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A new station for the endangered fern *Woodwardia radicans* (L.) Sm. (Blechnaceae) in Northern Campania (Italy)

Antonio Croce

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***Correspondence:**
antocrx@gmail.com
https://orcid.org/0000-0002-1549-677X

Affiliations:
Via Chiesa, 44 - Tuoro, 81057 Teano (CE), Italy.
Telephone: 3807991091.

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Abstract

The thermophilous fern *Woodwardia radicans*, is an iconic species of the Southern Italian flora. This species, endemic to Southern Europe and Macaronesia, likely represents a Macaronesian relict in Europe. Here, I describe a new station for this endangered species, in the Northern part of the Campania region (Southern Italy), that extends northward the distribution limit in the Italian peninsula. The site is located along the stream Savone delle Ferriere, on the Roccamonfina Volcano, within the Roccamonfina-Foce Garigliano Regional Park. The vegetation of the area shows the same feature of other *Woodwardia radicans* communities in Italy and grows on the very steep slopes in the lower part of the gorge of the stream, in a section characterized by huge waterfalls. The new station extends both the area of occupancy (AOO) and the extent of occurrence (EOO), two parameters used to assess the extinction risk by IUCN. In addition, new observations for other fern species, which are rare at regional level (as *Pteris cretica*, *Struthiopteris spicant* and *Dryopteris affinis* subsp. *affinis*), were reported.

Key words - Biodiversity, conservation, field research, Habitat directive, flora of Community interest

Riassunto

La felce termofila *Woodwardia radicans*, è una specie iconica della flora dell'Italia meridionale. Questa specie, endemica dell'Europa meridionale e della Macaronesia, rappresenta probabilmente un relitto macaronesiano in Europa. In questo lavoro, descrivo una nuova stazione situata nel Nord della regione Campania (Italia meridionale) che estende il limite settentrionale di distribuzione di questa specie nella penisola italiana. Il sito è localizzato lungo il corso del torrente Savone delle Ferriere, sul Vulcano di Roccamonfina, entro i confini del Parco Regionale Roccamonfina-foce Garigliano. La vegetazione è caratteristica delle comunità con *Woodwardia radicans* presenti in Italia e occupa versanti molto acclivi, nella porzione inferiore della gola del torrente, in una sezione caratterizzata da alte cascate. La nuova stazione estende i valori di occupazione dell'area (area of occupancy; AOO) e di tasso di occorrenza (extent of occurrence; EOO), parametri usati per valutare il rischio di estinzione secondo i criteri IUCN. Infine, sono riportate nuovi dati distributivi per alcune felci rare a livello regionale (come *Pteris cretica*, *Struthiopteris spicant* e *Dryopteris affinis* subsp. *affinis*).

Parole chiave - biodiversità, conservazione, ricerche di campo, Direttiva Habitat, flora di interesse comunitario

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Introduction

Distribution data for rare species are essential to assess the extinction risk under the IUCN Red List, as they are used to calculate the Extent of Occurrence (EOO) and the Area of Occupancy (AOO; IUCN, 2012). Therefore, species' conservation planning and management are impossible without a careful description of their distribution ranges.

Woodwardia radicans (L.) Sm. is a thermophilous fern endemic to Southern Europe and Macaronesia (Li *et al.*, 2016) and is considered a macaronesian relict in Europe (Pichi Sermolli, 1979). Its highly fragmented distribution extends from Macaronesia (Azores, Madeira and Canaries) to Atlantic Spain, Portugal, Corse, Southern Italy, Sicily, Algeria and Crete (Gargano *et al.*, 2016). In Italy it is located in 36 stations in Campania, Calabria and Sicily (Fig.1) while in other 24 sites, where it was previously found, it is now considered extinct (Spampinato *et al.*, 2008; Gargano *et al.*, 2016). *Woodwardia radicans* is classified as Vulnerable (VU) for Europe (Christenhusz *et al.*, 2017) and as Endangered (EN) in Italy (Rossi *et al.*, 2016). This species is protected by the Campania Regional law 40/1994 and listed in the annexes II and IV of the Council Directive 92/43/EEC, the so-called Habitat Directive, and so monitoring it is an obligation arising from Art. 11 (Giacanelli *et al.*, 2016). In the Campania region the species only occurs in

two small populations, one located on the island of Ischia and the other near to Amalfi (Caputo & De Luca, 1970), with a total of only 82 individuals out of more than 5400 living in Italy (Spampinato *et al.*, 2008).

The first discover of the species in Italy dates back to the botanist Pietro Antonio Micheli from Florence. In 1706 or 1710 he visited Naples and its surroundings, and recorded the presence of *Woodwardia radicans* in the Sorrentine peninsula and in Ischia (Pampanini, 1911). Several other sites in the two areas were later discovered by other botanists, though in most of them the

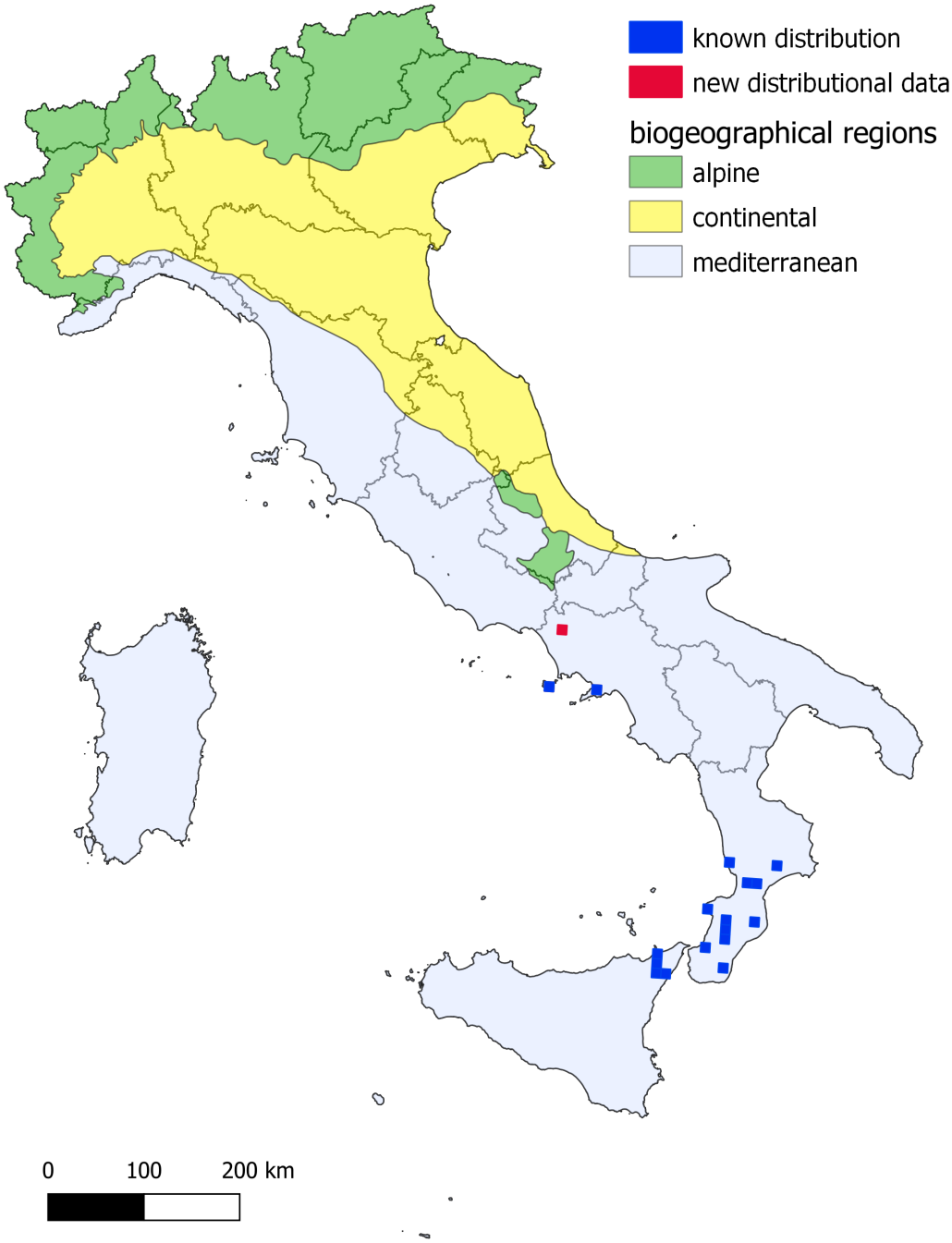

Figure 1: Distribution of Woodwardia radicans in Italy. In red the new station. (modified from Gargano et al., 2016).

species has not been recorded anymore in the last decades and is thus supposed to be disappeared. The Roccamonfina volcano is a middle Pleistocene volcanic complex active from 630 kya to 53 kya (De Rita *et al.*, 1997), reaching the altitude of 1005 m a.s.l. and covering a surface of about 250 km^2. A recent floristic detailed checklist for the area listed the remarkable number of 871 taxa (Croce *et al.*, 2008). The area, however, includes zones of difficult accessibility that have been less explored. Therefore, in the last decade the field surveys continued with particular attention to these areas. One of such areas, the Savone delle Ferriere stream, hosts some species of phytogeographic interest such as *Struthiopteris spicant* (L.) Weiss, *Dryopteris affinis* (Lowe) Fraser-Jenk. subsp. *affinis*, *Lysimachia vulgaris* L., which are very rare for the region (Croce *et al.*, 2008), the narrow endemic and Critically Endangered *Epipactis maricae* (Fenu et al., 2018) and a relict beech wood growing from 320 to 450 m a.s.l.

Due to its phytogeographic and conservation interest, the discovery of *Woodwardia radicans* on the Roccamonfina volcano, in a previously unexplorated section of the Savone delle Ferriere stream, in Summer 2019, deserves a note.

Material and Methods

The exploration of the Savone delle Ferriere has been carried each year in the last decade especially in summer, when the flow of the stream is at the minimum and even the deepest gorges can be walked through. The field study aimed at monitoring the population of the endemic *Epipactis maricae* and at improving the floristic knowledge for the area.

Some plants of *Woodwardia radicans* were observed the first time on the 6th of August 2019 and then the site was explored on the 7th and the 21st of August. The fern and the other species growing in the site were identified in the field and later checked according to Pignatti (2017) and Marchetti (2004). The nomenclature follows Bartolucci *et al.* (2018) for vascular plants and Aleffi *et al.* (2008) for mosses and liverworts. A portion of a leaf of *Woodwardia radicans* was collected and the specimen deposited in the Herbarium of the University of Naples (NAP). The other collected specimens were deposited in the author's herbarium.

The plants of *Woodwardia* in the site were counted, the station was georeferenced and delimited by the use of a GPS Device (Garmin etrex). The size of the station was estimated by the use of QGIS3.4 Madeira (Quantum Gis Development Team, 2019). To preserve the site from any disturbance, the coordinates and a detailed map of the station will not be provided in the present note.

As the species is listed in the Annex II and IV of the Council Directive 92/43/EEC, an official communication of the discovery was sent to the institutions

responsible for its conservation (i.e. the Regional Park of Roccamonfina - Foce Garigliano, Campania Region and Italian Ministry for the Environment, Land and Sea).

Results and Discussion

More than one fifth of the known species of plants are at risk of extinction (Pimm & Raven 2017). Therefore new distribution data for rare species, especially the discovering of new sites, is crucial for conservation planning and management (Rondinini *et al.*, 2006). Here, I report a new station for the rare fern species *Woodwardia radicans* located in the northern part of the Campania region. This new station is located along a 250 m long section of the stream, both on the left and the right slopes of the gorge globally oriented E-SE at an altitude of about 180 m a.s.l. (Fig. 2). In this section the stream deeply eroded layers of tuff and flows on a bed of lavas, below a waterfall more than 30 m high. About 160 plants of *Woodwardia radicans* live on very steep slopes, from 1.5 to 10 m above the riverbed. Above them, where the slopes become less steep, and the atmospheric moisture is drastically lowered, the vegetation is a xerophilous woodland dominated by hornbeams and holm oaks. No seedlings were noted and a few plants at the beginning of the sporification were observed only during the visit of the 21st of August.

The rich in ferns plant communities can be referred to the alliance *Polysticho setiferi-Phyllitidion scolopendri* (Ubaldi *et al.,* 2014) due to the presence of the diagnostic species *Asplenium scolopendrium* L. subsp. *scolopendrium*, *Polystichum setiferum* (Forssk.) T.Moore ex Woyn., *Dryopteris affinis* (Lowe) Fraser-Jenk. subsp. *affinis*, *Athyrium filix-femina* (L.) Roth. More precisely the association *Conocephalo-Woodwardietum radicantis* (Brullo *et al.,* 1989) is well represented with the remarkable presence of *Pteris cretica* L. and *Struthiopteris spicant* (L.) Weiss in addition to *Woodwardia radicans* and the liverworts *Conocephalum conicum* (L.) Dumort. Also abundant are *Adiantum capillus-veneris* L., *Staphylea pinnata* L., the mosses *Thamnobryum alopecurum* (Hedw.) Gangulee and *Plagiomnium undulatum* (Hedw.) T.J.Kop. and some species characteristic of riparian habitats as *Angelica sylvestris* L. subsp. *sylvestris* and *Carex pendula* Huds. Less common are *Asplenium onopteris* L., *Asplenium trichomanes* L. subsp. *quadrivalens* D.E.Mey, *Hypericum androsaemum* L., *H. hircinum* L. subsp. *majus* (Aiton) N.Robson while on the top of the communities appear more xerophilous and thermophilous species as *Ruscus aculeatus* L. In addition to *Woodwardia*, the station is also inhabited by three other rare ferns: *Pteris cretica* L. (first record for Roccamonfina volcano of this

species protected by the Campania regional law 40/94); *Struthiopteris spicant* (L.) Weiss (=*Blechnum spicant* L.) (in Campania region it is present only on the volcano (Croce *et al.*, 2008); *Dryopteris affinis* (Lowe) Fraser-Jenk. subsp. *affinis* (very rare in Campania, at present known only for the volcano and lake Corree (Croce *et al.*, 2008, 2011).

The Savone delle Ferriere stream site represents the third station of *Woodwardia radicans* for the Campania region (Caputo & De Luca, 1970, Gargano *et al.*, 2016) and the northern limit of its areal in the Italian peninsula. It is more than 20 km far from the Tyrrhenian sea, 60 km from the site of Ischia and more than 80 km from the site of Amalfi (Valle delle Ferriere). Curiously, the toponymy of both the sites refers to "Ferriere" (i.e., “ironworks") for the presence of iron factories active from the 16th to the 20th century (Rauccio 2010), powered by nearby waterfalls. The same waterfalls provide the right air humidity necessary to the plants (Caputo & De Luca 1970). The new station is at present out of the Natura 2000 network, only 2

Figure 2: A group of plants on the left slope of the Savone delle Ferriere gorge.

km away from the borders of the nearest Site (SIC IT8010022 "Vulcano di Roccamonfina"). Fortunately, the section of the gorge falls inside the Regional Park of Roccamonfina - Foce Garigliano, in the zone B - general reserve. With about 160 plants, the population is almost double than that previously known for Campania (Spampinato *et al.*, 2008).

The access to the site is very difficult, walking on the slippery bed of the stream being possible only in the driest summers. Therefore, the threats to the conservation can be related to the touristic exploitation (e.g., the opening of pathways and trampling) and especially to the modification of the hydraulic regime of the stream (e.g., consequent to water abstraction or building of bridles and dams). Even the gathering of plants must be kept into account as well as the modification of the woods covering the top part of the slopes of the gorge.

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