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Invasion of Emerald Ash Borer *Agrilus planipennis* and Ash Dieback Pathogen *Hymenoscyphus fraxineus* in Ukraine—A Concerted Action

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Abstract: Emerald Ash Borer (EAB), *Agrilus planipennis*, is a beetle that originates from East Asia. Upon invasion to North America in the early 2000s, it killed untold millions of ash trees. In European Russia, EAB was first detected in Moscow in 2003 and proved to have the potential to also kill native European ash (*Fraxinus excelsior*). The beetle has since spread in all geographic directions, establishing itself in eastern Ukraine by 2019 and possessing potential for further westward spread towards the EU. Apart from the approaching EAB, *F. excelsior* is currently threatened by the dieback disease (ADB) caused by the invasive ascomycete fungus *Hymenoscyphus fraxineus*. The infestation by EAB combined with ADB infection is expected to be more lethal than either of them alone, yet the potential consequences are unknown. To date, eastern Ukraine represents the geographic area in which both invasions overlap, thus providing the opportunity for related investigations. The aims of the study were to investigate: (i) the EAB expansion range in Ukraine, (ii) the relative susceptibility of *F. excelsior* and American ash (*Fraxinus pennsylvanica*) to EAB and ADB, and (iii) the combined effect/impact on ash condition imposed by both the pest and disease in the area subjected to the invasion. The results have demonstrated that (i) the invasion of EAB is currently expanding both in terms of newly infested trees and invaded geographic area; (ii) *F. excelsior* is more resistant to EAB than *F. pennsylvanica*, while *F. excelsior* is more susceptible to ADB than *F. pennsylvanica*; and (iii) the infection by ADB is likely to predispose *F. excelsior* to the infestation by EAB. It was concluded that inventory and mapping of surviving *F. excelsior*, affected by both ADB and EAB, is necessary to acquire genetic resources for the work on strategic, long-term restoration of *F. excelsior* in devastated areas, thereby tackling a possible invasion of EAB to the EU.

Keywords: emerald ash borer; ash dieback; *Fraxinus* spp.; forest pests; invasive populations; eastern Ukraine

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1. Introduction

The Emerald Ash Borer (EAB) *Agrilus planipennis* Fairmaire, 1888 (Coleoptera: Buprestidae), is a buprestid beetle that originates from East Asia. In its native range, EAB is a minor pest colonizing dying ash (*Fraxinus* spp.) trees and causing insignificant damage to viable ones [1]. It was first detected in North America (southeast Michigan) in 2002 (introduced with wood trade) and has since killed millions of trees in forest, riparian, and urban areas. It is estimated that EAB could virtually eliminate *Fraxinus* spp., one of North America's most widely distributed tree genera, with devastating economic and ecological impacts [2].

In European Russia, EAB was first detected in Moscow in 2003 (transported with wood) and proved to have the potential to kill native European ash (*Fraxinus excelsior*

Linnaeus, 1753). The beetle has since spread in all geographic directions, but most notably towards the west and southwest, by 2019 crossing the border of Belarus and entering and establishing in eastern Ukraine [3]. Notably, ash is continuously present in areas from the eastern borders of Ukraine and Belarus towards the west: apart from natural woodlands, in both countries, *F. excelsior* and (highly EAB-susceptible) North American green ash (*Fraxinus pennsylvanica* Marshall, 1785) have historically been extensively planted along roads, railways, field shelter belts, and in urban greenings [4]. These plantings and woodlands potentially provide an excellent route pathway for the spread of EAB towards EU countries, e.g., into Romania, Hungary, Slovakia, and Poland.

Importantly in this respect, EAB beetles are strong flyers. For example, in the Great Lakes region of North America, EAB adults were reported to be capable of long dispersal flights, and gravid females are estimated to fly more than 10 km in 24 h [5]. Moreover, EAB beetles are efficient "hitchhikers": they can easily travel by cars, being hidden behind flanges of the car body; the insect can even stay on a tree twig pressed by a wiper to a windshield of a car driving at speeds of up to 120 km/h [6]. Railway cars also often serve as means for traveling EAB [7]. Consequently, all this makes the invasion of EAB to the EU highly probable [8]. The possibility therefore cannot be excluded that such situation will also put *F. excelsior* under the threat of extinction, as American ash species currently are. Therefore, to monitor and predict the pace at which EAB is approaching the EU is an important task, e.g., for plant quarantine authorities and other stakeholders, for the prognosis of future developments, planning and imposing preventive measures, and to prepare for the mitigation of eventual impacts.

Apart from the approaching EAB, another threat to *F. excelsior* is the dieback disease (ADB) caused by the invasive ascomycete fungus *Hymenoscyphus fraxineus* (T. Kowalski) Baral et al. that has impacted ash forests all over Europe [9]. Yet, there is the evidence that a certain proportion of trees exhibits resistance to ADB, providing the basis for future propagation [10,11]. However, the proportion showing resistance to ADB is low, namely, 1–5% of individuals [12,13]. As EAB infestation combined with ADB infection is expected to be more lethal than either of them alone [13], the following questions arise: (1) what fraction of the 1–5% remaining viable *F. excelsior* individuals in ADB-devastated areas in Europe will survive subsequent infestation by EAB? (2) Will the number of survivors of the ADB epidemic combined with EAB invasion be enough for initiating sustainable restoration of *F. excelsior*?

Currently, eastern parts of Ukraine represent a geographic area over which the invasive ranges of EAB and ADB overlap, thus providing the opportunity to investigate the impact imposed over populations of *Fraxinus* spp. by both the invasive pest and disease simultaneously. Moreover, such investigations would allow one to compare the relative susceptibility of two ash species to EAB and ADB, namely, native *F. excelsior* vs. introduced *F. pennsylvanica*. In particular, the data regarding the consequences of infestation of EAB to *F. excelsior* are scarce and fragmented. Thus, during the survey of EAB in western Russia and eastern Ukraine, an overwhelming majority of the infestations were found on the highly susceptible *F. pennsylvanica*, and all observed cases of infestation of the native species *F. excelsior* occurred in artificial plantings [14]. On the other hand, despite such certain indications that *F. excelsior* might be more resistant to EAB, e.g., along roadsides and city plantings [15,16], a recent study conducted in the Moscow Province provided certain evidence that EAB is susceptible to massive outbreaks causing significant damage also in forest stands [17]. Consequently, more detailed studies are needed to elucidate the relative susceptibility of *F. excelsior* compared to *F. pennsylvanica*. The aims of the present study were to investigate the following: (1) the EAB expansion range in Ukraine; (2) the relative susceptibility of *F. excelsior* and *F. pennsylvanica* to EAB and ADB; and (3) the combined effect/impact on ash conditions imposed by both the pest and disease in the area subjected to the invasion.

2. Materials and Methods

To estimate the extent of spread of EAB and to assess the health condition of ash, visual surveys have been carried out in forest stands of *F. excelsior* and shelterbelts composed of *F. pennsylvanica* in eastern Ukraine, in the years 2019 to 2021. Symptoms of EAB infestation (canopy decline, woodpecker attacks, D-shaped exit holes, and epicormic sprouting) were preliminary recorded and mapped. Simultaneously, the frequency of occurrence of ADB-symptomatic trees has been assessed based on the presence of typical bark necroses on branches and shoots, shoot dieback, and wilting leaves. The presence of ADB (*Hymenoscyphus fraxineus*, formerly *H. pseudoalbidus*) was confirmed earlier in the research regions using fungal culturing followed by ITS rDNA sequencing [18,19] and using ITS rDNA sequencing directly from the infected tree tissues [9,20]. Based on information acquired during the surveys, locations of 10 monitoring plots of the present study were selected (Figure 1). They were located in areas where the earliest infestation by EAB in Ukraine was observed, as well as in its advancing front and in the areas where the EAB presence could have been expected. All monitoring plots were subjected to ash dieback disease for at least a decade.

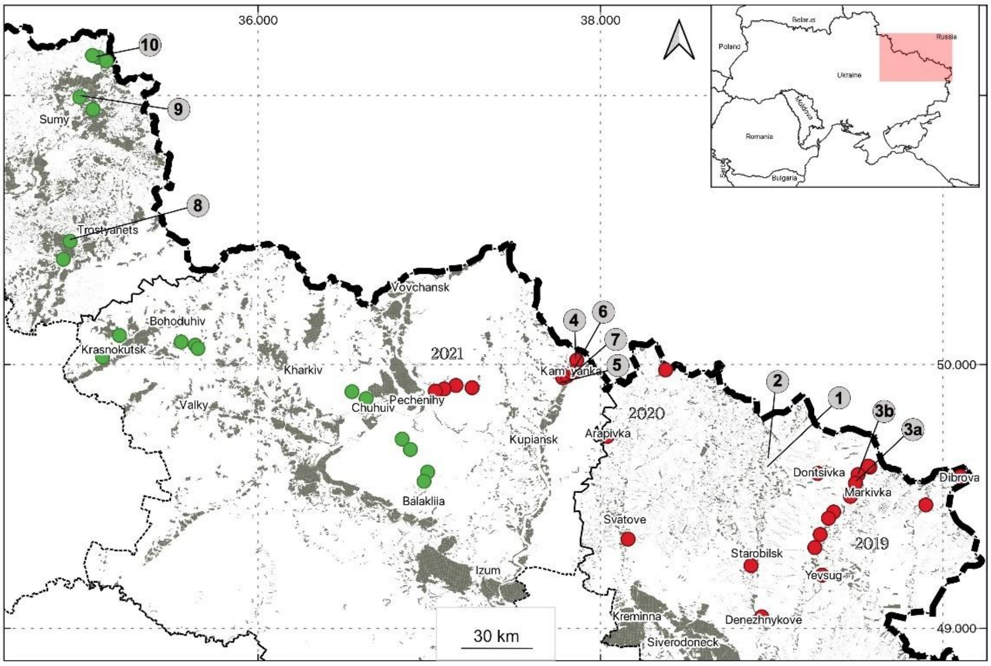

Figure 1. Map of eastern Ukraine showing locations of survey sites and monitoring plots of the present study. Red circles indicate survey sites where the emerald ash borer has been detected, and green indicates where the beetle has not been detected. Numbers of the monitoring plots correspond to those in the Tables 1 and 2.

There were two distinct types of the monitoring plots, depending on ash species investigated. All monitoring plots for *F. pennsylvanica* were located in field shelterbelts, where the trees were positioned in rows. Monitoring plots for *F. excelsior* were located in the interior of forest stands (Plot 3b in the urban forest) and were comprised of compact groups of trees within the area of approx. 15 × 50 m. In each plot, ash trees were investigated in a simple systematic manner: after the inspection of the first tree (located at the edge of a plot), the next nearest tree was inspected, and so on. Each examined tree was assigned a specific number and mapped. During the detailed investigations in the monitoring plots, apart from examining crowns (for woodpecker activity and decline) the lower part of tree stems was visually inspected for incidence of bark loosening and cracks and for the direct signs of EAB infestation: exit holes, dead beetles, larval galleries, and larvae (Figure 2). Simultaneously, the presence of galleries of ash bark beetles (genus *Hylesinus* Fabricius, 1801) and symptoms of ADB were recorded based on the disease symptoms listed above.

The upper part of the stems and thick branches were inspected using binoculars. Numbers of trees examined on each monitoring plot are shown in the Table 1.

Chi-squared tests for comparison of proportions were calculated, applying Yates correction.

Table 1. Infestations of the ash dieback disease fungus *Hymenoscyphus fraxineus* (ADB) and emerald ash borer *Agrilus planipennis* (EAB) on *Fraxinus pennsylvanica* and *F. excelsior* trees in eastern Ukraine. The plots are as shown in Figure 1.

Plot	*Fraxinus* spp.	Trees Monitored, no. (%) All	Year 2020 ADB	Year 2020 EAB	Year 2020 Of those, ADB and EAB	Year 2020 Dead [a]	Year 2020 Visually Healthy	Year 2021 ADB	Year 2021 EAB	Year 2021 Of Those, ADB and EAB	Year 2021 Dead [a]	Year 2021 Visually Healthy
Luhansk region (LH)												
1LH	*F. pen.*[b]	38	1 (3)	19 (50)	0	12 (32)	18 (47)	2 (5)	37 (97)	1 (3)	29 (76)	0
2LH	*F. pen.*	25	0	16 (64)	0	7 (28)	9 (36)	1 (4)	22 (88)	0	14 (56)	2 (8)
3aLH	*F. pen.*	25	0	21 (84)	0	9 (36)	4 (16)	0	25 (100)	0	17 (68)	0
All LH *F. pen.*		**88**	**1 (1)**	56 (64)	**0**	**28 (32)**	**31 (35)**	**3 (3.5)**	**84 (95)**	**1 (1)**	**60 (68)**	**2 (2)**
3bLH, **all LH *F. ex.*** [c]		**16**	**4 (25)**	**3 (19)**	**2 (13)**	**2 (13)**	**11 (69)**	**6 (38)**	**7 (44)**	**3 (19)**	**7 (44)**	**6 (38)**
χ^2 test *F. pen.* vs. *F. ex.* [d]			***	**		**n.s.**	*	****	****	**	**n.s.**	****
Kharkiv region (KH, northwest from LH)												
4KH	*F. ex.*	60	-	-	-	-	-	15 (25)	17 (28)	9 (15)	9 (15)	37 (62)
5KH	*F. ex.*	55	-	-	-	-	-	18 (33)	12 (22)	6 (11)	9 (16)	31 (56)
6KH	*F. pen.*	52	-	-	-	-	-	7 (13)	31 (60)	4 (8)	23 (44)	18 (35)
7KH	*F. pen.*	45	-	-	-	-	-	3 (7)	24 (53)	2 (4)	19 (42)	20 (44)
All KH *F. pen.*		**97**	-	-	-	-	-	**10 (10)**	**55 (57)**	**6 (6)**	**42 (43)**	**38 (39)**
All KH *F. ex.*		**115**	-	-	-	-	-	**33 (29)**	**29 (25)**	**15 (13)**	**18 (16)**	**68 (59)**
			χ^2 test *F.pen.* vs. *F.ex.*					**	****	**n.s.**	****	**
Sumy region (SU, northwest from KH)												
8SU	*F. ex.*	50	-	-	-	-	-	32 (64)	-	-	31 (62)	18 (36)
9SU	*F. ex.*	50	-	-	-	-	-	27 (54)	-	-	19 (38)	23 (46)
10SU, **all SU *F. pen.***		**25**	-	-	-	-	-	**8 (32)**	-	-	**5 (20)**	**17 (68)**
All SU *F. ex.*		**100**	-	-	-	-	-	**59 (59)**	-	-	**50 (50)**	**41 (41)**
			χ^2 test *F.pen.* vs. *F.ex.*					*			**	*
All plots (LH + KH + SU)												
All *F. pen.*		**210**	-	-	-	-	-	**21 (10)**	**139 (66)**	**7 (3)**	**107 (51)**	**57 (27)**
All *F. ex.*		**231**	-	-	-	-	-	**98 (42)**	**36 (16)**	**18 (8)**	**75 (32)**	**115 (50)**
			χ^2 test *F.pen.* vs. *F.ex.*					****	****	*	****	****
Plots infested by the emerald ash borer (LH + KH)												
LH + KH *F. pen.*		**185**						**13 (7)**	**139 (75)**	**7 (4)**	**102 (55)**	**40 (22)**
LH + KH *F. ex.*		**131**						**39 (30)**	**36 (27)**	**18 (14)**	**25 (19)**	**74 (56)**
			χ^2 test *F.pen.* vs. *F.ex.*					****	****	**	****	****

[a] All showing ADB and/or EAB infestations. [b] *Fraxinus pennsylvanica* (field shelterbelts). [c] *Fraxinus excelsior* (forest interior). [d] Significance of χ^2 tests: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$; n.s. not significant.

Table 2. Colonization by the ash bark beetles (*Hylesinus* spp.) on trees of *Fraxinus excelsior* and *F. pennsylvanica* infected by the ash dieback disease (ADB) fungus *Hymenoscyphus fraxineus*. The plots are as shown in Figure 1.

Plot	*Fraxinus* spp.	Trees with ADB Symptoms, No. (%) All (100%)	Colonized by *Hylesinus* spp. [a]	Dead (% of Colonized by *Hylesinus* spp.)
4KH	*F. excelsior*	15	4 (27)	4 (100)
5KH	*F. excelsior*	18	7 (39)	5 (71)
6KH	*F. pennsylvanica*	7	3 (43)	1 (33)
7KH	*F. pennsylvanica*	3	1 (33)	1 (100)
8SU	*F. excelsior*	32	31 (97)	31 (100)
9SU	*F. excelsior*	27	22 (81)	19 (86)
10SU	*F. pennsylvanica*	8	5 (63)	5 (100)
All	*F. excelsior*	92	64 (70)	59 (92)
	F. pennsylvanica	18	9 (50)	7 (78)
χ^2 test *F. excelsior* vs. *F. pennsylvanica* [b]			**n.s.**	*

[a] Galleries of *H. fraxini* and *H. crenatus*. [b] Significance of $\chi 2$ tests: * $p < 0.05$; n.s. not significant.

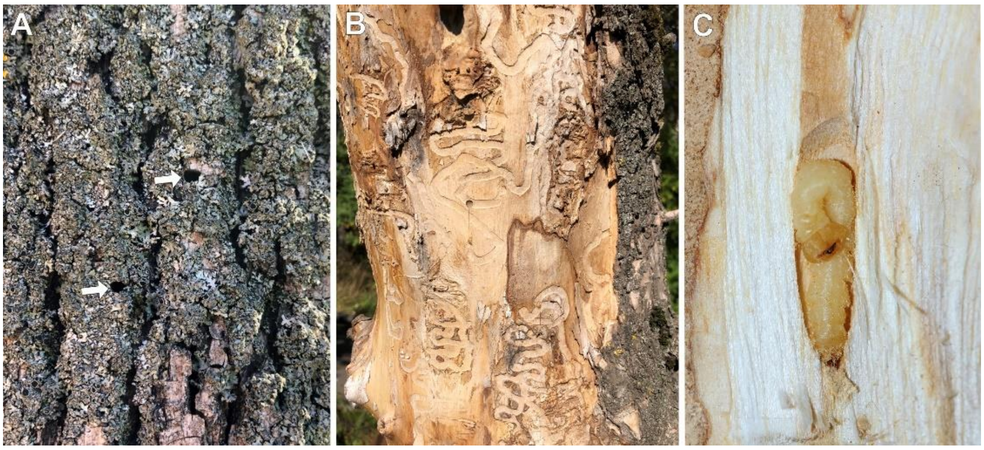

Figure 2. The emerald ash borer, *Agrilus planipennis* on ash trees: (**A**) Exit holes, shown by white arrows; (**B**) Old galleries on a dry-sided stem; (**C**) Larva.

3. Results

According to the results of surveys, in the Luhansk region with the longest EAB invasion history, in 2019, approx. 10–30% of ash trees were infested by the beetle, and in the years 2020–2021, this proportion had increased up to 60 to 90%. Typically, many of those trees exhibited old EAB exit holes, bark cracks, and dry-sided stems (Figure 2A,B), indicating that the initial invasion took place at the eastern Russian–Ukrainian border several years previously, e.g., in the years 2016–2017 at the latest. Further northwest in the Kharkiv region, no EAB attacks had been observed in 2019, but already in 2020 up to 10–30% of trees were infested, and in 2021, this proportion increased up to 60 to 90%. Neither of the surveys accomplished during the period of 2019–2021 revealed the presence of EAB in the neighboring Sumy region (Figure 1).

Investigations in the monitoring plots of the Luhansk region (1, 2, 3a; LH) demonstrated that 56% of *F. pennsylvanica* trees were infested by EAB in year 2020, and in 2021, the proportion had increased to 68%. For *F. excelsior* (plot 3bLH), the corresponding numbers were 19% and 44%. A similar trend was observed in 2021 in the plots of Kharkiv region (4, 5, 6, 7; KH), where EAB infested 57% *F. pennsylvanica* and 25% *F. excelsior* trees. Pooled data from all plots where EAB was observed (LH + KH) showed that out of 185 *F. pennsylvanica* trees, 139 (75%) were EAB-infested, while the corresponding proportion for *F. excelsior* was 36 out of 131 (31%). In this respect, all comparisons between the two tree species were statistically significant (Table 1).

The situation with frequencies of infections by ADB was the reverse. Thus, in 2020 in the LH plots, ADB symptoms were observed on 1% of *F. pennsylvanica* and on 25% of *F. excelsior* trees, and in 2021, the respective proportions increased up to 3.5% and 38%. Consistently, in 2021 in the KH plots, ADB symptoms were observed on 10% and 29% of *F. pennsylvanica* and *F. excelsior* trees, respectively, and in the Sumy plots (8, 9, 10; SU), on 32% and 59% of *F. pennsylvanica* and of *F. excelsior* trees, respectively. Pooled data from all study plots (LH + KH + SU) had shown that out of 210 *F. pennsylvanica* trees, 21 (10%) were ADB-infected, while the corresponding proportion for *F. excelsior* was 98 out of 231 (42%). In this respect, all comparisons between the two tree species were statistically significant. In the plots invaded by both EAB and ADB (LH + KH), 7 (4%) *F. pennsylvanica* and 18 (14%) *F. excelsior* trees were affected by both the pest and disease, and the difference in proportions was significant (Table 1).

The proportion of dead *F. pennsylvanica* trees in LH plots between the years 2020 and 2021 increased significantly from 32% to 68% (χ^2 test; $p < 0.00001$), although the increase in dead *F. excelsior* (13% to 44%) was statistically insignificant ($p = 0.12$). The differences in proportions of dead trees between the two species were insignificant ($p = 0.20$ and $p = 0.06$; Table 1). This was in contrast with the KH and SU plots, where significant differences in interspecific mortality rates have been noted, but for different reasons: in KH, it was higher in *F. pennsylvanica* due to EAB, while in SU, in *F. excelsior* due to ADB. The mortality in EAB-infested plots (LH + KH), as well as in the whole study area, was to a significant extent higher in *F. pennsylvanica* due to prevailing infestations by EAB (Table 1).

In reverse, the proportions of visually healthy (no signs neither of EAB nor ADB) *F. pennsylvanica* trees in LH plots between the years 2020 and 2021 decreased significantly, from 35% to 2% (χ^2 test; $p < 0.00001$), although the decrease in visually healthy *F. excelsior* (69% to 38%) was statistically insignificant ($p = 0.16$). In each accomplished comparison, the proportion of visually healthy *F. pennsylvanica* was significantly lower than that of *F. excelsior*, except in the SU plots, where the proportion was higher (68% vs. 41%) due to the absence of EAB infestation (Table 1).

Galleries of ash bark beetles (*Hylesinus* spp.) were observed only on trees with ADB symptoms and only in the KH and SU plots. In all, 64 out of 92 (70%) ADB-symptomatic *F. excelsior* trees and 9 of 18 (50%) *F. pennsylvanica* trees were colonized by the beetles, yet the difference in proportions was not significant ($p = 0.11$). Among the trees colonized by *Hylesinus* spp., 59 (92%) of *F. excelsior* and 7 (78%) of *F. pennsylvanica* were dead. Of all trees with ADB symptoms, this comprised 64% and 39% of *F. excelsior and F. pennsylvanica*, respectively, and the difference in the proportions was (marginally) statistically significant ($p = 0.046$; Table 2).

4. Discussion

Rapid geographic expansion of EAB and a steady increase in its killed trees (for *F. pennsylvanica*, very significant) in 2020–2021 point out that the ecological conditions are indeed suitable for the development of EAB populations in eastern Ukraine. This is different from the situation observed in populations of the beetle approx. 1200 km north in Saint Petersburg, where, following the invasion, further spread of EAB was slow and locally restricted, likely due to climatic conditions characterized by cool and wet summers and freezing winter temperatures [8]. Preceding studies have shown that the life cycle of EAB in eastern Ukraine fells into two cohorts: (1) a "spring" cohort, comprised of larvae hatching in May to June, which develop to prepupae, overwinter in pupal chambers, and adult beetles emerge in May to June the next year (one-year generation); (2) a "summer" cohort, comprised of larvae that hatch later in the summer and overwinter twice—first winter as larvae and the second as prepupae; the ratio of the cohorts is about 1:1 [21]. For comparison, in European Russia, the life cycle of the EAB lasts more than 1 year for most individuals in Moscow [22] and at least 2 years in Saint Petersburg [8].

The current study demonstrated significantly higher susceptibility to EAB of *F. pennsylvanica* as compared to *F. excelsior* (Table 1). This is in agreement with the results of the previous study in eastern Ukraine (the same study area), wherefrom it has been reported that EAB inhabits mainly *F. pennsylvanica*, and in *F. excelsior* it occurs more occasionally, preferring sprouts, trees in the stands with low relative stocking density, and trees at the edges and along the perimeter of small forests or forest belts. Here, despite that the density of EAB larvae in colonized branches did not differ significantly between the two ash species (approx. 0.6 and 0.7 larvae/dm^2, respectively), the numbers of viable EAB larvae in branches collected from attacked *F. pennsylvanica* (91.4%) were significantly higher than in *F. excelsior* (76.1%) [23]. Differently, a study from Saint Petersburg (1200 km north) showed that the EAB exhibited a slightly more successful development in *F. excelsior* than in *F. pennsylvanica*: larval densities, numbers of larval galleries, exit holes, viable larvae, and emerged adult beetles were slightly higher in *F. excelsior* than in *F. pennsylvanica*; larval densities were 0.1–0.5 larvae/dm^2 for *F. pennsylvanica* and 0.3–0.8 for *F. excelsior* [8]. Yet, the cited work was conducted in the city environment and consisted of small and fragmented empirical data.

On the other hand, the current study demonstrated significantly higher susceptibility to ADB of *F. excelsior* as compared to *F. pennsylvanica* (Table 1). This is the first report of its kind and is supported not only by the data acquired in SU monitoring plots, where invasion of EAB was still absent, but also from the whole study area, as in all comparisons the proportions of *F. excelsior* trees with ADB symptoms was significantly higher than that of *F. pennsylvanica*. In monitoring plots located in EAB-invaded areas (LH + KH), the proportion of trees affected by both ADB and EAB simultaneously was also higher for *F. excelsior*, indicating that its trees diseased with ADB are to a certain extent also predisposed to EAB infestation. In case of *F. pennsylvanica*, this demonstrates such vulnerability of the species to EAB that the beetle infests and kills trees indiscriminately of their health condition (e.g., despite presence/absence of ADB). Indeed, the previous study in the eastern Ukraine has reported regular attacks of EAB on vigorous *F. pennsylvanica* trees and the aggressiveness of the pest was emphasized [23].

The results of our work demonstrated a common occurrence of *Hylesinus* bark beetles on ADB-diseased ash (slightly preferring native *F. excelsior*), and the prevailing majority of the colonized trees were already dead. Similarly, the report from ADB-infected ash stands in southeastern Germany had shown that breeding galleries of *Hylesinus* were only found in ADB-diseased trees that have recently died, concluding that the beetle is not able to colonize vigorous trees and is acting as a secondary opportunistic pest [24].

Finally, it must be noted that only a minority of *F. excelsior* trees in affected sites by EAB and ADB (LH + KH) have died, while over a half remained visually healthy. Therefore, those over 100 of *F. excelsior* trees that survived or were not susceptible to attacks by EAB (Table 1) constitute a source of material for further monitoring and eventual propagation, for which the current work represents a starting point. As it was emphasized previously [8], inventory and mapping of surviving ash trees, focusing on European native *F. excelsior*, affected by both ADB and EAB is necessary to acquire genetic resources for the work on strategic, long-term restoration of devastated areas, thereby tackling a possible invasion of EAB to the EU.

5. Conclusions

1. Invasion of EAB to Ukraine occurred 2–3 years previously to its first records in 2019, and is currently expanding both in terms of newly infested trees and invaded geographic area.
2. *Fraxinus excelsior* (in interior of forest stands) is more resistant to EAB than *F. pennsylvanica* (in field shelterbelts).
3. *Fraxinus excelsior* is more susceptible to ADB than *F. pennsylvanica*.
4. Infection by ADB is likely to predispose *F. excelsior* to infestation by EAB.
5. Ash trees infected by ADB are predisposed for the colonization by ash bark beetles *Hylesinus* spp.
6. Inventory and mapping of surviving *F. excelsior*, affected by both ADB and EAB, is necessary to acquire genetic resources for the work on strategic, long-term restoration of devastated areas, thereby tackling a possible invasion of EAB to the EU.

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