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Cistus ×skanbergii Lojac., the 'phoenix' hybrid that became extinct in its type locality to revive in the global plant web market

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ABSTRACT This paper is focused on the emblematic case story of *Cistus ×skanbergii* Lojac., a hybrid rockrose issuing from the breeding between *C. parviflorus* Lam. and *C. monspeliensis* L. To this purpose, a bibliographic research has been carried out to trace the available knowledge about the past and current distribution of this hybrid within its primary distribution range. Extinct in its type locality (Lampedusa Island) and very rare in the Mediterranean Basin, this hybrid proves to be intensely traded worldwide instead. The case of *C. ×skanbergii* shows that the international greening network vehiculated by websites may transform naturally rare plants into cosmopolitan aliens which could become invasive in the near future in several countries subject to Mediterranean or temperate climates. The indiscriminate spread of this rockrose outside its primary distribution range should be discouraged – if not forbidden – also because *C. ×skanbergii* possesses many of the traits (e.g., tolerance to drought and thermal stress, allelopathy, adaptation to fire disturbance) typical to many well-known invasive plants. Additionally, the use of this hybrid rockrose is troublesome because most of the currently traded material has been obtained by crossing several provenances of both parent species under non-natural conditions to obtain the hardiest, hence even more dangerous, breeds.

KEY WORDS Horticulture; International plant trade; Invasion biology; Mediterranean-type Biomes.

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INTRODUCTION

In one of his contributions to the vascular flora of Lampedusa Island, Lojacono-Pojero (1885) described *Cistus skanbergii* (Fig. 1) a natural hybrid between *Cistus parviflorus* Lam. and *Cistus monspeliensis* L., two rockrose species which only rarely co-occur throughout the whole Mediterranean area (Fig. 2; Alberto et al., 2020).

The dramatically fast and intense disruption of the island's territory, due to land overexploitation during the second half of the 19th century (Pasta & La Mantia, 2003), triggered the fast shrinkage of the local populations of both parent species and of the hybrid itself, originally reported to be extremely common there. As a result, *C. ×skanbergii* was probably extinct in the early 20th century, as reported by Sommier (1908).

This work aims at pointing out the current distribution of *C. ×skanbergii* within its native distribution range, i.e. in the Mediterranean Basin, and highlighting its wide spread due to human activities. Further research was carried out to find out whether

and to what extent this hybrid could be of some interest in the international market of plants traded for ornamental purposes.

MATERIAL AND METHODS

In order to reconstruct the knowledge on the historical and current distribution of *C.* ×*skanbergii*, the botanical literature available for Sicily and the Euro-Mediterranean area, as well as several contributions focused on genus *Cistus* (e.g., Rizzotto, 1979; Demoly, 1996, 2006) were consulted. Most data concerning the international trade and the worldwide distribution of the Skånberg rockrose were obtained via *ad hoc* internet searchs and/or by using the *iNaturalist* platform (https://www.inaturalist.org/).

RESULTS

Ecology and distribution of C. ×skanbergii *in its primary distribution range*

Figure 1. Original plate of *Cistus* ×*skanbergii* (from Lojacono-Pojero, 1885).

Due to its putative hybrid origin, *C.* ×*skanbergii* should theoretically be present everywhere its parent species co-occur. As matter of fact, this case is not so frequent: according to literature, in fact, this hybrid rockrose has been reported only for western Cyprus (Meikle, 1977; Fig. 2) while the two parent species only seldom co-occur in Crete (Strid, 2016). Despite being closely related to each other from a phylogenetic viewpoint (Civeyrel et al., 2011), the distribution ranges of *C. monspeliensis* and *C. parviflorus* only seldom overlap. The former is mainly a western Mediterranean plant which occurs in few localities in Greece, Cyprus and Crete (Alberto et al., 2020), while the latter is mainly an eastern Mediterranean plant, whose distribution range includes, besides the above-mentioned Island of Lampedusa, Turkey and Turkey-in-Europe, Cyprus, the East Aegean Islands, Greece, Crete, N-Africa (Egypt, Libya and Tunisia). According to the available literature (Böhling et al., 2002; Pignatti et al., 2017–2019) the two species would also have different requirements in terms of soil reaction and light (Table 1).

Demoly (1996) states that *C.* ×*skanbergii* is mostly sterile in Southern Greece. More recently, Demoly (2006) described *Cistus* ×*akamantis*, a hybrid between *C.* ×*skanbergii* and *C. salviifolius* L. living close to the Akamas River in western Cyprus; few years later, the same scholar described a white-flowered form of *C.* ×*skanbergii* from the same place (Demoly, 2008).

The only claim about the occurrence of *C. parviflorus* elsewhere in Italy refers to Apulia; this record, reported in the first edition of "Flora Europaea" (Tutin et al., 1968), has not been supported neither by herbarium specimens nor by recent observations (Rizzotto, 1979; L. Forte and R.P. Wagensommer, *pers. comm.*). Also the past occurrence of *C. parviflorus* in the garrigues near Caltagirone (south-eastern Sicily) needs to be confirmed. Indeed, the only mention for this area is rather ambiguous, as Taranto & Gerbino (1845: 46) quoted "*Cistus complicatus*" (a synonym of *C. parviflorus*) as host of *Cynomorium coccineum* L., while few pages before they report only three species of rockroses growing in the area, i.e. *Cistus salviifolius* L., *C. creticus* L. and *C. monspeliensis* L. As a matter of fact, no specimen of *C. parviflorus* was found in the herbarium of Taranto by Gargano et al. (2018).

Taxon, geographical area and source	**L**	**F**	**R**	**N**	**T**	**K**	**S**
Cistus monspeliensis L.							
S-Aegaean islands, Greece (Böhling et al., 2002)	7	4	8	3	8	3	1
Italy (Pignatti et al., 2017–2019)	10	2	2	2	9	4	0
Cistus parviflorus Lam.							
S-Aegaean islands, Greece (Böhling et al., 2002)	8	2	8	n.a.	8	6	1
Italy (Pignatti et al., 2017–2019)	11	2	2	2	9	5	0

Table 1. Ellenberg's Ecological Indicator Values (EIVs) assigned to *Cistus monspeliensis* and *C. parviflorus* within their native distribution range according to different sources. Standard abbreviations of EIVs: L (= Light), F (= Soil moisture), R (= Soil reaction, pH), N (= Nitrogen soil content), T (= Temperature), K (= Continentality) and S (= Salinity); n.a. = not assessed.

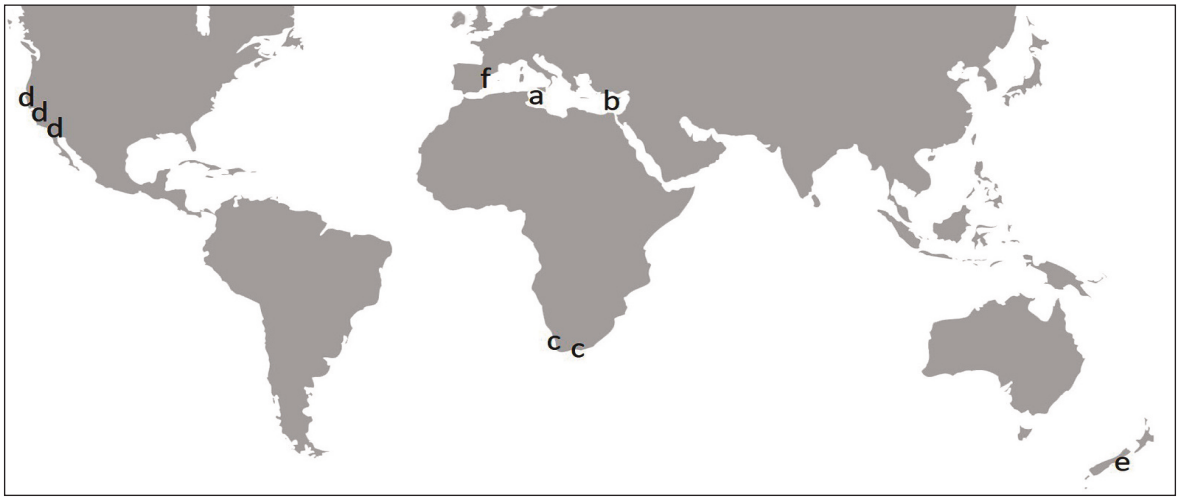

Figure 2. Primary (a: Lampedusa Island, Italy; b: Cyprus) and secondary (c: Republic of South Africa; d: California, US; e: New Zealand; f: Spain) distribution range of *Cistus ×skanbergii* (for further details cf. https://www.inaturalist.org/observations?locale=it&nelat=45.425957498334846&nelng=180&subview=map&swlat=-80.45301214297774&swlng=-180&taxon_id=415891).

An unexpected journey: Skånberg Rockrose "world tour"

Despite its extinction on Lampedusa Island and its extreme rarity throughout the whole Mediterranean Basin, an automatic query made on the internet (October 2022) using the words '*Cistus*' or 'rockrose' + '*skanbergii*' (or '*skanbergi*') revealed a really unespected truth. In fact, the total number of results (c. 9200 pages) issuing from this quick search shows that this handsome plant, also known as 'dwarf pink rockrose', is massively produced by many nurseries and used for private greening purposes all over Europe (UK, The Netherlands, Germany, Italy, Spain) and worldwide (e.g., USA, Australia and New Zealand). Such reproductive

hybrid individuals have been obtained by crossing on purpose the parent plants from Greece or Cyprus.

C. ×*skanbergii* was introduced as an ornamental plant in the 2000s in some green areas of Valencia (Guillot et al., 2000) and in the roadsides of Morella (Castellón), where it escaped and started to spread at the beginning of the 2010s (Senar Lluch, 2014). Similarly, ten years ago (May 2011) *C.* ×*skanbergii* was also found growing in an abandoned quarry near Gabbro (Tuscany, Italy; see Lazzeri et al., 2015), where it was probably planted by privates or professionals with no idea - or at least with a weird concept - about what habitat restoration is. No data are available on the destiny of these introduced plants during last decade, but it should better be interpreted as a rare casual alien in Tuscany (V. Lazzeri, *pers. comm*.).

During the last 10–15 years the Skånberg rockrose was introduced worldwide in all the countries with Mediterranean-type climate like Chile, Southern Australia, as well as in South Africa and California, where it starts to behave as a casual or fully naturalized alien plant (Fig. 2).

DISCUSSION

Nemo invasor in patria*? Evolutionary and ecological drivers*

The evergrowing bulk of knowledge on the most effective biology predictors of invasiveness (Hayes & Barry, 2008) allows to make some more considerations on the specific case of *C.* ×*skanbergii*.

First, narrow-ranged does not mean harmless (Pasta, 2022). In fact, vascular plants with no close relatives may pose serious problems to the ecosystems of newly colonized areas (e.g., Callaway & Aschenhoug, 2000; Colautti et al., 2017). The dreadful weapon represented by 'phylogenetic originality' has been confirmed by many recent studies carried out worldwide, emphasizing that the more distinct are local floras, the more they are subject to be outcompeted by alien invaders (Harvey et al., 2012).

Second, if we consider ecological pre-adaptation (Colautti & Barrett, 2013), *C.* ×*skanbergii* looks just predestined to spread all over the Mediterranean biomes worldwide. In fact, thanks to their high stress and disturbance-tolerance (Troia & Laguna Lumbreras, 2015) rockroses can survive and spread in all the arid and fire-prone habitats.

Although homoploid hybrids are rare in nature, nonetheless they exist, as shown by Kadereit (2015). Even if *Cistus* species are with no exceptions diploid (Totta et al., 2017), they may be easily crossed and form plenty of hybrids and intermediates either in nature or under cultivation; for this reason, hybridization has been hypothesized as the major mode of evolution in *Cistus* since the early 20th century (Dansereau, 1940; Demoly, 1996).

The possibility that *C.* ×*skanbergii* may be able not only to overcome sterility but also to show improved fitness like other *Cistus* hybrids (Navarro-Cano et al., 2017) sheds light on the potential threat posed by Skånberg rockrose. Additionally, hybrid origin represents another favourable trait shared by many invasive plants, as already pointed out by Stebbins (1985) and recently confirmed for many evolutionarily distant plants (e.g., Abbott et al., 2003; Schierenbeck & Ellstrand, 2009; Yakimowski & Rieseberg, 2014).

Moreover, the specific case of this 'home-made hybrid rockrose' is particularly troublesome because of its production in non-natural conditions by crossing several provenances of both parent species. In fact, the enhanced genetic diversity issuing from admixture may significantly increase the ecological plasticity and fitness of many introduced plants and animals (Lavergne & Molofsky, 2007).

Is it just a question of time (and speed)?

Mankind started changing the worlds' floristic assemblages already many thousand years ago, when the first seafarers brought with them the propagules (seeds, tubers, bulbs, etc.) of the food and medicine plants they needed (Merlin, 2003; Fuller et al., 2011; Hofman & Rick, 2018), and the same did for centuries sailors, monks and nomad shepherds following ancient trade routes and carrying with them useful plants to be cultivated on islands after crossing immense oceans or grown in the oases after weeks of wandering across hostile deserts. If compared with past times, the international commerce of potentially dangerous weeds has dramatically increased in terms of speed, inten-

Wide climatic niche (able to thrive under cooler conditions and/or to enjoy global warming)	**NE**
Disturbance-tolerant (e.g. volcanic eruptions, wildfires, floods, rockfalls)	**Y**
Hybrid/Polyploid	**Y**
Dominant species	**N**
Early reproductive	**Y**
Long-lasting flowering/fruiting season	**Y**
Wide edaphic niche (indifferent to soil chemistry)	**NE**
Multiple pollination strategy and wide pollination range	**NE**
Multiple dispersal strategy and wide seed dispersal range	**N**
Able to produce vegetative propagules	**N**
Habitat transformer/accumulator (e.g. nitrogen-fixing, allelopathy)	**Y**
Stress-tolerant (e.g., CAM, C4, salt-tolerant, pollution-tolerant, drought-tolerant)	**Y**

Table 2. Ecological traits of *C. ×skanbergii* which could favour (Y) or prevent (N) its invasive behaviour and spread outside its primary range. NE = not evaluated, to be checked outside its native range.

sity, frequency and species-richness. Seed and plant delivery via airplanes and online shopping, often used for the illegal commerce of very endangered and internationally protected plants (Vaglica et al., 2017), represents at the same time the worst enemy of rare plants and the best ally for invasive ornamental ones (Humair et al., 2015).

The fact that *C. ×skanbergii* did not turn invasive yet does not mean that it cannot become so in the future, especially if it turns to be able to overcome sterility. Indeed, we should beware of apparent unharmfulness (Zenni & Nuñez, 2013), considering that many introduced alien species show a very long lag time before becoming pests (Crooks & Soulé, 1999; Groves, 2006; Lambdon et al., 2008). A synthesis on the ecological traits making *C. ×skanbergii* a 'dangerous trade item' is provided in Table 2.

CONCLUSIONS

How to translate scientific discoveries on biological invasions into everyday's conservation policy and practice? Perhaps we should start from raising awareness and changing the way of perceiving invasive organisms. In fact, teaching stakeholders and common people to go beyond the aesthaetical look of alien plants and to see their impact on natural and semi-natural ecosystems (Andreu et al., 2009; Lindemann-Matthies, 2016; Dehnen-Schmutz & Conroy, 2018) could make them the first detectors of invasion events (see Encarnação et al., 2021, and reference therein). With no doubt, it is more cost-effective to prevent and forbid the intentional introduction of potentially invasive alien plants instead of fighting the very widespread and well-established ones (Hulme, 2003; Hulme et al., 2008).

Perfectly aware of their past and present responsabilities and duties (Dehnen-Schmutz, 2011; Hulme; 2011; Dehnen-Schmutz & Conroy, 2018), the European horticulturalists and the botanic gardens are networking to find out joint policies focused on the most appropriate way of dealing with (and avoiding) invasive ornamental species. Such increasingly tight collaboration between private and public gardening organisations and public research institutions led to the recent publishing of various international codes or guidelines (Heywood & Brunel, 2011), whose authoritative suggestions, however, are still waiting to be taken seriously in many countries, where the introduction of apparently unharmful alien plant species such as *C. ×skanbergii* has been encouraged in rural and urban ecosystems until recent times (Nicholls et al., 2001; Fraga i Arguimbau, 2009; Canales-Ide et al., 2022).

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