Bad and good news for ash trees in Europe: alien pest *Agrilus planipennis* has spread to Ukraine and the south of European Russia, but serious damage of *Fraxinus excelsior* in the forests is not detected

Marina J. ORLOVA-BIENKOWSKAJA[1]*, Alexander N. DROGVALENKO [2] , Ilya A. ZABALUEV[1], Alexey S. SAZHNEV[3], Elena Y. PEREGUDOVA[4], Sergey G. MAZUROV[5], Evgenij V. KOMAROV[6], Vitalij V. STRUCHAEV[7], Andrzej O. BIEŃKOWSKI[1]

* Corresponding author

[1] A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 33 Leninskiy Prospect, Moscow, Russia 119071

[2] V.N. Karazin Kharkiv National University, 4 Svobody Square, Kharkiv, Ukraine 61022

[3] Papanin Institute for Biology of Inland Waters, Russian Academy of Sciences, Borok, Nekouz District, Yaroslavl Region, Russia 152742

[4] Saint Petersburg State Forest Technical University, Institutskiy per., 5, Saint Petersburg, Russia 194021

[5] Middle School of General education, Leski, Krasnoe District, Lipetsk Region, Russia 399675

[6] All-Russian Scientific Research Institute of Irrigated Agriculture, Timiryazev str., 9, Volgograd Russia 400002

[7] Agrobiotekhnologia, Kolkhoznaya Street 3/1, Churaevo, Shebekino District, Belgorod Region, Russia 309251

Email address

Marina J. Orlova-Bienkowskaja

e-mail: marinaorlben@yandex.ru

Alexander N. Drogvalenko

e-mail: triplaxxx@ukr.net

Ilya A. Zabaluev

e-mail: fatsiccor66@mail.ru

Alexey S. Sazhnev

e-mail: sazh@list.ru

Elena Y. Peregudova

e-mail: dinamo-l@mail.ru

Sergey G. Mazurov

e-mail: mazusergej@yandex.ru

Evgenij V. Komarov

e-mail: evkomarov@rambler.ru

Andrzej O. Bieńkowski

e-mail: bienkowski@yandex.ru

Short title

EAB range in European Russia and Ukraine

Keywords
Emerald Ash Borer; EAB; *Fraxinus pennsylvanica; Fraxinus excelsior*; invasive pest; ash

Contributions of the co-authors
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Key message
Alien pest Emerald Ash Borer (*Agrilus planipennis*) posing a threat to ash trees all over Europe has spread to Ukraine and the south of European Russia and severely damages green ash (*Fraxinus pennsylvanica*), but serious damage of European ash (*Fraxinus excelsior*) in the forests is not detected.

Abstract
Context:
Emerald Ash Borer (EAB) *Agrilus planipennis*, a devastating alien pest of ash trees was first detected in Europe in Moscow in 2003. Its outbreak in the cities of European Russia (ER) seriously damaged plantations of *F. pennsylvanica* introduced from North America.
Aims:
To determine the current range of the pest and its impact on *Fraxinus excelsior* in the forests.
Methods:
In 2017–2019 more than 5000 ash trees were examined in 55 localities of ER, Ukraine and Belarus and more than 500 trees of *F. excelsior* in the large forest in the center of EAB range.
Results:
EAB is first detected in in Ukraine and in Volgograd and Kursk regions of ER. Current range exceeds the area of Spain and includes 15 regions of ER: Bryansk, Kaluga, Kursk, Lipetsk, Moscow, Orel, Ryazan, Smolensk, Tambov, Tula, Tver, Vladimir, Volgograd, Voronezh, Yaroslavl and Luhansk Region of Ukraine. EAB is not detected in Belarus. All cases of infestation of *F. excelsior* refer not to the forests, but to the artificial plantations.
Conclusion
There is no doubt that EAB will appear in other European countries soon and damage *F. pennsylvanica* plantations. But it could be less dangerous for *F. excelsior* in European forests.
Keywords: Emerald Ash Borer; EAB; *Fraxinus pennsylvanica; Fraxinus excelsior*; invasive pest; ash

1. Introduction

Emerald ash borer (EAB) *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae) is a devastating alien pest of ash trees in European Russia and North America (Baranchikov et al. 2008; Herms and McCullough 2014). The native

range of this wood-boring beetle occupies a restricted territory in East Asia (Orlova-Bienkowskaja and Volkovitsh 2018). In 2003 *A. planipennis* was first recorded in European Russia, namely in Moscow, and the severe outbreak and quick spread of the pest began (Baranchikov et al. 2008). By 2013 the pest was recorded in 9 regions of European Russia: from Yaroslavl in the north to Voronezh in the south (Straw et al 2013; Orlova-Bienkowskaja 2014a). The probabilistic model of spread has shown that in the next few years the range of *A. planipennis* can significantly expand, and the pest can appear in the neighboring countries (Orlova-Bienkowskaja and Bieńkowski 2018a). The first aim of our study was to determine the current range of *A. planipennis*. To do this we have compiled all published data about localities of *A. planipennis* detection (Table 1), made survey in the regions where EAB was not detected before, and made a map of the current range of the pest.

Fraxinus pennsylvanica Marshall introduced from North America is widely planted in European Russia as an ornamental and landscaping tree. It is highly susceptible to *A. planipennis* both in North America and Russia (Herms and McCullough 2014; Baranchikov et al. 2014). The overwhelming majority of detected infestations of ash trees in European Russia refer to this ash species (Baranchikov et al. 2008; Straw et al 2013; Orlova-Bienkowskaja 2014a etc.). The only native ash species *F. excelsior* L. is also susceptible to the pest (Baranchikov et al. 2014), but studies on the feeding preferences of adult *A. planipennis* on different species of ash suggest that *F. excelsior* is not as susceptible as *F. pennsylvanica* (Pureswaran and Poland 2009). *Fraxinus excelsior* is rare in Moscow Region and other regions of Central Russia. So the information about infestation of *F. excelsior* by *A. planipennis* was scarce and referred only to urban plantations and artificial shelterbelts, where *F. excelsior* was planted together with *F. pennsylvanica* (Straw et al. 2013; Baranchikov 2018). There were no information about the impact of *A. planipennis* on *F. excelsior* in natural forests. Therefore, it was a great deal of uncertainty surrounding the likely future impact of *A. planipennis* on ash in European forests (Straw et al. 2013). So the second aim of our study was to get the information about current condition of *F. excelsior* in natural forest stands in the regions occupied by *A. planipennis*.

2. Material and methods

2.1. Localities of survey

In 2017, 2018 and 2019 we examined more than 5000 ash trees in 55 localities: 44 localities in 21 regions of European Russia, 8 localities in 4 regions of Belarus and 3 localities in 3 regions of Ukraine (Table 2, Fig. 1):

1. We examined ash trees in 46 cities, where *A. planipennis* had not been detected before. The aim was to determine the current range of the pest. We selected particular survey areas so that they are situated in all directions from previously known range of *A. planipennis*. If we found the pest outside the previously known range, we made the next survey in locality situated further in the same direction. And then we repeated this procedure until found the locality without the pest. This protocol was flexible, since we used all the possibilities to examine as much localities as possible.
2. We examined ash trees in 7 cities, where *A. planipennis* was found 16–4 years ago. The aim was to determine if ash trees and populations of *A. planipennis* still exist there.
3. We examined more than 500 *F. excelsior* in two localities of the large natural forest Tulskie Zaseki situated in the center of current range of *A. planipennis*. The aim was to determine if *A. planipennis* damages trees in this forest.

2.2. Method of survey

The survey of ash trees in each city always started from the main railway station. Usually we stayed one day in each city and examined as much ash trees as we could. In the most of the localities we examined artificial plantations in the cities, along motorways and railroads an in the field shelter belts. The survey of 500 *F. excelsior* trees in the large Tulskie Zaseki Forest was made in two localities situated 25 km from each other (see Table 2).

We used the standard method of *A. planipennis* detection used by many authors (Baranchikov and Kurteev 2012; Straw et al. 2013 etc.). We looked for ash trees with the symptoms of the general decline (dieback of the upper part of the stem, reduced foliage, epicormic shoots, loose bark etc.) and examined the lower part of the stem below 2 m. The presence of the pest was detected by D-shaped exit holes on the stem, larval galleries under the bark (Figs 2–5). If we found the exit holes and larval galleries, we made the photos and tried to collect larvae from under the bark and adults: alive specimens on leaves or dead specimens in exit holes. Larvae preserved in alcohol and adults on entomological pins were examined in the laboratory to confirm the identification and deposited to the authors collections.

3. Results

3.1. Ukraine

On 20–22 of June 2019 ash trees in Starokozhiv Forest and field shelter belt in its vicinity were examined (Markivka District of Luhansk Region of Ukraine) (the survey was made by A.N. Drogvalenko). The forest consists of *Quercus* sp., *Acer platanoides* L., *Fraxinus excelsior* and *Pyrus* sp. Undergrowth and edges consist of *Acer campestre* L., *Acer tataricum* L., *Fraxinus excelsior, F. pennsylvanica, Prunus spinosa* L., *Prunus fruticosa* Pallas. Forest belts consisted mainly from *F. pennsylvanica.* As a result of examination of 250 ash trees, three trees of *F. pennsylvanica* damaged by *A. planipennis* were detected. These trees were situated at the edge of the forest belts and have the diameter of 7–10 cm. Characteristic D-shaped exit holes were situated at a height of 50–200 cm. The infested trees had dying of upper branches, foliage density reduced (small leaves) and fewer seeds.

On July 2 2019 we posted the manuscript of the current article on the Internet as a preprint. Immediately following the appearance of this preprint on the Internet, National Plant Protection Organization of Ukraine conducted an official survey in the same area and did not detect the pest. And since we had no specimens or photos for confirmation, our record of *A. planipennis* in Ukraine was considered unreliable (EPPO 2019). Description of the forest provided in the report of the Ukrainian Plant Protection Organization indicates that the employees of this organization did not find the infested forest belt. Unfortunately, they did not ask A.N. Drogvalenko to show them these trees or indicate the exact coordinates of his finding.

On September 4–6 2019 A.N. Drogvalenko visited Markivka District of Luhansk Region of Ukraine again and repeated his survey of ash trees. He found the same three trees and more than 40 other trees of *F. pennsylvanica* heavily infested with *A. planipennis*, made the photos of larvae, larval galleries and exit holes (Figs 2–5) and collected more than 20 larvae of different instars including the last instar. The coordinates of trees, where the larvae were collected: 49.614991 N, 39.559743 E; 49.614160 N, 39.572402 E and 49.597043 N, 39.561811 E (roadside plantation). The larvae were deposited in the collection by A.N. Drogvalenko in Kharkiv.

After these larvae were shown to Olga Vladimirovna Bashinskaya (o.bashynska@dpss.gov.ua), the head of Department of phytosanitary expertise and risk analysis of the Ukrainian State Consumer Service, she went to Starokozhiv forest and also found signs of infestation of ash trees with *A. planipennis*.

Our survey of ash trees in other localities of Ukraine: Luhansk City, Donetsk City and Kharkiv City did not reveal infestations (see Table 2).

3.2. Belarus and western regions of Russia: Tver, Pskov, Smolensk regions and St-Petersburg

In 2017–2019 we tried to find *A. planipennis* in eastern and central regions of Belarus: in the cities of Borisov, Stolbtsy, Mogilev, Orsha, Vitebsk, Minsk, Krichev and Gomel. We did not find any signs of infestations in spite of *F. pennsylvanica* and *F. excelsior* are common in these cities (Table 2).

We also tried to find *A. planipennis* in the 10 localities of European Russia situated west and north-west to the border of previously known range: in Pskov Region (Sebezh, Velikie Luki), Smolensk Region (Roslavl, Sychevka), St.-Petersburg, Tver Region (Bologoye, Ostashkov, Rzev, Torzhok, Vyshniy Volochek). But we detected no symptoms of infestation there. It is interesting, that we failed to find the pest even in the city of Rhev, which is only 15 km north-west from Zubtsov, where the outbreak of *A. planipennis* was detected in 2013 (Straw et al. 2013) and is still continuing (our observations in 2019).

3.3. Volgograd Region

The survey of declined plantations of *F. pennsylvanica* (104.9 ha) in Sarpinsky Island in the Volga River (the city of Volgograd) in October 2018 has shown that the trees are severely damaged by *A. planipennis* (the survey was made by E.V. Komarov) (Figs 6–9). The island is occupied with the floodplain forest, which initially consisted of *Qurecus* sp., *Populus* sp., *Ulmus* sp. later replaced by artificially planted *F. pennsylvanica*. In different parts of the island the degree of damage of ash trees varied from 20–30% to 90–100%. The decline of the ash plantations because of the pest outbreak attracted the attention of the local TV (Vesti Volgograd 2018). Since 21 May 2019 the mass emerging of adult *A. planipennis* in the island began. In 2019 the outbreak was also detected in the left bank of Volga – in Volga-Akhtuba floodplain (more than 500 damaged *F. pennsylvanica*) and in Sarepta Peninsula (more than 200 ones). Besides that, one tree damaged by *A. plannipennis* was also detected in the center of Volgograd city (Mira Street). The official phytoquarantine zones are declared in Sarpinsky Island and Volga-Akhtuba floodplain (Rosselkhoznadzor 2019).

3.4. Kursk Region

In 2014 we made a survey of more than 100 trees of *F. pennsylvanica* in Kursk near the main railway station and did not find evidences of the pest (Orlova-Bienkowskaja and Bieńkowski, unpublished data). In 2016 the survey in Kursk was repeated by the expert from All-Russian Center of Plant Quarantine Y.N. Kovalenko, and he also didn't find the pest (unpublished data). In 2019 the survey in Kursk was repeated by Vitalij V. Struchaev. He examined more than 100 trees of *F. pennsylvanica* in plantation along the railway near the main railway station and found that at last half of them have exit holes of *A. planipennis*. One dead adult specimen was collected in the exit hole (Fig. 10). Then examination of *F. pennsylvanica* trees in the parks Boeva Dacha (Fig. 11) and Pyatidesyatiletiya VLKSM showed that they are in poor condition and have exit holes of *A. planipennis*.

3.5. Lipetsk Region

Lipetsk Region is surrounded by the regions where *A. planipennis* was found in 2013 (Orlova-Bienkowskaja 2014a), but the survey by M.J. Orlova-Bienkowskaja in the city of Gryazy in Lipetsk region in 2013 did not revealed the infestation of trees by *A. planipennis*, though the trees of *F. pennsylvanica* were in poor condition, and the species *Agrilus convexicollis* Redtenbacher usually associated with *A. planipennis* was found (Orlova-Bienkowskaja and Volkovitsh 2014). In 2018 *A. planipennis* was first found in Lipetsk Region – in the city of Elets (Baranchikov 2018). On 22 June 2019 S.G. Mazurov collected one adult of *A. planipennis* in 40 km from Elets: plantations of *F. pennsylvanica* along the railway in Leski, Lipetsk Region. This specimen is in his collection. Examination of 10

trees in this plantation didn't reveal exit holes, but all the trees are in poor conditions: have dieback in the upper canopy.

3.6. Voronezh Region

Agrilus planipennis was first detected in Voronezh region in 2013 in the city of Voronezh (Orlova-Bienkowskaja 2014a). In 2018 it was detected in other localities: in the very south of the region (50°12'N, exact locality is not indicated) and in the city of Talovaya (Baranchikov et al. 2018a) as well as in Olkhovatskoe Forestry (Rosselkhoznadzor 2019). In 2019 we surveyed ash trees in four other localities of Voronezh region (the survey was made by Andrzej O. Bieńkowski and Marina J. Orlova-Bienkowskaja). The pest was not found in the north-east of the region (Borisoglebsk and Povorino), but was found in the center and south of the region:

1. Rossosh. More than 100 *F. pennsylvanica* heavily infested by *A. planipennis* with larval galleries and exit holes were found in the forest belt around Chkalovskij district (50.201158 N, 39.604695 E). One *F. pennsylvanica* and one *F. excelsior* with exit holes and larval galleries were found near the main railway station (50.184266 N, 39.600577 E)
2. Kantemirovka. One *F. pennsylvanica* with *A. planipennis* exit holes and larval galleries was found in the territory of House of Culture (49.698968 N, 39.860308 E) (Fig. 12). Trees of *F. pennsylvanica* with EAB exit holes and larval galleries were also found near the Gas station near the road R-194 (49.758194 N, 39.843341 E).

3.7. Kaluga Region

Agrilus planipennis was first detected in Kaluga Region in Obninsk City in 2012 and in Kaluga City in 2013 (Orlova-Bienkowskaja 2014a). The survey of more than 100 trees of *F. pennsylvanica* in the city of Maloyaroslavets on 31 August 2019 have revealed EAB exit holes and larval galleries on at least 50 of them (observations by A.A. Bienkowski).

3.8. Bryansk Region

The first survey of ash trees in the city of Bryansk was made in 2013 and did not reveal signs of infestations by *A. planipennis* (Orlova-Bienkowskaja 2014a). In 2019 *A. planipennis* was detected in Majskij Park in Bryansk by National Plant Protection Organization, and an official phytoquarantine zone was declared there (Rosselkhoznadzor 2019). On 1 July 2019 I.A. Zabaluev examined ash trees in other districts of Bryansk and found the trees of *F. pennsylvanica* heavily infested with *A. planipennis* in the square named after M.P. Kamozin and in the streets Krasnoarmejskaya, Ulyaniva and Kharkovskaja.

3.9. Surveys in localities where *A. planipennis* was detected earlier

In 2019 we examined ash trees in 7 cities, where *A. planipennis* was found 16–4 years ago: Moscow (first record in 2003), Kolomna (2012), Zelenograd (2011), Vyazma (2012), Tula (2013), Tver (2015) and Zubtsov (2013) (see Table 1 for the information about the first records). In all these localities ash trees are still common and populations of *A. planipennis* still exist. Larvae or adults were find in all these localities in 2019.

Moscow was the entry point of invasion of *A. planipennis*. By 2013 the most of ash trees in the city were heavily damaged (Orlova-Bienkowskaja 2014b) and some experts believed the ash trees would disappear all over the city (Mozolevskaya 2012). But the survey in 18 districts of Moscow in 2016 and 2017 showed that *F. pennsylvanica* was still common all over the city, and *A. planipennis* became rare (Orlova-Bienkowskaja and Bieńkowski 2018b). The survey in 2018 and 2019 confirmed this result.

Infestations were found in all cities of Moscow Region surveyed by us in 2017–2019 (see Table 2). The severe outbreak was recorded in 2019 in the city of Shakhovskaya. Almost all ash trees in the city are heavily infested. On 16 of July 2019 Marina Orlova-Bienkowskaja and Andrzej O. Bieńkowski collected more than 100 adults and larvae there.

3.10. The results of survey of *F. excelsior* in the natural Tulskie Zaseki Forest in the center of the pest range

The large broad-leaved Tulskie Zaseki Forest (65 000 ha) is situated in Tula Region in the center of current range of *A. planipennis*. *Fraxinus excelsior* is one of the main tree species of this forest. In 2013 the pest was detected in its vicinity – in Tula and Shchekino as well as in surrounding regions: Kaluga and Orel (Straw et al. 2013; Orlova-Bienkowskaja 2014a). Trees of *F. pennsylvanica* are very usual in the cities of Tula and Shchekino, and now almost all of them are destroyed by the pest (Baranchikov et al 2018b and observations by I.A. Zabaluev). On 19–20 of June 2019 more than 500 trees of *F. excelsior* were examined by I.A. Zabaluev in the Tulskie Zaseki Forest in two localities: near Krapivna village and in Severno-Odoevskoe Forestry (Fig. 13). The trees were situated both in the edge and in the depth of the forest. No signs of infestation by *A. planipennis* have been found. Ash trees are in good condition.

4. **Discussion**

4.1. Current borders of the range

Previously published records (Table 1) and our surveys in 2017–2019 (Table 2) have shown that by 2019 *A. planipennis* occurs in at least 16 regions of European Russia: Bryansk, Kaluga, Kursk, Lipetsk, Moscow city and Region, Orel, Ryazan, Smolensk, Tambov, Tula, Tver, Vladimir, Volgograd, Voronezh, Yaroslavl and in Luhansk Region of Ukraine (see Table 1, 2 and Fig. 1).

The westernmost localities are in Smolensk region: Semirechje (Zvyagintsev et al. 2015) and Smolensk (Baranchikov and Seraya 2018). In the north-west the border of the range is in Tver Region: Zubtsov and Tver. The northernmost locality is Yaroslavl. The border of the range in the east is poorly known. The extreme localities in this direction are Yaroslavl, Petushki (Vladimir Region), Vysokoe (Ryazan Region), Michurinsk (Tambov Region) and Volgograd. But it is unknown if it is the real eastern border of the range, since few surveys were made east to these localities. The most eastern and the most southern locality is Volgograd. In the south-west the border crosses Voronezh Region and Bryansk regions of Russia and Luhansk Region of Ukraine.

The northern and north-western border of the pest range is almost the same as in 2013. The northernmost locality – Yaroslavl is at the latitude 57.63 N, i.e. much to the north of the northernmost locality in North America (47.31 N) (Emereld Ash Borer Info 2019) and in Asia (49.42 N) (Orlova-Bienkowskaja and Volkovitsh 2018). Therefore, it is unknown if *A. planipennis* will spread further north – to St.-Petersburg and northern Europe, or it has already reached the range of its potential border in the north. To answer this question the ecological model of potential range in Europe should be done.

In the south the situation is much worse. The pest has already appeared in Ukraine, and since there the outbreaks of the pest in Volgograd, Bryansk, Kursk and all over Voronezh Region, the pest will probably enter Ukraine and Belarus with a broad front.

4.2. Mechanism of spread is unknown

Natural spread of *A. planipennis* populations is limited to only a few kilometers per year (Siegert et al. 2010). So the disperse of the pest in the vast territory: 600 000 km^2 in 16 years after the first detection can be explained only by human-assisted dispersal. The important vector of spread of this pest in North America is unintentional introduction with firewood (Herms and McCullough 2014). But unlike the United States, ash firewood is not used in European Russia. Ash wood is also not used for making package in Russia, since the wood of *F. excelsior* is expensive and *F. pennsylvanica* is an ornamental and landscaping tree not used for timber. It is also doubtful that larvae can be transported with seedlings, since *A. planipennis* in Moscow Region occur only in the trees more than 10 cm thick (Orlova-Bienkowskaja 2014). It is suspected that the vector of dispersal is hitchhiking of adult beetles on vehicles (Straw et al. 2013). Up to now no specimens of *A. planipennis* have been yet detected in vehicles in Russia, but other Buprestidae sometimes occur in transport. In particular, jewel beetles have been detected in cruise ships sailing along the Volga River (Komarov E.V., unpublished data). So it is not excluded that *A. planipennis* was introduced from Moscow to Volgograd by ships.

4.3. Perspectives for European forestry

The distance from Moscow to Volgograd is more than 900 km. It is more than the distance from Moscow to Lithuania, Latvia and Estonia. Obviously, the pest can be detected in any part of Eastern Europe. Besides that, *A. planipennis* can soon appear in Kazakhstan, since the distance between the Volgograd and the border of country is about 150 km.

Since there are no infested trees of *F. excelsior* in the large Tulskie Zaseki Forest in the center of *A. planipennis* range, it seems that *F. excelsior* is more resistant to the pest than American ash species, at least in natural forest stands. All cases of infestation of *F. excelsior* in Russia refer to the trees which grow near plantations of *F. pennsylvanica*. *Fraxinus pennsylvanica* is highly susceptible to the pest and triggers the outbreak of the pest, which can also attack *F. excelsior* growing near. The similar situation was observed in China: in 1964 the plantations of *F. americana* L. introduced from North America triggered the outbreak of *A. planipennis* in Harbin (Yu 1992). The pest damaged both *F. americana* and native ash species in the region, but after the trees of *F. americana* were cut off, the outbreak finished.

Agrilus planipennis has not become a forest pest in European Russia and Ukraine. It occurs only in artificial plantations: urban plantations, along motor roads and railroads, in field shelter belts. The overvelming majority of damaged and killed trees are *F. pennsylvanica*. The only native ash species *F. excelsior* is also susceptible to *A. planipennis*, but there are still no evidences of massive damage of this ash species in the forests. There is no doubt that *A. planipennis* will severely damage plantations of *F. pennsylvanica* in Europe. But there is a hope that natural forests consisting of *F. excelsior* are more resistant to the pest.

5. Conclusion

Current range of *Agrilus planipennis* has the area of 600 000 km^2 (i.e. exceeds the area of Spain) and includes 15 regions of ER and Luhansk Region of Ukraine. The pest is quickly spreading to the south and will undoubtedly appear in other European countries soon. No expansion of the range to the north is detected since 2013. No cases of serious damage of *F. excelsior* in the forests have been detected. So it is still unknown if EAB will become a devastating forest pest in Europe or just a pest of urban plantations.

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Tables

Table 1 Previously published records of *Agrilus planipennis* in European Russia.

Region	Locality	Year of the first detection	Sources of information
Moscow	Moscow (*A. planipennis* occurs all over the city)	2003	(Baranchikov et al. 2008; Izhevskii and Mozolevskaya 2010; Straw et al. 2013)
Moscow	Manikhino	2006	(Baranchikov et al. 2008)
Moscow	Serpukhov	2009	(Baranchikov et al. 2010)
Moscow	Mozhaisk	2009	(Baranchikov et al. 2010)
Moscow	Mytiszhi	2009	(Baranchikov et al. 2010)
Moscow	Pushkino	2009	(Baranchikov and Kurteev 2012)
Moscow	Zelenograd	2011	(Orlova-Bienkowskaja 2014b)
Moscow	Kolomna	2012	(Orlova-Bienkowskaja 2014a)
Smolensk	Localities along the road Moscow-Vyazma	2012	(Baranchikov and Kurteev 2012)
Moscow	Sergiev Posad	2012	(Baranchikov and Kurteev 2012)

Ryazan	Vysokoe	2012	(Baranchikov 2013)
Tula	Shchekino	2013	(Straw et al. 2013)
Tver	Zubstov	2013	(Straw et al. 2013)
Tver	Novozavidovskiy	2013	(Straw et al. 2013)
Tver	Emmaus	2013	(Straw et al. 2013)
Moscow	Uzunovo	2013	(Orlova-Bienkowskaja 2014a)
Moscow	Klin	2013	(Orlova-Bienkowskaja 2014b)
Moscow	Staraya Kupavna	2013	(Orlova-Bienkowskaja 2014a)
Voronezh	Voronezh	2013	(Orlova-Bienkowskaja 2014a)
Tula	Tula	2013	(Orlova-Bienkowskaja 2014a)
Kaluga	Kaluga	2013	(Orlova-Bienkowskaja 2014a)
Tver	Konakovo	2013	(Orlova-Bienkowskaja 2014b)
Orel	Orel	2013	(Orlova-Bienkowskaja 2014a)
Yaroslavl	Yaroslavl	2013	(Orlova-Bienkowskaja 2014a)
Tambov	Michurinsk	2013	(Orlova-Bienkowskaja 2014a)
Vladimir	Petushki	2013	(Baranchikov 2013)
Orel	Livny	2013	(Rosselkhoznadzor 2014)
Moscow	Solnechnogorsk	2014	(Orlova-Bienkowskaja and Belokobylskij 2014)
Moscow	Planernaya	2014	(Orlova-Bienkowskaja and Bieńkowski 2016)
Moscow	Povarovka	2014	(Orlova-Bienkowskaja, Belokobylskij 2014)
Smolensk	Semirechje	2014	(Zvyagintsev et al. 2015)
Smolensk	Andreykovo	2014	(Zvyagintsev et al. 2015)
Tver	Khiminstituta Settlement	2015	(Peregudova 2016)
Voronezh	Talovaya	2018	(Baranchikov et al. 2018a)
Lipetsk	Elets	2018	(Baranchikov 2018a)
Smolensk	Smolensk	2018	(Baranchikov and Seraya 2018)
Tver	Doroshiha railway station	2018	(Peregudova 2019)

Voronezh	Olkhovatskoe Forestry	2018	(Rosselkhoznadzor 2019)
Bryansk	Majskij Park	2019	(Rosselkhoznadzor 2019)

Table 2 Title and/or description of the elements of the table.

Table 2. Surveys of ash trees in Russia, Ukraine and Belarus in 2017–2019. Localities where *Agrilus planipennis* was detected are marked with red. Localities where *A. planipennis* was not detected are marked with green. New localities of detection are marked with the label "New!" Kinds of plantations: F – forest, U – urban, M – along the motorway, R – along the railway, B – field shelter belts. Surveys were made by AA – Andrzej A. Bieńkowski, AB – Andrzej O. Bieńkowski, AD – Alexander N. Drogvalenko, AR – Alexander B. Ruchin, AS – Alexey S. Sazhnev, AV – Alexey N. Volodchenko, EK – Evgenij V. Komarov, EP – Elena Yu. Peregudova, IZ – Ilya A. Zabaluev, LE – Leonid V. Egorov, ML – Mikhail V. Lavrentiev, MO – Marina J. Orlova-Bienkowskaja, RI – Roman N. Ishin, SM – Sergey G. Mazurov, TN – Tatyana V. Nikulina, VA – Vasilij V. Anikin, VM – Vladimir V. Martynov, VS – Vitalij V. Struchaev.

Region	Locality	Examined ash trees (*Fraxinus*)		Kind of plan-tations	Symptoms of infestation with *A. planipennis*	Year of survey	Who examined the trees
		pennsylvanica	*excelsior*				
			Belarus				
Gomel Reg.	Gomel	>100	1	U	No	2019	AA
Minsk Reg.	Borisov	>100	5	U	No	2017	MO & AB
Minsk Reg.	Stolbtsy	>100	–	U	No	2018	MO & AB
Minsk Reg.	Minsk	>100	–	U	No	2019	AS
Mogilev Reg.	Mogilev	>100	21	U	No	2018	MO & AB
Mogilev Reg.	Krichev	>50	20	U	No	2019	IZ
Vitebsk Reg.	Orsha	>100	7	U	No	2018	MO & AB
Vitebsk Reg.	Vitebsk	>100	11	U	No	2018	MO & AB
			Russia				
Belgorod Reg.	Belgorod	>50	>50	U & R	No	2019	VS
Belgorod Reg.	Staryj Oskol	>100	–	U	No	2019	AA
Bryansk Reg.	Bryansk	>100	5	U	Exit holes, larval galleries	2019	IZ
Chuvashia	Cheboksary	>100	–	U	No	2017	LE

Kaluga Reg.	Maloyaroslavets New!	>100	–	U	Exit holes, larval galleries	2019	AA
Krasnodar Reg.	Krasnodar	>50	10	U	No	2018	MO & AB
Krasnodar Reg.	Sochi	–	>50	U & F	No	2018	MO & AB
Kursk Reg.	Kursk New!	>20	>30	U & R	Exit holes, one dead adult	2019	VS
Lipetsk Reg.	Leski New!	10	–	R	One alive adult	2019	SM
Mordovia	Saransk	>50	>50		No	2019	AR
Moscow	Moscow	>100	–	U	Alive adults, larvae, exit holes	2019	MO & AB
Moscow Reg.	Dedinovo New!	20	–	U	Alive adults, larvae, exit holes	2017	MO & AB
Moscow Reg.	Kolomna	>50	–	U	Larvae, exit holes	2017	MO & AB
Moscow Reg.	Shakhovskaya New!	>100	2	U	Alive adults, larvae, exit holes	2019	MO & AB
Moscow Reg.	Stupino New!	>100	–	U	Exit holes, larval galleries	2017	MO & AB
Moscow Reg.	Zelenograd	>100	–	U	Larvae, one dead adult, exit holes	2019	MO & AB
Pskov Reg.	Sebezh	–	122	U	No	2019	MO & AB
Pskov Reg.	Velikie Luki	>100	>100	U	No	2019	MO & AB
Rostov Reg.	Millerovo	>100	–	U	No	2017	TN & VM
Rostov Reg.	Shakhty	>100	–	U	No	2017	TN & VM
Rostov Reg.	Rostov-na-Donu	>50	>50	U	No	2017	TN & VM
Saratov Reg.	Balashov	>100	>50	U	No	2019	AV
Saratov Reg.	Saratov	>100	>100	U	No	2019	ML & VA
Smolensk Reg.	Roslavl	>50	>50	U	No	2019	IZ
Smolensk Reg.	Sychevka	22	8	U	No	2019	MO & AB
Smolensk Reg.	Vyazma	107	67	U	One dead adult, larvae, exit holes	2019	MO & AB
St.-Petersburg	St.-Petersburg	>100	–	U	No	2018	MO & AB
Tambov	Tambov	>50	>50	U	No	2019	RI
Tula Reg.	Tula	>100	–	U	Fresh exit holes, traces of adult feeding on leaves	2019	IZ

Tula Reg.	Tulskie Zaseki: Krapivna	–	>250	F	No	2019	IZ
Tula Reg.	Tulskie Zaseki: Severno-Odoevskoe Forestry	–	>250	F	No	2019	IZ
Tver Reg.	Bologoye	53	5	U	No	2019	MO & AB
Tver Reg.	Ostashkov	76	8	U	No	2019	MO & AB
Tver Reg.	Rzev	99	–	U	No	2019	MO & AB
Tver Reg.	Torzhok	82	9	U	No	2019	EP
Tver Reg.	Tver	134	–	U	Adults, larvae, exit holes	2019	EP
Tver Reg.	Vyshniy Volochek	103	6	U	No	2019	EP, MO & AB
Tver Reg.	Zubtsov	>100	–	U & M	Larvae, exit holes	2019	MO & AB
Volgograd Reg.	Volgograd New!	>500	–	F	Adults, larvae, exit holes	2018–2019	EK
Voronezh Reg.	Borisoglebsk	24 in the city and >100 in the forest	21 in the city and >500 in the forest	U & F	No	2019	MO & AB
Voronezh Reg.	Kantemirovka New!	>100	–	U & M	Exit holes, larval galleries	2019	MO & AB
Voronezh Reg.	Povorino	47	–	U	No	2019	MO & AB
Voronezh Reg.	Rossosh New!	>100	1	U & B	Exit holes, larval galleries	2019	MO & AB
Yaroslavl Reg.	Borok	15	–	U	No	2019	AS
Ukraine							
Donetsk	Donetsk	>100	>100	U & M	No	2019	TN & VM
Kharkiv Reg.	Kharkiv	>50	>50	U	No	2019	AD
Luhansk Reg.	Starokozhiv Forest New!	>100	>100	B & F	Larvae, exit holes	2019	AD

Captions of figures

Fig.1 Range of *Agrilus planipennis* in European Russia and Ukraine in 2019. Blue dots – localities, where *A. planipennis* was previously detected. Red dots – localities, where we detected the pest in 2017–2019. Green squares – localities, where it was not detected during surveys in 2017–2019. Green triangles – localities of surveys of *Fraxinus excelsior* in the broad-leaved Tulskie Zaseki Forest, where ash trees are healthy and have no signs of *A. planipennis* infestations. Russia: BR – Bryansk Region, KA – Kaluga Region, LI – Lipetsk Region, LU – Luhansk Region, MO – Moscow Region, OR – Orel Region, RY – Ryazan Region, SM – Smolensk Region, TA – Tambov Region, TU – Tula Region, TV – Tver Region, VG – Volgograd Region, VL – Vladimir Region, VO – Voronezh Region, YA – Yaroslavl Region. Sources are indicated in Tables 1 and 2.

Fig.2 Trees of Fraxinus pennsylvanica heavily damaged by *Agrilus planipennis* in Luhansk Region of Ukraine, 5.09.2019. Photo by A.N. Drogvalenko..

Fig.3 Larva and larval galleries of *Agrilus planipennis* in *Fraxinus pennsylvanica* in Luhansk Region of Ukraine, 5.09.2019. Photo by A.N. Drogvalenko.

Fig.4 Larvae of *Agrilus planipennis* in *Fraxinus pennsylvanica* in Luhansk Region of Ukraine, 5.09.2019. Photo by A.N. Drogvalenko.

Fig.5 Exit hole of *Agrilus planipennis* in *Fraxinus pennsylvanica* in Luhansk Region of Ukraine, 5.09.2019. Photo by A.N. Drogvalenko.

Fig.6 Exit hole of *Agrilus planipennis* on *Fraxinus pennsylvanica* in Volgograd, 10.2018. Photo by E.V. Komarov.

Fig.7 Larval galleries of *Agrilus planipennis* on *Fraxinus pennsylvanica* in Volgograd, 10.2018. Photo by E.V. Komarov.

Fig.8 Adults of *Agrilus planipennis* in the pupal cells on *Fraxinus pennsylvanica* in Volgograd, 10.2018. Photo by E.V. Komarov.

Fig.9 Adult of *Agrilus planipennis* on the leaf of *Fraxinus pennsylvanica* in Volgograd, 10.2018. Photo by E.V. Komarov.

Fig.10 Dead adult of *Agrilus planipennis* found in Kursk on *Fraxinus pennsylvanica*. Photo by V. Struchaev.

Fig.11 Declined *Fraxinus pennsylvanica* in Boeva Dacha Park in Kursk with exit holes of *Agrilus planipennis*. Photo by V. Struchaev.

Fig.12 Exit hole of *Agrilus planipennis* on *Fraxinus pennsylvanica* near the House of Culture in the city of Kantemirovka, Voronezh Region, 13 km from the border of Ukraine, 14.08.2019. Photo by Marina J. Orlova-Bienkowskaja.

Fig.13 The broad-leaved Tulskie Zaseki Forest (shaded with green), where *F. excelsior* is usual. The range of *A. planipennis* is shaded with gray. Green triangles - locations of survey of of *F. excelsior* trees: 1 – Severno-Odoevskoe Forestry, 2 – vicinity of Krapivna village. Blue dots – localities, where *A. planipennis* has been detected.

Figures

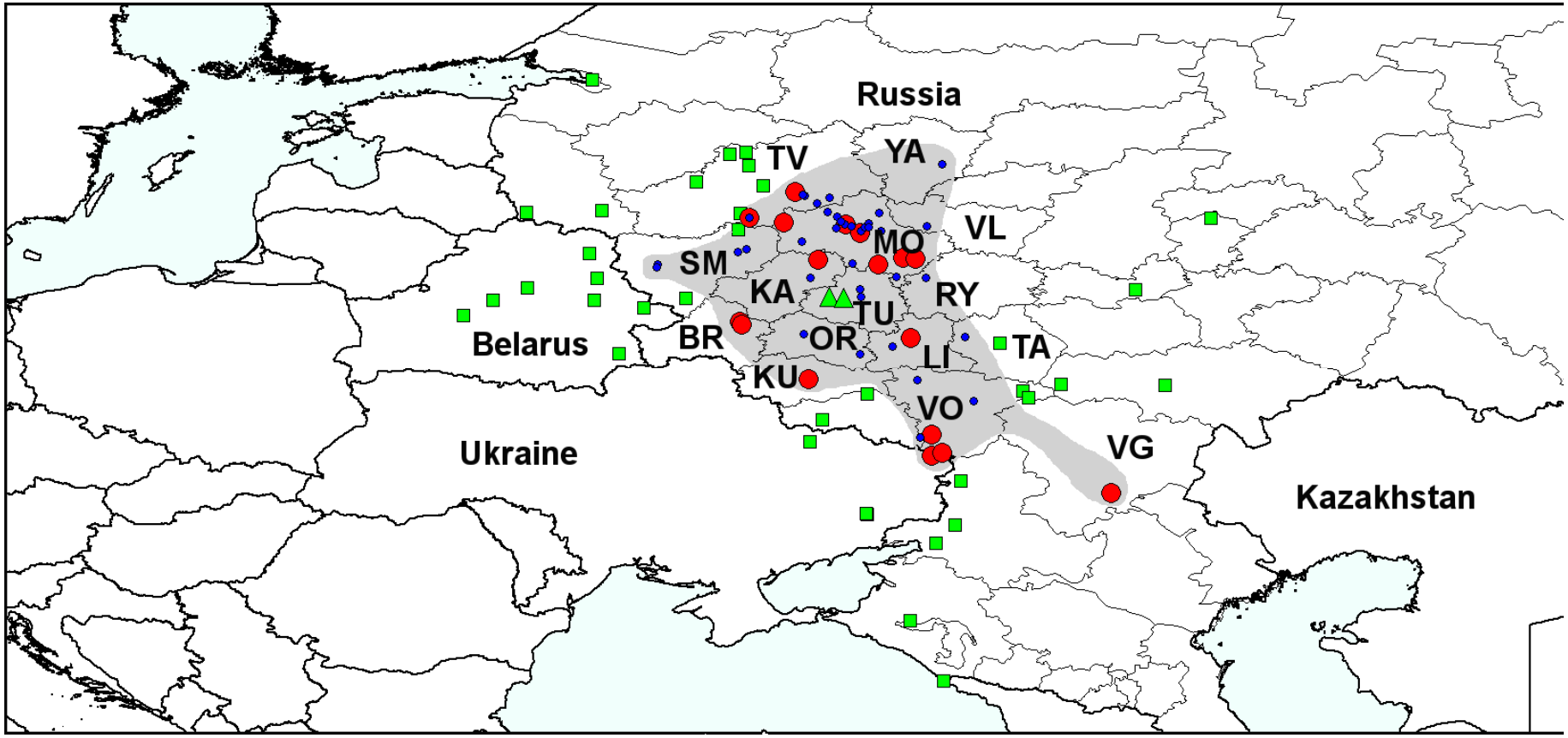

Fig. 1

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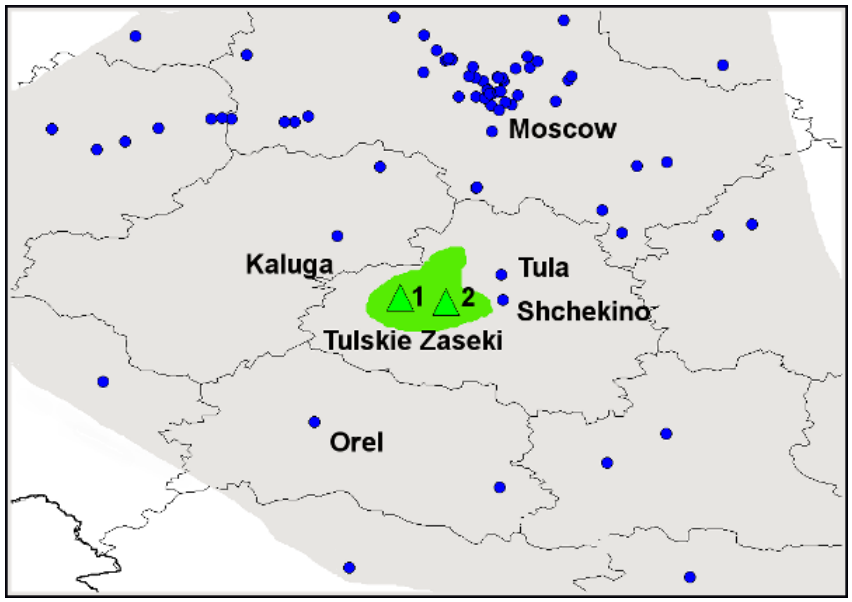

Fig. 13