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First records of an invasive bug in Europe: *Halyomorpha halys* Stål (Heteroptera: Pentatomidae), a new pest on woody ornamentals and fruit trees?

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In 2007 five incidences of the brown marmorated stink bug *Halyomorpha halys* Stål 1855 (Heteroptera: Pentatomidae) were recorded from the area around the City of Zürich in Switzerland. While most records were of single individuals, in one case exotic ornamentals suffered from a mass attack. These are the first records of this invasive bug not just in Switzerland but also in Europe. This phytophagous species is native to East Asia and was introduced into the USA about a decade ago. It is considered a pest both in its countries of origin and introduction, especially for horticultural crops such as stone fruit and pomes as well as for woody ornamentals. Moreover, it can become a nuisance in residential areas when it aggregates on buildings and in homes seeking shelter for overwintering.

A brief literature review is given here of its biology, host plants, natural enemies and economic impact in East Asia and in the USA. The possible significance of this new potential pest in Central Europe is also assessed.

Keywords: Fruit feeding, horticulture, introduced pest, nuisance, ornamental trees

INTRODUCTION

The brown marmorated stink bug (*Halyomorpha halys* Stål 1855; Heteroptera: Pentatomidae) is a phytophagous bug that is indigenous to China, Korea, Taiwan, and Japan (Hoebeke & Carter 2003). It is a polyphagous species with up to 100 known host plants reported, many of them of horticultural, agricultural, and ornamental interest. Adults and nymphs suck on the leaves and fruit of their hosts. In its native range it regularly provokes severe damage to mainly horticultural crops and soybean. It was introduced into the USA towards the end of the 20th century and was positively identified for the first time in 2001 in Allentown, Pennsylvania (Bernon 2004). It then spread rapidly, and is reported today throughout Pennsylvania and New Jersey with scattered populations in other eastern states. In 2004 an isolated population was found in Oregon on the west coast of the USA (Bernon *et al.* 2007). This bug is now recognized as a potentially serious pest mainly for pome and stone fruit (Bernon 2004). In addition, the brown marmorated stink bug can act as a nuisance pest because it aggregates in homes seeking overwintering sites. This article reports on the first incidences of *H. halys* at five different places in the Zürich region in Switzerland, which to our knowledge are at the same time the first records of the genus *Halyomorpha* in Europe (Aukema & Rieger 2006). A synopsis of the literature on its distribution, ecology, and economic significance is presented.

FIRST EUROPEAN RECORDS IN SWITZERLAND

In August 2007 the Swiss Forest Protection Service was provided with a sample of bug nymphs from a garden near Lake Zürich (for details, see below). The owner reported that this unknown insect infested various exotic ornamental shrubs. The nymphs were identified as pentatomid larvae, but could not be further identified. Therefore, they were reared to the adult stage on shoots of the butterfly bush (*Buddleja davidii*). After passing through another larval instar, they developed into adults. A specialist (DW) on Heteroptera identified the stink bug as *H. halys*, a finding that was confirmed by the heteropterist T. Yasunaga (presently at Rajamangala University, Thailand). Based on this identification, several nymphs received in June 2007 from the public pest-consulting service in Zürich turned out to be the same species. Likewise, a nymph sucking on a maple seed that was photographed earlier that year could be identified as *H. halys* as well. In autumn of the same year, we obtained two more specimens from Zürich.

In summary, the following records were known by the end of 2007 from Switzerland, in chronological order:

Zürich (canton of Zürich ZH): 2 egg masses and several nymphs feeding on *Asparagus* sp. (Beratungsstelle Schädlingsbekämpfung, Umwelt- und Gesundheitsschutz UGZ), 18.vi.2007.

Adliswil (ZH): 1 nymph feeding on the seed of an *Acer pseudoplatanus* tree, 1.viii.2007.

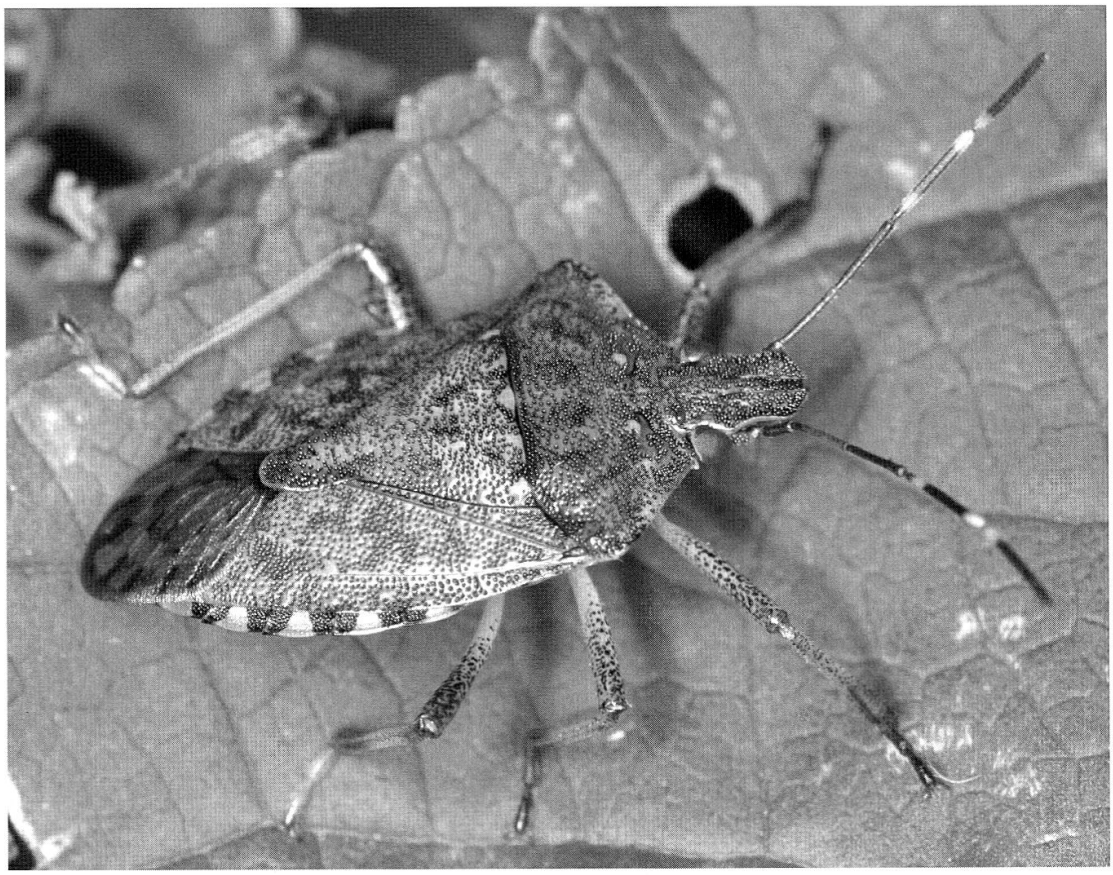

Fig. 1: Adult *Halyomorpha halys* reared from a nymph on foliage and fruit from butterfly bush (*Buddleja davidii*).

Erlenbach (ZH): infestation of ornamental shrubs by nymphs in a garden on *Amelanchier lamarckii* (slight infestation), *Buddleja davidii* (slight), *Aralia elata* (heavy), *Tropaeolum majus* (heavy), *Decaisnea fargesii* (excessive), *Stewartia pseudocamellia* (excessive), 24.viii.2007. 3 nymphs subsequently reared to adult on *B. davidii*.

Zürich-Riesbach (ZH): 1 nymph on an unknown plant in the Chinese Garden, 12.ix.2007, subsequently reared to adult on *B. davidii*.

Zürich-Friesenberg (ZH): 1 adult in apartment, 26.ix.2007.

MORPHOLOGY, BIOLOGY AND NATURAL ENEMIES

The literature on this invasive species available in English is quite scarce because the insect has only recently been found outside East Asia. Most information presented here relies on the literature review by Hoebeke & Carter (2003) and on data from the first studies done in Allentown, PA in the USA after the positive

Fig. 2: 4th instar nymph of *Halyomorpha halys* with spines on the pronotum and white bands on the tibiae.

confirmation of *H. halys* (Bernon 2004). Allentown is located some 150 km west of New York. Along general lines, the life cycle described in the US study can be adopted for Southern and Central European countries. Where available, the above sources are complemented with additional literature.

The morphology of *H. halys* is described in detail in Hoebeke & Carter (2003). The adult is 12–17 mm in length, brownish or grayish, mottled and variable in size and color (Fig. 1). The pronotum of the younger nymphs is armored with spines, and the tibiae of instars 3 to 5 show a white band (Fig. 2). In Europe, *H. halys* might be confused with *Holcostethus* sp. Fieber and *Rhaphigaster nebulosa* (Poda). In contrast to *H. halys*, *Holcostethus* sp. is 9–10 mm in length, and the front edges of the pronotum and the apex of the scutellum are pale. The head of *R. nebulosa* is quite regularly cone-shaped while that of *H. halys* shows a marked angle with a broadly rounded front.

The brown marmorated stink bug overwinters in the adult stage. In spring, i.e. after the end of April, the bugs leave their overwintering sites and can be observed at their feeding and reproduction sites in late May/June. After quite a long mating and preoviposition period, the females lay eggs from approx. June to August (Funayama 2002; Hoebeke & Carter 2003). The threshold for ovarian development is 16.3 °C (cited in Funayama 2002). Depending on the host plant species, females produce 50 to 150 eggs (Funayama 2002) by depositing egg masses comprising 20–30 eggs each. The egg masses are deposited on the underside of leaves in the central area. Oviposition peaks in July and ends in late August.

After hatching from the eggs, the first instar nymphs remain for some days clustered on the egg mass before dispersing. Their immature development comprises five instars, and the total juvenile development time amounts to 467.8 day-degrees at a developmental threshold of 13.8 °C (cited in Kiritani 2007). Further details on immature development may be found in Hoebeke & Carter (2003). While feeding on the upper leaf surface, they often aggregate with other heteropterans between overlapping leaves. Adult offspring can be observed in August feeding mainly on fruit (Funayama 2004). When disturbed, they drop off the leaves or rapidly hide. On warm days, the adults may take short flights. Photoperiod is an important environmental clue affecting developmental speed, reproductive maturation as well as the morphological traits of both nymphs and adults (Niva & Takeda 2003).

In fall, the late instar nymphs and the adults often move on from pome and stone fruit to woody ornamentals, where they suck on the berries. In addition, host switching in search of the most nutritious fruit can be observed throughout the whole growing season (Funayama 2002). Adults do not mate before overwintering. Starting in September, the bugs aggregate and seek shelter in homes and sheds or in natural crevices where they spend wintertime in diapause (Kiritani 2006; Toyama *et al.* 2006). In all populations monitored in the USA and in most of East Asia, generations were univoltine (Hoebeke & Carter 2003; Bernon 2004; Bernon *et al.* 2007). *Halyomorpha halys* is cold hardy but its survival rate in winter depends on temperature (Kiritani 2006).

Among the known natural enemies, most are typical for other pentatomid bugs. As predators spiders, ants, and lacewings have been reported. There seem to be only few parasitoid species. One scelionid (*Telenomus* sp.) and some eupelmid (*Anastatus* spp.) egg parasitoids have been found in the USA. Tachinid flies paras-

itize adult stink bugs and emerge from their hosts after overwintering (Bernon 2004). They are attracted by the pheromone of *H. halys* (Aldrich *et al.* 2006).

HOST PLANTS

The brown marmorated stink bug is an extremely polyphagous insect. Primary hosts are woody plants, including fruit trees and ornamentals. In the US study (Bernon 2004) and in the literature from the East Asian countries of origin (Hoebeke & Carter 2003; Funayama 2004; Kiritani 2007), up to 100 plant species are listed. The most important hosts include fruit trees and bushes such as apricot (*Prunus armeniaca*), cherry (*Prunus avium*), peach (*Prunus persica*), plum (*Prunus domestica*), apple (*Malus* spp.), pear (*Pyrus* spp.), *Citrus* spp., mulberry (*Morus* spp.), persimmon (*Diospyros* spp.), raspberry (*Rubus* spp.), and grape (*Vitis vinifera*); leguminous field crops such as soybean (*Glycine max*), common bean (*Phaseolus vulga-*

Fig. 3: Late instar nymph of *Halyomorpha halys* sucking on a seed of *Acer pseudoplatanus*.

ris), and pea (*Pisum sativum*); forest trees such as maple (*Acer* spp.) and willow (*Salix* spp.); as well as ornamental trees and shrubs such as butterfly bush (*Buddleja davidii*), *Paulownia tomentosa*, firethorn (*Pyracantha coccinea*), honeysuckle (*Lonicera* spp.), lilac (*Syringa* spp.), *Hibiscus* spp., Japanese cedar (*Cryptomeria* spp.), and cypress (*Cupressus* spp.). Moreover, *H. halys* also feeds on weeds (e.g. *Arctium* spp.).

In Japan the effect of host species on the performance of the brown marmorated stink bug has been studied in more detail (Funayama 2002). Apple trees do not seem to be a prime host since apple-fed females produced fewer eggs. However, apple leaves serve as an early food source for sexual maturation and the fruits are important when other, more suitable fruits are scarce.

In the Swiss records from 2007 presented here, the 8 reported host plants (see above) belong to 8 different botanical families. Most species were woody shrubs or trees and only two (*Tropaeolum majus*, *Asparagus* sp.) were herbaceous. Interestingly, 5 out of the 8 hosts originate from Asia, the origin of the brown marmorated stink bug. However, in one case a native tree species, i.e. *Acer pseudoplatanus*, also served as a host (Fig. 3).

ECONOMIC SIGNIFICANCE

The most significant damage caused by *H. halys* is the result of fruit feeding on pome, stone fruit, and legume pods. The sucked fruits become blotchy and show discoloration. They are therefore unmarketable after a heavy attack. In the countries where *H. halys* is indigenous, this bug has been reported to cause significant damage to soybean and various horticultural crops (Hoebeke & Carter 2003; Funayama 2004; Toyama *et al.* 2006). In recent years, apple crops in northern Japan have become more and more impaired by bug feeding (Funayama 2004).

Currently, the marmorated stink bug is spreading rapidly in the USA. At one infestation site, the peach crop was completely lost in two consecutive years due to fruit feeding. Even regular spraying with insecticide between April and August did not prevent damage (Bernon 2004). The crops most preferred are peach, pear and apple. Nevertheless, damage has so far been limited to small-scale, garden-type orchards. No significant damage has been reported from the USA so far from field crops such as soybean, though there was an infestation in 2005 (Bernon *et al.* 2007).

Other commercially important plants are ornamentals. In the US infestation the bugs preferred *Buddleja* (Bernon 2004). In Switzerland, this bush was less infested than other species. A *Stewartia pseudocamellia* plant reportedly died due to the excessive attack, and a *Decaisnea fargesii* plant would have been killed as well without insecticidal treatment.

Though forest trees are also among the hosts of *H. halys*, this bug does not seem to cause damage in forests. However, in Japan it is well known to feed on coniferous cones and is considered a pest in cedar and cypress seed farms (Funayama 2005; Kiritani 2007).

In China, the brown marmorated stink bug is a vector of several phytoplasma diseases such as witches' broom disease (Hiruki 1999). Some phytoplasmas (= bacteria-like organisms) can have disastrous effects on plant growing.

Not only is *H. halys* a pest on plants, but it can also have considerable impact as a nuisance pest. In fact, this was why people first noticed this new invasive spe-

cies in the USA. When seeking shelter for overwintering, the adults may aggregate in large numbers on walls, window and door frames and in homes (Hoebeke & Carter 2003; Bernon 2004; Kiritani 2006). They discharge a foul-smelling scent when disturbed or swept up in a vacuum cleaner. They are also a major problem in Japan as a nuisance and this may be the most important aspect of this bug in residential areas.

The pheromone of a related pentatomid has also proven attractive for *H. halys*. Field applications of pheromone traps are currently being tested in the USA (Khrimian *et al.* 2008).

PERSPECTIVES

As in most cases of invasive insects, it is not known how it was introduced into Switzerland. The chances are that the insect was imported together with woody or floral ornamentals or fruit. Since the individuals of this species were found within an area of some 40 km^2, it is very likely that they will spread further. Although native generalist predators and parasitoids which also feed on pentatomid bugs will probably also accept *H. halys* as a prey or host, this species will most likely establish as one of the many phytophagous insects more or less affecting woody ornamentals. Whether this bug will also cause problems in horticulture in Switzerland or in Europe cannot be predicted at this point. The yearly average temperatures, and, even more relevant, the average summer temperatures are clearly higher in the countries of origin and in the region of the US introduction than in Central Europe. In any case, the current global warming will certainly foster the propagation of *H. halys* populations. Warmer winters are likely to reduce winter mortality by an estimated 13 % with every centigrade of warming (Kiritani 2006; Kiritani 2007). In particularly warm years and regions *H. halys* may also become relevant as a nuisance in homes.

In order to keep track of the dispersion of this bug in Switzerland, the authors (DW) would appreciate being informed about any further records.

ZUSAMMENFASSUNG

Im Jahr 2007 wurden in der Grossregion Zürich 5 Funde von *Halyomorpha halys* Stål (Heteroptera: Pentatomidae) bekannt, einer davon in Form eines starken Befalls von Ziersträuchern. Die phytophage Wanze, die hiermit mit dem deutschen Namen "Marmorierte Baumwanze" bezeichnet wird, ist in Ostasien heimisch und wurde kürzlich in die USA eingeschleppt. Sie gilt sowohl in ihrem Ursprungsgebiet als auch am neuen Einschleppungsort als Schädling in Stein- und Kernobstkulturen sowie im Ziergehölzbereich. Ausserdem kann sie auch als Lästling im Siedlungsbereich auftreten, da sie sich im Herbst auf der Suche nach Überwinterungsorten in Massen an Gebäuden und in Wohnhäusern ansammeln kann.

Aufgrund einer Literaturstudie über die Biologie, die Wirtspflanzen, die natürlichen Feinde und die Bedeutung werden die Kenntnisse über diese Baumwanze zusammengefasst. Schliesslich wird die mögliche Bedeutung einer Etablierung dieser neuen Wanze in Europa diskutiert.

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