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RAPID COMMUNICATION

First record and current status of the brown marmorated sting bug *Halyomorpha halys* damaging peaches and olives in northern Greece

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Abstract

The species *Halyomorpha halys* (Stål), which is endemic in East Asia, was first detected in North America in 1996 and was probably introduced into Europe in 2008. The species is polyphagous. It consumes over 170 host plant species and significantly impacts crop production. In Greece the first recording of its presence was in 2014, when it was reported as a nuisance in houses in the region of Athens. The present study describes the systematic spread and damage of this invasive pest, including the first recorded identification in peach and olive cultivations in the prefecture of Imathia in central Macedonia, Greece. Sampling was carried out in representative peach and olive farms during July and August, 2018 and 2019 in which significant levels of fruit damage were recorded, especially during 2018. The population of the species was recorded throughout the winter seasons of 2018 and 2019 in which overwintering adults were systematically recorded in shelters and other constructions near fruit orchards. Given the dynamics of the species and its destructive impact on a wide range of host species, *H. halys* is expected to be a major pest. Additionally, considering that the prefecture of Imathia is the most important peach growing area of Greece, further studies of the presence and population dynamics of this species along with the establishment of particular management actions to control the population is imperative for the future protection of horticultural production in Greece.

Keywords: integrated pest management, invasive pest, Pentatomidae

Halyomorpha halys (Stål, 1855) (Heteroptera: Pentatomidae), or brown marmorated stink bug, is a temperate/subtropical species native to China, Japan, Korea and Taiwan (Lee *et al.* 2013). However, in recent years, the species has been detected in other countries, primarily in North America and most of Europe (Cianferoni *et al.* 2018; Leskey and Nielsen 2018). In southern Europe, particularly, the species was found in 2007 in Liguria, Italy (Maistrello and Dioli 2014; Dioli *et al.* 2016), in 2011 in Athens, Greece (Milonas and Partsinevelos 2014), in northeastern France in 2012 (Callot and Brua 2013), in Ile-de-France (Garrouste *et al.* 2014; Maurel *et al.* 2016; Kriticos *et al.* 2017) and in Corsica in 2018 (Burne 2019). *Halyomorpha halys* was also recorded in Girona, Spain, in 2016 (Dioli *et al.* 2016), and in 2019 on the Maltese Islands (Tassini and Misfud 2019). Recently, the species has been recorded in the Czech Republic (Kment and Březíková 2018), in Belgium (Claerebout *et al.* 2019) as well as in kiwi fruit plantations in Greece (Andreadis *et al.* 2018).

The current communication aims to provide new information on the first records of the presence and damage caused by the species in peach and olive trees in northern Greece. Fieldwork was conducted during the growing seasons of 2018 and 2019 from July to August in two peach fruit orchard plantations located in Nea Lycogiani (Lat: 40.571426, Long: 22.233038) and Kavasila (Lat: 40.59449, Long: 22.337542) and one

young olive tree plantation located in Kavasila (Lat: 40.595611, Long: 22.332908) in the prefecture of Imathia in northern Greece. To date these regions are the most important in terms of fruit production in Greece, particularly for peaches (Kukurjannis 1985).

Each peach orchard, used as an experimental block, had a parallelogram shape and was separated from other plantations by a 10–20 m wide cultivation road. Each block consisted of about 40 peach trees (industrial candy variety Loadel) planted in a regular rectangular 5 × 5 m grid with 10 rows and 10 columns. The tree height was ca. 2.5–3.5 m, and the trees were ca. 10+ years old. The olive orchards consisted of about 30 young olive trees (3–4 years old) of the Halkidiki variety planted in a 5 × 6 grid with 8 rows and 10 columns. The tree height of was ca. 1.5–2.5 m. No insecticides were applied to these orchards and only mating disruption dispensers were used for the peach orchards against *Anarsia lineatella* and *Grapholita molesta*.

In order to have a representative grid of samples from each experimental block every second tree from every second row of each experimental block was used to collect data. One 2-year branch, ca. 1–2 m above the ground where the majority of fruits or olives hang, was used as a sampling unit. Exhaustive counts of sampling units were performed and all fruits on the given branch were inspected for the presence of *H. halys* individuals as well as feeding damage. A total of 132 statistical sampling units was used.

Damage by adults and nymphs, which resulted from the insertion of the proboscis into the plant material (Martinson *et al.* 2015), was assessed by counting the small necrotic areas, which in most cases led to subderfications. Peach fruits and olive crops were considered to be damaged regardless of the number of feeding sites observed. The Mann-Whitney nonparametric U test was applied to perform pairwise comparisons between the different levels of damage and to compare mean ranks (Sokal and Rohlf 1981, IBM Corp. Released 2013).

The presence of *H. halys* individuals (mainly nymphs) was very high in both peach and olive orchards which were inspected, especially during 2018 (Fig. 1). The initial damage caused by *H. halys* caused fruit deformation which in most cases led to suberifications which varied significantly between the two observation years ($p < 0.01$, Mann-Whitney-U and Kolmogorov-Smirnov tests). In particular, the percentage of peach damage due to *H. halys* feeding was 63 ± 3% and 25 ± 5% during 2018 and 2019, respectively. However, in most cases, the extent of damage (one feeding entrance or more per fruit) to olives was 87 ± 6% and 34 ± 8% during 2018 and 2019, respectively.

In this work the damage which occurred in olive trees (60 ± 6%, $n = 42$) was significantly higher than that observed in peach fruit crops (44 ± 3%, $n = 90$), which is of considerable concern ($p < 0.01$, Mann-Whitney-U and Kolmogorov-Smirnov tests, pooled data for 2018 and 2019). It is important to note that the adult population of *H. halys* was observed to be overwintering in shelters and other buildings in both the 2018 and 2019 seasons. This would suggest that careful inspection of buildings during the winter period may be effective for treatment and control of the species before the fruit production season. Although no spatial analysis was performed, in the peach orchards the most severe damage tended to be located on the periphery of the orchards. This can be explained by

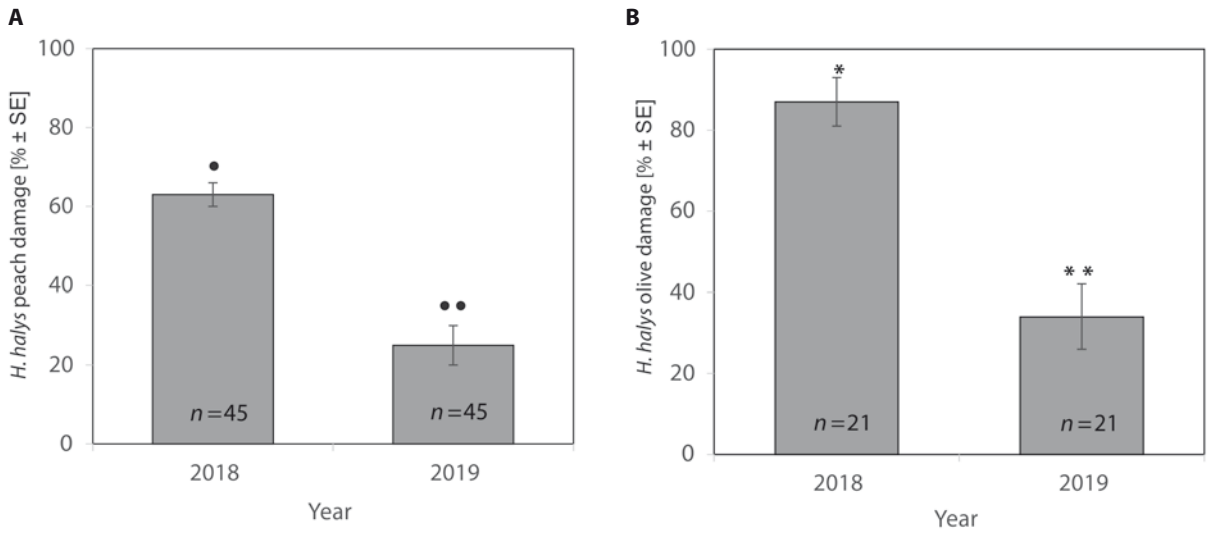

Fig. 1. Mean damage caused by *Halyomorpha halys* feeding entrances in peach fruits (A) and olive crops (B) during two successive observation years (2018 and 2019) in the prefecture of Imathia in northern Greece. Columns followed with a different number of symbols are significantly different ($p < 0.05$) according to Mann-Whitney-U and Kolmogorov-Smirnov nonparametric pairwise mean rank tests

the fact that usually the species has two to three generations in temperate climates (Costi *et al.* 2017; Kistner 2017; Maistrello *et al.* 2017) and due to its strong nymphal dispersal capacity it may move from orchard edges to nearby farms (Lee *et al.* 2014).

Although the observations were carried out in only a few representative orchards this is the first systematic record of *H. halys* in peaches and olives in northern Greece since the first record in Athens in 2011. In addition, the feeding damage was, in most cases, severe and resulted in significant economic losses. To date the Brown marmorated stink bug caused $37 million in losses to mid-Atlantic apple growers (American/Western Fruit Grower 2011). In 2016 Greek canned peach production reached 300,000 tons (Nanaki and Koroneos 2018), while apple production, primarily cultivated in the same region in northern Greece, reached 297,594 tons (USDA Foreign Agricultural Service 2017), suggesting that the establishment and spread of *H. halys* may have significant implications for the gross economy.

Considering that *H. halys* has a wide host range, including fruit trees, field crops, forest trees as well as wild hosts (Bergmann *et al.* 2016) it is expected that it will have a regular presence in more cultivations during the coming years. It has been reported that preferred plants also include apricot (*Prunus armeniaca* L.), sweet cherry (*Prunus avium* L.), plum (*Prunus domestica* L.), apple (*Malus* spp.), pear (*Pyrus* spp.), citrus (*Citrus* spp.), mulberry (*Morus* spp.), berries (*Rubus* spp.) and grape vine (*Vitis vinifera* L.). Moreover, *H. halys* also attacks many horticultural and row crops including tomato (*Solanum lycopersicum* L.), pepper (*Capsicum annuum* L.), eggplant (*Solanum melongena* L.), corn (*Zea mays* L.), sunflower (*Helianthus annuus* L.), cotton (*Gossypium hirsutum*) and many more (Macavei *et al.* 2015). Considering that all the above crops and especially fruit crops, including apples and pears, are extensively cultivated in northern Greece, the potential impact of *H. halys* for further damage and economic loss is expected to cause concerns (Damos *et al.* 2019).

However, experience in the USA has shown that despite being polyphagous this pest has a preference for peach as a host of choice, while experience in Italy in 2015 has shown that the species caused severe damage particularly in pear orchards (Bariselli *et al.* 2016). Thus, the current results are of special interest considering that peaches are cultivated in the same region as apples and pears (Damos *et al.* 2015). Therefore, tracking the present spread of *H. halys* is particularly important in areas cultivated with plants that might suffer severe financial losses due to the uncontrolled development of this invasive alien pest (Krawczyk *et al.* 2018; Vandervoet *et al.* 2019).

However, currently it is unknown if populations of *H. halys* cause severe damage in other fruit orchards in Greece which received pesticides. For instance, there are studies which have shown that insecticides applied by growers in the USA in response to this fruit pest were not effective (Leskey *et al.* 2012). Therefore, early detection is crucial for the management of introduced species, particularly in the case of pests that are recognized for their destructive potential such as *H. halys* which is of special interest. Moreover, careful inspection of the presence of overwintering individuals near fruit orchards may make treatment and control of the species possible before the onset of the growing season.

In conclusion, based on the systematic field monitoring in the current study, it is clear that *H. halys* has established itself in northern Greece and has the potential for future expansion with associated crop and economic losses. The increasing spread of this pest, particularly with its preference for peach and olives, highlights the urgent need for immediate development of efficient and sustainable management strategies for the future. Therefore, further research is urgently required to determine the population dynamics, spread and control.

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