DIVERSITY OF INVASIVE AUCHENORRHYNCHA SPECIES DETECTED IN APPLE AND PLUM ORCHARDS IN MOARA DOMNEASCĂ IN THE 2022-2024 PERIOD

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Abstract: *This paper presents data on the presence, abundance and diversity of invasive Auchenorrhyncha species in two orchards, apple and plum, in the experimental field Moara Domnească Didactic Station, Ilfov county (Southern Romania) in the years 2022, 2023 and 2024. The insects were collected on yellow sticky traps, 9 traps/orchard were installed and replaced every two weeks from mid-April until early November. A total of 339 individuals were collected (86.14 % from apple and 13.86% from plum) belonging to seven species, Japananus hyalinus, Scaphoideus titanus, Orientus ishidae, Erasmoneura vulnerata, Stictocephala bisonia (syn. Ceresa bubalus) and Metcalfa pruinosa identified in both orchards, to which Phlogotettix cyclops species is added in apple orchard. Cicadellidae family was the most abundant in both studied orchards, reaching a relative abundance of 93.15% in apple and 80.85% in plum of the total captures. The most abundant species was the Japanese mosaic leafhopper Orientus ishidae (62.67%) in apple and the North American leafhopper Erasmoneura vulnerata (42.55%) in plum orchard. Ecological parameters and indices of similarity, species richness and diversity were calculated and analyzed for each orchard and sampling year.*

Key words: *invasive Auchenorrhyncha species, apple, plum, diversity.*

INTRODUCTION

Invasive species have become an extremely important area of study in recent years, especially in Europe and the America continents. In the context of human activity and global warming, different species of insects penetrated new regions. Because of the high number of insects and their large diversity, with an estimated range between 1 to 10 million species (Stork, 2018), the number of known non-native insect species exceeds that of all other animal groups (Seebens et al., 2017). Auchenorrhyncha, as the largest Hemiptera suborder with 43,691 described species (Liebhold et al., 2024), including groups such as cicadas, leafhoppers, treehoppers, planthoppers, froghoppers and spittlebugs contains some of the highly invasive species. Worldwide, 288 species from this suborder have been described as established non-native species (Liebhold et al., 2024). They are phytophagous insects equipped with specialized mouthparts adapted for piercing and sucking sap from the organs of their host plants, causing an important economic impact on native vegetation and crops. Of particular importance are invasive vectors that besides their feeding damage, they can also transmit plant pathogens which cause major diseases. In addition, invasive Auchenorrhyncha species can also be a threat to local biodiversity.

A wide range of scientific papers have approached the Auchenorrhyncha invasiveness, especially in the European continent (Roques et al., 2009; Mifsud et al., 2010; Gjonov & Shishiniova, 2014; Šćiban & Kosovac, 2020). Several invasive leafhoppers and planthoppers

species have also been reported in Romania in the last two decades, including phytoplasma vectors (Chireceanu et al., 2011; 2017; 2020; Teodoru et al., 2021; Cojocariu & Crâșmaru, 2023).

The aim of this paper was to investigate the invasive species of Auchenorrhyncha associated to apple and plum orchards in the south part of Romania in order to obtain data on their ecological parameters and diversity, important for the management of fruit trees areas.

MATERIAL AND METHODS

Study area description The research was conducted in two commercial orchards, apple and plum, in the experimental field Didactic Station belonging to the University of Agronomic Sciences and Veterinary Medicine Bucharest, located in Moara Domnească commune, Ilfov County in the south part of Romanian (44°30′01.6″N/26°15′30.6″E, 80 m a.s.l.) from 2022 to 2024.

The orchards were chemically managed to control pests and diseases. For each year, a number between 8-11 treatments were applied from March to July against the main pests such as the European red mite *Panonychus ulmi* (Koch), the San José scale *Diaspidiotus* (*Quadraspidiotus*) *perniciosus* (Comstock), codling moth *Cydia pomonella* (L.), leaf miner species *Phyllonorycter* (*Lithocoletis*) *blancardella* (F.), *Stigmella malella* (Stt.), *Leucoptera malifoliella* (Costa), *L. scitella*, tortrix moths *Adoxophyes orana*, *A. reticulana* (Hb.), *Archips podana* (Scopoli), aphids *Aphis pomi* (De Geer) and *Dysaphis* spp. in apple; the seed wasp *Eurytoma schreineri* (Schreiner), the fruit moth *Cydia funebrana* (Treitschke) and aphids *Myzus persicae* (Sulzer) and *Hyalopterus pruni* (Geoffroy) in plum. Contact and systemic fungicides were used to prevent and control pathogens like *Venturia inaequalis* (Cooke), *Erwinia amylovora* (Burrill), *Podosphaera leucotricha* (Ellis & Everh) and *Monilinia laxa* (Aderh. & Ruhland) in apple, and *Pseudomonas syringae* (van Hall), *Agrobacterium radiobacter* (Beijerinck & van Delden), *Polystigma rubrum* (Pers) in plum. The space between tree rows was covered with spontaneous plants that were mowed once during the summer season.

During the study, the average air temperature ranged from 12.05°C to 25.8°C in 2022, from 9.8°C to 26.6°C in 2023, and from 12.3ºC to 26.9ºC in 2024. The lowest values were in autumn months, November (2022, 2023) and October (2024) and the highest ones in August (2022) and July (2023, 2024). The maximum temperature exceeding 30°C was registered from May to September in 2022, from June to October in 2023, and from April to September in 2024. The highest maximum temperature was in July, 38°C in 2022 and 40.5°C in 2023 and 2024. Annual rainfall was 240.1 mm in 2022, 219 mm in 2023 and 314.2 mm in 2024.

Auchenorrhyncha sampling and species identification Insects were collected on yellow panels traps (21 x 29.7cm) with adhesive on both sides from mid-April until early November in the 2022-2024 period. The traps were hanged in the apple and plum trees canopy at a height of approximately 1.5m. For each year, 9 traps /orchard were set up and replaced every two weeks, summing a total of 117 traps /orchard/year. The traps covered the entire surface of the orchards, from interior to the outer edges.

Traps with captured insects were analyzed under a stereomicroscope (Stemi 2000-C, Zeiss) and the identification of Auchenorrhyncha species was made following the morphological characters and identification keys described by Dietrich (2005), Biedermann and Niedringhaus (2009) and Mozaffarian (2018). Species classification as invasive was based on the results from databases for invasive species in Europe, such as DAISIE - Inventory of alien invasive species in Europe, EASIN - European Alien Species Information

Network and NOBANIS - The European Network on Invasive Alien Species. The samples were placed in the Entomological Collection of Plant Protection Institute Bucharest.

Data analysis Species composition, diversity and similarity of communities of Auchenorrhyncha invasive species from the two study orchards were analyzed. The ecological parameters of abundance (A), dominance (D%), constancy (C%) and ecological significance index (W%) were calculated (Stan, 1994). For dominance, species were classified as eudominant species (D>10%), dominant species (D=5-10%), subdominant species (D=2-5%), receding species (D=1-2%) and subreceding species (D<1%). For constancy, there were euconstant species (C=75-100%), constant species (C=50-75%), accessory species (C=25-50%) and accidental species (C=1-25%). With regard to ecological significance index, there were characteristic species (W>5%), accessory species (W=1-5%) and accidental species (W<1%).

To compare similarity of the Auchenorrhyncha invasive species from the two orchards, the Jaccard (C_j), Sørensen (C_s) and Bray-Curtis (C_N) coefficients (Henderson, 2003) were used. First two binary coefficients are based on species frequencies, taking into account the number of common species and the number of species found exclusively in one of the orchards. Bray and Curtis coefficient was calculated by considering the sum of the lower abundance values for each species found in both orchards divided by the total number of individuals sampled in both orchards. Species richness was calculated following the Margalef (Mf) and Menhinick (Mk) diversity indices (Magurran, 2004) that take into account the number of species (S) and the total number of individuals in the samples (N). The Simpson's diversity index (1-D) based on the relative abundance of the species, and Simpson's evenness index (D_E) (Magurran, 2004) were used to assess diversity and equitability of species for each orchard and sampling year.

RESULTS AND DISCUSSIONS

The results in this study showed that altogether, a total of seven invasive species of Auchenorrhyncha were identified in the apple and plum orchards, classified into 3 families and 4 subfamilies (Table 1). Five of the identified species belong to the Cicadellidae family and one species each to the Flatidae and Membracidae families.

Table 1. Invasive Auchenorrhyncha species sampled from apple and plum orchards at MD Station

Superfamily	Family	Subfamily	Species
Membracoidea	Cicadellidae (leafhoppers)	Deltocephalinae	*Phlogotettix cyclops*
			Japananus hyalinus
			Scaphoideus titanus
			Orientus ishidae
		Typhlocybinae	*Erasmoneura vulnerata*
	Membracidae (treehoppers)	Smiliinae	*Stictocephala bisonia* (syn. *Ceresa bubalus*)
Fulgoroidea	Flatidae (planthoppers)	Flatinae	*Metcalfa pruinosa*

Six of the seven species recorded in this study, namely *Metcalfa pruinosa*, *Stictocephala bisonia*, *Erasmoneura vulnerata*, *Scaphoideus titanus*, *Orientus ishidae* and *Japananus hyalinus*, were found in both orchards. Only one species, namely *Phlogotettix cyclops* was sampled exclusively in the apple orchard (Table 2).

Table 2. Abundance of invasive Auchenorrhyncha species sampled at MD Station

	Family/Species	Apple				Plum			
		2022	2023	2024	2022-2024	2022	2023	2024	2022-2024
	Cicadellidae								
1	*Phlogotettix cyclops* Mulsant & Rey 1855	8	0	5	13	0	0	0	0
2	*Japananus hyalinus* Osborn 1900	3	5	0	8	2	1	1	4
3	*Scaphoideus titanus* Ball 1932	7	2	0	9	1	1	0	2
4	*Orientus ishidae* Matsumura 1902	113	70	0	183	7	5	0	12
5	*Erasmoneura vulnerata* Fitch 1851	48	9	2	59	17	3	0	20
	Membracidae								
6	*Stictocephala bisonia* Kopp & Yonke 1977	5	3	9	17	2	3	2	7
	Flatidae								
7	*Metcalfa pruinosa* Say 1830	3	0	0	3	2	0	0	2
	No of individuals	187	89	16	292	31	13	3	47
	Relative abundance (%)	64.04	30.48	5.48	100	65.96	27.66	6.38	100

A total of 339 individuals were collected on yellow traps from both orchards during the entire sampling period, of which 292 individuals from the apple and 47 from the plum orchard, representing 86.14 and 13.86% respectively. Data in the table 2 shows that the total and annual captures in the apple orchard were of 6.2 times and between 5.3 and 6.8 times higher than from the plum orchard. The numerical variations of annual captures observed in this table indicate that the most insects were captured in 2022, then 2023 and 2024 for both orchards.

Cicadellidae family was the most abundant in both orchards, reaching a relative abundance of 93.15% in apple and 80.85% in plum of the total captures, followed by Membracidae with 5.82% and 14.89%, and Flatidae with 1.03% and 4.26% in the apple and plum orchard, respectively. Among species, *O. ishidae* (62.67%) in the apple and *E. vulnerata (*42.55%) in the plum orchard were the most abundant (Table 2).

Three of the invasive species identified in our study, *S. bisonia* (sin. *Ceresa bubalus*), *J. hyalinus* and *Ph. Cyclops*, are mentioned in autochthonous fauna since the 50s, 60s and 70s, respectively (Teodorescu, 2018). The other species were recently detected in the country, *M. pruinosa* and *S. titanus* in 2009 (Preda & Skolka, 2009; Chireceanu et al., 2011), *O. ishidae* and *E. vulnerata* in 2016 (Chireceanu et al., 2017; 2020).

The mosaic leafhopper *O. ishidae* has become a frequent presence on apple trees after entering European territory. This is a species more relevant for viticulture, but large number of nymphs and adults were collected from cultivated apple orchards in Slovenia and Italy, and apple trees were indicated as good host plants (Lešnik et al., 2017; Dalmaso et al., 2023). The species found optimal conditions to develop its entire life cycle on apple, even better than those offered by grapevine (Dalmaso et al., 2023). The authors suggested that *O. ishidae* could become a new and important pest of apple crops in the future due to the direct damage to leaves caused by feeding, such as chlorosis followed by necrosis that lead to the leaf fall, as well as the insect's ability to spread the quarantine phytoplasma "*Candidatus* Phytoplasma mali", the causal agent of apple proliferation diseases that significantly increases the risk of damage for apple orchards. After first detection of *O. ishidae* in our country in the Bucharest city in 2016, its population increased and spread over the next two years in apple and plum orchards, especially in those without insecticide applications (Teodoru et al., 2021).

The North American grapevine leafhopper *E. vulnerata* is another example of a leafhopper associated with vineyards but found in substantial numbers on other alternative host plants. Seljak (2011) found populations of *E. vulnerata* feeding on Judas-trees (*Cercis siliquastrum*) in Slovenia, close to the Italian border. Specimens of this species were also

collected in Hungary on European yew (*Taxus baccata*) and northern white-cedar (*Thuja occidentalis*) (Schlitt et al., 2024). This species was observed in Romania since 2016 in different vineyards in the eastern part of Romania (Chireceanu et al., 2020). Later, it spread further south and found in large numbers in abandoned apple and plum orchards in the southern part of Romania, where *O. ishidae* was also detected (Teodoru et al., 2021).

The other species associated with vineyards are *Ph. cyclops* and *S. titanus* that were also collected on other possible host plants in Romania: *Ph. cyclops* was caught on common hawthorn (*Crataegus monogyna*) and Chinese date (*Ziziphus jujube*) (Chireceanu et al., 2017b) and *S. titanus* in abandoned apple and plum orchards (Teodoru et al., 2021).

The dynamics of insect captures in both orchards for each year of monitoring is shown in Figure 1.

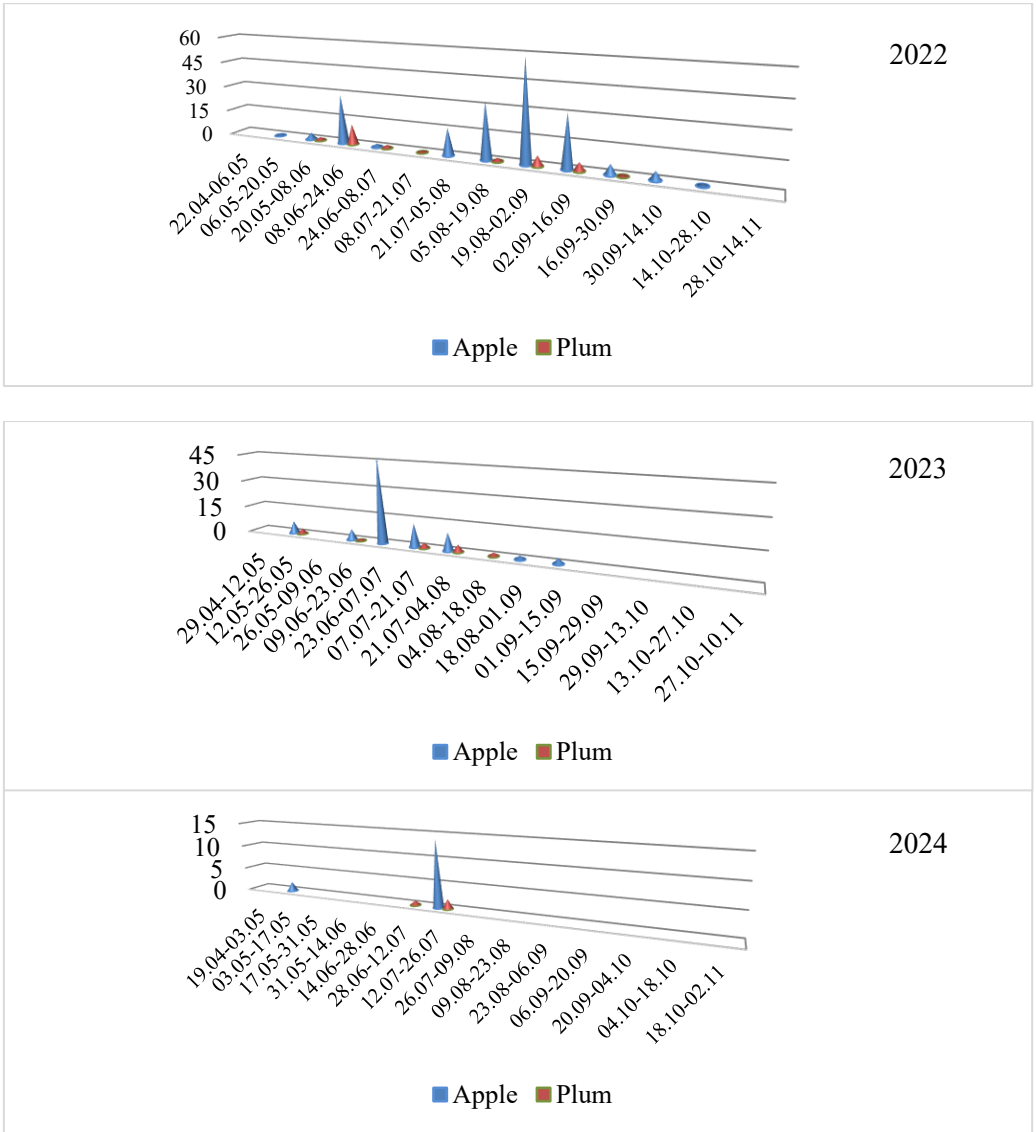

Figure 1. Seasonal captures of Auchenorrhyncha invasive species on yellow sticky traps during a 3-year period at MD Station

In all three monitoring years, first Auchenorrhyncha captures were in early May. In 2022, the captures presented two peaks in both the apple and plum orchards, both being recorded in the same periods, namely 8-24th of June (29 specimens in apple and 12 specimens

in plum), and 19th of August-2nd of September (59 specimens in apple and 6 specimens in plum), respectively. In 2023, there was a peak in the apple captures between 23rd of June and 7th of July (48 specimens) and two small peaks in the plum ones, the first one between 12-26th of May (3 specimens) and the second one between 21st of July and 4th of August (4 specimens). In 2024, with a total abundance of only 19 specimens, there was only a peak of both orchards in the period 12-26th of July (14 specimens in apple and only 2 in plum).

Geographical origin of the invasive species of Auchenorrhyncha detected in our study is from two continents, America and Asia. Of the seven species, four species (57.14%) are native to North America (*M. pruinosa*, *S. bisonia*, *E. vulnerata* and *S. titanus*) and three species (42.86%) native to Asia (*O. ishidae*, *Ph. cyclops* and *J. hyalinus*) (Table 3). According to the first reports in Europe (Horvath, 1912; Bonfils & Schvester, 1960; Zangheri & Donadini, 1980; Della Giustina, 1989; Duso et al., 2005; Guglielmino, 2005; Teodorescu, 2018), three species (*M. pruinosa*, *E. vulnerata*, *O. ishidae*) were first found in Italy, two in France (*Ph. Cyclops, S. titanus*), one in Hungary (*S. bisonia*) and one in Austria and Romania (*J. hyalinus*).

Table 3. Data on origin and first record in European continent and Romania for the invasive Auchenorrhyncha species sampled from apple and plum orchards at MD Station, 2022-2024

Species	Common name	Origin	First report in Europe and references	First report in Romania and references
Metcalfa pruinosa	The citrus flatid planthopper	North America	1979, Italy Zangheri & Donadini, 1980	2009, Constanta County, Southeastern Romania Preda & Skolka, 2009
Stictocephala bisonia (syn. *Ceresa bubalus* Fabr., 1794)	The buffalo treehopper	North America	1912, Hungary Horvath, 1912	1955 Popescu-Gorj, 1955 (Teodorescu, 2018)
Erasmoneura vulnerata	The North American grapevine leafhopper	North America	2004, Italy Duso et al., 2005	2016, Bucharest, Southern Romania Chireceanu et al., 2020
Orientus ishidae	the Japanese mosaic leafhopper	Eastern Asia	1998, Italy Guglielmino, 2005	2016, Bucharest, Southern Romania Chireceanu et al., 2017a
Phlogotettix cyclops	The Asian leafhopper	Asia and Russia	1987, France Della Giustina, 1989	1977 Dlabola, 1977 (Teodorescu, 2018)
Scaphoideus titanus	The American grapevine leafhopper	North America	1958, France Bonfils & Schvester, 1960	2009, Bucharest, Southern Romania Chireceanu et al., 2011
Japananus hyalinus	The Japanese maple leafhopper	eastern Asia	1961, Austria and Romania Wagner & Franz, 1961 (Teodorescu, 2018)	1961 Wagner & Franz, 1961 Nast 1972 (Teodorescu, 2018)

Ecological assessment values in terms of the ecological indices dominance, constancy and ecological significance, calculated for invasive Auchenorrhyncha species collected from both study orchards, are presented in Tables 4 and 5.

The dominance ranking of these species in the apple orchard (Table 4) showed that eudominant species (D>10% of the total individuals) included two species *Orientus ishidae* and *Erasmoneura vulnerata* in the 2022 and 2023 sampling years and total insects collected with yellows traps. In 2024, when only 16 individuals were captured and in the absence of *O. ishidae*, another two species became eudominant *Stictocephala bisonia* and *Phlogotettix cyclops* beside *E. vulnerata*. Dominant species (D=5-10%) were *Japananus hyalinus* in captures in the year 2023 and *S. bisonia* in the total captures. Subdominant species (D=2-5%) were *Ph. cyclops*, *S. titanus, J. hyalinus* in the total captures; *S. bisonia, Ph. cyclops* and *S. titanus* in 2022, and *S. bisonia* and *S. titanus* in 2023. Receding species group (D=1-2%) consisted of three species, *M. pruinosa* and *J. hyalinus* in the captures in 2022 and *M. pruinosa* in the total captures of the three sampling years.

Table 4. Ecological parameters for invasive species of Auchenorrhyncha collected from apple orchard in MD Station during the 2022-2024 period

	Species	2022			2023			2024			2022-2024		
		D%	C%	W%	D%	C%	W%	D%	C%	W%	D%	C%	W%
1	*Metcalfa pruinosa*	1.60	23.08	0.37							1.03	7.69	0.08
2	*Stictocephala bisonia*	2.67	15.38	0.41	3.37	15.38	0.52	56.25	7.69	4.33	5.82	12.82	0.75
3	*Erasmoneura vulnerata*	25.67	76.92	19.74	10.11	15.38	1.56	12.50	7.69	0.96	20.21	33.33	6.74
4	*Orientus ishidae*	60.43	38.46	23.24	78.65	30.77	24.20				62.67	23.08	14.46
5	*Phlogotettix cyclops*	4.28	15.38	0.66				31.25	7.69	2.40	4.45	7.69	0.34
6	*Scaphoideus titanus*	3.74	23.08	0.86	2.25	7.69	0.17				3.08	10.26	0.32
7	*Japananus hyalinus*	1.60	15.38	0.25	5.62	7.69	0.43				2.74	7.69	0.21

Data on frequency of occurrence in the apple samples revealed that only one species, *E. vulnerata* in 2022, was classified as euconstant (C=75-100%). Accessory species (C=25-50%) were *O. ishidae* in 2022 and 2023 and *E. vulnerata* in the total captures. Accidental species (C=1-25%) included *M. pruinosa S. bisonia, Ph. cyclops*, *S. titanus, J. hyalinus* in 2022*, S. bisonia*, *E. vulnerata, S. titanus* and *J. hyalinus* in 2023, and *S. bisonia*, *E. vulnerata* and *Ph. cyclops* in 2024. Except for *E. vulnerata* (accessory species), the other species were accidental in the total captures.

Regarding the ecological significance index in the apple orchard, characteristic species (W>5%) were represented by *O. ishidae* and *E. vulnerata* in 2022 and the total captures, and *O. ishidae* also in 2023. Accessory species (W=1-5%) were *E. vulnerata* in 2023, and *S. bisonia* and *Ph. cyclops* in 2024. Accidental species (W<1%) included *S. bisonia, S. titanus* and *J. hyalinus* in 2022 and 2023, to which *M. pruinosa* and *Ph.* cyclops were added in 2022 and *E. vulnerata* in 2024. Five of the seven identified species, *M. pruinosa, S. bisonia, Ph. cyclops*, *S. titanus* and *J. hyalinus*, were accidental in the total samples from the apple orchard.

In the plum orchard, the eudominant species (D>10%) (Table 5) included *E. vulnerata* and *O. ishidae* in the 2022 and 2023 sampling years to which *S. bisonia* was added in 2023 and 2024, all three species were eudominant in the total captures. *J. hyalinus* was also eudominant in 2024. Dominant species group (D=5-10%) was represented by *M. pruinosa*, *S. bisonia* and *J. hyalinus* in 2022, *S. titanus* and *J. hyalinus* in 2023 and *J. hyalinus* in the total captures. Subdominant species (D=2-5%) were *S. titanus* in 2022 to which *M. pruinosa* and *S. titanus* was added for the total captures.

Regarding the presence in samples, accessory species (C=25-50%) was *E. vulnerata* in the captures in 2022. Accidental species (C=1-25%) were most of species, *S. bisonia* and *J. hyalinus* in all sampling years, to which *M. pruinosa, O. ishidae* and *S. titanus* were added in 2022, and *E. vulnerata, O. ishidae* and *S. titanus* in 2023. All six identified species in the plum orchard were accidental in the total captures.

Table 5. Ecological parameters for invasive species of Auchenorrhyncha collected from plum orchard in MD Station during the 2022-2024

	Species	2022			2023			2024			2022-2024		
		D%	C%	W%	D%	C%	W%	D%	C%	W%	D%	C%	W%
1	*Metcalfa pruinosa*	6.45	15.38	0.99							4.26	5.13	0.22
2	*Stictocephala bisonia*	6.45	15.38	0.99	23.08	15.38	3.55	66.67	7.69	5.13	14.89	12.82	1.91
3	*Erasmoneura vulnerata*	54.84	30.77	16.87	23.08	7.69	1.77				42.55	12.82	5.46
4	*Orientus ishidae*	22.58	15.38	3.47	38.46	23.07	8.87				25.53	12.82	3.27
5	*Scaphoideus titanus*	3.23	7.69	0.25	7.69	7.69	0.59				4.26	5.13	0.22
6	*Japananus hyalinus*	6.45	15.38	0.99	7.69	7.69	0.59	33.33	7.69	2.56	8.51	10.26	0.87

Values of ecological significance index showed three characteristic species (W>5%), *E. vulnerata* in 2022, *O. ishidae* in 2023 and *S. bisonia* in 2024 and total captures. Accessory species (W=1-5%) were *O. ishidae* in 2022, *S. bisonia* and *E. vulnerata* in 2023 and *J. hyalinus* in 2024; *S. bisonia* and *O. ishidae* in all samples. Accidental species (W<1%) were *M. pruinosa, S. bisonia, S. titanus* and *J. hyalinus* in the samples from 2022, *S. titanus* and *J. hyalinus* in 2023, and *M. pruinosa*, *S. titanus* and *J. hyalinus* in all samples.

The similarity level of the two communities of Auchenorrhyncha invasive species from the two study orchards, measured by calculating of the Jaccard and Sørensen indices that are based on the presence/absence of species in the habitats, and the Bray-Curtis index based on species abundance, is shown in Figure 2. According to data in this figure, the values of the three indices showed similar tendencies. The highest similarity was expressed by Sørensen index (between 0.44 and 0.50) followed by Jaccard (between 0.26 and 0.33) and Bray-Curtis (between 0.21 and 0.28). Maximum values for Sørensen and Jaccard indices were in the year 2023 when both orchards shared all five species identified in this year, and for Bray-Curtis index was in the year 2022 when number of identified species was the highest for both orchards. The lowest values for all three indices were recorded in the year 2024; this year was the poorest both in species identified and individuals captured.

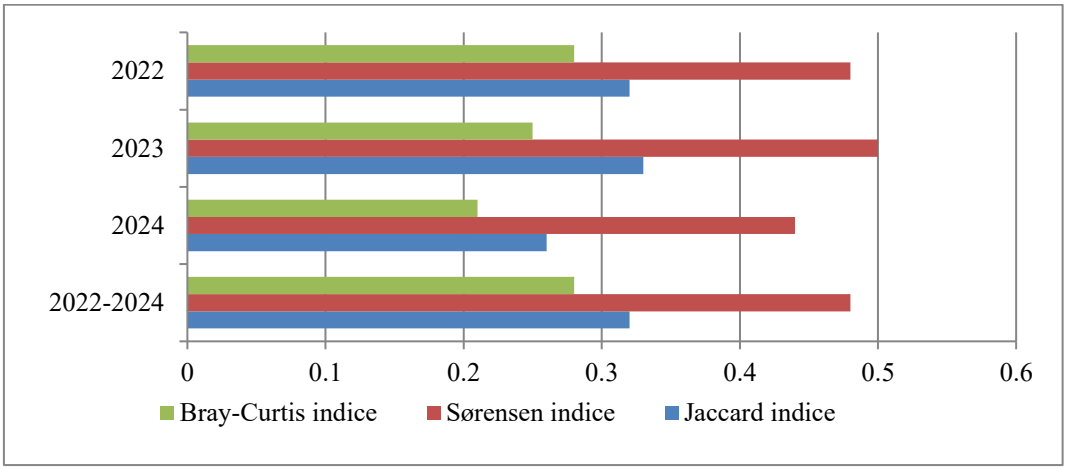

Figure 2. The similarity indices of Auchenorrhyncha invasive species sampled from apple and plum orchards in MD Station

Results in our study showed that all diversity indices calculated for Auchenorrhyncha invasive species indicated higher diversity values in the plum than in the apple orchard, both for each year of sampling and total period, except for the Simpson's diversity index in the year 2024 (Figure 3).

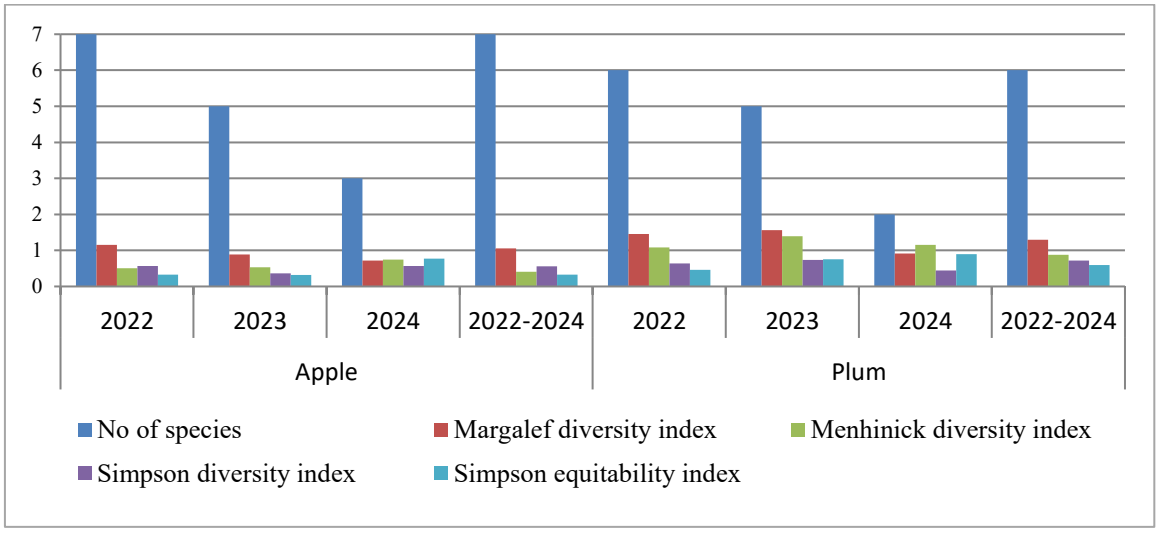

Figure 3. The diversity indices of Auchenorrhyncha invasive species sampled from apple and plum orchards in MD Station

The richness species of Auchenorrhyncha invasive species assessed by Margalef and Menhinick diversity indexes showed a more species richness in plum than in apple orchard. Values of the Margalef species richness index were between 0.91 and 1.56 for species sampled in the plum orchard and between 0.72 and 1.15 for those in the apple orchard. The highest values of this index were observed in the year 2023 for plum and in the year 2022 for apple; the lowest levels were observed in the year 2024 for both orchards. The richness species calculated by the Menhinick index had values between 1.08 and 1.39 for invasive species of Auchenorrhyncha sampled from the plum orchard and between 0.51 and 0.75 for those from the apple orchard. The highest levels of this index were recorded in the year 2023 for plum and in the year 2024 for apple; the lowest values were in the year 2022 for both orchards.

The level of diversity expressed by values of Simpson's diversity index (1-D) ranged from 0.44 to 0.73 for Auchenorrhyncha invasive species sampled from the plum orchard, and from 0.37 to 0.57 for those from the apple orchard. The maximum values of diversity measured by this index were observed in 2023 for species in plum and in 2024 for species in apple orchard, and the minimum values were recorded in 2024 for plum and in 2023 for apple orchard. The Simpson's equitability index revealed an evenness of species higher in the plum (0.46-0.90) than in the apple orchard (0.32-0.78); the maximum equitability values were reached for both orchards in the year 2024 when the fewest species were identified, 2 species for plum and 3 for apple, and the number of individuals per species decreased.

This study provides important results of the ecological analysis and diversity of the invasive Auchenorrhyncha species associated with apple and plum orchards in the south part of Romania that can be a starting point for further in-depth comparative studies.

CONCLUSIONS

The number of invasive species especially of economically importance that have entered Romania has increased in recent years.

The community of invasive Auchenorrhyncha species monitored in two orchards, apple and plum, during the 2022-2024 period in the experimental field Moara Domnească Didactic Station, Ilfov county (Southern Romania) included *Japananus hyalinus*, *Scaphoideus titanus*,

Orientus ishidae, *Erasmoneura vulnerata*, *Stictocephala bisonia* (syn. *Ceresa bubalus*) and *Metcalfa pruinosa* for both orchards, to which *Phlogotettix cyclops* was added for apple orchard.

A total of 339 individuals (86.14 % from apple orchard, 13.86% from plum orchard) were sampled, distributed as follows 64.3% in 2022, 30.1% in 2023 and 5.6% in 2024.

Cicadellidae family was the most abundant in both study orchards, reaching a relative abundance of 93.15% in apple and 80.85% in plum orchard of the total captures.

The most abundant species were the Japanese mosaic leafhopper *Orientus ishidae* (62.67%) in apple and the North American leafhopper *Erasmoneura vulnerata (*42.55%) in plum orchard.

The indices of similarity, species richness and diversity recorded higher values in plum than in the apple orchard.

REFERENCES

BIEDERMANN, R., NIEDRINGHAUS, R. (2009). The Plant- and Leafhoppers of Germany. Identification key to all species. Scheessel, Germany: Wissenschaftlich Akademischer Buchvertrieb-Fründ, 409.

BONFILS, J., SCHVESTER, D. (1960). The leafhoppers (Homoptera: Auchenorrhyncha) and their relationship with vineyards in south-western France. *Annales des Epiphyties*, 11, 325-336.

CHIRECEANU, C., PLOAIE, P., GUTUE, M., NICOLAE, I., STAN, C., COMSA, M. (2011). Detection of the Auchenorrhyncha fauna associated with grapevine displaying yellows symptoms in Romania. *Acta phytopathologica et entomologica hungarica*, *46,* 2, 253-260.

CHIRECEANU, C., TEODORU, A., GUTUE, M., DUMITRU, M., ANASTASIU, P. (2017). Two new invasive hemipteran species first recorded in Romania: *Orientus ishidae* (Matsumura 1902) and *Acanalonia conica* (Say 1830) (Acanaloniidae). *Journal of Entomology and Zoology Studies*, 5, 2, 824-830.

CHIRECEANU, C., BOSOI, M., PODRUMAR, T., GHICA, M., TEODORU, A., CHIRILOAIE-PALADE, A., ZAHARIA, R. (2020). Invasive Insect Species Detected on Grapevines in Romania during 2016-2019 and First Record of *Erasmoneura vulnerata* (Fitch, 1851) (Hemiptera: Cicadellidae). *Acta Zoologica Bulgarica*, 72, 4, 649-659.

COJOCARIU, A., CRÂȘMARU, A.E. (2023). New Data and Recent Updates on Invasive Horticultural Pest Species *Acanalonia conica* (Hemiptera: Auchenorrhyncha) in Romania. *Horticulturae*, 9, 8, 949.

DALMASO, G., IORIATTI, C., GUALANDRI, V., ZAPPONI, L., MAZZONI, V., MORI, N., BALDESSARI, M. (2023). *Orientus ishidae* (Hemiptera: Cicadellidae): Biology, Direct Damage and Preliminary Studies on Apple Proliferation Infection in Apple Orchard. *Insects*, *14,* 3, 246. https://doi.org/10.3390/insects14030246.

DELLA GIUSTINA, W. (1989). Homoptères Cicadellidae volume III, compléments aux ouvrages d'Henri Ribaut. *Faune de France*, Paris, 350.

DIETRICH, C.H. (2005). Keys to the families of Cicadomorpha and subfamilies and tribes of Cicadellidae (Hemiptera: Auchenorrhyncha). *Florida Entomologist*, 88, 502-517.

DUSO, C., BRESSAN, A., MAZZON, L., GIROLAMI, V. (2005). First record of the grape leafhopper *Erythroneura vulnerata* Fitch (Hom., Cicadellidae) in Europe. *Journal of Applied Entomology*, 129, 170-172.

GJONOV, I., SHISHINIOVA, M. (2014). Alien Auchenorrhyncha (Insecta, Hemiptera: Fulgoromorpha and Cicadomorpha) to Bulgaria. *Bulgarian Journal of Agricultural Science*, 20, 1, 151-156.

GUGLIELMINO, A. (2005). Observations on the genus *Orientus* (Rhynchota Cicadomorpha Cicadellidae) and description of a new species: *O. amurensis* n. sp. from Russia (Amur Region and Maritime Territory) and China (Liaoning Province). *Marburger Entomologische Publikationen*, 3, 99-110.

HENDERSON, P.A. (2003). Practical Methods in Ecology. Blackwell Publishing, Oxford, UK, 163p.
HORVÁTH, G. (1912). Az amerikai bivalykabócza Magyarországon. *Rovartani Lapok*, 19, 10-12, 145-147.
LIEBHOLD, A.M., TURNER, R.M., BARTLETT, C.R., BERTELSMEIER, C., BLAKE, R.E., BROCKERHOFF, E.G., CAUSTON, C.E., MATSUNAGA, J.N., MCKAMEY, S.H., NAHRUNG, H.F., OWEN, C.L., PURESWARAN, D.S., ROQUES, A., SCHNEIDER, S.A., SANBORN, A.F., YAMANAKA, T. (2024). Why so many Hemiptera invasions? *Diversity and Distributions*, 30, 12, e13911.
LEŠNIK, M.; SELJAK, G.; VAJS, S. (2017). Populacijska dinamika škržatka *Orientus ishidae* Matsumura v nasadih jablan v letih 2015 in 2016. In Proceedings of the 13th Slovenian Conference on Plant Protection with International Participation, Rimske Toplice, Slovenia, 7-8 March 2017, 39-46.
MAGURRAN, A.E. (2004). Measuring biological diversity, Oxford, UK: Blackwell Publishing, 256p.
MIFSUD, D., COCQUEMPOT, C., MÜHLETHALER, R., WILSON, M.R., STREITO, J.-C. (2010). Other Hemiptera Sternorrhyncha (Aleyrodidae, Phylloxeroidea, and Psylloidea) and Hemiptera Auchenorrhyncha. Chapter 9.4. *BioRisk*, 4, 1, 511-552.
MOZAFFARIAN, F. (2018). An Identification key to the species of Auchenorrhyncha of Iranian fauna recorded as pests in orchards and a review on the pest status of the species. *Zootaxa*, 4420, 4, 475-501.
PREDA, C., SKOLKA, M. (2009). First record of a new alien invasive species in Constanta - *Metcalfa pruinosa* (Homoptera: Fulgoroidea). In: PĂLTINEANU C. (Ed.) *Lucrările Simpozionului Mediul și agricultura în regiunile aride*; Prima ediție. București. Estfalia, 141-146.
ROQUES, A., RABITSCH, W., RASPLUS, J.-Y., LOPEZ-VAAMONDE, C., NENTWIG, W., KENIS, M. (2009). Alien Terrestrial Invertebrates of Europe. In: DRAKE, J., Handbook of Alien Species in Europe. *Springer Netherlands*, 3, 63-79.
SCHLITT, B. P., LAJTÁR, L., OROSZ, A. (2024). New grape-feeding leafhoppers in Hungary–first records of *Erasmoneura vulnerata* (Fitch, 1851) and *Arboridia kakogawana* (Matsumura, 1931) (Hemiptera: Clypeorrhyncha: Cicadellidae). *Folia Entomologica Hungarica*, 85, 41-52.
ŠĆIBAN, M., KOSOVAC, A. (2020). New records and updates on alien Auchenorrhyncha species in Serbia. *Journal Pesticides and Phytomedicine*, 35, 1, 9-17.
SEEBENS, H., BLACKBURN, T.M., DYER, E.E., GENOVESI, P., HULME, P.E., JESCHKE, J.M., PAGAD, S., PYŠEK, P., WINTER, M., ARIANOUTSOU, M., BACHER, S., BLASIUS, B., BRUNDU, G., CAPINHA, C., CELESTI-GRAPOW, L., DAWSON, W., DULLINGER, S., FUENTES, N., JÄGER, H. (2017). No saturation in the accumulation of alien species worldwide. *Nature Communications*, 8, 14435.
SELJAK, G. (2011). First record of the Nearctic leafhopper *Erasmoneura vulnerata* (Fitch, 1851) [Hemiptera, Cicadomorpha:Cicadellidae] in Slovenia. *Acta Entomologica Slovenica*, 19, 1,37-42.
STAN, G. H. (1994). Statistical methods with applications in entomological research. *Information bulletin*, 5, 2, 113-126.
STORK, N.E. (2018). How many species of insects and other terrestrial arthropods are there on Earth? *Annual Review of Entomology*, 63, 31-45.
TEODORESCU, I. (2018). Contribution to database of alien/invasive Homoptera insects in Romania. *Romanian Journal of Biology*, 63, 1-2, 29-68.
TEODORU, A., FLORESCU, I., GEICU, A.G., CHIRECEANU, C. (2021). Auchenorrhyncha fauna associated with abandoned apple and plum orchards in Northern Bucharest in 2020. *Scientific Papers. Series B, Horticulture*, 65, 1, 256-265.
WAGNER, W., FRANZ, H. (1961). Unterordung Homoptera, Überfamilie Auchenorrhyncha (Zikaden). *Die Nordost-Alpen im Spiegel ihrer Landtierwelt*, 2, 7, 1-58.
ZANGHERI, S., DONADINI, P. (1980). Appearance of neartic homopterous *Metcalfa pruinosa* Say (Homoptera: Flatidae), 63, 301-305.