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MONOGRAPH

The alien leafhopper *Balclutha brevis* Lindberg, 1954 (Hemiptera Cicadellidae) and its hostplant, the invasive Poaceae *Pennisetum setaceum* (Försskal) Chiov.: a real risk in the scenario of Mediterranean land biodiversity?

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ABSTRACT The possible effects on Mediterranean biodiversity of the alien leafhopper *Balclutha brevis* Lindberg, 1954 (Hemiptera Cicadellidae) and its alien hostplant, *Pennisetum setaceum* (Försskal) Chiov., are discussed; *Pennisetum setaceum* is a perennial grass of Poaceae spread worldwide and recently colonizing very quickly also Mediterranean countries, it being an invasive species that colonises several environments and is able to modify ecosystems replacing the herbaceous indigenous vegetation. *Balclutha brevis*, described from the Canary Islands, has been reported in Sicily and Malta Islands. In Sicily, conspicuous populations of this species, with specimens of different generations living together during the whole year, are present. A *Wolbachia* Hertig, 1936 strain and the Trichogrammatidae *Oligosita balcluthae* Viggiani et Laudonia, 2015, parasitoid of eggs, affect *B. brevis*. The aggressiveness of *P. setaceum* and the speed of colonization of *B. brevis* could cause a banalization of the flora and also the fauna with modification of the entomocoenosis and possible transmission of disease to wild and cultivated plants.

KEY WORDS Alien species; *Balclutha brevis*; *Oligosita balcluthae*; *Pennisetum setaceum*; Sicily; *Wolbachia*.

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INTRODUCTION

The alien species of leafhopper *Balclutha brevis* Lindberg, 1954 (Hemiptera Cicadellidae), living on the alien Crimson Fountain Grass *Pennisetum setaceum* (Försskal) Chiov., has been recently reported in Sicily (Bella & D'Urso, 2012).

The Crimson Fountain Grass is a perennial Poaceae with a thermo-cosmopolitan distribution. The areas of origin of this species are North and East Africa, the Near East and the Arabian Peninsula; from these areas the species has spread worldwide, recently also to Mediterranean countries: the Canary Islands, Southern France, Southern Spain, Balearic Islands, Southern Italy, Sicily and Sardinia. Recently reported also from Malta Island (D'Urso & Mifsud, 2012). Its spread is linked especially to its use as an ornamental, it having an attractive appearance, low nutritional requirements and resistance to soil aridity, also in its cultivar "*rubrum*" (Figs. 1, 2).

According to Pasta et al. (2010), *P. setaceum* was reported for the first time in Sicily by Bruno (1939) (sub *P. ruppelii*) in the Botanical garden of

Palermo, where seeds imported from Abyssinia were planted in 1938.

Pennisetum setaceum was found in natural environment in about 1959 on the slopes of Mount Pellegrino (Pignatti & Wikus, 1963) and Catania (Borruso & Furnari, 1960) (sub *P. villosum* R. Brown). Currently, this species is in rapid expansion along the coastal areas and the main roads of Sicily (D'Amico & Gianguzzi, 2006; Giardina et al., 2007; Pasta et al., 2010) where there are suitable environmental conditions.

Outside of its native areas, *P. setaceum* is an invasive species that colonises several environments and is able to modify and to alter ecosystems replacing the herbaceous indigenous vegetation (Pasta et al., 2010). It also increases the risk of fire since it is highly flammable (Rahlao et al., 2009), resists after fire and indeed its vegetation is stimulated by fire (Smith & Tunison, 1992; Brooks & Pyke, 2001). As widely documented, it has escaped from cultivation as ornamental many times (e.g. in the USA) (Poulin et al., 2005) and it is a major threat to native vegetation in many areas (also natural reserves) such as in the Hawaii, where it is subjected to control and eradication methods (Castillo et al., 2007).

Balclutha brevis is a leafhopper 3.20–3.80 mm long, yellowish-green (Fig. 3). The species of the genus *Balclutha* Kirkaldy, 1900 live on various grass species by feeding sap; the genus has a cosmopolitan diffusion with about seventy described species (McKamey, 2010); in the Mediterranean area 1/3 of those species are present with at least 6 species reported also in Italy. *Balclutha brevis*, described from the Canary Islands by Lindberg (1954), was subsequently reported from Cape Verde Islands. Recently, the species has been reported from Sicily (Bella & D'Urso, 2012) and Malta Islands (D'Urso & Mifsud, 2012).

The presence in Sicily of this alien species could be due to introduction via North Africa, where it is supposed to be present though not yet reported due to the lack of fieldwork. In Malta, the species was probably introduced together with *P. setaceum*, used as ornamental plant and now spreading rapidly (Mifsud, personal communication). According to Aguin Pombo et al. (2005), *B. brevis* is probably a native species from the Cape Verde Islands. In our opinion, this species is likely native from the same native range of *P. setaceum* (the wide area comprising North and East Africa, the Near East and the Arabian Peninsula) and the leafhopper should be considered as an established alien outside that area.

MATERIAL AND METHODS

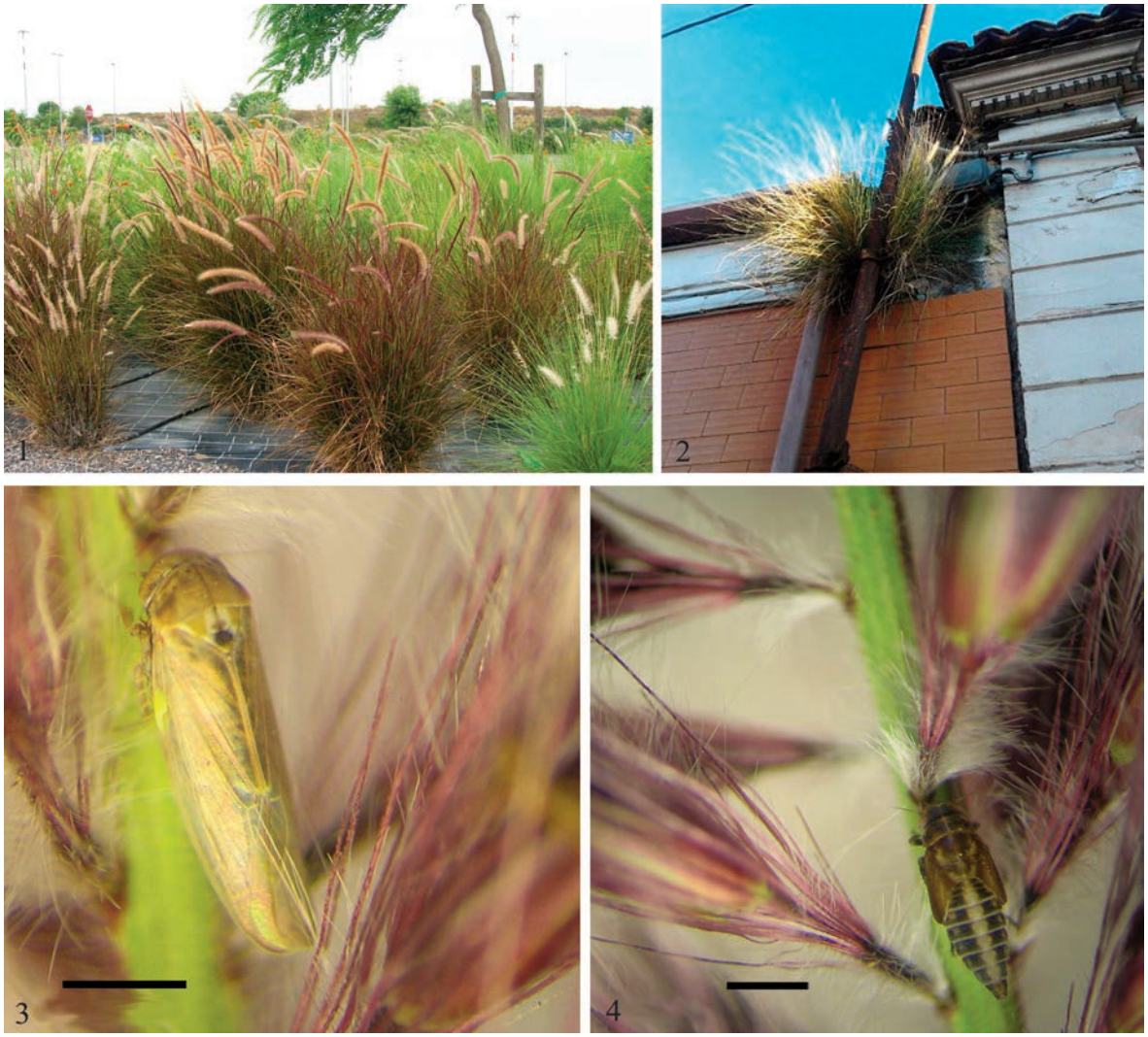
The present paper takes into consideration part of the results of an investigation conducted in the territory of the town of Catania (on which a specific, detailed paper on the life cycle of *B. brevis* is in preparation): during the years 2012–13 two sites, one in the town and one in a suburban area, were monitored about every twenty days. Ten ears of *P. setaceum* were collected every time and all arthropods found on them were identified and counted.

RESULTS AND DISCUSSION

In Sicily, conspicuous populations of adults and immature stages (Fig. 4) of *B. brevis* develop exclusively on *P. setaceum* ears (also on the cultivar "*rubrum*"), both on spontaneous and ornamental plants. The eggs are laid in groups inside the glumes. The observed life cycle of *B. brevis* lasted about 17 days and several generations follow one another throughout the year, with specimens of different generations living together; actually, all stages (immature stages, adults and eggs) can be found together in every period of the year.

When these insects are very numerous, the ears contain many microdrops of honeydew that blur the plants heavily (Fig. 5). In addition, the honeydew can attract other feeders especially Formicidae; as a matter of facts, the highest number of ants found corresponded well to the peaks of *B. brevis* population. The honeydew could attract also several species of Apoidea, especially *Apis mellifera* Linnaeus, 1758. In our land, honeydew honey is produced when there are large populations of aphids or whiteflies.

Up to now, little is known about the fauna associated to *P. setaceum*; a report concerns a new aphid (Homoptera Aphididae) from Saudi Arabia and Eritrea (Aldryhim & Ilharco, 1997). In Sicily, the arthropod fauna associated to the Crimson Fountain Grass is not very rich. Ants are the most numerous in specimens (represented by 6 species) followed by the Trichogrammatidae (although present with a



Figures 1, 2. *Pennisetum setaceum* as ornamental green near Catania (Fig. 1) and a clump living on an house wall in the city (Fig. 2). Figures 3, 4. *Balclutha brevis* adult (3) and fifth stage (4). Scale bar = 1 mm

single species); rare araneids, beetles and bugs but with more species (Table 1).

The Trichogrammatidae (Hymenoptera Chalcidoidea) include parasitoid of insect eggs; the species found, *Oligosita balcluthae* Viggiani et Laudonia, 2015 was identified into the eggs of *B. brevis*. *Oligosita balcluthae* belongs to the *collina*-group and is very similar to *O. biscrensis* Nowicki, 1935 known only for a female collected on palm orchad in Biskra (Northern Sahara, Algeria) (Bella et al., 2015). The above mentioned similarity could confirm our hypothesis of the provenience in our land of *B. brevis* from North Africa. The presence of the parasitoid indicates that there is a natural population control of the leafhopper; besides, from this it can be inferred that *B. brevis* is well established in Sicily for a time long enough to allow the consolidation of the relationship between parasitoid and host.

In addition, recently a *Wolbachia* Hertig, 1936 strain, belonging to the taxonomic supergroup B, in males and females specimens of *B. brevis* from Sicily, has been detected by molecular screening study (PCR) with three *Wolbachia* specific genes (16S rRNA, ftsZ, wsp) (Pappalardo et al., 2016).

Wolbachia is the most widespread intracellular α-proteobacteria maternally inherited endosymbiont of insects and nematodes. The well known ef-

FORMICIDAE	6 species
TRICHOGRAMMATIDAE	*Oligosita balcluthae*
APHIDOIDEA	at least 1 species
THYSANOPTERA	at least 1 species
ACARINA	at least 1 species
ARANEIDA	at least 3 species
COLEOPTERA	at least 3 species
HETEROPTERA	at least 2 species

Table 1. Taxa of arthropods collected on *P. setaceum*.

Figure 5. Ear of *Pennisetum setaceum* with drops of honeydew.

fects of *Wolbachia* on reproduction of its hosts (e.g., cytoplasmic incompatibility, parthenogenesis, male killing, feminizing of genetic males and modifying fecundity) considered, it can be hypothesized that these bacteria have influenced biology, ecology, diversification and speciation of their hosts (Lis et al., 2015). In spite of *Wolbachia* infections in both males and females of *B. brevis*, no morphostructural alteration commonly related to the presence of the bacterium, has been noticed in all the examined specimens (Pappalardo et al., 2016).

It is known that host plants can mediate *Wolbachia* infection in phytophagous insect populations. The natural horizontal transmission of *Wolbachia* can take place by consumption of infected or contaminated food, e.g. plant sap and/or from parasitoids, e.g. parasitoidal wasps.

The Crimson Fountain Grass could have mediated *Wolbachia* transmission from infected *Balclutha* to other insects and vice versa. Moreover, it is not inconceivable that the infection could be transmitted either by predation (some injury, e.g. by wasp) or more probably by parasitoids, which may function as a vector for *Wolbachia* bacteria and transfer it to other arthropods (Lis et al., 2015).

To date, there is no evidence for a vector role of *B. brevis* and, moreover, the species has not been found jet by us on any other grass species except for *P. setaceum*. However, some species belonging to the genus *Balclutha* are vectors of plant diseases. According to Han (2012), *B. punctata* (Fabricius, 1775) is able to transmit mulberry dwarf phytoplasma to mulberry; according to Morgan et al. (2013), *B. rubrostriat*a (Melichar, 1903) is known to be a vector of the phytoplasma that causes sugarcane white leaf disease to sugarcane and according to Dakhil et al. (2011), almond witches'- broom phytoplasma in Lebanon was also detected in *Balclutha* sp., therefore considered potential phytoplasma carrier.

In addition, in Mississippi, *P. setaceum* resulted positive to Maize Dwarf Mosaic Virus and Sugarcane Mosaic Virus. These viruses are transmitted by sap and by several species of aphids (Rosenkranz, 1980). In conclusion, it cannot be excluded *a priori* a possible extension of the diet for *B. brevis* in new habitats colonized, or its possible role in the transmission of plant pathogens.

IMPACT ON MEDITERRANEAN BIODIVERSITY

As already emphasised by Pasta et al. (2010), *P. setaceum* is a strongly invasive species in rapid expansion which threatens to supplant the natural and ruderal vegetation of many Sicilian environments; this can happen even in the southern European countries where it is an alien species (as it happened for example in parts of Hawaii). The result will be a banalization of the flora and also of the fauna. According to Litt & Steidl (2010) while invasions by nonnative plants alter the structure and composition of native plant communities, those invasions can also alter the function of ecosystems for animals that depend on plants for food and habitat. Consequently to the spread of *P. setaceum*, the presence of *B. brevis* will rapidly increase as well.

As already stated, though there is no evidence for a role of vector of *B. brevis* in the transmission

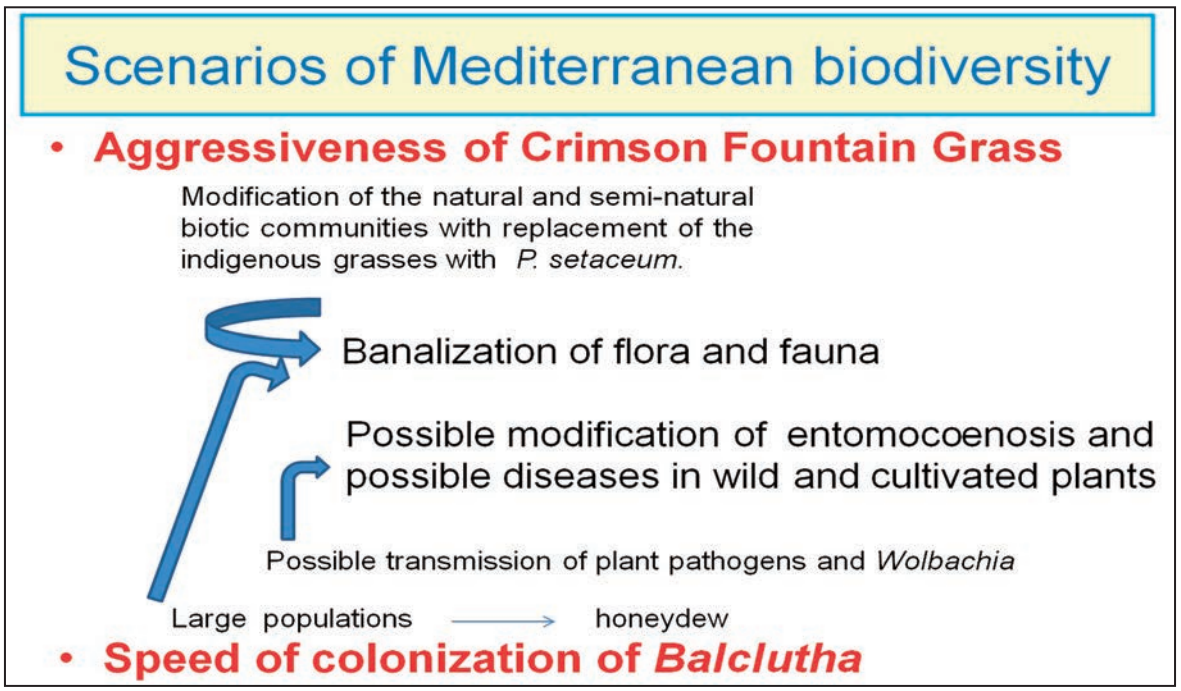


Figure 6. Actions of *Pennisetum setaceum* and *Balclutha brevis* on the Mediterranean biodiversity.

of plant pathogens, it cannot be excluded a potential transmission of phytoplasmas and viruses if *B. brevis* moves to other host plants (to be monitored) and/or if other insects feed on the sap of *P. setaceum*.

One has to consider also the effect of *Wolbachia* and its possible transmission, vertical and horizontal, to other taxa, (e.g. the sap feeders Homoptera and Heteroptera) and to parasitoid wasps.

The result could be a modification of entomocoenosis and the possibility of diseases on wild and cultivated plants: the latter hypothesis appears at the moment quite unrealistic.

In addition, a positive action of the massive presence of *B. brevis* could be the possible production of honeydew honey (Fig. 6).

CONCLUSIONS

In the light of the discussed framework, with the linked risks, some recommendations are necessary:

- *B. brevis* is probably more widespread than it appears; it is necessary to check in other Mediterranean areas with Crimson Fountain Grass and, in addition, to check if the leafhopper can live on other herbaceous plants, especially Graminaceae.

- The knowledge about the biology of the parasitoid *O. balcluthae* should be improved.

- According to Pasta et al. (2010) the spread of Crimson Fountain Grass should be monitored and the plant should be kept under control by means of eradicating new populations to avoid an eco-catastrophe in Sicilian coasts. In Hawaii, containment and eradication programs of this alien plant have been implemented; the same protocols should be followed also in the European countries.

-The use and sale of *Pennisetum* as ornamental plant should be strongly discouraged, if not forbidden.

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