

## First Record of *Halyomorpha halys* and Mass Occurrence of *Nezara viridula* in Slovakia

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### Abstract

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The brown marmorated stink bug, *Halyomorpha halys* Stål, 1855 (Hemiptera: Heteroptera: Pentatomidae), is recorded from Slovakia for the first time based on a 5<sup>th</sup> instar larva collected in the town of Štúrovo, Slovakia. The current distribution, economic importance and biology of the species are briefly reviewed. During the visit to Štúrovo, a mass occurrence of adults and larvae of the southern green stink bug, *Nezara viridula* (Linnaeus, 1758) (Pentatomidae), so far captured in Slovakia in 2014 only as a single specimen, was also observed. This observation confirms the presence of *N. viridula* as an established species in southern Slovakia. Both species are important pests to a large number of crops (vegetables, fruit trees, decorative plants, etc.) and can cause considerable economic losses.

**Keywords:** brown marmorated stink bug; southern green stink bug; Europe; polyphagous; phytophagous; invasive species

The brown marmorated stink bug, *Halyomorpha halys* Stål, 1855 (Hemiptera: Heteroptera: Pentatomidae: Pentatominae: Cappaeini), is native to East Asia, where it occurs in large areas of China, Japan, Korea, Russian Far East, Taiwan and northern Vietnam (JOSIFOV & KERZHNER 1978; RIDER *et al.* 2002; RIDER 2006; VÉTEK *et al.* 2014). From there it was introduced to North America, where it was first detected in September 2001 at a number of sites in coastal regions of Pennsylvania but later specimens were found in collections documenting the first North American records in 1996 (HOEBEKE & CARTER 2003; NIELSEN & HAMILTON 2009a). After 2001, the species rapidly spread through the entire United States and in 2012 it was already known from 38 states of the USA from the Atlantic coast to the Pacific coast and from the Mexican border to

the Canadian border, as well as in southern Canada (Ontario, Québec) (FOGAIN & GRAFF 2011; LESKEY *et al.* 2012). Recently, *H. halys* was reported also from Puerto Rico, though misidentified as *Apateticus lineolatus* (Herrich-Schäffer, 1840) (SEGARRA-CARMONA *et al.* 2015). In Europe it was first collected in 2004 in Liechtenstein (ARNOLD 2009) and then in 2007 in Switzerland (WERMELINGER *et al.* 2008). Several years of gradual acclimatisation in urban greenery in large Swiss cities (Zürich, Basel, St. Gallen, Schaffhausen) (WYNIGER & KMENT 2010) were followed by rapid spreading of *H. halys* into neighbouring countries – southern Germany (November 2011 in Konstanz; HECKMANN 2012), northeastern France (August 2012 in Strasbourg; CALLOT & BRUA 2013), and northern Italy (September 2012 in Modena; MAISTRELLO *et al.* 2014). In autumn 2011 another introduction was

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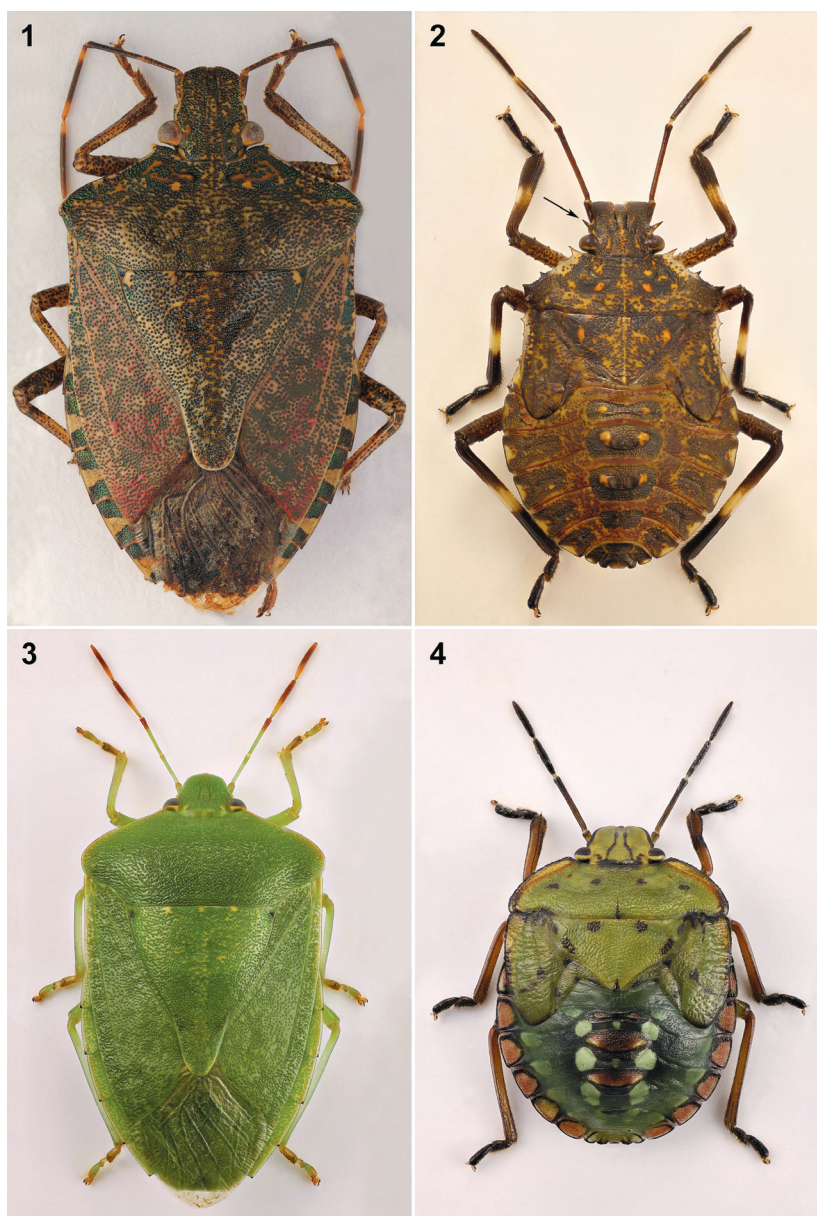
found in Athens, Greece (MILONAS & PARTSINEVELOS 2014). At the beginning of August 2014 *H. halys* was found also in Sochi, Krasnodar Kray, South European territory of Russia (MITYUSHEV 2016a, b), and in October 2014 it was also recorded in Budapest, Hungary (VÉTEK *et al.* 2014). Expected occurrence in the Balkan Peninsula was soon confirmed by MACAVEI *et al.* (2015) in the botanical garden in Bucharest, Romania (September 2015) and by ŠEAT (2015) in three localities in Serbia (October–December 2015). In August 2015, *H. halys* was found also in Austria at two distant localities – in Vienna and Dornbirn (Vorarlberg) (RABITSCH & FRIEBE 2015). During the autumn of 2016 this species was also found for the first time in Spain (Girona), Sardinia (DIOLI *et al.* 2016), Georgia and Abkhazia (GAPON 2016). Moreover, it was found during border checks of imported goods in England, Australia, and in New Zealand (HARRIS 2010; MALUMPHY 2014; BERGMANN *et al.* 2016). Also the record of the Oriental *Halyomorpha picus* (Fabricius, 1794) from Egypt by GADALLA (2004) most probably belongs to *H. halys*.

The diversity of genetic haplotypes in Europe indicates dispersion of *H. halys* within the continent and formation of secondary invasion centres but there is also evidence for recurrent introductions from Asia or USA (GARIEPY *et al.* 2015). Ecological niche modelling even suggests that its expansion has just begun because the models have predicted large areas suitable for *H. halys* in all of Europe approximately between 40 and 50°N, i.e. from the Mediterranean coast to Scotland and the southern coasts of Norway and Finland (ZHU *et al.* 2012; HAYE *et al.* 2015).

*Halyomorpha halys* (Figure 1) is a relatively large stink bug (12–17 mm) with the dark coloured dorsum with yellowish-brown and/or reddish-brown tones alternating with black or dark metallic green spots in places with concentration of black punctation. The margins of the abdomen (connexivum) have a yellowish spot in the middle of each segment while its anterior and posterior parts are dark green metallic. The antennae are mostly black, with only the bases and apices of the last two antennal segments yellowish. The legs and underside of the body are yellow or yellowish brown with more or less sparse black punctures. For identification of adults see the key by WYNIGER and KMENT (2010) and detailed illustrations of genitalia by VÉTEK *et al.* (2014). The larva of *H. halys* is easy to identify thanks to its long, sharp anteocular processes on the head (Figure 2).

*Halyomorpha halys* is a polyphagous phytophage feeding on a wide range of dicotyledonous plants including many economically important species. In a long list of its hosts there are many native as well as exotic ornamental woody plants, in Europe e.g. *Euonymus europaea*, *Pyrus* spp., *Malus* spp., *Fraxinus* spp., *Acer* spp., *Sophora japonica*, *Sorbus aucuparia*, *Ulmus* spp., *Viburnum* spp., *Catalpa bignonioides*, *Parthenocissus quinquefolia*, *Morus* spp., *Ailanthus altissima*, *Paulownia tomentosa*, *Platanus* spp., *Rosa* spp., *Prunus* spp., *Cornus sanguinea*, and *Syringa* spp. (e.g. HOEBEKE & CARTER 2003; WERMELINGER *et al.* 2008; NIELSEN & HAMILTON 2009b; LESKEY *et al.* 2012; LEE *et al.* 2013; HAYE *et al.* 2014; VÉTEK *et al.* 2014; BERGMANN *et al.* 2016). Also, it has often been found on conifers but its development on them has not been confirmed (BERGMANN *et al.* 2016). On economic plants, *H. halys* can cause damage on cultivated apple, peach, and other stone fruit trees, and also on grapevine and berry plants. Besides the direct injury caused by sucking on fruits themselves, the punctures by the rostrum of the stink bugs often represent a gateway for secondary bacterial and fungal infections of plants, and the defensive secretion from the metathoracic scent glands often depreciates the flavour of fruits and pressed juices (especially during the compression of wine from grapes). *Halyomorpha halys* also attacks vegetables (e.g. peppers, tomatoes, aubergines, asparagus, cruciferous, and cucurbit crops), beans, soybean, maize, wheat, and other cereals (LESKEY *et al.* 2012; LEE *et al.* 2013). An additional important problem is that the species may disrupt existing integrated pest management in agrobiocoenoses (LESKEY *et al.* 2012). *Halyomorpha halys* can also act as a vector of a phytoplasma causing witches' broom on *Paulownia* plants in China (SUN *et al.* 1999) and Japan (NAKANO *et al.* 1997).

In Pennsylvania, *H. halys* has only one generation per year and overwinters in the adult stage. The first egg batches were found in the first week of June. The following changes in the frequency of larvae on individual host plants were observed during the larval development: the highest abundance at the beginning of season was recorded on *Paulownia*, in the middle of season on *Viburnum opulus* var. *americanum*, and at the end of season on *Viburnum prunifolium* and *Rosa rugosa*. This indicates possible changes of host plants during the vegetation season. In subtropical areas of China, Korea, and Japan, *Halyomorpha halys* has 1–2 generations per year and in tropical southern China even 4–6 generations (LEE



Figures 1–4. 1–2: Brown marmorated stink bug, *Halyomorpha halys* Stål, 1855: 1 – adult collected from China: Sichuan (NMPC) (KMENT 2016), 2 – 5<sup>th</sup> instar larva collected recently from Štúrovo; 3–4: southern green stink bug, *Nezara viridula* (Linnaeus, 1758) collected from Štúrovo: 3 – adult, 4 – 5<sup>th</sup> instar larva (Photo: Luboš Dembický)

*et al.* 2013). At the end of October, the adults do not feed anymore and move to sheltered places for overwintering (NIELSEN & HAMILTON 2009b). They can move individually or in large groups into buildings, causing significant nuisance to their inhabitants because of their scent secretions, humming flight, contamination of walls and floors (INKLEY 2012), and, less frequently, also allergic reactions (MERTZ *et al.* 2012). High numbers of individuals can hibernate on walls, inside insulation layers, in lofts and other suitable slits providing a mild and dry microclimate and become active especially during warm days in winter and spring. An owner of a country house in Maryland collected in his house 26 205 individuals of *H. halys* from January to June 2011, from which

10 584 (40.4%) were found on the first and second floors, and the rest in the loft (INKLEY 2012).

The southern green stink bug, *Nezara viridula* (Linnaeus, 1758) (Pentatomidae: Pentatominae: Nezarini), is one of the economically most important species of Heteroptera. Its geographic origin is uncertain, probably being in eastern Africa and/or in the Mediterranean (HOKKANEN 1986). Currently the species is widespread in tropical and subtropical regions of Eurasia, Africa, Australia, North and South America, between ca. 45°N and 45°S (TODD 1989; PANIZZI *et al.* 2000; MUSOLIN 2007; RABITSCH 2010). This distribution area has been expanding continually; the phenomenon was studied in detail in Japan where the northern limit of the *N. viridula*

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distribution shifted 85 km northwards since the 1960s. Mild winters as a result of global climate change are supposed to be a driving force behind this shift (KIRITANI 2011). In Europe the species was originally known from the Mediterranean, but since the 1950s it has been spreading northwards (RABITSCH 2008). In the last decade, established breeding populations were documented in southern England, western Germany, northern Switzerland, and Hungary (BARCLAY 2004; WERNER 2005; RÉDEI & VÉTEK 2005) and most recently in western Romania, Austria, and the Netherlands (AUKEMA 2016; GROZEA *et al.* 2016; RABITSCH 2016). Scattered records are also known from Belgium and Finland, although *N. viridula* is not considered established there yet (RABITSCH 2008).

*Nezara viridula* (Figures 3–4) is a large species (13–18 mm) with an elongate oval body and usually pale green coloration. For identification see e.g. RIBES and PAGOLA-CARTE (2013). *Nezara viridula* is one of the most commonly studied true bugs and there is a rich bibliography on it (e.g. TODD 1989; PANIZZI *et al.* 2000). It is known to develop on more than 150 plant species belonging to more than 30 families, though it has a strong preference for Fabaceae. It is the most important heteropteran pest of legumes (especially soybean), but it can also damage vegetables, maize, tobacco, fruits, nuts, and ornamental plants (OHO & KIRITANI 1960; KIRITANI *et al.* 1965; TODD & HERZOG 1980; TODD 1989; PANIZZI 1997; PANIZZI *et al.* 2000).

## MATERIAL AND METHODS

Specimens were collected by hand, killed in a vial with vapours of ethyl acetate and dry mounted by gluing on card stock. The material is deposited in the following collections: Moravian Museum, Brno, Czech Republic (MMBC); National Museum, Praha, Czech Republic (NMPC); Slovak Museum of Nature Protection and Speleology, Liptovský Mikuláš, Slovakia (SMLS); and Vladimír Hemala private collection (VHJS). Habitus photographs were taken using a Canon MP-E 65 mm macro lens attached to a Canon EOS 6D camera and stacked from multiple layers using the Helicon Focus 5.1 Pro software.

## RESULTS

One fifth instar larva of *Halyomorpha halys* (Figure 2) was collected in southern Slovakia in Štúrovo,

on a house wall in the Hlavná street, 47°47'56.12"N 18°43'9.05"E, on 23.X.2016, by V. Hemala. The identification of the specimen was confirmed by P. Kment. The specimen is deposited in MMBC.

On the same day, the first author also observed ca. 300 specimens of *Nezara viridula*, both adults and larvae, throughout the town of Štúrovo. Thirty-eight specimens (15 males, 17 females, 6 larvae) were collected and are deposited in MMBC, NMPC, SMLS (1 male, 1 female, and 1 male of *torquata* colour form in each collection), and VHJS (9 males, 14 females, and 6 larvae). The specimens were observed on the walls, doors, and windows of different buildings, on benches and waste bins in streets and parks and also on various plant species (e.g., *Hylotelephium* sp. and *Humulus lupulus*). Some specimens of *N. viridula* were observed also around the train station, ca. 3 km distant from the town centre (47°47'58.30"N 18°40'46.44"E).

## DISCUSSION

The single larva collected in Štúrovo represents the first record of *H. halys* in Slovakia and confirms a further spreading of this invasive species northwards; the nearest known localities in central Europe were in the environs of Budapest in Hungary (VÉTEK *et al.* 2014) and in Vienna in Austria (RABITSCH & FRIEBE 2015). Although the capture of a larva indicates that the species probably reproduces in Slovakia, further records in southern Slovakia are still needed to verify the presence of an established population. Nevertheless, considering the potential distribution of *H. halys* in Europe as predicted by ecological niche modelling (ZHU *et al.* 2012; HAYE *et al.* 2015), its establishment and further spreading throughout Slovakia can be expected.

*Nezara viridula* has been captured in Slovakia only once in Štúrovo, based on a single fifth instar larva (later moulted to adult) in October 2014 (VÉTEK & RÉDEI 2014). However, VÉTEK and RÉDEI (2014) also reported an established population of that species in neighbouring Esztergom (Hungary) just across the River Danube. In Hungary, *N. viridula* was recorded from Budapest, Szeged, Szeged-Kiskundorozsma, and Esztergom (RÉDEI & TORMA 2003; VÉTEK & RÉDEI 2014) as a locally abundant species (e.g. in the environs of Budapest: D. Rédei, pers. comm.). In Austria, hundreds of larvae and adults were found in Vienna in autumn 2016 (RABITSCH 2016). The

present observation from Štúrovo confirms that *N. viridula* has become an established species in southern Slovakia and the number of specimens recorded, including both sexes and larvae suggests that a further spreading into adjacent regions of Slovakia can be expected in the near future.

The occurrence of both *H. halys* and *N. viridula* in Slovakia requires their further monitoring as potential pests in agriculture. In neighbouring Hungary, *N. viridula* has become one of the most significant pests in vegetable production in the past decade. Its impact is important especially for the two following reasons: (i) it causes yellow spots on fruits and vegetables by its feeding (sucking) that are more than merely a 'beauty imperfection'; that is, such products cannot be eaten, because they have an unpleasant bug smell, rendering them impossible to sell; and (ii) in fields, orchards, and glasshouses where producers apply ecological farming methods, the population size of the bugs rapidly increases, forcing the producers either to give up the biological control of other pests and to start with insecticide treatments, or to hire special staff to walk around in the glasshouse and pick up the bugs manually (RIMÓCZI 2015).

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