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European Range of the Emerald Ash Borer *Agrilus planipennis* (Coleoptera: Buprestidae) Is Expanding: The Pest Destroys Ashes in the Northwest of Moscow Oblast and in Part of Tver Oblast

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Abstract—Emerald ash borer *Agrilus planipennis* is a serious pest of ash. It was accidentally introduced to Moscow in the 1990s. In May 2013, ashes in four cities located to the northwest of Moscow were examined. In Zelenograd (20 km from Moscow), Klin (70 km from Moscow), and Konakovo (100 km from Moscow), most of the ashes have been already killed or severely damaged by the pest. Obviously, within the next several years, ashes will be entirely eliminated from green plantations of these cities. Ashes examined in Tver (145 km from Moscow) are not damaged. The European range of the pest has significantly expanded to the northwest. Its border now crosses Tver oblast.

Keywords: *Agrilus planipennis*, emerald ash borer, ash, *Fraxinus*, pest, invasion, Moscow oblast, Tver oblast, range

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INTRODUCTION

Emerald ash borer (EAB) *Agrilus planipennis* Fairmaire (Coleoptera, Buprestidae) is a serious pest of ash, rapidly colonizing the territory of the European part of Russia and North America. It is included in the quarantine list of the European and Mediterranean Plant Protection Organization (EPPO, 2013).

Deciduous forests of East Asia are the natural range of EAB: Korea, northwest China, Japan, Mongolia, Taiwan, and also Primorskii krai and Khabarovsk krai (Jendek, 2006; Yurchenko et al., 2007). There, the bug is not an economically significant pest, because it is found relatively seldom and develops only in trunks of dying or significantly weakened trees (Yurchenko et al., 2007).

When the borer was introduced into the United States, it began to feed on healthy trees and rapidly expand its range, damaging ash plantations and forests. Larvae feed on the cambial layer, which leads to the death of a tree in 2–6 years. (Knight and Brown, 2013). EAB was firstly found in America in 2002. Currently, it is distributed in 19 states in the United States and in two Canadian provinces, having destroyed tens of millions of trees (Emerald Ash Borer Website, 2013). Effective methods against the pest have not yet been developed. Therefore, in America, managers of ash forests are recommended to fully replace ashes by other trees. (Ash Management..., 2012).

In Europe, EAB is acclimated to date only in Moscow oblast and some adjacent regions. It is assumed that the bugs were introduced in the 1990s from North America with planting material (Mozolevskaya and Izhevskii, 2007) or from China with tare from planks which was not cleaned from the bark (Baranchikov et al., 2008). The area of maximum affection of ashes by the pest is constantly increasing, because in Central Russia the EAB has no parasites and the species of ashes *F. pennsylvanica* Marshall and *F. excelsior* L. prevalent in plantations are not able to resist the new pest (Baranchikov and Kurteev, 2012).

HISTORY OF DISPERSION OF THE EAB IN CENTRAL RUSSIA

2003—The first specimen of *A. planipennis* was found in Moscow (Shankhiza, 2007).

2004—The first focuses of drying of ashes appear in the city (Ismailov, 2008).

2006—The borer was for the first time found outside Moscow—along railway lines in areas close to Moscow (Shankhiza, 2007).

2009—The range of mass affection of trees expanded in the direction to the west to Mozhaisk, to the south to Serpukhov, and to the north to Mytishchi; the first traces of the presence of borers were found near Pushkino (Baranchikov, 2009; Baranchikov and Kurteev, 2012).

2012—EAB infected ashes everywhere in Pushkino and continued dispersing to the north: in Sergiev Posad, two trees with traces of the pest's action were found. The range of affection expanded to the west, covering Vyaz'ma (Baranchikov and Kurteev, 2012). In the southwest, the border reached Obninsk according to the Regnum News Agency (Regnum News Agency, 2012); in the south, it reached Tula (Gninenko, 2012). In southern part of the range, EAB closely approached regions where ashes are found not only in plantations but also in forests. As for Moscow, there were no longer local focuses: the invasion by EAB became total. According to the opinion of Mozolevskaya (2012), with time we will find total elimination of ashes from city plantations in Moscow and its outskirts.

In May 2013, we examined green plantations of four cities located to the northwest of Moscow: Zelenograd, Klin, Konakovo, and Tver, to define where currently the border of EAB colonization in this direction is and evaluate the scale of affection of trees.

Fig. 1. Traces of action of birds eating larvae under the cortex.

SYMPTOMS OF AFFECTION OF THE TREE

EAB deposits eggs on the trunks of trees with a thickness more than 10 cm. Hatched larvae penetrate the cortex. Until the moment of first flight of the bugs, an infected tree hardly differs from a healthy one. Birds bites could indicate the presence of larvae (Fig. 1).

The larva makes a flat zigzag-like passage in the cambial layer, which expands to 5 mm during its growth (Fig. 2). Sometimes, trees weakened by the EAB are occupied by bark beetles (Fig. 3).

In autumn, older larva usually begins moving up, and from that, a typical loop is formed in the end of the passage. Further, larva makes a hole in the wood and builds a pupal cell, where it spends the winter. The exit of young beetles occurs at the end of May–June. Gnowing from the tree, beetles leave emergence holes in the cortex of typical D-like shape with the width of approximately 4 mm and height of approximately 3.5 mm. One of the sides of the hole is practically straight, and the opposite is prominent (Fig. 4).

Beetles once more deposit eggs on the cortex. The cortex detaches on the affected tree, epicormic shoots appear, the crown becomes thinned out. The top of tree withers (Fig. 5). There is no sense in removing the dry tops, because the tree will die anyway (Fig. 6).

Further the trunk and branches of ash completely die. Only the epicormic shoots remain alive.

Fig. 2. Larval passages under the cortex.

RESULTS OF EXAMINATION OF GREEN PLANTATIONS

The range of total affection of ashes has covered Zelenograd, Klin, and Konakovo, but in Tver, traces of the pest's activity have not yet been found (table).

Fig. 3. Tree damaged by EAB and bark beetles. At the top are the passages of bark beetles, and at the bottom are the wide passages of the EAB.

In autumn 2010, branches of some ashes in Boldov Ruchey street in Zelenograd withered. In July 2011, the first specimen of imago of *A. planipennis* was found there. In summer 2012, affection of ashes on the street became total. Typical symptoms appeared on the trees—epicormic shoots and withering of tops. The tops on many trees were removed; however, that action did not help. In May 2013, it became obvious that all ashes on the street were dying. Leaves appeared only on several branches, and the cortex was detached. During examination of the trunks, emergence holes of the EAB were found on the trunks, and under the cortex, typical larval pathways with terminal loop and residuals of *A. planipennis* imago were found. Examination of other green plantations of Zelenograd showed that ashes were dying all over the city. Dead and extremely weakened trees were found on Panfilovskii, Central, and Moscow avenues, in Zelenograd forest park, and also in the districts Andreevka and MZhK.

Fig. 4. Flight aperture.

In Klin, trees in the area near railway station were examined. Almost all of them had already died. Only one tree without significant damage was found.

In Konakovo, we examined ashes on Energetikov street and Lenin avenue. The portion of trees without any visible symptoms of invasion was higher than in Zelenograd and Klin. However, most ashes had already died.

In the northwest direction from Moscow, ashes were affected not only in city plantations. Individual withering trees were found along the railway near the stations Rizhskaya, Ostankino, Petrovsko-Razumovskoe, NATI, Levoberezh'e, Khimki, Skhodnya, Malino, Kryukovo, Povarovka, Povarovo, Podsolnechnaya, Golovkovo, Frolovskaya, Klin, Zavidovo, and Kuzminka. Thus, in the northwest of Moscow oblast and adjacent areas of Tver oblast, we are not able to speak about individual focuses of pest dissemination. Affection of ashes by EAB is total.

In Tver, withered trees were not found. Multiple ashes on the railway station square, on Tchaikovskii avenue, on the quay of the left bank of the Volga, on Tver avenue, and on Mayakovskii street look healthy. The cortex of 144 trees in different districts of the city was examined. Typical flight aperture and larval passages were not found. However total invasion of the pest in Tver is expected in the next few years, because ashes are affected just in 10 km from the city.

Fig. 5. Ash with root sprouts, water shoots, and withered top.

DISCUSSION

In autumn 2012, Pushkino, a town located 14 km from the Moscow ring road, was considered as being an extreme point of total invasion of ashes (Barannchikov and Kurteev, 2012). In Sergiev Posad, 50 km to the north of Moscow, only two trees with traces of the pest's activity were found. Our data indicates that EAB has dispersed extremely far: its northwest border of dispersion is now located in Tver oblast at a distance of

Condition of trees examined in May 2013

	Moscow oblast		Tver oblast	
	Zelenograd	Klin	Konakovo	Tver
Distance from the Moscow ring road	20 km	70 km	100 km	145 km
Fraction of trees without significant damage, %	4.4	1.1	11.7	100
Fraction of greatly damaged trees, %	32.3	11.4	25	0
Fraction of dead trees, %	63.3	87.5	63.3	0
Number of examined trees	161	88	128	144

Fig. 6. Tree that died in spite of removal of dry tops.

more than 100 km from Moscow. According the condition of trees in Klin and Konakovo, the EAB appeared there at least two years ago. Most probably, explosive dispersion of the pest occurred owing to the weakening of trees during abnormal drought in 2010. Rows of trees planted along highways and roads could be passages of penetration of the EAB between cities. Already in 2006, "half-dead ashes extended like a chain from Moscow to neighboring cities and settlements of the region" (Shankhiza, 2007).

It is advisable to conduct an examination of green plantations in cities of Central Russia to detect current borders of the range of invasion. It is necessary to much more fully inform the population about the pest using the Internet and mass media and to direct attention to the cases of mass death of ashes in the regions. It is especially important to monitor how far the EAB has extended in the southerly direction. Rapid dispersion of the pest precisely in that direction is highly probable, because natural range of EAB in Asia is significantly farther to the south than Moscow. Penetration of the EAB in the area of deciduous forests of European Russia, where logging of ash wood is conducted, could become extremely harmful for the wood industry. If the EAB penetrates even farther, into the forest-steppe or steppe area, then forest belts and, as a consequence, ground cover could be damaged.

Currently, testing of pheromone traps and experimental production of entomophages are being conducted; however, no effective methods against the pest have been created either in our country or in the United States (Gninenko, 2012; Emerald Ash Borer Website, 2013). The most valuable specimens of ashes, e.g., in botanical gardens, could be protected by installation of injectors with pesticides (McCullough et al., 2005). However, the usage of pesticides in settlements is impossible. Experience shows that removing dry branches could not save the tree. Strict internal quarantine adopted in the United States was not effective (Emerald Ash Borer Website, 2013). In spite of prohibition of export of seedlings and products of ash from affected regions, EAB continues dispersing in the United States. Therefore, it is not clear whether quarantine measures could prevent dispersion of the pest in European Russia.

In the next few years, large-scale felling of ashes in Moscow oblast and adjacent affected regions should be performed, as is done in states in the United States colonized by the EAB (Ash Management..., 2012). Otherwise, an emergency situation due to a great number of dead trees will occur in cities. Falling trunks and branches are dangerous to residents. In addition, dead ashes could be sources of different pests and diseases, which could affect other trees. Planting ashes in the region around Moscow and adjacent regions and, possibly, in all of Central Russia should be rejected.

Entomogentic catastrophes of recent years, in particular, mass death of fir trees in Siberia due to invasion of *Polygraphus proximus* Blandford (Baranchikov, 2012) and destruction of Moscow ashes by the EAB, clearly show how important it is to detect the focuses of new pests in time. Individual agricultural, foresty, and ecology organizations cannot manage these problems themselves. It is necessary to combine their forces and create a common database. Russia needs a special institute to monitor entomofauna, similar to ones that exist in many developed countries, e.g., in Great Britain (National Biodiversity Network, 2013).

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