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Rapid Communication

First record of *Heptapleurum arboricola* Hayata (Araliaceae) as a casual non-native woody plant in the Mediterranean area

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Abstract

I report here the first record of *Heptapleurum arboricola* Hayata (syn. *Schefflera arboricola* (Hayata) Merr.) (Araliaceae) as a casual non-native plant throughout the Mediterranean area. I observed the natural regeneration in urban areas at Castellammare del Golfo, a small coastal town in north-west Sicily (Mediterranean Italy). Due to the lack of self-sustaining populations and the short-term observational period, *Heptapleurum arboricola* should be considered as a casual species according to the classification of non-native plants. The detection of early signs of naturalization of non-native plants is of crucial importance for the management and control of invasive species. The main abiotic and biotic factors involved in the possible future spread of the species are briefly discussed.

Key words: coastal areas, dwarf umbrella tree, early detection, naturalization, *Schefflera,* urban ecosystems, woody invasive species

Introduction

Invasive plant species are a major environmental issue on a global level; a concern which is bound to increase in coming decades due to the boosting effect of interacting and additive factors, such as a growing world population with related global trade and tourism, and the aggravating effects of climate change (Dullinger et al. 2017; Pyšek et al. 2020). In addition to the greater likelihood of introducing new invasive taxa, these conditions may also enhance the competitive ability of non-native species; native species possibly being less suited to cope with rapid environmental changes (Liu et al. 2017). Indeed, no sign of saturation in the accumulation of non-native species worldwide has been found hitherto (Seebens et al. 2017). Amongst the various pathways, introduction via horticulture is the principal point of entry for invasive plant species (Hulme et al. 2018) and at least 75% and 93% of all naturalized plants are grown in domestic and botanical gardens, respectively (van Kleunen et al. 2018). This is primarily due to the vast international trade in ornamental plants and subsequent spread to private and public places, such as streets, parks and gardens, resulting in high propagule pressure by many potential invasive species. For instance, most

new records of non-native plant species in Italy concern ornamental species (Stinca et al. 2017; Motti et al. 2018). It is not only a matter of numbers: many popular and selected traits in horticulture (e.g., wide ecological plasticity, rapid growth, resistance to pathogens, etc.) are also commonly associated with invasiveness and their preferential use may favour the spread of invasive species (Guo et al. 2019). In the Mediterranean, an increasing number of plant taxa arriving from tropical and sub-tropical countries have naturalized over the last few years (e.g. Laface et al. 2020). In Italy, a similar pattern has been observed, witnessed by the steady increase in naturalization reports (Stinca et al. 2016; Salerno and Stinca 2017; Conti et al. 2019; Stinca and Mei 2019; Musarella et al. 2020; Rosati et al. 2020). This rising trend has also been favoured by climate change, which is progressively increasing the chance that species from warmer-climate areas will find suitable ecological niches, become established and invade new areas in Mediterranean-type ecosystems (Haeuser et al. 2018). In this general framework, the early detection of potentially invasive plants is considered the most effective tool to prevent the future spread of invaders and/or to mitigate their adverse effects on native ecosystems and species. Indeed, the high degree of uncertainty and temporal variability in the lag-phase (the period from the first signs of natural regeneration up to invasive stage) make it very difficult to monitor the entire naturalization process, which is generally evident only during the outbreak stage (Walsh et al. 2016). In this paper, I report the first record throughout the Mediterranean area of *Heptapleurum arboricola* Hayata (Araliaceae), a small shrub native to Taiwan and Hainan of great ornamental interest in Europe, as a casual non-native species.

Materials and methods

After the first discovery on 10th June 2017 of self-sown seedlings of *H. arboricola* in urban areas in Castellammare del Golfo (Province of Trapani), other surveys were carried out in subsequent years (once per year) up to February 2020. Observations were performed within a radius of approximately 500 m near cultivated individuals (e.g. at Corso Bernardo Mattarella, Villa Regina Margherita, etc.) in addition to random observations in other Sicilian towns (e.g. Palermo and Carini). Castellammare del Golfo is a small coastal town in north-west Sicily, characterized by a typical Mediterranean climate, with mild, rainy winters, followed by hot, dry summers. Drought period, with rainfall entirely or almost entirely absent, is extended for 3–4 months, while mean annual precipitation is 849 mm and mean annual temperature is 18.3 °C (SIAS, Sicilian agro-meteorological information service: http://www.sias.regione.sicilia.it/). The species was identified based on the description reported in the protologue (Hayata 1916) and in more recent literature (Hiroyoshi 1993; Xiang and Lowry II 2007), particularly considering

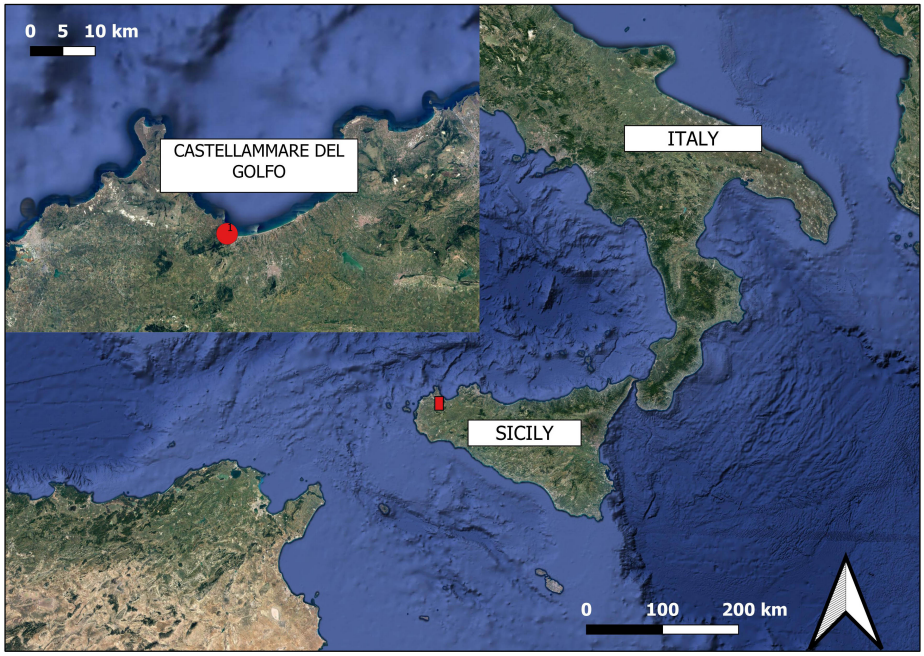

Figure 1. Location of the record of *Heptapleurum arboricola* in Sicily (Mediterranean Italy).

the vegetative (leaves size, leaflets size, shape and number) and flower traits. The plant nomenclature follows Pignatti et al. (2017), Galasso et al. (2018), as well as the recent taxonomic revision of the genus *Schefflera* (Lowry II and Plunkett 2020). Voucher specimens are deposited in the SAF Herbarium (SAF100037 and SAF100038). Naturalization status was assessed according to the classification by Pyšek et al. (2004), which takes into account the ability to establish self-sustaining populations (naturalized species) or even to actively invade new areas distant from the likely source (invasive species). Conversely, casual non-native plants may occasionally flourish and reproduce outside cultivation but they rely on man for long-term persistence and are bound to disappear without the repeated supply of viable propagules (Pyšek et al. 2004). With the aim of verifying current distribution of *H. arboricola* as non-native species in Europe and elsewhere, the main databases available at a European (Euro+Med 2006-), national (Pignatti et al. 2017; Galasso et al. 2018), and global level (Randall 2017), as well as recent updates and other specific contributions in literature (e.g. Verloove 2017), were accessed.

Results

At Castellammare del Golfo, on the north-west coast of Sicily (Figure 1), three self-sown seedlings of *Heptapleurum arboricola* (= *Schefflera arboricola* (Hayata) Merr.) were observed in three consecutive years from June 2017 to June 2019. The main characteristics of the Typus are the following (Hayata 1916). Shrub up to 3–4 m tall, with branches up to 7–8 mm in diameter. The leaves are alternate, long petiolate, with petioles 12–15 cm long, palmately compound with 7–8 leaflets (9–20 cm × 4–10 cm), with

Figure 2. One self-sown individual of *Heptapleurum arboricola* growing at the base of a step at Via Discesa Annunziata, Castellammare del Golfo (North-western Sicily); 10th June 2018. Photograph by Emilio Badalamenti.

petiolules 2.5–3.5 cm long. The central leaflet is obovate-oblong, 9 cm × 4 cm, with entire margin, obtuse or acute apex, both leaf surfaces glabrous, shiny green on the upper surface, pale-glaucous on the lower surface, with 5–6 pairs of primary veins on both sides of the midrib. The inflorescence is a terminal panicle of umbels, about 20 cm long, each umbel with about 10 flowers, with flower pedicels 5–7 mm, glabrous or sparsely tomentose. The calyx is entire, depressed-campanulate, 1.5 mm long and 2 mm in diameter. Petals are 5–7 linear-triangular, 2.5 mm × 1–1.5 mm. Stamens are 5–7, smooth and flat, 2.5 mm long, with broadly rounded anthers up to 1 mm long. The ovary is 5–7 locular. The stylus is almost nil, and the stigma is depressed-rounded 1.5 mm in diameter and 0.25 mm high. The fruit is an obovoid-globose drupe ≈ 5 mm wide. Natural regeneration was not observed further in 2020 due to physical removal performed by a small restaurant, owner of nearby pot-cultivated *Heptapleurum* plants, during outdoor maintenance and cleaning activities. Other surveys in the same city and elsewhere were unsuccessful. Natural regeneration occurred on the lower treads of a flight of steps in a small pedestrian street, where water and nutrient may accumulate (Figure 2, 38°1′40.69″N; 12°52′50.56″E, 5 m a.s.l.). Other plant species occurring in the study area were typical synanthropic and nitrophilous and/or ruderal species thriving in urban and suburban contexts, such as *Ampelodesmos mauritanicus* (Poir.) Dur. & Schinz, *Antirrhinum siculum* Mill., *Erigeron bonariensis* Hort. ex Link, *Hyoscyamus albus* L., *Oxalis corniculata* L., *Polycarpon tetraphyllum* s.l. (L.) L., *Sonchus* cfr. *oleraceus* L., *Sonchus tenerrimus* L., *Symphyotrichum squamatus* (Spreng.) G. L. Nesom and *Urtica membranacea* Poir. in Lam.

Discussion

Plant invasions in urban areas

As known, cities are important areas for the study of plant invasions as they can be the first sites where naturalization begins, also concerning taxa which then invaded natural habitats. Furthermore, it has been argued that peculiar selective pressures in urban areas may also drive the rapid evolution of invasive traits, thus favouring invasive establishment, spread and impact (Borden and Flory 2021). For instance, experiencing the higher temperatures found in urban environments (e.g., due to the heat island effect), may allow plant species to adapt further and thus cope with similar ecological conditions found in nearby natural areas (Borden and Flory 2021). Furthermore, Mediterranean cities host a large number of plant species introduced for ornamental purposes and used as street trees; these species often arrive from many parts of the world, including tropical and sub-tropical countries (Heywood 2017). The accelerated rise in temperatures due to climate change has offered the opportunity for an increasingly higher number of tropical plants to start to reproduce naturally; a phenomenon which is likely to continue (Haeuser et al. 2018). Accordingly, the first cases of naturalization by tropical non-native plants have been recently reported in Mediterranean regions (Stinca 2020), including Sicily (Pasta et al. 2014; Badalamenti and La Mantia 2018). In this framework, observations of early life stages of *H. arboricola* in a Mediterranean coastal town, representing the first case in the Mediterranean area, is of considerable interest. Indeed, studying the invasion process from the early beginning stage may allow us to assess its spatio-temporal dynamics and detecting spreading in the lag phase, which is as difficult as useful in management strategies attempting to tackle invasive species.

Heptapleurum arboricola *in the native range and general traits*

Heptapleurum arboricola is native to Taiwan and Hainan, island ecosystems located in the North Pacific Ocean of the Far East (Hiroyoshi 1993), where it thrives in forests and along stream banks, especially below 900 m a.s.l. (Xiang and Lowry II 2007). It can also grow as an epiphyte as suggested by its scientific epithet ("arboricola" means living on trees). Very recently, from the polyphyletic genus *Schefflera* J. R. Forst & G. Forst (Frodin et al. 2010), all the species from the Asian clade have been reassigned to the genus *Heptapleurum* Gaertn. (Lowry II and Plunkett 2020). In Taiwan, the average climate is subtropical, with mean winter temperatures of 18 °C and mean summer temperatures of 28 °C. Particular climate traits are high air humidity, limited annual temperature range, high annual rainfall (mean of 2,600 mm), frequency of extreme weather events (e.g. typhoons), and absence of a summer dry season (Department of Information Services 2014). *Heptapleurum arboricola* is a small shrub up to 4 m tall (Xiang and Lowry

II 2007), quite common and valued as an ornamental species worldwide, where it is mainly cultivated indoor and as a foliage plant (Gilman and Watson 1994). Many cultivars have been selected, such as "Luseane", "Charlotte" and, in particular, "Gold Capella" with gold variegated leaves (Rezaei Baghbidi and Jowkar 2018). The common name of the species, dwarf umbrella tree, recalls the congeneric species *Heptapleurum actinophyllum* (umbrella tree), native to New Guinea and Queensland (Australia) (Lowry II and Plunkett 2020).

Heptapleurum arboricola *and* Heptapleurum *spp. in the introduced range*

Heptapleurum arboricola is a neophyte which was introduced to Europe approximately a century ago, through Kew Gardens in London (Hill 1926). In Italy and Sicily, *Heptapleurum* spp. (reported as *Schefflera* spp.) were introduced between the second half of the 19th century and the first half of the 20th century (Todaro 1868; Maniero 2000). *Heptapleurum arboricola* is at an early stage of its invasion process worldwide. Indeed, naturalization records are largely restricted to the last 20 years, spanning from the Hawaiian Archipelago (Imada 2019), Florida (USA) (Wunderlin et al. 2021), Turkey (Uludağ et al. 2017), India (Negi and Hajra 2007) and the Canary Islands (Spain) (Verloove 2017) in the northern hemisphere, to Brazil (Marciniak et al. 2020), South Africa (Foxcroft et al. 2003) and New Zealand (Heenan et al. 2002) in the southern hemisphere. Although we still do not possess adequate knowledge of its full invasive potential, information from the above-mentioned references suggests its climate and habitat preferences. Warm-humid climates, with annual precipitation of at least 1,600 mm, mean annual temperatures of at least 15 °C and the absence of a summer dry season, are the most suited (Starr et al. 2003; Negi and Hajra 2007; Marciniak et al. 2020). The most affected habitats are synanthropic (fence posts, buildings and structures), trees as an epiphyte, and wet forests (Heenan et al. 2002; Foxcroft et al. 2003; Starr et al. 2003; Verloove 2017; Wunderlin et al. 2021). Recently, Marciniak et al. (2020) have shown the effective promoting role of local birds for seed dispersal, seedling emergence and establishment, and considered *H. arboricola* a potential threat to the biodiversity of the Atlantic forest based on some peculiar traits, such as the ecological plasticity, and prolonged flowering and fruiting.

Although *Heptapleurum* is the largest genus of Araliaceae, composed of 317 described species (Lowry II and Plunkett 2020), only *H. actinophyllum* is considered invasive to date, making it one of the most underrepresented among invasive woody genera (Richardson and Rejmánek 2011). *Heptapleurum actinophyllum* is a serious invader in many tropical and sub-tropical areas, such as Hawaii, Fiji, Tahiti, Cuba and southern Florida (CABI 2021). The genus *Heptapleurum* (the same holds for *Schefflera*) is absent from the Italian non-native flora (Pignatti et al. 2017; Galasso et al.

2018). *Heptapleurum arboricola* should be added as a casual species to the 10 species of non-native Araliaceae already occurring in Italy, belonging to the genera *Hedera* (4 taxa), *Hydrocotyle* (3 taxa), *Aralia* (1 taxon), *Fatsia* (1 taxon) and *Tetrapanax* (1 taxon), only one of which presently classified as invasive (Galasso et al. 2018). I think that this non-native species should be considered as casual due to the short-term of observational period (three years) and the lack of sexual maturity; it has still not established self-sustaining populations, still relying on continuous human introduction (Pyšek et al. 2004). Morphologically, *H. arboricola*, a perennial evergreen shrub with palmately-compound leaves, sharply differs from the other genera of Araliaceae occurring in Italy, encompassing a perennial evergreen shrub with simple and palmately lobed leaves (*Tetrapanax*), deciduous shrubs or small trees with pinnately compound leaves and thorny stem (*Aralia*) or with simple and palmately lobed leaves (*Fatsia*), woody vines (*Hedera*), and geophytes or hydrophytes linked to aquatic habitats (*Hydrocotyle*) (Xiang and Lowry 2007; Pignatti et al. 2017; Galasso et al. 2018).

Heptapleurum arboricola *in the Mediterranean area*

Heptapleurum arboricola has not been reported as naturalized in Mediterranean-type ecosystems hitherto. However, we must be extremely cautious when assessing the future spatio-temporal dynamics and invasion risk of non-native plant species as long-time adaptation processes and/or environmental variations can cause abrupt changes in the behaviour of introduced taxa, thus triggering the invasion process (Fournier et al. 2019). Furthermore, this discovery proves that the first abiotic and biotic barriers for early life stages up to seedling emergence have been overcome. The major abiotic constraint for the future spread of *H. arboricola* in Mediterranean-climate areas is limited humidity, mostly depending on the almost total absence of summer rainfall and the amount of annual rainfall. In this regard, the presence of specific microhabitats, such as riverine habitats or wet valleys, may be especially favourable for *H. arboricola* establishment and its future spread. The annual rainfall in my study site (≈ 850 mm) is only half as much as the minimum annual rainfall (≈ 1,600 mm) found in other areas of its secondary distribution range. As *H. arboricola* has only invaded areas without a summer dry season, it may not be equipped to cope with summer drought (Negi and Hajra 2007; Marciniak et al. 2020). Future climate projections would suggest a possible reduction in annual rainfall in the Mediterranean basin (Caloiero et al. 2018), including Sicily (Bonaccorso et al. 2003). However, recent research has shown large variability on small spatial scales (Deitch et al. 2017). A positive trend in annual rainfall in Sicily has also been found (Liuzzo et al. 2016), especially in the north-western sectors of the island (Caloiero et al. 2018), where Castellammare del Golfo is localized. Therefore, a progressive match with

the water requirements of *H. arboricola* could also occur. Conversely, the generalised rise in air temperatures due to climate change will likely have a strong promoting effect on *H. arboricola*. Indeed, although the mean annual temperature in my study site (≈ 18 °C) is in line with that reported in other areas (e.g., Negi and Hajra 2007), *H. arboricola* may well withstand warmer conditions. If *H. arboricola* should successfully overcome the main barriers for active reproduction and seed dispersal, a favourable factor in Sicily and Mediterranean cities is its widespread use as an ornamental plant (Domina and Mazzola 2008), which makes many potential invasion foci readily available and produces high propagule pressure (Lockwood et al. 2005). Seed dispersers, mainly birds, subsequently may play an important promoting role both in long-distance and short-distance colonization processes. In particular, *H. arboricola* may be dispersed by small birds, considering its small-sized drupes (≈ 5 mm) and given that many buildings and other artificial structures near the discovery site may offer suitable perches for bird species. Hence, even temporary and short-term stepovers may be sufficient for avifauna to eat and eject *Heptapleurum* seeds, a passage that can enhance seed germination and/or seedling establishment (van der Pijl 1982). Indeed, similar bird species, belonging to the same functional types as those observed and studied in Brazil (Marciniak et al. 2020), are present in Sicily. More specifically, some species of *Turdus*, such as Blackbird (*Turdus merula* Linnaeus, 1758), a nesting species, and Song Thrush (*T. philomelos* C.L. Brehm, 1831), a common migratory and wintering species on the island (Ientile and Massa 2008), are involved in the seed dispersal of many woody species in Sicily (La Mantia et al. 2019).

In conclusion, I deem that, although *H. arboricola* has currently shown a limited invasive behaviour in Mediterranean-climate areas, the regular monitoring of its incipient naturalization process is needed as the widespread use, the potential role of birds and the effects of climate change could favourably affect its future dynamics and invasion process.

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