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Research article

Damage caused by singing cicadas (Hemiptera: Cicadidae) in the field protective forest belts in South Dobrudzha, Bulgaria

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Abstract: During the period 2020–2023, strong damage caused by singing cicadas (Hemiptera: Cicadidae) were registered on ash trees (*Fraxinus* spp.) in the field protective forest belts (FPFBs) in South Dobrudzha, northeastern Bulgaria. Bioacoustic studies have shown that the sounds are of *Cicada orni*. Many exuvia of the species were also found on the trunks and branches of ash trees. On the upper shoots and petioles, numerous oviposition holes were observed, which lead to leaf fall and drying of branch tips. In different FPFBs, tree crown damage ranges from a moderate (25-60% defoliation) to a severe (over 60% defoliation) degree. The attacks were stronger on *Fraxinus excelsior* and *F. americana* compared to *F. angustifolia*. The cicadas affect both old trees and young ash saplings. In young plantations, other tree species (*Sophora japonica, Gleditsia triacanthos*) were also affected. Imaginal activity of *Cicada orni* was recorded in July and August, and the peak of egg hatching occurred from early August to mid-September. The high number of *Cicada orni* necessitates the development of measures to control the pest in the FPFBs.

Keywords: *Cicada orni,* damage, field protective forest belts, *Fraxinus,* singing cicadas, South Dobrudzha

Introduction

The field protective forest belts (FPFBs) are linear forest plantations created to protect agricultural land and improve the microclimate. They protect the soil from wind erosion and degradation, reduce evaporation, evenly distribute the snow cover, and thus contribute to improving the microclimate and increasing the fertility of the adjacent agricultural lands (Georgiev, 1960; Dodev et al., 2023).

In the Bulgarian part of Dobrudzha, the first FPFBs were planted in 1925–1940, but the system as a whole was built mainly in the 1950s (Georgiev, 1960; Dodev et al., 2023). In 2022, the area of FPFBs in Northeast Bulgaria covers 10695.5 ha (Mateva & Kirilova, 2022).

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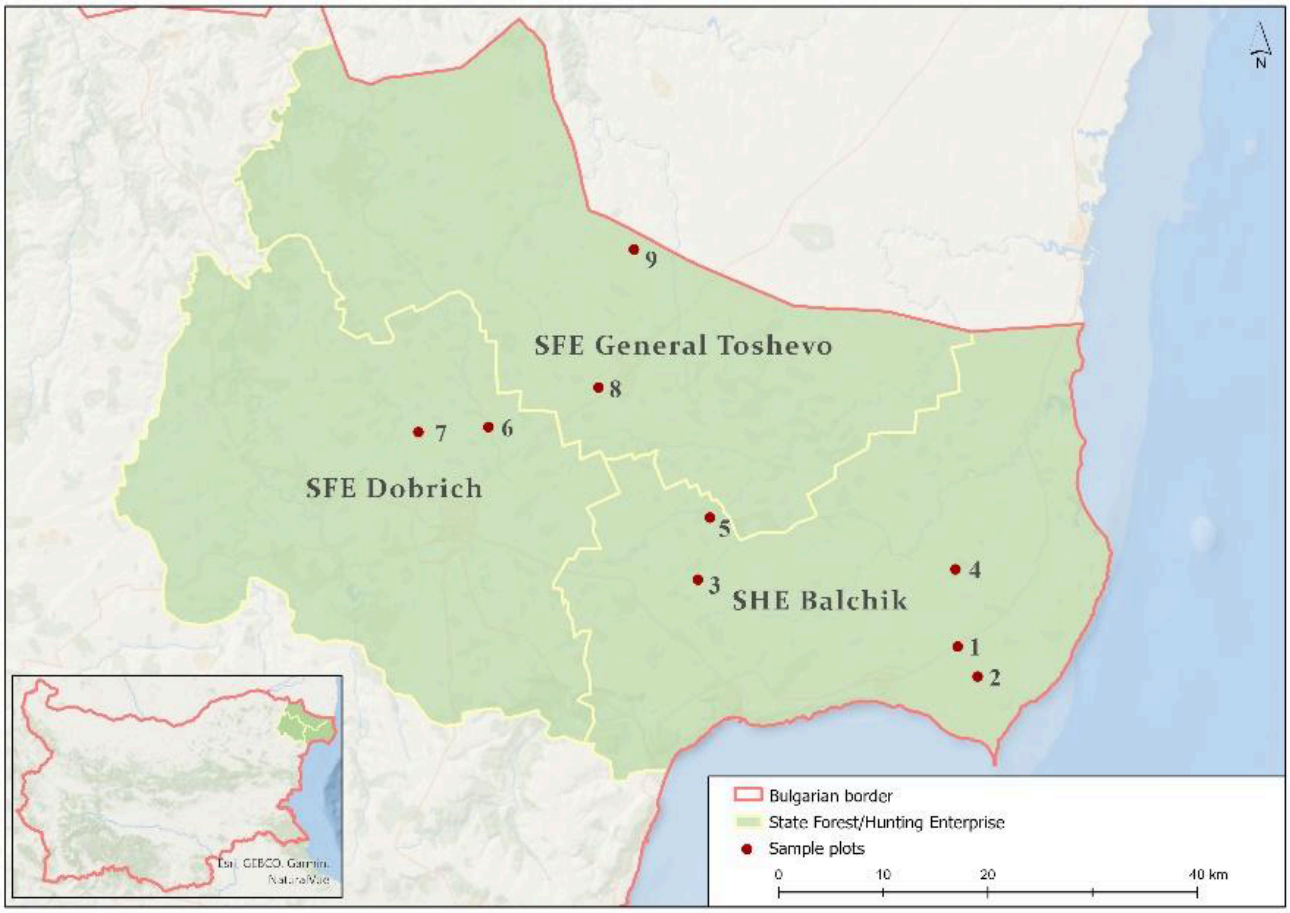

Fig. 1. Studied sites: 1 – Balgarevo Village 1, 2 – Balgarevo Village 2, 3 – Dabrava Village, 4 – Gorichane Village, 5 – Dropla Village (SHE Balchik); 6 – Tsarevets Village, 7 – Rosenovo Village (SFE Dobrich); 8 – Ravnets Village, 9 – Ograzhden Village (SFE General Toshevo).

Since 2020, there has been a very serious deterioration in the health status of the ash trees (*Fraxinus* spp.) in the FPFBs (Mateva & Kirilova, 2021). The largest affected and drying areas are in the State Hunting Enterprise (SHE) Balchik, State Forestry Enterprise (SFE) General Toshevo and SFE Dobrich (Mateva & Kirilova, 2022; Dodev et al., 2023).

The present work reports data on severe damage by *Cicada orni* Linnaeus, 1758 (Hemiptera: Cicadidae) and the occurrence of mass crown dieback (dying back of branches and branch tips) of ash trees in FPFBs in Southern Dobrudzha.

Material and methods

The observations were carried out during the period 2020–2023 in the FPFBs of the territory of SHE Balchik, SFE Dobrich and SFE General Toshevo. The biological material was collected in nine FPFBs – five on the territory of SHE Balchik and two each on the territory of SFE Dobrich and SFE General Toshevo (Fig. 1).

The geographical coordinates, altitudes, tree species and other main characteristics of the studied FPFBs are presented in Table 1.

The assessment of the health status of *Fraxinus excelsior* L., *F. angustifolia* Vahl, *F. americana* L. and other tree species was conducted in June–September. The condition of trees in the studied localities was assessed by estimating the degree of defoliation of 40 trees compared to the amount of foliage on a standard reference tree (Eichhorn et al., 2020). Defoliation of individual trees was assessed in 5% steps, and average values were allocated to mild, moderate or severe categories of damage according to the scores of defoliation and presence of dry

Table 1. Main characteristics of the studied areas.

No.	Locality	Geographical coordinates	Altitude, m a.s.l.	Tree species	Age, years	Height, m	$D_{1.30}$, cm
1	Balgarevo Village 1	N 43.463388° E 28.424021°	111	*Fraxinus excelsior* *Fraxinus angustifolia*	67	21	34
2	Balgarevo Village 2	N 43.437482° E 28.446770°	86	*Fraxinus excelsior*	62	17	26
3	Dabrava Village	N 43.524344° E 28.117981°	223	*Fraxinus excelsior*	67	17	22
4	Gorichane Village	N 43.529967° E 28.422755°	96	*Fraxinus excelsior* *Fraxinus americana* *Sophora japonica* *Gleditsia triacanthos*	4	1.0	2
5	Dropla Village	N 43.57749° E 28.13350°	203	*Fraxinus excelsior*	67	18	26
6	Tsarevets Village	N 43.65772° E 27.87223°	216	*Fraxinus excelsior*	10	4.5	8
7	Rosenovo Village	N 43.65389° E 27.78908°	239	*Fraxinus excelsior*	68	18	26
8	Ravnets Village	N 43.69070° E 28.00316°	237	*Fraxinus excelsior*	69	17	30
9	Ograzhden Village	N 43.80852° E 28.04745°	180	*Fraxinus excelsior*	56	16	26

branches, as follows: mild (damage cover ≤25% of tree crown); moderate (damage cover between 25 and 60% of tree crown); severe (damage cover ≥60% of tree crown).

The research materials (young shoots with an approximate length of 30 cm) were collected from 3-5 trees in each FPFB and transported to the entomological laboratory of the Forest Research Institute in Sofia. The samples were analysed for the presence of damage and were placed in plastic transparent boxes with a size of 40 × 30 × 20 cm at room temperature (18–22 °C). The samples were analysed twice a week for the appearance of insect pests. The emerged insects were stored in ethanol.

In the field conditions, the sounds of singing cicadas (Hemiptera: Cicadidae) were determined according to Trilar et al. (2020) and Gogala (2023).

Photographs of the FPFBs, the damage in them and the cicadas that emerged in laboratory conditions were made with the following photographic equipment: Olympus E-30 equipped with Olympus 14-54 mm f/2.8-3.5 Zuiko Digital and Olympus 50 mm f/2.0 Zuiko Digital Macro lenses; Nikon D-610 equipped with Sigma 105mm f/2.8 EX DG OS HSM Macro lens; Canon EOS 70D camera, Canon MP-E 65mm macro photo lens, Yongnuo YN24EX twin macro flash.

The biological material was deposited in the Entomological collection of the Forest Research Institute in Sofia and in the Zoological collection of Sofia University (Faculty of Biology).

Results

Field observations showed that all surveyed FPFBs were in poor condition – the average defoliation and drying of the top shoots was moderate (covering 25-60% of tree crown) (Fig. 2 A, B) or severe (exceeding 60%) (Fig. 2 C).

Detailed examinations showed that the drying of the upper shoots and leaves was due to numerous cicada oviposition holes. The eggs were laid both on the upper shoots (Fig. 3 A) and on the petioles (Fig. 3 B). The attack affects not only old trees (Fig. 3 A, B), but also young saplings (Fig. 3 C). The degree of

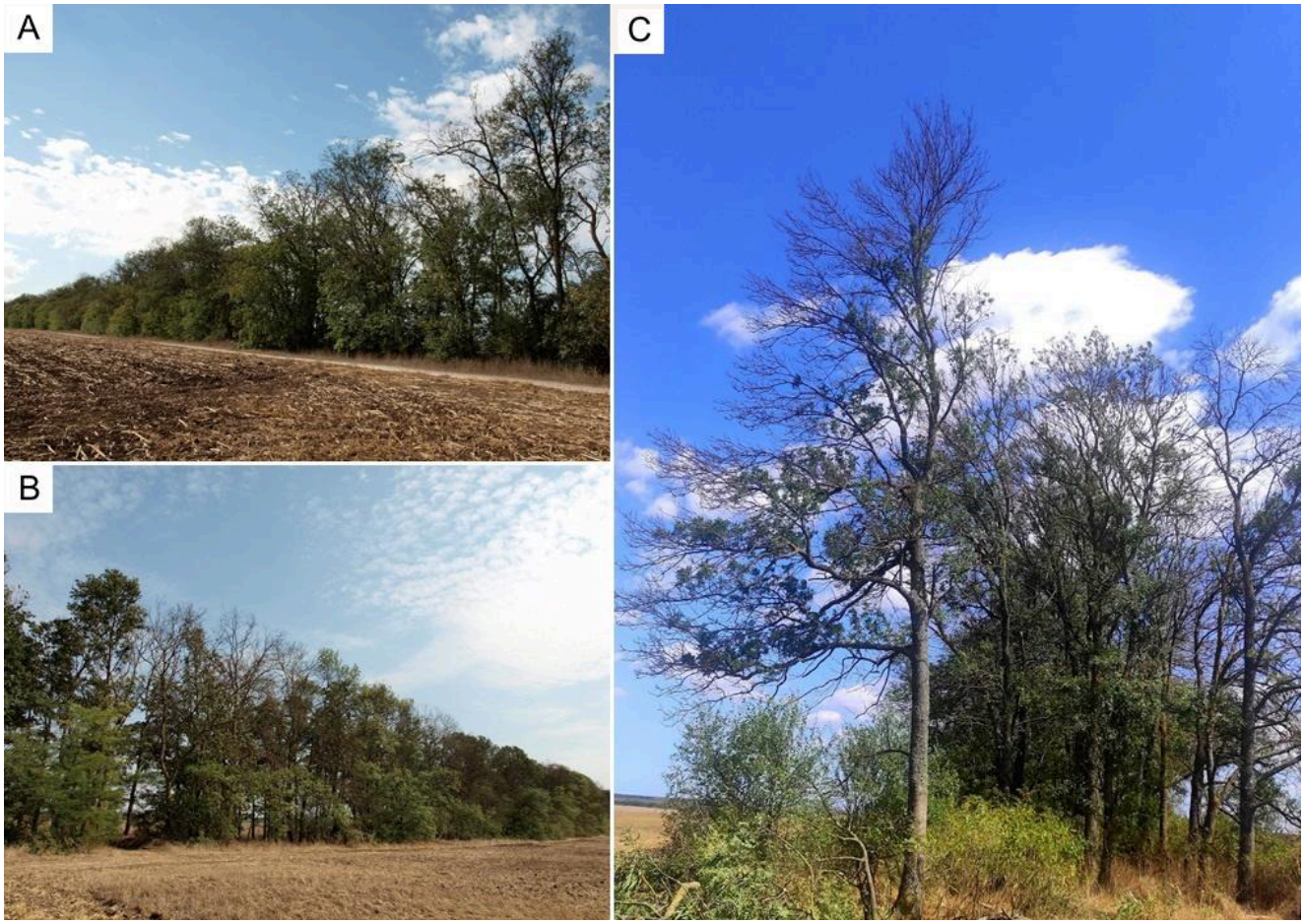

Fig. 2. Defoliation and crown dieback in *Fraxinus excelsior* FPFBs: A – Balgarevo Village 1 (3.09.2020); B – Balgarevo Village 2 (23.08.2023); C – Dabrava Village (12.09.2023).

attack was stronger on *Fraxinus excelsior* and *F. americana* than on *F. angustifolia*.

During the field surveys in July and August, mass sounds of *Cicada orni* were recorded in the ash FPFBs. Numerous exuvia of the species were also observed on the trunks and branches of ash trees (Fig. 4 A, B). In individual cases, other species of singing cicadas have been recorded, e.g. *Tibicina haematodes* (Scopoli, 1763) (Fig. 4 C). *Oligoglena tibialis* (Panzer, 1798) was another species of singing cicada found in large numbers on the surrounding scrub vegetation.

Females of *Cicada orni* make holes in the upper shoots with their ovipositor (Fig. 5 A). Numerous eggs were laid in the holes with a diameter of 1.5-2.0 mm and a length of 6.0–8.0 mm (Fig. 5 B, C). Under laboratory conditions at room temperature, the embryonic period lasts about one month. The peak of egg hatching occurred from early August to mid-September. Newly hatched nymphs are white, about 1.5 mm long (Fig. 5 D, E).

Discussion

In the past, many economically important insect pests have been reported on different tree species in the FPFBs in South Dobrudja: *Lytta vesicatoria* (Linnaeus, 1758) (Zlatanov, 1957, 1970), *Phylloxera quercina* (Ferrari, 1872) (syn. *Phylloxera spinulosa* Targioni Tozzetti) (Zlatanov, 1960), *Phalera bucephala* (Linnaeus, 1758) (Zlatanov, 1959, 1970), *Lymantria dispar* (Linnaeus, 1758), *Euproctis chrysorrhoea* (Linnaeus, 1758), *Tortrix viridana* Linnaeus, 1758, *Operophtera brumata* (Linnaeus, 1758), *Yponomeuta malinellus* Zeller, 1838,

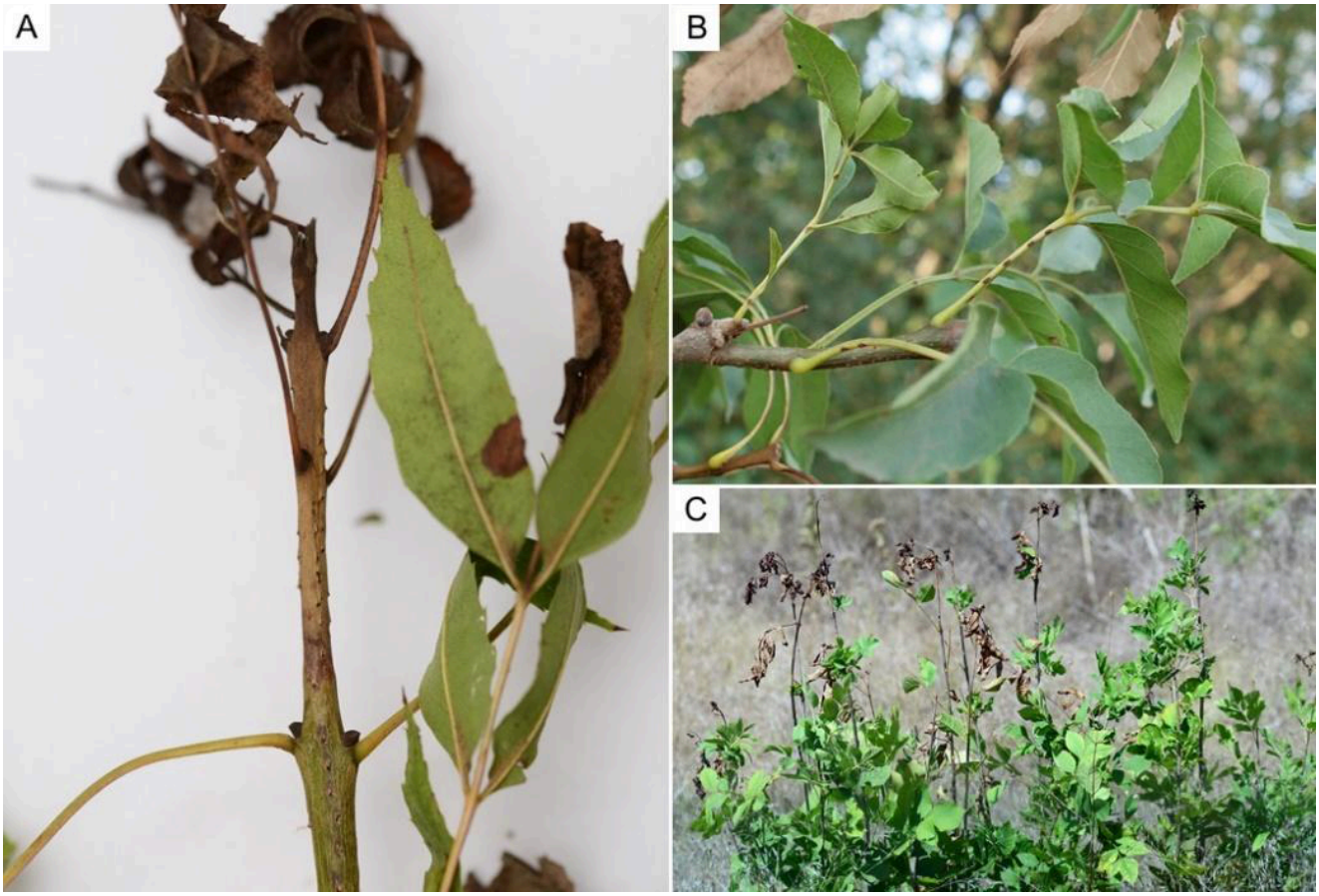

Fig. 3. Damage on ash trees caused by cicadas: A – egg-laying places on the top shoot of *Fraxinus excelsior* (Dabrava Village, 12.09.2023); B – egg-laying sites on petioles of *Fraxinus angustifolia* (Balgarevo Village, 23.08.2023); C – drying of upper shoots of young saplings of *Fraxinus americana* (Gorichane Village, 14.09.2023).

Xanthogaleruca luteola (Müller, 1766) (Zlatanov, 1962, 1970), *Holochelus aequinoctialis* (Herbst, 1790), *Pentodon idiota* (Herbst, 1789), *Rhizotrogus vernus* (Germar, 1824) (Zlatanov, 1970). Missing from the list are singing cicadas, which are being established as pests for the first time in this study.

Singing cicadas are generally known as minor pests in forests (Hill et al., 2015), but there are occasional reports of economically significant damage (Schumanov, 1950; Apostolov & Topciev, 1970, etc.). In North America periodical cicadas (*Magicicada* spp.) cause extensive branch dieback (flagging) on trees and shrubs where eggs were laid, but they are not considered as major pests in forests (Hoppers et al., 2021). Cook, Holt (2002) pointed that the oviposition damage from *Magicicada cassini* (Fisher, 1852) did not have any important effects on successional dynamics of the host plants, suggesting that the trees appeared to compensate sufficiently for physiological damage during the emergence.

In agriculture, there are many reports of damage from singing cicadas. In Bulgaria, severe damage on fruit trees (apple, pear, cherry, loquat, quince) was recorded by *Tibicina haematodes, Pagiphora annulata* (Brullé, 1832), *Lyristes plebejus* (Scopoli, 1763) (Arabadzhiev, 1963) and *Cicadatra atra* (Olivier, 1790) (Dirimanow & Harisanow, 1965).

The Bulgarian fauna of singing cicadas consists of 16 confirmed species, 8 of which were recorded in South Dobrudzha (Dobrich Province), including *Cicada orni* and *Tibicina haematodes* (Trilar et al., 2020).

Cicada orni is a xerophilous species distributed in the Mediterranean, the Carpathians, the Crimea, the Caucasus, Kopetdag in Iran and Asia Minor

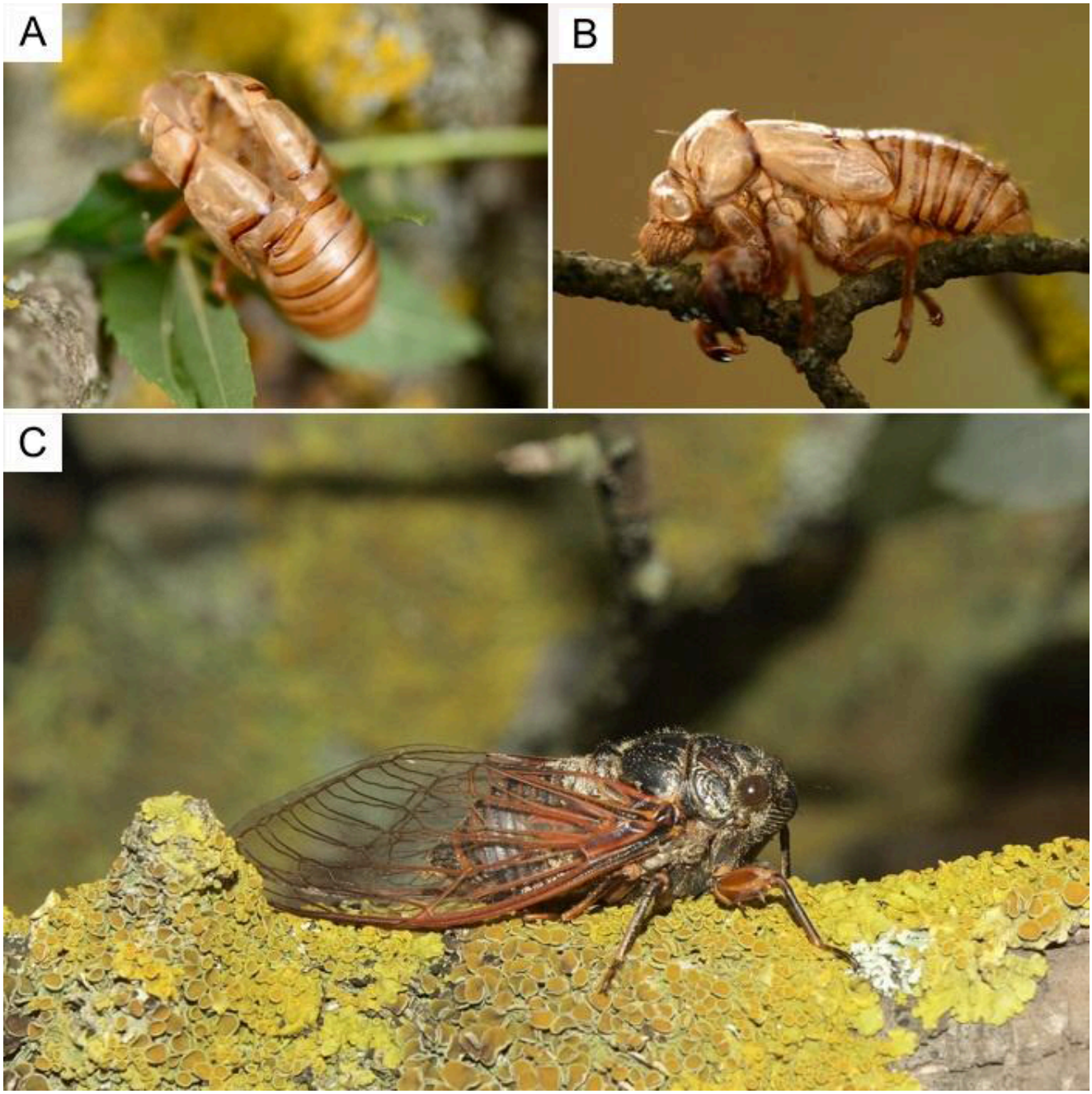

Fig. 4. Cicadas on *Fraxinus excelsior* trees: A – exuvia of *Cicada orni,* dorsal view (Dabrava Village, 31.07.2023); B – exuvia of *Cicada orni,* lateral view (Dabrava Village, 31.07.2023); C – *Tibicina haematodes,* lateral view (Dropla Village, 5.07.2021).

(Kudriasheva, 1979). According to the author, in the Mediterranean and the Crimea, the species inhabits the xerophytic formations of *Fraxinus ornus* L., but it is also able to penetrate into sub-xerophytic deciduous forests. In Georgia, it is known as a pest of fruit trees, and in Crimea, the Caucasus and Moldova – as a pest of *Vitis* sp.

The identification of nymphs is based both on the paucity of literature data on morphology and differential diagnosis (Silvestri, 1921; Kudriasheva 1979) and on ecological features of oviposition in *Cicada orni*. The abundance of *C. orni* is regulated by a number of biotic factors, including the wild boar (*Sus scrofa* L.), which feeds on nymphs of the species

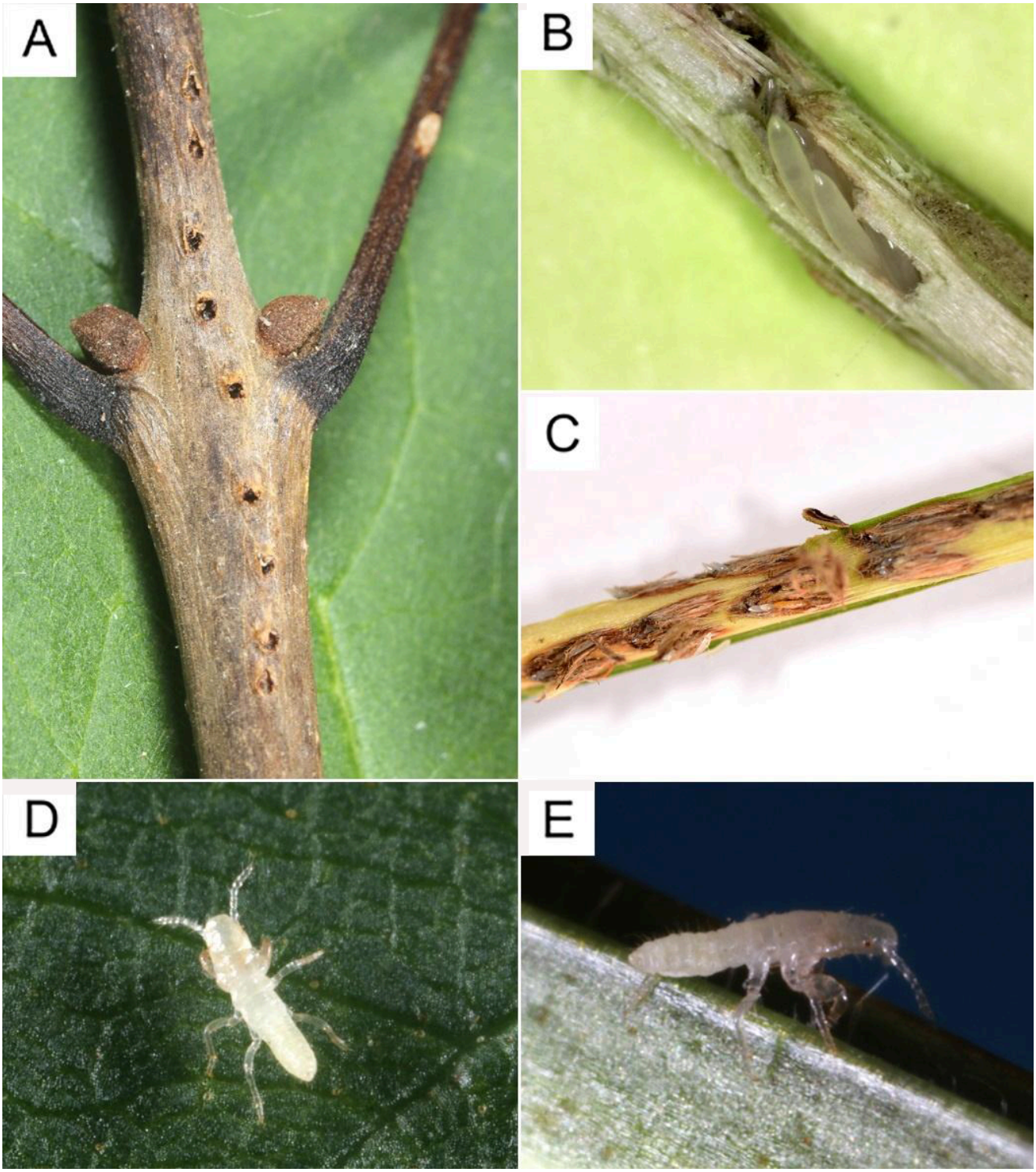

Fig. 5. *Cicada orni* on *Fraxinus* spp.: A – egg-laying places on a top shoot (Balgarevo Village 1, 5.07.2021); B – eggs in an oviposition hole (Dropla Village, 5.07.2021); C – strong damage by oviposition in young shoots (Dropla Village, 31.07.2023); D – first-instar nymph, dorsal view (Rosenovo Village, 12.09.2023); D – first-instar nymph, lateral view (Tsarevets Village, 12.09.2023).

(Genov et al., 2014). According to Genov & Ahmed (2014) the wild boar does not significantly affect the number of cicadas. However, the strong deterioration of the health status of the FPFBs and the sharp decline

in the wild boar population after 2020 as a result of the African swine fever epizootic is a reason to hypothesise that there may be a connection between the two phenomena.

Conclusions

The damage by singing cicadas is most likely due to the weakening of ash trees with increasing age. It is possible that the damage are indirectly related to climate change because cicada diversity is highly susceptible to climate warming (Moriyama & Numata, 2019). The uneven distribution of precipitation leads to the appearance of a humidity deficit, physiological weakening and drying of the attacked trees. The high number of the pests necessitates the development of measures to control them, because they are a threat not only to the adult trees, but also to the young saplings during the reconstruction of the FPFBs.

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