Studii şi Cercetări	Mai 2023	Biologie	32/2	56-63	Universitatea"Vasile Alecsandri" din Bacău

THE ROLE OF *PENTATOMIDAE* INSECTS IN THE VEGETABLE AGROECOSYSTEMS OF BACĂU REGION

Gabriel-Alin Iosob, Tina Oana Cristea, Claudia Bălăiță, Denisa Severin

Key words: *phytophagous stink bugs; predatory stink bugs; integrated pest management (IPM); vegetable agroecosystems*

INTRODUCTION

The economic importance of *Pentatomidae* (stink bugs) insects in agriculture, particularly in the context of vegetables, is underscored by their distinctive feeding habits and their capacity to influence crop health and productivity (Lavore et al. 2018; Sparks et al. 2020). These insects belong to the suborder *Heteroptera*, a subset of the *Hemiptera* order, characterized by their elongated mouthparts designed for piercing and sucking fluids from plants and animals (Henry 2017; Schaefer 2009). Heteropterans, including *Pentatomidae* members, play a unique role in agriculture due to their ability to pierce plant tissues and consume the nutrient-rich fluids within (Matheus 2022). Unlike many other herbivorous insects that chew or scrape plant surfaces, heteropterans bypass numerous plant defenses, making them particularly challenging pests for vegetable growers (Blossey and Hunt-Joshi 2003). Their feeding preference for reproductive parts of plants, such as flowers, ovules, ovaries, and ripening seeds, poses a direct threat to crop yield and quality, since these are the very plant parts prized by humans for consumption and economic value (Matheus 2022; Sparks et al. 2020). The presence of scent glands in heteropterans, both in their immature and adult stages, contributes to their economic significance. These glands serve as a defense mechanism, repelling potential predators, including ants and other insect species. This natural defense allows heteropterans to build large populations when food sources are abundant, further intensifying their impact on crops (Schaefer and Panizzi 2000). Stink bugs are one of the most diverse insect groups in suborder *Heteroptera* (*Hemiptera*) and play a significant role in the context of vegetable crops, which makes them an important component of agricultural ecosystems. Their importance in vegetable crops can be seen from different points of view, including both beneficial and harmful aspects (Haye et al. 2015; Kacar and Dursun 2015).

Phytophagous stink bugs are a group of stink bug species that are primarily herbivorous, and they can be highly polyphagous (Panizzi and Lucini 2022). They can reduce crop yields and quality by feeding on plant tissues, puncturing fruits, and injecting digestive enzymes that can lead to fruit deformation and reduced market value. The economic impact can vary depending on the severity of infestations and the specific crop affected (Panizzi et al. 2017). Farmers and plant protection researchers employ various methods to manage phytophagous stink bug populations. These methods may include the use of chemical pesticides, biological control agents, cultural practices (such as crop rotation and planting resistant varieties), and monitoring to assess the presence and abundance of stink bug populations (Conti et al. 2021; Panizzi, Lucini, and Aldrich 2022; Tillman 2008). There are numerous species of phytophagous stink bugs, and their specific host plants and geographic ranges can vary widely. Some well-known phytophagous stink bugs include the brown marmorated stink bug (*Halyomorpha halys* Stal, 1855) (Haye et al. 2015), the southern green stink bug (*Nezara viridula* L., 1758) (Lavore et al. 2018).

Predatory stink bugs, are a group of stink bug species that play a valuable role in agriculture by preying on other insects, particularly plant-feeding insects that can be harmful to crops (Schaefer and Panizzi 2000). Unlike their herbivorous relatives, predatory stink bugs are considered beneficial insects because they help control pest populations in various agricultural and natural ecosystems (Meed and Richman 2000). They are voracious predators and use their piercing-sucking mouthparts to extract fluids from their prey (Smith, Capinera, and Martini 2021). Their diet mainly consists of soft-bodied insects like aphids, caterpillars, leafhoppers, mites, and other small arthropods. Some species are generalist predators, while others have more specific prey preferences (Meed and Richman 2000; Winsor 2022). These insects are considered natural enemies of agricultural pests and can help reduce the need for chemical pesticides in crop protection (Plata-Rueda et al. 2022). Predatory stink bugs are often used as part of integrated pest management (IPM) strategies in agriculture (Blassioli-Moraes et al. 2019; Conti et al. 2021). To maintain populations of predatory stink bugs, it's important to avoid the excessive use of broad-spectrum pesticides, which can harm both

beneficial and harmful insects. Implementing practices that support biodiversity and natural pest control can help conserve these beneficial insects (Conti et al. 2021; Panizzi et al. 2000).

Our study provides a critical perspective on the ecological relationships between *Pentatomidae* insects and vegetable agroecosystems from Bacau, shedding light on some of the specific challenges they pose in this region. We highlight their significance both as pests and as potential allies in pest control. By presenting a comprehensive analysis, our research provides useful recommendations for improving pest management practices, reducing pesticide use and stimulating sustainable vegetable growth in the Bacau area. Also, this study contributes to the knowledge of *Pentatomidae* insects.

MATERIAL AND METHOD

The study was carried out at the Vegetable Research and Development Station Bacau (VRDS Bacau), located in the Bacau region of Romania. The station comprises various crops for seed vegetables and is a suitable place to investigate the impact of *Pentatomidae* insects in vegetable agroecosystems. Observations were carried out over an extended period from May to October for three years in a row (2021-2023), covering the entire growing season of vegetable seed crops. Observations were made at regular intervals, more precisely every 10 days, to capture seasonal variations and insect activity. During each field survey, several essential parameters were recorded in the observation notebook:

1. The observation date was noted to track seasonal changes and trends in insect activity.
2. The specific vegetable crop being observed was documented. This included a variety of seed vegetable crops commonly grown at the research station.
3. Pentatomidae stink bug species present in the monitored crops were identified and noted. This information was essential for understanding the diversity of stink bug species in agroecosystems.

To complement the observational data, photographs were taken using a Xiaomi Redmi Note 9 Pro smartphone. The photos provided a visual description of stink bug species, their behaviour and their interactions associated with cultivated vegetables.

Data collected during the observations were subjected to rigorous analysis to assess the role of *Pentatomidae* insects in vegetable agroecosystems. The analysis involved species composition, temporal patterns, and visual documentation.

RESULTS AND DISCUSSIONS

The observations were conducted within the conventional agriculture fields at VRDS Bacău from May to October during 2021-2023. These observations revealed that more species of insects from suborder *Heteroptera* are present in seed vegetable crops.

In figure 1, the percentages indicate the relative abundance of each family within the observed *Heteroptera*. Therefore, it is observed that the *Pentatomidae* family commonly known as stink bugs, is the most dominant family observed, comprising 50% of the observed *Heteroptera* during study period. The large presence of *Pentatomidae* suggests that they are an important group of insects in the study area. This may have implications for pest management and crop protection, as some species of stink bugs may be harmful to certain vegetable crops. *Miridae* is the second most abundant family observed, making up 25% of the observed *Heteroptera*. This family includes plant bugs, some of which can be phytophagous. The significant presence of *Miridae* indicates that they are a significant group in the study area. Depending on the species within *Miridae*, they may have varying effects on cultivated vegetables. *Coreidae* family, constituting 9% of the observed insects, includes leaf-footed bugs and squash bugs, which are typically phytophagous and may feed on various plant parts, potentially causing damage to crops. While insects of the family *Coreidae* are present, the lower abundance compared to pentatomids suggests that this family may be less common or have less impact as a pests group for agricultural in the study area. *Pyrrhocoridae* represents 8% of the observed *Heteroptera*. *Pyrrhocoris apterus* L., commonly known as the firebug, is the main representative of the family *Pyrrhocoridae* found in vegetable crops at VRDS Bacau.

The species is not considered a major agricultural pest, its feeding habits can sometimes result in damage to crops. The economic importance of this species in vegetable agroecosystems may vary depending on factors such as population density and the specific crops being cultivated (Özyurt Koçakoğlu 2021). *Anthocoridae*, represents 8% of the observed *Heteroptera*, includes flower bugs, some of which are predatory and feed on other insects, including pest species. The presence of *Anthocoridae* suggests that there is a beneficial predatory component within the observed *Heteroptera*, which may help control other insect pests in the ecosystem.

The stink bugs, comprises a diverse group of insects with both phytophagous and predatory species. These insects can have significant economic importance in agricultural crops, and their impact varies depending on whether they are phytophagous or predatory (Li et al. 2021).

These observations (table 1.) highlight the presence of various *Pentatomidae* species with different plant preferences and feeding behaviors in the vegetable crops at VRDS Bacău.

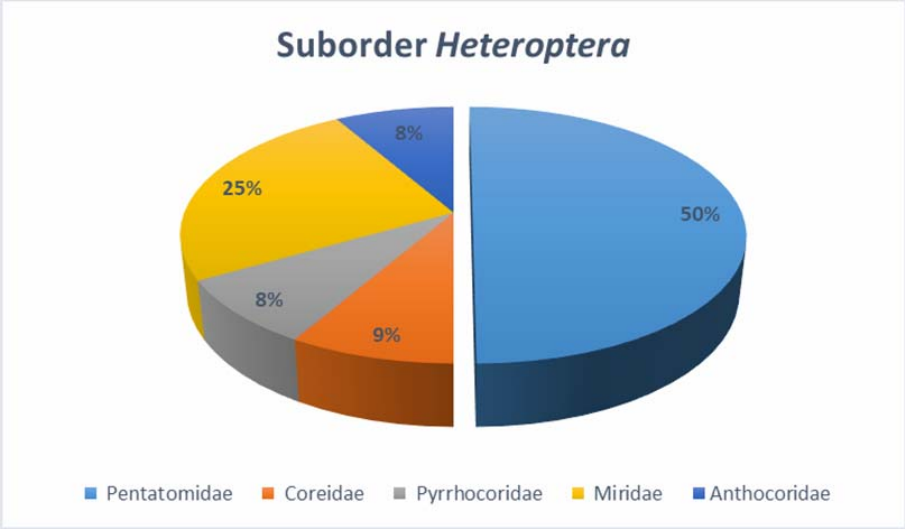

Fig. 1. The composition of different families of the suborder *Heteroptera* observed during the plant vegetation period at VRDS Bacău between 2021 and 2023

Table 1. Pentatomidae species observed on various vegetable crops and feeding preferences on vegetation period of vegetables cultivated for seed at VRDS Bacău between 2021 and 2023

No crt	*Pentatomidae* species from VRDS Bacău	Plant species where stink bugs have been observed	Stink bug feeding preference
1	*Dolycoris baccarum* (Linnaeus, 1758)	*Cicer arietinum* L.	Polifagus
		Phaseolus vulgaris L.	
		Weeds	
2	*Graphosoma italicum* (Müller, 1766)	*Petroselinum crispum* (Mill.) Fuss	Apiaceae
		Levisticum officinale W.D.J.Koch	
3	*Halyomorpha halys* (Stål, 1855)	*Cicer arietinum* L.	Polifagus
4	Nezara viridula (Linnaeus, 1758)	*Solanum lycopersicum* L.	Polifagus
5	*Perillus bioculatus* (Fabricius, 1775)	*Solanum melongena* L.	Predators
6	*Zicrona caerulea* (Linnaeus, 1758)	*Solanum melongena* L.	Predators

Some are polyphagous and may pose a potential threat to multiple crops, while others are beneficial predators that help control pest populations in eggplant crops. Understanding the specific preferences and behaviors of these stink bugs is important for effective pest management and crop protection in the region.

D. baccarum (fig. 5) is a polyphagous stink bug species, meaning it feeds on various plant species. At VRDS Bacau, this species is observed on *C. arietinum* (chickpea), *P. vulgaris* (common bean), and weeds. This adaptability can make it a potential pest in multiple crop types.

G. italicum (fig. 7) has a more specialized feeding preference, primarily targeting plants in the *Apiaceae* family, which includes *P. crispum* (parsley) and *L. officinale* (lovage). This species can represent a potential threat to lovage crops from VRDS Bacau.

H. halys, also known as the brown marmorated stink bug (fig. 2), is another polyphagous species. This species can feed on various plants, but at VRDS Bacau is a potential pest for *C. arietinum* (chickpea).

N. viridula is a polyphagous stink bug observed on *S. lycopersicum* (tomato) in 2021. This species wase reported only once on tomato plant at VRDS Bacau.

P. bioculatus (fig. 8) is a predatory stink bug species that feeds on other insects. It can be beneficial to agricultural ecosystems as a natural predator of *Leptinotarsa decemlineata* Say (Colorado potato beetle). At VRDS Bacau wase reported for the first time in 2022 in a eggplant culture (Iosob and Cristea 2022).

Similar to *P. bioculatus*, *Z. caerulea* is a predatory stink bug species that preys on other insects, which can contribute to biological pest control in agricultural settings. The species was observed this year in the eggplant culture but does not seem to have a stable population.

Table 2. Presence of *Pentatomidae* insects (at different stages: adult, nymph, and egg) on various host plants across different months and years (2021, 2022, and 2023) in the vegetable crops from VRDS Bacau

2021																		
Host Plant/Sp.	**May**			**Jun**			**Jul**			**Aug**			**Sep**			**Oct**		
	E	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**
Lovage/*G. italicum*	-	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-	-
2022																		
Host Plant/Sp.	**May**			**Jun**			**Jul**			**Aug**			**Sep**			**Oct**		
	E	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**
Parsley/*G. italicum*	-	-	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-	-
Lovage/*G. italicum*	-	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-	-
Eggplant/*P. bioculatus*	-	-	-	-	-	-	-	-	-	*○●	*○●	*○	-	-	-	-	-	-
Chickpea/*H. halys*	-	-	-	-	-	-	-	*	*	*○●	*○●	*○	-	-	-	-	-	-
2023																		
Host Plant/Sp.	**May**			**Jun**			**Jul**			**Aug**			**Sep**			**Oct**		
	E	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**	**E**	**M**	**L**
Parsley/*G. italicum*	-	-	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-	-
Lovage/*G. italicum*	-	-	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-	-
Eggplant/*P. bioculatus*	-	-	-	-	*	*	*	*	*	*○●	*○●	*○	-	-	-	-	-	-
Chickpea/*D. baccarum*	-	-	-	-	-	-	-	*	*	*	*○	*	-	-	-	-	-	-
Chickpea/*H. halys*	-	-	-	-	-	-	-	*	*	*○●	*○●	*○	-	-	-	-	-	-

***** E: The early 10 days of a month. M: The middle 10 days of a month. L: The last 10 days of a month., * Adult, ○ Nymph, ● Egg, - No individuals observed

The data from table 2, shows variations in the presence of *Pentatomidae* insects across different crops, months, and years. The presence of adults, nymphs, and eggs in specific months suggests the seasonal dynamics of these insects in vegetable crops at VRDS Bacau. These observations can be valuable for understanding the life cycle and potential impact of these insects on crops.

G. italicum is known to be a phytophagous insect, primarily feeding on plants from the *Apiaceae* family. The presence of adults in both parsley and lovage crops during the specified months in all three years suggests that this species has a consistent presence in these crops. The absence of eggs and nymphs in the observations might be due to several factors, including their preference for different plants or habitats for these life stages, or the specific timing of the observations. It's important to note that *Pentatomidae* insects often have complex life cycles with specific requirements for egg-laying and nymph development (Powell 2020). Further research into the behavior, life cycle, and potential damage caused by *G. italicum* in parsley and lovage crops can provide insights into effective pest management strategies if this species becomes a significant threat. IPM practices, such as field monitoring, targeted pesticide application, and maintaining crop health, can be considered for managing *G. italicum* populations if they pose a risk to crop yield and quality. Continued monitoring in subsequent years will help determine whether *G. italicum* populations in these crops remain stable, increase, or decrease, allowing for more informed pest management decisions.

The presence of *P. bioculatus* in eggplant crops is promising from an agricultural perspective. This predatory insect is known to be a natural enemy of the Colorado potato beetle, a significant pest for eggplant crops. By preying on all stages of the Colorado potato beetle, including eggs, nymphs, and adults, *P. bioculatus* can help in naturally controlling the population of *L. decemlineata*. The fact that adults, eggs, and nymphs (fig. 8 and 9) of *P. bioculatus* were observed in eggplant crops from VRDS Bacau, suggests that it has a stable presence and is likely contributing to the suppression of the Colorado potato beetle population in these crops (Iosob and Cristea 2022). Farmers and researchers can use this information to develop integrated pest management strategies that harness the natural predation capabilities of *P. bioculatus* to reduce the need for chemical pesticides in eggplant cultivation. Continued monitoring of *P. bioculatus* populations and their interactions with Colorado potato beetle is essential for sustainable and environmentally friendly pest management in eggplant crops.

H. halys is considered an agricultural pest, as it has a wide range of host plants and can cause damage to various crops. The presence of both adults

and nymphs (fig. 2-4) in chickpea crops from VRDS Bacau indicates potential crop damage. The eggs observed in August suggest that *H. halys* is reproducing in chickpea crops, which could lead to future generations and increased pest pressure on these crops. Monitoring and early detection of this insect can help implement appropriate pest management strategies to minimize crop damage. IPM practices, such as the use of pheromone traps, natural enemies, and targeted pesticide applications, can be considered to control *H. halys* populations and reduce the impact on chickpea.

D. baccarum is known to be a phytophagous insect, primarily feeding on plant material, including seeds and fruits. The presence of adults and nymphs (fig. 5 and 6) in chickpea crops during July and August of 2023 suggests potential feeding damage to these crops. While adults and nymphs were observed, no eggs were recorded during the monitoring period. This could be due to the specific timing of the observations or the preference of *D. baccarum* for egg-laying sites outside the observed areas. Further research into the biology, behavior, and seasonal dynamics of *D. baccarum* in chickpea crops may provide valuable insights for pest management strategies specific to this pest-crop interaction. Continued monitoring of *D. baccarum* in chickpea crops in subsequent years can help determine if its presence in 2023 was an isolated incident or if it poses a recurring threat to chickpea cultivation in the region.

Fig. 2. An adult brown marmorated stink bug, *Halyomorpha halys*. Photograph by Iosob Gabriel-Alin

Fig. 3. Recently hatched nymphs of the brown marmorated stink bug, *Halyomorpha halys*, aggregated near their egg clutch. Photograph by Iosob Gabriel-Alin

Fig. 4. Nymphs of the brown marmorated stink bug, *Halyomorpha halys*. Photograph by Iosob Gabriel-Alin

Fig. 5. An adult hairy shieldbug, *Dolycoris baccarum.* Photograph by Iosob Gabriel-Alin

Fig. 6. Late instar nymph hairy shieldbug, *Dolycoris baccarum.* Photograph by Iosob Gabriel-Alin

Fig. 7. Two adult Italian striped bugs, *Graphosoma italicum*, mating. Photograph by Iosob Gabriel-Alin

Fig. 8. Two adult twospotted stink bug, *Perillus bioculatus*, mating, one of them feeding on larva of a Colorado potato beetle. Photograph by Iosob Gabriel-Alin

Fig. 9. Recently hatched nymphs of the twospotted stink bug, *Perillus bioculatus*, aggregated near their egg clutch. Photograph by Iosob Gabriel-Alin

CONCLUSIONS

The economic importance of *Pentatomidae* (stink bugs) in agriculture, especially in vegetable production, is highlighted by their unique feeding habits and their significant impact on crop health and productivity. They belong to the suborder *Heteroptera* and can bypass many plant defenses, posing a direct threat to crop yield and quality.

The research emphasizes the diversity within the *Pentatomidae* family, with both phytophagous and predatory species. This diversity can have varying impacts on agricultural ecosystems, from potential pests to beneficial natural enemies of other pests.

The study provides valuable insights into the presence and behavior of *Pentatomidae* insects in vegetable crops over multiple years. This information can inform pest management strategies, such as integrated pest management, to reduce the need for chemical pesticides and promote sustainable agriculture.

The research sheds light on the specific challenges and opportunities presented by *Pentatomidae* insects in the Bacau region. It offers recommendations for improving pest management practices, reducing pesticide use, and enhancing sustainable vegetable growth in the area. Additionally, the study contributes to the knowledge of *Pentatomidae* insects, enhancing our understanding of their role in agricultural ecosystems.

ABSTRACT

The Bacau region, known for the diversity of its agricultural landscapes, is essential for vegetable production in Romania. Among the many factors influencing vegetable cultivation, insects contribute significantly to crop health and yield, especially those in the *Pentatomidae* family. This study investigates the role of *Pentatomidae* insects in vegetable agroecosystems from the Bacau region. Through systematic field surveys and data analysis conducted during 2021, 2022 and 2023, we examine the population dynamics, species composition, and behavioral patterns of *Pentatomidae* insects. The study aims to elucidate their impact on vegetable

crops, including potential damage, feeding habits, and ecological interactions. In addition, we explore the implications of these findings for sustainable pest management strategies in vegetable agriculture in Bacau. This study increases knowledge about *Pentatomidae* insects and provides practical guidance for local farmers and researchers.

REFERENCES

1. BLASSIOLI-MORAES, MARIA C., RAÚL A. LAUMANN, MIRIAN FF MICHEREFF, AND MIGUEL BORGES. 2019 - "Semiochemicals for Integrated Pest Management." *Sustainable Agrochemistry: A Compendium of Technologies* 85–112.
2. BLOSSEY, BERND, AND TAMARU R. HUNT-JOSHI. 2003 - "Belowground Herbivory by Insects: Influence on Plants and Aboveground Herbivores." *Annual Review of Entomology* 48(1):521–47.
3. CONTI, ERIC, GONZALO AVILA, BARBARA BARRATT, FERNANDA CINGOLANI, STEFANO COLAZZA, SALVATORE GUARINO, KIM HOELMER, RAUL ALBERTO LAUMANN, LARA MAISTRELLO, AND GUILLAUME MARTEL. 2021. "Biological Control of Invasive Stink Bugs: Review of Global State and Future Prospects." *Entomologia Experimentalis et Applicata* 169(1):28–51.
4. HAYE, TIM, TARA GARIEPY, KIM HOELMER, JEAN-PIERRE ROSSI, JEAN-CLAUDE STREITO, XAVIER TASSUS, AND NICOLAS DESNEUX. 2015 - "Range Expansion of the Invasive Brown Marmorated Stinkbug, Halyomorpha Halys: An Increasing Threat to Field, Fruit and Vegetable Crops Worldwide." *Journal of Pest Science* 88:665–73.
5. HENRY, THOMAS J. 2017. "Biodiversity of Heteroptera." *Insect Biodiversity: Science and Society* 279–335.
6. IOSOB, GABRIEL-ALIN, AND TINA OANA CRISTEA. 2022 - "The Study of Perillus bioculatus F. (Heteroptera, Pentatomidae) Population as a Potential Key Factor in the Development of Biological Management Strategies for Leptinotarsa Decemlineata Say at Solanum Melongena L." *Romanian Journal of Horticulture* Volume III:91–98. doi: 10.51258/RJH.2022.10.
7. KACAR, GÜLAY, AND AHMET DURSUN. 2015 - "Survey and Abundance of Suborder Heteroptera: Pest and Beneficial Species in Olive Groves of Turkey." *Egyptian Journal of Biological Pest Control* 25(2).
8. LAVORE, ANDRÉS, LUCILA PEREZ-GIANMARCO, NATALIA ESPONDA-BEHRENS, VICTORIO PALACIO, MARIA INES CATALANO, ROLANDO RIVERA-POMAR, AND SHEILA ONS. 2018 - "Nezara Viridula (Hemiptera: Pentatomidae) Transcriptomic Analysis and Neuropeptidomics." *Scientific Reports* 8(1):17244.
9. LI, XINYU, LI TIAN, HU LI, AND WANZHI CAI. 2021 - "Ultrastructural Variations of Antennae and Labia Are Associated with Feeding Habit Shifts in Stink Bugs (Heteroptera: Pentatomidae)." *Biology* 10(11):1161.
10. MATHEUS, SARTORI MORO. 2022 - "Population Genomics and Partial Metagenomics of the Soybean Stink Bug Complex: Euschistus Heros and Piezodorus Guildinii from the Americas."
11. MEED, FRANK W., AND DAVID B. RICHMAN. 2000 - "Florida Predatory Stink Bug (Unofficial Common Name), Euthyrhynchus Floridanus (Linnaeus)(Insecta: Hemiptera: Pentatomidae)." *Document EENY157, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida*.
12. ÖZYURT KOÇAKOĞLU, NURCAN. 2021 - "Morphology and Histology of the Alimentary Canal, Salivary Glands and Malpighian Tubules in Pyrrhocoris Apterus (Linnaeus, 1758)(Hemiptera: Pyrrhocoridae): A Scanning Electron and Light Microscopies Study." *International Journal of Tropical Insect Science* 41(2):1845–62.
13. PANIZZI, ANTONIO R., TIAGO LUCINI, A. ČOKL, AND M. BORGES. 2017 - "Host Plant-Stinkbug (Pentatomidae) Relationships." Pp. 31–58 in *Stinkbugs: Biorational control based on communication processes*. CRC Press Boca Raton, FL, USA.
14. PANIZZI, ANTÔNIO R., JE MCPHERSON, DAVID G. JAMES, M. JAVAHERY, AND ROBERT M. MCPHERSON. 2000 - "Stink Bugs (Pentatomidae)." *Heteroptera of Economic Importance* 828.
15. PANIZZI, ANTÔNIO RICARDO, TIAGO LUCINI, AND JEFFREY R. ALDRICH. 2022 - "Dynamics in Pest Status of Phytophagous Stink Bugs in the Neotropics." *Neotropical Entomology* 51(1):18–31.
16. PANIZZI, AR, AND TL LUCINI. 2022. "The Overlooked Role of Weed Plants Affecting Pest Stink Bug (Hemiptera: Heteroptera: Pentatomidae) Bioecology in the Neotropics." *Arthropod-Plant Interactions* 16(1):1–14.
17. PLATA-RUEDA, ANGELICA, LUIS CARLOS MARTÍNEZ, JOSÉ COLA ZANUNCIO, AND JOSÉ EDUARDO SERRÃO. 2022 - "Advances Zoophytophagous Stinkbugs (Pentatomidae) Use in Agroecosystems: Biology, Feeding Behavior and Biological Control." *Journal of Pest Science* 95(4):1485–1500.

18. POWELL, GLEN. 2020 - ”The biology and control of an emerging shield bug pest, Pentatoma rufipes (L.)(Hemiptera: Pentatomidae).” *Agricultural and Forest Entomology*, 22(4), 298-308.
19. SCHAEFER, CARL W. 2009 - “Prosorrhyncha: Heteroptera and Coleorrhyncha.” Pp. 839–55 in *Encyclopedia of insects*. Elsevier.
20. SCHAEFER, CARL W., AND ANTONIO RICARDO PANIZZI. 2000 - “Economic Importance of Heteroptera: A General View.” Pp. 25–30 in *Heteroptera of economic importance*. CRC Press.
21. SMITH, HUGH A., JOHN L. CAPINERA, AND XAVIER MARTINI. 2021 - “Natural Enemies and Biological Control.”
22. SPARKS, MICHAEL E., RAMAN BANSAL, JOSHUA B. BENOIT, MICHAEL B. BLACKBURN, HSU CHAO, MENGYAO CHEN, SAMMY CHENG, CHRISTOPHER CHILDERS, HUYEN DINH, AND HARSHA VARDHAN DODDAPANENI. 2020 - “Brown Marmorated Stink Bug, Halyomorpha Halys (Stål), Genome: Putative Underpinnings of Polyphagy, Insecticide Resistance Potential and Biology of a Top Worldwide Pest.” *BMC Genomics* 21:1–26.
23. TILLMAN, GLYNN. 2008 - “Populations of Stink Bugs (Heteroptera: Pentatomidae) and Their Natural Enemies in Peanuts.” *Journal of Entomological Science* 43(2):191–207.
24. WINSOR, SUSAN. 2022 - “Beneficial Arthropods of the Corn Belt and Great Plains.” *Crops & Soils* 55(2):56–64.

AUTHORS' ADDRESS

IOSOB GABRIEL-ALIN, CRISTEA TINA OANA, BĂLĂIȚĂ CLAUDIA, SEVERIN DENISA - Vegetable Research and Development Station Bacau, Bacau, Romania, Corresponding author, e-mail: iosob.gabriel@gmail.com