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RESEARCH ARTICLE

Aleuroclava aucubae (Homoptera: Aleyrodinea), a new adventive species for Russian Black Sea Coast, and its concomitant entomoparasitic fungus *Conoideocrella luteorostrata* (Ascomycota: Hypocreales: Clavicipitaceae)

Aleuroclava aucubae (Homoptera: Aleyrodinea) – новый адвентивный вид для Российского Черноморского побережья и сопутствующий энтомопаразитический гриб *Conoideocrella luteorostrata* (Ascomycota: Hypocreales: Clavicipitaceae)

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Abstract. An Oriental species of whiteflies, *Aleuroclava aucubae* (Kuwana, 1911), was collected for the first time from the territory of Russia (the Black Sea Coast of Russian Caucasus, Sochi National Park). The species was found to form dense colonies of ultimolarvae (pseudopupae) on leaves of *Ficus carica* and *Ulmus glabra*. Some of the ultimolarvae were infected by the fungus *Conoideocrella luteorostrata* (Zimmermann, 1901) Johnson et al., 2009. A morphological description of the pseudopupa of *A. aucubae*, with the original figure and photos are provided.

Резюме. Ориентальный вид белокрылок, *Aleuroclava aucubae* (Kuwana, 1911), впервые обнаружен на территории России на Черноморском побережье Кавказа в Сочинском национальном парке. Плотные колонии личинок последнего возраста (псевдопупариев) этого вида найдены на листьях *Ficus carica* и *Ulmus glabra*. Часть личинок была заражена энтомопаразитическим грибом *Conoideocrella luteorostrata* (Zimmermann, 1901) Johnson et al., 2009. Приведено морфологическое описание псевдопупариев *A. aucubae*, с оригинальным рисунком и фотографиями.

Key words: alien species, whiteflies, Sochi National Park, morphological description, ecological association, Aleyrodidae

Ключевые слова: чужеродный вид, белокрылки, Сочинский национальный парк, морфологическое описание, экологическая связь, Aleyrodidae

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Introduction

Species of the whitefly genus *Aleuroclava* Singh, 1931 are mostly known from the Oriental Region. Although, the genus presently comprises about 120 species (Evans, 2007; Martin & Mound, 2007), the only one of them, *Aleuroclava similis* (Takahashi, 1938), was previously reported from the territory of Russia, where it is mainly feeding on leaves of *Vaccinium vitis-idaea* (Danzig,

1980, as *Japaneyrodes similis*). In October 2019, B.A. Borisov conducted a regular collecting survey in Sochi National Park (Russia, Krasnodar Territory, the Black Sea Coast of Caucasus) and discovered unusually small black pseudopupae of whiteflies which he never seen before. After studying of the material in the laboratory and preparation of microscopic slides, we were able to identify the species as *Aleuroclava aucubae* (Kuwana, 1911). The species originated from Japan and China, but in the XXI century, it was found by different authors in the southern countries of Western Europe: Italy (Pellizzari & Šimala, 2007), Slovenia (Seljak, 2012), Croatia (Šimala et al., 2014), Montenegro (Malumphy et al., 2015), and also in USA (Evans, 2007). In October 2019, the species was also found in Azerbaijan (G. Ismayilova, personal communication).

In this publication, we are providing a morphological description of the pseudopupa of *A. aucubae* (Kuwana, 1911), with the original figure and photos, and discussing its ecological association with the entomoparasitic fungus *Conoideocrella luteorostrata* (Zimmermann, 1901) Johnson et al., 2009.

Material and methods

Dry material of the whitefly species (colonies of ultimolarvae) and seven slide-mounted specimens are deposited at the Zoological Institute, Russian Academy of Sciences, St Petersburg; collecting and preserving number K 1546.

For the method of preparation of the morphological Canada balsam slides see, for example, Danzig & Gavrilov-Zimin (2014) or Gavrilov-Zimin (2018).

Description and discussion

Order **Homoptera**

Suborder **Aleyrodinea**

Family **Aleyrodidae**

Aleuroclava aucubae (Kuwana, 1911)
(Figs 1–3)

Material examined. Russia, *Krasnodar Terr.*, Black Sea Coast of Russian Caucasus, Sochi National Park, Agur Gorge, 43°33′18″N, 39°48′15″E, 120 m altitude, on lower side of leaves of *Ficus carica* and *Ulmus glabra*, 13.X.2019 (B.A. Borisov leg.).

Description. Ultimolarva (*pseudopupa*) black, with fine secretions of white wax along midline, longitudinal and transverse moulting sutures. Body broadly oval, tapered posteriorly, about 0.8 mm long and 0.5 mm wide; body margin slightly jagged. Vestigial legs and antennae of usual size and shape for larvae of Aleyrodidae. Anal (vasiform) orifice cordate in form, about 25 μm in inner diameter, with strongly sclerotised margins and with notch on posterior margin. Anal operculum large, totally covering lingula. Anal (caudal) furrow well developed, about 75 μm long. Clearly visible pair of tracheal notches present on margin of prothorax. Submargin separated from dorsal disc by suture. Abdominal part of dorsal disc with characteristic "trilobite-like" sclerotisation. Glandular areas of irregular shape and size present along midline on dorsum and forming two symmetrical longitudinal rows in submedial zone of dorsal disc. Minute tubular wax glands, each about 5 μm long, sparsely scattered on all dorsal surface of body. Setae of dorsal disc forming one pair in anterior part of body, one par near transverse moulting suture and one pair near anal apparatus. Caudal setae two in number, each about 75 μm long. Ventral setae forming two symmetrical pairs on last abdominal segments.

Imago and *larvae* of other instars not found.

Mode of life. Similar to other species of Aleyrodinae, *A. aucubae* has a life cycle including a mobile primolarva with well-developed legs and antennae and three immobile larval instars, bearing vestigial poorly visible appendages (Fig. 4). An ultimolarva (IV instar) is often incorrectly named "puparium" in the applied and even in the fundamental literature on whiteflies. Meanwhile, in classical entomological literature, the real puparium is represented by larval exuviae covering the pupa, a quiescent instar which moults into imago (for example, in Diptera – Cyclorrhapha and Strepsiptera). To the contrary, there is no pupa inside of ultimolarval exuviae of whiteflies; the imaginal cuticle is forming just under the larval cuticle (Weber, 1934; Kluge, 2010; Gavrilov-Zimin, 2018). Thus, the preimaginal instar of whiteflies may be correctly named as ultimolarva (Kluge, 2010) or pseudopupa. All larvae of whiteflies, including *A. aucubae*, are obligatory associ-

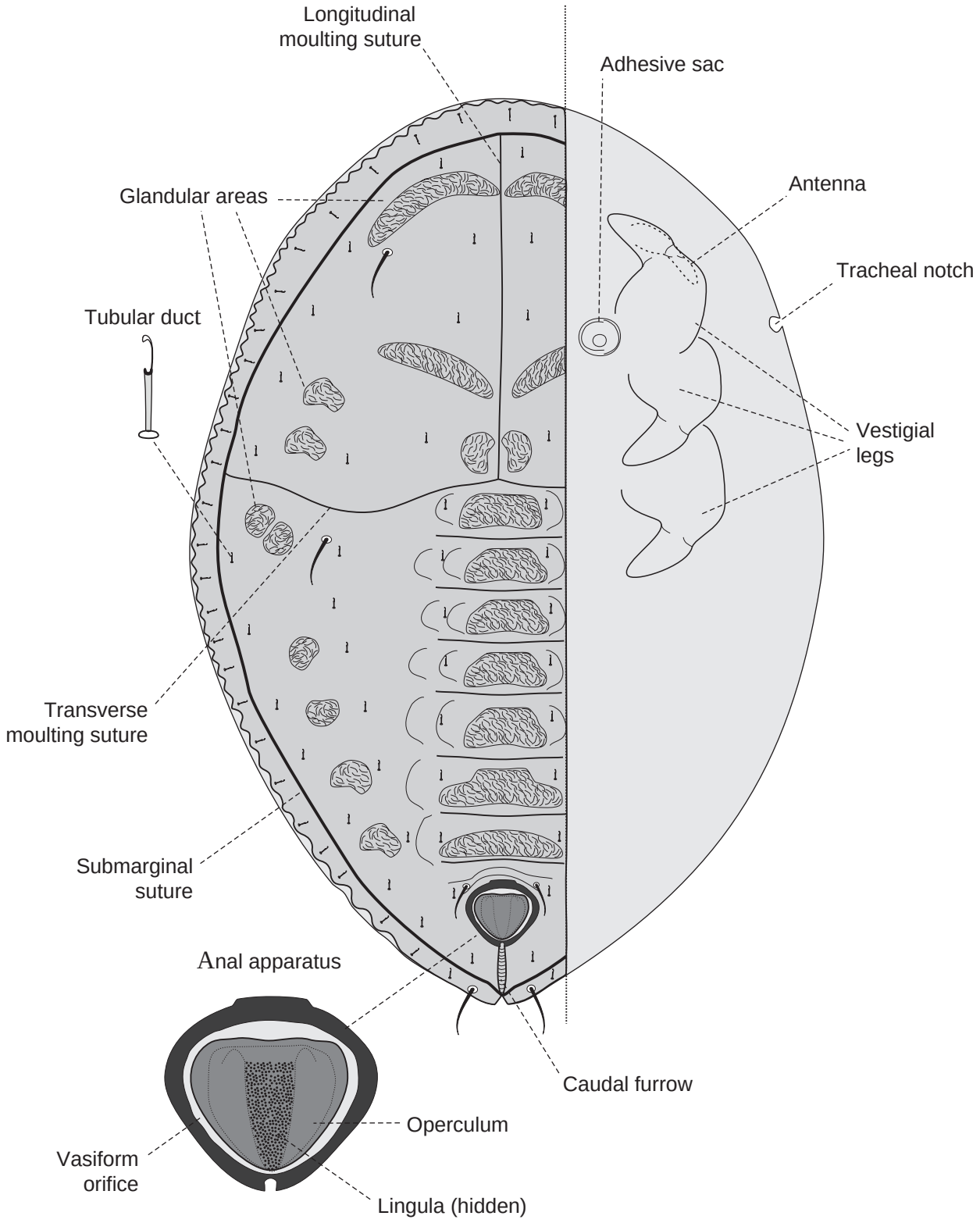

Fig. 1. Morphology of the prepared ultimolarva (pseudopupa) of *Aleuroclava aucubae*, dorsal and ventral surfaces.

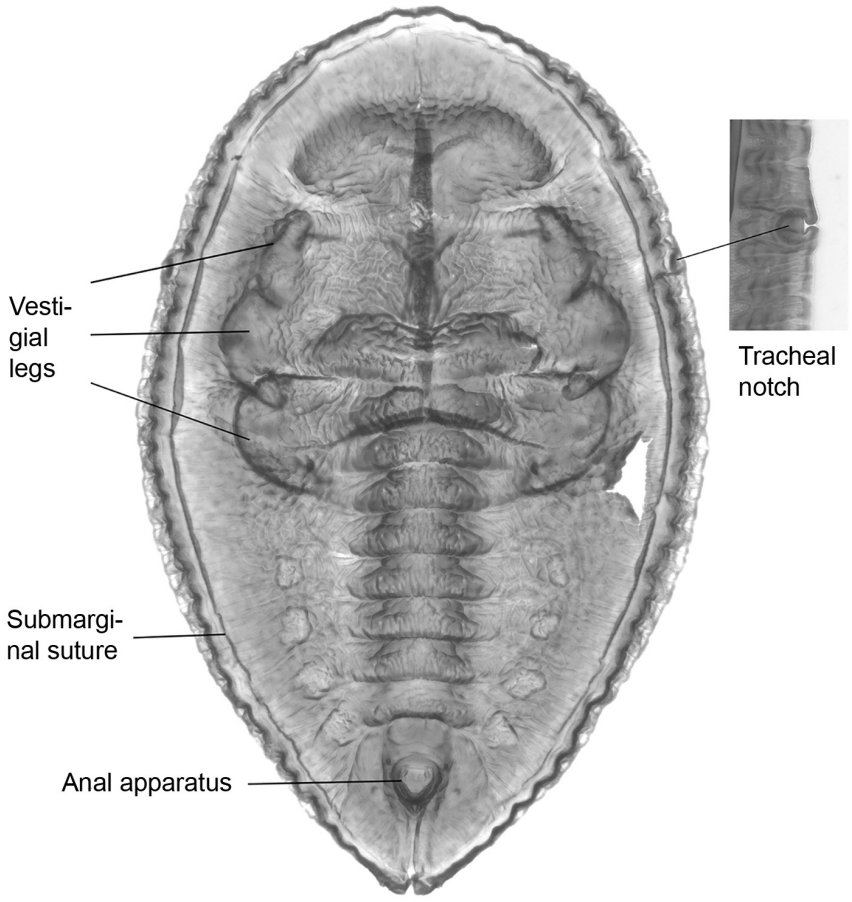

Fig. 2. Photo of the microscopic slide with an ultimolarva (pseudopupa) of *Aleuroclava aucubae*.

ated with their host plants. At the same time, winged imago can easily change their host plants; after mating, the females lay and attach eggs on the plant surface (usually a lower surface of leaves). A primolarva searches suitable place on the leaf surface for feeding and then inserts its stylets into the plant tissue. After the first moulting, the larva loses normally developed legs and antennae and looks like a flat oval scale, often covered with quaint wax secretion.

The species is polyphagous and it was reported from different countries on the plants from the families Aquifoliaceae, Araliaceae, Caprifoliaceae, Cornaceae, Flacourtiaceae, Juglandaceae, Lauraceae, Moraceae, Oleaceae, Pittosporaceae, Rosaceae, Rubiaceae, Rutaceae, Theaceae, and Ulmaceae. In Western Europe, the most usual host plants are different species of the genera *Citrus*, *Prunus* and *Ficus*. In the Russian Black Sea

Fig. 3. A colony of ultimolarvae (pseudopupae) of *Aleuroclava aucubae* on leaves of *Ficus carica*, and a separate ultimolarva enlarged.

Coast area, specimens of *A. aucubae* were found in large colonies on *Ficus carica* (Moraceae) which is an aboriginal plant for the region and common in the lowlands as well as in the foothills along river gorges and on rocks (Timukhin, 2006). Smaller colonies were also discovered in the same place on leaves of *Ulmus glabra* (Ulmaceae).

Distribution. China, Japan. Adventive for South Europe (France, Italy, Slovenia, Croatia, Montenegro), Russia (Krasnodar Territory), Azerbaijan, and USA.

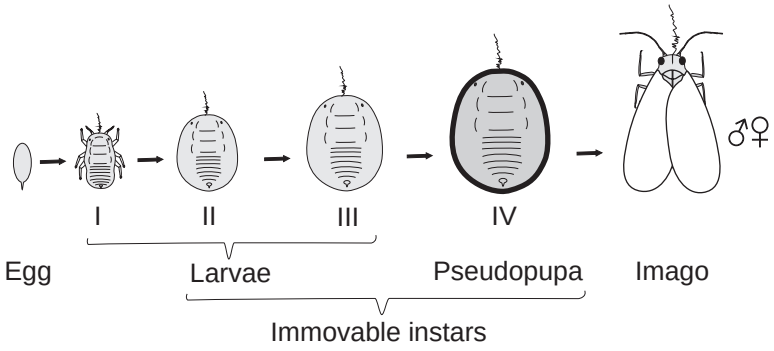

Fig. 4. A generalised scheme of ontogenesis in whiteflies.

Ecological association with an entomoparasitic fungus. A new adventive whitefly species, *Aleuroclava aucubae*, was collected in a course of long-term survey of entomoparasitic fungi, conducted by the second author in different parts of European Russia and especially in the Black Sea Coast of Caucasus. Six years ago, the tropical fungus *Conoideocrella luteorostrata* was found for the first time in the European part of Russia in Sochi Region (Agur Gorge), as associated with the whitefly *Aleyrodes* sp. which was feeding on leaves of *Salvia glutinosa* (Lamiaceae). In subsequent years, the fungus was collected in other humid gorges on the territory of Sochi National Park, as well as in the Yew and Boxwood Grove (Caucasus Nature Reserve), where the fungus was found on a western red scale, *Chrysomphalus dictiospermi* (Morgan, 1889) (Diaspididae), feeding on the leaves of *Hedera colchica* (Araliaceae) (Borisov, 2017). The infected insects demonstrate a very characteristic appearance, they resemble round velvety "wart", about 2–6 mm in diameter, of white, yellow, orange, pink, brownish colour, depending of the age of the mycelium (Fig. 5). The same fungal bodies were again found in October 2019 in the Agur Gorge of the Sochi National Park, firstly on the leaves of *Salvia glutinosa*, and then also on the leaves of *Ficus carica*. Only later, numerous min-

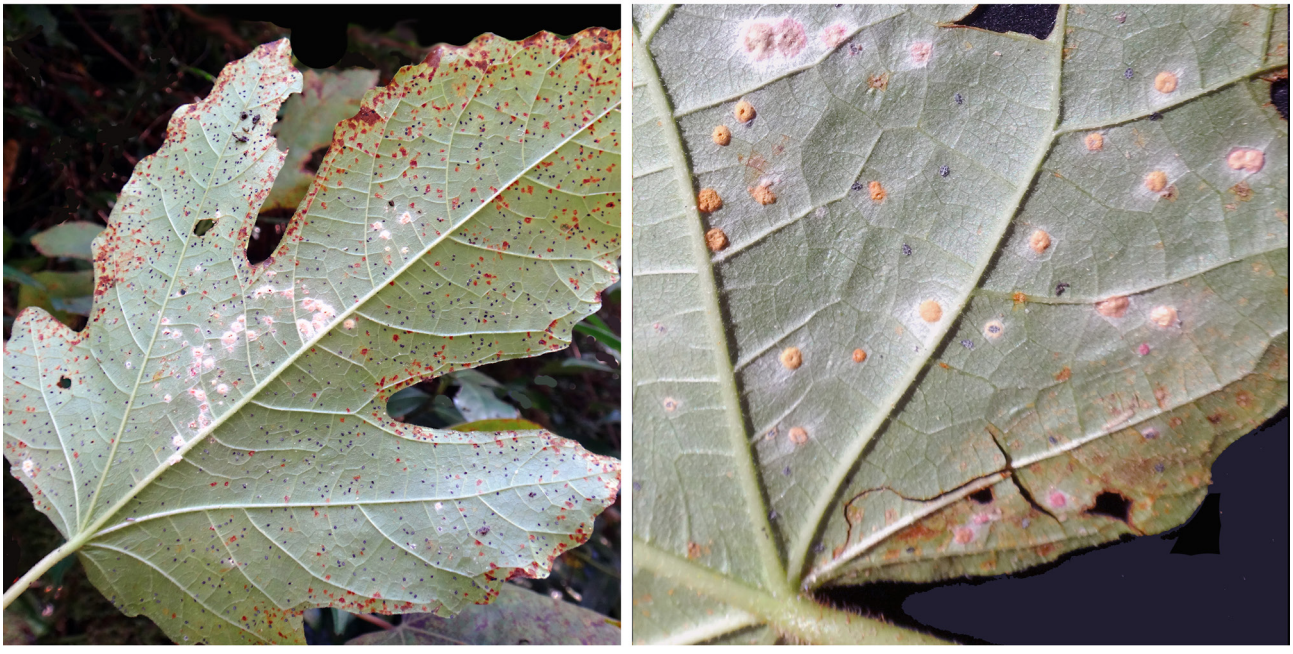

Fig. 5. Ultimolarvae of *Aleuroclava aucubae*, infected by *Conoideocrella luteorostrata*.

ute ultimolarvae of *A. aucubae* (both infected and not infected) were detected and collected for the laboratorial studies.

Conoideocrella luteorostrata is widely distributed in wet tropical and subtropical regions of the world: South and Central America, Mexico, Southern USA (Florida), equatorial Africa (Ghana), Japan, Thailand, Sri-Lanka, Indonesia, Seychelles, Samoa, and New Zealand, where it is a parasite of different scale insects and whiteflies (Hywel-Jones, 1993; Saito et al., 2012). *C. luteorostrata* was first reported from Russia in 1950s from two localities in the Far East (Amur Province) as associated with an armored scale insect, *Lepidosaphes ulmi* (Linnaeus, 1758) (Diaspididae), (Koval, 1984). Then, it was found in 1993 on the Kuril Islands as associated with another armored scale insect, *Kuwanaspis* sp. (Diaspididae), feeding on the leaves of *Sasa kurilensis* (Poaceae, Bambusoideae) (Borisov, 2017). In 2015–2016, the fungus was unexpectedly discovered in one locality of the Moscow Province (Russia) on a whitefly, *Aleyrodes asari* (Schrank, 1801), feeding on the leaves of *Asarum europaeum* (Aristolochiaceae) (Borisov, 2017). *C. luteorostrata* always inhabits very humid habitats and it could be used for decreasing the number of the injurious whiteflies and scale insects in humid conditions only. For example, Saito et al. (2012) considered *C. luteorostrata* as a promising agent for biological control of the populations of *Aleurocanthus camelliae* Kanmiya et Kasai, 2011 (Aleyrodinea), injuring humid tea plantations in Japan.

Conclusion

Although the field survey and collecting of phytophagous insects in the Agur Gorge, and in other localities of the Sochi National Park and in the neighboring territories have already been conducted for many years, *Aleuroclava aucubae* was only found in 2019. This fact suggests a recent invasion of this alien species in the region. The situation is similar to some other recent insect invasions in the European part of Russia, for example, the brown marmorated stink bug, *Halyomorpha halys* (Stål, 1855) (Pentatomidae), appeared in 2013 (Gapon, 2016; Mityushev, 2016); the soft scale insect, *Ceroplastes ceriferus* (Fabricius, 1798) (Coccidae), appeared in 2015 (Karpun, 2018); the mealybugs *Trochiscococcus speciosus* (De Lotto, 1961) and *Ripersiella aloes* (Williams et Pellizzari, 1997) (Pseudococcidae) appeared at least several years before 2016 (Gavrilov-Zimin & Gapon, 2016); the eastern chestnut gallwasp, *Dryocosmus kuriphilus* Yasumatsu, 1951 (Cynipidae), appeared in 2016 (Gninenko & Lyanguzov, 2017); and others.

Until now, *Aleuroclava aucubae* has been collected in the native forest only, about 2.5–4.0 km of the seacoast where numerous gardens and parks with decorative alien plants are cultivated. It is unclear why *A. aucubae* has not been detected in these anthropogenic plantations, but probably a more intensive survey is need, especially on the host plants common to the species, such as *Ficus* spp., *Citrus* spp., and others. It is important to note that in the Sochi National Park, *A. aucubae* forms dense colonies with up to ten larvae per 1 cm^2 of the leaf surface, whereas in Western Europe, this species was found as rare occasional larvae, one to five larvae per leaf (Šimala et al., 2014; Malumphy et al., 2015). In the climatic conditions of the Russian Black Sea Coast, this new adventive species could potentially demonstrate new peculiarities of its ecology and the mode of life, and can start to significantly damage the host plants as it was earlier happen, for example, after invasion of the injurious true bugs, *Halyomorpha halys* and *Corythucha arcuata* (Say, 1832), in the region (Borisov et al., 2018, 2019).

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