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True Bugs (Hemiptera, Heteroptera) Chapter 9.1

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Abstract

The inventory of the alien Heteroptera of Europe includes 16 species alien *to* Europe, 25 species alien *in* Europe and 7 cryptogenic species. This is approximately 1.7% of the Heteroptera species occurring in Europe. Most species belong to Miridae (20 spp.), Tingidae (8 spp.), and Anthocoridae (7 spp.). The rate of introductions has exponentially increased within the 20th century and since 1990 an approximate arrival rate of seven species per decade has been observed. Most of the species alien *to* Europe are from North America, almost all of the species alien *in* Europe originate in the Mediterranean region and were translocated to central and northern Europe. Most alien Heteroptera species are known from Central and Western Europe (Czech Republic, Germany, Netherlands, Great Britain). Ornamental trade and movement as stowaways with transport vehicles are the major pathways for alien Heteroptera. Most alien Heteroptera colonize habitats under strong human influence, like agricultural, horticultural, and domestic habitats, parks and gardens. A few species prefer woodland including plantations of non-native forest trees. Impacts of alien Heteroptera in Europe are poorly investigated. A few species are considered pests in agriculture, forestry, or on ornamentals. More research is needed for a better understanding of the ecological and economic effects of introduced Heteroptera.

Keywords

alien, non-native, Hemiptera, Heteroptera, Europe

9.1.1 Introduction

The Heteroptera, or true bugs, is a highly diverse insect taxon with approximately 42,300 described species worldwide, separated into seven infraorders and 75–89 families (Henry 2009, Schuh and Slater 1995). Their body size ranges from less than 1 mm to 10 cm. True bugs feed on many different resources (e.g., haemolymph of insects, blood of endotherms, fungi cytoplasma, phloem-, xylem- or parenchym-sap of mosses, ferns, monocotyledons, mostly dicotyledons, algae, the endosperm of seeds, plant pollen). Heteropterans live in virtually all terrestrial and aquatic ecosystems from Antarctic birds' nests to rainforest canopies, from the open surface of the ocean (almost uniquely for insects), to torrential and stagnant rivers, from ephemeral rain pools and phytotelmata to large lakes, and in aphotic caves and man-made buildings (Schuh and Slater 1995).

Among the characteristic features are the mouthparts, which evolved as sucking stylets for the uptake of liquid food and the injection of secretions from the salivary gland; restricted diets are commonly observed. Most species are phytophagous, some feed exclusively on particular plant species, genera or families, whereas others are polyphagous species feeding on dozens to hundreds of different host plants. Some species are of considerable economic concern in agriculture or (more rarely) forestry, many species are predatory and some are used as biocontrol agents against agricultural pests (Schaefer and Panizzi 2000).

Although some heteropteran species have reduced wings or wing musculature, and some are sexually dimorphic in this respect, many species are good flyers and capable of negotiating long distances. Subsequent spread after introduction by humans into a new area is commonly observed. Eggs and nymphs are translocated with host plants over long distances. Unlike the situation in many other Hemiptera, sexual reproduction prevails, with only one parthenogenetic species known in the European fauna, and depending on the species, one to several generations develop under temperate conditions. Many species deposit their eggs inside the host plant, which effectively fosters passive translocation and facilitates spread.

9.1.2 Methods

Previously published information on alien Heteroptera species is available for some countries, e.g., Germany (Geiter et al. 2002) but see Hoffmann (2003) for a critical review, Austria (Essl and Rabitsch 2002), Switzerland (Kenis 2005), Czech Republic (Kment 2006b, Šefrová and Laštùvka 2005), and the Azores (Borges et al. 2005). Comparison of these lists is hindered by the use of different terminology and criteria for selecting species. The first attempt at a comprehensive treatment of the alien Heteroptera of Europe was published recently Rabitsch (2008) and serves as basis for this work, but is supplemented by new data (up to May 2009 including a few works in press). The reader is referred to Rabitsch (Rabitsch 2008) for a more detailed account on the history of introductions for each species.

This present chapter deals with species alien *to* Europe and species alien *in* Europe, but excludes continental European species alien to European islands. For example, Borges et al. (2005) stated that *Tingis cardui* (Linnaeus, 1758) and *Gastrodes grossipes* (De Geer, 1773), which both feeding on non-native host plants, are alien to the Azores. On the contrary, Heiss & Péricart (2007) argued that *Aradus canariensis* Kormilev, 1954 may have been introduced to Mallorca. The anthropogenic contribution of some recent range changes of continental "European" species to Great Britain and to Scandinavia, and hence their alien status, is particularly difficult to identify. For example, Ødegaard & Endrestøl (2007) present three hypotheses, not mutually exclusive, for the recent occurrence of *Chilacis typhae* (Perris, 1857) in Norway. For the time being, only *Deraeocoris lutescens* is here considered alien in Sweden and Norway, but the status of additional species needs careful re-examination, e.g. *Pinalitus atomarius* (Meyer-Dür, 1843) in Sweden (Lindskog and Viklund 2000), *Chilacis typhae* and *Heterogaster urticae* (Fabricius, 1775) in Norway (Ødegaard and Endrestøl 2007). Kirby et al. (2001) review several similar cases for Great Britain.

9.1.3 Taxonomy of the alien Heteroptera of Europe

Alien Heteroptera are non-uniformly distributed across the seven infraorders. There are no alien species in Enicocephalomorpha and Dipsocoromorpha, the basal infraorders with 420 and 340 species worldwide, respectively. These predatory, usually tiny and fragile species live their secret lives in seclusion of riparian habitats and ground litter. No alien Gerromorpha are known in Europe; members of this predatory infraorder with more than 2100 species worldwide are commonly known as "Jesus-bugs" due to their ability to move on the surface of running and standing waters. Among Nepomorpha, the aquatic true bugs, with 2300 species worldwide, and Leptopodomorpha, the "shore bugs", with 380 species worldwide, there is a single alien species in each infraorder, *Trichocorixa verticalis* and *Pentacora sphacelata*, both originally from North America, being introduced to the western Mediterranean region. Most alien Heteroptera belong to the most species-rich infraorders Cimicomorpha (20,500 species worldwide, 37 alien species in/to Europe) and Pentatomomorpha (16,200 species worldwide, 9 alien species in/to Europe).

Within Hemiptera, Heteroptera constitute only a small fraction of alien species compared to aphids and scales (see chapters 9.2 and 9.3). At the end of the chapter, Table 9.1.1 and 9.1.2 list 48 Heteroptera species considered alien in this study of which 16 species are alien to Europe (i.e., species introduced from outside Europe), 25 species are alien in Europe (i.e., species introduced from one part of Europe to another), and seven cryptogenic species are of unknown origin. According to Aukema & Rieger (1995–2006), there are approximately 2860 Heteroptera species (including subspecies) in Europe, which means that 1.7% of the European fauna is alien.

At the family level, Miridae (20 spp.) and Tingidae (8 spp.) prevail, followed by Anthocoridae (7 spp.) and Lygaeidae *sensu lato* (5 spp.) (Figure 9.1.1). The systematic classification of Lygaeidae is still under discussion. While most heteropterists agree that Lygaeidae are paraphyletic (Henry 1997), there is no consensus on how to arrange them.

The most species-rich family is Miridae, both in the native and the non-native faunas. Species of nine families are represented in the alien fauna, which is only 10% of the known families worldwide. Genera with more than one alien species are *Amphiareus* (2), *Anthocoris* (2), *Corythucha* (2), *Deraeocoris* (2), *Orthotylus* (4), *Stephanitis* (4), and *Tuponia* (5). Whereas all alien species belong to families present in Europe, 10 genera (13 genera including the cryptogenics, asterisked here) are alien at the genus level (*Amphiareus*, *Belonochilus*, **Buchananiella*, *Corythucha*, *Halyomorpha*, **Nesidiocoris*, *Nezara*, *Pentacora*, *Perillus*, **Taylorilygus*, *Trichocorixa*, *Tropidosteptes*, *Tupiocoris*).

Anthocoridae

All Anthocoridae (flower bugs or minute pirate bugs) are small insects (< 5 mm body size) and most species are predatory, actively searching and hunting for their prey, which regularly consist of soft-bodied Sternorrhyncha. About 450 species are known at the world level (Henry 2009) of which 75 are considered native in Europe (Aukema and Rieger 1995–2006). The alien Heteroptera of Europe only include 4 species alien *to* Europe and 3 alien *in* Europe (Figure 9.1.1). Hence several species, especially in the genera *Anthocoris* and *Orius*, are successfully used commercially in biological control programs in greenhouses and sometimes in the wild, e.g., (Lattin 1999, Schaefer and Panizzi 2000). Apparently, only one species, the western and southern European *Orius laevigatus* is established outside its natural range in the Netherlands (Aukema and Loomans 2005) although these authors do not rule out the possibility that this species has shifted northwards due to climate change. Similarly, the true cause of the recent westward spread of the East-Palaearctic *Amphiareus obscuriceps* cannot definitely be identified. Although predatory, several anthocorid species are specialized to host plants, where they search for prey, e.g., *Anthocoris butleri* on *Buxus* and *A. sarothamni* on *Cytisus*. Both host plants are widely used as ornamentals and introduction of the Heteroptera with the host plants, as well as a range shift from western to eastern Europe, is possible. The origin of the pan-tropical *Buchananiella continua* is unknown. It is known from western Europe and appears to have spread both in Great Britain and in continental Europe (Aukema 2007, Aukema and Hermes 2009, Kirby 1999). Likewise, the origin of the cosmopolitan *Amphiareus constrictus* is unclear. It was introduced to the Netherlands (Aukema and Hermes 2009) and may further spread in Europe. The alien status of *Lyctocoris campestris* in Europe is debatable.

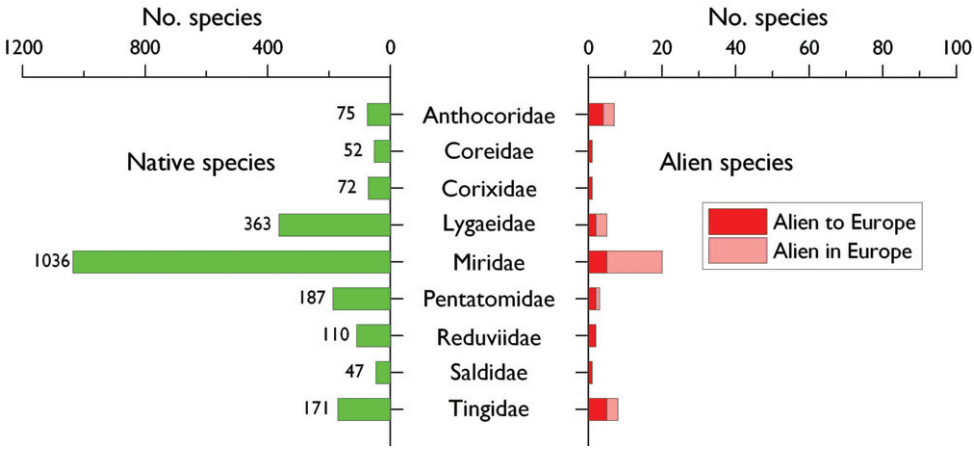

Figure 9.1.1. Taxonomic overview of the alien Heteroptera of Europe at the family level. Species alien *to* Europe include cryptogenics.

Coreidae

The leaf-footed or squash bugs is a species-rich family with species of medium to large body size. A total of 1900 species have been described throughout the world (Henry 2009), including 52 in Europe (Aukema and Rieger 1995–2006) but only one alien species has so far established on the continent. For several reasons, this single alien species, *Leptoglossus occidentalis*, is of particular interest. The native range is presumed to be west of the Rocky Mountains and following its spread in North America since the 1950s, it was introduced to Europe only in the late 1990s. The first date recorded in European record was 1999 in northern Italy (Bernardinelli and Zandigiacomo 2001) and the species rapidly spread over most of Europe (Dusoulier et al. 2007, Rabitsch 2008) with no foreseeable stop (Lis et al. 2008). This spread is likely to be the result of multiple introductions into Europe, and secondary translocations within it. When feeding on conifer seeds, fertility of the seeds is reduced, causing an economic impact for forestry. Recently, infrared receptive organs were found in *L. occidentalis*, orienting specimens towards conifer cones (Takács et al. 2009). Because individuals aggregate in autumn seeking hibernation sites in buildings, this species may also become a nuisance to people. Recently, it was found in Japan (Tokyo) (Ishikawa and Kikuhara 2009).

Corixidae

The family has about 600 described species in the world (Henry 2009), and 72 in Europe (Aukema and Rieger 1995–2006). The single aquatic species yet recognized as alien to Europe, *Trichocorixa verticalis*, is of nearctic origin and was introduced to

Europe (Portugal) between 1997 and 2003 (Sala and Boix 2005). Its pathway and potential impact is not known, but it may well have been introduced as a stowaway with mosquitofish (*Gambusia* sp.) and may outcompete native corixids and lead to a simplification of the aquatic community (Kment 2006a, Millán et al. 2005, Rodríguez-Pérez 2009).

Lygaeidae *sensu lato*

Lygaeidae or seed-bugs are a species-rich group of about 4000 species (Henry 2009) of medium body size that include both seed-feeding and predatory species with economic impact that is sometimes significant (Schaefer and Panizzi 2000). A total of 363 species are native to Europe (Aukema and Rieger 1995–2006) but only two species are alien to Europe, *Nysius huttoni* from New Zealand, and *Belonochilus numenius* from North America. Both species currently are locally distributed, but have the potential to spread over large parts of Europe. The former is known from the Netherlands, Belgium, northern France and Great Britain, where it occurs in ruderal sites, waste grounds and abandoned fields (Smit et al. 2007). *N. huttoni* feeds on several weeds and crops and attains pest status in its native area (Sweet 2000). The latter has been found in Corsica and mainland southern France in the vicinity of a railway station and at a university campus (Montpellier) (Matocq 2008) as well as in Catalonia, Spain (Castelldefels, Barcelona) (Gessé et al. 2009) on or near ornamental sycamore (*Platanus* sp.). These almost simultaneous findings and the fact that its host plant is regularly planted in urban parks and gardens, indicates that the species is already much more widely distributed and that further spread in Europe is very likely.

Three further lygaeid species are here considered alien in Europe. The first is *Arocatus longiceps*, an eastern Mediterranean species living on sycamore, whose occurrence is restricted to urban settings where it sometimes reaches high abundance causing a nuisance to people. Due to its variability, heteropterists debate its separation from native *Arocatus* species, considering possible hybridization and post-invasion colour changes (Hoffmann 2008). The second, *Orsillus depressus*, is a Mediterranean species living on Cupressaceae. Its adaptation to ornamental *Thuja*, *Chamaecyparis*, and *Juniperus* promoted its northward spread. Intraguild competition on native *Juniperus*-stands is likely, but so far not investigated. Lastly, *Oxycarenus lavaterae* is a western Mediterranean species living on Malvaceae s.l. with a preference for lime trees (*Tilia* sp.). The species builds spectacular large aggregations of millions of individuals, also sometimes causing nuisance to people, e.g., at market places in cities or when entering buildings.

Miridae

With more than 10,000 described species (Henry 2009) of which 1036 in Europe (Aukema and Rieger 1995–2006), Miridae or plant bugs is the most species-rich family

within Heteroptera. Plant bugs include tiny to large, soft-bodied, dull to brightly coloured, phytophagous, zoophytophagous and predatory species (Wheeler 2001). Only 5 species alien *to* Europe have established whereas 15 species are considered alien *in* Europe (Figure 9.1.1.). Whereas some species are considered serious agricultural pests, others are used in biological control programmes. *Closterotomus trivialis* and *Dicyphus escalerae* are examples of Mediterranean species occurring locally in central Europe, the latter recently also found in Great Britain (Kirby et al. 2009), being introduced with their host plants. The same is most likely true for *Deraeocoris lutescens*, a western Palaearctic species introduced to Scandinavia. Another predatory, remarkably fast spreading species, is the Mediterranean *Deraeocoris flavilinea*, that presumably has been introduced unintentionally along transportation routes. *Tupiocoris rhododendri* was described from specimens collected in 1971 in Kew Gardens, London, but it originally comes from North America. Recently, this predatory species was found in continental Europe, and its further spread is to be expected (Aukema 2007, Aukema et al. 2005a). One of the most recent members of the European alien Heteroptera fauna is *Tropidosteptes pacificus* from North America, collected on European ash (*Fraxinus excelsior*) in a natural environment in the Netherlands (Aukema et al. 2009a). Three *Orthotylus* species live zoophytophagously on *Cytisus* and probably were introduced with their host plant to central and eastern Europe. The mediterranean *Orthotylus caprai* was only recently observed in central and western Europe on Cupressaceae, and is considered an alien species in Europe north of the Alps. Five *Tuponia* species, living phytophagously on *Tamarix*, were most likely introduced with their ornamental host plants.

Pentatomidae

Pentatomidae or stink bugs are a species-rich and medium to large body-sized heteropteran family with often stout and colourful bodies. About 4700 species have been recognized (Henry 2009), including 187 species in Europe (Aukema and Rieger 1995–2006). Members of one subfamily (Asopinae) are predatory and some are used in biocontrol programmes. This is true for *Perillus bioculatus*, native to North America and used against the Colorado potato beetles *Leptinotarsa decemlineata* in several European countries (De Clercq 2000). However, successful establishment in the wild apparently so far only occurred in Turkey and Greece. Recently, the Brown Marmorated Stink Bug *Halyomorpha halys*, native to Asia, was introduced to Switzerland (see factsheet 14.49) (Wermelinger e al. 2008). This species lives on ornamentals, vegetables and fruit trees where it may become a pest and it is regarded as a nuisance when seeking hibernation sites. The Southern Green Stink Bug *Nezara viridula*, a polyphytophagous pest species on several crops, is presumably of African and/or Mediterranean origin. *Nezara viridula* is a clear case of establishment of populations outside its original distribution in Germany, Hungary, Great Britain, and northern Switzerland. In addition, this species is found regularly in other parts of Europe, and is regularly intercepted by plant quarantine (Malumphy and Reid 2007).

Reduviidae

Reduviidae, the assassin bugs, are a species-rich and morphologically highly diverse predatory heteropteran family including 6900 species in the world (Henry 2009) of which 110 occur in Europe (Aukema and Rieger 1995–2006). However, only two cryptogenic, pantropical species are included here. *Empicoris rubromaculatus* is found in southwestern Europe with isolated records in Belgium, Croatia and Greece; the latter records may reflect a recent eastward range shift, but maybe this species was previously overlooked in the eastern Mediterranean region. *Ploiaria chilensis* is known from Macaronesia and Spain, with doubtful records from the central and eastern Mediterranean.

Saldidae

Shore bugs or Saldidae are a species-poor (340 species in the world (Henry 2009)), medium-sized, predatory family, living in littoral habitats along the edges of running and standing waters, marine shoreline and bogs. Whereas the native fauna includes 47 species (Aukema and Rieger 1995–2006), there is only one species alien to Europe. This single species, *Pentacora sphacelata*, is known since the 1950s from the Iberian Peninsula and Sardinia. This is a halophilous species living in the tidal-zone and close to saline waters.

Tingidae

Lace bugs or Tingidae are a species-rich, small-sized (< 8 mm body size), phytophagous family, with characteristic ornate and lacelike hemelytra and pronotum. Most species live on or near their host plants with a usually tight preference to particular plant species or families. About 2100 species are recognized in the world (Henry 2009) but only 171 are native to Europe (Aukema and Rieger 1995–2006). Thus, the alien fauna which includes 5 species alien to Europe is proportionally a little more important than in Miridae (2.9% of the total fauna vs. 0.5%; Figure 9.1.1). Both *Corythucha*-species were introduced from North America to Italy and live arboreally on their host plants, including the oak lace bug *C. arcuata* on *Quercus* (see factsheet 14.51) and the sycamore lace bug *C. ciliata* on *Platanus* (see factsheet 14.52). The former species was introduced a decade ago and only started to spread (Dioli et al. 2007), whereas the latter was introduced in the 1960s and nowadays is very widespread across Europe. *Stephanitis pyrioides* and *S. takeyai* were introduced from Japan and *S. rhododendri* from North America with ornamental Ericaceae (*Rhododendron*, *Azalea*, *Pieris*). *Dictyonota fuliginosa* and *Elasmotropis testacea* are both considered alien in parts of Europe where the host plants are also alien, although unambiguous evidence on their introduction status often is lacking. The alien status of *Stephanitis oberti* in Central Europe is debatable.

9.1.4 Temporal trends of introduction of alien Heteroptera in Europe

The (published) year when first recorded is known for all species (Table 9.1.1 and 9.1.2; see also Rabitsch (2008) for all country records), although it is evident that this need not be identical with the year of introduction. Usually it takes a few years for introduced insects to increase in abundance above a certain threshold to establish reproducing populations and to get recognized. This time-lag is known as a common characteristic of biological invasions and it can extend over long time periods in some organisms, e.g. decades or even centuries in some plants (Kowarik 1995). For insects, however, this time-lag usually extends over much shorter periods, but several years may still elapse since an alien species is discovered and information is communicated.

Some Heteroptera were already introduced in ancient times, such as the notorious bed bug *Cimex lectularius* Linnaeus, 1758 and maybe some others following human expansion associated with agricultural land reclamation. Those ancient introductions were rarely if ever documented and are therefore excluded in this study. However, there is no doubt that the rate of introductions has exponentially increased within the 20th century and reached unprecedented magnitudes in the 21st century (Figure 9.1.2). Since 1990, an approximate arrival rate of seven species per decade has been observed (Rabitsch 2008). Currently, Heteroptera alien *to* and alien *in* Europe both establish at a rate of 0.33 species per year; this means that on average every third year an Heteroptera species from outside Europe arrives in Europe. Even within the last eight years, five species have been detected: *Corythucha arcuata*, *Tropidosteptes pacificus* and *Belonochilus numenius* from North America (2000, 2007, 2008, respectively), *Nysius huttoni* from New Zealand (2002) and *Halyomorpha halys* from East Asia (2007).

Some species are suspected of having been introduced in the 19th century together with ornamental plants, e.g. *Anthocoris butleri* on *Buxus sempervirens*, *Anthocoris sarothamni*, *Orthotylus adenocarpi*, *O. concolor*, *O. virescens*, *Dictyonota fuliginosa* on *Cytisus scoparius*, and *Macrolophus glaucescens*, *Elasmotropis testacea* on *Echinops sphaerocephalus*. More recently, several *Tuponia* species were introduced with the increasing use of ornamental *Tamarix* species in public and private gardens.

The time of introduction for cryptogenic species into Europe is unclear and may well be several centuries before present. Most are pan-tropically distributed, zoophagous species.

9.1.5 Biogeographic patterns of the alien Heteroptera of Europe

9.1.5.1 Origin of alien species

A total of 16 species are alien to Europe, 10 of these from North America, 4 from the eastern Palaearctic and East Asia and one each from South America and Oceania. Almost all of the 25 species alien in Europe originate in the Mediterranean region and

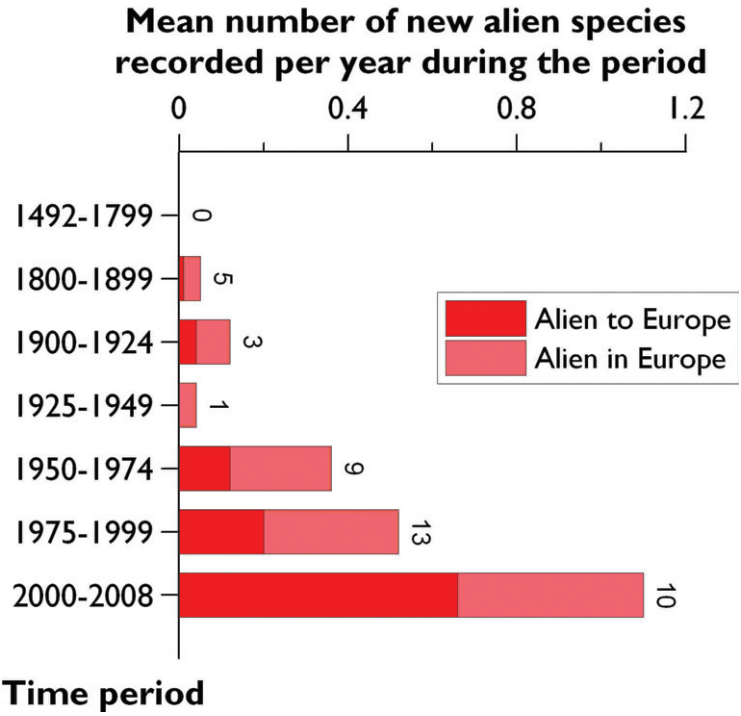

Figure 9.1.2. Temporal trends in the mean number of new records per year for Heteroptera species alien *to* Europe and alien *in* Europe from 1492 to 2008. Cryptogenic species are excluded. The number above the bar indicates the absolute number of species in this time period.

were translocated to central and northern Europe. Seven species are considered cryptogenic with unknown origin and cosmopolitan distribution (Figure 9.1.3).

Rabitsch (2008) mentioned the increasing trend of North American species arriving in Europe (Figure 9.1.4). This is corroborated by the most recent introductions of *Tropidosteptes pacificus* in the Netherlands (Aukema et al. 2009a) and *Belonochilus numenius* in Corsica, continental France and Spain (Gessé et al. 2009, Matocq 2008). Few species have been introduced from Oceania (New Zealand, *Nysius huttoni,* see factsheet 14.47) and South America (*Fulvius borgesi*). The latter species was only recently described as new to science, based on specimens collected in banana plantations at low altitudes on the Azores (Chérot et al. 2006). The authors argued, based on morphological characters, that the species was introduced from South America. *Nezara viridula* is considered the only alien species of African origin, although some were previously intercepted during plant health inspections, e.g. the Grain Chinch Bug, *Macchiademus diplopterus* (Distant, 1903) (Lygaeidae) and *Natalicola pallidus* (Westwood, 1837) (Tessaratomidae) at Heathrow Airport, London, on fruits and plants imported from South Africa (Malumphy and Reid 2007, 2008). Suitable climate seems to be a significant factor for the establishment of Heteroptera alien to Europe since 87% (14 species) come from temperate climates and only two species were introduced from the southern hemisphere.

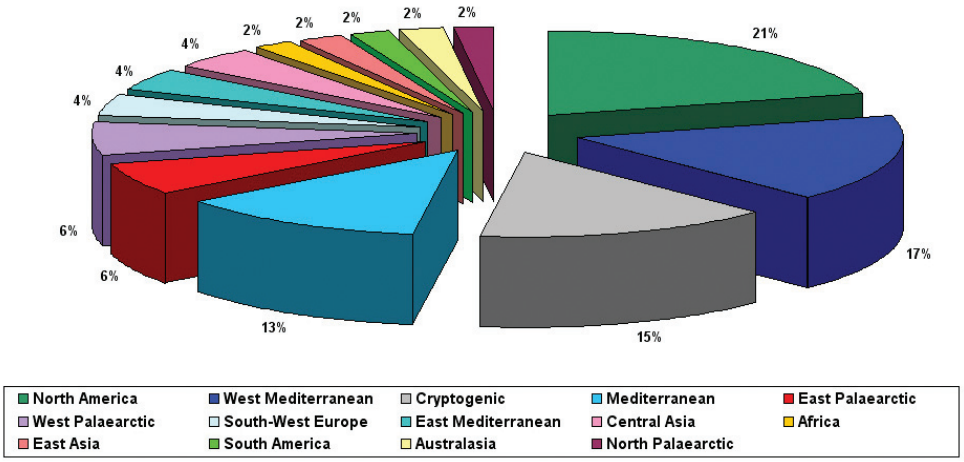

Figure 9.1.3. Geographic origin of the alien Heteroptera species of Europe.

9.1.5.2 Distribution of alien species in the European countries

Most alien Heteroptera species are known from Central Europe (Czech Republic: 22 species, that is 47% of all species, Germany: 20 species) and Western Europe (Netherlands: 20 species, Great Britain: 17 species) (Figure 9.1.5). One reason for the subordinate relevance of South Europe as a recipient for alien Heteroptera lies in the fact that almost all species alien *in* Europe originate in the Mediterranean region and were translocated north. This is likely a consequence of the increasing north-south exchange of people and merchandise (e.g., summer holiday tourism, fruits, vegetables) (Rédei and Torma 2003). A west-east pattern, however, can be found in suspected previous introductions of species living on western European ornamental plants, which were later widely planted across Europe. This concerns species living on *Buxus sempervirens*, *Cytisus scoparius*, and *Echinops* spp. Those plants are nowadays widely planted in cemeteries and private gardens and host monophagous Heteroptera species (e.g. *Anthocoris butleri*, *A. sarothamni*, *Dictyonota fuliginosa*, *Elasmotropis testacea*, *Macrolophus glaucescens* and *Orthotylus* spp.).

This northwest-southeast gradient is also demonstrated by a significant negative rank correlation of alien species numbers and longitude when the diversity of alien heteropterans is tentatively correlated to environmental and economic variables using a Spearman rank correlation (ϱ= -0.548; P < 0.001; Rabitsch, unpublished data). Whereas the number of native Heteropteran species per country appears to be significantly correlated with both the number of native plant species (ϱ= 0.887; P < 0.001) and the country size (ϱ= 0.576; P < 0.001), the number of alien Heteroptera species does not (ϱ= -0.548 and ϱ= 0.093, respectively, n.s.). On the contrary, whereas the number of alien Heteroptera is positively correlated with some economic variables (GDP per capita, ϱ = 0.417; P < 0.01; average trade import 1990–1997, ϱ= 0.748;

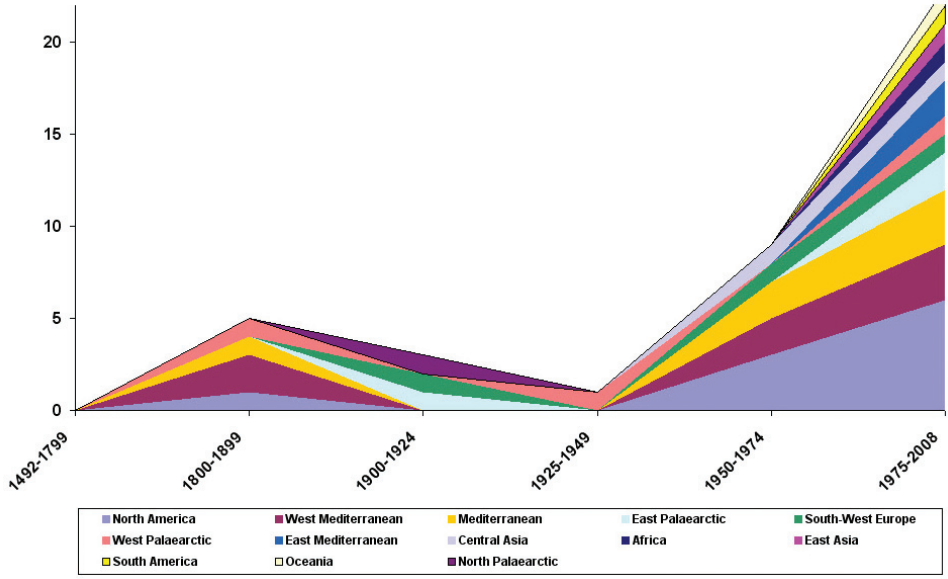

Figure 9.1.4. Numbers of established alien Heteroptera species of Europe by period of introduction and geographic origin. Cryptogenic species are excluded.

P < 0.001), the number of native species is not (ϱ= -0.049, n.s.). The distribution patterns of alien Heteropterans also seem to match these of alien plants (ϱ= 0.394; P<0.05) and alien terrestrial invertebrates (ϱ= 0.703; P<0.001); this likely is a fact of the overwhelming importance of urbanisation and trade import for the establishment of alien terrestrial invertebrate species in Europe (Roques et al. 2008). The Netherlands must be regarded as an invasion focus for the alien Heteroptera of Europe, with seven species having been first recorded in this country (Tables 9.1.1 and 9.1.2). A more sophisticated statistical analysis with several explanatory variables and taking into account area and sample effects, autocorrelation, multicollinearity, etc. will be presented elsewhere (Rabitsch and Moser, in prep.).

9.1.6 Pathways of introduction of the alien species of Heteroptera

Heteroptera are rarely intercepted (Roques and Auger-Rozenberg 2006) or at least rarely reported, in part due to their ancillary role as pest organisms. Recently, however, a number of such cases were published from regular plant health inspections in Great Britain. For example, *Natalicola pallidus* (Tessaratomidae) was found on *Crassula multicava* from South Africa (Malumphy and Reid 2008) and one specimen of *Leptoglossus occidentalis* was found in a timber shipment from the USA (Malumphy et al. 2008) indicating multiple introductions of this species into Europe. Ornamental trade and movement as stowaways with transport vehicles are the major pathways for alien Heteroptera (Rabitsch

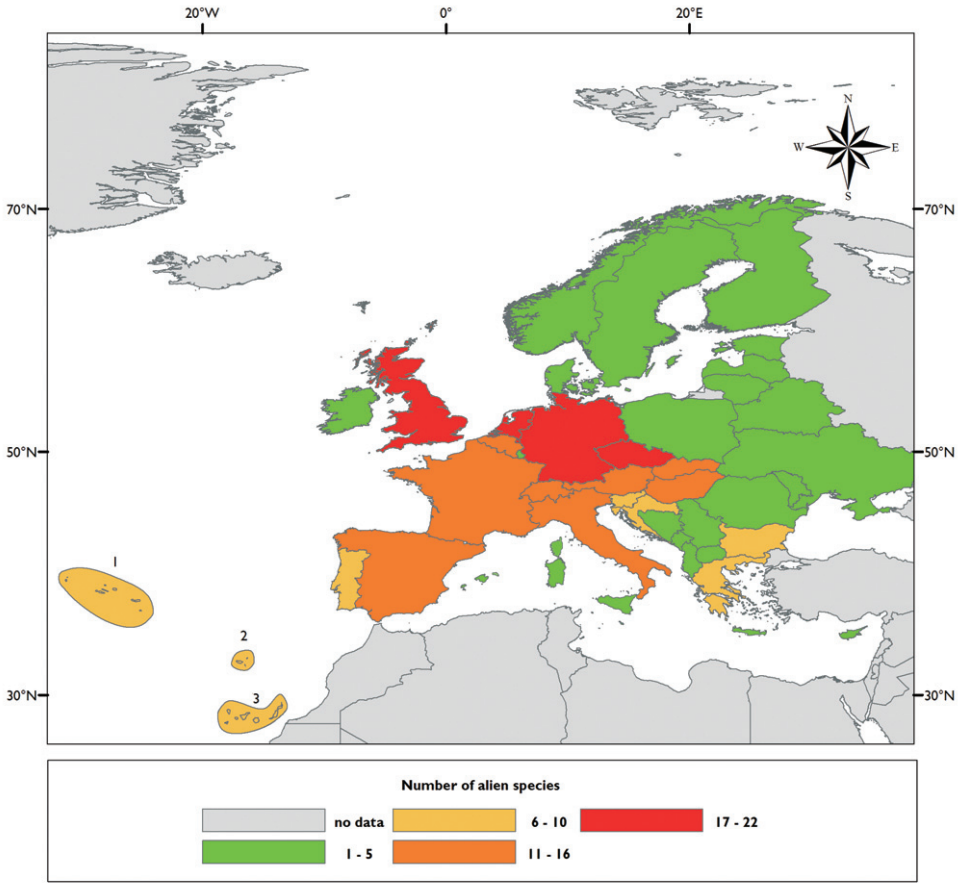

Figure 9.1.5. Numbers of established alien Heteroptera species per European country. Data rely on Tables 9.1.1 and 9.1.2. Aliens with doubtful status are included. Archipelago: **1** Azores **2** Madeira **3** Canary islands.

2008), also confirmed by the interruption of introductions between 1925 and 1949 (Figure 9.1.4).

9.1.7 Ecosystems and habitats invaded by alien Heteroptera in Europe

Most alien Heteroptera colonize habitats under strong human influence, like agricultural, horticultural, and domestic habitats (51%) and parks and gardens (27%) (Figure 9.1.6). Some species prefer woodland including plantations of non-native forest trees. It is worth mentioning that *Leptoglossus occidentalis* has not only spread across Europe, but has also

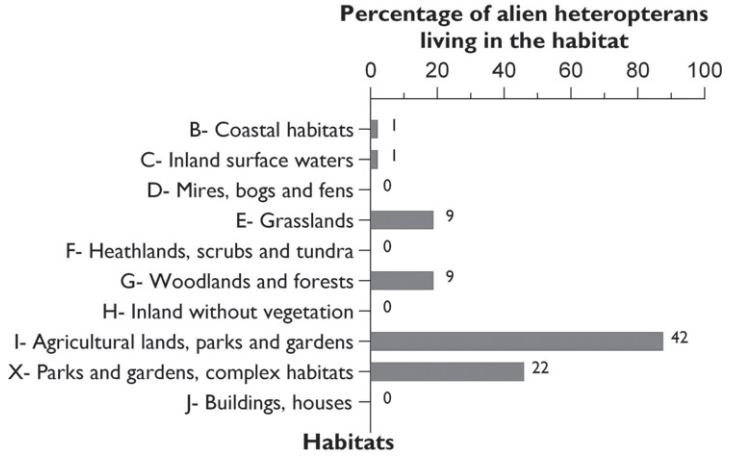

Figure 9.1.6. Main habitats colonized by alien Heteroptera species in Europe. The number above each bar indicates the absolute number of alien species recorded per habitat. Note that a species may have colonized several habitats.

expanded its occupied habitat: first records in most countries are indoors, from cities and harbours, but increasingly records in the field are observed at higher elevations. In France, *L. occidentalis* has twice been captured above 1000 m (Dusoulier et al. 2007) and in Austria (Styria) there is a documented record at 1500 m (Gepp, in litt.) (see factsheet 14.42).

9.1.8 Ecological and economic impact of alien Heteroptera in Europe

Impacts of alien Heteroptera in Europe are poorly investigated (Rabitsch 2008). A few species are considered pests in agriculture or forestry, e.g. *Nysius huttoni*, and *Leptoglossus occidentalis*, or on ornamental plants, e.g. *Corythucha ciliata* and *Stephanitis takeyai*, but damage is only locally reported in Europe to date. No data are available on any negative ecological impact on native species either due to predation, hybridization, competition or pathogen-transfer. However, as mentioned by Rabitsch (2008), no one has yet looked at such effects. It may be worth investigating intraguild competition within the juniper-feeding guild or the effects of *Trichocorixa verticalis* in aquatic communities.

9.1.9 Conclusion

It is essential to observe and document range changes of species. Clearly, the number of introduced Heteroptera will increase. Climate change and habitat modification will further promote establishment of additional species. Some introduced species, currently considered as not established, were excluded in this study, but may establish populations in the near

Figure 9.1.7. Adults of some alien Heteroptera species: **a** *Arocatus longiceps* (Credit: Wolfgang Rabitsch) **b** *Leptoglossus occidentalis* feeding on Scots pine (Credit: Alain Roques) **c** *Oxycarenus lavaterae* aggregating on trunk (Credit: Wolfgang Rabitsch) **d** *Oxycarenus lavaterae* detail (Credit: Wolfgang Rabitsch) **e** *Stephanitis takeyai* (Credit: Wolfgang Rabitsch) **f** *Tupiocoris rhododendri* (Credit: Ab Baas).

future; e.g., *Orius flagellum* Linnavuori, 1968 in the Netherlands (Aukema and Hermes 2009), *Xylocoris flavipes* (Reuter, 1875) in several European countries (Péricart 1972, 1996). Also, recent range changes of some continental European species need to be carefully reconsidered when new data become available as some of these may deserve alien status; e.g. Ødegaard & Endrestøl (2007), see Rabitsch (2008) for additional examples. Taking into account the increasing number of Heteroptera species introduced from North America and the often observed previous range increase in the native areas, it is recommended for Europe to keep an eye on range changes in North America, which may be an early indicator for possible future alien species to Europe. Finally, more research is needed for a better understanding of the ecological and economic effects of introduced Heteroptera.

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Table 9.1.1. List and main characteristics of Heteroptera species alien *to* Europe. Status: **A** Alien *to* Europe **C** cryptogenic species. For details see Rabitsch (2008). ? = occurrence doubtful, * = probably not established. New data since Rabitsch (2008) are given in bold. Country codes abbreviations refer to ISO 3166 (see appendix I). Habitat abbreviations refer to EUNIS (see appendix II). Only selected references are given. Last update May 2009.

Family *Species*	Status	Feeding Regime	Native range	1st record in Europe	Invaded countries	Habitat	Hosts	Refs
Anthocoridae								
Amphiareus obscuriceps (Poppius, 1909)	A	Zoo-phagous	East Palaearctic	1987, BG	AT, BE, BG, BY, CZ, DE, EE, FI, HU, IT, NL, SK	E, I	–	Aukema (2007), Aukema et al. (2005a), Hradil et al. (2008), Péricart and Stehlík (1998)
***Amphiareus constrictus* (Stål, 1860)**	C	Zoo-phagous	Cosmopolitan	2007, NL	**NL**	E	–	Aukema and Hermes (2009)
Buchananiella continua (White, 1880)	C	Zoo-phagous	Pantropical	1880, PT-MAD	**BE,** ES, ES-CAN, FR, GB, IT, **NL,** PT, PT-AZO, PT-MAD	I, X	–	Aukema and Hermes (2009), Aukema et al. (2009b), Kirby (1999)
Lyctocoris campestris (Fabricius, 1794)	C	Zoo-phagous	West Palaearctic? Cosmopolitan	?	AL, AT, BA, BE, BG, BY, CH, CZ, DE, DK, EE, ES, ES-CAN, FI, FR, GB, GR, HR, HU, IE, IT, IT-SAR, IT-SIC, LT, LU, LV, MD, ME, MK, MT, NL, NO, PL, PT, PT-AZO, PT-MAD, RS, SE, SI, SK, UA	I	–	Péricart (1972)
Coreidae								
Leptoglossus occidentalis Heidemann, 1910	A	Phyto-phagous	North America	1999, IT	AT, BE, **BG,** CH, CZ, DE, ES, FR, GB, **GR** , HR, HU, IT, **ME, NL,** PL, **RO,** RS, SI, SK	G, I, X	Pinaceae (*Pinus*, *Pseudotsuga*, *Picea*, *Abies*), Cupressaceae (*Libocedrus*)	Aukema (2008), Bernardinelli and Zandigiacomo (2001), Dusoulier et al. (2007), Hradil (2008), Kment et al. (2005), Malumphy et al. (2008), Protić (2008), Ruicănescu (2009)

Family *Species*	Status	Feeding Regime	Native range	1st record in Europe	Invaded countries	Habitat	Hosts	Refs
Corixidae								
Trichocorixa verticalis (Fieber, 1851)	A	Omni-vorous	North America	1997, PT	ES, PT	C	–	Kment (2006a), Sala and Boix (2005)
Lygaeidae								
Nysius huttoni F.B.White, 1878	A	Phyto-phagous	New Zealand	2002, NL	BE, FR, **GB,** NL	I	Poaceae, Brassicaceae and others (polyphagous)	Aukema et al. (2005b), Cuming (2008)
***Belonochilus numenius* (Say, 1831)**	A	Phyto-phagous	North America	2008, FR	**ES, FR, FR-COR**	I	Platanaceae (*Platanus*)	Gessé et al. (2009), Matocq (2008)
Miridae								
***Fulvius borgesi* Chérot, J. Ribes & Gorczyca, 2006**	A	Zoophyto-phagous?	South America	2003, PT-AZO	**PT-AZO**	I	–	Chérot et al. (2006)
Nesidiocoris tenuis (Reuter, 1895)	C	Zoophyto-phagous	Pantropical	?	CY, ES, ES-CAN, FR, GR, GR-CRE, IT, MT, PT-MAD	I	–	Kerzhner and Josifov (1999)
Taylorilygus apicalis (Fieber, 1861)	C	Phyto-phagous	Pantropical	?	AL, BA, BG, CY, ES, ES-CAN, FR, FR-COR, GR, HR, IT, IT-SAR, IT-SIC, MT, PT, PT-AZO, PT-MAD, SI, UA	I	Asteraceae and others (polyphagous)	Kerzhner and Josifov (1999)
***Tropidosteptes pacificus* Van Duzee, 1921**	A	Phyto-phagous	North America	2007, NL	**NL**	G	Oleaceae (*Fraxinus excelsior*)	Aukema et al. (2009a)
Tupiocoris rhododendri (Dolling, 1972)	A	Zoo-phagous	North America	1971, GB	BE, DE, GB, NL	I, X	Ericaceae (*Rhodo-dendron*)	Aukema et al. (2005a), Aukema et al. (2007), Dolling (1972)

Family *Species*	Status	Feeding Regime	Native range	1st record in Europe	Invaded countries	Habitat	Hosts	Refs
Pentatomidae								
Halyomorpha halys (Stål, 1855)	A	Phyto-phagous	East Asia	2007, CH	CH	I, X	fruit trees and ornamentals (polyphagous)	Wermelinger et al. (2008)
Perillus bioculatus (Fabricius, 1775)	A	Zoo-phagous	North America	1992, TU	GR, TU	G, I	–	Kivan (2004)
Reduviidae								
Empicoris rubromaculatus (Blackburn, 1889)	C	Zoo-phagous	Pantropical	?	**BE,** ES, ES-CAN, FR, FR-COR, **GR,** HR, IT, PT, PT-AZO, PT-MAD	I	–	Aukema et al. (2009b)
Ploiaria chilensis (Philippi, 1862)	C	Zoo-phagous	Pantropical	?	?CY, ES, ES-CAN, ?IT, PT-AZO, PT-MAD	I	–	Putshkov and Putshkov (1996)
Saldidae								
Pentacora sphacelata (Uhler, 1877)	A	Zoo-phagous	North America	1953, ES	ES, IT, PT	B	–	Carapezza (1980)
Tingidae								
Corythucha arcuata (Say, 1832)	A	Phyto-phagous	North America	2000, IT	CH, IT	G	Fagaceae (*Quercus*, *Castanea*)	Dioli et al. (2007), Forster et al. (2005)
Corythucha ciliata (Say, 1832)	A	Phyto-phagous	North America	1964, IT	AT, BE, BG, CH, CZ, DE, ES, FR, GB, GR, HR, HU, IT, ME, **NL,** PT, RS, SK, SI	I, X	Platanaceae (*Platanus*)	Aukema and Hermes (2009), Kment (2007), Servadei (1966), Stehlík (1997), Streito (2006)
Stephanitis pyrioides (Scott, 1874)	A	Phyto-phagous	Japan	1904, NL	CH, *FR, GR, IT, NL	I, X	Ericaceae (*Rhodo-dendron*)	Kment (2007), Streito (2006)
Stephanitis rhododendri Horváth, 1905	A	Phyto-phagous	North America	<1900, NL	*BE, BG, CH, CZ, DE, DK, *FI (J100), *FR, GB, NL, *PL, SE	I, X	Ericaceae (*Rhodo-dendron*)	Halstead and Malumphy (2003), Jindra and Kment (2006), Simov and Pencheva (2007)
Stephanitis takeyai Drake & Maa, 1955	A	Phyto-phagous	Japan	1994, NL	BE, **CZ**, DE, FR, GB, IT, NL, PL	I, X	Ericaceae (*Pieris*, *Rhododendron*)	Aukema (1996), Halstead and Malumphy (2003), Ishikawa and Kikuhara (2009), Streito (2006)

Table 9.1.2. List and characteristics of the Heteroptera species alien *in* Europe. For details see Rabitsch (2008). ?N = Alien status doubtful (species could be native), ? = occurrence doubtful, * = probably not established. New data since Rabitsch (2008) are given in bold. Country codes abbreviations refer to ISO 3166 (see appendix I). Habitat abbreviations refer to EUNIS (see appendix II). Only selected references are given. Last update May 2009.

Family *Species*	**Feeding Regime**	**Native range**	**1st record in invaded areas**	**Invaded countries**	**Habitat**	**Hosts**	**References**
Anthocoridae							
Anthocoris butleri Le Quesne, 1954	Zoo-phagous	Southwest Europe	1962, CZ	AT, BE, CH (?N), CZ, DE (?N), IE, LU, NL, SE (Gotland), SK	I, X	Buxaceae (*Buxus*)	Kment et al. (2006)
Anthocoris sarothamni Douglas & Scott, 1865	Zoo-phagous	West Mediterranean	1953, CZ	*AT, CZ	I, X	Fabaceae (*Cytisus*)	Kment (2006b)
***Orius laevigatus* (Fieber, 1860)**	Zoo-phagous	Southwest Europe	2005, NL	**NL**	I	–	Aukema and Loomans (2005)
Lygaeidae							
Arocatus longiceps Stål, 1872	Phyto-phagous	East Mediterranean	1990, HU	AT, BE, CH, CZ, DE, **ES,** FR (N?), **GB,** HU, NL, **PT,** SI (?N), SK	I, X	Platanaceae (*Platanus*)	Göricke (2008), Kondorosy (1997), Nau and Straw (2007), Ribes and Pagola-Carte (2008)
Orsillus depressus (Mulsant & Rey, 1852)	Phyto-phagous	Mediterranean	1971, DE	AT (?N), BE, CZ, DE, *FI, GB, HU (?N), LU, NL, SK	E, I, X	Cupressaceae	Hradil et al. (2002), Voigt (1977)
Oxycarenus lavaterae (Fabricius, 1787)	Phyto-phagous	West Mediterranean	1985, ME	AT, BG, CH (north), CZ, DE, *FI, FR(north), HU, ME, ***NL**, **RO,** RS, **SI,** SK	G, I, X	Malvaceae (*Tilia*)	Hradil et al. (2008), Kment (2009), Kondorosy (1997), Rabitsch and Adlbauer (2001), Velimirovic et al. (1992), Wermelinger et al. (2005)
Miridae							
Closterotomus trivialis (A. Costa, 1853)	Phyto-phagous	Mediterranean	1998, NL	NL	I	Weeds, olive trees, Citrus (polyphagous)	Aukema (1999), Aukema and Hermes (2009)
***Deraeocoris lutescens* (Schilling, 1837)**	Zoo-phagous	West Palaearctic	1990, NO	**NO, SE**	I, X	Malvaceae (*Tilia*)	Lindskog and Viklund (2000), Ødegaard and Endrestøl (2007)

Family *Species*	**Feeding Regime**	**Native range**	**1st record in invaded areas**	**Invaded countries**	**Habitat**	**Hosts**	**References**
Deraeocoris flavilinea (A. Costa, 1862)	Zoo-phagous	Mediterranean	1961, FR-COR	AL, AT, BE, CH, CZ, DE, FR (Alsace), FR-COR, GB, LU, MT, NL, SE, SI	I, X	Many trees and shrubs	Kment et al. (2006), Péricart (1965)
Dichrooscytus gustavi Josifov, 1981	Phyto-phagous	European – Cryptogenic	1934, DE	AT, BE, CZ, DE, FI, FR, GB, HU, ?IT, LU, NL, SK	I	Cupressaceae	Bryja and Kment (2002), Hradil et al. (2008)
Dicyphus escalerae Lindberg, 1934	Phyto-phagous	West Mediterranean	1994, DE	CH, DE, **GB**	I	Veronicaceae (*Antirrhinum majus*)	Hollier and Matocq (2004), Kirby et al. (2009), Servadei (1966)
Macrolophus glaucescens Fieber, 1858	Zoo-phagous	Mediterranean	<1858, CZ	CZ	E	Asteraceae (*Echinops*)	Kment (2006b)
Orthotylus adenocarpi (Perris, 1857)	Zoophyto-phagous	West Mediterranean	<1892?, CZ	CZ (?N)	E, G, I	Fabaceae (*Cytisus*)	Kment (2006b)
Orthotylus caprai Wagner, 1955	Zoophyto-phagous	Mediterranean	2006, GB	DE, GB	I	Cupressaceae	Nau (2007), Simon (2007)
Orthotylus concolor (Kirschbaum, 1856)	Zoophyto-phagous	West Mediterranean	<1892?, CZ	***AT,** CZ (?N)	E, G, I	Fabaceae (*Cytisus*)	Frieß and Rabitsch (2009), Kment (2006b)
Orthotylus virescens (Douglas & Scott, 1865)	Zoophyto-phagous	West Mediterranean	2003, HU	CZ (?N), HU	E, G, I	Fabaceae (*Cytisus*)	Kment (2006b), Kondorosy (2005)
Tuponia brevirostris Reuter, 1883	Phyto-phagous	West Mediterranean	2001, GB	DE, GB, **GR (?N)**, HR	I, X	Tamaricaceae (*Tamarix*)	Barclay and Nau (2003), Simon (2007)
Tuponia elegans (Jakovlev, 1867)	Phyto-phagous	Central Asia	1964, HU	AT, CZ, HU, SK	I, X	Tamaricaceae (*Tamarix*)	Benedek and Jászai (1968), Bryja and Kment (2002), Hradil et al. (2008), Rabitsch (2002)
Tuponia hippophaes (Fieber, 1861)	Phyto-phagous	Mediterranean	<1982, SK	CZ, BE, SK	I, X	Tamaricaceae (*Tamarix*)	Bryja and Kment (2002), Hradil et al. (2008)
Tuponia macedonica Wagner, 1957	Phyto-phagous	East Mediterranean	2003, SK	SK	I, X	Tamaricaceae (*Tamarix*)	Hradil et al. (2008)

Family *Species*	**Feeding Regime**	**Native range**	**1st record in invaded areas**	**Invaded countries**	**Habitat**	**Hosts**	**References**
Tuponia mixticolor (A. Costa, 1862)	Phyto-phagous	Mediterranean-Central Asia	1979, GB	DE, GB, SI (?N)	I, X	Tamaricaceae (*Tamarix*)	Nau (1980), Simon (2007)
Pentatomidae							
Nezara viridula (Linnaeus, 1758)	Phyto-phagous	Mediterranean and/or Africa	1979, DE	*AT, *BE, BG (?N), CH (north), DE, *FI, GB, HU, *UA	I, X	Fabaceae, cultivated and uncultivated plants (polyphagous)	Barclay (2004), Rédei and Torma (2003), Wheeler (2001)
Tingidae							
Dictyonota fuliginosa A. Costa, 1853	Phyto-phagous	West Mediterranean	1954, CZ	CZ	E, G, I	Fabaceae (*Cytisus*)	Kment (2006b)
Elasmotropis testacea (Herrich-Schäffer, 1830)	Phyto-phagous	Palaearctic	<1844, CZ	CZ, DE (?N), ?PL	E, I	Asteraceae (*Echinops*)	Kment (2006b)
Stephanitis oberti (Kolenati, 1857)	Phyto-phagous	North Palaearctic	<1906?, DE	*AT, BE (?N), CZ (?N), DE (?N), NL (?N)	I, X	Ericaceae (*Rhodo-dendron*, *Vaccinium*)	Bruers and Viskens (1999)