

INVASIVE TRUE BUGS (HETEROPTERA) ESTABLISHED IN EUROPE

P.V. Putchkov

Schmalhausen Institute of Zoology NAS of Ukraine,
B. Khmelnytsky str., 15, Kyiv, 01601, Ukraine reduvion@mail.ru

Till now at least 19 extra-European true bug species have established in Europe. Four of them were registered before 1960 (North American *Stephanitis rhododendri* Horvath and *Pentacora sphacelata* (Uhler, 1877); East Asian *Stephanitis pyrioides* (Scott) and *Amphiareus obscuriceps* Poppius), three — in 1961–1991 (North American *Corytucha ciliata* (Say) and *Tupiocoris rhododendri* (Dolling); *Buchananiella continua* (White) of unknown origin), and twelve — after 1991 (North American *Perillus bioculatus* (Fabricius), *Trichocorixa verticalis* (Fieber), *Leptoglossus occidentalis* Heidemann, *Corytucha arcuata* (Say), *Tropidosteptes pacificus* (Van Duzee), *Belonochilus numenius* (Say), *Zelus renardii* (Kolenati), *Tempyra biguttula* Stal; East Asian *Stephanitis takeyai* Drake et Maa, *Halyomorpha halys* (Stal); New Zealand *Nysius huttoni* White; *Amphiareus constrictus* (Stal) of unknown origin). Probably, six other species (*Empicoris rubromaculatus* (Blackburn), *Ploiaria chilensis* (Philippi), *Nesidiocoris tenuis* (Reuter), *Taylorilygus apicalis* (Fieber), *Dichroscytus gustavi* Josifov, *Nezara viridula* (Linnaeus)) have extra-European origin too; except *Ploiaria chilensis*, they have expanded their European ranges during the last 20–50 years. Also many south European true bug species advanced recently to Middle, North-West and partially — to North Europe and settled down there. The recent acceleration of alien true bugs range expansion and naturalization process takes place due to various human-induced (intensification of intercontinental and intra-continental flows of people and goods; broad-scale introduction of numerous alien plants — hosts to many invasive bugs or to their prey; man-made changes of native landscapes and communities; the industrial “islands of warmth” in megalopolises) and natural warming effects. Appearance in and expansion within Ukraine of two alien pests of sycamores (lace bug *Corytucha ciliata*) and conifers (coreid *Leptoglossus occidentalis*), as well as an extension of sycamore feeding seed bug *Arocatus longiceps* Stal beyond Crimea are the regional emergences of this general tendency.

Key words: Heteroptera, alien species, range extension, Europe, Ukraine

Адвентивні види клопів (Heteroptera) у Європі

П. В. Пучков

Щонайменше 19 позаєвропейських видів клопів закріпилися у Європі. Чотири з них оселилися тут ще до 1960 р. (північноамериканські *Stephanitis rhododendri* Horvath та *Pentacora sphacelata* (Uhler); східноазійські *Stephanitis pyrioides* (Scott) та *Amphiareus obscuriceps* Poppius), три — у 1961–1991 (північноамериканські *Corytucha ciliata* (Say), *Tupiocoris rhododendri* (Dolling) та *Amphiareus constrictus* (Stal) невстановленого походження) і дванадцять — після 1991 р. (північноамериканські *Perillus bioculatus* (Fabricius), *Trichocorixa verticalis* (Fieber), *Leptoglossus occidentalis* Heidemann, *Corytucha arcuata* (Say), *Tropidosteptes pacificus* (Van Duzee), *Belonochilus numenius* (Say), *Zelus renardii* (Kolenati) та *Tempyra biguttula* Stal; східноазійські East Asian *Stephanitis takeyai* Drake et Maa та *Halyomorpha halys* (Stal); новозеландський *Nysius huttoni* White і *Buchananiella continua* (White) — невстановленого походження). Вірогідно, шість інших видів (*Empicoris rubromaculatus* (Blackburn), *Ploiaria chilensis* (Philippi), *Nesidiocoris tenuis* (Reuter), *Taylorilygus apicalis* (Fieber), *Dichroscytus gustavi* Josifov, *Nezara viridula* (Linnaeus)) теж мають позаєвропейське походження. Всі вони, крім *Ploiaria chilensis*, розширили свої ареали в Європі за останні 20–50 років. Багато південноєвропейських клопів нещодавно

давно проникло до Середньої, Північно-Західної та, частково, навіть до Північної Європи. Прискорення натуралізації аллохтонних клопів зумовлено багатьма антропоїчними чинниками (інтенсифікація між- та внутрішньоконтинентальних перевезень людей та товарів; масштабні переміщення та посадки саджанців екзотичних рослин — кормових для багатьох адвентивних клопів або для їх здобичі; зміни й руйнація людиною природних ландшафтів; індустріальні «острови тепла» в мегаполісах), доповненими ефектами природного потепління, що сприяють поширенню теплолюбних видів. Серед вищеназваних адвентивних клопів — 2 види закріпились і в Україні. Крайовик *Leptoglossus occidentalis*, шкідник багатьох хвойних, відмічений у 2010-2013 в Києві, Харкові, Черкасах, Донецьку, Запоріжжі, Сімферополі та у мм. Дніпрорудному, Запорізької і Верхньодніпровську, Дніпропетровської областей. Злісний шкідник платанів мереживниця *Corytucha ciliata*, що відмічена в 2007 у Сімферополі, була знайдена в цьому ж місті у 2013, а також у мм. Севастополь та Миколаїв. Європейська платанова лігеїда *Arocatus longiceps* Stal, що донині була обмежена в Україні Південним берегом Криму, у 2013 виявлена і у м. Миколаїв.

Ключові слова: Heteroptera, адвентивні види, розширення ареалів, Європа, Україна

Адвентивные виды клопов (Heteroptera) в Европе

Пучков П. В.

В Европе зарегистрировано 19 видов клопов, приспособившихся здесь к жизни, но являющихся выходцами с иных континентов. Из них четыре отмечены до 1960 г. (североамериканские *Stephanitis rhododendri* Horvath и *Pentacora sphacelata* (Uhler); восточноазиатские *Stephanitis pyrioides* (Scott) и *Amphiareus obscuriceps* Poppius), три — с 1961 по 1991 гг. (североамериканские *Corytucha ciliata* (Say), *Tupiocoris rhododendri* (Dolling) и *Amphiareus constrictus* (Stal) — неясного происхождения) и двенадцать — после 1992 г. (североамериканские *Perillus bioculatus* (Fabricius), *Trichocorixa verticalis* (Fieber), *Leptoglossus occidentalis* Heidemann, *Corytucha arcuata* (Say), *Tropidosteptes pacificus* (Van Duzee), *Belonochilus numenius* (Say), *Zelus renardii* (Kolenati), *Tempyra biguttula* Stal; восточноазиатские *Stephanitis takeyai* Drake et Мaa, *Halyomorpha halys* (Stal); новозеландский *Nysius huttoni* White и *Buchananiella continua* (White) — неясного происхождения). Вероятно, шесть других видов (*Empicoris rubromaculatus* (Blackburn), *Ploiaria chilensis* (Philippi), *Nesidiocoris tenuis* (Reuter), *Taylorilygus apicalis* (Fieber), *Dichroscytus gustavi* Josifov, *Nezara viridula* (Linnaeus)) тоже адвентивны в Европе. Все они, кроме *Ploiaria chilensis*, расширили свои европейские ареалы за последние 20-50 лет. Кроме того, многие южно-европейские клопы продвинулись недавно в Среднюю, Северо-Западную и, частично, Северную Европу. Ускорение расселения и натурализации адвентивных видов клопов обусловлено антропоическими факторами (интенсификация меж- и внутриконтинентальных потоков людей и товаров, масштабные расселение и посадки ряда экзотических растений, кормовых для многих адвентивных клопов или для их добычи, изменения и/или разрушение квазиприродных ландшафтов и сообществ, индустриальные «острова тепла» в мегаполисах), дополненные эффектом природного потепления за последние десятилетия, благоприятные для теплолюбивых видов. Среди вышеназванных вселенцев в Европу — 2 вида утвердились и на Украине. Краевик *Leptoglossus occidentalis*, вредящий хвойным, отмечен в 2010-2013 в Киеве, Харькове, Черкасах, Донецке, Запорожье, Одессе, Симферополе, Днепрорудном Запорожской и Верхнеднепровске Днепропетровской областей. Злостный вредитель платанов, *Corytucha ciliata*, отмеченная в 2007 в Симферополе, выявлена в здесь же в 2013 же, а также — в гг. Севастополь и Николаев. Европейская лигеїда *Arocatus longiceps* Stal, живущая на платанах, прежде ограниченная на Украине Южным Берегом Крыма, также обнаружена в г. Николаев.

Ключевые слова: Heteroptera, адвентивные виды, расширение ареалов, Европа, Украина

Introduction. During the last 300 years more than 1000 alien insect species naturalized in Europe; the most of naturalization cases took place in the last 50 years (Roques et al., 2008). This trend is quite evident for the true bugs (Heteroptera). The alien true bugs established in Europe (except those confined only to Canary, Azores and Madeira islands as well as those in Europe restricted to greenhouses exclusively) might be divided into three groups: 1) of indisputable extra-European origin; 2) of probable

extra-European origin; 3) of European origin whose native ranges were not long ago much smaller than now. These 3 groups are considered below and the reasons for their range expansion are shortly commented.

Group 1. Certainly extra-European invasive species. At present there are nineteen such species. Among them 11 are land phytophages (8 — pests of ornamental or agricultural plants), 6 are land predators and 2 — members of water or riparian ecosystems (tables I—III). One could

subdivide them to 4 subgroups depending on their initial range.

Sub-group Ia. North American expatriates. There are 12 such species or 63 % of all true bugs indisputably invasive to Europe.

1. Western leaf-footed bug (western conifer seed bug) *Leptoglossus occidentalis* Heidemann, 1910 (Coreidae) originally lived in western part of North America between 53° and 25° North. Between 1950 and 2000 it occupied the most of eastern part of the USA as well as south-east of Canada. Such expansion resulted most probably from human-assisted dispersal in the course of commercial pine and other conifer plantings and landscaping. Then the bug appeared in Europe and Asia (Peking in China, Tokyo in Japan and Asiatic Turkey) due to transcontinental shipping. The first European record dates from 1999 from northern Italy (near Vicenza). During 1999-2012 it occupied the most of Europe from extreme south to middle Sweden and from Ireland to Rostov-on-Don. In most countries rapid spread and increasing abundances were observed (e. g. Moulet, 2006; Dusoulier et al., 2007; Rabitsch, 2008, 2010; Hradil, 2008; Lis et al., 2008; Protic, 2008; Malumphy et al., 2008; Simov, 2008; Mouquet, 2009; Derjanschi, 2010; Petrakis, 2011; Sousa, Naves, 2012; Simov et al., 2012; etc.). The same is true for Ukraine. Here to the published records of 2010-2012 in Simpheropol, Donetsk, Dneprorudny in Zaporozhye region and Verkhnedneprovsk of Dnepropetrovsk region (Gapon, 2012; Putshkov et al., 2012) the following locations should be added: Kiev (adult in the city appartement, 15.IX.2011, photo of N.A. Matushkina; park Feofania, 2.X. (male) and 15.X.2013 (female), coll. M.I. Zaika), Kharkov (Rogan' on wall of Dokuchayev Kharkov Agricultural University near spruces, 30.IX.2013, coll. and photo A. A. Shekhovtsov; Botanic Garden, 2.IX.2013 and 29.X.2013, information from B.M. Loboda), Cherkassy (male and female near hotel "Dnipro", 8-11.X.2013, coll. A. Mikhaylenko, information from B.M. Loboda), Zaporozhye (adult, 8.X.2013, information from B.M. Loboda) and Odessa (male, settlement Kotowsky on asphalt, 15.XI.2011, coll. A.V. Gontarenko). As yet, all Ukrainian records are confined to artificial urban and suburban tree-stands (botanical gardens and parks inclusive) and to houses where

bugs gather for hibernation. These big bugs disperse actively by flight and passively (as egg, nymph, or adult) with host conifer plants, used for decoration and forestry as well as with merchantable wood, etc. Considering its "old" and "new" North American ranges (that is before and after 1950), this pest of various conifers should stop its expansion in Europe near the January isotherm of -12° C (Dusoulier et al., 2007; Rabitsch, 2008; Gapon, 2012).

2. Sycamore-feeding seed bug *Belonochilus numenius* (Say, 1831) (Lygaeidae) was found on urban sycamores in several countries from 2008 to 2013 (tables I-II) (Matocq, 2008; Gesse et al., 2009; Rabitch, 2010; Gesse, 2011; Hradil, 2011; Baena, Torres, 2012; Torma, 2012; Werner et al., 2013).

3. Another seed bug *Tempyra biguttula* Stal, 1874 originating from Mexico and Southern USA has been recently found in Spain (e. g. Baena et Torres, 2012; Aukema et al., 2013).

4. Sycamore lace bug, *Corythucha ciliata* (Say, 1832) (Tingidae) naturally inhabits USA to the east of the Rocky Mountains. In 1964-2012 it occupied nearly all European terrains with natural or planted plane-trees, sometimes inflicting to them quite serious harm (its French nickname is "tigre des platanes") (e. g. Pericart, 1983; Voigt, 2002; Kalinkin et al., 2002; Aukema et al., 2007; Kment, 2007; Derjanschi, 2007; Rabitsch, 2008, 2010; Tomov et al., 2009; Aukema, Hermes, 2009; Aukema, 2011; Hradil, 2011; Tatu, Tausan, 2011; Simov et al., 2012). In 2007 this pest was found in Ukraine (Simpheropol) (Stryukova, 2009) without being cited as yet in the summary reviews (e. g. Rabitsch, 2010; Aukema et al., 2013). Now it prospers not only in Crimea (Simpheropol and Sebastopol, larvae and adults on plane-trees foliage, 7. VI. 2013, coll. P. V. Putshkov) but also in Nikolayev province (Nikolayev city, adults under the plane-trees bark and exuvia upon the leaves, 15. X. 2013, coll. P. V. Putshkov and V. Yu. Nazarenko). The damage rate (% of damaged leaves, number and square of discolored and/or moldy spots per leaf) was from weak to considerable (damage from 0 to 4 points according to the damage scale used by Kalinkin et al., 2002: 26). The bugs disperse with wind-drift and by people via clothes or motor vehicles. The transportation with the host plant material is common too: the bugs were found in England

on sycamores imported from France and Italy (Malumphy, Reid, 2006). These bugs penetrated to Asian Turkey, China, Korea, Japan, Chili and Australia too (e. g. Tatu, Tausan, 2011).

5. Oak lace bug, *Corythucha arcuata* (Say, 1832) (Tingidae), occupied Italy in 2000-2008 and penetrated to Switzerland as well as to Asiatic Turkey, wherefrom the bugs arrived in Bulgaria (Plovdiv and Simeonovgrad) due to the intensive road traffic. In Italy they prefer European oaks (*Quercus petraea*, *Q. robur*, *Q. pubescens*, and *Q. cerris*) over the North American *Q. rubra*. The same and other oak species are attacked in Bulgaria and Turkey. The bug is feeding on *Castanea* and *Rubus* too. It is curious that both *Corythucha* spp. alike *Leptoglossus occidentalis* began their "conquest of Europe" from the north of Italy (Foerster et al., 2005; Dioli et al., 2007; Rabitsch, 2008; Mutun et al., 2009; Dobрева et al., 2013).

6. Lace bug, *Stephanitis rhododendri* Horvath, 1905 (Tingidae) living on ornamental *Rhododendron* spp. and on other Ericacea was introduced to Europe (the Netherlands) in the 1890s and then were indicated in many countries (tables I-III), though its present state is not clear. It was introduced to South Africa and New Zealand too (Pericart, Golub, 1996; Rabitsch, 2008, 2010).

7. Plant bug *Tupiocoris rhododendri* (Dolling, 1972) (Miridae) is a native of North American Atlantic coast. Its 1st European finding is in Kew Gardens, London (in 1971) and now it preys on aphids of ornamental *Rhododendron* spp. in England, the Netherlands, Belgium and Germany (Aukema et al., 2007; Aukema, Hermes, 2009; Rabitsch, 2008, 2010).

8. Plant bug *Tropidosteptes pacificus* (Van Duzee, 1921) (Miridae) originates from western USA and British Columbia, where it lives on maples, ashes and poplars. Before 1974 it has been introduced to Eastern USA (Pennsylvania). In 2007-2008 it was collected on European ash (*Fraxinus excelsior*) in natural environment in the Netherlands and Belgium. It was probably imported in Europe as eggs in plant material of North American ashes. Then it was found in England too (Aukema et al., 2009, 2013; Aukema, 2010, 2011).

9. Predacious shield bugs (or stink bugs) *Perillus bioculatus* (Fabricius, 1775) and *Podisus maculiventris* (Say) (Pentatomidae) from labo-

ratory populations were repeatedly released in 1930-60-ies onto potato fields for the sake of control of Colorado potato beetle in many countries. It seemed that the bugs dispersed without leaving a trace. Nevertheless, the "feral" *Perillus bioculatus* have been recently found in natural habitats as well as in gardens and fields in Serbia, Bulgaria, Greece and European Turkey. They prey on various other pests more often than on the notorious potato beetle and occur in non-potato fields and orchards more often than in potato fields (e. g. Rabitsch, 2008; Protic, Zivic, 2012; Simov et al., 2012).

10. The leafhopper assassin bug *Zelus renardii* (Kolenati, 1956) (Reduviidae) is a predator on various pests and useful insects in North America that was intentionally or unintentionally introduced to Chili, Philippines, Hawaii, Samoa, Jonston island. In 2010 it was revealed in Greece (Athens and the neighbouring woods of Attica) and Southern Spain (Murcia, Andalusia) (Davranoglou, 2011; Petrakis, Moulet, 2011; Vivas, 2012a; Baena, Torres, 2012). Probably it arrived as eggs on exotic plants (Davranoglou, 2011). It resembles native East-Mediterranean *Nagusta goedelii* (Kolenati, 1957), but differs by a lack of the post antennal spines (cornicles) as well as by some other traits.

11. The shore bug *Pentacora sphacelata* (Uhler, 1877) (Saldidae) was originally spread along the west American coast from California to Panama. In 1950 it was registered in Morocco and then it was found in some sea-coast habitats of Portugal, Spain and Italy (Sardinia) (Rabitsch, 2008). This halophilous species prefers the tidal zone close to saline waters, but at times may inhabit areas near fresh water as well (Polhemus 1968 — cyt. by Rabitsch, 2008).

12. A halophilic water boatman *Trichocorixa verticalis* (Fieber, 1851) (Corixidae), is a native of the east coast of America from Canada to the West Indies. In 1997-2004 years it was established in stagnant and slow lentic waters of some coastal saline territories of southern parts of Portugal and Spain. Before this it was introduced with the mosquito fish *Gambusia affinis* to New Caledonia and South Africa and this pathway is suggested for the European populations as well (Rabitsch, 2008).

Sub-group 1b. East Asian expatriates. There are four such species.

13. The brown marmorated shield bug *Halyomorpha halys* (Stal, 1855) (Pentatomidae) is a polyphagous horticultural pest on fruit trees and vegetables. In 1996–2004 it occupied a considerable part of the USA and in 2005 its nymphs and adults were collected in Switzerland near Zurich (Wermelinger et al., 2008; Rabitsch, 2008, 2010). Then it appeared in Germany and Lichtenstein too (Aukema et al., 2013).

14-15. Lace bugs *Stephanitis pyrioides* (Scott, 1874) and *S. takeyai* Drake et Maa, 1955 (Tingidae), feeding on ornamental *Rhododendron* spp. and on other Ericacea were repeatedly introduced to various European countries with planting stock. It seems that they consolidate their positions in several countries (tables I-II) using artificial plantings in cities and other settlements, cemeteries and botanic gardens. Both species were introduced also to North America whereas *S. pyrioides* — to South America and Australia and *S. takeyai* — to India too (e. g. Pericart, Golub, 1996; Aukema, 1996; Kment, 2007; Rabitsch, 2008, 2010; etc.).

16. Flower bug *Amphiareus obscuriceps* Poppius, 1909 (Anthocoridae). There are early date indications for Bulgaria (1901 — Tomov et al., 2009: 29; misprint? — *P. P.*) and for Serbia (1st half of XX century?) (Protic, 2011: 142). Since 1987 it has been detected in many European countries (tables I–III); it is treated as an invasive species for Asiatic Turkey and probably for Iran too (Aukema et al., 2007; Rabitsch, 2008, 2010). Its presence in Ukraine noted in Fauna Europea electronic source is plausible although remains unconfirmed and territorially unspecified.

Sub-group 1c. New Zealand expatriates. This group is represented by 1 species only.

17. Seed bug *Nysius huttoni* F.B. White, 1878 (Lygaeidae) was a New Zealand endemic species where it feeds on various weeds and crops. It had been unintentionally introduced to Europe probably with shipments via Antwerp somewhat before 2002. Then it settled down the dry and warm sites like waste grounds, roadsides, and abandoned fields in the Netherlands, Belgium, Northern France and England (e. g. Aukema et al., 2007, 2013; Smit et al., 2007; Rabitsch, 2008, 2010).

Sub-group 1d. Expatriates whose primary range remains unknown. There are two species belonging to this sub-group.

18. Flower bug *Amphiareus constrictus* (Stal, 1860) (Anthocoridae) was known from all continents except Europe. Only recently it was found in the Netherlands (2007) and in Belgium (2007). The future spread is probable: this predator is transported with orchids, food items, plant materials (Aukema, Hermes, 2009; Rabitsch, 2008, 2010; Aukema, 2011).

19. Flower bug *Buchananiella continua* (White, 1880) (Anthocoridae) has a pantropical area. It was described from Madeira and only after 1960 appeared in West and Southern Europe (tables I-II) as well as in Turkey and Israel (Péricart, 1996; Aukema, 2007; Rabitsch, 2008, 2010). In England it had appeared before 1972 (Péricart, 1972) and settled down before 1999 (Kirby — cyt. by Aukema, 2007 and Aukema et al., 2013).

Remark 1. Thus, out of 19 species of the 1st group four species established in Europe within 1890–1960, three within 1961–1991 and twelve ones after 1991. The recent acceleration of their introduction, naturalization and expansion processes is evident. Only 1 species (*Perillus bioculatus*) was brought by man in Europe on purpose while the other 18 species were introduced unintentionally. The prevalence of North American expatriates (12 species) over the bugs originating from other continents is considerably determined by climatic similarities between Europe and North America as well as by vast inflow to Europe of North American plant materials and other goods. The four Asian and one New Zealand expatriates might have arrived in Europe not only from their native lands but from North America where they had established earlier than in Europe (Rabitsch, 2008). The expansion to Europe (as well as to North America) of *Nysius huttoni* in spite of the presence of the several native *Nysius* spp. is remarkable since the natives of remote islands and southern continents are rarely successful in settling northern continents. Usually the reverse situation would take place: Eurasian or North American expatriates settled down in insular, Australian and South American ecosystems where they would often oust or exterminate the native species. Apparently, its establishment is limited to heavily disturbed habitats and not to quasi-natural ones.

Group 2. Probably extra-European invasive species. There are six European true bug species

continue by table 1

Bug species	Homeland, food habits	PT	SP	IT	SL	HR	BA	SB	ME	MK	BG	AL	GR	ETR
<i>Dicyphus escalerae</i>	SW/Europe, PR	>1999 ?Ab	1934 Ab	<1960 Ab	-	-	-	-	-	--	-	-	-	-
<i>Perillus bioculatus</i>	North America, PR	-	-	-	-	-	-	1996	-	-	?1972 2002	-	2004	1992
<i>Zelus renardii</i>	North America, PR	-	2010	-	-	-	-	-	-	-	-	-	2010	-
<i>Pentacora sphacelata</i>	North America, PR	1959	1953	1977	-	-	-	-	-	-	-	-	-	-
<i>Trichocorixa verticalis</i>	North America, AQ	1997 2003	2004	-	-	-	-	-	-	-	-	-	-	-
<i>Stephanitis pyrioides</i>	Japan, OF*	-	-	2004	<2010	-	-	-	-	-	-	1974	1995	-
<i>Stephanitis takeyai</i>	Japan, OF*	-	-	2000	-	-	-	-	-	-	-	-	-	-
<i>Empicoris rubromaculatus</i>	Unknown, PR	?<1964	?<1915	?<1926	-	1988	-	-	-	-	-	-	<2009	-
<i>Ploiaria chilensis</i>	Unknown, PR	-	<1966	?<1914	-	-	-	-	-	-	-	-	-	-
<i>Nesitocoris tenuis</i>	Unknown, MX*	<2009 ?Ab	<1985 ?Ab	?<1999 ?Ab	-	-	-	-	-	-	-	-	<1999 ?Ab	-
<i>Taylorilygus apicalis</i>	Unknown, PF*	<1958 ?Ab	1861 ?Ab	<1937 ?Ab	?+ ?Ab	<1894 ?Ab	<1894 ?Ab	-	-	-	?1964 ?Ab	<1937 ?Ab	?1937 ?Ab	<1999 ?Ab
<i>Nezara viridula</i>	? S/Europe ?Africa, PF*	<1957 ?Ab	?Ab	<1884 ?Ab	?+	?Ab	?+	?+	?+	?Ab	?1957 ?Ab	?Ab	?Ab	?Ab

Countries codes:

PT — Portugal, SP — Spain, IT — Italy, SL — Slovenia, HR — Croatia, BA — Bosnia-Herzegovina, SB — Serbia, ME — Montenegro, MK — Macedonia, BG — Bulgaria, AL — Albania, GR — Greece, ETR — European Turkey.

Table 2

Current presence of alien and partially alien bug species in Western (except Spain and Portugal) and Central European countries

Bug species	Homeland, food habits	IE	GB	NL	BE	FR	DE	SZ	AT	CZ	SK	PL	HU	RO
<i>Amphiareus obscuriceps</i>	East Asia, PR	-	-	2003	2007	-	2001	-	1998	1994	2000	<2010	1989	-
<i>Amphiareus constrictus</i>	Unknown, PR	-	-	2007	2008	-	-	-	-	?	-	-	-	-
<i>Anthocoris butleri</i>	S/W Europe, PR	1986	Ab	1969	1984	Ab	<1957	2000	1974	1962	2003	-	-	-
<i>Anthocoris sarothamni</i>	S/W Europe, PR	Ab	Ab	Ab	Ab	Ab	?<1921	?<1937	?<1921	?<1953	? +	?<1954	-	-
<i>Buchananella continua</i>	Unknown, PR	-	<1972 <1999	2007	<2009	1968	-	-	-	-	-	-	-	-
<i>Leptoglossus occidentalis</i>	North Amer., OF*	2010	2007	2007	2007	2006; 2005	2006	2002	2005	2006	2006	2007	2004	2008
<i>Arocatus longiceps</i>	S/Europe, OF	-	2006	2007	2007	1986; 1961	2007; 1995	2000; 1997	1995	1998	2000	-	1990	E. Ab
<i>Belonochilus numenius</i>	North Amer., OF	-	-	-	-	2008	2012	-	2010	2011	<2013	-	<2012	-
<i>Orsillus depressus</i>	S/Europe, OF	-	1987	1986	1986; LU1983	Ab	1971	1992; ?1954	?1948; ?AB	1993	1989	<2010	1900 ?Ab	Ab
<i>Oxycarenus lavaterae</i>	SW/Europe, OF	-	?2008 Inds	? 2007	-	1999; Ab	2004	2001; 1891 Ab	2001; 1870 ?Ab	2004	1995	-	<1958 ?Ab	2009
<i>Corytucha ciliata</i>	N. Amer., SF*	-	2005	2008	2006	1974	1983	1975	1982	1995	<1997	2009	1976	1990
<i>Corytucha arcuata</i>	N. Amer., SF*	-	-	-	-	-	-	2002	-	-	-	-	-	-
<i>Stephanitis rhododendri</i>	N. Amer., OF*	-	1901	?1890	1910	1913	1915	<1936	-	1941	-	<1927	-	-
<i>Deraeocoris flavilinea</i>	Italy, PR	-	1996	1985	1992	1984; 1961	1985	1987	2002	2003	-	-	-	-
<i>Dichroscytus gustavi</i>	Unknown, OF	-	<1988	1990	1943	?1971 <1987	?1934 ?Ab	?1900 ?Ab	?1932 2002	2000	1991	-	<1987	-
<i>Dicyphus escalerae</i>	SW/Eurp., PR	-	<2009	-	-	<1996 ?Ab	1994	2004	-	<2010	-	-	-	-
<i>Tripodostepes pacificus</i>	North Amer., PF	-	<2013	2007	2009	-	-	-	-	-	-	-	-	-
<i>Tupiocoris rhododendri</i>	North Amer., PR	-	1971	2002	2007	-	2004	-	-	-	-	-	-	-
<i>Halymorpha halys</i>	East Asia, PF*	-	-	-	-	-	<2013	2007	LI 2013	-	-	-	-	-
<i>Stephanitis pyrioides</i>	Japan, OF*	-	?<1960	1904	?	2005	-	2007	?<1963	-	-	-	-	-
<i>Stephanitis takeyai</i>	Japan, OF*	-	1995	1994	2003	2004	2002	<2011	<2011	<2008	-	1999	-	-

continue by table 2

Bug species	Home-land, food habits	IE	GB	NL	BE	FR	DE	SZ	AT	CZ	SK	PL	HU	RO
<i>Nysius huttoni</i>	N. Zeal, PF*	-	2008	2002	2003	2005	-	-	-	-	-	-	-	-
<i>Empicoris rubromaculatus</i>	Unknown, PR	-	-	?<2012	?<2009	?1914	-	-	-	-	-	-	-	-
<i>Nesidiocoris tenuis</i>	Unknown, MX	-	-	-	-	<1999	-	-	-	-	-	-	-	-
<i>Taylorilygus apicalis</i>	Unknown, PF*	-	-	-	-	1870 ?Ab	-	-	-	-	-	-	?1937	-
<i>Nezara viridula</i>	? Africa PF*	-	?1959 2003	-	?1950	1789 ?Ab	1979	<1960 2005	?1870 1962	-	-	-	?<1960 2002	+

Countries codes:

IE — Ireland, GB — Great Britain, NL — Netherlands, BE — Belgium (with Luxembourg: indicated as LU in case of *O. depressus*), FR — France (with Monaco and Andorra), DE — Germany, SZ — Switzerland, AT — Austria (with Lichtenstein: indicated as LI in case of *H. halys*), CZ — Czech Republic, SK — Slovakia, PL — Poland, HU — Hungary, RO — Romania.

with sub-cosmopolite range and unknown origin. They are easily propagated by man. Among them 2 are predators, 1 is mix-feeder and 3 are plant-feeders.

20. Assassin thread-legged bug *Empicoris rubromaculatus* (Blackburn, 1889) (Reduviidae) has a pan-tropical distribution. It is not clear whether it conquered such enormous area solely by human propagation or by means of natural wind transportation as well. It is equally unclear whether its presence in the Iberian Peninsular and in Southern France is native or secondary one (Putskov, Moulet, 2009). However, its advance to the North/West and to the South/East of Europe (tables I-II) is surely a recent phenomenon.

21. Assassin thread-legged bug *Ploiaria chilensis* (Philippi, 1862) (Reduviidae) has probably a pan-tropical distribution (e. g. Putshkov, Moulet, 2009). While being quite common in the Canaries, the Azores and the Madeira islands, its presence on mainland Europe is testified only by old findings in Spain (Tarragona: Tortosa, <1966) and Italy (Liguria: San Remo, <1914). It seems that it did not expand its range in Europe as opposed to other species considered here.

22. Leaf bug *Nesidiocoris tenuis* (Reuter, 1895) (Miridae) is a sub-cosmopolitan species, originally described from Tunis and Madeira that has been transported widely with goods. It was not recorded for Europe till 1985 (Wagner, 1974; Kerzher, Josifov, 1999), but the possibility that some southern outskirts of the continent were naturally populated by this bug could not be ruled out. It is a zoo-phytophage feeding on its host plants of Solanaceae family and preying on small arthropods, including the aphid *Myzus persicae* Sulzer, 1776 as well as the eggs and small caterpillars of the invasive tomato leafminer *Tuta absoluta* (Meyrick, 1917) originating from South America and having invaded many European countries after 2006. *N. tenuis* in the Mediterranean region enters greenhouses (especially tomato cultures) inflicting both use and damage (Malausa, 1989; Rabitsch, 2008).

23. Leaf bug *Taylorilygus apicalis* (Fieber, 1861) (Miridae) is reputed to be a tropical (African?) species that has been transported by man throughout the tropical, subtropical, and temperate regions of the world. Indeed it moves easily with commerce and might have been

introduced to Europe several times independently (e. g. Rabitsch, 2008; Tomov et al., 2009). However, it was recorded for Spain, Southern France and Western Balkans in XIX century (tables I-II) (Fieber, 1861; Wagner, Weber, 1964; Kerzhner, Josifov, 1999) and the possibility of its native status in the Mediterranean region (Wagner, Weber, 1964) could not be denied too.

24. Leaf bug *Dichrooscytus gustavi* Josifov, 1981 (Miridae) feeding on *Juniperus communis* and on introduced Cupressaceae (*Chamaecyparis*, *Thuja*, *Juniperus*) became a widespread species in XX century (tables I-III). There are many of its findings in parks, gardens, and cultivated juniper stands but its presence in the natural ones is questioned (e. g. Bryja, Kment, 2002; Aukema, 2003; Rabitsch, 2008, 2010). However, the possibility of its native status for Switzerland, Austria and Southern Germany could not be completely discount as yet.

25. Southern Green Shield Bug *Nezara viridula* (Linnaeus, 1758) (Pentatomidae) is a polyphagous pest of various crops that extended its presence widely to tropical, subtropical and warm-temperate regions of all continents by transport of goods and living plants. It is not clear whether its original range were confined to Tropical Africa or some parts of the Mediterranean Region including South Europe were its native lands too. About 1860 it was rather common there ("Im suedlichen Europa nicht selten" — Fieber, 1861: 330). In Southern France it was certainly present in the late XVIII century (Rider, 2006: 329) but the large-scale shipping of tropical plants and plant production to Europe had begun about 300 years before... By now, *N. viridula* has been found in many European countries (tables I-III). To some of them (Hungary, etc.) it has expanded recently whereas in some others (England, Bulgaria, etc.) it becomes more common than before (e. g. Redej, Torma, 2003; Rabitsch, 2008, 2010; Tomov et al., 2009). Particularly, in 2013 a serious damage to tomatos (chlorosis) was noted in some localities of Crimea (Rybachye) where up to 40 sucking individuals (adults and larvae) sucking per one tomato fruit were found (A. G. Radchenko, pers. comm.). Similar situation took place in some regions of Bulgaria in 2006-2007 (Simov et al., 2012).

Remark 2. Among six species of the 2nd group five species (*Nezara viridula*, *Empicoris*

rubromaculatus, *Ploiaria chilensis*, *Nesidiocoris tenuis* and *Taylorilygus apicalis*) are either earlier man-aided intruders to Southern Europe or this region was the northern outpost of their mostly tropical ranges. *Dichrooscytus gustavi* was either imported to Europe with Cupressaceae seedlings or it was a rare native species probably confined to foothills of Alps. All species of this group except the rare *Ploiaria chilensis* extend now their ranges within Europe.

Group 3. Intra-European invasive species.

Many bugs native for Southern Europe, expanded to their middle or even to boreal part.

The notorious common bed bug (*Cimex lectularius* L.) might be the first true bug that realized such expansion. Its presence was registered for Greece in V century BC (Aristophane comedy "Bed Bug", etc.), while for France, Germany and England it was mentioned for the first time in the 11th, 13th and early 16th centuries AC correspondingly (Brehm, 1895; Rabitsch, 2008). However, the presence of "wild" bed bug populations living on bats well beyond Southern Europe (e. g. in Ukrainian Carpathian caves) give some rise to doubts in the purely alien origin of the Middle and North European synanthropic populations of this species. The presence of synanthropic assassin bug *Reduvius personatus* L. (probably of Mediterranean origin) is ascertained for Southern France of 15th (Dusoulier, 2007) and for England of 17th (Dolling, 2007) centuries correspondingly.

Several true bug species expanded their ranges in XIX-XX centuries due to the human-driven expansion of their host plants. One of them is *Anthocoris butleri* Le Quesne, 1954 (Anthocoridae), preying the psyllid *Psylla buxi* (Linnaeus) and living on the boxwood shrub *Buxus sempervirens*. This shrub is native and quite common in France, Spain, and Great Britain and is (was) commonly used as an ornamental plant in house gardens and cemeteries across Europe, whence it sometimes escaped here and there and established locally. Therefore, records of *A. butleri* outside the natural range of *B. sempervirens*, especially in urban settings, should be regarded as alien ones (Péricart, 1972; Rabitsch, 2008). The same considerations motivate to consider the Central-European findings of flower bug *Anthocoris sarothamni* Douglas et Scott, 1865 (Anthocoridae), leaf bugs *Orthotylus*

adenocarpi (Perris, 1857), *O. concolor* (Kirschbaum, 1856), *O. virescens* (Douglas et Scott, 1865) (Miridae) and lace bug *Dictyonota fuliginosa* (Tingidae) as alien ones: all these bugs are confined to Spanish broom (*Cytisus scoparius*) that is commonly used as an ornamental plant across Europe. The leaf bug *Macrolophus glaucescens* Fieber, 1858 (Miridae) and lace bug *Elasmotropis testacea* (Herrich-Schaeffer, 1830) (Tingidae) expanded their ranges to Central Europe with their host-plants *Echinops* spp. (Stichel, 1937; Rabitsch, 2008, 2010).

After 1950 so many Mediterranean bug species advanced to Middle (Austria, Hungary, Slovakia, Czech Republic, Southern Germany, Switzerland) and North-Western (Great Britain, Northern France, Western Germany, Holland, Belgium, Luxemburg) Europe; the term «mediterraneanization» of entomofaunas was even proposed (Rabitsch, 2008, 2010; Musolin, Saulich, 2012). For example, *Deraeocoris flavilinea* (A. Costa, 1862) (Miridae), a tree-living predator on aphids, psyllids, small flies and on eggs of various bugs, had been known only from Italy (*e. g.* Stichel, 1937: 384) till 1961 when it was registered on Corsica. Later it was found in a great part of Europe (tables I–III) occurring mostly in cultivated and urban landscapes. It is supposed that it was introduced unintentionally along transportation routes (Kment et al., 2005; Rabitsch, 2008, 2010; Gesse, 2011; Vivas, 2012b; Simov et al., 2012). The seed bug *Arocatus longiceps* Stal, 1872 (Lygaeidae) living on plane-trees was originally a ponto-eastmediterranean species that appeared in Southern France in 1960-ies and invaded sycamores in many Central and West European lands in 1980–2008 (tables I–II). It advances along Western (via the Rhine valley) and Eastern (from the Balkan through eastern Austria and Czech Republic) ways by active flight and due to unintentional introduction with motor vehicles and the transportation of plane-tree seedlings (Hoffmann, 2008; Rabitsch, 2008; Aukema, 2011). In Ukraine it was known only in Southern Crimea (Putshkov, 1969: 77; Pericart, 1998: 173; Putshkov, Putshkov, 1996: 62) and now it is found under the plane-tree bark in Nikolayev too (15. X. 2013, coll. P. V. Putshkov). Likewise, the seed bug *Orsillus depressus* (Mulsant & Rey, 1852) (Lygaeidae) advanced considerably northwards to Central Europe, being unintentionally intro-

duced with seeds or plant material from the Mediterranean region. It uses here non-native Cupressaceae (planted alien *Juniperus* spp., *Thuja*, *Chamaecyparis*) and invades the native *Juniperus communis* stands too (Pericart, 1998; Rabitsch, 2008, 2010). Also West-Mediterranean seed bug *Oxycarenus lavaterae* (Fabricius, 1787) living on Malvales (*e. g.*, *Lavatera*, *Corylus*, *Tilia*) expanded considerably its range. It was known from southern Switzerland, southern France and Slovenia since 19th century, but recently it has been found (probably introduced) further into northern and eastern countries (tables I–III) (Rabitsch, 2008, 2010; Tomov et al., 2009; Simov et al., 2012). This recent formation of its established populations beyond the West Mediterranean region became possible thanks to milder winter temperatures than before and due to increasing number of introductions (exchange of host plant material, traffic). The species was found even in North Germany (2004) with Italian plant material and (indoors) — in Finland (2003) (Kment et al. 2006, Kment, 2009, Rabitsch, 2008, 2010; Simov et al., 2012). *Dicyphus escalerae* Lindberg, 1934 is a native of Spain, Italy and southern France. It has expanded recently to northern France, south-western Germany and Switzerland. It lives on snapdragon *Antirrhinum majus* that was a popular and widespread garden plant throughout Europe for a long time before. Only now the warming and the increasing quantity of transportation of goods allowed this bug to move north-eastwards following its host plant (Hollier, Matocq, 2004). Several *Tuponia* spp. previously known from South Europe and Middle Asia expanded to Central and/or North-Western Europe due to the wide use of their host plants *Tamarix* spp. for the urban gardening. There are many other similar cases (*e. g.* Kment et al., 2005; Rabitsch, 2008, 2010; Aukema, Hermes, 2009; Aukema, 2011; Simov et al., 2012; Aukema et al., 2013).

Remark 3. The range expansion of some South European true bugs took place since the Middle Ages if not earlier. More species were involved in the process in 1800–1950 and considerably more after 1950.

Recent distribution of alien true bugs throughout various European countries is shown below in tables I–III. Species of the groups 1 and 2 are included in these tables completely along with some species of the group 3.

Table 3

Current presence of alien and partially alien bug species in North and East European countries

Bug species	Homeland, food habits	DK	SE	NO	FI	EE	LV	LT	BY	MD	UA	REN	RES
<i>Amphiareus obscuriceps</i>	? East Asia, PR	?	-	-	2003	2004	-	<2009	1992	-	?	?	?
<i>Anthocoris butleri</i>	S/W Europe, PR	<2013	<1967	-	-	-	-	-	-	-	-	-	-
<i>Anthocoris sarothamni</i>	S/W Europe, PR	<2009	<2005	-	-	-	-	-	-	-	-	-	-
<i>Leptoglossus occidentalis</i>	North America, PE	2009	+	2009	-	-	-	-	-	2008	2010	-	2011
<i>Arocatus longiceps</i>	S/Europe, SF	-	-	-	-	-	-	-	-	-	2013; K:Ab	-	Ab
<i>Orsilius depressus</i>	S/Europe, OF	<2009	-	-	1978?	-	-	-	-	-	Ab	-	Ab
<i>Oxycarenus lavaterae</i>	SW/Europe, PF	-	-	-	?2003 GHS	-	-	-	-	-	-	-	?
<i>Corytucha ciliata</i>	North Amer., SF*	-	-	-	-	-	-	-	-	<2007	<2007	-	1997
<i>Stephanitis rhododendri</i>	North Amer., SF*	1912	<1948	-	1983 GHS	-	-	-	-	-	-	-	-
<i>Deracocoris flavilinea</i>	Italy, PR	<2013	<2005	-	-	-	-	-	-	-	-	-	-
<i>Dichroscytus gustavi</i>	Unknown, OF	<2013	-	-	2003	-	-	-	-	-	-	-	-
<i>Tupiocoris rhododendri</i>	North Amer., PR	<2013	-	-	-	-	-	-	-	-	-	-	-
<i>Taylorilygus apicalis</i>	Unknown, PF*	-	-	-	-	-	-	-	-	-	<1964	-	-
<i>Nezara viridula</i>	? Africa, PF*	-	-	-	?1956	-	-	-	-	-	K:1906; K:1928	-	<1933

Countries codes:

DK — Denmark, SE — Sweden, NO — Norway, FI — Finland, EE — Estonia, LV — Latvia, LT — Lithuania, BY — Byelorussia, MD — Moldavia, UA — Ukraine (in cases of *A. longiceps* and *N. viridula*: K — Southern Crimea), REN — Northern part of European Russia, RES — Southern part of European Russia.

The sources used for these tables are mentioned above with every species comments.

In the 1st column species names are given; the authors' names (see text above) are omitted. In the 2nd column initial homelands (continent/island for extra-European species or part of Europe for European ones) are indicated together with the food habits codes. These codes are the following: AQ — aquatic phytophagan, MX — omnivorous (eventual predator or phytophagan according to situation), OF — oligophagous plant-feeder (a phytophagan on plants of one or several related families), PF — polyphagous plant-feeder (a phytophagan on plants of many families, including the distantly related ones), PR — predator, SF — stenophagous plant-feeder (a phytophagan on plants of one genus). An asterisk with the food habits codes (OF*, SF*, PF*) means that the species was repeatedly registered as a pest of agricultural and/or ornamental plants.

In the columns from 3rd to 15th the species presence/absence in European countries are shown. Countries codes are decoded under every table. Symbols in squares are the following: “1995” (or other cipher) — year of the 1st verified capture of the invasive species for the country; “<1995” — the invasive species was certainly present in the country somewhat before the year indicated in the square; “?<1964” — the invasive species was probably present in the country well before the year indicated in the square; “>1999” — the invasive species was recorded for the country after the year indicated in the square; “?1901 1987” — two years non-divided with semicolon mean that the first invasive species introduction was or might be unsuccessful one; “+” or “?+” — the species is certainly or probably invasive for the country though the time of its naturalization could not be appreciated; “2008; 2010” or “1986; 1961” — two years divided with semicolon mean the different time of the invasive species record in northern (1st cipher) and southern (2nd cipher) part of the country; “Ab” or “?Ab” — species is certainly or probably native for the country; “1999 Ab” or “?1934 ?Ab” — the year of the 1st verified capture for species that is certainly or probably native for the country; “1999; Ab” or “+; ?Ab” — the species is invasive for northern and native or probably native for southern part of the country; “E: Ab” — the species is native

only for eastern part of the country; “–” for a moment the species is “absent” (has no free living reproducing populations) in the country; “?” the current presence of the species in the country is probable; “Inds” — the alien species in the country is found only indoors; “GHS” — the alien species in the country is found only in greenhouses.

Reasons of the invasive true bugs expansion into Europe. The main reasons of such a vast alien bugs expansion are various aspects of human activity. Among them, broad-scale introduction of numerous alien plants to urban and extra-urban environments is very important. This together with human-induced decline (up to extinctions) of many native plants and animals due to man-made changes of native communities (up to their total or quasi-total destruction) often create the suitable conditions for alien species naturalization. The unprecedented intensification of intercontinental and intracontinental flows of people and goods extraordinarily increased frequency of alien bugs unintentional introduction and raised their possibilities for the stable populations formation beyond the borders of previous species range. The most important pathway of alien Heteroptera is unintentional translocation with ornamental plants and goods aided with passive and/or active natural dispersal. These human-driven effects are supplemented by those of the natural warming trend of the last decades (the notorious “global warming”) that create milder condition for bugs expatriates from warm climate countries. However, humans intensify the natural warming impact as well by creating industrial “islands of warmth” in megalopolises and along intensively used autobahns. Previously euryoecic (eurybiotic) and polytrophic species had more chances for successful naturalization in new countries. Now the mass introduction of exotic plants favors to insects oligophagous and monophagous on these plants. Many of invasive bug species remain confined to urban/suburban horticultural and/or domestic habitats while others penetrate well to quasi-natural ecosystems (e. g. Rabitsch, 2008; Roques et al., 2008; Musolin, Saulich, 2012).

Conclusion. During the last 50 years many true bug species of European and extra-European origin have occupied vast territories in

Europe previously devoid of them. Such range expansion took place due to various human-induced (intensification of intercontinental and intracontinental flows of people and goods, broad-scale introduction of numerous alien plants, changes of native landscapes and communities, creating the industrial “islands of warmth” in megalopolises) and natural warming effects. Appearance and expansion of two alien pests of sycamores (lace bug *Corytucha ciliata*) and conifers (coreid *Leptoglossus occidentalis*) in Ukraine as well as appearance beyond Crimea of sycamore feeding seed bug *Arocatus longiceps* are regional emergences of this general tendency.

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