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THE EVOLUTION OF THE *METCALFA PRUINOSA*, *NEZARA VIRIDULA* AND *HALYOMORPHA HALYS* SPECIES SINCE THE FIRST REPORTING IN AGROECOSYSTEMS IN ROMANIA

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Abstract: After more years since the first notification, the following species of pests *Metcalfa pruinosa, Nezara viridula* and *Halyomorpha halys* are still present in agroecosystems in Romania. The high polyphagism, the easy adaptability to new areas and host plant species as well as the lack of a well-defined strategy to fight are characteristics that have contributed to maintaining an active population that still produces damage. Through the present paper, we have proposed to bring attention to their evolution since their first signalling on various plant species from various agroecosystems. We also focused on the current analysis of the numerical level of the active and inactive stages and the damages produced in agricultural and horticultural crops in the west of the country, in period 2020-2022. As a result of the evolution study, it was found that all 3 targeted species are still present on a large number of plant species from agro-horticultural crops composition (both in open or closed spaces). The active (nymphs and adults) and inactive (eggs) stages were observed on the analysed plants and their level was high especially in the species of *M. pruinosa* and *H. halys*, while the species of *N. viridula* species, registered a slight decrease. Thus, the damages produced were commensurate with the numerical level. Continuous monitoring of these highly agile polyphagous pests is necessary to prevent the gradual increase in populations in public places (parks) and the extension to plants in agroecosystems.

Key words: *Metcalfa pruinosa*, *Nezara viridula*, *Halyomorpha halys*, agroecosystems, evolution, host plant.

INTRODUCTION

Recently, in Europe and implicitly in Romania, three species of Hemiptera have consolidated their position as extremely dangerous through polyphagism and adaptation to new and new host plants, without being controlled by clear strategies. These are the following harmful species: *Metcalfa pruinosa*, *Nezara viridula* and *Halyomorpha halys*.

The citrus flatid planthopper *Metcalfa pruinosa* (Say 1830) (Flatidae) is native to America and appeared for the first time in Europe in 1979 in Italy (Zangheri & Donadini, 1980). In Romania, it was reported for the first time in 2009 in the southeast (Constanța) (Preda & Skolca, 2009) and a few months later in the opposite part, i.e. in the west (Timișoara, Timiș county) (Gogan & Grozea, 2010) expending in other areas (Chireceanu & Gutue, 2011). It is difficult to fight this species, because the nymph stage has some filaments that ensure protection at the same time, but also due to the progressive adaptability to new spaces and plants (Vlad & Grozea, 2016) being adapted to both woody and herbaceous plants (Blidariu et al., 2013), from agricultural areas but also from green areas (Muntean & Grozea, 2021). However, classic methods through chemical and biological control trough using the *Neodryinus tiphlocibae* parasitoid wasp (Alma et al., 2005) have been brought to attention until now, although the effect is not very clear.

In the category of stink bugs, *Nezara viridula* (Linnaeus 1758) (Pentatomidae) is first of all, which is originally from Africa and which entered and spread in Europe (Mizzel, 2005; Panizzi, 2008) and reported in Romania as pest in 2010 (Grozea et al., 2012; Mencinicopschi, 2013; Grozea et al., 2015). It is a polyphagous species that widens its range of host plants when it arrives in a new place, causing damage both to field crops but especially to vegetables and ornamental plants in gardens. Fighting the species is currently focused on biological solutions (bioinsecticides) considered friendly but also effective (Marcu & Grozea, 2017).

Halyomorpha halys (Stål, 1855) (Pentatomidae) is another polyphagous pest in the stink bug category. It originates from Asia (Arnold, 2009), from where it has spread to various geographical areas, recent information showing that it falls within the geographical limits of 75˚N and 55˚S (De Michele & Grozea, 2019). In Europe it was observed for the first time in 2004 (Arnold, 2009; Haye et al., 2013) and in Romania in 2015 in the central part (Macavei et al., 2015), later being reported in other areas as well (Ciceoi, 2017; Grozea, 2018). As host plants, field crops such as corn and soybeans, vegetables, shrubs and fruit trees as well as ornamental plants have been identified so far (Riccucci & Maistrello, 2016; Massimo et al., 2016; Costea & Grozea, 2019; Muntean & Grozea, 2021; Keszthelyi et al., 2022). Pentatomid bugs are generally difficult to manage, monitor and combat because they have the ability to move quickly from one place to another and to adapt easily to other species they meet in the new place (Grozea & Stef, 2020).

Bearing in mind the above and the similar bioecological characteristics (adaptability, host plant area) we proposed that through this work we would update the existing informative set with research data on numerical evolution and negative effects on plants considering the active stages of the three harmful pest.

MATERIALS AND METHODS

The researches were focused on two directions, one to collect material to update the existing information and to bring to attention a general picture of the global spread as well as to study the numerical evolution, identification and monthly dynamics of three target species of harmful Hemiptera in five different work spaces or agroecosystems. The study sites for the numerical evolution were chosen in the western part of Romania, in 5 localities from 3 counties, as detailed in table 1. Also, 5 different types of agroecosystems were chosen to be able to make comparisons and evaluate preferences. In these, various plants were integrated/analysed as follows: orchard (diverse fruit trees), field crop (corn), mixed garden (vegetables, ornamental shrubs), vineyard plantation (vines) and green area (shrubs and ornamental trees).

Table 1. Characteristics of the study sites

Nr crt	Place	Type of agroecosystem	Available Surface	Analyzed surface	Position
			m^2	m^2	
1	Timisoara	Orchard	2500	1000±10	outside the city
2	Jimbolia	Field crop	5000	1000±5	outside the locality
3	Dumbravita	Mixed garden	1000	1000±1	in the locality
4	Caransebes	Vineyard plantation	2000	1000±10	in the locality
5	Arad	Green area	500+500	1000±1	in the locality

The analysed surface was established at approximately 1000 m^2 of the total surface per agroecosystem category (table 1), covering both spaces inside the localities and outside. In each chosen space, 30 plants were analysed monthly, marked at the first reading. Observations were combined, directly and by traps (1 traps/place/month). The direct ones consisted of the quantification without collection. Observations on symptoms were also made together with the monthly reading.

RESULTS AND DISCUSSIONS

The evolution of spread and expansion in the last time. The updated situation of the distribution of the species *M. pruinosa* in the world highlights four continents: North America (Canada, the United States and Mexico), South America, Europe and Asia (Figure 1). Being also the place of origin, it is clear that the area affected by this pest is larger than on the other continents, moreover in Europe there are areas that show compact expansion. In Asia and South America, where the species was reported later, the expansion took place in isolated areas.

Regarding the situation of the *N. viridula* species, originated from Africa, it can be said that it covered almost the entire continent with the exception of the extremely cold northern areas. As such, it is present in all continents of the world (Figure 2).

Halyomorpha halys is currently present in Asia (first signalling), North America, Europe, Africa and South America (Figure 3). In the last two mentioned continents, the presence is only isolated in two countries in the North of Africa and only in Chile in South America.

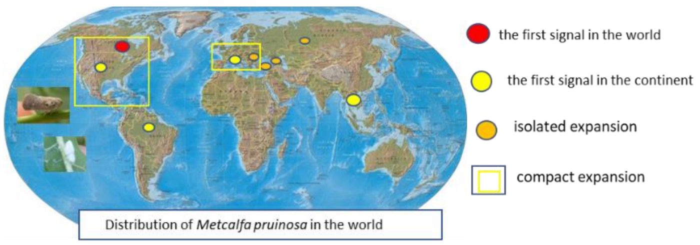

Figure 1. The updated situation of the distribution of *M. pruinosa* in the world

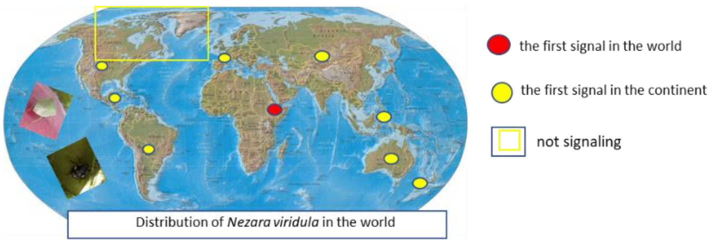

Figure 2. The updated situation of the distribution of *N. viridula* in the world

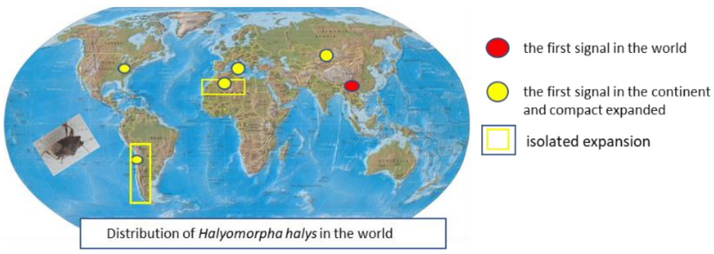

Figure 3. The updated situation of the distribution of *H. halys* in the world

Numerical evolution of active and inactive stages in different agroecosystems in Romania
The life stages of the three species observed in the 5 places analysed from 3 counties in western Romania (Timis, Arad and Caras Severin) were both active (nymphs and adults) and inactive (eggs) (Table 2). Regardless of the type of agroecosystem (fruit or vine plantations, field crop as corn, mixed gardens or green spaces), the 3 species had a positive status, being present in one form or another.

Metcalfa pruinosa was present in a complete set-in plantations and green spaces, while in the mixed garden and field crop (maize) no eggs were present. The explanation would be that these were most likely migratory stages from a place of appearance in the spring, that is, with woody plants, as it is known that eggs are laid in the bark of trees (Alma et al., 2005).

The stink bugs *Nezara viridula* and *Halyomorpha halys* had similar statuses, having the same stages present in a certain type of ecosystem, with small exceptions. Thus, in the orchard and vineyard, field culture, mixed garden and green space, both stink bugs were observed the same combinations of stages. Namely, in the fruit plantation all active stages (adult and nymph) were present in the field crop and in the green space only adults and nymph. However, in the vineyard, unlike *N. viridula*, *H. halys* was also present through the nymph stage.

Table 2. The active and inactive stages of the target pests observed in analysed places, June-September, 2020-2022

Nr crt	Place	Type of agroecosystem	Stages observed/species*		
			M. pruinosa	*N. viridula*	*H. halys*
1	Timisoara	Orchard	A +N+E	A+ N	A+N
2	Jimbolia	Field crop	N	A	A
3	Dumbravita	Mixed garden	A+ N	A+ N+E	A +N+E
4	Caransebes	Vineyard plantation	A+ N+E	A	A +N
5	Arad	Green area	A+ N+E	A	A

*A-adults; N- nymphs; E- eggs (ponta) present

Following the average monthly captures of *M. pruinosa* in active forms (nymphs and adults) in the Table 3, it appears that in the period June-October for all observation points, the numerical evolution was progressive from June ($\bar{x}$ = 4.60 individuals) until August ($\bar{x}$=137.00 individuals), and then it decreased slightly until October ($\bar{x}$ = 15.40 individuals). There were big differences between the 5 study sites. Even after the mentioned period, filaments were observed that remained on the leaves in November.

Table 3. Monthly number of total active individuals of *M. pruinosa* in study places, July-October 2020-2022

Nr crt	Study place	Type of agroecosystem	Number of individuals				
			VI	VII	VIII	IX	X
1	Timisoara	Orchard	4	26	58	35	18
2	Jimbolia	Field crop	0	0	78	21	0
3	Dumbravita	Mixed garden	5	71	190	90	32
4	Caransebes	Vineyard plantation	1	12	103	22	10
5	Arad	Green area	13	88	256	73	17
$\bar{x}$ = mean; s = standard deviation; Sx = standard error; CV = coefficient of variability		$\bar{x}$	4.60	39.40	137.00	48.20	15.40
		s	5.13	38.22	83.44	31.48	11.74
		Sx	2.29	17.09	37.31	14.08	5.25
		CV	111.49	97.01	60.90	65.30	76.23

If we look at the monthly captures of the species *N. viridula* in the Table 4, we will extract the idea that situation is somewhat different compared to the previous species. The increase in the number of individuals was progressive starting from June when there were few individuals (x̄=0.20) until September when it was maximum recorded (x̄=25.20) then it suddenly decreased in October (x̄=12.60). In November, adults of N. *viridula* were observed in the mixed garden, we assume that due to the existence of shelters.

Table 4. Monthly number of total active individuals of N. *viridula* in study places, July-October 2020-2022

Nr crt	Study place	Type of agroecosystem	Number of individuals				
			VI	VII	VIII	IX	X
1	Timisoara	Orchard	0	3	20	21	10
2	Jimbolia	Field crop	0	5	11	13	11
3	Dumbravita	Mixed garden	1	21	55	67	22
4	Caransebes	Vineyard plantation	0	2	18	15	13
5	Arad	Green area	0	3	18	10	7
x̄ = mean; s = standard deviation; Sx = standard error; CV = coefficient of variability		x̄	0.20	6.80	24.40	25.20	12.60
		s	0.45	8.01	17.44	23.71	5.68
		Sx	0.20	3.58	7.80	10.60	2.54
		CV	223.61	117.83	71.49	94.09	45.11

The monthly data on the species *H. halys* is evident in Table 5. The increase of average number of individuals was noticed after the first month of observations, June (x̄ = 1.60) to July when the average number of individuals suddenly increased to 18.20. In any case, the increase was achieved until August (x̄ = 43.80), after which it gradually decreased until October (x̄ = 26.20). Like the N. *viridula* species, H. *halys* adults were seen especially in places near shelters.

Table 5. Monthly number of total active individuals of H. *halys* in study places, July-October 2020-2022

Nr crt	Study place	Type of agroecosystem	Number of individuals				
			VI	VII	VIII	IX	X
1	Timisoara	Orchard	1	6	45	39	21
2	Jimbolia	Field crop	1	11	18	17	14
3	Dumbravita	Mixed garden	3	43	81	99	61
4	Caransebes	Vineyard plantation	1	8	32	22	16
5	Arad	Green area	2	23	43	25	19
x = mean; s = standard deviation; Sx = standard error; CV = coefficient of variability		x	1.60	18.20	43.80	40.40	26.20
		s	0.89	15.35	23.40	33.76	19.64
		Sx	0.40	6.87	10.47	15.10	8.78
		CV	55.90	84.35	53.43	83.57	74.96

Among the five study sites, the mixed garden and green space were the most preferred by the three target species (Figure 4). The planthopper *M. pruinosa* was predominant species in all the spaces analyzed, followed by the stink bugs *H. halys* and *N. viridula*.

If we observe the total values quantified over the entire analysed period between the target species of hemipterans in all the study sites, we see a clear difference between the species (Figure 5). With a total of 1223 individuals representing 55.09%, *M. pruinosa* predominated but we should also take into account the morphological size, the cycads being much smaller than the stink bugs.

The differences between the two stink bugs *N. viridula* and *H. halys* are obvious, the latter registering almost double the value found in the former (651 and 346 individuals, respectively).

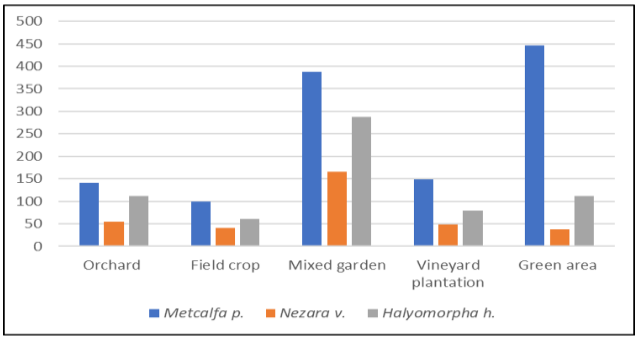

Figure 4. Comparison of the total values of the target species for the analyzed places

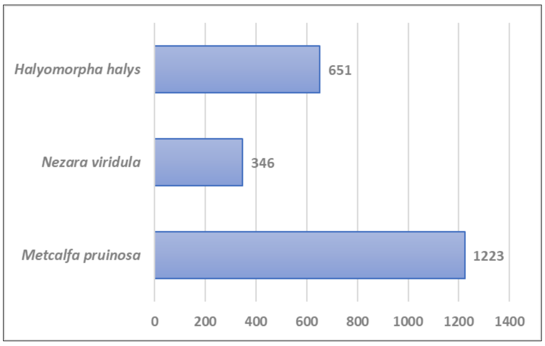

Figure 5. Comparison of the total values of the target species for the analyzed period

The negative effects on the analysed agroecosystem. Among all the plant categories analysed, vegetables and ornamental plants (shrubs and trees) were the most affected (28%) by the three studied species. The association of these pests with the place of study is obvious, being predominant in the mixed garden and green space. The maize was also affected (5%) but not in a visible quantitative way in terms of production. In the tree and vine plantations, the stink bugs, especially *H. halys*, had a more harmful effect on fruits than by attacking leaves. The attack manifested itself differently for the planthopper and similarly for the two stink bugs. In case of *M. pruinosa*, the leaves and shoots were indirectly affected, by the presence of white filaments, according previous mention (Vlad & Grozea, 2016)). In case of stink bugs, both the quantitative and qualitative depreciation of the fruits occurred (Figure 6).

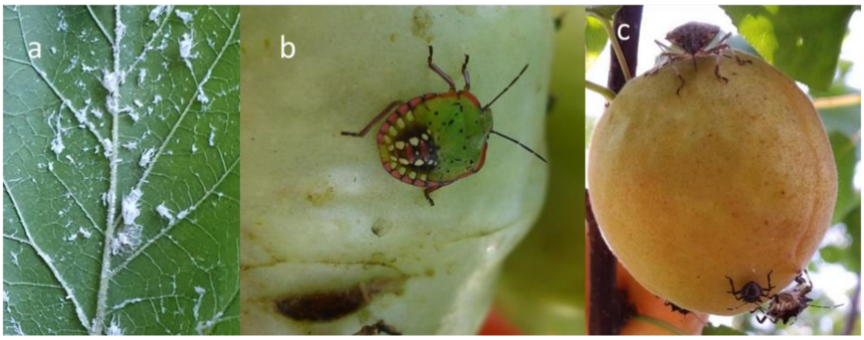

Figure 6. a) *M. pruinosa* - Nymphs, b) *N. viridula* – Nymph, c) *H. halys* - Nymphs and adults (photos made by Grozea)

CONCLUSIONS

Based on the results in this study it can be concluded that the target species of this work, the planthopper *Metcalfa pruinosa* and the stink bugs *Nezara viridula* and *Halyomorpha halys* are still present producing negative effects in various agro-horticultural agro-ecosystems in Romania. Of these, *M. pruinosa* and *H. halys* pests are increasing and require special attention. It seems that these species easily adapt to new plants, therefore periodic monitoring and orientation towards non-polluting solutions could be the solution to reduce the pest populations from year to year.

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