

Alien phytophagous insects in forest and urban stands of Ukraine

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Abstract. The aim of the research was to present current data on the distribution and development of some alien phytophagous insects in the territory of Ukraine. We considered 19 species of alien phytophagous insects, including 2 species of Coleoptera, 7 Hemiptera (including 4 bug species), 7 Lepidoptera, 2 Hymenoptera, and 1 Diptera. *Hyphantria cunea* penetrated Ukraine about 70 years ago and sometimes outbreaks in orchards or shelterbelts. *Cameraria ohridella* and *Cydalima perspectalis* pose a great threat to *Aesculus hippocastanum* and *Buxus sempervirens*, respectively, in urban stands. *Parectopa robinella*, *Macrosaccus robinella*, *Nematus tibialis*, and *Obolodiplosis robiniae* did not attract the attention of researchers until recently, since did not show a noticeable effect on the health condition of *Robinia pseudoacacia*. *Phyllonorycter issikii* is not abundant in most parts of Ukraine. *Phyllonorycter platani* and *Corythucha ciliata* are not serious pests because their host plant (*Platanus* sp.) is rather rare in Ukraine. *Trichoferus campestris* is known long ago but has not yet shown any harmful effects. The threat from sucking insects (aphids and bugs) increases due to their ability to vector tree pathogens. The polyphagous *Halyomorpha halys* can pose a threat to forest, ornamental and agricultural plants. *Leptoglossus occidentalis* poses a great danger to the restoration of Scots pine forests because its feeding decreases the seeds' germination. *Corythucha arcuata* is found only in two regions but is moving northward and may pose a threat to oak stands. *Agrilus planipennis* has spread over several years from the eastern border with Russia to the entire Luhansk and partly Kharkiv region, inhabits *Fraxinus excelsior* and *F. pennsylvanica*, and can move west.

Keywords: defoliators, leafminers, sucking insects, *Agrilus planipennis*, *Corythucha arcuata*, *Leptoglossus occidentalis*.

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Introduction

Every year, many species of insects change their ranges (Panzavolta et al. 2021). Some species do not survive in a new place. Others exist there for years and remain unknown because they do not have a noticeable effect on native species. The species of the third group become invasive because they actively reproduce, displace native species, and disturb natural ecosystems (Liebhold et al. 2017). The identification of invasive insects is complicated by the fact that under new conditions their development rates, hibernation sites, the level of harmfulness, and interaction with new host plants and competitors change. Invasive species can carry pathogens or parasites to new regions (Venette and Hutchison 2021). Therefore, the prediction of the behavior, abundance, interspecific interactions, and ecological impacts of alien species in new ranges is one of the priority tasks (Ricciardi et al. 2021). The amount of such information about alien phytophagous insects is being accumulated in different countries.

However, many sources are inaccessible to a wide range of specialists, in particular, because they are not written in English (Angulo et al. 2021). Therefore, the references in Russian and Ukrainian are mainly cited here.

The aim of the research was to present current data on the distribution and development of some alien phytophagous insects at the territory of Ukraine.

Materials and methods

This review is based on publications on the distribution and some biological features of alien phytophagous insects in the territory of Ukraine, including our own unpublished data and materials from the Ukrainian Biodiversity Information Network (UkrBIN 2020). Data on the findings of alien phytophagous insects are grouped by administrative regions, which are shown on the map of Ukraine (Figure 1). Ukraine borders Poland, Belarus, Russia, and Moldova in the plain part of the territo-



Figure 1 Administrative regions of Ukraine. Regional centers are indicated.

ry, with Slovakia, Hungary, and Romania - in the Carpathians, with Romania and Russia also partially by sea. In such areas, penetration of alien phytophagous insects is possible. At the same time, the possibility of direct penetration of these insects with planting material delivered by aircraft does not depend on the distance to the borders.

The territory of Ukraine is located between 52°N and 42°N and between 22°E and 40°E, the distance from the west to the east is 1300–1400 km, and from north to south almost 900 km. Natural conditions vary with latitude and longitude. The Forest zone (or Polissya) is in the northern part of the country and covers about 20% of the territory. The Forest-Steppe zone is located south of the Forest zone and covers 35%, and the Steppe zone is even to the south and covers about 40% of the territory (Information on forests of Ukraine, 2020). From west to east, the continentality of the climate increases (differences between winter and summer temperatures), which also adds diversity to the natural conditions of individual regions. Thus, the plains occupy about 95% of the territory of Ukraine, and the mountains (Carpathian and Crimean) account for about 5%.

Forest coverage is 15.9%, it is 26.8% in the Forest zone, 13% in the Forest-Steppe zone, 5.3% in the Steppe zone, 42% in the Carpathian Mountains, and 10.4% in the Crimean Peninsula (Information on forests of Ukraine 2020). The forests are dominated by *Pinus sylvestris* L., *Quercus robur* L., *Fagus sylvatica* L., *Picea abies* (L.) H. Karst., *Betula pendula* Roth., *Alnus glutinosa* (L.) Gaertn., *Fraxinus excelsior* L., *Carpinus betulus* L., *Abies alba* Mill., *Tilia cordata* Mill., *Acer platanoides* L., *Ulmus* L., etc. Coniferous stands form 43% of the total area, particularly *Pinus sylvestris* - 35%.

Fraxinus pennsylvanica Marsh. and various *Acer* species also grow in roadside and field-protective forest belts and other protective stands of Forest Steppe zone; *Robinia pseudoacacia*, *Gleditsia triacanthos* L. and

Elaeagnus commutata Bernh. ex Rydb. in the Steppe zone.

In urban stands, the list of plants is wider depending on climatic conditions. *Aesculus hippocastanum* L., *Tilia cordata*, *Acer platanoides*, *Fraxinus excelsior*, *Betula pendula*, and *Ulmus* spp. are most abundant. In arbore-tums, tree species diversity is the highest.

Alien phytophagous insects are diverse in taxonomy, feeding habits, development, and potential damage to forest or urban stands. We characterize alien phytophagous insects in systematic order and then discuss their possible threat due to their biological features.

Results

In this paper, we consider 19 alien species of phytophagous insects.

Woolly ash aphid (ash leaf curl aphid) *Prociphilus fraxinifolii* (Riley 1879) (Hemiptera: Eriosomatidae) got from North America to Europe together with its host (*Fraxinus pennsylvanica*) which was introduced for urban stands (Orlova-Bienkowskaja, Bienkowski 2021). Ash leaf curl aphid was registered in Hungary in 2003, and in 2005 in the Zakarpattia region of Ukraine. In 2012 – 2014 it was found in Kyiv (Chumak et al. 2016), in 2015 – 2016 in Donetsk and Luhansk regions (Martynov and Nikulina 2016b), in 2020 in Kharkiv (Ukrbin 2020). *P. fraxinifolii* is monoecious, i.e. does not change host plants during its life cycle. This feature distinguishes it from other European representatives of the genus feeding on ash trees: *Prociphilus fraxini* and *P. bumeliae* migrate from *Fraxinus* to *Abies* in summer (Chumak et al. 2016). *P. fraxinifolii* lives in colonies consisting of apterae and alatae viviparae inside the large open pseudogalls. The insects excrete white honeydew, which can be a medium for pathogenic bacteria and fungi. The large population density of *P. fraxinifolii* brings to a decrease in ornamental, photosynthesis, and growth of shoots.

Citrus flatid planthopper (CFP) or honeycomb cicada *Metcalfa pruinosa* (Say 1830) (Auchenorrhyncha: Flatidae) originated in eastern North America. It was recorded in Italy in 1979 and soon penetrated most European countries. In its native region, it damages only citrus (Matsiakh and Kramarets 2020). In invaded regions it has about 300 host plants, including trees, bushes, and grasses (Uzhevskaya et al. 2012). In Ukraine, CFP was registered for the first time in 2011 in Odesa where 182 of its host plants were identified (Uzhevskaya et al. 2012). Later the pest was found in Donetsk (Martynov and Nikulina 2018), Dnipropetrovsk, Kharkiv, Kyiv, and Zakarpattia regions (Ukrbin 2020). CFP hibernates as eggs. The larvae suck the sap, white or yellow, then brown spots on the leaves or shoots appear and later merge. Damaged shoots are deformed and wither. The growth of shoots slows down, the viability of plants decreases. Wax and honeydew decrease the ornamentalness of urban plants, the honeydew is the medium for different pathogens. The harm of CFP in new regions increases due to its high gregariousness, mobility, lack of natural enemies, and the ability to carry pathogens, in particular *Pseudomonas syringae* (Donati et al. 2017).

Lilac leafhopper, *Igutettix oculatus* (Lindberg 1929) (Hemiptera: Cicadellidae, Typhlocybinae) penetrated from East Asia and far East to Europe (Belarus, Estonia, Finland, Latvia, Lithuania, Russian Federation) (Stalažs 2013, Gnezdilov 2014) and East Ukraine (Matsiakh and Kramarets 2020). It damages *Syringa*, *Ligustrum*, and *Fraxinus* in urban stands. This insect has high fertility, a short development cycle, is able to parthenogenesis. Damage of foliage by *I. oculatus* brings losses in ornamentalness, and plant weakening, especially when this insect vectors the pathogens. The female of *I. oculatus* oviposits into dormant leaf buds in late summer (Söderman 2005). The nymphs of the first generation develop in spring – the beginning of summer de-

pending on the region, the adults of the second generation occur in September – October. In the northern countries, the second generation is partial. The phenological data from Ukraine are absent.

Western Conifer Seed Bug (WCSB) *Leptoglossus occidentalis* Heidemann (Heteroptera: Coreidae) originates from Western North America (Putchkov et al. 2012, Putchkov 2013). From California in the 90s of the last century, it spread to the east coast (New York and Pennsylvania), and in 1999 it was discovered in Europe - in Northern Italy. In the next decade, it spread from Spain to the Scandinavian countries, as well as in Tunisia (North Africa), Japan, China, Korea (Asia), and Chile (South America). This bug damages the seeds of 48 species of conifers (Gapon 2012). In Ukraine, WCSB was found in 2005 in Kharkiv and Kherson regions, in 2011 – 2012 in Zaporizhzhia, Dnipropetrovsk, Donetsk, and Luhansk regions, in 2018 in Zhytomyr region (Meshkova et al. 2014). Currently, its presence is also confirmed in the Zakarpattia, Odesa, Cherkasy, Kyiv regions and the Autonomous Republic of Crimea (UkrBIN 2020).

WCSB has peculiar leaflike expansions on the metatibia which are not characteristic of native (European) Coreidae. Adult bugs hibernate in buildings or in the birds' nests in large groups. In spring it returns to the forest and feeds by green cones and developing seeds also by large groups, including nymphs and adults. Unlike other cone pests, WCSB leaves almost no visible signs of cone damage. However, as a result of its feeding, the seeds stop developing, shrivel, and do not germinate. The harmfulness of the bug is especially high at seed plantations and breeding objects. Since WCSB feeds during the period of development in different trees, it is able to be the vector of pathogens, in particular *Sphaeropsis sapinea* – the causal agent of the Diplodia Tip Blight disease (Luchi et al. 2012).

Brown marmorated stink bug *Halyomorpha*

halys (Stal 1855) (Heteroptera: Pentatomidae) origins from Southeast Asia. Since 1996, it began to spread in the United States, in 2007 got to Switzerland, in 2014 in the Krasnodar region of Russia (Gapon 2016, Musolin et al. 2018). In Ukraine, it was found in 2016 in Odesa (Uzhevskaya 2017), and since 2020 it is known from Kherson, Zakarpattia, and Dnipropetrovsk regions (Ukrbin 2020). *H. halys* damages about 300 species of cultivated plants out of 49 families, including vegetables, fruit trees, soybean, berries, grain, and leguminous plants, ornamental woody plants (catalpa, ailanthus, magnolia, sycamore, etc.), and forest trees, particularly maple and ash (Musolin et al. 2018).

Oak lace bug (OLB) *Corythucha arcuata* (Say 1832) (Hemiptera: Tingidae) is native to North America, particularly the USA and Canada. In 1999 it got to Italy and has spread in recent 20 years in many countries of Europe (Csóka et al. 2020). In 2016 OLB was registered in Crimea Peninsula (Golub et al. 2020), in 2017 in the South - Western part of the Kherson region of Ukraine, and in the Zakarpattia region in 2020 (Meshkova et al. 2020, Ukrbin 2020). OLB is a dangerous pest of different oak species (Csóka et al. 2020). Its larvae and adults suck sap from the leaves. Eggs, larvae, and adults can be seen on the underside of the leaves. Adults hibernate under the fallen leaves, under the bark, or in other protected sites. Damaged trees decrease their productivity and resistance to other damaging causes. It spreads actively, flying over distances of several hundred meters, and passively: by wind, vehicles, and plant material. We assessed the highest infestation in oak (*Quercus robur* L.) stands near forest roads and the waterway (Meshkova et al. 2020). In 2021, a pest moved to the north and to the eastern parts of the Kherson region (Meshkova et al. 2021c). The development of three generations of OLB was successfully completed in the study area during the season.

The sycamore lace bug *Corythucha ciliata* (Staudinger 1870) (Hemiptera: Tingidae) pen-

etrated Europe from North America in the 60s. In the Crimean Peninsula and in the Mykolaiv region it was found in 2013 (Putchkov 2013), in the Kherson region in 2017 (Ukrbin 2020). In appearance and biology, the sycamore lace bug is similar to the oak lace bug (Glod and Nasarenko 2020). The spread of sycamore lace bug in Ukraine is poorly studied because its host plant *Platanus sp.* is not common. This tree grows only in the Crimean Peninsula, in southern regions of Ukraine (Odesa, Kherson, Mykolaiv, Zaporizhzhia), and in certain botanical gardens or arboretums.

Emerald ash borer *Agrilus planipennis* Fairmaire, 1888 (Coleoptera: Buprestidae) (EAB) has been studied in detail in its homeland (China and the Far East of Russia) and in the regions of its introduction – the United States and European Russia (Orlova-Bienkowskaja et al. 2020). In the summer of 2019 EAB was recorded in the Luhansk region of Ukraine (Orlova-Bienkowskaja et al. 2020), although the presence of exit holes indicated its penetration no later than in 2018 (Kucheryavenko et al. 2020). Despite the sanitary felling of colonized trees in the primary foci, in 2020 *A. planipennis* inhabited *Fraxinus pennsylvanica* Marsh. and *Fraxinus excelsior* L. almost in all forests and road and field protective shelter belts of the Luhansk region (Meshkova et al. 2021a), and in 2021 it was found in the Kharkiv region (Meshkova et al. 2021b). Usually, the EAB inhabits the same tree for several years, starting from the branches of the crown. Therefore, in the first years, the symptoms of infested trees are the same as when they are colonized by *Hylastes sp.* or are affected by diseases. Traces of woodpeckers feeding and 2.5 – 3.5 mm exit holes of a characteristic D-shape can be distinctive features of EAB.

Velvet longhorned beetle *Trichoferus campestris* (Faldermann 1835) (Coleoptera: Cerambycidae) is native to Eastern Asia and the Far East of Russia (Grebennikov et al. 2010). It inhabits healthy and weakened deciduous and coniferous tree species of over

40 genera, as well as felled timber, wooden structures, and buildings. Causes technical harm, because, the diameter of larval galleries is about 1 cm. Signs of this pest include round emergence holes in stems and branches, larval galleries beneath the bark, excrements at the base of the tree, the symptoms are leaf yellowing and canopy thinning. Development rate depends on local climate and timber humidity; in Ukraine it is at least two years. The first data on *T. campestris* in Ukraine obtained since the 90s 20th century, particularly since 1992 in Crimea, and 1994 in Donetsk region, later in Kharkiv, Luhansk (Terekhova and Bartenev 2007), Zakarpattia (Zamoroka 2017,) and many other regions (Martynov and Nikulina 2016a; Zamoroka and Korytnianska, 2018), particularly Poltava, Odesa, Zaporizhzhia, Chernivtsi (Ukrbin 2020).

Elm zigzag sawfly *Aproceros leucopoda* (Takeuchi 1939) (Hymenoptera, Argidae) origins from East Asia and the Far East of Russia. It was registered in Europe for the first time in Hungary and Poland in 2003. In Ukraine, it was found in the Luhansk region in 2006 and in the Kharkiv region in 2009. It exists in Rivne region (Ukrbin 2020) and West Polissya (Sirenko and Zabroda 2013). In 2014 – 2015 it was found in Zaporizhzhia, Donetsk regions and Crimea (Martynov and Nikulina 2016b, 2017, 2021, Martynov et al. 2021). Feeding traces of early-stage larvae on leaves show a characteristic zigzag pattern. Pupae hibernate. Parthenogenetic reproduction, the short life cycle of summer generations, and the ability to produce up to four generations per year are characteristics of this pest. In Donetsk, elm zigzag sawfly severely damaged introduced *Ulmus pumila*, and had low density in *U. minor* and *U. glabra*.

Summer generations pupate on the underside of leaves, branches, and bark cracks in a light lacy cocoon. In the Donetsk region, adults occur from mid-April to early August (Martynov and Nikulina 2017). The development of the first generation larvae was noted from the end of April to the beginning of June,

the second - from the beginning of June to the beginning of July, the third - from the beginning to the end of July, the fourth - from the end of July to mid-August. The larvae of the fourth generation that have completed their feeding hibernate in the forest litter or soil as eonymph in the dense cocoons. These eonymphs pupate the next spring. Larvae of the first generation develop mainly in the lower and the middle crown layers. Part of the larvae of each generation migrate into the soil, where they form wintering cocoons, creating a reserve population part, while the majority of individuals continue their seasonal development (Martynov et al. 2021).

Locust sawfly or false acacia sawfly, *Nematus (Pteronidea) tibialis* (Newman 1837) (Hymenoptera: Tenthredinidae) origins from North America and got to Europe in the 19th century with its host tree *R. pseudoacacia*. In Ukraine, this sawfly is known since 1979 (Ermolenko 1981). It is present in the West Polissya and Northern megaloslope of the Ukrainian Carpathians (Sirenko and Zabroda 2013). Larvae of younger instars perforate leaflets of complex leaf blades between veins. Usually, they feed by 2-4 larvae per one simple leaf. At older instars, they feed singly - they eat leaves from the edges, less often they gnaw them to the petioles (Martynov and Nikulina 2021).

The fall webworm, *Hyphantria cunea* (Drury 1773) (Lepidoptera: Erebidae), is native to North America. In Europe, namely Hungary, it was brought with cargo in 1940. In Ukraine, it was first discovered in 1952 in the Zakarpattia region (Krivosheev 2009). Now American fall webworm presents in Vinnytsia, Dnipropetrovsk, Donetsk, Zakarpattia, Zaporizhzhia, Ivano-Frankivsk, Kyiv, Kirovohrad, Luhansk, Mykolaiv, Odesa, Poltava, Rivne, Ternopil, Kharkiv, Kherson, Khmelnytskyi, Cherkasy, Chernivtsi regions and in the Autonomous Republic of Crimea (Ukrbin 2020), also in Volyn, Sumy, Chernihiv region (Stankevich 2021). Damages over 300 plant species in forests, gardens, urban stands, and shelterbelts. Has one to three generations depending on region and year.

Horse-chestnut leaf miner, *Cameraria ohridella* Deschka and Dimič, 1986 (Lepidoptera: Gracillariidae) has origin from Balcan forests, on the border between Macedonia and Albany. It got to Ukraine in 1998 (Zakarpattia), in 2003 was found in Kyiv (Akimov et al. 2003) and in 2006 in Kharkiv. Now horse-chestnut leaf miner is registered in most administrative regions (Holoborodko et al. 2018, Ukrbin 2020) – Cherkasy, Zaporizhzhia, Lviv, Volyn, Dnipropetrovsk, Kherson, Rivne, Vinnytsia, Zhytomyr, Poltava, Luhansk. The pupae hibernate in fallen leaves. The moths oviposit on leaves of *Aesculus hippocastanum* L. In Kharkiv (Ukraine), *Aesculus carnea* and *A. glabra* are relatively resistant to *Cameraria ohridella*, and *A. parviflora* is absolutely resistant to it (Meshkova et al. 2013). The larvae of horse-chestnut leaf miner develop inside mines which increase their size. The almost total leaf surface is covered by mines at the end of the summer. It prevents photosynthesis and weakens the tree. Sometimes the leaves fall off prematurely. The tree becomes susceptible to infection by pathogens. Horse-chestnut leaf miner develops in 2–4 generations (Meshkova, Mikulina 2013, Uzhevskaya 2017) depending on region and year. Like any leafminer, it is protected from diurnal temperature fluctuations and aerotechnogenic pollutants. In the Kharkiv region, horse chestnut miner develops in three generations. The beginning of swarming after winter coincides with phenological indicators, complete frondescence of horse chestnut, and beginning of flowering (end of April – beginning of May). Imago of new generation swarm in the second half of June – at the beginning of July, the next generation swarms at the end of July – beginning of August. Mines can be found on foliage from the middle of May to September. In some years the mines of the 4th generation appear on the secondary foliage, which grows at the end of August – in September. These larvae did not complete their development (Meshkova, Mikulina 2013).

Lime leafminer, *Phyllonorycter issikii*

(Kumata, 1963), (Lepidoptera: Gracillariidae) origins from Japan and the Far East of Russia. In 2007 lime miner has spread to the European part of Russia, and now it is common in the forests with lime in the stand composition and in the green stands of settlements (Ermolaev, Domrachev 2021). Now it is found in Zakarpattia, Lviv, Cherkasy, Kharkiv and Sumy regions (Ukrbin 2020, Matsiakh, Kramarets 2020). Adults hibernate in cracks in the bark. In the spring, they oviposit on the underside of the leaves. The larvae form mines under the leaf cuticle; at the last instar, they pupate inside the mine. Lime leafminer has two complete generations per year in the Kharkiv region and sometimes has the third incomplete generation. Swarming after winter begins in the 1st ten-day period of May. The first eggs were found in the 2nd ten-day period of May when lime foliage had maximal size. The first mines on limes were found in the 3rd ten-day period of May. Mass pupation was observed in the middle-end of June and coincided with mass flowering of lime. Imago was found in the middle of June. Mines of the 2nd generation appeared in mass in the 2nd ten-day period of July, pupae appeared at the end of July. Imago oviposited in August, larvae of the 3rd generation hatched, but because of foliage yellowing and fall, they did not complete development and die (Meshkova, Mikulina 2012). Limes *Tilia americana*, *T. tomentosa*, *T. europaea*, and *T. sibirica* are relatively resistant to *Phyllonorycter issikii*, and *T. amurensis* i *T. japonica* were resistant in the years of our investigations (Meshkova et al. 2013).

The locust digitate leafminer, *Parectopa robinella* Clemens, 1863 (Lepidoptera: Gracillariidae), origins from North America. It got to Europe (Italy) in 1970 (Meshkova et al. 2013). It was registered in Kyiv in 2003, In Odesa and Kharkiv in 2008, and now is spread in Cherkasy, Lviv, Kirovohrad, Dnipropetrovsk, Zakarpattia, Volyn, Kherson regions (Uzhevskaya 2017, Holoborodko et al. 2018, Ukrbin 2020). The host plants are *Robinia pseudoacacia* L. and *R. viscosa* Vent.

The pest pupates in the foliage litter. Has 2 generations per year (Meshkova and Mikulina 2012, Uzhevskaya 2017).

Locust Leaf Miner *Macrosaccus robiniella* (Clemens 1859) (Lepidoptera: Gracillariidae), formerly known as *Phyllonorycter robinella*, also originates from North America. It got to Europe (Switzerland) in 1983 and then spread to different regions. In Ukraine it was found in 2008 and now exists in Cherkasy, Kyiv, Lviv, Volyn, Ternopil, Zakarpattia, Dnipropetrovsk, Kherson, Odesa, Kharkiv regions (Uzhevskaya 2017, Meshkova and Mikulina 2012, Holoborodko et al. 2018, Ukrbin 2020).

The plane leaf miner, *Phyllonorycter platanii* (Staudinger 1870). Natural range covers Balkans and West Asia like a range of *Platanus orientalis* L. (Šefrova 2003). In the middle of the 19th century, it penetrated Central Asia, then to the Mediterranean and North Africa, and later to Central European countries. In Ukraine it was found in the Crimean Peninsula in 80s (Valeeva 2003, Budashkin et al. 2004), in the Kherson region in the middle 90s (Meshkova and Nazarenko, 2012), in 2003 - 2004 in Zaporizhzhya, later in Lviv, Dnipro and Zakarpattia (Ukrbin 2020, Matsiakh and Kramarets 2020), Kyiv (Lesovoy et al. 2019). The pupae of the plane leaf miner hibernate inside the mines in fallen leaves. In the Southern regions of the sycamore range, a significant part of the foliage does not fall for the winter, there pupae also hibernate on the leaves remaining in the crowns. Therefore, the removal of fallen leaves does not prevent the trees from being colonized by plane leaf miner in spring. There are 3 generations of the plane leaf miner per year in Crimea (Budashkin et al. 2004). At the high population density of plane leaf miner, the photosynthetic surface of leaves decreases, the growth and health condition of trees, and their decorative effect worsen.

Box tree moth, *Cydalima perspectalis* (Walker 1859), (Lepidoptera: Crambidae) is native to Eastern Asia and the Far East of Russia. It got to Europe (Germany and

Switzerland) in 2006. In 2012, the pest was brought to Sochi in preparation for the Winter Olympic Games 2014, along with seedlings of evergreen boxwood (*Buxus sempervirens*). Then box tree moth spread to the territory of the Caucasus (Matsiakh et al. 2018). In Ukraine, caterpillars of the box tree moth were found in the summer of 2014 in Zakarpattia (Turys 2015). In 2011 it got to Kyiv, in 2014 – 2015 to Donetsk (Martynov and Nikulina 2016a), in 2017 to Odesa (Uzhevskaya 2017), in 2018 to Lviv (Matsiakh and Kramarets 2020). Now it exists in Odesa, Kyiv, Dnipropetrovsk, Ivano-Frankivsk, Khmelnytskyi, Lviv, Chernivtsi, Kherson, Zhytomyr regions (Budashkin 2016, Uzhevskaya 2017, Ukrbin 2020). It damages ornamental box trees in urban areas, has 1 to 3 generations. Larvae form a large nest, connecting branch fragments with silk. It has 6 instars. Larvae of 2–3 instar hibernate in dense white winter cocoons joined by silk with young leaves of the host plant. On the south bank of the Crimean Peninsula (Budashkin 2016), the development of wintering larvae resumes from the end of February-March. Adults swarm from the end of May to the middle of September, the second generation from the end of July to the beginning of September, and the 3rd one in September-October. Boxwood is widely used in landscaping. However, it grows slowly. During the box tree moth development, the caterpillars completely defoliate the plant and wrap it in webs. The plant turns yellow and dries up. Therefore, an outbreak of this pest in urban stands leads to large economic losses.

Black locust gall midge, *Obolodiplosis robiniae* (Haldeman 1847) (Diptera: Cecidomyiidae) originates from the Central and Western parts of North America. On the European continent, *O. robiniae* has been recorded since 2003. In Ukraine black locust gall midge was registered in 2006 (Berest 2006, Berest and Titar 2007) and Donetsk (Popov and Gubin 2012, Martynov and Nikulina 2016a, Levchenko and Martynov 2019), in 2016 in Lviv (Matsiakh and Kramarets 2020) and Zakarpattia (Ukrbin 2020), in 2020 in Kharkiv. The larvae black lo-

cust gall midge develop inside corrugated or more or less smooth ridges formed as a result of wrapping the edges of individual leaflets on the underside. Late galls are red, dead ones are brown. In autumn, larvae pupate in the soil. Adults appear in spring.

Discussion

We reviewed 19 species of alien phytophagous insects, including 2 species of Coleoptera, 7 Hemiptera (including 4 bug species), 7 Lepidoptera, 2 Hymenoptera, and 1 Diptera. *Hyphantria cunea* and *Cameraria ohridella* considerably damaged their host plants and are quite deeply studied. Pests of *R. pseudo-acacia* – *Parectopa robiniella*, *Macrosaccus robiniella*, *Nematus tibialis*, and *Obolodiplosis robiniae* could penetrate Ukraine long ago, but did not attract the attention of researchers until recently, since did not show a noticeable effect on the health condition of trees or the host tree is not very valuable. *Phyllonorycter issikii* is known as a serious pest of *T. cordata* in the Northern part of the range (Ermolaev and Domrachev 2021), but is not abundant in most parts of Ukraine. On the other hand, a *Phyllonorycter platani* and *Corythucha ciliata* are serious pests in the south part of the range (Šefrova 2003) but their host plant (*Platanus sp.*) is rather rare in Ukraine.

Trichoferus campestris is known from 8 regions but has not yet shown any harmful effects. However, publications on its wide polyphagy and ability to colonize felled timber, wooden structures, and buildings (Grebennikov et al. 2010) indicate the need to pay attention to the study of this species. *Cydalima perspectalis* has also spread to 12 regions and is a threat to ornamental stands of boxwood, which is slowly recovering after defoliation. The threat from sucking insects (aphids and bugs) increases with their ability to vector tree pathogens (Luchi et al. 2012, Donati et al. 2017). The polyphagous *Halyomorpha halys* is distributed only in 4 regions, but as it moves to more

Northern areas, it can pose a threat to forest, ornamental and agricultural crops.

The most important alien pests for forestry are those that damage the most common tree species: Scots pine, English oak, and European ash. So *Leptoglossus occidentalis*, which has already spread in 12 regions of Ukraine, can pose a great danger to the restoration of Scots pine forests. Traces of its nutrition in pine cones are invisible, but the proportion of undamaged seeds and their germination have decreased in recent years.

Corythucha arcuata presents only in two regions but is moving northward (Meshkova et al. 2021c). Information from other European countries (Csóka et al. 2020) and data on damage to oak foliage in the Kherson region make us pay attention to this pest.

The most recent invader, *Agrilus planipennis*, has spread over several years from the Eastern border with Russia to the entire Luhansk and partly Kharkiv region, inhabits *Fraxinus excelsior* and *F. pennsylvanica*, which grows in roadside forest belts, and has the ability to move further west (Meshkova et al. 2021b). The weakening of ash stands in recent years, the spread of ash dieback, root rot, and bacteriosis (Meshkova et al. 2021d), may be aggravated by the new invader.

Conclusions

19 species of alien phytophagous insects, including 2 species of Coleoptera, 7 Hemiptera (including 4 bug species), 7 Lepidoptera, 2 Hymenoptera, and 1 Diptera are analyzed. *Hyphantria cunea* sometimes defoliates orchards and shelterbelts. *Cameraria ohridella* and *Cydalima perspectalis* damage urban stands. The polyphagous *Halyomorpha halys* can pose a threat to forest, ornamental and agricultural crops.

Leptoglossus occidentalis, *Corythucha arcuata*, and *Agrilus planipennis* pose a great danger to forest stands. The first species damages cones and seeds of *Pinus sylvestris*

and is widely spread in Ukraine. The second one damages the foliage of *Q. robur*, is present only in the two Southern regions of Ukraine, and tends to move North. The last species is a dangerous stem pest of *F. excelsior* and *F. pennsylvanica*, is present in two Eastern regions of Ukraine and tends to move West.

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