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ABUNDANCE AND DIVERSITY OF *AUCHENORRHYNCHA* SPECIES IN VINEYARDS FROM ROMANIA

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Abstract

The Auchenorrhyncha is one of the most abundant and species-rich insect groups present on grapevine. In our study there are presented the results on abundance, dominance, constancy and ecological significance as well as species diversity of Auchenorrhyncha group monitored in 2016-2018 and 2020-2021 in a network of ninety-five vine plots distributed in vineyards from Banat, Crişana and Maramureş Hills (Western Romania) and Moldova Hills (Eastern Romania). The collecting of insects was on yellow double sticky traps from May /June to October every year. Scaphoideus titanus, the vector for quarantine disease Flavescence dorée, was the most abundant species in vineyards from both zones, followed by Erasmoneura vulnerata, Empoasca spp., Neoaliturus fenestratus, Anoplotettix fuscovenosus and Fieberiella florii. Number of species varied between 31 and 49 species. Shannon-Wiener diversity indexes was 1.61 bits for insects in vineyards of Moldova Hills and 2.09 bits for insects in vineyards of Banat, Crişana and Maramureş Hills. Simson's diversity index was 0.68 for insects in vineyards of Moldova Hills and 0.83 for insects in vineyards of Banat, Crişana and Maramureş Hills. Sorensen' similarity coefficient was between 0.79 and 0.94 suggesting that the communities of Auchenorrhyncha in vineyards had a similar species composition.

Key words: *Auchenorrhyncha fauna, leafhoppers, planthoppers, Romanian grapevine.*

INTRODUCTION

The vineyard agroecosystem in Romania covered in 2020 an important area of about 190 thousand hectares (OIV, 2021). It is host of a wide range of insect species belonging to harmful and the useful entomofauna. The *Auchenorrhyncha* (Insecta: Hemiptera: Fulgoromorpha and Cicadomorpha) is one of the most abundant and species-rich pest insect groups associated with grapevine. There are two types of damage related to the presence of *Auchenorrhyncha*, direct damage as a result of their feeding, sting and suck the sap from plant tissues, and indirect damage generated by the ability of some species to act as vector for the economically important pathogens that multiply in the conductive tissues of the plants, like phytoplasma 'Candidatus Phytoplasma' (Ca. P.) (IRPCM 2004) causing devastating diseases known as the yellows of grapevine (Weintraub and Beanland, 2006) and bacteria *Xylella fastidiosa* responsible for the of Pierce's disease (Saponari et al., 2014, Cornara et al., 2016). In addition, the invasive species that have recently appeared in grapevine have considerably increased importance of the *Auchenorrhyncha* group. Therefore, knowing the status of plant and leafhoppers is essential in the economics of grapevine. Many studies have focused on the involvement of *Auchenorrhyncha* species in the epidemiology of phytoplasmic diseases (Mehle et al., 2010, Trivellone et al., 2015, Quaglino et al., 2019, Quiroga et al., 2020). Other studies assessed the diversity of species (Kunz et al., 2010, Saguez et al., 2014, Ramos et al., 2019).

However, plant and leafhoppers species in grapevine have not received an appropriate attention and have not represented themes of many studies in Romania. The studies have mainly focused on the North American leafhopper *Scaphoideus titanus* Ball, the vector of Flavescence Dorée and were published by the authors of present study.

The aim of present study was to investigate the species belonging to *Auchenorrhyncha* group detected in vineyards located in Western and Eastern Romania, in term of ecological characteristics and diversity of species, in order to provide background knowledge with scientific and practical utility in this field.

MATERIALS AND METHODS

Samplings of plant and leafhoppers were carried out in two periods 2016-2018 and 2020-2021 in a network of ninety-five vineyard plots located in the western and eastern parts of Romania, within the framework of two research projects with financial support from Ministry of Agriculture and Rural Development.

Locations of collection areas during this study are presented on map in Figure 1. Of the ninety-five vineyard plots, eighty plots were surveyed in 2016-2018 and fifteen in 2020-2021, of which forty one in west and fifty-four in east of the country. The plots in the west were located in eleven wine centres from four vineyards, as follows: the wine centre Recaș (4) from Recaș-Tirol vineyard in the Viticulture Region of Banat (Banat Hills); the wine centres Păuliș (2), Miniș (5), Ghioroc (3), Cuvin (1), Covăsânț (3), Măderat (6), Pâncota (5) from Miniș - Măderat vineyard, the wine centres Biharia (1), Diosig (1) from Diosig vineyard from the Viticulture Region of Crișana (Crișana Hills); the wine centre Beltiug (1) from Rătești vineyard in the Viticulture Region of Maramureș (Maramureș Hills).

The plots in the east were located in eleven wine centres in four vineyards from the Viticulture Region of Moldova (Moldova Hills) as follows: the wine centres Odobești (18), Jaristea (2) from Odobești vineyard, the wine centres Panciu (5), Ţifeşti- Sârbi (4) from Panciu vineyard, the wine centres Vârteşcoiu (9), Cârligele (3), Dumbrăveni (2), Beciu (1), Faraoanele (1), Grebănu (2) from Coteşti vineyard, and the wine centre Huși (9) from Huși vineyard.

The plantations were of 3-11 years old, generated through the national program of reconversion and restructuring in Romanian viticulture started since 2014, excepting four plantations investigated in 2020 and 2021 (two in west and two in east of the country). All plots were for commercial production and were composed of national and international cultivars of *Vitis vinifera* L., nine in western and ten in eastern areas. Some of the vineyards showed symptoms typical to yellow diseases associated with phytoplasma. The vineyards were located on the slopes, mainly in the west part, or in the flatland. The plantations belonged to owners in the area and were protected differently with chemical products against pest and diseases. Generally, five to eight treatments for main pathogens and one to two against lepidepteras and mites were applied. None of the *Auchenorrhyncha* species has undergone any insecticides, not even *S. titanus*, which has shown high populations in some plantations. In practice, it is considered that this problem is solved by the insecticides applied against moths. In some plantations, every second interval between the vine rows was permanently covered with a mixture of plants, in others the inter-rows was partially covered or free of weeds that were controlled by tillage and standard herbicides. In the abandoned plots no control has been applied for several years.

The insect sampling was done using double-face sticky traps (Atraceras type), placed in a linear pattern on a row inside the plots. In each plot, four traps in 2016-2018 and six traps in 2020-2021 were used. Traps were changed every two weeks for the first three years and weekly for the last two years from May/June to October.

Adult insects from sticky traps were determined to genus and species level using a stereomicroscope, following the taxonomic keys in Biedermann and Niedringhaus (2009), Kunz et al. (2011) and Wilson et al (2015). Specimens are kept in entomological collection of the laboratory. The resulting data were used for calculating the indices of synecological analysis and estimating the diversity of species per zone and year of sampling.

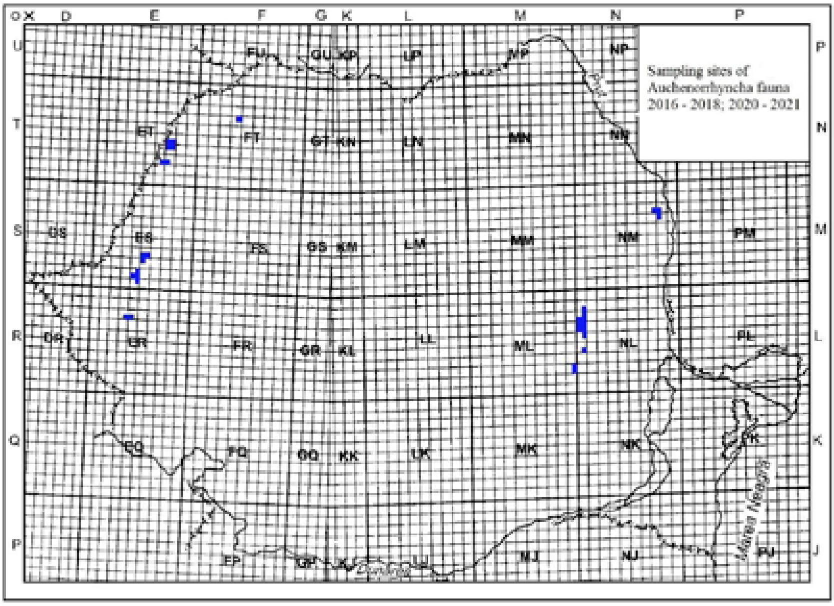

Figure 1. Map of sampling areas in west and east part of the country in periods 2016-2018 and 2020-2021

There were computed the analytic ecological indices, abundance (A), dominance (D%), constancy (C%) and synthetic indices of ecological significance (W%), following specific formulas (Stan, 1994).

D% = (A/n) x 100, where A is number of individuals of a species, n is total number of individuals of all species. Species were grouped as subrecedent (D_1 <1%), recedent (D_2 = 1.1-2%), subdominant (D_3 = 2.1-5%), dominant (D_4=5.1-10%) and eudominant (D_5 > 10%).

C% = (ns/n) x 100, where ns is number of samples with one species, n is total number of samples. Species were grouped as accidental (C_1 = 1-25%), accessory (C_2 = 25.1-50%), constant (C_3 = 50.1-75%) and euconstant (C_4 = 75.1-100%).

W% = (D x C) x 100. Species were grouped as subrecedent (W_1<0.1%), recedent (W_2 = 0.1-1%), subdominant (W_3=1.1-5%), dominant (W_4 = 5.1-10%) and eudominant (W_5 > 10%).

To measure the diversity of sampled species two widely used diversity indices were calculated: Simpson's index of diversity (Gini-Simpson's index) (Magurran, 2004) that take into account the relative abundance of each species, $D = 1- \Sigma p_i^2$ (Pielou, 1969), where p_i is the proportion of abundances belonging to species. It represents the probability that two individuals randomly drown from a sample belong to different species. According to this equation, the value of this index ranges between 0 and 1, the higher the index values, the more complex a biocenosis. Shannon-Wiener index considers both species richness and evenness, $H' = -\sum pi \ln pi$ (Magurran, 1988). This ranges from 0 to 1 when all species in a sample have even abundances.

To measure species evenness describing the pattern of relative abundance of species in a community, the equitability derived from Shannon index and the other from Simson's index were assess, J and E_{1-D} respectively. $J = H'/H_{max} = H'/\ln S$; $E_{1-D} = (1-D)/1-1/S)$, where S is species richness. Values for both indexes range between 0 and 1, high values indicating low variation between species.

To compare the species composition in the communities of *Auchenorrhyncha*, the Sorensen′ coefficient of similarity was calculated, $CC = 2C/(S_1+S_2)$, where C is the number of species common to the two communities, S_1 and S_2 represent the number of species found in community 1 and 2, respectively. Values of this coefficient between 0 and 1, high values indicate that the communities share similar species composition.

RESULTS AND DISCUSSIONS

A total of 229,514 specimens of leafhoppers and planthoppers were sampled in 95 vine plots located in vineyards in the eastern and western Romania (ER, WR) investigated in two periods, from 2016 to 2018 and from 2020 to 2021 (Table 1). Number of specimens differed between zones and years of sampling as well. During sampling periods, plant and leafhoppers collected in the ER grapevines were higher than in the WR grapevines. Of the total insects collected, 76% were recorded in the region Moldova Hills (ER) for 54 vine plots and 24% in the regions Banat, Crisana and Maramures Hills (WR) for 41 vine plots. The difference could be due to the higher number of plots as well as different management strategies of pest, disease and weeds conducted in each plot. The increase in number of insects from year to year was considerable in both regions although the number of sampled plots was equal to or less up to 5 times. In the region Moldova Hills (ER), in the first three-years of sampling, 16 vine plots were sampled each year and the insects collected were more numerous in the third year, 1.6 times than in the first and 1.2 times in the second sampling year. Numerical increase of specimens was also preserved in the second collection period, when for the same number of sampled plots, the number of detected specimens in 2021 was 1.3 times higher than 2020 (Table 1). A similar situation was found in the vineyards in the regions Banat, Crisana and Maramures Hills (WR). In both sampling periods, plant and leafhoppers catches were substantially higher from one year to the next, except in 2018 when slightly fewer insects were caught than in 2017. The highest increase was in the second sampling period, especially in the ER grapevines (Table 1).

Table 1. Number of individuals assigned on sampling vine plots, years 2016-2018 and 2020-2021

	Moldova Hills					Banat-Crisana-Maramures Hills				
	2016	2017	2018	2020	2021	2016	2017	2018	2020	2021
No of vine plot investigated	16	16	16	3	3	10	10	12	5	4
No of samples	128	160	160	69	69	80	90	84	110	88
No of samples (5yrs)	586					452				
No of specimens	9891	14578	16431	57735	75651	3265	8971	8615	14700	19677
Mean of specimens/vine plot	618	911	1027	19245	25217	327	897	718	2940	4919
Total No of specimens (5yrs)	174286					55228				

Our data in this study showed the presence of a consistent number of plant and leafhopper insects on grapevine in Romania. This is accordance with many results in literature presenting this agroecosystem as a suitable host for a large range of species of Auchenorrhyncha (Özgen & Karsavuran, 2009; Kunz et al., 2010; Saguez et al, 2014; Safarova et al. 2018, Ramos et al., 2019; Vizitiu et al, 2022). Overall, the collected specimens by us were assigned to 57 species (including the genus level), 11 families and 21 subfamilies. Per zone, the community of *Auchenorrhyncha* in the ER grapevines had the average of species richness of 56 assigned to 11 families and 20 subfamilies, while in WR grapevines, the average of species richness was 50 assigned to 9 families and 17 subfamilies. The species of plant and leafhoppers identified in the east and west zones are listed in Table 2 together with the values of ecological indices, abundance, dominance, constancy and ecological significance calculated for all specimens cumulated all the five years of sampling.

According to abundance and dominance indices obtained for the insects of each zone, the family Cicadellidae counted the most specimens, representing 98.15% in east and 92.77% in west vineyards. It included the most species, 37 (65% of total species) belonging to 8 subfamilies, Deltocephalinae, Typhlocybinae, Iassinae, Cicadellinae, Eupelicinae, Eurymelinae, Eurymelinae, Aphrodinae and Idiocerinae. Similar results were also reported for *Auchenorrhyncha* species in Italian vineyards (Kunz et al., 2010). Within subfamilies of Cicadellidae, Deltocephalinae was by far the most abundant in both zones, with 77.31% in WR and 64.82% in ER vineyards followed by Typhlocybinae with 33.23% in ER and 14.48% in ER vineyards. Cixidae and Aphrophoridae were the next two most abundant families collected in this study, with 3.58 and 1.96% in WR, and 0.77 and 0.24% in ER vineyards, respectively. The other families were numerically small, represented by only one or two species with few specimens. Of the species collected, the North American leafhopper *Scaphoideus titanus* (Deltocephalinae) was the most in both zones, reaching a level of 50.54% in ER and 28.68% in WR of total abundance of each zone. This result confirms the previous ones in other vineyards in the country (Chireceanu et al, 2011). *S. titanus* is natural vector of FD diseases on grapevine in Europa with high populations widely distributed on the continent (EFSA, 2020). Other species with more than ten percent, classified as eudominant species like *S. titanus*, were: *Erasmoneura vulnerata* (19.18%) and *Empoasca* spp. (11.85%) in ER and *Anoplotettix fuscovenosus* (17.50%), *Neoaliturus fenestratus* (17.22%) and *Empoasca spp.* (14.11%) in WR vineyards. Two dominant species were counted, *N. fenestratus* (9.35%) in ER and *Fieberiella florii* (9.12%) and WR. Only subdominant species was *Reptalus quinquecostatus* with a relative abundance of 3.28% in WR grapevine. As recedent species were *Platimetopius rostratus* for both zones, and *Phylaenus spumaris* in WR and *Arboridia kakogawana* in ER vineyards. The other species (89% in ER and 84% in WR) had low abundances, below 1%.

In samples from WR vineyards, *Fieberiella florii* was the most frequent (euconstant species) accounting for 81.64% of the samples, followed by *Neoaliturus fenestratus* (52.21%) (constant species) and eight accessory species *Reptalus quinquecostatus*, *Stictocephala bisonia, Philaenus spumarius, Scaphoideus titanus, Anoplotettix fuscovenosus Platymetopius rostratus, Allygidius atomarius* and *Empoasca* spp. with frequencies between 29.20 and 48.78%.

In samples from ER vineyards, *S. titanus, Platymetopius rostratus* and *Empoasca* spp. were the most common (between 49.78 and 42.92%) grouped as constant species, followed by *R. quinquecostatus*, *S. bisonia* and *P. spumarius, N. fenestratus* and *E. vulnerata* found between 29.52 and 45.05 of the samples and grouped as accessories species. The presence of a large number of species with low frequency in samples (<25%) was noted, 85.7% in ER and 80% in WR. These were classified as accidental species. Among the species with few individuals in ER vineyards is *Orientus ishidae*, too. This is confirmed as a new natural vector of FD to grapevine (Mehle et al., 210). Its presence on Romanian grapevine is reported for the first time in this study. There were species with low frequency in the samples although they were represented by a high number of individuals, e.g. *A. kakogawana* (2268 individuals) and *F. florii* (1585 individuals) in Moldova Hills and *Allygidius atomarius* and *Marosteles spp* (375 individuals each) in Banat-Crisana-Maramures Hills.

The results on the ecological significance index indicated that the most significant ecologically species were: *S. titanus* (eudominant species), *F. florii, A. fuscovenosus*, *N. fenestratus* and *Empoasca* spp. (dominant species), *R. quinquecostatus* (subdominant species) and *Laodelphax striatellus, S. bisonia, P. spumarius Macrosteles* sp., *P. rostratus, A. atomarius, Japananus hyalinus* (recedent species) for WR vineyards; *S. titanus* (eudominant species), *E. vulnerata* and *Empoasca spp.* (dominant species), *N. fenestratus* (subdominant species), *R. quinquecostatus*, *S. bisonia, P. spumarius, F. florii, Macrosteles* sp., *P. rostratus, Penthimia nigra, Zygina flamigera* and *A. kakogawana* (recedent species) for ER vineyards. The other species (76.78% in ER and 74% in WR) were grouped as subrecedent, their ecological significance index were below 0.1%. This group includes accidental species.

It is worth noting the invasive species *E. vulnerata* and *A. kakogawana* in the vineyards of Moldova Hills in ER with high populations. They were first captured in 2018 (Chireceanu et al., 2020) and in 2021 these reached abundances 25 and 6 times larger. It is also important to consider the consistent proportion of species vectors for pathogens responsible for grapevine phytoplasmoses, *S. titanus*, R. *quinquecostatus, A. fuscovenosus, N. fenestratus, F. florii, P. spumaris* and *Platymetopius rostratus* (Šafářová et al., 2018; Quaglino et al., 2019). In addition, *P. spumaris* is also a very important vector of the bacterium *Xylella fastidiosa* causing the Pierce's disease (Bodino et al., 2021).

Table 2. Values of and ecological indices and significance index of the *Auchenorrhyncha* species collected in Romanian vineyards

Family/Subfamily/Genus/Species	Moldova Hills							Banat-Crisana-Maramures Hills						
	A	D		C		W		A	D		C		W	
		(%)	Class	(%)	Class	(DxC)	Class		(%)	Class	(%)	Class	(DxC)	Class
Cixiidae/Cixinae														
Cixius wagneri (China)	58	0.03	D1	3.75	C1	<0.01	W1	57	0.10	D1	6.42	C1	0.01	W1
Hyalesthes obsoletus (Sing)	148	0.08	D1	11.26	C1	0.01	W1	103	0.19	D1	12.17	C1	0.02	W1
Reptalus quinquecostatus (Löw)	1094	0.63	D1	33.45	C2	0.21	W2	1814	3.28	D3	37.83	C2	1.24	W3
Reptalus cuspidatus (Fieber)	41	0.02	D1	1.54	C1	<0.01	W1	3	0.01	D1	0.66	C1	<0.01	W1
Issidae/Issinae														
Agalmatium bilobum (Fieber)	29	0.02	D1	3.41	C1	<0.01	W1							
Issus coleoptratus (Fabricius)	2	<0.01	D1	0.17	C1	<0.01	W1							
Delphacidae/Criomorphinae														
Laodelphax striatellus (Fallen)	108	0.06	D1	9.56	C1	0.01	W1	323	0.58	D1	21.46	C1	0.13	W2
Delphacidae/Delphacinae														
Javesella pellucida (Fabricius)	69	0.04	D1	5.46	C1	<0.01	W1	32	0.06	D1	4.20	C1	<0.01	W1
Dictyopharidae/Dictyopharinae														
Dictyophara europaea (L)	18	0.01	D1	2.39	C1	<0.01	W1	35	0.06	D1	3.98	C1	<0.01	W1
Membracidae/Smiliinae														
Stictocephala bisonia (K et Y)	518	0.30	D1	44.54	C2	0.13	W2	406	0.74	D1	32.74	C2	0.24	W2
Membracidae/Centrotinae														
Centrotus cornutus (L.)	18	0.01	D1	0.85	C1	<0.01	W1	51	0.09	D1	2.21	C1	<0.01	W1
Aphrophoridae/Aphrophorinae														
Philaenus spumarius (L)	696	0.39	D1	37.88	C2	0.15	W2	1038	1.88	D2	36.95	C2	0.69	W2
Neophilaenus campestris (Fallen)	34	0.02	D1	4.95	C1	<0.01	W1	42	0.08	D1	5.31	C1	<0.01	W1
Aphrophora salicina (Goeze)	4	<0.01	D1	0.68	C1	<0.01	W1	3	0.01	D1	0.66	C1	<0.01	W1
Lepyronia coleoptrata (L)	2	<0.01	D1	0.17	C1	<0.01	W1							
Cicadidae/Cicadettinae														
Cicadetta montana (Scopoli)								7	0.01	D1	1.11	C1	<0.01	W1
Cercopidae/Cercopinae														
Cercopis sanguinolenta (Scopoli)	6	<0.01	D1	0.68	C1	<0.01	W1	19	0.03	D1	0.88	C1	<0.01	W1
Tettigometridae/Tettigometrinae														
Tettigometra macrocephala (Fieber)	6	<0.01	D1	0.51	C1	<0.01	W1							
Tettigometra virescens (Panz.)	2	<0.01	D1	0.34	C1	<0.01	W1	7	0.01	D1	0.88	C1	<0.01	W1
Cicadellidae/Agalliinae														
Anaceratagallia ribauti (Ossiannilsson)	326	0.18	D1	19.62	C1	0.04	W1	161	0.29	D1	11.95	C1	0.03	W1
Cicadellidae/ Deltocephalinae														
Scaphoideus titanus (Ball)	88082	50.54	D5	67.92	C3	34.32	W5	15838	28.68	D5	49.78	C2	14.28	W5
Fieberiella florii (Stal)	1585	0.91	D1	20.14	C1	0.18	W2	5039	9.12	D4	81.64	C4	7.45	W4
Anoplotettix fuscovenosus (Ferrari)	205	0.12	D1	15.02	C1	0.02	W1	9665	17.50	D5	48.23	C2	8.44	W4
Neoaliturus fenestratus (H-S)	16289	9.34	D4	45.05	C2	4.21	W3	9509	17.22	D5	52.21	C3	8.99	W4
Macrosteles sp.	1380	0.79	D1	25.09	C1	0.20	W2	375	0.68	D1	14.16	C1	0.10	W2
Platymetopius rostratus (H-S)	2337	1.34	D2	60.75	C3	0.81	W2	733	1.33	D2	42.92	C2	0.57	W2
Platymetopius major (Kirschbaum)	149	0.08	D1	10.75	C1	0.01	W1	8	0.01	D1	1.77	C1	<0.01	W1
Platymetopius guttatus (Fieber)	5	<0.01	D1	0.68	C1	<0.01	W1							
Psammotettix spp.	199	0.11	D1	8.70	C1	0.01	W1	70	0.13	D1	6.64	C1	0.01	W1
Phlogotettix cyclops (M et R)	357	0.20	D1	19.62	C1	0.04	W1	93	0.17	D1	7.08	C1	0.01	W1
Allygus modestus (Scott)	301	0.17	D1	19.80	C1	0.03	W1	171	0.31	D1	21.24	C1	0.07	W1
Allygus mixtus (Fabricius)	46	0.02	D1	2.73	C1	<0.01	W1	24	0.04	D1	3.98	C1	<0.01	W1
Allygidius atomarius (Fabricius)	405	0.23	D1	20.99	C1	0.05	W1	375	0.68	D1	29.20	C2	0.20	W2
Japananus hyalinus (Osborn)	101	0.06	D1	9.56	C1	0.01	W1	360	0.65	D1	15.49	C1	0.10	W2
Selenocephalus obsoletus (Germar)	89	0.05	D1	4.78	C1	<0.01	W1	214	0.39	D1	11.50	C1	0.04	W1
Deltocephalus pulicarius (Fallen)	157	0.09	D1	6.83	C1	0.01	W1	22	0.04	D1	3.98	C1	<0.01	W1
Penthimia nigra (Goeze)	1098	0.60	D1	17.06	C1	0.11	W2	162	0.29	D1	11.95	C1	0.04	W1
Euscelidius variegatus (Kirschbaum)	191	0.11	D1	4.78	C1	0.01	W1	39	0.07	D1	2.43	C1	<0.01	W1
Orientus ishidae (Mats.)	2	<0.01	D1	0.34	C1	<0.01	W1							
Phlepsius ornatus (Perris)	2	<0.01	D1	0.34	C1	<0.01	W1							
Cicadellidae/Typhlocybinae														
Zygina flammigera (Fourcroy)	1309	0.75	D1	22.87	C1	0.17	W1	101	0.18	D1	5.09	C1	0.01	W1
Zyginella pulchra (Low)	6	<0.01	D1	0.85	C1	<0.01	W1	19	0.03	D1	2.43	C1	<0.01	W1
Erasmoneura vulnerata (Fitch)	33429	19.18	D5	29.52	C2	5.66	W4	11	0.02	D1	1.55	C1	<0.01	W1
Arboridia kakogawana (Matsumura)	2268	1.30	D2	12.46	C1	0.16	W2	32	0.06	D1	5.75	C1	<0.01	W1
Arboridia sp.	160	0.09	D1	6.48	C1	0.01	W1	4	0.01	D1	0.44	C1	<0.01	W1
Empoasca spp.	20651	11.85	D5	52.90	C3	6.27	W4	7793	14.11	D5	45.13	C2	6.37	W4
Eurhadina pulchella (Fallen)	15	0.01	D1	1.71	C1	<0.01	W1	15	0.03	D1	1.99	C1	<0.01	W1
Eupteryx sp.	73	0.04	D1	2.22	C1	<0.01	W1	23	0.04	D1	1.77	C1	<0.01	W1
Cicadellidae /Iassinae														
Iassus lanio (L)	4	<0.01	D1	0.34	C1	<0.01	W1	17	0.03	D1	1.99	C1	<0.01	W1
Cicadellidae/Cicadellinae														
Cicadella viridis (L)	79	0.04	D1	7.68	C1	<0.01	W1	318	0.58	D1	15.93	C1	0.09	W1
Oncopsis flavicollis (L)	2	<0.01	D1	0.34	C1	<0.01	W1	5	0.01	D1	1.11	C1	<0.01	W1
Cicadellidae/Eupelicinae														
Eupelix cuspidate (Fab)	2	<0.01	D1	0.34	C1	<0.01	W1	2	<0.01	D1	0.22	C1	<0.01	W1
Cicadellidae/Eurymelinae														
Macropsis fuscula (Zetterstedt)	54	0.03	D1	6.14	C1	<0.01	W1	23	0.04	D1	4.42	C1	<0.01	W1
Cicadellidae /Aphrodinae														
Aphrodes bicinctus (Schrank)	6	<0.01	D1	0.68	C1	<0.01	W1	6	0.01	D1	1.33	C1	<0.01	W1
Aphrodes makarovi (Curt.)	8	0.01	D1	0.51	C1	<0.01	W1	8	0.01	D1	1.33	C1	<0.01	W1
Cicadellidae/ Idiocerinae														
Metidiocerus rutilans (Kirschbaum)	1	<0.01	D1	0.17	C1	<0.01	W1	1	<0.01	D1	0.22	C1	<0.01	W1
Flatidae/Flatinae														
Metcalfa pruinosa (Say)	60	0.03	D1	5.46	C1	<0.01	W1	52	0.09	D1	3.76	C1	<0.01	W1

The data obtained in this study revealed a community of Auchenorrhyncha on Romanian grapevine with 57 species that gives it a satisfactory degree of stability (Table 3). The ER vineyards showed a species richness, total and per year, slightly higher than those in WR. Out of a total of 57 species identified, forty-nine species were common to both regions.
According to the values of Shannon diversity index (H′) in Table 3, the insect community in the WR vineyards was more diverse than community in the ER vineyards, both in each year and throughout the sampling period, indicating a better uniformity of species abundance in this zone. Value of H' for species collected in WR amounts to 2.47 bits (average 2.09) and for species collected in ER amounts to 2.05 bits (average 1.61). This result is in line with those of Kunz et al., (2010) and Saguez et al. (2014) for *Auchenorrhyncha* species found in Italian and Canadian vineyards, respectively. The lower diversity of species in ER vineyards can be attributed to the high abundance of the leafhopper *Scaphoideus titanus* with percentage of 50.54% out of total abundance of the zone, 1.7 times more than in WR. This together with other two species accounted for more than 81% of the specimens collected from ER zone. During the sampling period, there is a decrease in the value of this index from 2016 to 2021 in both zones.
The Shannon Equitability index (J) applied to the collected species also showed the *Auchenorrhyncha* community in WR with a more equitable distribution of abundances than in ER vineyards. The average value of J equitability was 0.53 (0.44 - 0.72) in WR vineyards and 0.40 (0.32-0.57) in ER vineyards, suggesting a less homogeneous distribution of collected specimens among the registered species over the years.
Referring to Simpson's Diversity Index (D), this also indicated higher values for the insect's community in WR vineyards as did the Shannon diversity index (Table 3). The decrease of the values of this index from 2016 to 2021 was observed as in Shannon diversity index in both vineyards regions. The equitability E_{1-D} calculated for collected species reached average values of 0.33 (0.22-0.43) in ER and 0.17 (0.11-0.29) in WR vineyards. The uneven distribution of specimens among the recorded species is suggested as well. Lake in annual agriculture systems, diversity of arthropod species in grapevine is under influence of numerous agricultural practices. The ecological imbalance induced by harmful factors, such as pesticides can lead to changes in species richness and the distribution model of dominances, which in turn leads to a decrease in species diversity (Teodorescu & Cogalniceanu, 2005; Beketov et al., 2013). A strong correlation was found between the high pressure of insecticides and herbicides and negative effects on composition and behaviour of leafhopper communities sampled in vineyards in Southern Switzerland (Trivellone et al., 2012). A better plant cover of the soil between the rows can create a favorable microclimate with a good effect for organisms.

Table 3. Shannon-Wiener's and Simpson's diversity indexes and Equitability indexes of leafhoppers collected in Romanian vineyards (2016-2018; 2020-2021)

	Moldova Hills					Banat-Crisana-MM Hills				
	2016	2017	2018	2020	2021	2016	2017	2018	2020	2021
No of species	37	31	40	38	49	31	33	38	38	43
Total No of species (5yrs)	55					50				
Shannon -Wiener's Diversity Index (H)	2.05	1.38	1.89	1.35	1.24	2.47	2.20	2.12	1.71	1.65
Shannon-Wiener's Diversity Index (H) 5 yrs	1.61					2.09				
Shannon's Max Diversity Index (H_{max})	3.61	3.43	3.69	3.64	3.89	3.43	3.50	3.64	3.64	3.76
Shannon's Max Diversity Index (H_{max})	4.01					3.91				
Equitability (J)	0.57	0.40	0.51	0.37	0.32	0.72	0.63	0.58	0.47	0.44
Equitability (J) 5 yrs	0.40					0.53				
Simpson's Diversity Index (D)	0.79	0.58	0.73	0.65	0.59	0.89	0.85	0.84	0.76	0.72
Simpson's Diversity Index (D) 5 yrs	0.68					0.83				
Equitability (E_{1-D})	0.22	0.43	0.28	0.36	0.42	0.11	0.15	0.16	0.25	0.29
Equitability (E_{1-D}) 5 yrs	0.33					0.17				

The high values of Sorensen′ similarity coefficient between 0.79 and 0.94 suggest that the communities of Auchenorrhyncha in WR and WR vineyards had a similar species composition (Table 4). The value of this coefficient calculated for total specimens collected entire sampling period was 0.92 reflecting the high number of species that are associated both WR and ER vineyards.

Table 4. Sorensen′ coefficient of similarity

		Moldova Hills					
		2016	2017	2018	2020	2021	2016-2021
Banat-Crisana-Maramures Hills	2016	0.91					
	2017		0.94				
	2018			0.85			
	2020				0.79		
	2021					0.89	
	2016-2021						0.92

CONCLUSIONS

The present study provides basic information about the presence, species richness and diversity of the *Auchenorrhyncha* fauna collected in vineyards located in Moldova Hills in Eastern Romania and Banat, Crisana and Maramures Hills in Western Romania in period 2016-2021. Management system of pest, diseases and weeds in vineyards was conventional and different. The data collected in this study showed the presence on grapevine in Romania of a consistent number of species belonging to *Auchenorrhyncha*. The *Auchenorrhyncha* community in vineyards from Moldova Hills displayed the largest number of species with the highest number of individuals. On the other hand, the highest diversity of *Auchenorrhyncha* species was in vineyards from Banat, Crisana and Maramures Hills. The communities of *Auchenorrhyncha* in vineyards had a similar species composition. The North American leafhopper *Scaphoideus titanus* (Deltocephalinae), the vector for quarantine disease *Flavescence dorée* of grapevine, was the most abundant in all vineyards. Other important species, vector or with potential to be vector of grapevine phytoplasmas, were *Reptalus quinquecostatus* and *Neoaliturus fenestratus, Anoplotettix fuscovenosus* and *Fieberiella florii.* Two invasive species, *Erasmoneura vulnerata* and *Arboridia kakogawana* recently recorded in Romania, were found in vineyards in Moldova Hills. *Orientus ishidae*, a new natural vector of FD, is reported for the first time in this study on grapevine in Romania.

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