

Alien leaf beetles of European Russia: native ranges, invasion history, biology and vectors of dispersal

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Abstract

Invasions of leaf beetles are of great ecological and economic significance, but poorly studied. The rate of these invasions in Europe is dramatically increasing. Some established species spread quickly occupying almost the whole continent within several decades. We present the first inventory of alien leaf beetles of European Russia. For each species the map of distribution is provided and the history of invasion in the world is discussed. Two species native to Mediterranean Region: *Chrysolina americana* (pest of *Rosmarinus* and *Lavandula*) and *Leptomona erythrocephala* feeding on *Lotus corniculatus* are recorded in European Russia for the first time. A polyphagous pest of floriculture *Luperomorpha xanthodera* native to China and Korea and pest of soybeans *Medythia nigrobilineata* native to East Asia were recorded in 2016. A pest of tobacco *Epitrix hirtipennis* native to North America was recorded in 2013. A pest of corn *Diabrotica virgifera* was intercepted at the border of Russia in 2011, but is not established. Three alien species were recorded in the 20th century: *Zygogramma suturalis* introduced from North America for control of *Ambrosia*, *Phyllotreta reitteri* native to Afghanistan and Tajikistan and feeding on *Lepidium latifolium*, and the Colorado potato beetle *Leptinotarsa decemlineata*. The Black Sea region is more prone to leaf beetle invasions than other regions of European Russia. Leaf beetles usually occur only on alien or cultivated plants. Some species feed on native plants in native communities. So it is difficult to distinguish species established before the 20th century from native ones.

Keywords Chrysomelidae; pests; beetles; alien species; non-native species; distribution.

Introduction

There are major gaps in knowledges on regional alien floras and faunas and data availability varies among regions (Pyšek et al. 2017). In particular, alien insects of European Russia are poorly studied. The most of information is published in local sources and stays unknown to the wide audience, because is not included to international databases. We present the first inventory of alien leaf beetles of this territory.

Leaf beetles (Chrysomelidae except Bruchinae) is a large group of phytophagous beetles (more than 36 000 species in the world, about 600 in European Russia) (Jolivet 1995; Bieńkowski 2011). Negative economic impact of invasions of these insects is significant, since some of them, e.g. *Leptinotarsa decemlineata*, *Diabrotica virgifera* and *Epitrix papa*, are major pests of various crops (EPPO 2017). In spite of it, invasions of leaf beetles are poorly studied (Beenen 2006). Before 2010 only 11 species alien to Europe were recorded (Beenen and Roques

2010), and the information about invasions of leaf beetles to European Russia was restricted to *Leptinotarsa decemlineata* and *Zygogramma suturalis* (Ivanchik and Izhevsky 1981; Kovalev and Medvedev 1983; Maslyakov and Izhevsky 2011).

Four alien species were first recorded in European Russia in 2011–2016: *Diabrotica virgifera* (VNIIKR 2012), *Epitrix hirtipennis* (Orlova-Bienkowskaja 2014), *Luperomorpha xanthodera* (Bieńkowski and Orlova-Bienkowskaja 2018a) and *Medythia nigrobilineata* (Bieńkowski and Orlova-Bienkowskaja 2018b). Analysis of ecology and dynamics of ranges of some other species has revealed that they could represent archeoinvaders, i.e. alien species established in European Russia before the 20th century (Orlova-Bienkowskaja 2013a, b). Here we present the first records of two alien species new to European Russia: *Leptomona erythrocephala* and *Chrysolina americana* and the review of all other leaf-beetles alien to this region. For each species a database of records and a map of geographical distribution are compiled and the following information is provided: data on host plants and other features of biology, description of native range, invasion history, possible vectors of dispersal and economic impact of establishment. This article is a part of the project "Alien beetles of European Russia".

Materials and methods

Distribution of alien species was studied on the base of own collection of the authors in European Russia in 1988–2017, examination of specimens from collections of ZIN (Zoological Institute of Russian Academy of Sciences, St. Petersburg, Russia), ZMMU (Zoological Museum of Moscow State University, Moscow, Russia), FNMS (Senckenberg Naturmuseum, Frankfurt am Main, Germany), HNHM (Hungarian Natural History Museum, Budapest, Hungary), MTD (Museum für Tierkunde, Dresden, Germany), NHMW (Naturhistorisches Museum, Wien, Austria), NMP (National Museum in Prague, Prague, Czech Republic), VNIIKR (Russian Plant Quarantine Center, Bykovo, Russia), BSU (Belgorod State University, Belgorod, Russia), OSU (Orel State University, Orel, Russia), BNR (Belogorie Nature Reserve, Borisovka, Russia), and 17 private collections in Russia: AB (A.O. Bieńkowski, Zelenograd), AK (A.G. Koval, St. Petersburg), AP (A.I. Prikhodko, Zelenograd), AR (A.B. Ruchin, Saransk), AU (A.S. Ukrainsky, Moscow), EI (E.V. Iljina, Makhachkala), GK (G.A. Korostov, Elista), MD (M.M. Dolgin, Syktyvkar), NN (N.E. Nikolaeva, Tver), NO (N.V. Okhrimenko, Krasnodar), PP (P.N. Petrov, Moscow), PR (P.V. Romantsov, St. Petersburg), RI (R.N. Ishin, Tambov), SM (S.A. Mosyakin, Simferopol), TM (T.A. Mogilevich, Zelenograd), VF (V.I. Filippov, Sochi), YK (Y.N. Kovalenko, Moscow). In addition data from Global Biodiversity Information Facility and from

82 literature sources were used. We use criteria of alien status and terminology used in invasion biology defined by Richardson et al. (2000) and Blackburn et al. (2011).

Here we adhere to the system adopted in the Catalogue of Palaearctic Coleoptera (Kippenberg 2010; Beenen 2010; Döberl 2010). We study invasions only of leaf-beetles in the narrow sense of the word, i.e. all subfamilies of Chrysomelidae except seed beetles (Bruchinae), because seed beetles are very different from other Chrysomelidae in biology and ecology and have different vectors and trends of invasions (Beenen and Roques 2010). Species below are presented in reverse chronological order of their first records in European Russia.

2017 – *Leptomona erythrocephala* (Olivier, 1790) (Galerucinae)

Native range. *Leptomona erythrocephala* is native to mainland Spain, Mallorca, Portugal, south France, Sicily, Algeria and Morocco (Fig. 1) (Reitter 1886; Biondi et al. 1995; Beenen 2010; Aberlenc 2010). Junior synonym *Monolepta verticalis* Reitter, 1886 was described from Portugal (Reitter 1886). *Leptomona erythrocephala* was also recorded from northern Italy, but this record is supposed to be questionable (Biondi et al. 1995). Database on localities of *L. erythrocephala* is provided in electronic supplementary material 1.

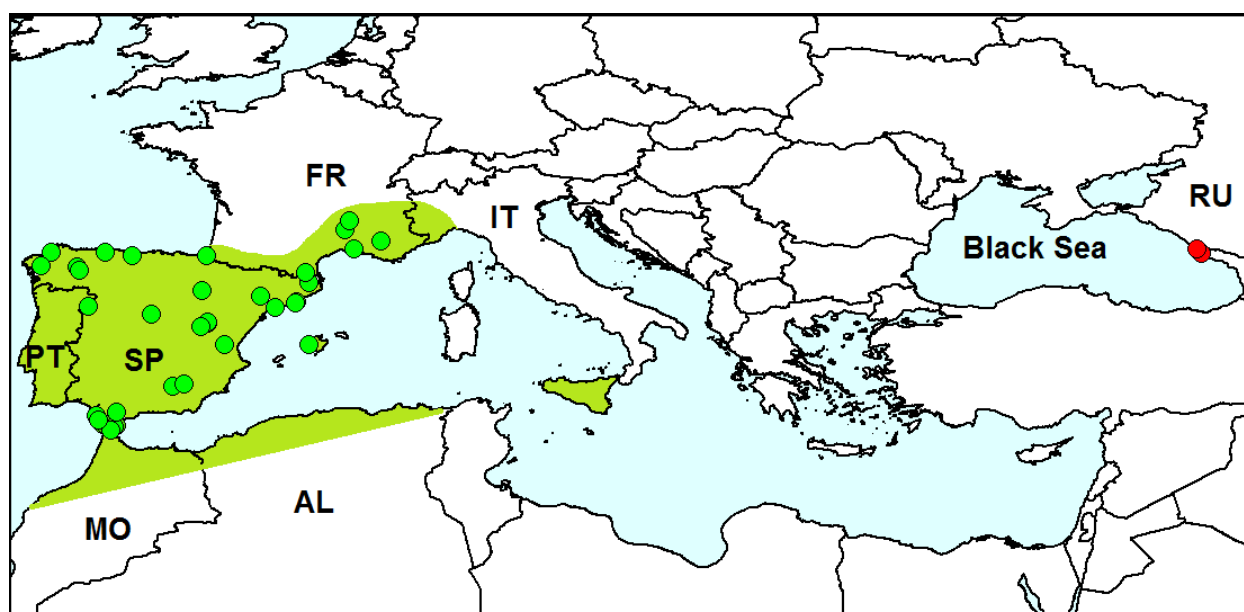


Fig. 1. Distribution of *Leptomona erythrocephala*. Red dots – localities of specimens outside species native range (original data), green dots on the green background – localities of specimens in the native species range. AL – Algeria, FR – France, IT – Italy, MO – Morocco, PT – Portugal, RU – Russia, SP – Spain. Sources of information about localities of the species in its native range: Heyden and Allard (1870), Reitter (1886), Champion (1902), Daccordi and Petitpierre (1977), Petitpierre (1981, 1997, 2005, 2007), Aberlenc (1987, 2010), Biondi et al. (1995), García-Ocejo and Gurrea (1995), Baselga and Novoa (2003, 2004, 2006), Staines and

Whittington (2003), Schmidt et al. (2005), Petitpierre et al. (2011, 2017), Petitpierre and Daccordi (2013), GBIF (2017a).

Invasion history. This species was not recorded outside its native range before.

Records in European Russia. In 2017 we found *L. erythrocephala* in the north-west Caucasus, near the Black Sea coast. The first specimen was found on June 3 on the bank of the pond in Imeretian resort by sweep-netting (43°24'N, 39°58'E). Then on June 6 about 50 specimens were found on the ruderal plant *Lotus corniculatus* in Razdolnoe, in the floodplain of Bzugu River (43°36'N, 39°46'E).

Taxonomy and identification. The genus *Leptomona* Bechyné, 1958 was distinguished by J. Bechyné from the large genus *Monolepta* Chevrolat, 1836 and includes four species: *L. erythrocephala* distributed in Mediterranean region, *L. russica* (Gmelin, 1790) distributed in the steppes of Eastern Europe and western Asia, *L. fulvicollis* (Jacoby, 1885) distributed in Japan and *L. subseriata* (Weise, 1887) distributed in East Siberia and the Far East. Only one species – *L. russica* has been recorded in European Russia (Bieńkowski and Orlova-Bienkowskaja 2013).

Leptomona erythrocephala differs from other species of the genus by the shape of aedeagus (Fig. 2) and by the following characters: punctation of elytra entirely confused; pronotum covered with punctures which slightly smaller than those on elytra; head, pronotum, prosternum, coxae, femora, tibiae and antennomeres 1–3 reddish, mesosternum brown, elytra blue, labrum, tarsi, metasternum, abdominal tergites and sternites black; hind wings reduced. Identification of specimens collected in Sochi (see electronic supplementary material 2) was confirmed by their comparison with specimens of *L. erythrocephala* from ZIN collected in Spain.

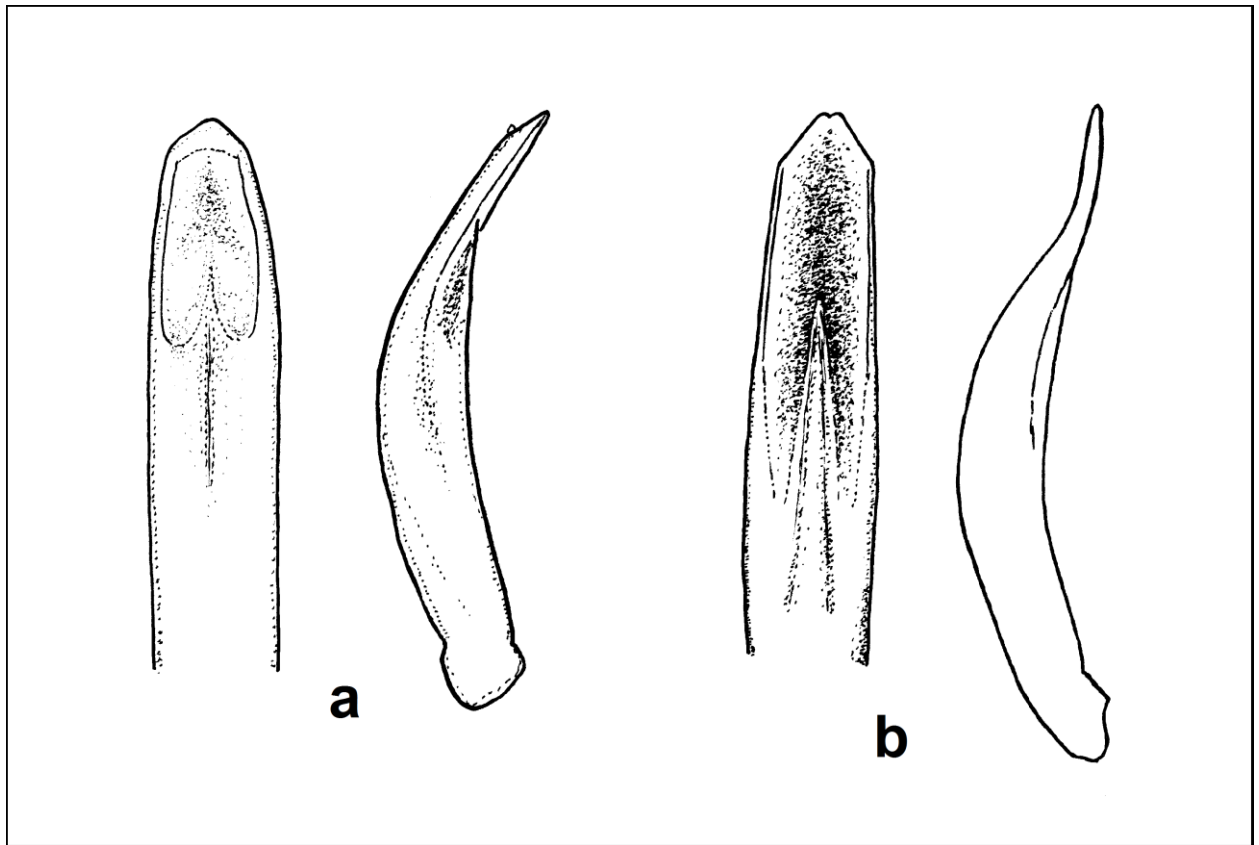


Fig. 2. Aedeagus of *Leptomona erythrocephala* from Sochi (a) and *L. russica* (b).

Biology. Host plant of this species was unknown till now. But *L. russica* and representatives of the closely related genus *Monolepta* feed mainly on Fabaceae (Medvedev and Roginskaya 1988). Our observations in nature have shown that *L. erythrocephala* feeds on *Lotus corniculatus* (Fabaceae), which is a common ruderal plant in the city. Feeding on this plant was confirmed by our observations in cage. Ten specimens were placed in cage with the following Fabaceae plants collected in the same biotope: *Trifolium repens*, *Trifolium aureum*, *Gleditsia triacanthos* and *Lotus corniculatus*. The beetles fed only on *L. corniculatus*: gnawed margins of leaves and petals.

Invasion status. Obviously, *Leptomona erythrocephala* is established in the region. First, many specimens were collected in the wild in two localities. Second, it feeds on the native plant.

Vector of dispersal. Sochi is more than 2000 km far from the native range of the species. So the natural spread is impossible. The most probable dispersal vector is an unintentional introduction with planting material or soil. The distance between two localities where *L. erythrocephala* was found in the Caucasus is 28 km. Since *L. erythrocephala* is a flightless beetle and its natural dispersal ability is restricted, it seems that dispersal of *L. erythrocephala* in the region is connected with an unintentional introduction by man.

Economic impact. *Leptomona erythrocephala* is not regarded as a pest in its native range. But special attention should be paid to trophic specialization of this species in the Caucasus, especially if it becomes abundant. It should be taken into account that the representatives of the genera *Leptomona* and *Monolepta* feed on Fabaceae, and one of them, *Monolepta quadriguttata* (Motschulsky, 1860), is a serious pest of soybean (Medvedev and Roginskaya 1988; Moseiko 2010).

2016 – *Luperomorpha xanthodera* (Fairmaire, 1888) (Alticinae)

Native range. Rose flea beetle is native to China and Korean peninsula (Döberl 2010).

Invasion history. (Fig. 3). This pest was firstly found in Europe in 2003 on British Islands (Johnson and Booth 2004). Then it quickly spread to Italy (Conti and Raspi 2007), France (Doguet 2008), Germany, Switzerland (Döberl and Sprick 2009), The Netherlands (Beenen et al. 2009), Hungary (Bodor 2011), Austria (Geiser and Bernhard 2012), Poland (Kozłowski and Legutowska 2014), Belgium (Fagot and Libert 2016), Spain (Viñolas et al. 2016) and European Russia (Bienkowski and Orlova-Bienkowskaja 2018a).

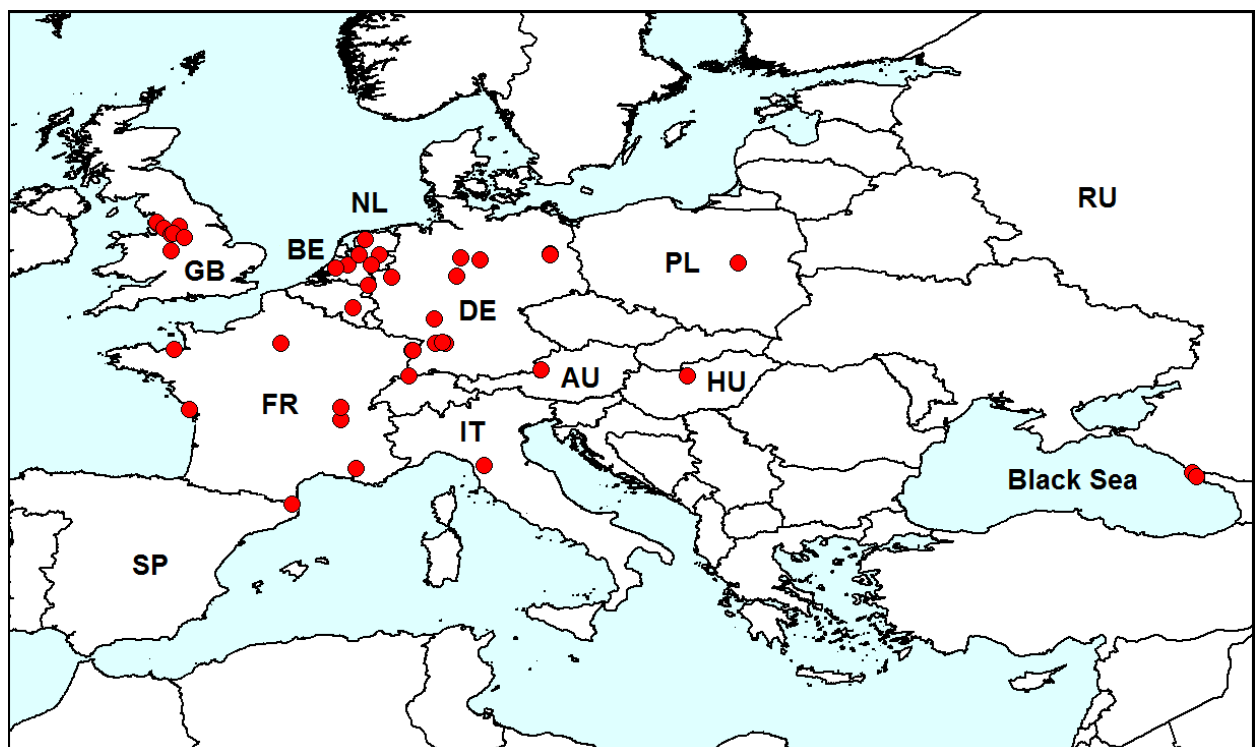


Fig. 3. Distribution of *Luperomorpha xanthodera* in Europe. Red dots – localities of *L. xanthodera* in Europe. AU – Austria, BE – Belgium, DE – Germany, FR – France, GB – Great Britain, HU – Hungary, IT – Italy, NL – Netherlands, PL – Poland, RU – Russia, SP – Spain. Sources of information: Johnson and Booth (2004), Doguet (2008), Conti and Raspi (2007), Döberl and Sprick (2009), Beenen et al. (2009), Vincent and Doguet (2011), Bodor (2011), Geiser and Bernhard (2012), Kozłowski and Legutowska (2014), Fagot and Libert (2016),

Viñolas et al. (2016), Callot (2017), Heinig and Schöller (2017), Bieńkowski and Orlova-Bienkowskaja (2018a) and original data (see below). Database on localities of *L. xanthodera* is provided in electronic supplementary material 3.

Records in European Russia. In 2016 *L. xanthodera* was firstly recorded in European Russia (Bieńkowski and Orlova-Bienkowskaja 2018a). On 22.05.2016 we found one female in Adler district of Sochi in the wastelands and roadside at south-west border of the international airport Sochi (Adler) (43°26'N, 39°55'E). On 23.05.2016 numerous beetles were observed in the Central district of Sochi (43°35'N, 39°45'E) on rose flowers. On 8.06.2017 two males and one female were collected with a sweep net in Adler district of Sochi, in Olympic Village on grasses on the bank of the pond (43°25'N, E 39°56'E).

Biology. *Luperomorpha xanthodera* is a polyphagous species. Adults feed on flowers of many plants (23 genera from 19 families), larvae develop on roots of these plants (Del Bene and Conti 2009). In Sochi adults of *L. xanthodera* feed flowers of roses and citrus plants (Bieńkowski and Orlova-Bienkowskaja 2018a).

Vector of dispersal. *Luperomorpha xanthodera* was probably unintentionally introduced as larvae on roots of imported seedlings, or as adults transported as cargo stowaways in airplanes. Both vectors are quite possible in the region of Sochi. First, this city is close to the international airport. Second, mass planting with imported planting material was carried out there during the landscaping of the city in preparation for the Olympic Games, which took place in 2014. Many other invasive pests have been introduced and established in the city in this period (Bieńkowski and Orlova-Bienkowskaja 2018a).

Invasion status. *Luperomorpha xanthodera* is established in the region. Finds of numerous specimens in two subsequent years in different localities indicate, that a self-sustaining population exists in the wild, and the species is dispersing in the region.

Economic impact. Establishment of *L. xanthodera* in the south of European Russia could cause negative economic consequences, since it is a pest of ornamental flowers.

2016 – *Medythia nigrobilineata* (Motschulsky, 1861) (Galerucinae)

Native range. Two-striped leaf beetle *Medythia nigrobilineata* (= *Paraluperodes suturalis nigrobilineatus*) is native to North China, Japan, Nepal, Pakistan, South Korea, East Siberia and the Russian Far East (Fig. 4) (Medvedev 1992; Beenen 2010; Warchałowski 2010; Toepfer et al. 2014).

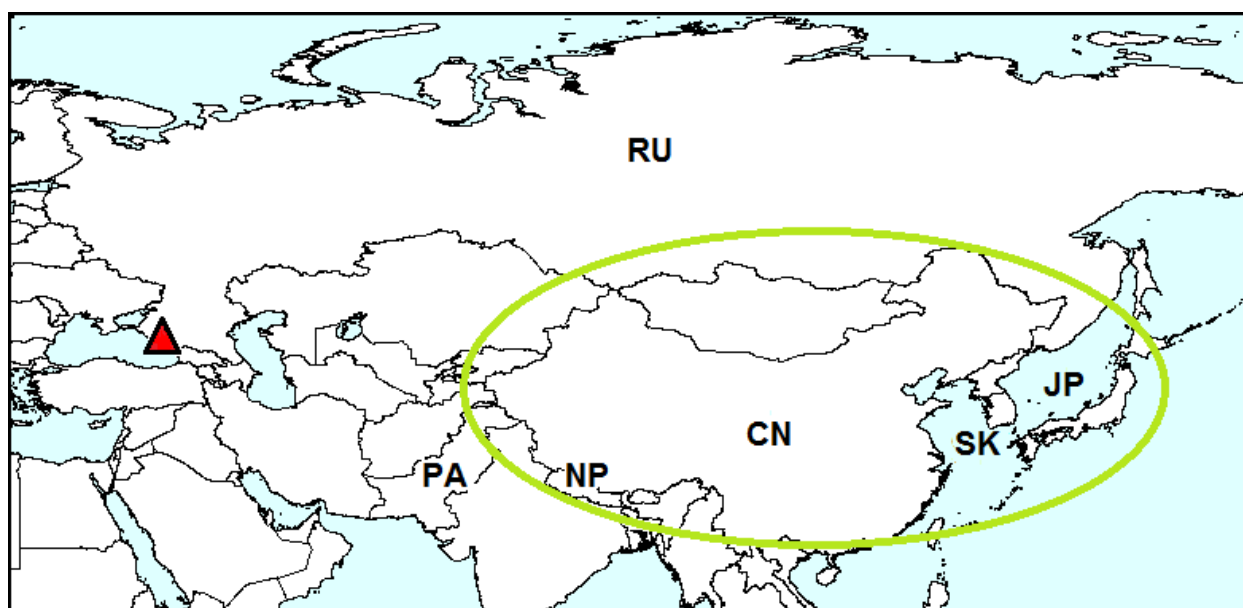


Fig. 4. Distribution of *Medythia nigrobilineata*. Red triangle – locality of the first record outside the native range: Sochi. Native range is circled with green. CN – China, JP – Japan, NP – Nepal, PA – Pakistan, RU – Russia, SK – South Korea. Sources of information: Medvedev (1992), Beenen (2010), Warchałowski (2010), Toepfer et al. (2014), Bieńkowski and Orlova-Bienkowskaja (2018b).

Invasion history. In 2016 this species was firstly found outside its native range – in the south of European Russia (Bieńkowski and Orlova-Bienkowskaja 2018b).

Record in European Russia. A single female specimen of *Medythia nigrobilineata* was collected by sweep-netting on grass (43°25'N, 39°59'E) on May, 19, 2016 in Krasnodar Krai, city of Sochi, near Adler, Imereti lowland, on wasteland with grasses (Bieńkowski and Orlova-Bienkowskaja 2018b).

Biology. Biology of *M. nigrobilineata* in its native range was described by Ogloblin (1936), Koyama (1940), Moseiko (2010) and Toepfer et al. (2014). *Medythia nigrobilineata* develops only on soybeans. Adults feed on leaves and often damage immature pods. Besides that, beetles can feed on leaves of rice and sugarcane. Adults hibernate among fallen leaves and in the soil. In spring they begin to feed on soybean seedlings and damage leaves. Females lay eggs in the soil. Larvae feed on root nodules and pupate in the soil.

Vector of dispersal. The specimen was collected 4 km from the international airport Sochi. We suspect that *M. nigrobilineata* could be unintentionally introduced from Asia through this airport.

Invasion status. Though we have found only one specimen, it is likely that it represents a population (at least temporal). First, the likelihood of collecting an individual in nature from current introduction rather than from a breeding population is vanishingly small. Second, the

establishment of *M. nigrobilineata* in Krasnodar Krai is quite possible, since soybean is widely cultivated in this region (Kondratenko 2012). Special surveys of soybean plantations are necessary to reveal, if the pest is established.

Economic impact. Adults and larvae of *M. nigrobilineata* are known to be serious pests of soybeans in China, Japan and the Russian Far East (Ogloblin 1936; Zhanglin et al. 1997; Moseyko 2010; Takei et al. 2014). So establishment of this species in Krasnodar Region pose a serious threat to soy bean production.

2013 – *Chrysolina americana* (Linnaeus, 1758) (Chrysomelinae)

Native range. Rosemary beetle is native to Mediterranean countries: Albania, Croatia, France, Greece, Italy, Malta, Portugal, Slovenia, Spain, Serbia, Macedonia, Algeria, Morocco, Tunisia and Turkey (Fig. 5) (Beenen and Roques 2010; Beenen 2010). In particular, it occurs on islands: Mallorca, Corsica, Sardinia, Cyclades, Crete, Madeira, North Aegean Islands and Malta (Pasqual et al 2017).

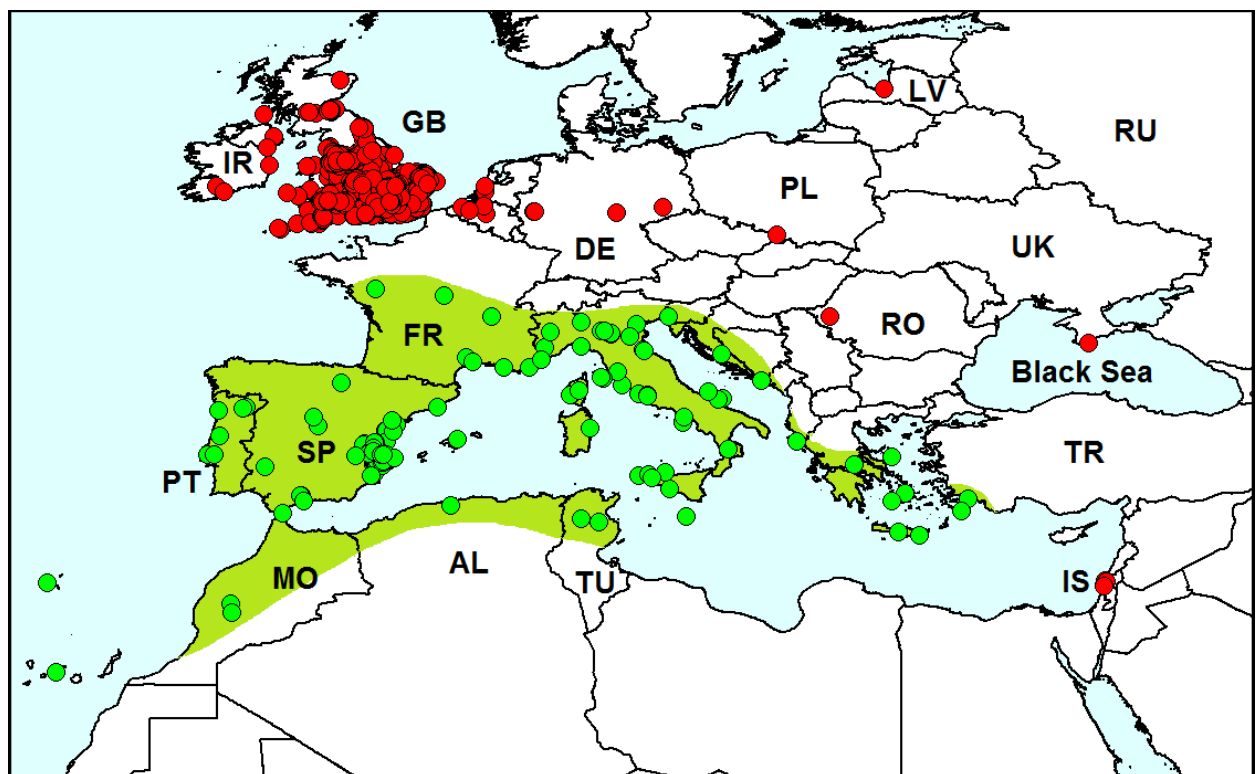


Fig. 5. Distribution of *Chrysolina americana*. Red dots – localities, where *Ch. americana* was recorded outside its native range, green dots on the green background – localities in the native range. Sources of information: examined specimens from museum collections (AB, HNHN, MTD, NHMW, NMP, NO, RI, ZIN) and literature: Bukejs and Telnov (2010), Beenen

(2010), Borowiec et al. (2011), Friedman (2016), Pasqual et al (2017), GBIF (2017b). Database on localities of *Chrysolina americana* is provided in electronic supplementary material 4.

Invasion history.

Before the 1990s specimens of *Ch. americana* were several times collected outside the native range: in 1936 and 1938 in Belgium (GBIF 2017b), before 1950 in Romania, Austria and Germany (examined specimens from MTD) and in 1963 in the United Kingdom (Johnson 1963). But probably these findings reflect just temporary populations. When *Ch. americana* was again recorded from the United Kingdom in the 1990s, MacLeod (2002) supposed that it would not establish because of the cold climate. But surprisingly *Ch. americana* established and began to spread quickly. Now it is common all over the United Kingdom and Ireland (Royal horticultural society 2014; GBIF 2017b). It was also reported to be introduced to several other European countries and Israel (Table 1).

Table 1. Records of *Chrysolina americana* outside its native range.

Invaded regions	Years of records	Sources of information
United Kingdom	1963, 1994–2017	Johnson (1963); MacLeod (2002); GBIF (2017b)
Poland	<2011	Borowiec et al. (2011)
Latvia	1996	Bukejs and Telnov (2010)
Israel	2014, 2015, 2016	Friedman (2016)
Belgium	1936, 1938, 2016, 2017	Beenen and Roques (2010); GBIF (2017b)
Netherlands	2005, 2017	Beenen and Roques (2010); GBIF (2017b)
Germany	<1950, 2008, 2017	Examined specimens from MTD; GBIF (2017b); Pasqual et al (2017)
Switzerland	<2017	Pasqual et al. (2017)
Ireland	2012, 2013, 2015	GBIF (2017b)
Romania	<1950,	Examined specimens from MTD; Maican (2005)
Crimea	2013	Examined specimens from NO

Records of *Ch. americana* from Poland, Romania, Germany and Switzerland were supposed to be questionable because of Mediterranean origin of the species (Maican 2005; Borowiec et al. 2011; Pasqual et al. 2017). We suppose that these records indicate the cases of introduction of the species outside its native range. It is difficult to determine, which records indicate establishment of species and which represent translocations or temporal populations.

Record in Crimea. *Chrysolina americana* has not been recorded from Russia or the Ukraine till now. Here we present the first record of *Ch. americana* on the Crimean peninsula: 13 specimens of this species were collected in Crimea in 2013 [Yalta, Bakhchisaray highway, sanatorium "Uzbekistan", 225 m a.s.l., on *Rosmarinus officinalis*, 01.06.2013, leg. N.V. Okhrimenko].

Biology. Adults and larvae feed on leaves of plants of the family Lamiaceae: *Rosmarinus officinalis*, *Lavandula* spp., *Salvia* spp., *Thymus* spp., *Perovskia atriplicifolia* and others (Friedman 2016).

Vector of dispersal. Because *Rosmarinus* and *Lavandula* are popular garden plants throughout Europe, *Ch. americana* has been translocated outside its native range along with its host plants (Beenen and Roques 2010). Opinions about natural dispersal abilities of *Ch. americana* are contradicting. MacLeod (2002) states that *Ch. americana* is flightless and therefore is restricted in its dispersal abilities. But Beenen and Roques (2010) indicate that this species has good flight capacities and disperses naturally by flight. Webster et al. (2017) suppose that expansion of the rosemary beetle to the United Kingdom has been expedited by climate change.

Invasion status. It is not quite clear if *Ch. americana* is established in Crimea or just a temporal population was recorded. Further observations are necessary to answer this question, since example of the population in the United Kingdom shows that this species is able to be established quickly and become a serious invasive pest.

Economic impact. Rosemary beetle is a garden pest. It damages the foliage and flowers of various aromatic plants including lavender, rosemary and sage (Friedman 2016). These plants are widely cultivated in Crimea. So if *Ch. americana* becomes abundant, it could cause negative economic consequences in the region.

2013 – *Epitrix hirtipennis* (Melsheimer, 1847) (Alticinae)

Native range. Tobacco flea beetle is native to the south of North America, north of South America and the Caribbean Islands (Fig. 6) (Riley et al. 2003; Bieńkowski and Orlova-Bienkowskaja 2017a).

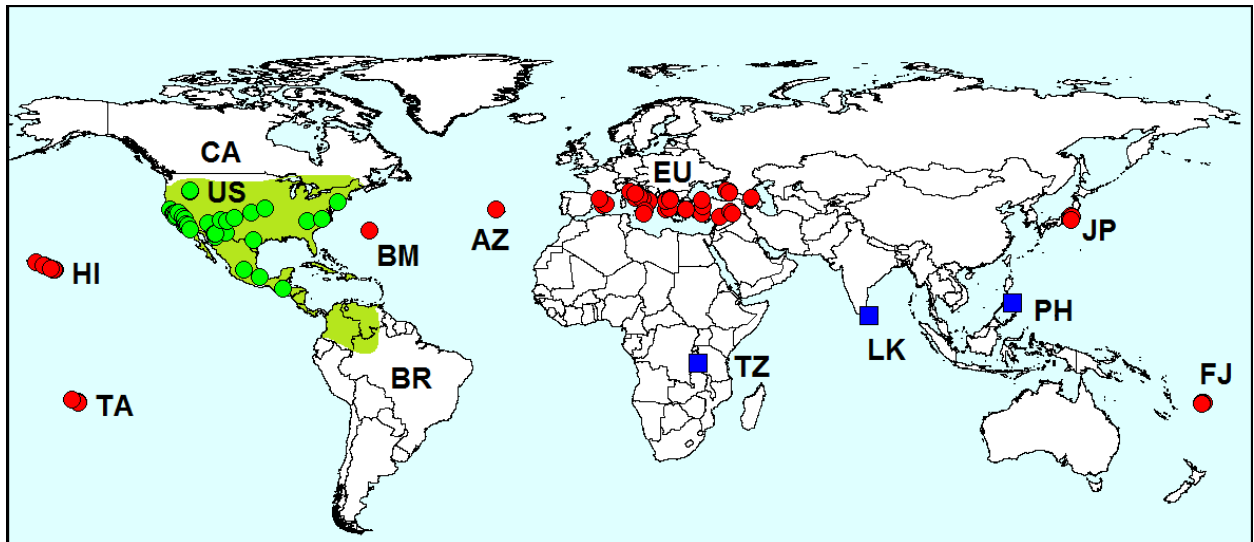


Fig. 6. Geographical distribution of *Epitrix hirtipennis*. Red dots – localities outside the native range, green dots on the green background – localities in the native range, blue squares – questionable records. AZ – Azores, BM – Bermuda, BR – Brazil, CA – Canada, EU – Europe, HI – Hawaii, FJ – Fiji, JP – Japan, LK – Sri Lanka, PH – Philippines, TA – Tahiti, TZ – Tanzania, US – the United States. Sources of information about records in the native range: examined specimens from VNIKR, ZIN and literature: Chamberlin and Tenhet (1923), Sannino et al. (1985), Furth and Savini (1996), GBIF (2017c). Sources of information about records outside the native range are indicated in Table 2. Database on localities of *Epitrix hirtipennis* is provided in electronic supplementary material 5.

Table 2. Records of *Epitrix hirtipennis* outside its native range

Invaded regions	Years of records	Sources of information
Hawaii	1892, 1893, 1927, 1942, 1960, 1961, 1962, 1967, ~1979, ~2002	Sharp (1900); Samuelson (1973); Gourves and Samuelson (1979); Nishida (2002), GBIF (2017c)
Bermuda	<1924, 1969	Ogilvie (1924); Hilburn and Gordon (1989)
Tahiti	1973, 1974, 1977, 1978	Gourves and Samuelson (1979)
Fiji	1978	Gourves and Samuelson (1979); Waterhouse (1997); GBIF (2017c)
Azores	1984	Israelson (1985)
Mainland Italy	1983, 1990	Sannino et al. (1984); Sannino and Balbiani (1990); Deseö et al. (1993)

Greece	1988, 2004	Lykouressis (1991); Deligeorgidis et al. (2007)
Turkey	1993, 2010, 2013, 2015, 2016	Döberl (1994a); Ekiz et al. (2013); Bolu (2016); Aslan and Başar (2016); Özdikmen et al. (2017)
Macedonia	1996, 2011, 2013	Krsteska et al. (2009); Spasov et al. (2013); Krsteska and Spirkoski (2017)
Albania	<1997	Krsteska and Spirkoski (2017)
Balearic Islands	1998, 2016	Petitpierre et al. (2017)
Bulgaria	<2000	Trenchev and Tomov (2000); Gruev (2006)
Sicilia	2000, 2010	Baviera and Biondi (2015)
Syria	2002	Gruev and Döberl (2005)
Japan	2011, 2016	Harada and Takizawa (2012); Kim et al. (2017)
Russia	2013, 2016	Orlova-Bienkowskaja (2014) and AB
Georgia	2014	Aslan et al. (2017)
Croatia	<2015	Raspudić et al. (2015)
Mainland Spain	2015	Viñolas et al. (2016)
Philippines (questionable record)	<1987	Martin and Herzog (1987); Deseö et al. (1993)
Sri Lanka (questionable record)	<1923	Chamberlin and Tenhet (1923); Deseö et al. (1993)
Tanzania (questionable record)	2013	Ntibiyoboka (2014)

Invasion history. *Epitrix hirtipennis* began to spread outside its native range in the end of the 19th century (Figs 6, 7; Table 2). First it was introduced to islands in Atlantic and Pacific oceans: Hawaii, Bermuda, Tahiti, Fiji and Azores and has become common there.

In 1983 this species was found in Europe for the first time in Northern Italy (Sannino et al. 1985). It was the first alien flea-beetle introduced to Europe. It then spread to South and Central Italy, Greece, Turkey, Spain, Macedonia, Bulgaria, Syria, European Russia and Georgia. In 2011 it was found that *E. hirtipennis* was common on Honshu (Japan) (Harada and Takizawa 2012). In some reviews the records from Sri Lanka (Chamberlin and Tenhet 1923), Philippines (Martin and Herzog 1987; Deseö et al. 1993) and Tanzania (Ntibiyoboka 2014) are mentioned. But these records are doubtful, since no references to the source of information are given.

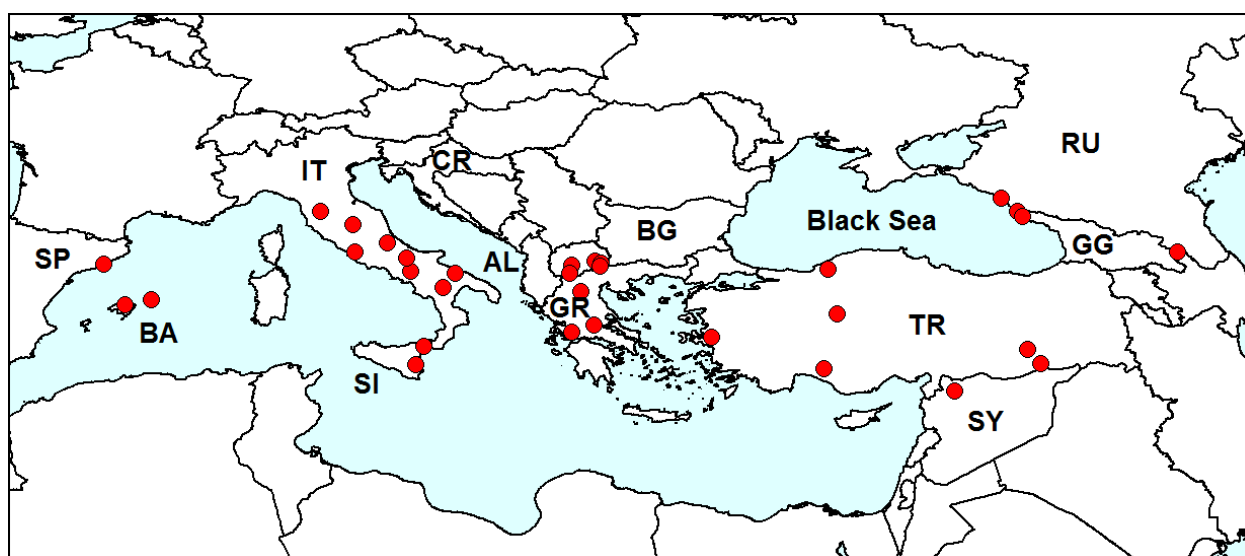


Fig. 7. Distribution of *Epitrix hirtipennis* in Europe. Red dots – localities in Europe. IT – Italy (first record in 1983), GR – Greece (1988), TR – Turkey (1993), AL – Albania (<1997), BA – Balearic Islands (1998), SY – Syria (2002), RU – Russia (2013), GG – Georgia (2014), CR – Croatia (<2015), SP – mainland Spain (2015), Sources of information are indicated in Table 2. Database on localities of *Epitrix hirtipennis* is provided in electronic supplementary material 5.

Records in European Russia In 2013 *E. hirtipennis* was first recorded in the Caucasus – in the cities of Sochi and Tuapse on the Black Sea coast (south of European Russia: Krasnodar Region) (Orlova-Bienkowskaja 2014). In 2016 we again found this species in the same region in the city of Adler. All specimens were sweep-netted on ruderal vegetation. It was supposed that *E. hirtipennis* was also found on tobacco field in Krasnodar (Plotnikova 2014), but the identification of species was incorrect. The expert in Chrysomelidae of the Caucasus N.V. Okhrimenko identified these specimens as *E. atropae* Foudras, 1860.

Biology. Adults feed on leaves of plants of the family Solanaceae. Larvae develop on roots. The review of host plants of *E. hirtipennis* in different regions was made by Bieńkowski

and Orlova-Bienkowskaja (2016). In Italy *E. hirtipennis* has been observed to shift onto native Solanaceae (Beenen 2006). We collected *E. hirtipennis* in Russia on ruderal vegetation.

Vector of dispersal. Since *E. hirtipennis* was the first alien flea beetle introduced to Europe, its record on the continent puzzled experts in Chrysomelidae. It was assumed that *E. hirtipennis* arrived in Europe as aerial plankton with easterly trade winds blowing from the New World to Europe (Döberl 1994b). But we believe that the most likely vector of dispersal is an unintentional introduction of larvae in soil with imported planting material.

Invasion status. *Epitrix hirtipennis* is established in the region. Localities of its records in Europe and Asia indicate that the species is dispersing eastward.

Economic impact. This species is known mainly as a pest of tobacco, but can also feed on eggplant, potato, tomato and many other solanaceous plants (Capinera 2001).

Remark. The representatives of the genus *Epitrix* are especially prone to invasions. Five species established outside their native ranges in other continents and islands (Fig. 8). One more representative of the genus – *Epitrix setosella* (Fairmaire, 1888) was reported to be introduced outside its native range – namely from East Asia to Georgia (Aslan et al. 2017). But our examination of the specimens identified as "*E. setosella*" from collection of G.O. Japoshvili has shown that the identification is incorrect, and these specimens belong to *E. pubescens* (Koch, 1803).

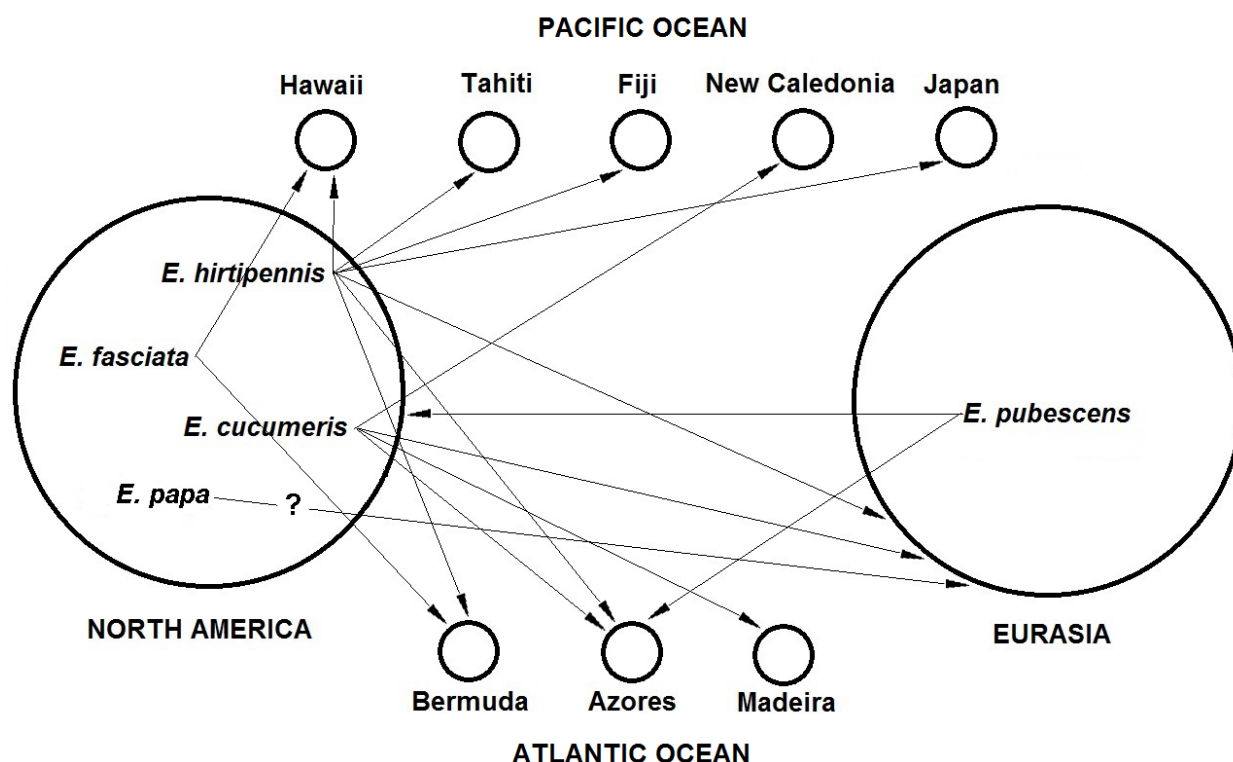


Fig. 8. Invasions of the species of the genus *Epitrix* from their native ranges to other continents and islands in Pacific and Atlantic oceans (Bieńkowski and Orlova-Bienkowskaja 2016).

2011 – *Diabrotica virgifera* LeConte, 1868 (Galerucinae)

Native range. The western corn rootworm originates from the New World. The initial range is Mexico or Central America (Lombaert et al. 2017). Now the range in the Americas includes Canada, Costa Rica, Guatemala, Mexico, Nicaragua and the USA (EPPO 2017).

Invasion history. Man has greatly increased the range of this species in the Americas by the cultivation of corn (Lombaert et al. 2017). In Europe *D. virgifera* was first observed near Belgrade airport, Serbia in 1992 (Bača 1994). After several introduction events to different regions of Europe (Ciosi et al. 2008) the species has become widespread. Now it is recorded in at least 22 European countries (Fig. 8) (EPPO 2017).

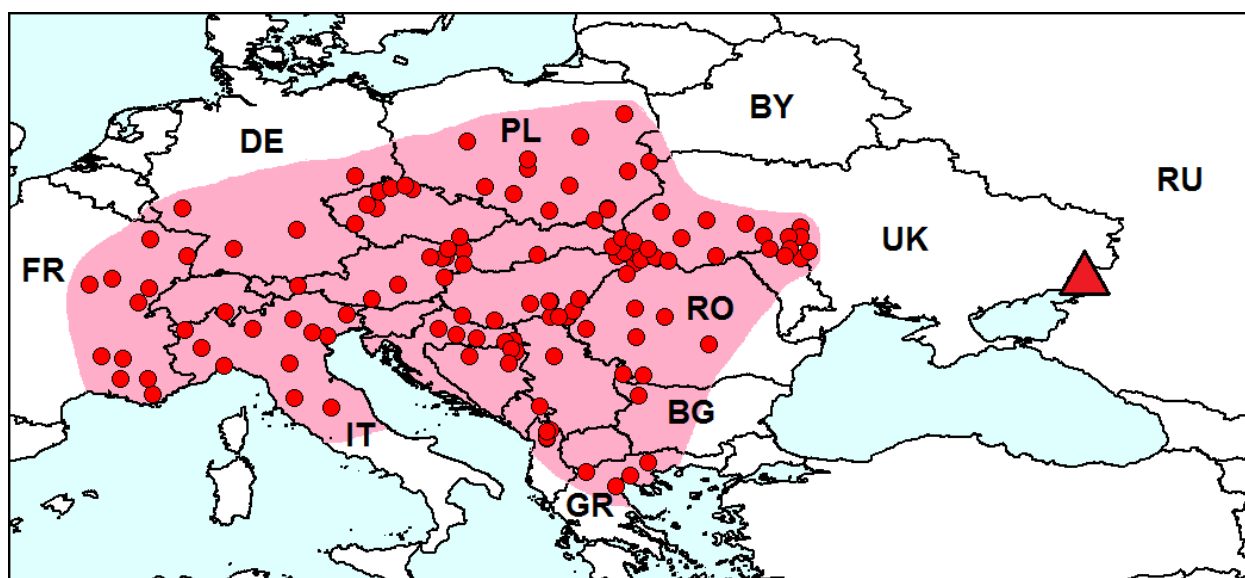


Fig. 9. Distribution of *Diabrotica virgifera* in Europe. Red dots on the pink background – localities of species in the secondary range. Red triangle – locality of the interception of one specimen in Russia in 2011. BG – Bulgaria, BY – Belarus, DE – Germany, FR – France, PL – Poland, RO – Romania, RU – Russia, UK – Ukraine. Sources of information: VNIKR (2012), Trepashko and Nadtocheva (2013), Butaliuk et al. (2016), EPPO (2017), GBIF (2017d), Manole et al. (2017). Database on localities of *Diabrotica virgifera* is provided in electronic supplementary material 6.

Record in European Russia. In 2011 *D. virgifera* was captured with a pheromone trap at the border of Russia in Rostov Region near the international highway (VNIKR 2012).

Biology. Adults of *Diabrotica virgifera* feed on leaves, silks, pollen, and young kernels of corn, larvae develop on roots (Branson and Krysan 1981).

Vector of dispersal. *Diabrotica virgifera* proved to have been translocated from North America to Europe several times in aircraft laden with goods and materials (Ciosi et al. 2008). The beetles fly well, so they spread in Europe both by hitchhiking and naturally (Hemerik et al. 2004).

Invasion status. It seems that *Diabrotica virgifera* has not been established in Russia yet, since it was intercepted only once in 2011.

Economic impact. *Diabrotica virgifera* is a major pest of cultivated corn. Most of the damage is caused by larvae feeding on the root system. The species is included to A2 List of quarantine pests of EPPO (2017).

1984 – *Phyllotreta reitteri* Heikertinger, 1911 (Alticinae)

Native range. We believe that the native range of *Ph. reitteri* is in Central Asia (Fig. 9), as its host plant *Lepidium latifolium* originates from this region (Hinz et al. 2008). Before the 1980s *Ph. reitteri* was recorded in Kazakhstan and Uzbekistan only (Heikertinger 1941; Lopatin 1977; Gruev and Döberl 1997). Probably the recent record from West China (Gerber et al. 2011) also belongs to the native range.

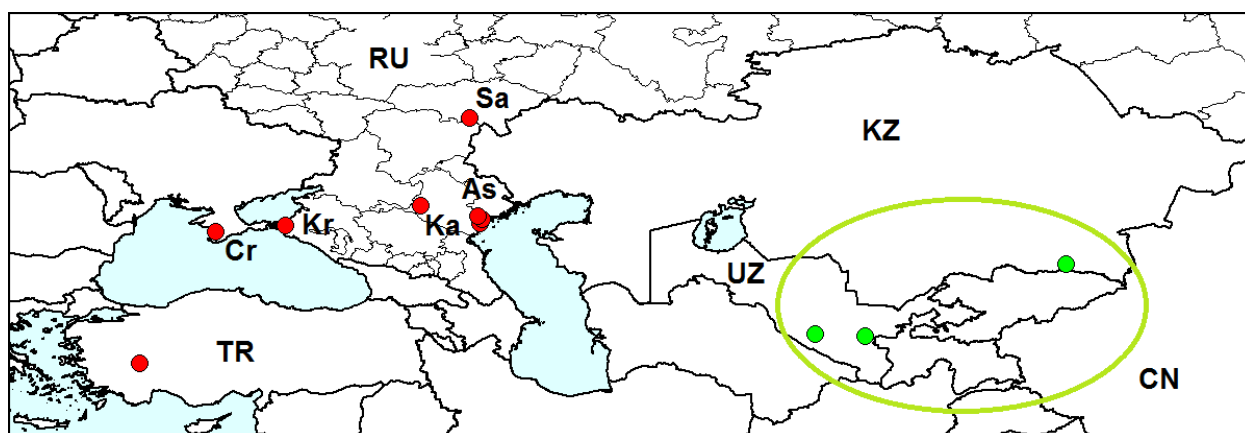


Fig. 10. Distribution of *Phyllotreta reitteri*. Green dots – localities in the native range, red dots – localities outside the native range (records after 1984), CN – China, KZ – Kazakhstan, RU – Russia, TR – Turkey, UZ – Uzbekistan, As – Astrakhan Region, Cr – Crimea, Kr – Krasnodar Territory, Ka – Kalmykia, Sa – Saratov Region. Sources of information are indicated in Table 3.

Invasion history. In 1984 *Ph. reitteri* was first found outside its native range, namely in Crimea (Mosyakin 1987). Then in 1986–2012 it was found in four regions in the South of European Russia (Table 3) and in 2002 in Turkey (Gök et al. 2002).

Table 3. Records of *Phyllotreta reitteri* outside its native range.

Invaded regions	Years of	Sources of information

	records	
Crimea: Simferopol	1984	Mosyakin (1987) and examined specimens from SM
Kalmykia: Elista, Lagan and Dzhalykovo	1986, 2011, 2012	Our collection and examined specimens from GK
Astrakhan Region: Liman	2010	Our collection
Saratov Region: D'yakovka	2004	Examined specimens from AU
Krasnodar Territory: Temryuk and Golubitskaya	2007, 2008, 2010	Examined specimens from ZIN (collected by B.A. Korotyaev and A.G. Moseyko)
Turkey: Denizli	2002	Gök et al. (2002)

Distribution in European Russia. *Phyllotreta reitteri* occurs in Kalmykia, Saratov Region, Astrakhan Region and Krasnodar Territory (see Table 3).

Biology. Experiments carried out in cage and in field have shown that the main host plant of *Phyllotreta reitteri* is perennial pepperweed *Lepidium latifolium* (Gerber et al. 2012). Adults feed on leaves, larvae mine in petioles and shoots. This plant of Asian origin has been cultivated as a spice and vegetable since the twelfth century (Hegi 1986). Now it is widespread in Asia and Europe and has been recorded in all continents and has become an invasive weed in North America (Gerber et al. 2012). In European Russia *Ph. reitteri* occurs in moist habitats: on the banks of rivers and ponds and in irrigated parks.

Vector of dispersal. Unknown.

Invasion status. We believe that *Ph. reitteri* is alien in European Russia. It corresponds to at least four criteria of alien beetle species (Orlova-Bienkowskaja 2016) as follows:

(1) Detection of an established population of the species, which has not been recorded earlier. – *Phyllotreta reitteri* appeared outside its historically known range (Central Asia) in the 1980s.

(2) Disjunction of the range, which cannot be explained by disjunction of suitable landscapes or host plant ranges. – The range of *Ph. reitteri* consists of two parts. The first one is in Central Asia, and the second one is in the south of European Russia, Crimean peninsula and Turkey. The distance between these two parts is more than 1500 km.

(3) Expansion of a part of the range isolated from its main part. – Records in Turkey, Astrakhan and Saratov Regions in the 2000s could probably indicate the expansion of the range.

(4) Feeding on an alien host plant. – *Lepidium latifolium* originates from Central Asia (Hinz et al. 2008).

It is unlikely, that the species occurred in the region, but stayed unnoticed for a long time, because this beetle is large for the genus *Phyllotreta* and has characteristic bright coloration. There are no specimens of *Phyllotreta reitteri* collected in the South of European Russia in the rich collection of Zoological Institute of Russian Academy of Sciences, though there are thousands specimens of other *Phyllotreta* species collected in this region in the end of the 19th and the first half of the 20th century.

Economic impact. *Phyllotreta reitteri* is regarded as a potential biological control agent of perennial pepperweed (Hinz et al. 2008).

1982 – *Zygogramma suturalis* (Fabricius, 1785) (Chrysomelinae)

Native range. Ragweed leaf beetle is native to the USA and the south of Canada (Riley et al. 2003).

Invasion history. *Zygogramma suturalis* (Fig. 10) was introduced to the USSR from Canada and the USA for control of one of the most noxious invasive weeds *Ambrosia artemisiifolia* (Kovalev et al. 2015). The beetles were released in 16 provinces of the USSR: in European Russia, Ukraine, Georgia, Kazakhstan and the Far East. The most intensive work was performed in the south of European Russia, mainly in Rostov Region and in Stavropol and Krasnodar Territories (Kovalev et al. 2015). First release (1500 specimens) was made in the vicinity of Stavropol in 1978. In 1981–1983 *Z. suturalis* became abundant and began to spread quickly. Now it is rather widespread in the south of European Russia and occurs also in south-east of the Ukraine and in Georgia (Sergeev 2012 and personal communication by M.E. Sergeev). In 1985 one specimen was found in Turkey, but the species did not establish, since there were no other records (Aslan et al. 2003; Özdikmen et al. 2014 and personal communication by H. Özdikmen).

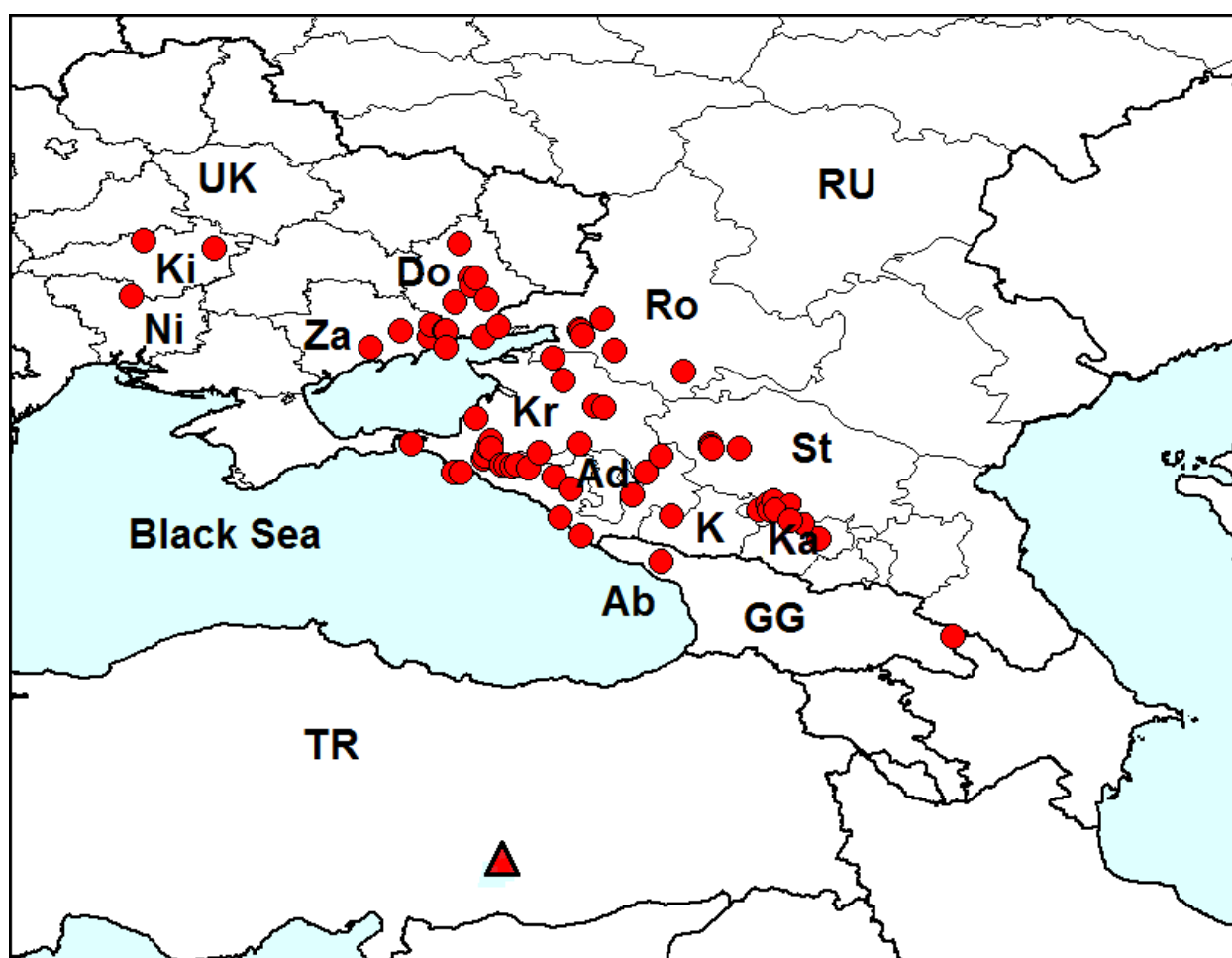


Fig. 11 *Zygogramma suturalis*. Distribution of *Zygogramma suturalis* in Europe. Red dots – localities of species. GG – Georgia, RU – Russia, TR – Turkey, UK – Ukraine, Ab – Abkhazia, Ad – Adyghea, Do – Donetsk Region, K – Karachay-Cherkessia, Ka – Kabardino-Balkaria, Ki – Kirovograd Region, Kr – Krasnodar Territory, Ni – Nikolaev Region, Ro – Rostov Region, St – Stavropol Territory, Za – Zaporizhje Region. Sources of information: examined specimens from the following collections: AB, AK, BSU, PR, TM, VNIKR, YK and literature: Yaroshenko (1994), Aslan et al. (2003), Reznik and Spasskaya (2005), Sergeev (2008, 2010, 2011, 2013). Database on localities of *Zygogramma suturalis* is provided in electronic supplementary material 7.

Zygogramma suturalis when introduced to the south of European Russia, showed rapid evolutionary changes in flight capacity (development of flight ability and morphological changes) within only five generations (Kovalev 2002). The morphological changes were so significant, that the new subspecies *Zygogramma suturalis volatus* Kovalev, 2002 was described (Kovalev 2002).

In 1982–1985 beetles from Stavropol Territory were released in Primorje (Far East). In the 1990s it was supposed that the population of *Z. suturalis* in the Far East disappeared. But in 2010 it was discovered that this species still occurred there, though it was not abundant (Aistova

and Bezborodov 2015). *Zygogramma suturalis* was also released in Croatia and Australia, but failed to establish, releases of *Z. suturalis* in China in 1985 resulted in establishment in some locations (Gerber et al. 2011). Record of *Z. suturalis* from Kazakhstan (Gerber et al. 2011) probably refers to the releases rather than to established populations. There are no current records of *Z. suturalis* from this country (Lopatin 2010).

Distribution in European Russia. Now *Z. suturalis* occurs in five provinces in the south of European Russia: Stavropol Territory, Krasnodar Territory, Adygea, Rostov Region, Karachay-Cherkessia (Kovalev et al. 2013; Reznik and Spasskaya 2005) and Kabardino-Balkaria (unpublished data by T.A. Mogilevich).

Biology. Larvae and adults feed on leaves, shoots and inflorescences of *Ambrosia artemisiifolia* (Kovalev and Medvedev 1983). The species is very abundant in some localities, occurs in river valleys, on the fringes of forests, and in saline areas (Sergeev 2013).

Vector of dispersal. Intentional introduction for biological control of *Ambrosia artemisiifolia*.

Invasion status. *Zygogramma suturalis* is established in European Russia.

Economic impact. Soon after the introduction of *Z. suturalis* to the Caucasus the density of some populations was as high as 100 million specimens per km². *Zygogramma suturalis* completely destroyed *Ambrosia* in some locations. But 10 years after the introduction surveys revealed that in spite *Z. suturalis* was still abundant in some places, however it does not significantly affect the general density of the host plant. The system “plant-phytophagous” reached the equilibrium (Kovalev et al. 2013; Reznik et al. 2008). The same situation is observed in the Far East (Aistova and Bezborodov 2015).

1958 – *Leptinotarsa decemlineata* (Say, 1824) (Chrysomelinae)

Native range. The Colorado potato beetle originates from central highlands of Mexico (Alyokhin et al. 2013).

Invasion history. From the beginning of the 19th to the beginning of the 20th century *L. decemlineata* colonized whole North America (Ivanchik and Izhevsky 1981; Alyokhin et al. 2013). In 1922 *L. decemlineata* was found to be established in Bordeaux (France) and began to spread in Europe. Now it is distributed almost throughout Europe and northern Asia (Kippenberg 2010; Maslyakov and Izhevsky 2011; Alyokhin et al. 2013; EPPO 2017). Presently, the Colorado potato beetle damages potato crops all over Europe, Asia Minor, Iran, Central Asia, and western China (Alyokhin et al. 2013). General distribution of *Leptinotarsa decemlineata* is

well known (EPPO 2017), so we present the map of distribution of this species in Russia only (Fig. 11).

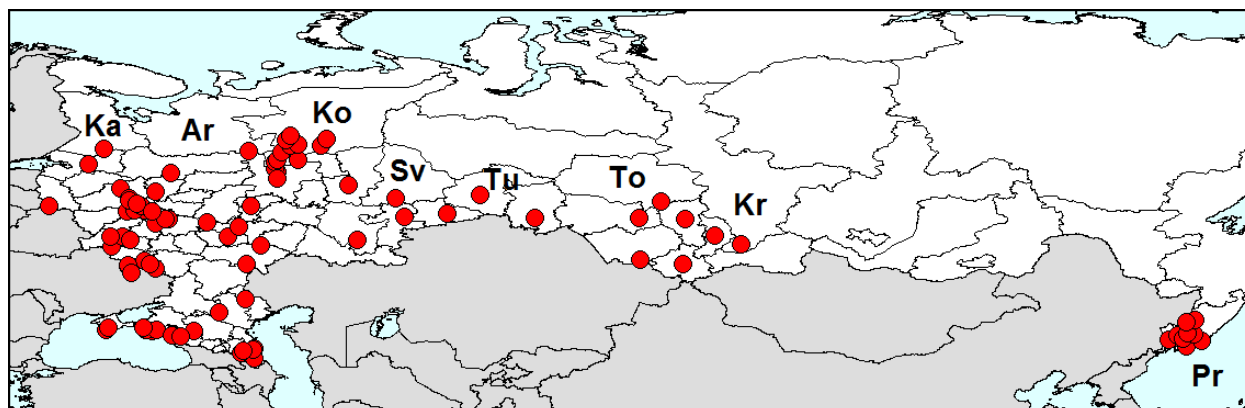


Fig. 12. Distribution of *Leptinotarsa decemlineata* in Russia. Ar – Arkhangelsk region, Ka – Karelia, Ko – Republic of Komi, Kr – Krasnoyarsk Territory, Pr – Primorsky Territory. To – Tomsk Region, Tu – Tumen Region, Sources of information: examined specimens from the following collections: AB, AP, AR, BNR, BSU, EI, GK, MD, NN, OSU, PP, VF, VNIKR, ZMMU, and literature: Matsishina (2011), Guskova (2013), Popova (2014). Database on localities of *Leptinotarsa decemlineata* is provided in electronic supplementary material 8.

Expansion to Russia. In 1958 expansion of the pest range reached the western border of the USSR (Maslyakov and Izhevsky 2011). Now the Colorado potato beetle is common all over European Russia, even in the north: in Leningrad Region (Maslyakov and Izhevsky 2011) and the Republic of Komi (Dolgin and Bieńkowski 2011). Its range has expanded to the most part of Siberia. The northern boundary of the area passes through Karelia, Arkhangelsk Region, Republic of Komi, Tumen Region, Tomsk Region and Krasnoyarsk Territory. Since 2000 the isolated part of the range exists also in the Far East – in Primorsky Territory (Maslyakov and Izhevsky 2011).

Biology. In European Russia *L. decemlineata* feeds on *Solanum tuberosum*, *S. lycopersicum*, *S. melongena*, *S. laciniatum*, *S. dulcamara*, *Hyoscyamus niger* and *Atropa belladonna* (Medvedev and Roginskaya 1988; Maslyakov and Izhevsky 2011; Bienkowski and Orlova-Bienkowskaja 2015). It occurs not only in agricultural landscapes, but also in undisturbed natural communities, in particular, on river banks (Bieńkowski 2011).

Vector of dispersal. This pest enters new territories mainly because of unintentional transportation with potato and self-dispersal of beetles sometimes aided with the winds (Ivanchik and Izhevsky 1981).

Economic impact. *Leptinotarsa decemlineata* is the most devastating pest of potato and other cultivated plants of the family Solanaceae (Alyokhin et al. 2013).

Species established before the 20th century – archeoinvaders

It can be assumed that some leaf beetles species spread from their native ranges with the spread of agricultural plants and weeds centuries ago. In particular, Beenen (2006) argued that the combination of *Buglossoides arvensis* and *Longitarsus fuscoaeneus* Redtenbacher 1849 might have taken the route from southwest Asia where they spread with agriculture to large parts of the temperate parts of the Northern hemisphere. By analogy with the term archeophytes, which is applied to alien plants, the term "archeoinvaders" was introduced for animals (Khlyap et al. 2010). It is very difficult to distinguish such established alien species from native ones. Thus, a number of species which are at present considered as native may indeed be originally alien (Beenen and Roques 2010). In some cases detail analysis of ecology and long-term dynamics of ranges could help to reveal archeoinvaders by the criteria similar to those used by botanists for revealing of archaeophytes (Orlova-Bienkowskaja 2016).

In particular, *Chrysolina eurina* (Frivaldszky, 1883) (Chrysomelinae) was argued to be probably an archeoinvader in Europe (Orlova-Bienkowskaja 2013a). The detailed analysis of all localities of this species available from literature and museum collections has shown that its range is disjunctive: consists of three isolated parts, which are at a great distance from each other. The western part is situated in Central Europe (Austria, Hungary, Slovakia, Romania, Poland, Czech Republic), the middle one – in European Russia (Moscow Region, Tambov Region, Nizhny Novgorod Region, Penza Region, Vladimir Region, Samara Region and Ryazan Region), and the eastern part – in the south-east of West Siberia (Kemerovo Region, Republic of Khakassiya, Krasnoyarsk Territory, Altai Republic). We believe that western and the middle parts probably appeared as a result of invasions more than 100 years ago. Firstly, the only host plant of this leaf-beetle is *Tanacetum vulgare*, a weed, which was introduced to Europe in antiquity (Pyšek et al. 2002). Secondly, *Ch. eurina* in Europe occurs mainly in the ruderal habitats, which is typical for nonnative species. Thirdly, the unintentional introduction of beetles by transport is quite possible, since the local populations often occur at the roadsides of highways. Disjunction of the range cannot be explained by disjunction of host plant range or suitable landscapes, since *T. vulgare* has a continuous range in Europe, and *Ch. eurina* occurs not in mountains or some kind of other rare or relict landscape, but on the contrary – in anthropogenic landscapes in highly populated areas.

Another example is *Lilioceris lili* (Scopoli, 1763) (Criocerinae). We studied dynamics of its range and came to conclusion that the species could be introduced from Asia to Europe in the 16th–17th century with bulbs of lilies (Orlova-Bienkowskaja 2013b, 2016). *Lilioceris lili* meets several criteria of alien species: (1) Until the beginning of the 20th century *L. lili* had a

disjunctive range consisting of the Asian and the West European subranges separated by a vast territory where the species was not found. The absence of *L. lili* in collections from the greatest part of European Russia and Western Siberia cannot be attributed to insufficient material, since the distribution map of the closely related species *Lilioceris merdigera* (Linnaeus, 1758) compiled from the same sources reveals a continuous range of the latter species in the 19th century (the method of comparison of ranges of related species; see Gorodkov, 1981). Since the beginning of the 20th century, the European range of the species has been expanding in the northern and eastern directions. (2) *Lilioceris lili* is prone to invasions, in particular, it became a common and widespread species on the British Isles and in North America where it appeared in the 1940s (Majka and LeSage 2008). (3) The main host plants of the species are cultivated *Fritillaria* and *Lilium* (Medvedev and Roginskaya 1988). (4) In Europe, *L. lili* can be found almost exclusively in anthropogenic biotopes: gardens and flowerbeds. Despite being common, the species was only sporadically recorded outside the artificially planted areas. (5) The genus *Lilioceris* as a whole is of Asian origin, and the great majority of its species occur in Asia (Berti and Rapilly 1976). (6) The known vector of invasion of *L. lili* to new territories is shipment of lily bulbs with soil.

Of course, it is not easy to distinguish alien beetle species established before the 20th century from native ones. All criteria listed above are mere indirect evidences of the alien status of a species in the given territory, because numerous exceptions exist. Usually it is impossible to recognize an alien species by a single criterion, but matching several criteria characterizes the species as an alien one with high probability.

Discussion

Analysis of invasions of leaf beetles to European Russia has revealed some general tendencies. First of all, it is obvious that recent translocations and establishment of Chrysomelidae species outside their native ranges have become much more common than previously. Only three alien leaf beetle species were recorded in European Russia in the 20th century: *Leptinotarsa decemlineata*, *Phyllotreta reitteri* and intentionally introduced *Zygogramma suturalis*. But in 2000–2017 as much as six alien species were found in the region. It corresponds to the general tendency exponential increase in the rate of invasions of leaf beetles to Europe (Beenen and Roques 2010) and increase of invasions of beetles feeding on living plants (Orlova-Bienkowskaja 2017). It reflects the increase of international trade, especially trade of living plants and the increase of air transport. In most cases leaf beetles are translocated to the remote regions with imported plants or (as in the case of *Diabrotica virgifera*) by hitchhiking in

airplanes (Hemerik et al. 2004; Ciosi et al. 2008). Most of alien leaf beetles are associated with agricultural plants. But some species (for example, *Phyllotreta reitteri*) develop on weeds.

After the establishment outside their native ranges leaf beetles can quickly spread by unintentional introduction by man and natural dispersal. For example, *Diabrotica virgifera* was first recorded in Europe in 1992, but now it has spread to at least 21 countries and become major pest of corn in some regions (EPPO 2017). *Luperomprpha xanthodera* has occupied the whole Europe from Spain to Russia in just 15 years. Therefore, the records of new alien pest leaf beetles are very important and should be published quickly.

In some cases invasions of leaf-beetles are unpredictable. For example, establishment of *Leptomona erythrocephala* native to Spain in the Caucasus is rather surprising. But in other cases emergence of alien species is easy to predict. For example, it was obvious that *Epitrix hirtipennis* could appear in the south of European Russia, since its range in Europe was expanding to the east. Similarly in the early 20th century it was obvious that *Leptinotarsa decemlineata* would appear in Europe, because of its outbreak and quick range expansion in North America. In general, if the range of some leaf beetle species is quickly expanding, or if the species has been recorded established somewhere outside its native range, this species should be regarded as a potential invader all over the world. For example, global invasion of *Epitrix hirtipennis* began from its establishment in Hawaii in the end of the 19th century (Sharp 1900).

Leaf beetles could be potentially translocated from any part of the world. Four species alien to European Russia originate from North America, two from Mediterranean region and three from Asia. Recently the invasions of beetles East Asia are becoming more important (Orlova-Bienkowskaja 2017). Establishment and quick spread of *Luperomprpha xanthodera* in Europe reflects this current tendency.

The Black Sea region is more prone to invasions of leaf beetles than other regions of European Russia. The large number of records of alien species in these regions could not be explained by more intensive survey, since we have the database of localities of leaf-beetles collected in all regions of European Russia (about 30000 localities) (Bienkowski and Orlova-Bienkowskaja 2017b). The large number of invasions in the Black Sea region corresponds to the general tendency of large number of invasions of leaf beetles in territories with warm and wet climate. For example, Italy occupies the first place in Europe on number of alien leaf beetles (Beenen and Roques 2010).

But it is difficult (or even impossible) to predict, if the introduced species could become established on the base of simple comparison of climate in its native range and invaded range, because establishment of species depends on a complex of interacting abiotic, biotic and

anthropogenic factors. For example, when *Ch. americana* was for the second time recorded from the United Kingdom in the 1990s, MacLeod (2002) supposed that it would not establish because of the cold climate. But it has established and become a common pest.

Alien leaf beetles can spread to native communities and become naturalized. For example, *Zygogramma suturalis* occurs even in native undisturbed communities of nature reserves (Sergeev 2008, 2011). Usually alien leaf beetles remain strictly related to their original, alien plants (Beenen 2006; Beenen and Roques 2010). This is also true for Chrysomelidae of European Russia. But some species can feed also on native plants or cultivated plants from other regions. In particular, *Leptinotarsa decemlineata* feeds not only on cultivated plants, but also on *S. dulcamara* and *Hyoscyamus niger*. If the species is established in native communities and feed on native plants it is fully naturalized, i.e. ecologically undistinguishable from native species. Just because of the full naturalization it is difficult to distinguish between native species and species established before the 20th century.

Since the invasions of leaf beetles can cause tremendous economic consequences and since the exponential increase in the rate of invasions is recently observed, special attention should be paid to the study of these invasions. The monitoring is necessary to reveal the cases of emergence of species outside their native ranges. General trends of invasions of leaf-beetles should be examined and analyzed carefully.

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