

First evidence of the brown marmorated stink bug and its population size in perennial crops in Croatia

Prvi nalaz smeđe mramoraste stjenice i veličina populacije u višegodišnjim nasadima u Hrvatskoj

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ABSTRACT

The brown marmorated stink bug, *Halyomorpha halys* Stål, is an invasive Pentatomidae species that causes damage to economically important agricultural crops. It originated in East Asia but has successfully spread to many European countries. It has been present in Croatia since 2017, and its first mass emergence was detected in a soybean field in 2019. Therefore, the aim of this study was to determine the occurrence and population size of *H. halys* in perennial crops in important fruit growing areas in Croatia. According to the monitoring data, *H. halys* was detected in all surveyed areas and crops (apple, apricot, cherry, fig, grapevine, pear, plum, olive, and hazelnut). The largest population size was detected for hazelnut in the locality of Tovarnik, Vukovar-Syrmia County (79 individuals), for pear in the locality of Marijanci, Osijek-Baranja County (31 individuals), and for apple in the locality of Staro Čiče, Zagreb County (25 individuals). In view of the fact that the weekly catches at some monitoring sites exceeded the established treatment threshold, control measures must be taken to prevent an increase in the population and significant damage in the future. In addition to hazelnuts, crops such as pears, apples and cherries are particularly threatened by this pest.

Keywords: fruit crops, *Halyomorpha halys* (Stål, 1855), invasive species, population density, threshold

SAŽETAK

Smeđa mramorasta stjenica (*Halyomorpha halys* Stål) je invazivna vrsta iz porodice Pentatomidae koja prouzrokuje štete na mnogim ekonomski značajnim poljoprivrednim kulturama. Porijeklom je iz istočne Azije, ali se uspješno proširila i u mnoge europske zemlje. U Hrvatskoj je prisutna od 2017. godine, a prva masovna pojava zabilježena je u usjevu soje 2019. godine. Stoga je cilj ovog istraživanja bio utvrditi pojavu i veličinu populacije vrste *H. halys* u višegodišnjim nasadima u važnijim voćarskim područjima u Hrvatskoj. Prema podacima praćenja, vrsta *H. halys* utvrđena je na svim istraživanim površinama i kulturama (jabuka, marelica, trešnja, smokva, vinova loza, kruška, šljiva, maslina i lijeska). Najveća populacija štetnika utvrđena je u nasadu lijeske na lokalitetu Tovarnik u Vukovarsko-srijemskoj županiji (79 jedinki), u nasadu kruške na lokalitetu Marijanci u Osječko-baranjskoj županiji (31 jedinka), te u nasadu jabuke na lokalitetu Staro Čiče u Zagrebačkoj županiji (25 jedinki). S obzirom na to da su tjedni ulovi na nekim lokalitetima praćenja bili iznad kritičnih brojeva, potrebno je poduzeti mjere suzbijanja kako bi se spriječio rast populacije i pojava značajnih šteta u budućnosti. Osim lijeske, kruška, jabuka i trešnja su kulture koje su najviše ugrožene od napada ovog štetnika.

Ključne riječi: *Halyomorpha halys* (Stål, 1855), invazivna vrsta, kritični broj, veličina populacije, voćarske kulture

INTRODUCTION

Halyomorpha halys (Stål, 1855) (Hemiptera: Pentatomidae) is one of the most polyphagous and invasive insect pest of agriculture, urban and domestic environments. It feeds on over 300 plant species, including significant crops and ornamentals (Haye et al., 2014; Kriticos et al., 2017; Leskey et al., 2012a; Rice et al., 2014). However, one of the main hosts are perennial crops, of which the most economically important are cherry (*Prunus avium* L.), plum (*Prunus domestica* L.), peach (*Prunus persica* L.), apricot (*Prunus armeniaca* L.), apple (*Malus* spp. Mill.), pear (*Pyrus* spp. L.), raspberry (*Rubus* spp. L.), and grape (*Vitis vinifera* L.) (Damos et al., 2020; Wermelinger et al., 2008; Wiman et al., 2015).

The species originated in East Asia (Lee et al., 2013) but spread rapidly and became established in North American and European countries (Haye et al., 2015; Leskey and Nielsen 2018). In our neighboring countries, it was first detected in Hungary (Vétek et al., 2014) and Italy (Maistrello et al., 2014) and then in Serbia (Šeat, 2015). Since this pest occurred in three of six neighboring countries, its occurrence in Croatia was expected. Therefore, the first report of *H. halys* in Croatia is from 2017, where the first individuals of the species were found in a house in the city of Rijeka and later that year, four more individuals were found on *Ailanthus* trees (*Ailanthus altissima* (Mill.) Swingle) nearby (Šapina and Šerić Jelaska, 2018). A short time later, this pest was also detected in Slovenia (Rot et al., 2018) and Bosnia and Herzegovina (Zovko et al., 2019). In 2019, Pajač Živković et al. (2021) observed its mass occurrence in rural areas in Croatia, where the population size of *H. halys* threatened soybean production.

This pest is considered a serious urban and household pest because it easily enters households to overwinter (Lee et al., 2013; Leskey and Nielsen, 2018). However, numerous cases of economic damage to agricultural production have been reported (Bariselli et al., 2016; Candian et al., 2018; Garipey et al., 2015; Lee, 2015; Schumm, 2020; Vétek and Korányi, 2017; Zaponi et al., 2022). Early infestation with *H. halys* can lead to

economically significant yield losses (Schumm, 2020). The initial damage caused by *H. halys* is typical of herbivorous pentatomids: suberification, discoloration, formation of necrotic areas, altered vegetative growth, and in the worst cases, tissue malformations. Other potential impacts of *H. halys* feeding on fruit production include secondary infections by plant pathogens (Bariselli et al., 2016; Wiman et al., 2015) and disruption of secondary metabolism of fruit, making them unsuitable for commercial production (Weber et al., 2021).

In the United States, *H. halys* is considered a serious economic pest of a wide range of crops (Leskey et al., 2012a), with report on significant damage to apples and pears (Nielsen and Hamilton, 2009). Leskey et al. (2012b) reported that *H. halys* infestations of apples in the United States resulted in immediate economic damage as the surface deformed, discolored, and the flesh turned brown. The damage caused by *H. halys* in 2010 resulted in some stone fruit growers losing 90% of their crop (Leskey and Hamilton, 2010). In Asia, *H. halys* is also an important pest of tree fruit and once established in an orchard, quickly becomes the predominant stink bug species (Leskey et al., 2012a).

In Croatian neighboring country Italy, Maistrello et al. (2017) reported severe economic damage caused by *H. halys*, showing that it has become an important pest in European orchards only a few years after its first discovery. The brown marmorated stink bug is the main pest in orchards in northern Italy, causing more than 50% crop damage in some early-maturing pear cultivars (Bariselli et al., 2016). It also causes great damage in hazelnut (*Corylus avellana* L.) orchards in Italy and Serbia, by significantly reducing the quality of nuts and their market value (Bosco et al., 2017; Bosco et al., 2020; Ivezić et al., 2020). Reports of *H. halys* occurrence and damage are becoming more frequent and widespread due to its polyphagy and invasive nature (Leskey and Nielsen, 2018), while current climate change trends are creating favorable climatic conditions for the spread of this species in many areas (Rot et al., 2022; Stoeckli et al.,

2020). In order to inform farmers about the current status of *H. halys* in perennial crops, the aim of this study was to determine the occurrence and size of the population in the continental part of Croatia and since the species was first discovered in Rijeka, we extended our investigations to Primorje-Gorski Kotar County and neighboring Istria.

MATERIALS AND METHODS

Over a six-month period, from June to November 2022, adult *H. halys* were monitored using pheromone lures and adhesive pads designed specifically for this species (TRÉCÉ PHEROCON® BMSB Insect Monitoring Kit). Monitoring was conducted at 14 sites in five counties in Croatia: Zagreb County (3 sites), Osijek-Baranja County (5 sites), Vukovar-Syrmia County (2 sites), Primorje-Gorski Kotar County (2 sites) and Istria County (2 sites) (Table 1).

The occurrence and population size of *H. halys* was monitored in nine economically important perennial

crops: apple (*Malus domestica* Borkh.), apricot (*Prunus armeniaca* L.), cherry (*Prunus avium* L.), fig (*Ficus carica* L.), grapevine (*Vitis vinifera* L. 1753), pear (*Pyrus communis* L.), plum (*Prunus domestica* L.), olive (*Olea europea* L.), and hazelnut (*Corylus avellana* L.) (Table 1).

The sticky pads and the special pheromone baits (one per site) were mainly placed in the centre of the orchard or in semi-urban areas near roads (in Rijeka and Tovarnik) at a height of about 1.2 m. The sticky pads were changed monthly, while the pheromone baits were changed every 12 weeks, according to manufacturer's instructions. The sticky pads with adult *H. halys* were appropriately packaged and transported to the Entomological Laboratory of the Faculty of Agriculture, University of Zagreb, where they were identified, counted, and preserved in 70% EtOH. The species *H. halys* was identified using the identification key of Hoebeke and Carter (2003).

Table 1. Monitoring locations of *H. halys* in Croatia in 2022.

No	Locality	County	Crop	Long and Lat
1.	Petrovina Turopoljska	Zagreb	apple	45.689562, 16.021316
2.	Mičevac	Zagreb	apple	45.736278, 16.047883
3.	Staro Čiče	Zagreb	apple	45.696737, 16.108477
4.	Osijek	Osijek-Baranja	pear	45.528993, 18.761097
5.	Kneževi Vinogradi	Osijek-Baranja	apricot, plum	45.748940, 18.721370
6.	Piškoveci	Osijek-Baranja	hazelnut	45.251844, 18.414542
7.	Marjančaci	Osijek-Baranja	hazelnut	45.628697, 18.395075
8.	Marijanci	Osijek-Baranja	pear	45.660854, 18.291529
9.	Tovarnik	Vukovar-Syrmia	hazelnut	45.169583, 19.151139
10.	Ivankovo	Vukovar-Syrmia	cherry	45.301438, 18.733608
11.	Rijeka	Primorje-Gorski Kotar	fig	45.344444, 14.378333
12.	Novi Vinodolski	Primorje-Gorski Kotar	grape	45.143333, 14.775833
13.	Škudelin	Istria	cherry, plum	45.457274, 13.644285
14.	Ipšići	Istria	olive	45.368765, 13.849296

RESULTS AND DISCUSSION

In the period from June to November 2022, adult *H. halys* were found in all surveyed areas and in all set traps (Table 1), i.e. in 14 locations and in 5 counties of Croatia (Figure 1). Species *H. halys* was detected in all sampled orchards, which is also the first report of its occurrence in perennial crops in Croatia. The pest was also detected in Istria County (in cherry, olive and plum), Primorje-Gorski Kotar County (in fig and grape), Zagreb County (in apple), Osijek-Baranja County (in hazelnut, pear, apricot and plum) and Vukovar-Syrmia County (in hazelnut and cherry). It is important to emphasize that this pest has been detected in Croatia so far only in urban areas (Primorje-Gorski Kotar County) and in soybean fields in Zagreb County (Šapina and Šerić Jelaska, 2018; Pajač Živković et al., 2021).

The highest population density of *H. halys* was recorded in the hazelnut orchard Tovarnik in Vukovar-Syrmia County (79 specimens) (Figure 1), which is located close to the border with Serbia. Given recent claims of economic damage to hazelnut production in Serbia (Ivezić 2020), it can be assumed that the pest has spread from Serbia to Croatia. This pest also poses a significant risk to hazelnut production in Italy where its survival and reproduction rates are exceptionally high (Bosco et al., 2017). A significant population of *H. halys* was also observed in pear orchards in Osijek-Baranja County, where 31 specimens were detected in the Marijanci locality and 24 specimens in the Osijek locality (Figure 1). Bariselli et al. (2016) and Rot et al. (2019) reported economic damage caused by this pest in Italy and Slovenia, which raises concerns about the occurrence of economic damage in Croatian pear orchards. Species *H. halys* was also detected in apple orchards in Zagreb County, where it reached a population size of 25 individuals in Staro Čiče locality (Figure 1), indicating that apple is a good host for this species, which was also confirmed in Italy and Slovenia, where it caused economic damage to commercial apple production (Rot et al., 2019; Candian et al., 2018). As Zagreb County borders Slovenia, there is a high risk of occurrence of economic damage in

Croatian apple production, as this pest can cause crop losses of up to 100 % in apple orchards (Leskey et al., 2012b). In the locality of Ivankovo in Vukovar-Syrmia County, 22 specimens of *H. halys* were found in a cherry orchard (Figure 1), indicating that this perennial crop may be severely damaged in the future. Moore et al. (2019) indicate that *H. halys* has the potential to cause significant damage to cherry production in Italy. In addition, three specimens were detected in a cherry orchard in Škudelin, Istria County, which is close to Italy and therefore has the potential to establish larger populations in the future (Figure 1).

In addition to all perennial crops with larger *H. halys* populations, somewhat smaller populations were also observed in several perennial crops (Table 1, Figure 1). In Kneževi Vinogradi, Osijek-Baranja County, 7 specimens of this pest were detected in apricot and plum orchards. In Istria County, three specimens were detected in a plum orchard in the locality of Škudelin (Figure 1). The population size of *H. halys* in these locations is not very high, but the results show that the species can migrate into these crops and thus potentially cause damage.

Notable occurrences of *H. halys* also include 3 specimens each detected in vineyard in the locality of Novi Vinodolski in Primorje-Gorski Kotar County, and in olive trees in the locality of Ipšić in Istria County (Figure 1). Although the population size was small, the finding of this invasive species is of concern given the importance of these perennial crops in Croatia. This pest caused damage in European countries and affected the quality of wine and olive oil. Infested olive fruits have lower quality and can lose between 9 and 22% of their mass, directly affecting yield (Ivancic et al., 2022). The species also causes necrosis and deformation in grapes (Rice et al., 2014), and there is a risk of altering the quality of grape juice and must (Mohekar et al., 2017; Kehrli et al., 2021). Therefore, it is necessary to monitor this pest to avoid potential quantitative and qualitative damage during harvest. In Primorje-Gorski Kotar County, in the locality of Rijeka, 4 specimens were observed on figs (Figure 1). Although this population size is not of concern, it is

important to emphasize that there are not many records of figs as hosts of *H. halys* in Europe, except in Croatian neighboring country Slovenia (Rot et al., 2018), from where it most likely spread. Fig is an important perennial crop in Croatia with high traditional and economic value.

Weekly catches of *H. halys* individuals were highest at the end of the growing season, reaching numbers above the treatment threshold of 10 adults established by Short et al. (2017), at five sites (Figure 2). The highest weekly catches were recorded in hazelnut orchard in the locality of Tovarnik in Vukovar-Syrmia County with 38 and 41 specimens, and in cherry orchard in the locality of Ivankovo in Vukovar-Syrmia County with 22 specimens (Figure 2). In pear orchards in Osijek-Baranja County the highest weekly catches were 16 specimens in the locality of Osijek, and Marijanci with 14 and 17 specimens, respectively. In apple orchard in the locality Staro Čiče

in Zagreb County, the highest weekly catches of *H. halys* were 11 specimens (Figure 2).

Although no fruit damage was observed at the sites studied, it is necessary to use insecticides to prevent the population from growing in the future. In addition to chemical control, successful and environmentally friendly control of *H. halys* has been achieved in many perennial crops in recent years. For example, by using the attract and kill method in the USA (Morrison et al., 2019) and exclusion nets to protect apple orchards in Italy (Candian et al., 2018). Therefore, it is recommended to use efficient and environmentally friendly methods to control *H. halys* to reduce population size and prevent further spread to other important crops. To prevent the occurrence of significant damage in perennial crops in Croatia, this species needs to be monitored extensively.



Figure 1. Population size of *H. halys* per site in Croatia during the vegetation season (Location sites explained in detail in Table 1)

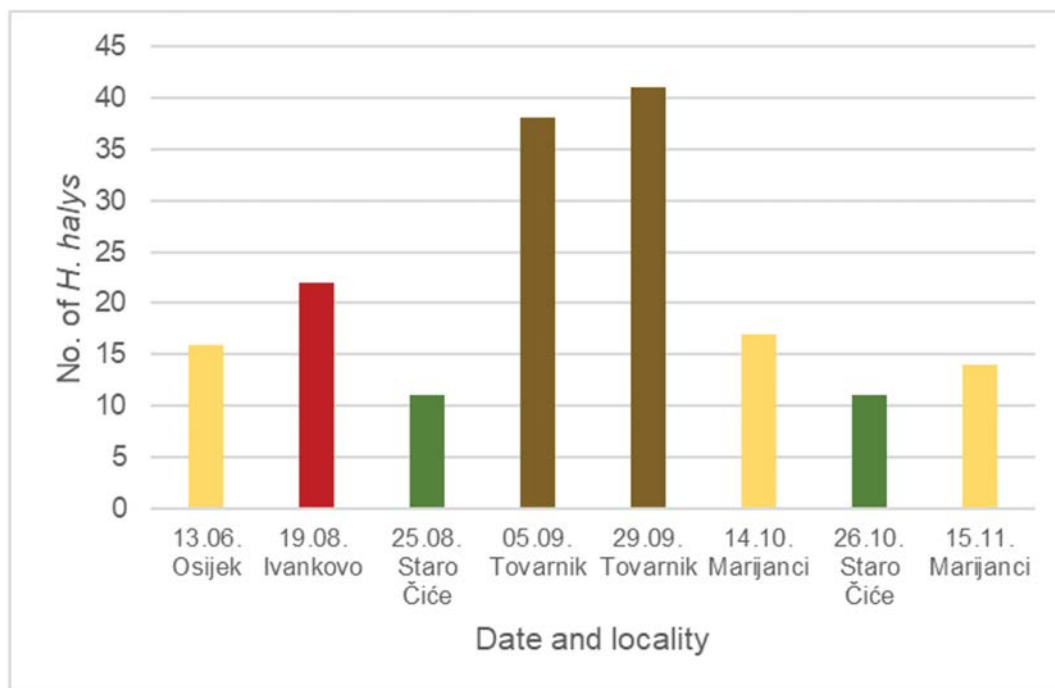


Figure 2. The highest weekly catches of *H. halys* in perennial crops in Osijek, Ivankovo, Staro Čiče, Tovarnik and Marjanci (Location sites explained in detail in Table 1)

CONCLUSIONS

Species *H. halys* was detected in all perennial crops examined. Although no fruit damage was observed, weekly catches of *H. halys* exceeded the established treatment threshold, requiring the application of control measures. Considering the invasive nature of *H. halys* and the favorable climatic conditions for its development in Croatia, besides hazelnut, the crops most threatened by this pest are pear, apple, and cherry. Since economic damage caused by *H. halys* has been detected in perennial crops of Croatian neighboring countries, it is urgent to strengthen monitoring of *H. halys* in order to prevent its further spread and occurrence of significant damage in Croatia as well.

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