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The Leafhopper Fauna of an Apricot Orchard in Hungary

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European stone fruit yellows (ESFY) is widespread in Europe. The disease, which is on the increase in Hungary, causes losses in yield, deterioration in fruit quality, decrease in the lifespan of fruit bearing trees and finally the death of the plant affected. It is most probably the leafhoppers and psyllids that play a role in the spread of the disease. In Hungary, the species composition of leafhoppers in apricot orchards had not been known before our research was carried out. In order to search for the potential vectors of the disease, research was undertaken to identify the leafhopper species present in the orchard along with their population changes. Samplings and checks were taken periodically in a pesticide-treated apricot orchard infected with ESFY in Pomáz, during the whole vegetation period of 2001. Various collecting methods were used for monitoring the species. Samples were obtained from the canopy, the undergrowth and the plants adjacent to the orchard by the means of Malaise traps, suction traps and yellow sticky boards.

3117 individuals belonging to 85 leafhopper species were collected during our samplings. A species (*Edwardsiana* sp.) presumably new to the fauna was also collected, although research is still underway to remove all doubts about its identification.

The leafhoppers were present throughout the vegetation period. A significant increase in the number of *Edwardsiana lamellaris, E. rosae* and of *Eupteryx calcarata* was detected between the end of May and the beginning of June, whereas in the middle of August, at the end of September and in mid-October an increase in the number of *Empoasca solani, E. decipiens* and *Zygina flammigera* was observed. On the basis of the abundance of the species as well as that of the study of the canopy it can be stated that apricot trees are among the host-plants of *Edwardsiana lamellaris, E. rosae* and *Eupteryx calcarata.* Our objectives for further studies are to assess the role in ESFY transmission of the leafhopper species collected.

Keywords: European stone fruit yellows (ESFY), leafhopper fauna.

European stone fruit yellows is widespread in Europe. Economical losses occur mainly in the Mediterranean countries (Italy, Spain, Greece, and France) but damage is also great in certain northern countries (Germany, Czech Republic). The pathogen occurs in stone fruit orchards in both the northern and southern halves of Italy (Poggi et al., 1997). Economical losses are great also in France, where its potential vectors have been studied by numerous researchers (Labonne et al., 1998; Jarausch et al., 1999) In Spain, the spread of the disease has been studied in peach, pear, plum, Japanese plum, apricot and almond orchards (Medina et al., 1981; Sánchez-Capuchino et al., 1976). In Hungary, the disease was first observed by Süle (Süle et al., 1997). In addition to apricot, the pathogen has been detected on peach, Japanese plum, almond, cherry and mahaleb cherry in Hungary (V. Németh et al., 2000a, b).

The disease of stone fruit trees has been known since the beginning of the 1900s although at that time it was thought to be connected with the apoplexy of apricot. Morvan was the first to succeed in transmitting the pathogen – which at the time he thought was of virus-origin – by grafting. Later he found that the disease was caused by the chlorotic leaf roll mycoplasma (Morvan 1957; Morvan et al., 1973), which was named European stone fruit yellows (ESFY).

Some of the symptoms characteristic of the disease are the following: brittle, pale green leaves rolling in conical shape, browning floem and drying ends of twigs. Initial symptoms are frequently restricted to only one or a few branches of the infected trees. The disease gradually spreads and in 2 to 3 years the whole canopy becomes affected. The infection leads to the early death of trees aged 8 to 10 years.

The pathogen spreads by vegetative propagation stock as well as through budding and grafting. In the laboratory, it can be transmitted by *Cuscuta* species. Its natural vectors are unknown. Yet, it is assumed that, like other diseases caused by phytoplasmas, the European stone fruit yellows is also transmitted by leafhoppers. Bonfils et al. (1976) regards *Fieberiella florii,* the vector of apple proliferation (Krczal et al., 1988) and of X-disease occurring in stone fruits in the USA (Jensen, 1969), as the vector of ESFY. In transmission tests, Mariano et al. (1994) has succeeded in transmitting the pathogen onto *Catharantus roseus* by the means of *Asymmetrasca decedens.* The presence of ESFY phytoplasma along with other phytoplasmas have been detected in leafhoppers belonging to the subfamily of *Typhlocybinae* as well as in species belonging to the genera of *Anaceratagallia* and *Euscelis* by Poggi et al. (1997). However, the proportion of phytoplasma-positive leafhoppers was low. According to recent studies, *Cacopsylla pruni* is one of the natural vectors of the disease (Carraro et al., 2001; Jarausch et al., 2001).

To be able to identify the potential vectors of ESFY it is essential to have some knowledge of the leafhopper species occurring in the orchard as well as of their population change. Hence, the aim of our research was to survey the leafhopper fauna of apricot orchards in Hungary.

Concerning environmental and human-toxicological viewpoints, the use of pesticides should be lowered in orchards, including apricot orchards. However, as a consequence of the decrease in insecticide treatments, the growing significance of leafhoppers is foreseeable in the future.

Material and Methods

Regular samplings were taken in a pesticide-treated apricot orchard infected with ESFY during the vegetation period of 2001 in Pomáz, Hungary. Due to its near-ideal natural attributes, Pomáz is highly suitable for growing apricots. However, a great deal of the trees show symptoms triggered by pathogens.

The orchard is surrounded by apple and peach orchards as well as by natural vegetation consisting of *Crataegus monogyna, Rosa canina, Prunus avium* var. *silvestris, Prunus spinosa, Juglans regia, Fragaria vesca* and grasses. In the row-spacing both mechanical and chemical weed control was undertaken.

The orchard was treated with phosphorus-acid esters (Dimecron 50, Parashoot CS, Danadim 40 EC) and pyrethroid (Karate 2,5 WG) four times between the beginning of April and the end of June. In addition to the orchard chosen for regular samplings, occasional samplings were done in untreated apricot orchards as well as in ones with fewer pesticide treatments.

Samplings were done with Malaise traps, suction traps and yellow sticky boards. Two Malaise traps were placed in the orchard: one at the orchard centre and one at the orchard edge. Traps were emptied weekly between the beginning of April and the middle of November. By means of suction traps (Mc Culloch), samplings were done in the canopy, in the undergrowth and in the vegetation adjacent to the orchard every two weeks. Ten yellow sticky boards (Csalomon) of size 10 × 16 cm were placed sporadically in the canopy and were changed every two weeks.

The catches were identified in the laboratory with the help of the identification handbook of Ossiannilsson (1981) and Ribaut (1936, 1952)

Results

A total number of 3117 individuals belonging to 85 genera of 5 families were captured in 2001. This represents 13% of the native fauna. A species (*Edwardsiana* sp.) probably new to the fauna has also been collected although its identification is still under way. *Table 1* contains the species list of leafhoppers captured in the apricot orchard, indicating the means of collection.

As there are cases when the identification of the females at genus-level proves to be impossible, we only considered the male individuals when processing the data.

A total number of 1473 individuals were captured with Malaise traps. Fifty-seven species belonging to 5 families have been identified *(Table 1)*. 70% of the species belong to the *Cicadellidae* family. In the orchard and in the vegetation adjacent to the orchard, *Edwardsiana lamellaris* proved to be the predominant species. Besides, a great number of *Edwardsiana rosae, Empoasca solani* and *Empoasca decipiens* were captured. A significant number of *Eupteryx calcarata* in the orchard and that of *Ribautiana tenerrima* at the orchard-edge were also captured *(Figs 1, 2).* On the body of the imagos of the *Edwardsiana rosae* parasitoids were often present.

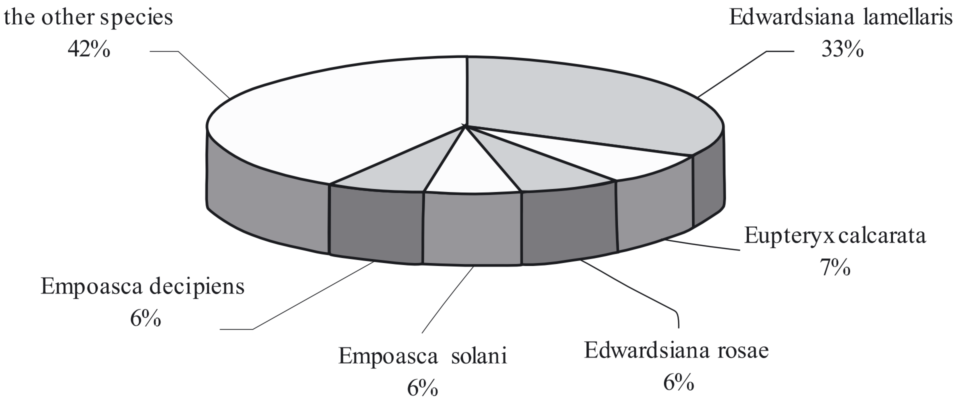

Fig. 1. The proportion of leafhopper species in the orchard (Malaise trap)

Table 1

Species list of leafhoppers captured in an apricot orchard (Pomáz, 2001)

Species name	Description list	Malaise trap in orchard		Yellow boards	Suction trap		
		centre	edge		canopy	under-growth	bordering vegetation
Cixiidae							
Cixius (Ceratocixius) *wagneri*	China, 1942	+	+				
Hyalestes luteipes	Fieber, 1876	+					
Pentastiridius leporinus	(Linnaeus, 1761)			+			
Reptalus cuspidatus	(Fieber, 1876)	+	+			+	+
Reptalus melanochaetus	(Fieber, 1876)	+	+				
Reptalus panzeri	(Löw, 1883)	+	+	+			
Reptalus quinquecostatus	(Dufour, 1833)			+			
Cercopidae							
Aphrophora alni	(Fallén, 1805)	+	+	+			
Cercopis sanguinolenta	(Scopoli, 1763)	+					
Neophilaenus lineatus	(Linnaeus, 1758)					+	
Philaenus spumarius	(Linnaeus, 1758)	+			+	+	
Membracidae							
Centrotus cornutus	(Linnaeus, 1758)						
Stictocephala bisonia	Kopp & Yonke, 1977	+	+				
Delphacidae							
Dicranotropis hamata	(Boheman, 1847)					+	
Javesella pellucida	(Fabricius, 1794)					+	
Laodelphax striatellus	(Fallén, 1826)	+	+	+		+	
Muirodelphax aubei	(Perris, 1857)					+	
Cicadellidae							
Adarrus multinotatus	(Boheman, 1847)	+		+			
Adarrus notatifrons	(Kirschbaum, 1868)					+	
Anaceratagallia ribauti	(Ossiannilsson, 1938)					+	
Alebra albostriella	(Fallén, 1826)			+			
Allygidius abbreviatus	(Lethierry, 1878)					+	
Allygidius furcatus	(Ferrari, 1882)			+			
Allygidius mayri	(Kirschbaum, 1868)			+			
Anoplotettix horváthi	Metcalf, 1955	+	+	+			
Aphrodes bicinctus	(Schrank, 1776)		+	+			+
Arboridia parvula	(Boheman, 1845)	+					
Arboridia velata	(Ribaut, 1952)	+					
Arocephalus longiceps	(Kirschbaum, 1868)					+	
Artianus interstitialis	(Germ, 1821)					+	
Austroasca vittata	(Lethierry, 1884)	+	+			+	
Balclutha punctata	(Fabricius, 1775)			+			
Chlorita viridula	(Fallén, 1806)	+					
Cicadella viridis	(Linnaeus, 1758)	+	+			+	
Cicadula placida	(Horváth, 1897)	+		+		+	
Circulifer fenestratus	(Herrich-Schäffer, 1834)			+			
Doratura homophyla	(Flor, 1861)					+	
Edwardsiana avellanae	(Edwards, 1888)		+				
Edwardsiana candidula	(Kirschbaum, 1868)	+		+			

Table 1 (cont)

Species name	Description list	Malaise trap in orchard		Yellow boards	Suction trap		
		centre	edge		canopy	under-growth	bordering vegetation
Edwardsiana crataegi	(Douglas, 1876)		+	+			+
Edwardsiana diversa	(Edwards, 1914)	+	+				
Edwardsiana lamellaris	(Ribaut, 1931)	+	+				
Edwardsiana prunicola	(Edwards, 1914)	+	+				+
Edwardsiana rosae	(Linnaeus, 1758)	+	+	+	+		+
Emelyanoviana mollicula	(Boheman, 1845)	+	+	+	+		
Empoasca decipiens	Paoli, 1930	+	+	+		+	+
Empoasca populi	(Edwards, 1908)	+	+				
Empoasca solani	(Curtis, 1846)	+	+	+	+		
Empoasca virgator	(Ribaut, 1933)	+	+				
Enantiocephalus cornutus	(Herrich-Schäffer, 1838)					+	+
Eupteryx atropunctata	(Goeze, 1778)	+	+	+		+	
Eupteryx calcarata	Ossiannilsson, 1936	+	+	+			+
Eupteryx collina	(Flor, 1861)	+	+	+			
Eupteryx cyclops	Matsumura, 1906	+					
Eupteryx melissae	Curtis, 1837		+				
Eupteryx stachydearum	(Hardy, 1850)	+	+	+		+	
Eupteryx tenella	(Fallén, 1806)		+				
Eupteryx vittata	Linnaeus, 1758					+	
Eurhadina pulchella	(Fallén, 1806)	+	+				
Fieberiella florii	(Stal, 1864)			+		+	
Jassargus obtusivalvis	(Kirschbaum, 1868)					+	+
Limotettix striola	(Fallén, 1806)		+				
Linnavuoriana sexmaculata	(Hardy, 1850)		+				
Macropsis sp.				+			
Macrosteles laevis	(Ribaut, 1927)	+	+			+	
Macrosteles sexnotatus	(Fallén, 1806)		+			+	
Micantulina stigmatipennis	(Mulsant and Rey, 1855)	+	+				+
Mocuellus collinus	(Boheman, 1850)					+	
Mocydia crocea	(Herrich-Schäffer, 1837)					+	+
Mocydiopsis attenuata	(Germar, 1821)					+	
Ophiola decumana	(Kontkanen, 1949)	+					
Phlogotettix cyclops	(Mulsant and Rey, 1855)	+	+	+			
Psammotettix alienus	(Dahlbom, 1850)	+	+	+	+	+	+
Psammotettix striatus	(Linnaeus, 1758)		+			+	
Rhopalopyx preyssleri	(Herrich-Schäffer, 1838)		+				
Recilia schmidtgeni	(Wagner, 1939)		+				
Ribautiana tenerrima	(Herrich-Schäffer, 1834)	+	+				
Ribautiana scalaris	(Ribaut, 1931)	+	+	+			
Streptanus aemulans	(Kirschbaum, 1868)			+		+	
Turrutus socialis	(Flor, 1861)		+				
Typhlocyba quercus	(Fabricius, 1777)			+			
Zygina angusta	Lethierry, 1874	+	+	+	+		+
Zygina flammigera	(Fourcroy, 1785)	+	+	+	+		+
Zygina suavis	Rey, 1891	+	+		+		
Zyginidia pullula	(Boheman, 1845)	+	+	+	+	+	

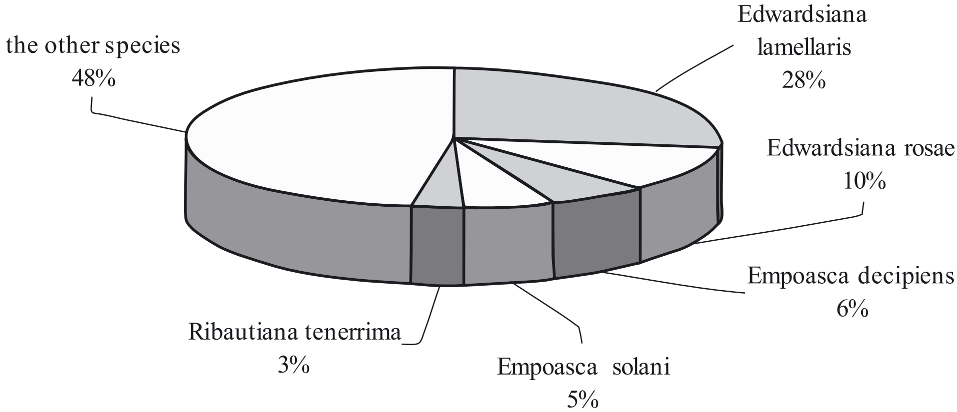

Fig. 2. The proportion of leafhopper species in the vegetation adjacent to the orchard (Malaise trap)

The most frequent species collected with Malaise traps were the same in the orchard and at the orchard-edge. Besides this, it was noted that their number was similar in both of these places, therefore only the change in the number of species captured in the orchard are shown in *Fig. 3.* Although samplings were started at the beginning of April, catches only reached a number of leafhoppers sufficient for processing after mid-May. Leafhop-

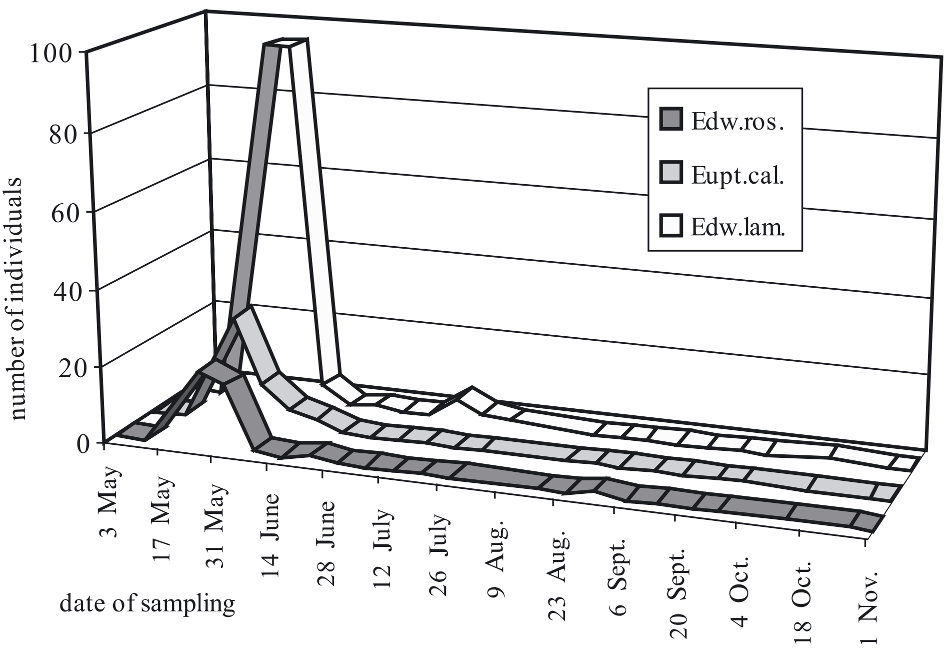

Fig. 3. Population changes of the species of *Edwardsiana lamellaris, E. rosae* and *Eupteryx calcarata* (Malaise trap)

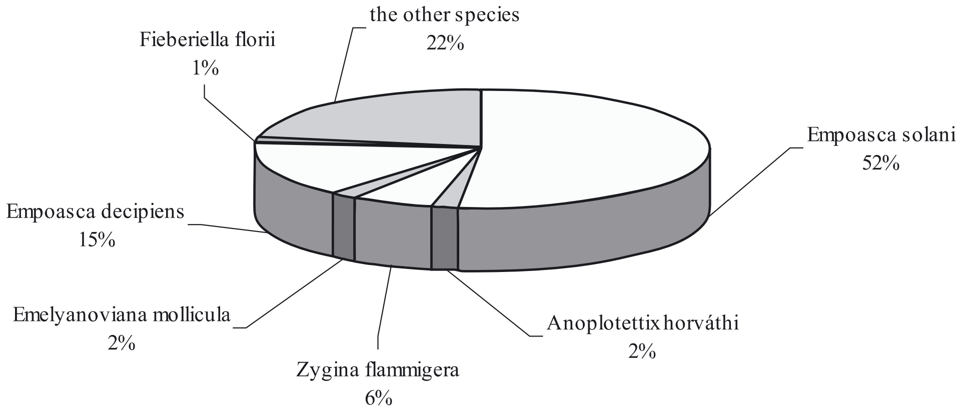

Fig. 4. Distribution of leafhopper species captured with yellow sticky boards

pers should be expected to appear sometime in May, depending on the weather, and they are present until the end of the vegetation period. Similarly to *Edwardsiana lamellaris, E. rosae* and *Eupteryx calcarata* were in peak numbers between the end of May and the beginning of June, despite pesticide treatments. *Edwardsiana lamellaris* also occurred in smaller numbers in the middle of July as well as between the end of September and the beginning of October.

Empoasca solani and *Empoasca decipiens* showed a moderate increase in their numbers in mid-August, at the end of September and in the middle of October. The number of *Empoasca decipiens* also increased slightly in May as well as at the end of June and of July.

742 individuals belonging to 35 leafhopper species were captured with the yellow sticky boards. 80% of these species belonged to the *Cicadellidae* family. *Empoasca solani* was the predominant species, representing 52% of the total catch. *Empoasca decipiens, Zygina flammigera, Emelyanoviana mollicula, Anoplotettix horváthi* and *Fieberiella florii* were also caught in high numbers *(Fig. 4).*

The numbers for the 3 most frequent species *(Empoasca solani, Empoasca decipiens* and *Zygina flammigera)* is shown in *Fig. 5.* An increased number of *Empoasca solani* was captured with yellow sticky traps in mid-August, as well as between the end of September and mid-October, similarly to catches with Malaise traps. The number of specimens at the second peak in October is 5 times as much as the one in August. By contrast, *Empoasca decipiens* peaked at the end of July and September. *Zygina flammigera* had a peak in mid-August.

The species living in the canopy and those in the undergrowth could be well distinguished by means of the sucking trap. The sucking trap mainly captured species characteristic of the undergrowth in the row-spacing, such as *Enantiocephalus cornutus, Mocydia crocea, Dicranotropis hamata* and *Psammotettix* sp. The vast majority of species captured in the undergrowth was found not to be present in the canopy. The same applies to the species collected in the canopy and in the vegetation adjacent to the orchard. The charac-

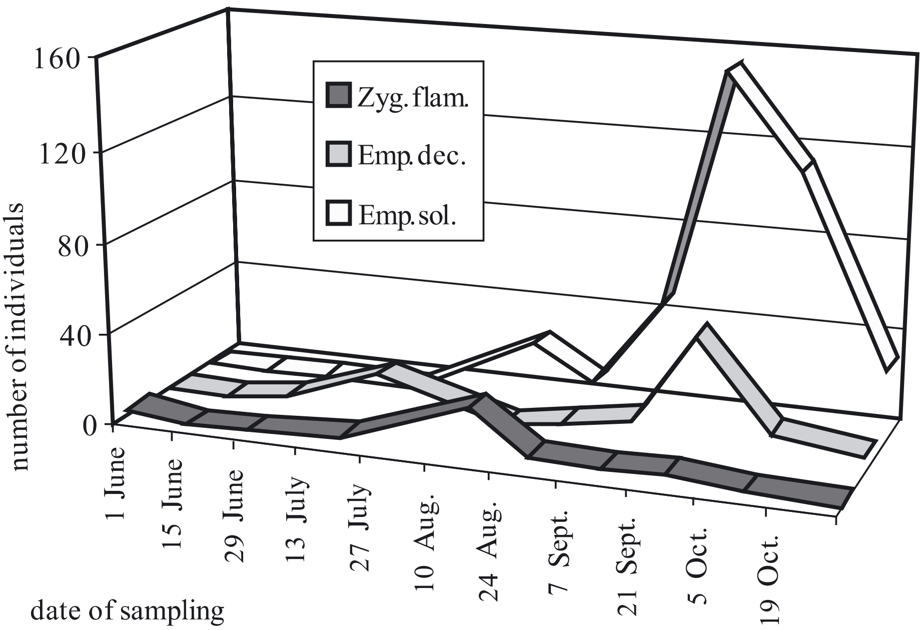

Fig. 5. Population changes of the predominant species captured with yellow sticky boards

teristic species in the bordering vegetation were *Edwardsiana prunicola, E. crataegi* and *Mocydia crocea.* In the canopy, *Philaenus spumarius, Edwardsiana rosae, Emelyanoviana mollicula, Empoasca solani, Psammotettix alienus* and *Zygina* sp. were captured *(Table 2).*

Table 2

List of the most important species captured with suction trap in the canopy, in the vegetation adjacent to the orchard and in the undergrowth

Canopy	Vegetation adjacent to orchard	Undergrowth
Edwardsiana rosae	Aphrodes bicinctus	Allygidius abbreviatus
Emelyanoviana mollicula	Edwardsiana crataegi	Cicadella viridis
Empoasca solani	Edwardsiana prunicola	Dicranotropis hamata
Philaenus spumarius	**Edwardsiana rosae**	*Emelyanoviana mollicula*
Psammotettix alienus	Empoasca decipiens	*Empoasca solani*
Zygina angusta	Enantiocephalus cornutus	Enantiocephalus cornutus
Zygina flammigera	Eupteryx calcarata	Jassargus obtusivalvis
Zygina suavis	Jassargus obtusivalvis	Laodelphax striatellus
Zyginidia pullula	Micantulina stigmatipennis	Macrosteles laevis
	Mocydia crocea	Mocydia crocea
	Psammotettix alienus	Neophilaenus lineatus
	Reptalus cuspidatus	*Philaenus spumarius*
	Zygina angusta	*Psammotettix alienus*
	Zygina flammigera	Reptalus cuspidatus
		Zyginidia pullula

At the end of August further samplings were done in apricot orchards treated with less pesticides. A great number of individuals belonging to the *Zygina* and *Empoasca genera* were captured in the canopy. In addition, species of *Emelyanoviana mollicula, Philaenus spumarius, Zyginidia pullula, Psammotettix alienus* and *Edwardsiana rosae* were also captured.

Discussion

In our studies the leafhopper fauna of Hungarian apricot orchards was monitored in order to reveal the species that might play a role in the spread of ESFY.

Despite the pesticide treatments, samplings resulted in a great number of both individuals and species: a total number of 3117 individuals belonging to 85 species of 5 families was captured. Comparing our species list with that of apricot orchards in other countries, it can be concluded that the most common species are similar, yet the species compound in Hungary is more varied.

The Malaise traps captured a high number of *Edwardsiana lamellaris.* According to Schiemenz (1990) this species occurs on the species of the *Rosaceae* family, yet it has also been found on *Alnus, Quercus, Ulmus* and *Prunus* species. It is the eggs that overwinter, but the number of generations per year is not yet known. On the basis of the data collected, a significant increase in the number of *E. lamellaris* could be observed between the end of May and the beginning of June, implying the occurrence of the first generation. It also occurred in mid-July, as well as between the end of September and the beginning of October, yet in much smaller numbers. Therefore, this does not fully indicate the occurrence of a second generation. Only little information is available about this species. It is not referred to as a pest in the international special literature on pest control. Further experiments are required to study its ontogenesis.

Edwardsiana rosae is a common pest in Hungary. Its main host plant is *Rosa canina* and cultivated roses. It flies from these plants onto fruit trees, such as apple and quince. It has several other host plants, mostly belonging to the *Rosaceae* family. According to Sáringer (1989) it has not been collected from nut *(Juglans regia)* and apricot. According to other references, it has also been found on *Salix* sp., *Alnus* sp., *Corylus* sp., *Quercus* sp. and *Tilia* sp. (Schiemenz, 1990). This species has three generations per year and the eggs overwinter in the epidermis of rose shoots (Sáringer, 1989). In the opinion of Day et al. (1995) it can overwinter on *Rubus caesius* as well. The fact that it occurs in abundant numbers might be due to its resistance to pesticides. Parasitoids were often found on the body of the captured imagos, but they did not decrease the number of the pest significantly.

Up to the present *Eupteryx calcarata* has been found on *Urtica* sp. (Ossiannilsson, 1981), *Ballota* sp. and *Salix* sp. (Schiemenz, 1990).

On the basis of the abundance of the species and that of species monitored in the canopy it can be stated that apricot is among the host plants of *Edwardsiana lamellaris, E. rosae* and *Eupteryx calcarata.* All three species appeared in the spring-early summer period when pesticide treatments were used. A great number were captured with Malaise traps, which indicates that the species might have flown into the orchard from outside.

Empoasca decipiens and *E. solani* are widely distributed, poliphagous species, which are present everywhere in Hungary. They appear in great numbers on vegetable plants such as potato (Kuroli, 2001), tomato, sweet pepper, peas, beans and carrot as well as on alfalfa, rape and grains. Damage caused by them have been observed on apple and grape (Sáringer, 1989). They play a significant role in the spread of aster yellows phytoplasma. They have 2–4 generations per year. The generations are mixed and the imagos overwinter. On the basis of the individuals captured with yellow sticky boards, 2 generations can be assumed in both species. A significantly lower number of the 2 species were captured with Malais traps, but still two peak values could be distinguished in August and in the middle of October. The two species were captured in great numbers with the sucking trap in the undergrowth in late autumn, which justifies the conclusion that the imagos overwinter at ground level.

Zygina flammigera, a species widespread throughout Europe, was captured in great numbers with yellow sticky boards. It occurs *en masse* on cultivated plants in dry, warm autumns along with *Empoasca* species. It is one of the most frequent species in stone-fruit orchards in Italy and Spain as well, but its role as a vector has not been proved so far (Mariano et al., 1994).

Fieberiella florii was captured with the sucking trap in the undergrowth as well as with yellow sticky boards in the autumn. It also occurred in large numbers in apricot orchards in southern-France, where the results of the transmission tests under lab conditions were positive (Bonfils et al., 1976). In addition, it has been found to be the vector of apple proliferation and the X-disease of stone-fruits occurring in the USA (Jensen, 1969; Douglas and McClure, 1988).

Mocydia crocea, which is proved to transmit the German grapevine yellows caused by stolbur phytoplasma, was a common species in the undergrowth and in the vegetation adjacent to the orchard. *Hyalestus luteipes,* whose role as a vector has not been fully elucidated, was also captured in the orchard (Sforza et al., 1998).

Comparing our results with those previously obtained by others sets the direction for further studies, that is, to clarify whether the captured species carry the ESFY phytoplasma and if so, whether or not they actually transmit it.

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