



Review of the occurrence of *Halyomorpha halys* (Hemiptera: Heteroptera: Pentatomidae) in Italy, with an update of its European and World distribution

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Abstract

The regions in which *Halyomorpha halys* (Stål, 1855) occurs in Italy are summarized and ordered chronologically according to the date of the first record. Details and verification about the first Italian record from Liguria (often overlooked), that dates back to 2007 the introduction of *H. halys* in this country, are also given. First exact localities are listed for the Italian regions of Tuscany, Marche, Latium, Abruzzo, Campania, and Apulia, in which only general occurrence was known so far. We included also additional records from Trentino-Alto Adige, where the presence of *H. halys* has only recently been reported through a few data. Furthermore first records for Sweden, Central Macedonia (Greece), and Manitoba (Canada) are reported, as well as first intercepted specimens from Iceland.

Keywords Brown marmorated stink bug · Alien species · Pest species · First records · New records

Introduction

Halyomorpha halys (Stål, 1855), commonly known as the brown marmorated stink bug, is an invasive and highly polyphagous species, feeding on and damaging diverse plants, including field crops, vegetables, tree fruits, and ornamentals (Bergmann et al. 2016). In a review of the Asian literature Lee et al. (2013) revealed in native range 106 host plants distributed in 45 families, while Haye et al. (2014) reported 51 hosts in 32 families in Europe and Berton (2004) quoted 73 species of plants ranging from annual crops to landscape trees only in the state of Pennsylvania. Now, over 275 species of host plants are cited in literature for this bug (Australian Government Department of Agriculture and Water Resources 2017) and it is considered a severe agricultural and horticultural pest (Kriticos et al. 2017). Feeding may occur on leaves, shoots,

stems and even through the bark of trees such as maple and catalpa (Rice et al. 2014). However, both nymphs and adults preferentially feed on developing and ripe fruits and seeds of their host plant (Martinson et al. 2015). This mode of feeding, and preference for fruits, directly leads to economic damage to a wide range of crops (Australian Government Department of Agriculture and Water Resources 2017).

The life cycle is commonly characterised by one or two generations (Nielsen and Hamilton 2009; Lee et al. 2013), but in Southern China four to six generations are assumed to occur (Hoffman 1931). Pre-reproductive adults overwinter in large number and they often use human houses as overwintering sites, with a documented case of 26,205 individuals in a single house during a 181-day study (Inkley 2012). Adults entering houses are a strong nuisance not only for their abundance, but also for the unpleasant odor they emit when disturbed (Haye et al. 2014). This behaviour leads to a variety of pest impacts also for the human life (Kriticos et al. 2017), which add to the problems that *H. halys* causes to agricultural, horticultural and silvicultural hosts (Haye et al. 2015).

There has been considerable confusion surrounding the systematics of this species. Described as *Pentatoma Halys* by Stål (1855: 182), Distant (1880, 1893, 1899) considered this taxon (sub *Dalpada brevis* Walker, 1867 and *D. remota* Walker, 1867) to be a junior synonym of *Halyomorpha picus* (Fabricius, 1794). Later, it was determined that this species

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was different from *H. picus*, but various authors used either *H. brevis* (Walker, 1867) or *H. remota* (Walker, 1867) as the proper name. Josifov and Kerzhner (1978) determined that there was only one species of *Halyomorpha* occurring in Japan, Korea, and eastern China, and that *H. halys* actually had priority; they also synonymized *Poecilometis mistus* Uhler, 1860, *Dalpada brevis*, and *D. remota* Walker, 1867 under this name. Recently *H. halys* was quoted also as *H. mista* (Uhler, 1860) (see Rider et al. 2002; Rider 2014; Hamilton et al. 2018).

Halyomorpha halys is native to Far East of Russia, Japan, China (it has not been reported from Xinjiang, Ningxia, Qinghai, and Gansu), Hainan island, Taiwan, North and South Korea (including Jeju island), northern Vietnam (see Rider et al. 2002; Hoebeke and Carter 2003; Rider 2006, 2014; Zhu et al. 2012; Lee et al. 2013; Gapon 2016; Hemala and Kment 2017; Kriticos et al. 2017), and Myanmar (Hamilton et al. 2018), although this latter record is doubtful (P. Kment, pers. com.; see discussion for further information). Zhu et al. (2016) found common haplotypes between Southern China population and those from South Korea and Japan, leaving the question open if these southern populations originate from long-distance dispersal itself or human-mediated transportation.

Allochthonous distribution in the world

In the last years, the species was detected in different parts of the world, mainly in North America and Europe (global distribution recently summarized by Leskey and Nielsen 2018).

The first record of established population out of the native range dates in 1996 in Pennsylvania, USA, although prior to its establishment, *H. halys* was sometimes probably intercepted—but identified as *H. picus* (Fabricius, 1794)—in shipments arriving at ports, the first time even in 1973 (Hoebeke and Carter 2003). At September 2017, this invasive species has been detected in almost all states of USA, including Alaska and Hawaii, lacking only in Oklahoma and Louisiana (see Kriticos et al. 2017; Walgenbach 2017; EPPO 2018). In North America *H. halys* is reported also in southern Canada, where it was firstly intercepted in the Province of British Columbia in 1993, when a specimen was found in a shipment originating from Asia (Haye et al. 2015). Now, in addition to the confirmation for British Columbia, in Canada records from Alberta, Saskatchewan, Ontario, Quebec, Prince Edward Island, and Nova Scotia are also known (see Fogain and Graff 2011; Kriticos et al. 2017; Walgenbach 2017; EPPO 2018). In South America *H. halys* is recorded from Chile, where it was intercepted for the first time in 2011 at an entry point in the far northern part of the country and then found again in 2017 outside of quarantine/

interception facilities near Santiago (Faúndez and Rider 2017). Finally, in the Caribbean a specimen was intercepted in 2011 in Puerto Rico, reported as *Apateticus lineolatus* (Herrich-Schäffer, 1840) by Segarra-Carmona et al. (2015), but corrected in *H. halys* by Hemala and Kment (2017).

In Asia, out of the native range, *H. halys* is quoted for India, reported in Maharashtra state in a study on Jangamhatti area carried out in the years 2014–2015 by Nikam and More (2016). However, this record is likely a misidentification with a different species (P. Kment, pers. com.; see discussion for further information).

In Oceania some sporadic records are known from New Zealand, when it was intercepted for the first time in 1999 (Duthie 2012), Australia, when it was intercepted for the first time in 2005 (Walker 2011), and Guam island, where a single specimen was collected in a hotel room in 2013 (Moore 2014).

In Africa the species is not documented, but the record for Egypt of *H. picus* (Gadalla 2004) could be a misidentification for *H. halys* according to Aukema et al. (2013) and Hemala and Kment (2017).

Distribution in Europe

The other continent where this invasive species has become a pest is Europe, where the oldest records date back to 2004: in that year *H. halys* was found in Liechtenstein (Arnold 2009) and Switzerland (Haye et al. 2014). Subsequently, it colonized many Swiss territories (Wyniger and Kment 2010; Haye et al. 2014) and some years later it spread into neighbouring countries: in southern Germany in 2011 (Heckmann 2012) and in northeastern France in 2012 (Callot and Brua 2013). Subsequently, in France it was reported also in Île-de-France (Garrouste et al. 2015), in the south part of the country (Maurel et al. 2016) and in Corsica (Kriticos et al. 2017). Meanwhile other introductions of *H. halys* occurred in other European countries, since this bug was found in 2007 in Liguria, Italy (Maistrello and Dioli 2014; Dioli et al. 2016) and in 2011 in Athens, Greece (Milonas and Partsinevelos 2014). Until now, many countries in Europe have been added to the list of those where the bug occurs: in 2013 it was firstly recorded in Hungary (Vétek et al. 2014) and in Krasnodar, Russia (Gapon 2016), in 2015 in Austria (Rabitsch and Friebe 2015), Serbia (Šeat 2015), Romania (Macavei et al. 2015), and Georgia (Gapon 2016), in 2016 in Spain (Dioli et al. 2016), Slovakia (Hemala and Kment 2017), Bulgaria (Simov 2016), and Abkhazia (Gapon 2016), and in 2017 in Slovenia (EPPO 2018), Turkey (Çerçi and Koçak 2017), and Croatia (Šapina and Šerić Jelaska 2018). Moreover, Malumphy (2014) reports that *H. halys* was intercepted twice in Great Britain, one in 2010 in London, in association with passenger luggage flown in from the USA, and the other in

2013 in North Yorkshire, associated with a consignment of stone imported from China.

Distribution in Italy

In Italy *H. halys* was recorded for the first time in 2007 in the surroundings of Genoa, Liguria region (Maistrello and Dioli 2014; Dioli et al. 2016), subsequently it was recorded in 2012 for Emilia-Romagna (Maistrello et al. 2013, 2014), in 2013 for Piedmont (Pansa et al. 2013), Lombardy (Maistrello et al. 2014; Maistrello and Dioli 2014), and Canton of Ticino, geographically belonging to the Italian region (Cesari et al. 2015), in 2014 for Veneto (Maistrello and Dioli 2014; Benvenuto et al. 2015) and Friuli-Venezia Giulia (Maistrello and Dioli 2014; Benvenuto et al. 2015), in 2016 for Trentino-Alto Adige (Hunterhurner 2016) and Sardinia (Dioli et al. 2016), and in 2017 for Sicily (Carapezza and Lo Verde 2017; Costi et al. 2017); moreover, it was recorded without published exact localities in 2014 for Marche (cf. Maistrello and Costi 2016; Pansa et al. 2017) and Abruzzo (Maistrello and Dioli 2014), in 2015 for Tuscany (cf. Maistrello and Costi 2016; Roversi et al. 2016; Pansa et al. 2017) and Latium (cf. Maistrello and Costi 2016; Pansa et al. 2017), in 2016 for Aosta Valley (cf. Maistrello et al. 2017; Meletti 2017), Campania (cf. Maistrello et al. 2017; Pansa et al. 2017), Apulia (cf. Maistrello et al. 2017; Pansa et al. 2017), and Calabria (cf. Maistrello et al. 2017; Pansa et al. 2017). Coordinates from Sabbatini Peverieri et al. (2017) for Central Italy are mistyped and thus these can not be considered to get a locality name.

Material and methods

The examined material consists of collected or photographed specimens, partly from websites (see abbreviations). Among the latter, only records with coordinates, date and photo were considered. The Global Biodiversity Information Facility (GBIF – www.gbif.org) was also consulted, but only the original sources are indicated here. All photos without any indication in the examined material are preserved in copy in the authors' archives. All listed records were recognized or confirmed by authors. Part of the material comes from data of the project “Insects of Florence” (see Cianferoni and Ceccolini 2016).

For each site, the following information is given: locality, date, collector or photographer, number of specimens and life cycle stage, repository or source. Records are listed geographically and Italian regions are arranged from north to south.

Concerning Italy, only records for the regions south of Tuscany and Marche (included) were listed; additional records for northern regions in which the occurrence of *H. halys* was only recently recorded (i.e. Trentino-Alto Adige) are also given.

Geographical coordinates are in decimal degrees (datum WGS84). The uncertainty (in metres) of data was indicated according to the point-radius method (Wieczorek et al. 2004); in some cases it was estimated a posteriori based on available data and indicated in square brackets.

In the maps, for “only intercepted” are intended countries for which the alien species was found exclusively in association with passenger luggages, commodities etc. but never collected in wild.

Abbreviations used in material examined:

CDA = D. Altobelli collection, Florence, Italy
 CFCe = F. Ceccolini collection, Rassina (Arezzo), Italy
 CFCi = F. Cianferoni collection, Florence, Italy
 CFG = F. Graziani collection, Florence, Italy
 CMD = M. Dutto collection, Verzuolo (Cuneo), Italy
 AP = www.artportalen.se
 EI = www.entomologiitaliani.net
 FB = www.facebook.com
 IN = www.inaturalist.org
 NM = www.naturamediterraneo.com
 OR = www.ornitho.it
 leg. = legit/legerunt
 un = uncertainty



Fig. 1 First specimen of *Halyomorpha halys* (Stål, 1856) collected in Italy, Liguria: Genoa, Voltri, 18.VIII.2007 (photo M. Dutto)

Listed records

Material examined EUROPE. ICELAND. Found in imported goods, 2014, 11 adults, photo by E. Ólafsson. **SWEDEN.** Stockholm County, Danderyd, Rinkebyvägen, 59.41602° N 18.04207° E (un = 225 m), 9.III.2016, 1 adult, photo by M. Johansson (AP). **ITALY. Trentino-Alto Adige.** Trento, Via Iori, 46.05102° N 11.12038° E (un = 24 m), 16.X.2016, 1 adult, photo by D. Miserocchi (IN); Trento, Via Oradini, 46.09984° N 11.11971° E (un = 10 m), 23.X.2017, 1 V instar nymph, photo by A. Peterlongo (IN); Trento, Via della Gotarda, 45.99902° N 11.10915° E (un = 172 m), 8.XI.2017, IV instar nymph, photo by A. Tomedi (IN); Grigno (Trento), Via Pertega, 46.013478° N 11.628163°

E (un = 5 m), 18.X.2016, 1 adult, photo by F. Minati (IN); Riva del Garda (Trento), Viale Prati, 45.88775° N 10.83959° E (un = 8 m), 2.IV.2017, 1 adult, photo by D. Iversen (IN); Caldonazzo (Trento), Via Prati, 45.986922° N 11.265137° E (un = 5 m), 4.IX.2017, 1 adult, photo by K. Tabarelli de Fatis (IN); San Michele all'Adige (Trento), 46.19468° N 11.13684° E (un = 17 m), 30.X.2017, 1 adult, photo by C. Paniccia (IN). **Liguria.** Genoa, Voltri, [44.43156° N 8.75601° E (un = 2000 m)], 18.VIII.2007, 1 adult (Fig. 1), M. Dutto leg., CMD (cf. Maistrello and Dioli 2014; Dioli et al. 2016); Arenzano (Genoa), [44.40193° N 8.67674° E (un = 1580 m)], 2012, 1 adult, M. Dutto leg., CMD. **Tuscany.** Florence, Via della Covacchia, 43.82388° N 11.23288° E (un = 15 m), 150 m a.s.l., 22.X.2016, 1 adult, photo by F.

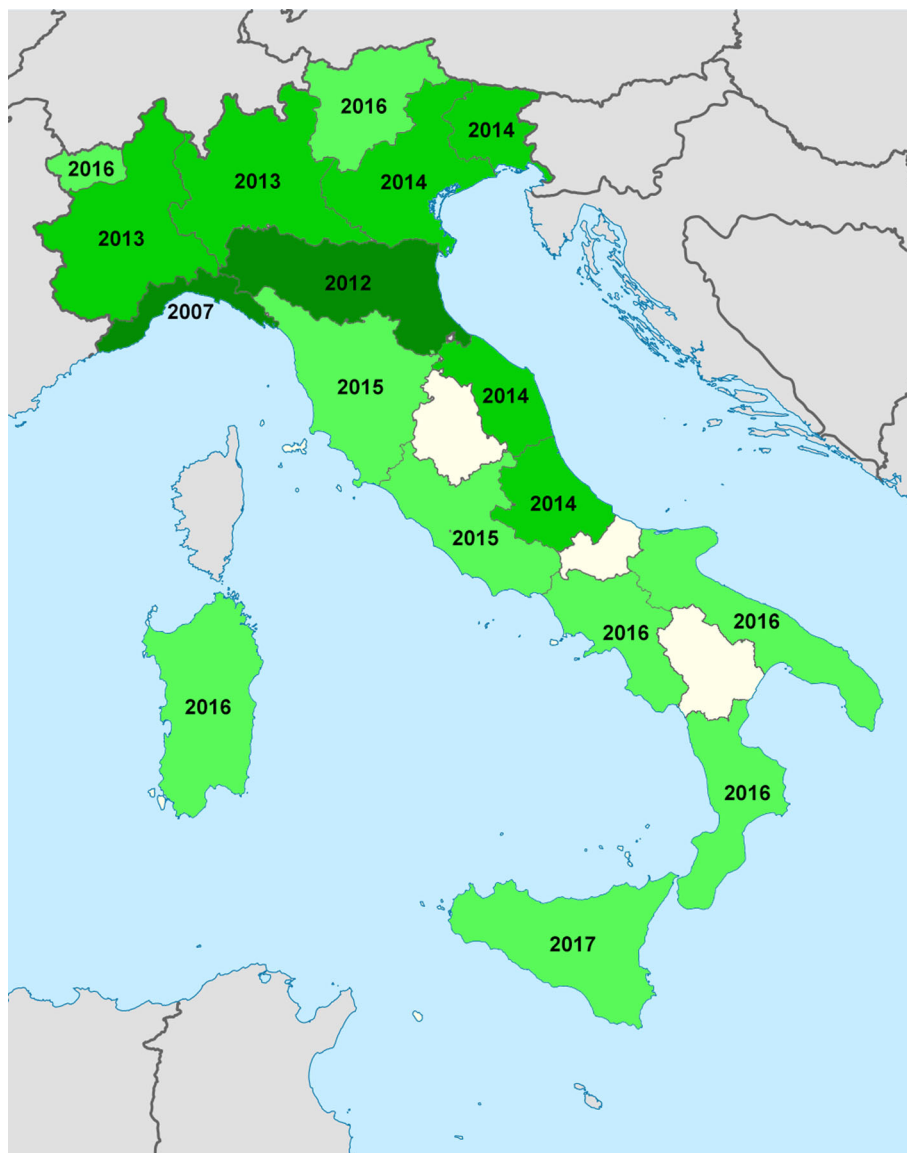


Fig. 2 Occurrence and year of first record of *Halyomorpha halys* in the Italian regions. Dark green = recorded before 2013; medium green = recorded in 2013–2014; light green = recorded in 2015–2017; white = no records.. Minor islands were considered separately

Graziani (IN); *idem*, 25.X.2016, 1 adult, photo by S. Graziani (IN); *idem*, 29.X.2016, 1 adult female, F. Graziani leg. (CFCi); *idem*, 6.I.2017, 1 adult female, F. Graziani leg. (CFCe); *idem*, 5.X.2017, 1 adult, F. Graziani leg. (CFCi); *idem*, 15.X.2017, 1 adult, F. Graziani leg. (CFG); *idem*, 6.XI.2017, 1 adult, F. Graziani leg. (CFG); Florence, Giardino dell’Orticultura, 43.78719° N 11.26157° E (un = 111 m), 55 m a.s.l., 12.IX.2017, 1 IV instar nymph, photo by R. Negroni (IN); Florence, Castello, Via Ciarpaglini [43.81094° N 11.23224° E (un = 50 m)], IX.2017, 1 adult female, D. Altobelli leg. (CDA); Florence, Via Burchiello, [43.76772° N 11.23732° E (un = 200 m)], 5.X.2017, 1 adult, photo by N. Papini; *idem*, 6.III.2018, 1 adult, photo by N. Papini; *idem*, 7.III.2018, 1 adult, photo by N. Papini; Florence, Natural History Museum, “La Specola”, 43.76404° N 11.24686° E (un = 5 m), 6.III.2018, 1 adult female, S. Bambi & F. Cianferoni leg.

(CFCi); Florence, Varlungo, Via Benuccio da Orvieto, 43.76662° N 11.30128° E (un = 2 m), 57 m a.s.l., 24.V.2018, 1 adult female, S. & F. Cianferoni leg. (CFCi); Sesto Fiorentino (Florence), Viale Machiavelli, 43.82988° N 11.20206° E (un = 15 m), 56 m a.s.l., 20.X.2017, 1 adult, photo by S. Giunti; Calci (Pisa), 43.72540° N 10.52090° E [un = 500 m], 7 specimens, photo by L. Puglisi; Pisa, Tenuta del Tombolo, 43.64647° N 10.34536° E [(un = 500 m), Parco regionale Migliarino San Rossore Massaciuccoli, 4.X.2017, more than 50 adults, photo by P.L. Taiariol; *idem*, 43.63750° N 10.34512° E [un = 500 m], Parco regionale Migliarino San Rossore Massaciuccoli, 4.X.2017, at least 15 specimens, photo by P.L. Taiariol (OR); Carmignano (PO), Verghereto, 43.78989° N 11.00725° E [un = 500 m], 4.X.2017, 1 adult, photo by S. Cutini (OR); *idem*, 9.II.2017, 8 specimens, overwintering together about 150 specimens of *Harmonia*

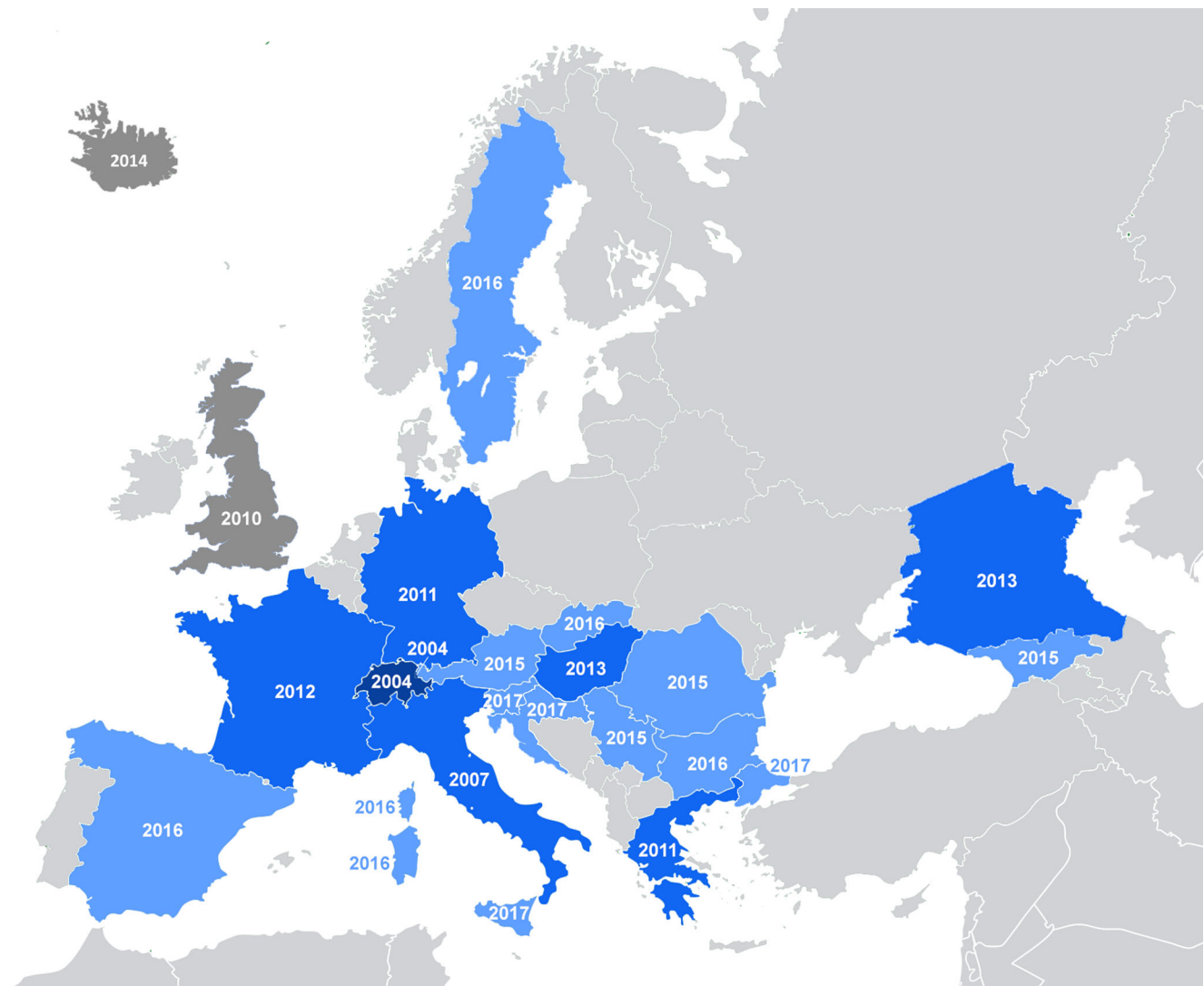


Fig. 3 Occurrence and year of first record of *Halyomorpha halys* in the European countries. Dark blue = recorded before 2007; medium blue = recorded in 2007–2014; light blue = recorded in 2015–2017; dark grey =

only intercepted (with year of first interception); light grey = no records. Major islands, Northern Ireland, and southern part of European Russia were considered separately

axyridis (Pallas, 1773), photo by S. Cutini (OR). **Marche.** Camerata Picena (Ancona), [43.57770° N 13.35081° E (un = 1500 m)], X.2016, 1 adult, photo by G. Giovagnoli (EI); Baratoff, Pesaro (Pesaro and Urbino), [43.88849° N 12.91298° E (un = 1000 m)], 16.X.2017, 3 adults, photo by M. Paglialunga (EI). **Latium.** Rome, 41.84696° N 12.63345° E [un = 500 m], 11.X.2017, 1 adult, photo by V. Sbordoni (OR). **Abruzzo.** Alba Adriatica (Teramo), [42.82680° N 13.92451° E (un = 1500 m)], 22.VIII.2017, 1 III instar nymph, photo by R. Allegretti (EI). **Campania.** Naples, Aeroporto di Napoli-Capodichino (Naples International Airport), [40.87921° N 14.28165° E (un = 1000 m)], 10.IV.2016, 1 adult, photo by L. Rapa (NM, OR) (cf. Nardi and Spada 2016). **Apulia.** Bari, south of town (in house), [41.10519° N 16.87373° E (un = 2000 m)], 13.XI.2017, 1 adult, photo by A. Cruso (FB). **GREECE. Central Macedonia.** Thessaloniki, Neapoli-Sykies, Sykies, 40.65360° N 22.95867° E (un = 122 m), 1 adult, photo by K. Zontanos (IN).

NORTH AMERICA. CANADA. Manitoba. Division No. 11, Winnipeg, Stafford St, 49.86923° N -97.16204° E (un = 6 m), 1 adult, photo by J. Gibbs (IN).

Discussion

Although many contributions on distribution of *H. halys* in Italy have been published in recent years, most of the

information is very scattered, often also originating from gray literature or non-scientific journals, and no comprehensive accounts existed (see references at the beginning of this paper). Here we summarized the Italian administrative regions in which the alien species occurs, ordering them chronologically according to date of their first record (Fig. 2). In spite of the majority of the papers dealing of *H. halys* quote the record from Emilia-Romagna in 2012 as the oldest one (e.g. Maistrello et al. 2014, 2016; Haye et al. 2015; Nardi and Spada 2016; Piemontese et al. 2016; Castracani et al. 2017; Costi et al. 2017; Hemala and Kment 2017; Lupi et al. 2017; Martorana et al. 2017; Leskey and Nielsen 2018), the first record is actually the specimen from Genoa (Liguria) collected in 2007 (Maistrello and Dioli 2014; Dioli et al. 2016) whose exact data label is here firstly reported. This can not be considered only as an occasional interception because additional specimens from same place were subsequently collected and observed (M. Dutto, pers. com.). Pathway of entry is still unknown but it is likely that the origin could be the international port of Genoa (cf. Dioli et al. 2016). Moreover, first exact localities are given for Tuscany, Marche, Latium, Abruzzo, Campania, and Apulia for which only general occurrence was published so far. We included also additional records from Trentino-Alto Adige, where the presence of *H. halys* has only recently been reported through a few data published on a non-scientific journal (Hunterhumer 2016). Thus, only three Italian regions, Umbria, Molise, and Basilicata,

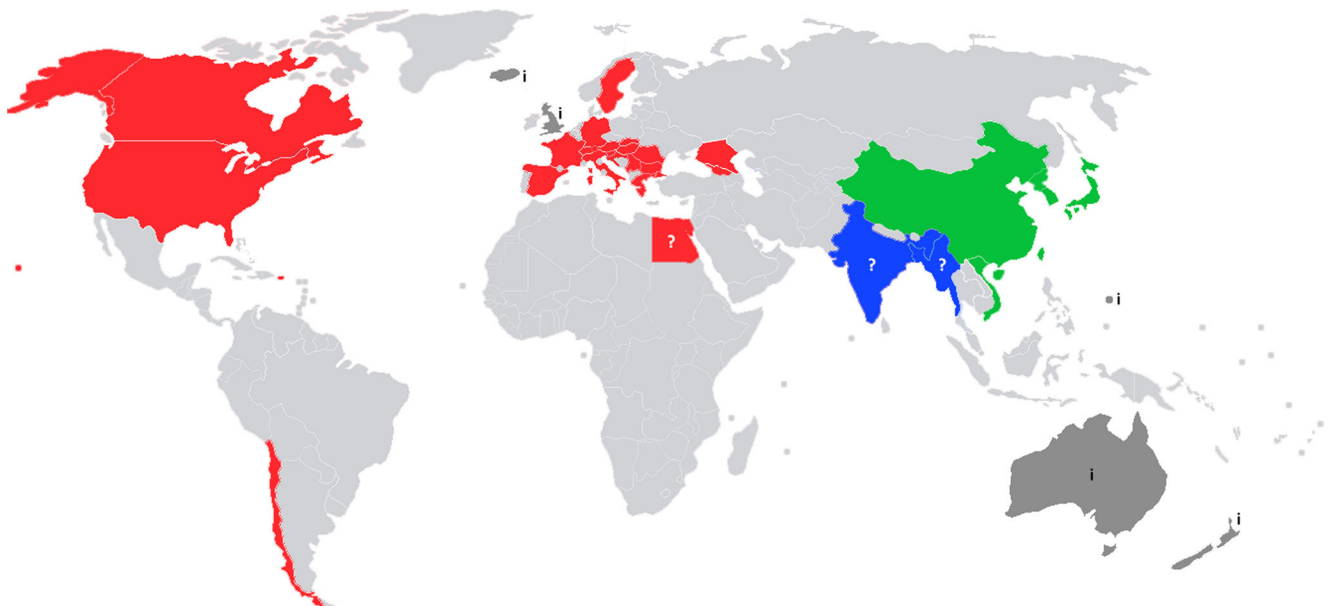


Fig. 4 Global occurrence of *Halyomorpha halys* (country level). Green = native; blue = doubtful nativeness – possible misidentifications; red = introduced; dark grey and letter “i” = only intercepted; light grey = no

records. Question mark = published record requiring confirmation. Major islands, Northern Ireland, and southern part of European Russia were considered separately

lack for official data, but the presence of this pest species is extremely probable. To date no records are known for any minor Italian islands. To ascertain the real spread of *H. halys* in Central and Southern Italy (islands included) a more in-depth study would be necessary. Furthermore, due to the multiple origin in the several countries and in particular in Italy (see Garipey et al. 2014; Piemontese et al. 2016), more research would be necessary to establish the origin of the Ligurian and southern Italian populations.

At European level (Fig. 3) we remark the first record for Sweden and the second record for Greece, where *H. halys* was known only from Athens (Milonas and Partsinevelos 2014), adding a new region, Central Macedonia, for this country. We report also the first record for Iceland, where some specimens, transported accidentally by goods, were intercepted in 2014; however, the species shows no indication of acclimatization in this country so far (E. Ólafsson, pers. com.).

The records of *H. halys* for India by Nikam and More (2016) and for Myanmar by Hamilton et al. (2018), unless they are based on examination of male genitalia, are probably misidentifications with different species like *H. yasumatsui* Abbasi & Ahmad, 1974 and *H. picus* (Fabricius, 1794), the latter of them being probably a complex of cryptic species identifiable only through male genitalia (P. Kment, pers. com.).

In North America, the record from Winnipeg is the first one for Manitoba province, Canada.

Therefore, the currently known world distribution of *H. halys* is here summarized (Fig. 4), updating the recent review by Leskey and Nielsen (2018).

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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