



# True Bugs (Hemiptera: Heteroptera) Collected in an Oil-Bearing Rose Agrocenosis in the Kazanlak Valley, Bulgaria

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**Abstract:** We studied the species composition and abundance of Heteroptera in an oil-bearing rose plantation in the Kazanlak Valley, Southern Bulgaria. Insects were collected using two types of traps – sticky and funnel traps – combined with three types of visual stimuli (fluorescent yellow, transparent and purple). Over a four-month period (June to September 2023), a total of 152 specimens representing 22 species of eight families were collected. Our results indicate that some species are significantly more attracted to certain colours and trap types than to others. Insects belonging to the suborder Heteroptera, are not among the pests causing economic losses in Bulgarian oil-bearing rose production. However, the presence of the invasive pest species, *Halyomorpha halys* (Stål, 1855), raises concerns about the damage this pest could cause to rose plantations in Bulgaria. Additionally, our findings suggest that the predator *Deraeocoris ruber*, the most abundant species in the samples, might contribute to aphid population control in the studied agricultural setting. Further research would be beneficial to assess its effectiveness as a biological control agent in oil-bearing rose plantations and other cultivated crops.

**Key words:** biological agents, oil-bearing rose, coloured traps, pests, *Rosa damascena* Mill.

## Introduction

Roses have been grown in Bulgaria since ancient times with the Thracians being the earliest known inhabitants who cultivated them (Herodotus, VIII, 138: ca. 430BC; Zarev 2018). The favourable conditions in the Sub-Balkan valleys and the low southern slopes of the Balkan Mountains (which have acquired the name “Rose Valley”), with moderate rainfall, a large number of sunny days and suitable light-textured soils, have been the prerequisites for

the successful cultivation of roses. The contemporary commercial rose production in Bulgaria is concentrated in the same distinct geographical region (Kovacheva et al. 2010) and oil-bearing roses are the most economically significant crops among essential oil-bearing plants in the country (Margina et al. 1999, Rusanov et al. 2020).

*Rosa damascena* Mill. (with common name Damask rose) is primarily used for rose oil production worldwide (Kovacheva et al. 2010). In Bulgaria, nowadays *Rosa damascena* Mill. f. *trigintipetala*

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Dieck. (Kazanlak rose) (Chalova et al. 2017, Caisard et al. 2023) has been mainly used for cultivation purposes. Some authors accept it as a separate taxon, *Rosa trigintipetala* Dieck. ex Koehne = *R. kazanlika* V. T. 1978 (see Topalov 1978 after Rusanov et al. 2020, Margina et al. 1999, Zlatev et al. 2001). In our study we use the widely accepted name *Rosa damascena* Mill. f. *trigintipetala* for the Kazanlak oil bearing rose.

The oil-bearing roses cultivated in Bulgaria are attacked by various pests, leading to a significant reduction in rose yields (Atanasov et al. 2008). This is why, after the mid-20th century, significant efforts were made to study insects and other invertebrates associated with oil-bearing roses cultivated in the country (Buresh & Lazarov 1956, Nikolova & Natskova 1965, Nikolova & Natskova 1968, Nikolova 1967, 1969a,b, 1972).

In respect to Hemiptera, some of the major pests of oil-bearing roses in Bulgaria belong to the suborders Auchenorrhyncha and Sternorrhyncha (Nikolova 1969a,b, Margina et al. 1999, Atanasov et al. 2008), among them *Edwardsiana rosae* (Linnaeus, 1758) *Macrosiphum rosae* (Linnaeus, 1758) and *Rhodococcus perornatus* (Cockerell & Parrott, 1899). Compared to the mentioned two Hemiptera suborders, Heteroptera (or true bugs) – a group with about 40,000 described species worldwide (Schuh & Weirauch 2020), has received significantly less attention in entomological studies exclusively focused on rose plantations in Bulgaria. In her book, Nikolova (1969b) reported that, in the studied experimental rose plantations, Heteroptera was represented by 59 species of eight families. Nikolova (1969b) further commented that two of these species, *Graphosoma lineatum* (Linnaeus, 1758) (Pentatomidae) and *Coreus marginatus* (Linnaeus, 1758) (Coreidae), were harmful to roses, eight were listed as zoophages and 49 were species with no significant influence on the target culture. Nevertheless, Nikolova (1969b) lists only the names of 15 species of Heteroptera (for more details see the Discussion section of this study). Also, in the same book, *Palomena prasina* (Linnaeus, 1761) (Pentatomidae) is listed among the zoophages (beneficial insects), while the species is in fact phytophagous (Rösch & Schmitz 2014). In a later study of pests in rose plantations in Bulgaria, only one additional species of Heteroptera is reported as a pest of oil-bearing roses (Margina et al. 1999) – *Eurydema ornata* (Linnaeus, 1758) (Pentatomidae). Later, Balevski et al. (2008) mentions species of Heteroptera as beneficial organisms in oil-bearing rose plantations in Bulgaria.

More data on communities of Heteroptera, including both phytophagous and zoophagous species (potential biological agents) and their relationship with oil-bearing roses in Bulgaria would be useful for pest management in rose plantations in the country. Therefore, we focused the present study on this group of insects.

Various methods have been employed to study insect abundance and species composition in agrocenoses (McCrary 2018). Among them, those relying on sticky traps are relatively effective and inexpensive in assessing the diversity of harmful insects and their natural enemies (Atakan et al. 2016). A disadvantage of this type of traps is that they become ineffective when the sticky surfaces are covered with insects (Ahmad & Kamarudin 2011). Funnel traps mitigate this issue and are reusable, which makes them very useful in entomological research (Lindgren 1983). However, their effectiveness can vary depending on the target insect species and environmental conditions (Allison et al. 2014). Therefore, the combined use of both trap types seems more reasonable than employing only funnel traps or only sticky traps.

In addition to the type of trap, its colour can also affect the composition of the caught insects. For example, yellow traps primarily attract whiteflies, flies, aphids and other herbivorous insects (Ilieva & Karova 2023). In contrast, individuals of *Lygus rugulipennis* Poppius, 1911 (Miridae) are captured more frequently in blue sticky traps than in yellow ones (Holopainen et al. 2001), while purple prism traps effectively collect species of family Pentatomidae (Pezzini et al. 2018). Additionally, the use of different types of colour traps, including pan trap, white coloured modified Moericke traps, sticky traps and dry funnel traps allows researchers to evaluate how attractive certain colours are to specific insect groups or species (Sakalian et al. 1993, Kalushkov & Dimova 1997, Langourov 2001, Sakalian & Langourov 2004, Langourov & Simov 2006, Guéorguiev & Ljubomirov 2009, Simov 2013, Subchev et al. 2013, Toshova et al. 2017, Lapeva-Gjonova & Ljubomirov 2020, Pavlova 2020).

In the present study, recognising their limitations and advantages, we employed both sticky and funnel traps. We combined each trap type with visual stimuli (fluorescent yellow, transparent and purple), to assess the species composition and abundance of Heteroptera in rose plantations in Stara Zagora Province. We also analysed the similarities among assemblages of Heteroptera, relative to the different trap types.



**Fig. 1.** Types and colours of traps: sticky traps (A–D); funnel traps (E–F); scheme of their distribution in the field (G).

## Materials and Methods

### Collection of Material and Taxonomic Identification

From June to September 2023, a survey was conducted to determine the species composition of insects in oil-bearing rose (*Rosa damascena* Mill. f. *trigintipetala*) plantations over an area of ten decares near Gabarevo Village, Pavel Banya Municipality, Stara Zagora Province. Two types of colour traps were used: sticky (prism type, PALs and others) and funnel (Lindgren type, MULt and others), both types have often been employed in such studies (Imrei et al. 2020a,b, Perkovich et al. 2022, Petrice et al. 2023). We combined the traps with three types of visual stimulus: fluorescent-yellow, transparent and purple colour. There were six combinations of

trap type and colour, with three replicates per combination, so in total 18 traps were set up (Fig. 1). The fluorescent-yellow and transparent traps were installed on 4<sup>th</sup> of June and the purple traps on 6<sup>th</sup> of July. The traps were placed 7–10 meters apart. Trap catches were collected every 7–14 days. No plant protection products were used during the study period. The analysis was performed in R version 4.4.2 (R Core Team 2025).

Identification of the collected insects was done using the following keys: Kerzhner & Yachevsky (1964), Wagner (1974), Josifov (1981), Pericart (1998). The database “Leafminers and Plant Galls of Europe” was used as the primary source of diet information for the collected species. Additional sources are cited in the species comments in the Discussion section.

## Statistical analysis

We tested whether a specific species of Heteroptera is more strongly attracted to a type of traps with certain colour, as well as independently to only the colour or only the trap type. For this purpose, we analysed data on the presence or absence of the collected species in each sample using the function `multipatt` from the R package `indicspecies` (De Cáceres & Legendre 2009). To quantify the association between a given species and a given trap type (or combination of trap type and colour) we used the test statistic `IndVal.g`. This variant of the original `IndVal` index accounts for differences in group sizes. In our case, such differences come from the fact that the purple traps were installed a month later than the rest of the traps (see the subsection above).

To explore patterns in insect specimen counts and species composition across different trap types, we used hierarchical clustering with the Bray-Curtis dissimilarity index, with species abundance (recalculated per 100 trapping days) summarized across all samples for each respective trap type. The species abundance used for the hierarchical clustering was calculated as the number of individuals collected per species in a given sample (see the table below) divided by the trapping days for the respective sample and then multiplied by 100.

We applied bootstrapping with 9,000 replicate resampling. The clustering analysis was performed using the program PAST 4.17 (Hammer & Harper 2001).

## Results

### Collected material

The number of collected specimens of each species is provided below (in parentheses) for each sampling period (the periods of trap installation and collection) and each trap type: fluorescent funnel (FF), fluorescent sticky (FS), purple funnel (PF), purple sticky (PS), control funnel (CF) and control sticky (CS). The families and species are listed in alphabetical order.

**Coreidae:** *Coreus marginatus* (Linnaeus, 1758): 06. VII–20. VII, PF (1); 16. VIII–9. IX, FF (1); 24. VI–3. VII, FF (1).

**Cydnidae:** *Ochetostethus* sp.: 24. VI–3. VII, FF (1). *Sehirus morio* (Linnaeus, 1761): 24. VII–04. VIII, PS (1). *Tritomegas sexmaculatus* (Rambur, 1839): 12. VI–24. VI, CF (1).

**Lygaeidae:** *Melanocoryphus albomaculatus* (Goeze, 1778): 04. VIII–16. VIII, PS (1), CS (1); 06. VII–20. VII, CS (2); 08. VI–12. VI, CF (1), CS (1); 12. VI–24. VI, FS (1), CS (2); 16. VIII–9. IX, PS (1);

20. VII–24. VII, CF (1); 24. VI–3. VII, FS (1), CS (1).

**Miridae:** *Adelphocoris lineolatus* (Goeze, 1778), CS (4); 04. VI–08. VI, CS (1); 12. VI–24. VI, CS (2); 24. VI–3. VII, CS (1). *Adelphocoris vandalicus* (Rossi, 1790), PS (1), CS (1); 20. VII–24. VII, CS (1); 24. VII–04. VIII, PS (1). *Deraeocoris ruber* (Linnaeus, 1758): 03. VII–6. VII, FS (2); 04. VIII–16. VIII, PS (3), CS (3); 06. VII–20. VII, FS (2), PF (7), PS (5), CS (1); 20. VII–24. VII, PS (10), CF (2), CS (11); 24. VII–04. VIII, PF (3), CF (1). *Lygus rugulipennis* Poppius, 1911: 20. VII–24. VII, PS (1).

**Oxycarenidae:** *Metopoplax origani* (Kolenati, 1845): 08. VI–12. VI, FS (1).

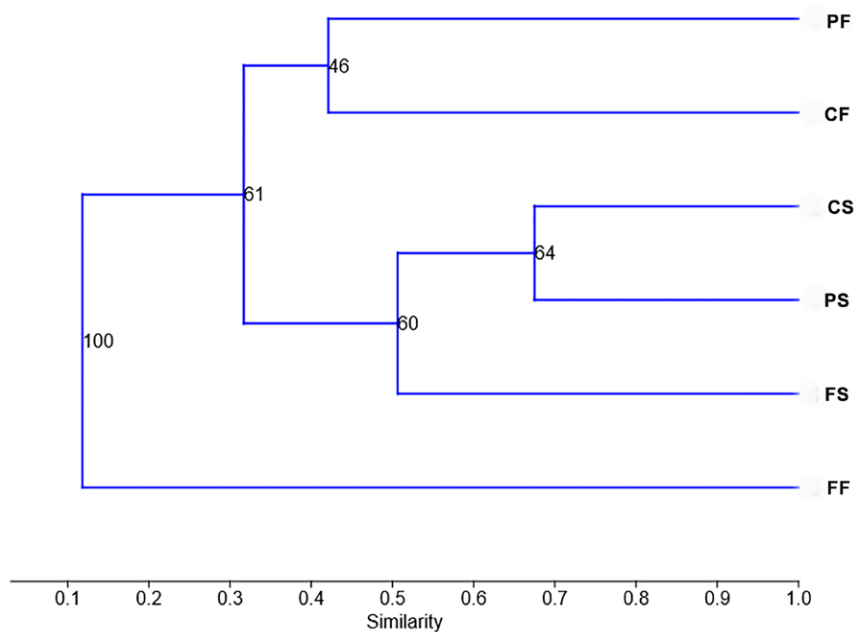
**Pentatomidae:** *Aelia acuminata* (Linnaeus, 1758): 04. VIII–16. VIII, FS (1); 08. VI–12. VI, FF (1); 20. VII–24. VII, PS (1), CF (1). *Carpocoris* sp.: 16. VIII–9. IX, FF (1). *Dolycoris baccarum* (Linnaeus, 1758): 03. VII–6. VII, CF (1); 04. VIII–16. VIII, PF (1), CF (1); 08. VI–12. VI, CF (2); 12. VI–24. VI, CF (1); 16. VIII–9. IX, CF (1). *Eurydema oleracea* (Linnaeus, 1758): 20. VII–24. VII, PS (1). *Eurydema ornata* (Linnaeus, 1758): 04. VIII–16. VIII, FS (4); 16. VIII–9. IX, PF (1); 20. VII–24. VII, FS (3), PS (5), CS (4); 24. VII–04. VIII, PS (2), CS (2). *Eysarcoris ventralis* (Westwood, 1837): 24. VII–04. VIII, CF (1). *Graphosoma italicum* (O.F. Müller, 1766): 03. VII–6. VII, CF (1); 06. VII–20. VII, FF (1), PF (1); 12. VI–24. VI, FS (1); 20. VII–24. VII, FS (1), CF (1); 24. VI–3. VII, CF (1); 24. VII–04. VIII, PF (1), CF (1). *Halyomorpha halys* (Stål, 1855): 20. VII–24. VII, PF (2). *Nezara viridula* (Linnaeus, 1758): 12. VI–24. VI, CF (1), CS (1). *Peribalus strictus* (Fabricius, 1803): 04. VIII–16. VIII, CS (1); 20. VII–24. VII, CS (1).

**Reduviidae:** *Phymata crassipes* (Fabricius, 1775): 12. VI–24. VI, FS (1). *Rhynocoris punctiventris* (Herrich-Schaeffer, 1846): 03. VII–6. VII, CF (1); 06. VII–20. VII, FF (1), PF (2), CF (1).

**Rhyparochromidae:** *Aphanus rolandri* (Linnaeus, 1758): 04. VIII–16. VIII, CS (3). *Beosus maritimus* (Scopoli, 1763): 16. VIII–9. IX, PS (1), CS (2). *Emblethis* sp.: 04. VIII–16. VIII, CS (1). *Megalonotus* sp.: 24. VI–3. VII, CS (1); 20. VII–24. VII, CS (1); 04. VIII–16. VIII, FS (1); 16. VIII–9. IX, FS (2), PS (2), CS (2). *Raglius* sp.: 16. VIII–9. IX, FS (1).

### Species composition of the samples

The total number of collected Heteroptera was 152 individuals, belonging to eight families, 27 genera and 22 species. Due to the poor condition of the material from the sticky traps, two specimens were identified only at the family level (one of Miridae and one of Lygaeidae, both not included in the listed



**Fig. 2.** Hierarchical cluster dendrogram based on Bray-Curtis Index values, showing the similarity among trap types in respect to assemblages of Heteroptera. Trap types: control funnel (CF), control sticky (CS), fluorescent funnel (FF), fluorescent sticky (FS), purple funnel (PF), purple sticky (PS). The percentage of replicates, where each node is still supported, is also presented.

above specimens) and five only at the genus level. The most abundant species was *Deraeocoris ruber* (Linnaeus, 1758) (Miridae), while *Eurydema ornata* (Linnaeus, 1758) (Pentatomidae) was the second most abundant species.

Among the collected species, there were both predators and phytophages. The predatory species were of families Miridae and Reduviidae. Phytophages or those with mixed feeding habits were of Coreidae, Cydnidae, Lygaeidae, Miridae, Oxyacarenidae, Pentatomidae and Rhyparochromidae. In terms of the number of captured specimens, phytophages predominated with 94 specimens. The number of predators was smaller – 56 specimens and there were only two specimens from species with a mixed feeding type.

#### Association between specific species and trap types

In the present study, *Deraeocoris ruber* (IndVal.g = 0.47,  $p = 0.03$ ) was most frequently collected with the purple sticky traps. The analysis in which we used only the colour of the traps confirmed that this species is mostly attracted to the purple colour (IndVal.g = 0.48,  $p = 0.04$ ). *Eurydema ornata* was collected predominantly by the purple sticky traps (IndVal.g = 0.44,  $p = 0.04$ ). In the analysis based solely on colours, there was no significant association between *Eurydema ornata* and the purple colour. The analysis in which we used only the type of

traps showed that *Dolycoris baccarum* and *Rhynocoris punctiventris* (Reduviidae) were mainly collected in funnel traps (IndVal.g = 0.42 and IndVal.g = 0.38, respectively and  $p = 0.01$  for both species). The results for the rest of the species were not statistically significant.

#### Similarities in assemblages of Heteroptera, relative to different trap types

The highest number of species – 11, was collected with control sticky traps, followed by purple sticky and fluorescent sticky – with nine species collected by each. Among the funnel traps, eight species were collected in control funnel, followed by purple funnel – six species and fluorescent funnel – five species. The clustering showed that the fluorescent funnel traps distinctly separated from the other traps types – low similarity index with strong support (100% bootstrap value). The sticky traps were grouped together and two of the funnel traps were also together (Fig. 2), but both of these groups were characterised with low support (62% bootstrap values).

## Discussion

### Species distribution, diet and host plant preferences

Among the collected species, nine belong to the Mediterranean complex (according to Josifov 1999), namely *Adelphocoris vandalicus*, *Aphanus rolandri*,

*Beosus maritimus*, *Eysarcoris ventralis*, *Melanocoryphus albomaculatus*, *Metopoplax origani*, *Phymata crassipes*, *Rhynocoris punctiventris*, *Tritomegas sexmaculatus* (Rambur, 1839). The rest of the species (with the exception of two alien species, commented below) are from the Euro-Siberian complex, represented in our study by Holarctic, Holopalaearctic and West Palaearctic species (characterised according to Josifov 1986 or Josifov 1999).

The largest number of individuals were of family Miridae, which is logical since it is the most diverse and species-rich family of suborder Heteroptera (Harizanov et al. 2010, Kim et al. 2023). The most abundant species in the present study, *Deraeocoris ruber*, belongs to the subfamily Deraeocorinae (Miridae). Representatives of this subfamily are predominantly predators, feeding on various small insects such as aphids and larvae of thrips and moths (Kim et al. 2023). The peak abundance of *D. ruber*, in June and July, coincides with the peak population levels of the green rose aphid *Macrosiphum rosae* (Linnaeus, 1758), a major pest causing economic losses in oil-bearing rose production in Bulgaria (Nikolova 1969b) and suggests a relationship between the abundance of these species. *Deraeocoris ruber* has also been found on other plants infested by aphids (Yazici 2019) and may prey on species like *Chaetosiphon tetraerhodum* (Walker, 1849), *Myzaphis bucktoni* H.R.L. Davis, 1919, *Aphis fabae* Scopoli, 1763, *Macrosiphum euphorbiae* (Thomas, 1878), *Myzus persicae* (Sulzer, 1776), which are found on roses but cause less damage (Andreev 2018). Additionally, *D. ruber* has been observed feeding on the scale insect *Eulecanium tiliae* (Linnaeus, 1758) in Serbia (Dervisevic et al. 2024). While it may help to control aphid populations in agriculture, its effectiveness in rose plantations remains undocumented, warranting further research.

*Adelphocoris lineolatus*, *Adelphocoris vandalicus* and *Lygus rugulipennis* (Miridae) were present within and around the studied area. These are phytophagous species, associated with herbaceous plants other than roses (Holopainen et al. 2001, Kment & Banar 2012, Fent & Okyar 2022).

The collected species of family Pentatomidae are widely distributed throughout the country. *Eurydema ornata* was the second most abundant species in the samples. This species has trophic relationships with plants of Brassicaceae and Apiaceae (growing near the plantation) rather than with roses – this could be the reason for the abundance of *E. ornata*. Another possible explanation could be that the individuals were attracted to the colour of the traps during migrations (captured in control sticky,

fluorescent sticky, purple sticky and purple funnel traps).

In the traps, two invasive alien phytophagous species, *Halyomorpha halys* and *Nezara viridula* (Pentatomidae) were found. *Halyomorpha halys* originates from East Asia (Zhu et al. 2012) and in 2016 was found for the first time in Bulgaria (Simov 2016). This polyphagous species affects both local and ornamental plants (Hemala & Kment 2017) and has become a major invasive pest with implications for plant production in many regions (Kriticos et al. 2017, Maistrello et al. 2017, Véték & Koranyi 2017, Pajač Beus et al. 2024). Between 2017 and 2024, the species spread rapidly across Europe and other regions, causing severe damage to fruit orchards and vegetable crops (Maistrello 2024). Species distribution models have indicated its potential for widespread colonisation, driven by its broad host range and its high climatic adaptability (Zhu et al. 2012, Kriticos, 2017). In Italy, in a study, combining crowdsourced data and spatial modelling, the invasion dynamics of this species have been tracked (Maistrello et al. 2018), indicating the important role that citizen-science can play in early detection. It should be mentioned, that for this species multiple introduction events have been suggested based on genetic studies across North America and Europe (Morrison et al. 2017, Valentin et al. 2017). *Halyomorpha halys* has been reported to cause damage to various agricultural crops in Bulgaria (Hristozova & Harizanova 2022). In the light of the results of the cited papers, the presence of *H. halys* in a rose plantation is concerning and its role as a potential pest requires further study. In respect to this species' natural enemies, a recent study carried out in Bulgaria, Plovdiv Province (Hristozova & Harizanova 2024), reports five species of egg parasitoids naturally occurring in eggs of *H. halys* and the authors suggest that the adaptation to this new host will lead to gradual increase of the parasitisation rates in natural populations of *H. halys*.

*Nezara viridula* is economically important pest affecting many agricultural and wild plants worldwide (Marcu & Grozea 2020, Prabhakar et al. 2023). It likely originates from the Mediterranean region or Africa (Hokkanen, 1986, Jones 1988) and in 1959, it was first registered in Bulgaria (Strawinski 1959). Recently, *Nezara viridula* has spread northwards (Simov et al. 2012).

In our traps we found the predators *Rhynocoris punctiventris* and *Phymata crassipes* of family Reduviidae. Both species are associated with grassy vegetation, shrubs and low trees. Given that in India, for example, other species of Reduviidae, *Rhynoco-*

*ris marginatus* (Fabricius, 1794) and *Rhynocoris fuscipes* (Fabricius, 1787), have been recognised as beneficial for agricultural pest management (Sahayaraj 2014), the potential of *R. punctiventris* and *P. crassipes* as biological control agents requires further investigation.

Species of families Coreidae, Cydnidae, Lygaeidae, Oxycarenidae and Rhyparochromidae, found in the traps, are not directly associated with oil-bearing rose plantations. The three species of Cydnidae – *Tritomegas sexmaculatus*, *Sehirus morio* and representatives of the genus *Ochetostethus* – inhabit the litter and upper soil layer (Lis 1999) and are associated with plants of Boraginaceae and Lamiaceae (Aukema et al. 2007, Kolak 2015). They have occasionally been found on *Rosa* sp. and *Morus* sp. (Bolu 2020, Ali 2021).

The families Rhyparochromidae and Oxycarenidae were represented by herpetobionts (no reported association with roses) feeding on seeds of various plants (Sweet 1960, Malenovský et al. 2011, Kenzhegaliev et al. 2021). *Coreus marginatus* (Coreidae), primarily feeding on plants of family Polygonaceae (Kment & Baňář 2012), was also observed in the traps. Nikolova (1969b) observed that nymphs of *C. marginatus* harm oil-bearing roses in Bulgarian plantations by feeding on their leaves. In the same study, she reported that adult *C. marginatus* feed on scale insects of the genus *Rhodococcus* and suggests that actually their presence might be more beneficial than harmful. This hypothesis needs further confirmation, since it has not been mentioned elsewhere that the species has a mixed diet. Additionally, in Romania, there are reports of *C. marginatus* being pest on *Rosa* sp., as well (Grozea et al. 2023).

Nikolova (1969b) carried out a study mainly in one experimental rose plantation in Bulgaria near Klisura Village (Plovdiv Province) and reported 59 Heteroptera species of eight families, but names of only 15 were provided: Anthocoridae – *Anthocoris pilosus* (Jakovlev, 1877); Nabidae: *Himacerus mirmicoides* (O. Costa, 1834), *Nabis pseudoferus* Remane, 1949; Reduviidae – *Rhynocoris iracundus* (Poda, 1761); Tingidae – *Dictyla echii* (Schrank, 1782); Miridae – *Deraeocoris ruber*, *Deraeocoris rutilus* (Herrich-Schaeffer, 1838), *Deraeocoris lutescens* (Schilling, 1837), *Orthops campestris* (Linnaeus, 1758) (as *Lygus campestris* L. in the paper); Coreidae – *Coreus marginatus*; Lygaeidae: *Lygaeus equestris* (Linnaeus, 1758); Pentatomidae – *Dolycoris baccarum*, *Eurydema oleracea*, *Graphosoma lineatum* (Linnaeus, 1758), *Palomena prasina* (Linnaeus, 1761). Only four of the species are reported

both by Nikolova (1969b) and in the present study – *C. marginatus*, *D. ruber*, *E. oleracea* and *Dolycoris baccarum*, suggesting that the species composition of Heteroptera in rose plantations may vary greatly, mainly due to differences in both the topography of the particular regions and the characteristics of the vegetation within the cultivated area and its surroundings.

#### Association between trap types and specific species and similarities in the assemblages relative to the different trap types

In the present study, the statistically significant IndVal.g values ranged from 0.38 to 0.48, with p-values between 0.01 and 0.04. According to Dufrêne and Legendre (1997), an IndVal.g value exceeding 0.5 is considered indicative of a strong association. Therefore, our results demonstrate moderate associations between the species and the respective trap types or colours. Additionally, due to the small number of captured insects, it is not possible to draw reliable conclusions about the colour preferences of the studied species. However, the presented below speculative trends might be useful in the conceptualisation of future studies on the attractiveness of different colours in respect to species of Heteroptera.

In the present study, *Dolycoris baccarum* and *Rhynocoris punctiventris* were most frequently collected using funnel traps, which aligns with the results of Lindgren (1983), where funnel traps were effective in collecting various insect species, especially larger ones. This can be explained by the design of these traps, which provides more efficient capture of more active and larger individuals (Lindgren 1983).

Our results about the association between *D. ruber* (Miridae) and the traps with purple colour were similar to those reported by Holopainen et al. (2001), where *Lygus rugulipennis* (Miridae) showed a preference for blue and purple traps compared to yellow. These facts suggest that some predatory species of Miridae may be attracted to certain light wavelengths associated with these cool colours. However, in the present study, *D. ruber* was captured in all types of traps except for the fluorescent funnel trap.

It is not surprising that *Eurydema ornata* was collected predominantly in the purple sticky traps, since other phytophagous insects of family Pentatomidae have also been collected using purple sticky traps (Pezzini et al. 2018). Relatively few studies have focused on the influence of trap colour on the capture of species from this family. For example, adults and nymphs of *H. halys* appear to prefer black

pyramid traps over yellow, white, green and transparent ones; this applies to both plastic and wooden traps (Leskey et al., 2012). Similar results were obtained by Joseph (2014) with black traps for *Bagrada hilaris* (Burmeister, 1835). Laboratory and field studies with the Harlequin bug, *Murgantia histrionica* (Hahn, 1834), have shown that this species is more attracted to green and black traps than to white, yellow, red or purple ones (DiMeglio et al. 2017).

It should be noted that the response of some of the collected species to the colour of the traps in the present study may be skewed due to differences in the temperature of the traps, which likely vary between lighter and darker traps under field conditions. This could be an important factor, considering that a recent study on *Leptoglossus occidentalis* (Coreidae) showed that this species uses infrared signals to locate host plants (Takács et al. 2009).

No single trap type (sticky or funnel) captured all species of Heteroptera and none collected more than half of the species studied. Clustering analysis revealed that both the type and colour of the traps influenced the species composition. These findings suggest that for comprehensive studies on the composition and abundance of Heteroptera, it is essential to use a variety of trap types and colours to account for these differences. In addition to the sticky traps and funnel traps, the use of white coloured modified Moericke traps (Langourov 2001) is also advisable, since they have proven very effective in studies on Heteroptera (Simov 2013) and in sampling of insects from other groups (Langourov 2001, Langourov & Simov 2006, Pavlova 2020).

## Conclusion

The collected species of Heteroptera have no practical significance as pests of cultivated oil-bearing roses in the studied region. The species composition of Heteroptera in the studied agrocenosis is largely determined by the presence of herbaceous plants within the agrocenosis or in the surrounding area. The discovery of the invasive species *Halyomorpha halys* raises the need for future monitoring of this species and timely alerts in case of a potential threat of it becoming an economically significant pest on roses.

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