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Original article (Orijinal araştırma)

A new parasitoid record for the invasive pest *Halyomorpha halys* (Stål, 1885) (Hemiptera: Pentatomidae) from Türkiye: *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae)[1]

İstilacı zararlı *Halyomorpha halys* (Stål, 1885) (Hemiptera: Pentatomidae) için Türkiye'den yeni bir parazitoit kaydı: *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae)

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Abstract

The brown marmorated stink bug, *Halyomorpha halys* (Stål, 1885) (Hemiptera: Pentatomidae), is an invasive quarantine pest that has spread rapidly worldwide and in Türkiye in recent years, causing significant damage to agricultural products. In this study, conducted in 2025, nymphs and adults of *H. halys* were collected from hazelnut orchards in Trabzon province, brought to the laboratory and cultured. As a result of the study, *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae) was reared from nymphs and adults of *H. halys*. The present study reports *M. scalaris* as a parasitoid of the *H. halys* for the first time. In addition to several biological observations regarding the parasitoid-host relationship, information on the parasitoid's distribution in Türkiye and worldwide, as well as its known hosts, is provided with support from the relevant literature. Further studies are required to evaluate the effectiveness of this parasitoid as a biological control agent.

Keywords: Brown marmorated stink bug, new host record, parasitoid, Türkiye

Öz

Kahverengi kokarca, *Halyomorpha halys* (Stål, 1885) (Hemiptera: Pentatomidae), son yıllarda dünya çapında ve Türkiye'de hızla yayılan ve tarım ürünlerine önemli zararlar veren istilacı bir karantina zararlısıdır. 2025 yılında gerçekleştirilen bu çalışmada, Trabzon ilindeki fındık bahçelerinden *H. halys*'in nimf ve erginleri toplanmış, laboratuvara getirilerek kültüre alınmıştır. Çalışma sonucunda, *H. halys*'in nimf ve erginlerinden *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae) elde edilmiştir. Bu çalışma, *M. scalaris*'in *H. halys*'in parazitoidi olduğunu ilk kez bildirmektedir. Parazitoit-konukçu ilişkisine yönelik bazı biyolojik gözlemlerin yanında, literatür yardımıyla parazitoitin Türkiye ve dünyadaki dağılımı ve bilinen konukçuları verilmiştir. Bu parazitoidin biyolojik mücadele ajanı olarak etkinliğini değerlendirmek için daha fazla çalışmaya ihtiyaç duyulmaktadır.

Anahtar sözcükler: Kahverengi kokarca, yeni konukçu kaydı, parasitoid, Türkiye

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Introduction

The brown marmorated stink bug, *Halyomorpha halys* (Stål, 1885) (Hemiptera: Pentatomidae), is an invasive quarantine pest that has rapidly spread worldwide and within Türkiye in recent years, causing significant damage to agricultural crops. Native to East Asia (China, Taiwan, Japan, and Korea), *H. halys* is a polyphagous pest that has expanded to many countries in a relatively short period (Hoebeke & Carter, 2003). In Europe, *H. halys* was first detected in Switzerland in 2004 (Haye et al., 2015). Since then, its presence has been reported in several European and Asian countries. In Türkiye, the species was first recorded in Istanbul province in 2017 by Cerçi & Koçak (2017) and in Artvin province the same year by Güncan & Gümüş (2019). Later, the species has been reported in various regions of Türkiye, including Rize, Trabzon, Giresun, Ordu and Samsun provinces in the Black Sea Region (Ak et al., 2019, 2023; Göktürk & Tozlu, 2019), Sakarya and Yalova provinces in the Marmara Region (Öztemiz et al., 2019; Özdemir & Tunçer, 2021), İzmir province in the Aegean Region (Çerçi, 2021) and Adana province in the Mediterranean Region (Kalkan & Satar, 2023).

Halyomorpha halys is characterized by a strong dispersal capacity and a high reproductive potential, factors that may facilitate its establishment and subsequent spread in invaded regions (Leskey & Nielsen, 2018). *Halyomorpha halys*, a highly polyphagous pest species, is an important pest capable of utilizing approximately 300 plant species, including both agricultural crops and ornamental plants, as hosts within its native range (Nielsen & Hamilton, 2009). Since its introduction to the United States, the brown marmorated stink bug has caused significant damage in the mid-Atlantic region, including an estimated US$37 million loss in the apple industry in 2010, along with severe impacts on peaches, nectarines, tomatoes, peppers, sweet corn, and soybeans (Leskey & Nielsen, 2018).

In Türkiye, within the areas where it has established, *H. halys* feeds on a wide range of host plants, including primarily hazelnut, as well as kiwi, maize, citrus, beans, pear, pepper, blackberry, tomato, apple, gooseberry, ornamental plants, peach, and blueberry (Ak et al., 2019, 2023; Göktürk & Tozlu, 2019; Özdemir & Tunçer, 2021; Özdemir et al., 2023). This pest particularly damages fruits during their early developmental stages by piercing and sucking, causing deformities. During the maturation stage, its feeding activity induces necrotic areas on the fruits, eventually leading to rot (Aşkın et al., 2022). The potential distribution map of the brown marmorated stink bug in Türkiye indicates that the coastal areas of the Black Sea region provide the most suitable climatic conditions for the species. These areas also represent the regions with the highest hazelnut production in the country. Given the importance of hazelnut among the pest's host plants, *H. halys* is considered a significant threat to hazelnut cultivation in the areas where it has established (Özdemir & Tunçer, 2021). Moreover, its tendency to aggregate in homes during the overwintering period and the unpleasant odors it produces create a significant urban nuisance with potential impacts on human well-being (Inkley, 2012). The risk of *H. halys* spreading to the Marmara, Aegean, and Mediterranean regions, where a significant portion of Türkiye's fruit and vegetable production takes place, is one of the greatest concerns for Turkish agriculture in the near future.

Mechanical, biotechnical, or chemical control methods used against the brown stink bug have not been fully successful due to the pest's high host diversity and widespread distribution (Tunçer, 2022). In addition to these control methods, biological control options for brown stink bugs are being investigated, and studies are being conducted both globally and in Türkiye to identify the natural enemies of this pest (Altanlar et al., 2023; Göktürk et al., 2023; Özdemir, 2023; Gençer et al., 2026).

Trissolcus japonicus (Ashmead, 1904) (Hymenoptera: Scelionidae), one of the most effective natural enemies and natural population suppressors of *H. halys*, has not yet reached Türkiye through natural means, making the pest's local parasitoids crucial. Meanwhile, studies are rapidly progressing to cultivate *T. japonicus* individuals brought from the Far East in laboratories and release them into regions where the pest is in high population density. However, the high density of the *H. halys* population in Türkiye and the slow adaptation of the parasitoid to field conditions appear to be the most important shortcomings of *T. japonicus* in pest control.

Megaselia Rondani, 1856 (Diptera: Phoridae) represents the largest genus within the family Phoridae, comprising approximately 1710 described species (Brown, 2026). The larvae of *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae) have been characterized as detritivores, parasites, facultative parasites, and parasitoids. They can feed on a broad spectrum of organic materials from both animal and plant sources, showing greater dietary flexibility than any other known insect (Koller et al., 2003; Disney, 2008; Koch et al., 2013). The larvae attack living plants on occasion and this species is significant for animal and human myiasis, as well as in forensic entomology (Disney, 2008; Varney & Noor, 2010). It is also known to parasitise arthropods from many orders, including Hymenoptera, Hemiptera, Orthoptera, Dictyoptera, Lepidoptera, Diptera, Coleoptera, Ixodida and Araneae (Disney, 2008; Koch et al., 2013; El-Hawagry et al., 2021). *M. scalaris* was first recorded in Türkiye by Özsisli & Disney (2011) and was subsequently reported by other researchers in later studies (Civelek & Önder, 1997; Özdemir & Tunçer, 2020; Doğan et al., 2024).

Here we present the first reports of *Megaselia scalaris* as parasitoid of *Halyomorpha halys.*

Materials and Methods

The study was conducted in Trabzon Province, Türkiye, in 2025. Nymph and adult *H. halys* specimens were collected from hazelnut orchards. The collected insects were brought to the laboratory together with their host plants, transferred into separate rearing boxes, and maintained at 25±2°C and 60-70% relative humidity. The boxes were regularly monitored, and the food was replaced as necessary.

In the rearing containers, mortality of *H. halys* nymph and adults was observed. The dead nymphs and adults were collected in groups and placed into petri dishes lined with filter paper. Subsequently, the emergence of parasitoid larvae and their pupation were observed. The pupae were later observed to develop into adults under the same conditions. After the emergence of adult parasitoids, the phorid specimens were prepared for identification and described according to Disney & Aguiar (2008) and confirmed by Dr. Bernd GRUNDMANN (Diekstr. 6, 33824 Werther, Germany). The parasitoid larvae, pupae, adult and the parasitized bug were photographed using a Leica MC170 digital camera attached to a Leica M205 C stereomicroscope. Adults of *M. scalaris* were preserved in 95% ethyl alcohol in the Plant Protection Museum in Tokat Gaziosmanpaşa University, Agricultural Faculty, Tokat, Türkiye.

Results and Discussion

Megaselia scalaris was determined as a parasitoid of *H. halys*. This parasitoid was obtained from *H. halys* for the first time.

The parasitoid: *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae) (Figure 1d)

Distribution: Cosmopolitan in world. In Türkiye: İzmir (Civelek & Önder, 1997), Adana (Özsisli & Disney, 2011), Samsun (Özdemir & Tunçer, 2020), Sakarya (Doğan et al., 2024).

Insect Hosts: *Triatoma brasiliensis* Neiva, 1911 (Hemiptera: Reduviidae) (Costa et al., 2007), *Nezara viridula* (L., 1758) (Hemiptera: Pentatomidae) (El-Hawagry et al., 2021), *Eurygaster integriceps* Puton, 1881 (Hemiptera: Scutelleridae) (Ebrahimi et al., 2023), *Zonocerus variegatus* (L., 1758), *Sphenarium purpurascens* Charpentier, 1845 (Orthoptera: Pyrgomorphidae) (De Gregorio & Leonide 1980), *Patanga succincta* (Johannson, 1763) (Orthoptera: Acrididae) (Thapasya et al., 2025), *Parastagmatoptera tessellata* Saussure & Zehntner, 1894 (Mantodea: Mantidae) (Koch et al. 2013), *Periplaneta americana* (L., 1758) (Blattodea: Blattidae) (Arafat et al., 2024), *Peridroma saucia* Hübner, 1808 (Lepidoptera: Noctuidae) (Ulloa & Hernandez, 1981), *Spodoptera frugiperda* J. E. Smith, 1797 (Lepidoptera: Noctuidae) (Deshmukh et al., 2021; Tang et al., 2021), *Agrotis ipsilon* (Hufnagel, 1766) (Lepidoptera: Noctuidae) (Sweelam et al., 2022), *Thyas coronota* (Fabricius, 1775) (Lepidoptera: Erebidea) (Rajan & Shamsudeen, 2024), *Isognathus caricae* L., 1758 (Lepidoptera: Sphingidae) (Souza et al. 2020), *Erionota torus* Evans, 1941 (Lepidoptera: Hesperiidae) (K. et al., 2024), *Hypantria cunea* (Drury, 1773) (Lepidoptera: Erebidae) (Karami et al., 2023),

Chrysomya megacephala (Fabricius, 1794), *Chrysomya albiceps* (Wiedemann, 1819), *Chrysomya putoria* (Wiedemann, 1830), *Cochliomyia macellaria* (Fabricius, 1775) (Diptera: Calliphoridae) (Batista-Da-Silva 2012), *Palaeosepsis* sp. Duda, 1926 (Sepsidae) (Marchiori, 2018), *Curculio caryae* G. H. Horn, 1873 (Coleoptera: Curculionidae) (Harrison & Gardner 1991), *Macrodactylus murinus* Bates, 1887 (Coleoptera: Scarabaeidae) (Arredondo Bernal & Trujillo-Arriaga 1994). In Türkiye: *Xeropicta derbentina* (Krynicki, 1836) (Pulmonata: Hygromiidae) (Özsisli & Disney, 2011), *Palomena prasina* (L., 1761) (Hemiptera: Pentatomidae) (Özdemir & Tunçer, 2020), *Anoplophora chinensis* (Forster, 1771) (Coleoptera: Cerambycidae) (Doğan et al., 2024).

Figure 1. a) Emergence of larvae of *Megaselia scalaris* from thorax of *Halyomorpha halys* for pupation; b) Larvae of *Megaselia scalaris* on abdomen of *Halyomorpha halys*; c) Pupae of *Megaselia scalaris*; d) Adult of *Megaselia scalaris*.

Biological data: *H. halys* specimens were collected in Trabzon (Yomra), 13.08.2025, 40.93°N 39.89°E, 250m, on *Corylus* sp. (Fagales) (approximately 4500 mixed nymphs and adults); 15.09.2025, (approximately 200 mixed nymphs and adults); 18.10.2025, 40.945°N 39.882°E, 170m, (approximately 1500 adults).

Parasitoids were obtained from each of the three different cultures established using *H. halys* specimens collected from the field at three different times. Parasitoid larvae emerged within 7-10 days. The emergence of parasitoids was observed intensively from both nymphs and adults. However, it was determined that parasitism was higher in nymphs. An average of 3-5 parasitoid larvae emerged from each individual. The larvae pupated approximately one week after emergence (Figure 1c). Adult emergence from the pupae occurred within an average of 10 days. The emergence of the parasitoids larvae generally occurred from the thorax of the dead insect (Figure 1a). Occasionally, emergence from the anal opening was also observed. It was determined that the internal parts of the thorax and abdomen of the dead insects were completely empty. While the body integrity of the parasitized adults was generally preserved, the nymphs became crushed along with liquefaction (Figure 1b).

Invasive species experience rapid population growth within a short period of time due to factors such as their ability to adapt to the climatic conditions of the areas they invade and the absence of natural predation pressure in these areas. This situation leads to invasive species becoming significant pests from ecological, economic, and environmental perspective (Venette & Hutchison, 2021). *Halyomorpha halys* has shown a rapid spread in recent years throughout the Black Sea region and poses a significant threat to many cultivated plants, particularly hazelnuts. Mechanical, biotechnical and chemical control methods have been the primary strategies implemented against this pest (Tunçer, 2022). However, due to the pest feeding over very large areas and on different crop plants, the desired success cannot be achieved with these control methods. Furthermore, the negative impact of intensive chemical use on the environment and human health limits the use of this control method. For this reason, biological control efforts against the pest are coming to the fore. In this context, classical biological control efforts, known as the determination of natural enemies in areas where the pest is native and the transfer of these beneficial organisms to new areas invaded by the pest for release there, are of great importance. Indeed, the Ministry of Agriculture and Forestry is currently continuing its production and release studies in Türkiye of the egg parasitoid *Trissolcus japonicus* (Ashmead) (Hymenoptera, Scelionidae), which is an important natural enemy of the pest in its native habitat. Furthermore, studies have been conducted to identify the pest's native natural enemies in Türkiye (Altanlar et al., 2023; Göktürk et al., 2023; Özdemir, 2023). In these studies, *Anastatus bifasciatus* (Geoffroy, 1785) (Hymenoptera: Eupelmidae) and *Telenomus turesis* (Walker, 1836) (Hymenoptera: Scelionidae) were identified as natural egg parasitoids of *H. halys* in Türkiye by Altanlar et al. (2023) and Özdemir (2023), respectively. Göktürk et al. (2023) also demonstrated that *Cylindromyia bicolor* (Olivier, 1812) (Diptera: Tachinidae) is an adult parasitoid of *H. halys*.

This study demonstrates for the first time that *Megaselia scalaris* parasitises *H. halys*. Parasitism of both nymphs and adults increases the value of parasitism. Our laboratory observations revealed that a large proportion of the cultured *H. halys* specimens were found to be parasitized, indicating a relatively high level of parasitism. Considering that the larvae of *M. scalaris* is found in very different habitats and is an omnivorous species with a wide feeding regime (Disney, 2008), detailed data is needed regarding the use of the parasitoid in biological control programmes.

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