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***PINELLIA TERNATA* (ARACEAE) A SILENT INHABITANT OF ITALIAN BOTANICAL GARDENS, OR SOMETHING MORE?**

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ABSTRACT

Pinellia ternata is a small geophyte endemic to East-Asia, and well-known in traditional herbal Chinese medicine for its medicinal properties and recently, as an ornamental plant. For these reasons it was cultivated in the past in many Botanical Gardens around the world and because of its dispersal capability, in some regions it has become a casual (adventitious) or naturalized neophyte. In Europe, *P. ternata* was apparently first introduced and cultivated in 1829 near Ascoli Piceno (Italy) and later also in Botanical Gardens in Florence and Pavia. Subsequent data testify to its presence as a weed in Botanical Gardens in Austria (Graz, Klagenfurt, Salzburg) and Germany (Erlangen, Berlin, Görlitz, Kufstein). Since about the beginning of the 20th century, *P. ternata* has been reported as a naturalized alien species in anthropic and natural environments in the Franconia region of Austria and in Graz cemetery.

Our recent findings attest, for the first time, to the presence of *P. ternata* in Piemonte (Italy). The species has recently been found growing in the Turin Botanical Garden, as a weed in some flowerbeds. Further research, based on seed catalogues, herbarium specimens, and an unpublished illustrated plate from *Iconographia Taurinensis*, has antedated the presence of this species in the Garden to before 1850; it was cultivated as a medicinal herb and then became a weed. Moreover, a newly-acquired specimen in the Herbarium of Turin (TO) collected at Lombriasco reports the first occurrence in the wild of this plant in Piemonte, and probably the first in Italy.

KEY WORDS: Invasive *Araceae*, *Arum triphyllum*, Botanical Gardens, Italian alien plants, bulbils.

INTRODUCTION

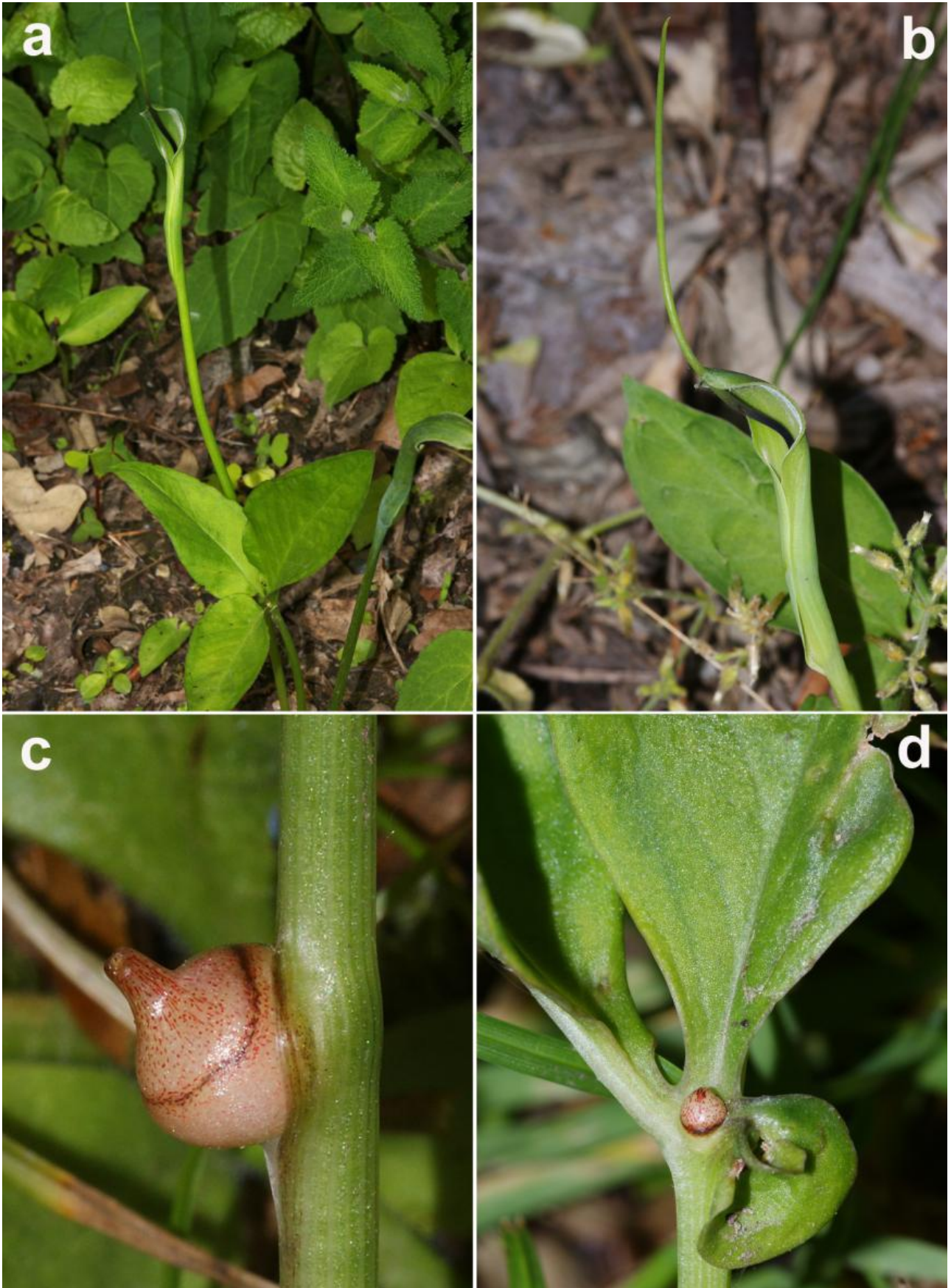
Biology and taxonomy

Pinellia Ten. (Araceae) is a small genus containing nine species endemic to East-Asia (China, Japan, and Korea). The maximum diversity of the genus is reached in eastern China (Anhui, Fujian, Zhejiang) where all nine species are present, seven of them endemic (Govaerts & Frodin, 2002; Zhu et al., 2007; Li & Bogner, 2010).

The genus was first named by M. Tenore in 1839, from *Pinellia tuberifera* Ten., in honor of the Italian botanist Giovanni Vincenzo Pinelli (1535-1601) (Zhu et al., 2007). *Pinellia* is characterized by the female zone of the spadix being adnate to the spathe, the male and female zones of the spadix with naked flowers being separated by a sterile zone, the presence of a long appendix of the spadix (Fig. 1b) and usually the presence of a septum at the constriction of the spathe (Zhu et al., 2007; Li & Bogner, 2010).

The phylogeny of the genus *Pinellia* has always been debated. The genus was initially placed in the tribe Areae, subfamily Aroideae, by Engler in 1920. According to the most recent attribution, suggested by Mayo et al. (1997), the genus is now assigned to the tribe Arisaemateae. Recent new molecular approaches, such as chloroplast DNA phylogeny, have thrown light on a very intricate scenario, placing *Pinellia* in a separate clade closely related to *Arisaema* Mart. and the tribe Areae (Renner et al., 2004; Renner & Zhang, 2004). Further, Cusimano et al. (2011) put *Pinellia* in the *Alocasia* clade, highlighting its ungrouping from *Arisaema*. It is thus clear that the relationships among *Arisaema*-*Pinellia*-*Areae* are difficult to explain with molecular markers.

Figure 1. *Pinellia ternata* growing as a weed in Turin Botanical Garden (15/05/2012, TO HG2866). The two upper panels show the trifoliate leaves (a) and the inflorescence with its peculiar incurved and long spadix (b). The two lower panels show the bulbils on both petioles (c) and leaves (d). (Photos: A. Vizzini) *Boll. Mus. Ist. Biol. Univ. Genova*, **75 (2)**, 2013



Pinellia ternata (Thunb.) Makino [≡ *Arum ternatum* Thunb., *Arisaema ternatum* (Thunb.) Schott; = *Pinellia tuberifera* Ten.; *Arum bulbiferum* Salisb. nom. illegit. non Roxb., *Arum triphyllum* Houtt. nom. illegit. non L.) - “Ban Xia” in Chinese, Crow-dipper in English - is perhaps the best-known species of the genus *Pinellia*, because of its importance in traditional Chinese medicine and as an ornamental plant. *P. ternata* (sub *Arum ternatum*) was described by Thunberg (1784), from a specimen collected in Japan (Zhu et al., 2007).

The species shows great variability at both the morphological and the cytological level (Li & Bogner, 2010) and thus its taxonomy has suffered from a lack of clarity. More than 20 synonyms have been listed, belonging not only to the genus *Pinellia* but also to *Arisaema* Mart., *Arum* L., *Hemicarpus* Nees and *Typhonium* Schott. The characteristic that discriminates *P. ternata* from congeneric species is the presence of bulbils in all parts of the petiole up to base of leaf blade (Fig. 1c, d).

P. ternata occupies the full distribution range of the genus: it is widespread in China (except in Nei Mongol, Qinghai, Xinjiang, and Xizang regions), Korea and southern and central Japan. It grows naturally on grassy land, secondary forest, wasteland and cultivated land, never above 2500 m (Li & Bogner, 2010).

Several metabolites have been isolated and characterized from *P. ternata* poisonous tubers: β -sitosterol, 1-ephedrine, nicotine, protoanemonin, alkaloids, pinellin, choline, saponins, pinelloside, and others compounds including volatile oils, organic acids, starches, sterols, flavonoids, tannins, and phenylpropanoids (Li & Wei, 2002; Han et al., 2006). The tubers also contain large amounts of proteins, up to 3-7% of the fresh weight (Wu et al., 2012). The pharmacological properties of these compounds have been widely studied; some of them, for example pinelloside (cerebroside), are characteristic of the tuber. Studies have chiefly focused on the antimicrobial, antioxidant, anti-cancer, and anti-obesity activities of these compounds (Chen et al., 2003; Kim et al., 2006; Han et al., 2006).

In traditional Chinese herbal medicine, the poisonous tubers of *P. ternata*, specifically treated, are used as analgesic, antiemetic, antiphlogistic, expectorant, febrifuge, sedative, and styptic agents (Luo et al., 2000; Zhu et al., 2007; Li & Bogner, 2010). The Asian trade in the roots of *P. ternata* is so extensive that excessive exploitation of this wild resource has led to a progressive decrease of the species (Chung et al., 2002). To meet increasing high demand and to protect the wild resource, *P. ternata* has been cultivated in China since the 1970s (Mao & Peng, 2002).

Partly because of its medicinal interest, *P. ternata* was probably cultivated in the past in many Botanical Gardens, mainly in Europe (Baroni, 1897; Peccenini Gardini & Terzo, 1985).

Due to both human trading and the plant's efficient vegetative propagation through both underground tubers and bulbils, *P. ternata* is therefore present also outside its primary areal, in Europe, North America, and Australia (Eberwein & Berg, 2010); it has become regionally naturalized in these areas.

Data from Europe

P. ternata was cultivated in many European Botanical Gardens as a medicinal plant (Eberwein & Berg, 2010), and was listed as *Arum triphyllum* L. or *Arum bulbiferum* Salisb.

In Italy, it was first grown in the first half of the nineteenth century. In his description of the genus *Pinellia*, Tenore states that he received the plants from the owner of a garden located near Ascoli Piceno in 1829 (Tenore, 1839). The species also grew in Pavia Botanical Garden in 1843, as reported by Penzig in 1878 in the manuscript «Catalogo dell'Erbario di Piante coltivate» (Peccenini Gardini & Terzo, 1985), and in that of

Florence, sub *Pinellia tuberifera* Ten.; in 1897 Baroni described in this Garden the successful flowering of tubers imported from China. It was probably also cultivated in other Botanical Gardens, not only in Italy.

At the beginning of the twentieth century, *P. ternata* was first reported as a weed that had naturalized in Botanical Gardens; it still remains a problem today.

In Europe, its presence in Botanical Gardens has frequently been reported in Germany and Austria. In his opus «Flora von Bayern» (1914), Vollmann reported that the presence of *P. ternata* had been a problem for the previous 40 years in Erlangen Botanical Garden (Bavaria, Germany). It is thus possible that it was already present in 1870; these data are also supported by Harz (1915).

In 1904, Aescherson and Graebner reported its presence in the Botanical Garden of Berlin, in the Defregger Garden in Kufstein (Austria), and in the Görlitz Garden (Germany); these observations are confirmed by Engler (1920).

P. ternata was subsequently reported in several Austrian Botanical Gardens: Salzburg in 1920, Klagenfurt in 1958 (Janchen, 1959) and Graz (University Botanical Garden, in the *Alpinetum*) (Melzer 1985, 1986; Eberwein & Berg, 2010).

In 1985, *P. ternata* was reported as a weed also in Italy in Pavia Botanical Garden (Peccenini Gardini & Terzo, 1985).

The occurrence of *P. ternata* has also been reported in the wild, where it tends to naturalize, especially in anthropic surroundings. It was first found as an accidental species in the wild by Speyer, in the Vorderpfalz region (Germany) in 1912, on dry and sandy soils and on rubble (Vollmann, 1914). It grows mainly in weed communities, as reported for SW-Franconia (Oberdorfer, 1983). In the St. Leonhard Cemetery, Graz, it was observed growing on graves; efforts to eradicate it with herbicide failed (Melzer, 1985, 1986). But a positive control of the species is possible by a three-year treatment with Triclopyr (3,5,6-Trichloro-2-pyridinyloxyacetic acid), a systemic, foliar herbicide in the pyridine group (Vincent Marrocco, Morris Arboretum of the University of Pennsylvania, pers. comm.). Furthermore, *Pectobacterium carotovorum* subsp. *carotovorum*, a bacterium causing soft-rot disease on *P. ternata* (Hu et al., 2008), could be used as a potential biocontrol agent against this species.

In Italy, near Pavia and Bologna, it has been reported since 1977, as a persistent invasive species on roadsides, cultivated land, plowed soil, and disturbed soil (Peccenini Gardini & Terzo, 1985), but at present no data confirm its presence in the wild.

However, *P. ternata* is not listed in Flora Europaea (Webb, 1980), as already pointed out by Merxmüller (1980) and Melzer (1985), and in Flora d'Italia (Pignatti, 1982). There are also no data for Italy in recent publications, i.e. Banfi & Galasso (2010), Celesti-Grapow et al. (2010), Bouvet (2013) or in the Italian flora checklist compiled by Conti et al. (2005).

COLLECTIONS FROM PIEDMONT

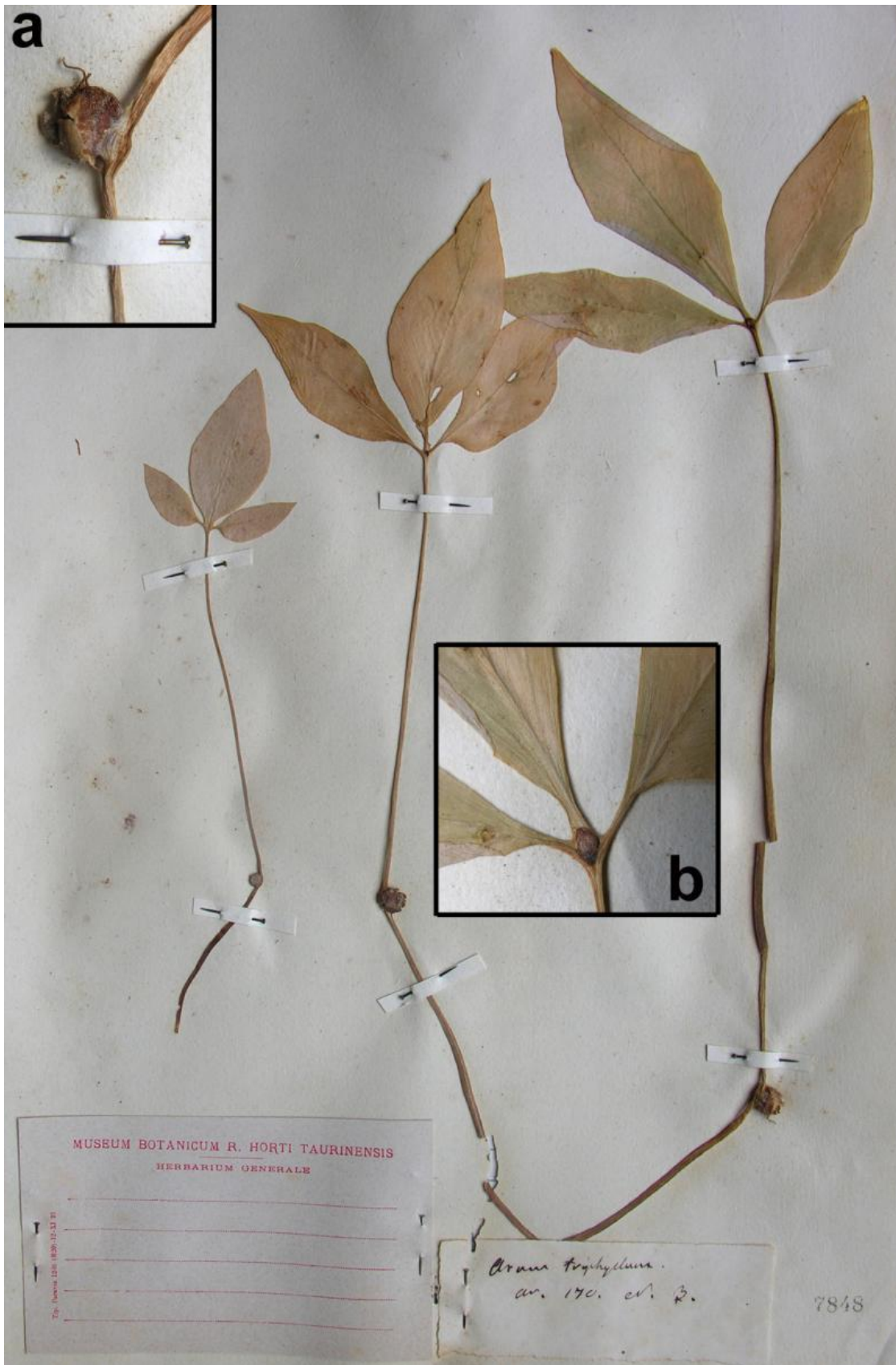
P. ternata at Turin Botanical Garden

In spring 2012, *P. ternata* was recognized by the authors growing at the edges of and in flowerbeds in Turin Botanical Garden (Fig. 1a). The species chiefly grows in beds of medicinal plants and in systematic flowerbeds, between shrubs and at the base of trees (especially near *Rosa* spp.). It has not spread beyond

the central tree-lined path, nor is it present in the *Alpinetum* or in the “Boschetto”. In this setting, *P. ternata* flowers between late April and late July.

P. ternata has been seen growing in the Botanical Garden for a number of years (Dr. G. Buffa, personal communication) but had not yet been recognized. Its presence has also been checked in the Valentino Park, which surrounds Turin Botanical Garden (in the rose garden, in flowerbeds, and in the garden of medicinal plants in the “Borgo Medievale” reconstructed medieval village), but no specimens have been found (pers. obs. by the authors).

Figure 2. Herbarium specimen of *Pinellia ternata* (sub *Arum triphyllum*) conserved in TO, collected in the Botanical Garden by Giovanni Battista Balbis. Enlargements show the bulbils on petioles (a) and leaves (b), a distinctive trait of this species.



Three catalogues of the Turin Botanical Garden, respectively dated 1880, 1881, and 1882 (Arcangeli, 1880; Bruno & Mattiolo, 1881, 1882), document the presence of *P. ternata* (sub *P. tuberifera*) in the Garden. However, one herbarium specimen from the collection of Giovanni Battista Balbis (1765-1831), conserved in the Turin Herbarium (TO), may anticipate the presence by several decades (Fig. 2): the handwritten label is undated, and specifies the flowerbed where the plant was cultivated: this indication is in fact similar to those reported in handwritten records of the sowings in the Botanical Garden. Giovanni Battista Balbis (1765-1831) was the director of the Garden between 1800 and 1814. He identified the plant as *Arum triphyllum*, because at that time the species had not been described as a separate entity, and the genus *Pinellia* was not yet established (Tenore, 1839).

An unpublished illustrated plate, labeled *Arum triphyllum* L., testifies to the incorrect identification of the species: it clearly shows all the typical traits of *P. ternata* (*Arum triphyllum sensu* Hoult. non L.), such as bulbils on all the petioles (Fig. 3). The true *Arum triphyllum* [\equiv *Arisaema triphyllum* (L.) Schott] is a North American species characterized by petioles and leaves without bulbils and a spadix lacking a long appendix (Treiber, 1980) (Fig. 4). This unpublished plate is part of the collection of botanical plates known as *Iconographia Taurinensis*. This collection, 7640 drawings in 64 volumes, illustrates plants cultivated in the Garden between 1752 and 1868, the year when the last painter died (see Chiapusso Voli, 1904). The plate of *Arum triphyllum* (t. 35), contained in volume 55, is estimated to date to between 1838 and 1846 (Forneris, 2008), i.e. after Balbis' death; however, the design predates the presence of the plant in the Garden as indicated in the catalogues.

Figure 3. Illustrated plate of *Pinellia ternata* (sub *Arum triphyllum*) from *Iconographia Taurinensis* (t35, vol. 55) conserved in the Library of Department of Life Sciences and Systems Biology (University of Turin).



In those years, the Director of the Garden was Giacinto Moris (1796-1869); each year, between 1830 and 1868, he published an *Index Seminum*. *Arum triphyllum* is mentioned in the “Indexes” between 1852 and 1868; however, it is very likely that the mention referred to *P. ternata*. *Arum triphyllum* was still mentioned in the “Indexes” after Moris’ death, and until 1906, but it is not clear whether the name applied in all cases to *P. ternata* or to the true *Arum triphyllum*.

Lacking further documentation, it is impossible to determine whether only *P. ternata*, misidentified as *Arum triphyllum*, or both species, were cultivated in the Botanical Garden; this makes it impossible to ascertain when *P. ternata* began to be cultivated. However, it was certainly present in the Botanical Garden in the second half of the nineteenth century.

P. ternata was probably first cultivated in Turin Botanical Garden as a medicinal plant, and then spread spontaneously into the flowerbeds.

Arisaema triphyllum was reported by Trinchieri (1905, as *Arum triphyllum*), Fiori (1923, as *Arisarum triphyllum* Torr.), Zangheri (1976, as *Arisarum triphyllum*), Abbà (1979, as *Arisarum triphyllum*) as a common neophyte in the Turin Botanical Garden. Based on these bibliographical data, *Arisaema triphyllum* was included in the exotics checklist of Italy by Celesti-Grapow et al. (2010) as an adventitious neophyte only for Piemonte. These reports probably refer to *P. ternata* specimens cultivated and collected in Turin Botanical Garden. Actually, the above-mentioned *exsiccatum* from the collection of Giovanni Battista Balbis (TO) and the unpublished plate from *Iconographia Taurinensis* (both labeled as *Arum triphyllum*) are clearly attributable to *P. ternata*. In addition, no specimens of *Arisaema triphyllum* collected in Piemonte or in Italy are present in TO.

Figure 4. North American herbarium specimen of *Arisaema triphyllum* conserved in TO, collected by Felice Ferrero (02/05/1907).



A new datum for Italy

In a recent collection (*herbarium* Pareto Angelo) acquired by TO, a *P. ternata* specimen, incorrectly identified as *Arum triphyllum*, was found. This specimen was collected in Lombriasco (Province of Turin) in 1956 (Fig. 5). Thanks to the author of this collection, it was possible to locate the exact place where it was harvested, near the banks of the River Po in a semi-natural area. This is, to our knowledge, the first firm indication of the occurrence of the taxon in Italy, outside a Botanical Garden. This report needs to be confirmed, and the presence of *P. ternata* verified in the neighborhood of this locality, along the River Po.

CONCLUSIONS

The article draws attention to a particular exotic plant, of which knowledge concerning Italy has been scanty. There are contrasting reports of its presence, in all major botanical works. Despite the documented report of *P. ternata* being present in the Pavia Botanical Garden (Peccenini Gardini & Terzo, 1985), for example, this is not cited by Banfi & Galasso (2010) in «La Flora Esotica Lombarda». In this area *P. ternata* may be extinct in the wild, but further investigation is necessary to assess its status.

P. ternata is classified by DAISIE (2013, Delivering Alien Invasive Species Inventories for Europe) as invasive but not established, in Germany and Austria. GCW (2013, Global Compendium of Weeds) assigns the status of “agricultural weed, casual alien, environmental weed, naturalised, weed” to the species. Essl & Rabitsch (2002) classify it as casual with a non-relevant impact on ecosystems.

Be that as it may, even if *P. ternata* spreads and becomes naturalized primarily in Botanical Gardens, its invasive potential must not be underestimated. Its accidental spreading in natural environments may be facilitated by human activities, such as gardening, or by nurseries

Figure 5. Herbarium specimen of *Pinellia ternata* (sub *Arum triphyllum*) newly acquired in TO, collected in 1956 by A. Pareto near the River Po at Lombriasco (Province of Turin).



When the old Botanical Garden of Klagenfurt was transferred to its present location, for example, *P. ternata* tubers were accidentally transported in the soil clods of plants as they were moved, and within a few years the plant colonized many areas of the new garden (Leute, 1988). This clearly stresses the invasive character of this plant where environmental conditions allow its spread. Indeed, some parts of the plant, i.e. bulbils or tubers, can accidentally be transported during plant exchanges or when transplanting, thus propagating the species. Another risk that should not be underestimated is the possibility of the species' spreading within or outside of an infested garden due to vegetative propagules (offshoots), which may be present in material resulting from pruning or mowing. Further, the ease of obtaining parts of the plant from herbalists, on-line outlets, or nurseries may increase the possibility of its accidental propagation in anthropic areas.

As a precautionary measure, it should be attempted to include *P. ternata* in EC legislation, at both the international and the national level, in consideration of the extensive world trade in this plant. Several species of *Arisaema*, for example, are already included in some regulations that discipline the international trade of wild flora and fauna, e.g. CE 407/2009.

The recent finding of the old *P. ternata* specimen, harvested in 1956 at Lombriasco (Province of Turin), draws attention to this species. Further investigation will thus be necessary to assess its dispersal status in the wild, and to confirm its presence in Piemonte and other parts of Italy. Additional efforts may then be addressed to understanding the environments that may favor its dispersal and naturalization. Further, the impact of *P. ternata* on plant communities, soil, and ecosystems is not properly understood, and should be studied.

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