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First record of a naturalized population of the tropical *Colocasia esculenta* (Araceae) in Italy, and clarifications about its occurrence in southeastern Europe

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Abstract – *Colocasia esculenta* (L.) Schott is an emergent aquatic and semi-aquatic species native to Asia, where it grows in tropical and subtropical areas. This species is widely cultivated for its edible corm and is considered as alien in various parts of the world, becoming sometimes invasive (e.g., in Spain), and in these areas eradication should be carried out. As part of ongoing studies on Araceae, in 2015 a population of *C. esculenta* was discovered in Rome (central Italy), where it grows along ditches. This is the first record of a naturalized population in Italy. A comprehensive view of this species in Italy and Europe was given, with clarifications about its occurrence in the Balkans, where *C. esculenta* was excluded from Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia, Serbia, and Slovenia. A morphological description based on the population found and considerations of its ecology and the climatic conditions at the Roman site are provided.

Key words: Alien species, Balkans, *Colocasia*, Mediterranean, microclimate, Rome, Italy

Introduction

Colocasia Schott (Araceae Juss., Aroideae Engl., Colocasieae Engl.) is a genus comprising 12–20 species (the number of species included in this genus is currently still debated) native to tropical and subtropical regions of Asia (Mayo et al. 1997, Li and Boyce 2010). The taxonomy of *Colocasia* is quite complex due to the high phenotypic and genotypic variability of some taxa, e.g., *C. esculenta* (L.) Schott or *C. antiquorum* Schott (Li and Boyce 2010, Helmkampf et al. 2018). These taxonomic questions led to nomenclatural confusion and many names have been published (Haigh et al. 2011).

Colocasia esculenta (commonly named Taro) is one of the highly variable species of this genus with respect to morphological, chemical, karyological, and molecular points of view (Helmkampf et al. 2018, and references therein). Taro is widely cultivated, mainly in the Tropics, with many naturalized clones occurring in South Asia, Malaysia and the Pacific Islands (Li and Boyce 2010). Further records of this species (as alien) have been published for other continents (Thompson 2000 for North America, Euro+Med 2006- for Europe, and Atlas of Living Australia 2020 for Australia).

As part of the ongoing revision of Araceae for the Italian flora (Iamonico and Iberite 2014, Ceschin et al. 2016, Iamonico 2020) and of the study of the flora of Lazio, Central Italy (Iamonico 2010, Iamonico et al. 2011, Iberite et al. 2017), I here present a contribution to understanding of the occurrence of *C. esculenta* in southeastern Europe.

Materials and methods

The present study was based on personal field investigations carried out during the period 2015–2020, extensive analysis of literature, and the examination of specimens preserved in Herbaria BM, HFLA, LINN, and RO (Thiers 2020).

The morphological description is based on the population found during this research.

The distribution map was prepared using Google Earth Pro (https://earth.google.com/download-earth.html). Data derive from both herbarium specimens and literature.

The climate characterization draws on the thermo-pluviometric data registered in the period 2003–2018 by the Tor Vergata weather station (http://www.idrografico.re-

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gione.lazio.it/annali/index.htm), the nearest to the site at which *Colocasia esculenta* was found (south east of the city of Rome). Monthly averages of both rainfall (mm) and temperature (°C) were calculated and a thermo-pluviometric diagram was produced using Microsoft Excel.

Results

Colocasia esculenta (L.) Schott, in Schott et Endlicher, Melet. Bot. 18. 1832 ≡ *Arum esculentum* L., Sp. Pl. 2: 965. 1753 ≡ *Caladium esculentum* (L.) Vent., Descr. Pl. Nouv.: 30. 1801 ≡ *Colocasia antiquorum* var. *esculenta* (L.) Schott ex Seem., Syn. Aroid. 1: 41. 1856 *Leucocasia esculenta* (L.) Nakai, Bull. Natl. Sci. Mus., Tokyo No. 31, 127. 1952.

Lectotype (designated by Howard 1979: 382): [Icon] Arum minus nympheae foliis esculentum in Sloane (1707: 167, t. 106, f. 1). Image of the lectotype available at https://www.biodiversitylibrary.org/item/11242#page/542/mode/1up

Specimina visa: Italy: Lazio region, Rome, Appia Antica Regional Park, locality Acquedotti, 41°85′05″ N, 12°55′66″ E, ditches, 56 m a.s.l., 8 August 2015, *D. Iamonico s.n.* (HFLA!); *ibidem*, 02 October 2019 (HFLA!); *ibidem*, 9 May 2020 (HFLA!, RO!).

Description

Perennial rhizomatous (geophyte/helophyte), 1.5–2.5 m tall. Rhizome horizontal, 5–6 cm in diameter (Fig. 1). Sto-

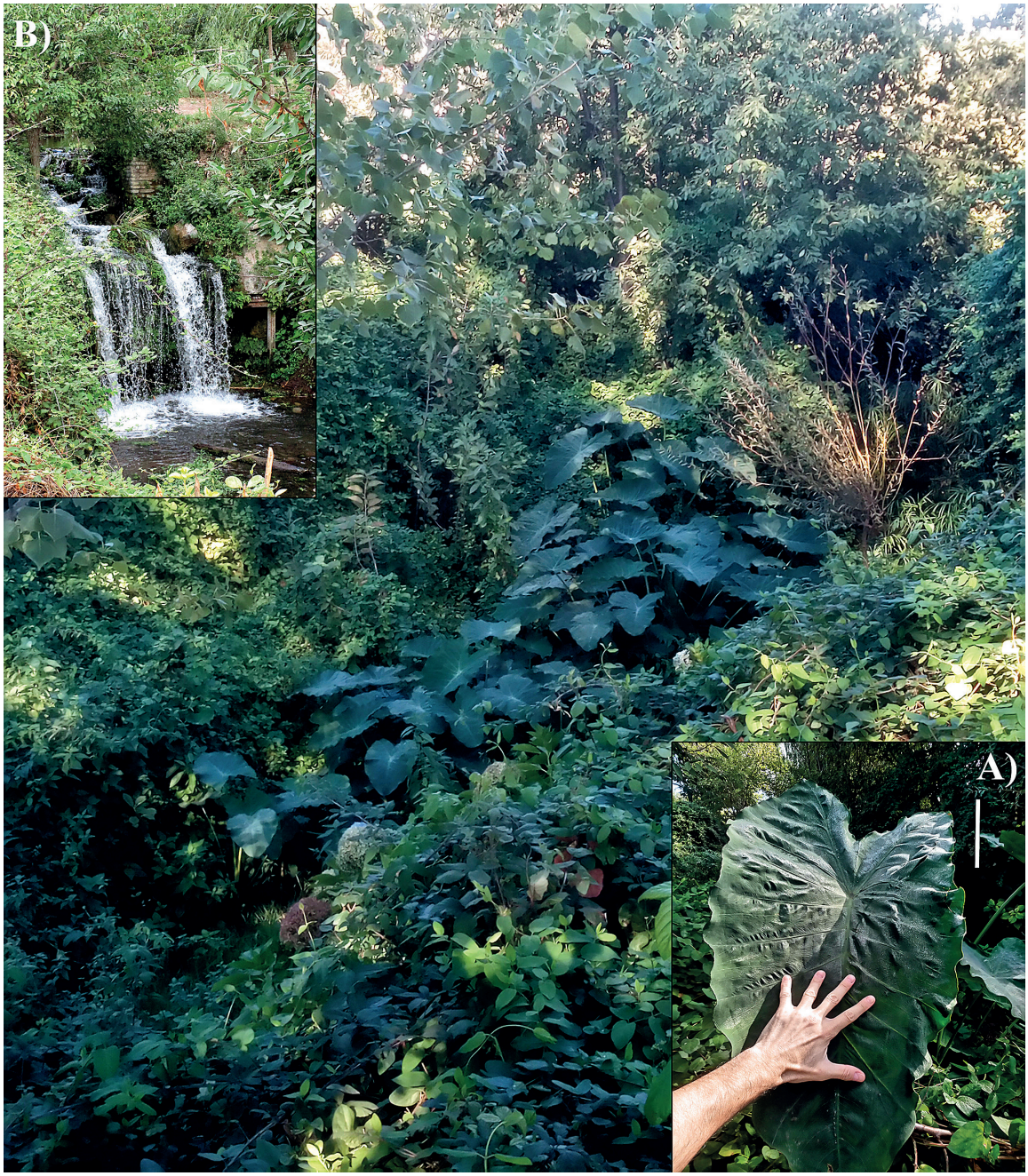

Fig. 1. *Colcasia esculenta* (L.) Schott in Lazio, central Italy: main population; A) detail of a leaf (scale bar = 10 cm); B) population located near the waterfall (photo by D. Iamonico, 18th October 2020).

lons absent. Leaves 15–25, petioled (petiole light-green, 25–80 cm long); blades adaxially waxy-glaucous and water-shedding, abaxially green, oblong, 13–45 × 10–35 cm, base cordate (sinus 1–4 cm), apex acute; veins (1st order) prominent more or less parallel. Flowers not seen.

Habitat and habit

The population found in Rome grows along a ditch (named "Acqua Mariana") occuring in the Acquedotti locality of the Appia Antica Regional Park. This ditch is a perennial water course (river flow ranging from 150 to 400 L s^{-1}) that originates in Molara Valley in the Castelli Romani Regional Park (Capelli 2015) about 20 km south of the Acquedotti locality. Plants of *C. esculenta* are perennial and rhizomatous (geophytes) which behave as helophytes, with root systems fixed under the water level (during the autumn and winter) or in mud (during the spring and summer) and epigeal parts above the water level.

Climate

On the basis of the updated world map of the Köppen-Geiger classification (Peel et al. 2007), the climate of the Roman site is temperate with dry and hot summer, which is characterized by the following data: temperature of the hottest month ≥ 22 °C, temperature of the coldest month 0 ≤ 18 °C, precipitation of the driest month in summer < 40 mm and < than a third of the precipitation of the wettest month in winter. The climatic characterization here presented shows that the annual average rainfall is 737.0 mm with the maximum in November (117.3 mm) whereas the minimum value occurs in August (18.5 mm). Summer is the hottest season with the average maximum temperature 25.5 °C in July, whereas the minimum value is registered in January (7.0 °C). As a consequence, a dry summer period occurs during three months, i.e. June, July, and August (Fig. 2).

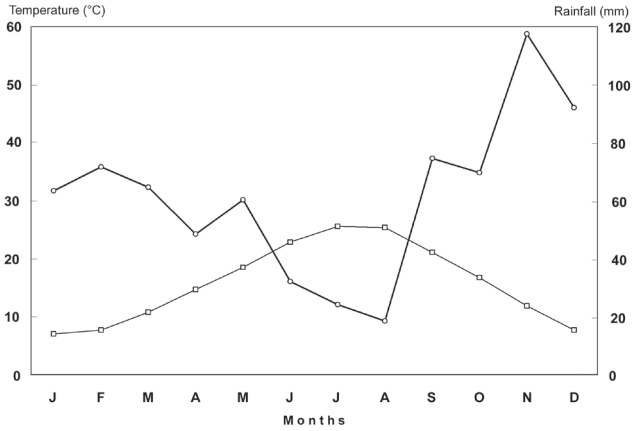

Fig. 2. Thermo-pluviometric diagram for meteorological station "Tor Vergata" (Lazio region, central Italy). Line with circles refers to rainfall and line with squares refers to temperature. Data registered in the period 2003–2018 (http://www.idrografico.regione.lazio.it/annali/index.htm).

Alien status in Italy

The population found in Rome is currently composed of about 40 well developed individuals. The first observation was in 2015 when I recorded just 4 individuals which were located in a single spot. During the years *C. esculenta* clearly spread and now further subpopulations or isolate individuals can be found far from the first observed spot. Seedlings and young plants were observed during the last four years. I here considered the Roman population the first to be naturalized in Italy.

Distribution in Italy

According to the recent Italian Checklist of Alien Flora (Galasso et al. 2018), *C. esculenta* is recorded in Italy in the two major islands [Sardinia and Sicily (in this latter region as not longer recorded)] and in Calabria (southern Italy).

Concerning Sardinia, on the basis of the last published alien flora (Camarda et al. 2016: 242), *C. esculenta* would be a casual. On the other hand, the previous works by Bacchetta et al. (2009: 46) and Puddu et al. (2016: Annex 1) indicated this species as naturalized, based on Fiori (1923: 208, "... *inselvat.* [inselvatichita] *lunghi i fiumi e nelle paludi in ... Sard.* [Sardegna]..." = "becomes wild along rivers and swamps in ... Sardinia"), Pignatti (1982: 625, "Coltiv. per ornamento … raramente subspont. …" = "Cultivated as ornamental plant … rarely subspontaneous...), and Viegi (1993: 156, "coltivata spontaneizzata" = "cultivated and becomes wild"). Parlatore (1852: 255) reported this species at "acque di *Milis* dove l'ha trovato il prof. Moris" (= "waters of *Milis* where it was found by Prof. Moris"). Ignazio Camarda (pers. comm.) informed me that he never observed *C. esculenta* in Sardinia in the wild, and had seen the species only in cultivation in public gardens. G. Bacchetta and L. Podda (pers. comm.), who said that they never seen any population in the wild, agree to assess the presence of *C. esculenta* in Sardinia as casual.

For Sicily, Raimondo et al. (2010: 242) did not give any status of naturalization for *C. esculenta*, while in the recent Italian Checklist of Alien Flora (Galasso et al. 2018) this species was reported as "Non più ritrovata" (= Not longer recorded). This datum derives from an old record by Da Ucria (1789, who did not report a specific locality indicating "*Sicilia*" only) which has been never confirmed (G. Domina pers. comm.). I also found a citation by Parlatore (1852: 255), who indicated this species "in Sicilia vicino Palermo lungo il fiume Oreto presso la Guadagna e la Grazia, a Santa Maria di Gesù lungo il canale dei molini, tra Siracusa ed Agosta a S. Cosimano" (= "in Sicily near Palermo along the river Oreto near Guadagna and Grazia, at Santa Maria di Gesù along the channels of mills, between Siracusa and Augusta at St. Cosimano").

The occurrence in Calabria of *C. esculenta* is casual according to Galasso et al. (2018), and it refers to both old citation of this species (Tenore 1820 "...dal gentilissimo Thomas è stato trovato spontaneo nelle paludi di *S. Eufemia* nella Calabria Ulteriore" [= it was found spontaneous by

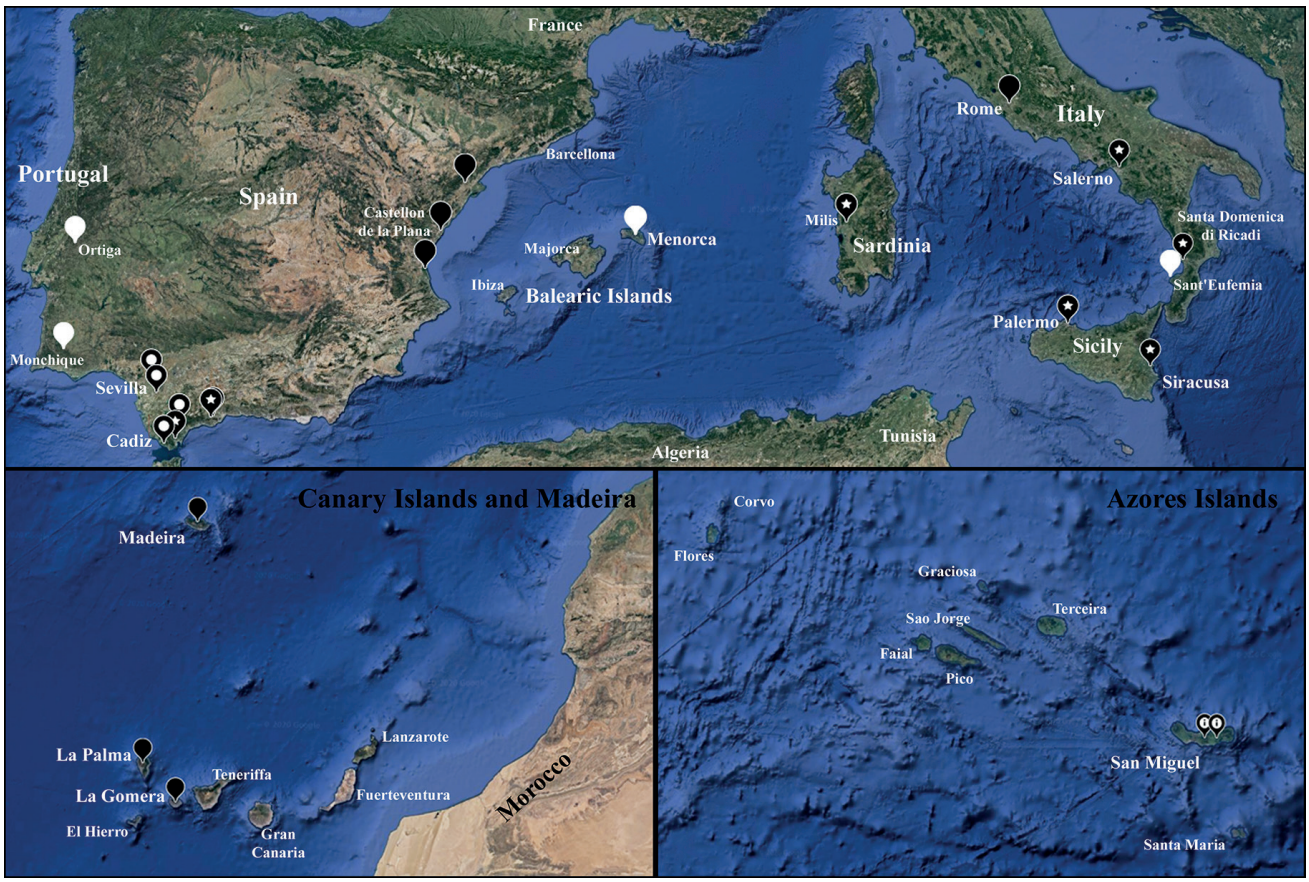

Fig. 3. Distribution maps of *Colcasia esculenta* (L.) Schott in Europe. Symbols: white marks = casual populations; black marks = naturalized population or (with circle white spot) invasive population, or (with central white star) not longer recorded population, or (with exclamation mark) with undefined status of naturalization.

the very kind Thomas in the swamp of *S. Eufemia* in Calabria Ulteriore], Tenore 1831: 475, "In stagnis Calabriae: *Maricello di S. Eufemia* (Thomas, Mumoli)", Parlatore 1852: 255 ["Nasce in Calabria nel *Maricell di Sant'Eufemia*"], Fiori 1923: 208 ["*...inselvat.* [inselvatichita] *lunghi i fiumi e nelle paludi in Cal.* [Calabria] ..." = "becomes wild along rivers and swamps in Calabria"]), and recent observations by L. Bernardo (pers. comm.) in the municipality Santa Domenica di Ricadi (Province of Vibo Valentia, Western Calabria).

Del Guacchio and La Valva (2018: Appendix) listed *C. esculenta* as no longer recorded, since 1950, for Campania (Southern Italy), based on an old indication by Colonna (1616) for a area which currently corresponds to the Province of Salerno.

All things stated, my finding in the Lazio region represents the first concerning a naturalized population in Italy (see Fig. 3). Note that Lucchese (2017), in his *Atlante della Flora Alloctona del Lazio*, did not list *C. esculenta*. Moreover, on the basis of the European distribution (see below), the Roman site also represents the most northerly station in the whole continent.

Distribution in Europe

As regards Europe (excluding Italy), *C. esculenta* has been recorded in Portugal [Algarve, Central Portugal, Lisbona regions (casual; Dana et al. 2017), Madeira (naturalized; Vieria Silva 2002: 188), Azores at San Miguel (no status of naturalization was given by Marcelino et al. 2011: 233)], Spain [Canary Islands at La Palma and Gomera and Valencian Community (as naturalized, see García-Camacho and Quintanar 2003: 29 and Ferrer-Gallego et al. 2015, respectively), Balearic Islands at Menorca (casual; Fraga et al. 2005: 61, Moragues and Rita 2005: 30), Andalusia and Cataluña (invasive; García-de-Lomas et al. 2012, Dana et al. 2017: 18–19)] (Fig. 3).

Concerning the occurrence of the *C. esculenta* in southeastern Europe, alleged records in Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia, Serbia, and Slovenia were reported in Euro+Med Plantbase as "Former Jugoslavia" (Euro+Med 2006-). Note, however, that the older Balkan flora by Hayek and Markgraf (1933: 419) recorded this species for "*Jon. et Cre.* culta et subspontanea..." where the abbreviations "*Jon. et Cre.*" means "*Insulae Jonicae* Corcyra, Leucas, Cephallonia et Zante (excluso insula Cythera [Cerigo])" and "Creta cum insulis parvis adjacentibus". No published record has been traced (see Vukićević 1976 for Serbia, Beck von Mannagetta 1903 for Bosnia and Herzegovina, Nikolić 2020 for Croatia, Jogan et al. 2001 for Slovenia (N. Kuzmanović, S. Malso, and S. Bogdanović personally confirmed the lack of records of *C. esculenta*, respectively in Serbia, Bosnia and Herzegovina, and Croatia), whereas for

Montenegro and North Macedonia personal communications were given, respectively, by D. Stešević and V. Matevski]. The occurrence of this species has to be excluded from the above mentioned Balkan countries. Dal Cin D'Agata et al. (2009: 311, Table 1) confirmed the presence of *C. esculenta* in Crete as "planted-only". All things considered, *C. esculenta* should be excluded from the Balkan flora in general.

Discussion

The discovery, in the south-eastern part of Rome (central Italy), of the first naturalized south-eastern European population of *Colocasia esculenta*, is a further example of the establishment of an alien species along water courses in Europe [e.g., *Alternanthera philoxeroides* (Mart.) Griseb. (Iamonico and Sánchez Del Pino 2016), *Lemna minuta* Kunth (Ceschin et al. 2016)]. Note that wetlands and other aquatic ecosystems are particularly threatened and the importance of their conservation has been emphasized internationally. The low endurance and resilience of these types of natural areas cause degradation and biodiversity loss more rapidly than in other ecosystems and the introduction of alien species is one of the factors for this degradation (Bolpagni et al. 2020, Lambdon et al. 2008). As a consequence, inland waters in Italy and Europe should be considered a priority for such measures of control of naturalized plants owing to the high level of native biodiversity, the importance of the ecosystem services provided, and the detrimental impacts caused by biological invasions. This is especially true in the context of urbanized zones, such as cities, where these natural areas are not only reduced in terms of area of occupancy due to the high building density, but also strongly and negatively affected by many factors part from biological invasion, e.g. pollution, infrastuctures, human density, etc. Moreover, it must be highlighted that the Roman locality "Acquedotti", in which *C. esculenta* grows, is located within a protected area, i.e. the Appia Antica Regional Park, which is one of the larger protected areas in the territory of Rome (about 34 km^2), representing an important hotspot of biological diversity for the Italian capital (Iamonico 2008).

On the basis of the climate data characterising the Roman locality, note that they are different from the climatic features typical of the geographical areas in which *C. esculenta* grows naturally, namely the tropics. According to Peel et al. (2007), the tropical climate is defined by temperature of the coldest month ≥ 18 **°C** [*vs.* 7.0 °C (January) in the Roman site] and precipitation of the driest month ≥ 60 mm [vs. 18.5 mm (August) in the Roman site]. As a consequence, the occurrence of the species in Rome is not or only partially related to the macroclimatic conditions. On the other hand, the following three micro-climatic factors, which are typical of the ecology of the species (Rojas-Sandoval and Acevedo-Rodríguez 2013), could explain the persistence of this species in my opinion: (i) soil: sandy sediments which are submerged during autumn and winter seasons, and are well-drained and partially soaked during spring and summer; (ii) brightness: low light intensity which characterize the site almost all the day and is related to the presence of tall plants, such as the giant reed (*Arundo donax* L.) or several tree species (*Salix alba* L., *Populus nigra* L., *Quercus ilex* L.); (iii) air: high humidity related to both the morphology of the site (a gorge) and the close occurrence of a small waterfall (height: 2.5–3.0 m).

In other words, I think that the occurrence in Rome of *C. esculenta* is not or only slightly linked to its ability to withstand the dry summer typical of the Mediterranean climate as stated by García-de-Lomas et al. (2012) for Spain, but is related to the specific environmental conditions mentioned above. In fact, along the ditches of the Appia Antica Regional Park (pers. obs.) there are further species the presence of which clearly depends on micro-climatic factors, e.g., *Canna indica* L., *Cyperus alternifolius* L., and *Zantedeschia aethiopica* (L.) Spreng. All these species compete for the resources (space, nutrients, light, etc.) and I can directly observe the reduction of the populations size of several native taxa, e.g., *Alisma plantago-aquatica* L., *Lemna minor* L., *Nasturtium officinale* R.Br. or *Veronica anagallis-aquatica* L.

All things considered, I advise the eradication of the Taro plants in the Roman locality. Since the land morphology of the ditch in which the *Colocasia* population was found does not allow the use of machines (a small ravine, 3–4 m high with slope angle ranging from about 70 to 90 °), I suggest hand-weeding as the appropriate methodology for removal.

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