		4
Sapindaceae		1		1	2
Solanaceae				1	1
Number of species	7	4	2	2	15

Table 12

Functionally classified host plant families (orchard and vineyard, Gödöllő, 2011-15)

Plant family	Trees shrubs climbers	Fruit plants	Feral plants	Total number of species
Asteraceae			1	1
Cannabaceae	2			2
Fabaceae	1			1
Juglandaceae		1		1
Rosaceae	1			1
Sapindaceae			1	1
Vitaceae		1		1
Number of species	5	2	2	8

DISCUSSION

M. pruinosa is a polyphagous pest preferring saplings and shoots of trees and bushes but it can feed also on weed plants. It attacks mainly dicotyledonous plants but some studies reported their feeding on monocotyledonous vegetation. In Greece, it was stated on *Bromus* sp., *D. sanguinalis* and *Setaria* sp. (Souliotis *et al*., 2008) and in Austria on winter wheat, *Canna indica* and not determined grasses (Moosbeckhofer *et al*., 2009). There are many data on its host plants and most of them are ornamental and fruit trees/shrubs and also some horticultural or agricultural crops.

Regarding the Central European region, Austrian data are the most detailed and also some Romanian papers can be of importance. Moosbeckhofer *et al*. (2009) published a thorough study in which they listed 251 plant species observed and evaluated in Vienna and its countryside with additional information on the degree of infestation of the planthopper. This assessment is the same which was presented in the methodical part and abbreviated as OV2. Except 16 species (*A. rosea*, *A. artemisiifolia*, *C. incana*, *C. sativa*, *C. occidentalis*, *Ch. indicum*, *C. bipennatus*, *E. salicifolia*, *F. vesca*, *G. triacanthos*, *H. tuberosus*, *P. serotina*, *Ph. virginiana*, *S. sclarea*, *S. nigrum* and *U. urens*) presented in *Table 2*, all the plants were associated and feed by *M. pruinosa* also in Austria and the degree of infestation was similar too to those of showed in *Tables 3-7*. Preda and Skolka (2011) sampled 37 places (parks with seminatural vegetation) along the Black See in Romania. Despite the geographical position difference of Hungary and Romania, the most frequent plants on which *M. pruinosa* commonly occurred in the Romanian study were similar to those of this study: *A. negundo*, *A, platanoides*, *A. altissima*, *E. japonica*, *Fraxinus* sp., *P. cerasifera*, *Ph. coronarius*, *R. pseudoacacia* and *S. x vanhuttei*). Another study (Grozea *et al*., 2015) conducted in the western counties of Romania, showed an even better match with the present data: *A. campestre*, *A. negundo*, *A. platanoides*, *B. sempervirens*, *C. sanguinea*, *H. lupulus*, *J. regia*, *M. domestica*, *P. domestica*, *Ph. coronarius*, *R. pseudoacacia*, *R. damascena*, *S. x vanhuttei*, *U. campestris* and *V. vinifera* were common hostplants in both countries. This list corresponds also to the Austrian observations mentioned above.

Tables 8-11 present – depending on the habitats' character – a functional classification (ornamental plants, trees/shrubs, fruit plants, weeds and feral plants) of the host plant families observed at the various habitats. In seminatural habitats (hedge and tree row) the trees and shrubs predominated but in areas of agricultural use (backside gardens, orchard and vineyard) ornamental plants and not cultivated deciduous trees were in the majority. Feral plants could be found almost at each site. Some of them such as *S. canadensis* or *P. serotina*, are invasive alien species of North American origin. The number of plants native to America, some of them introduced to Europe as ornamental plants or trees of agricultural or forestry importance is 10: *A. artemisiifolia*, *A. negundo*, *C. occidentalis*, *C. bipannatus*, *G. triacanthos*, *H. tuberosus*, *P. serotina*, *Ph. virginiana*, *R. pseudoacacia*, *S. canadensis*. Considering the frequency of host plants recorded and their degree of infestation of the planthopper, Asteraceae, Cannabaceae, Fabaceae, Juglandaceae, Lamiaceae, Rosaceae and Sapindaceae were the significant families. At least two host plants of American origin were found at each site not respecting the alfalfa field and the nettle stand.

Abiotic conditions like temperature, precipitation, moisture of air and soil play an important role in development, reproduction, survival and spread of CFP. In dry regions its distribution is limited (Strauss, 2009). This can be observed during surveys because in hot and dry conditions e.g. on the top of shoots and places exposed to direct sunshine and high temperature the *M. pruinosa* populations were very scarce or nil. Thus, one could often experience that the host plant preference was influenced by the abiotic conditions of the habitat and the plant density.

A number of papers mentioned the honeydew production of *M. pruinosa* (Souliotis *et al*., 2008; Kahrer *et al*., 2009; Strauss, 2009). Kahrer *et al*. (2009) stressed that a high quantity of honeydew was observed on *Acer* spp., *Malus* sp., *Parthenocissus quinquefolia* and *Clematis vitalba* in August. In order to study the honeybee's response to *M. pruinosa* honeydew, hives were placed adjacent to infested areas but no honeybee flight was detected. As to present investigations no honeydew of *M. pruinosa* has been perceived.

M. pruinosa density approached damage level on roses and raspberries in the Máriabesnyő backside garden in 2015. On raspberries the shoots and leaves were so heavily attacked that their development was hampered while on roses the presence of CFP was the damage. The three applications of Vectaphid A EC were efficient to stop the population increase and prevented the further damage. How is possible to manage potential outbreaks of CFP a more long-lasting or radical way? In Great Britain and Bohemia chemical eradication was successful (C. Malumphy and P. Lauterer, personnel communication in Strauss, 2009). Perhaps, it was due to the generally colder and more humid climate of both countries which did not favoure the development and reproduction of the pest. Thus, this eradication with pesticides in Hungary cannot be a right answer. In Austria there was a mass outbreak in Vienna in 2003 and the pest continued spreading and was found also in Graz. According to the risk analysis of Strauss (2010) mainly organic orchards and vineyards in Burgerland, Lower Austria and Styria are threatened by *M. pruinosa*. She proposed inspection of trade and trade pathways of trees and ornamentals, parking sites and gardens along transport routes, pesticide application and the introduction of *Neodryinus typhlocybae.* What can we do in Hungary? Our climatic conditions are more favourable for the planthopper than those in Austria. Our facilities (personnel or material) are limited. The spread of *M. pruinosa* is not estimated and known. The only efficient and environmental friendly control opportunity might be the introduction of

natural enemies, in this case *Neodryinus typhlocybae* already established in Italy, France, Switzerland, Slovenia and Croatia (Tommasini *et al*., 1998; Ciglar *et al*., 1998; Malausa, 1999; Jermini *et al*., 2000 in Strauss, 2009; Žeźlina *et al*., 2001). In 2007, the parasitoid has been released in Greece, the Netherlands and Spain (A. Sala, personal communication in Strauss, 2009). *N. typhlocybae* was tested for not target organisms in Austria and it is likely that its host range is restricted to Flatidae, of which merely CFP occurs in Austria (Strauss, 2009).

CONCLUSIONS

Host plant diversity and preference of *M. pruinosa* were detected from 2011 to 2015 at Gödöllő and its countryside. The pest could be found at each habitat sampled but the hedge, the tree row and the gardens as well as the orchard and vineyard proved to be the most infested. Frequency and population density of CFP were considerable on Asteraceae, Cannabaceae, Fabaceae, Juglandaceae, Lamiaceae, Rosaceae and Sapindaceae. Vegetation could be functionally classified as ornamental plants, trees, fruit plants, weeds and feral plants. Feral plants – some of them also invasive alien species – were found at each habitat. Plant species native to America were among them the most populated. This fact obviously might help the establishment and spread of *M. pruinosa*. Regarding the neglected hedgerows, the predominance of abandoned gardens, orchards and vineyards, there are excellent conditions (high plant diversity with many American plant species) for the quick and long-lasting establishment of *M. pruinosa*. The length of hedges which run often parallel with the railway line can be more than several hundred km only in Pest county. This means that the hedge can be a huge reservoir of *M. pruinosa*. These hedges have enormous beneficial importance as resources for firewood, medicinal plants, fruits, berries, mushrooms, bee pastures; structures like ecological networks, corridors and barriers, shelter for protected plant and animal species, and natural enemies. The general management of these hedges is cutting the trees in every five or 10 years to gain some heating material and making a better view. It is a chance that there is neither money, nor intension to apply chemical insecticides in these structures. This means that in case of introduced invasive pests without natural enemies, there is quite a high risk for establishing and spreading in such a highly suitable, new environment especially when many formerly established feral plants make easier this process. Although, the population density of the pest was considerable on many hostplants, economic damage or yield losses could not be assessed. Economic or significant damage was observed only on roses, raspberries and stinging nettle (there are recognised stinging nettle varieties in Germany and Finland; Dreyer, 1999). This highlights that CFP outbreaks may cause under favourable ecological circumstances considerable quality and yield loss. The most favourable and long-ranging control opportunity would be the introduction of the natural enemy, *Neodryinus typhlocybae* already introduced in many European countries. Concerning the environmental and climatic conditions as well as the crop protection opportunities of the country it is dubious that continual inspections or verifications could help not to mention the chemical eradication.

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