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Urban orchids: an updated checklist of the orchid flora of Cagliari (Sardinia, Italy)

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SUMMARY

In the last decades, urbanization has led to drastic changes in ecosystems. Although this phenomenon is one of the greatest threats to biodiversity, cities can host a high richness of biological diversity. Several authors have recently emphasized the role of urban biodiversity in mitigating the effects of climate change and in providing benefits to citizens. In this study, I investigate the orchid flora of the city of Cagliari. Although the Mediterranean cities have a significant native flora, purely floristic works in urban ecosystems are still rare. During a thirteen-year study I encountered seventeen species, two subspecies and three hybrids. However, three taxa were no longer found. This inventory can support urban conservation policies and their implementation in the development of sustainable cities.

INTRODUCTION

Urbanization consists in a profoundly transformed environment where human activity interferes with climate and biogeochemical cycles (Grim et al. 2008). This phenomenon carries dramatic impacts in ecosystems like climate change, habitat fragmentation, biotic homogenization and species invasion leading to reduction of native taxonomic, functional and

genetic diversity, loss of ecological function and ecosystem services (McKinney 2006; Radford and James 2013). Future projections estimate that human population will reach ten million in 2050 emphasizing the threat to local biodiversity especially in highly biodiverse regions of the world (Chen et al. 2014; Seto et al. 2012). Despite the increase of human pressure, several threatened species live in urban ecosystems contributing positively to human life like, for

example, stress reduction, reduced mortality and improved cognitive development in children (Shanahan et al. 2015). Within the Mediterranean Basin, the flora of Italian cities is one of the most historically investigated (Domina et al. 2019) and endemic taxa such as *Hieracium tolstoidii* Fen. & Zahn in Milan, *Stellaria media* subsp. *romana* Bég. in Rome have found a refuge despite the millennial anthropogenic impact (Peruzzi et al. 2015). Orchids have a cosmopolitan distribution (Dressler 1994) and they are recognized as indicators of ecosystem health because of the interactions with other life forms like fungi for seed germination and animals for pollination. The only demographic work about urban orchids in the Mediterranean Basin I am aware of has identified habitat fragmentations as a major driver of the low reproductive success increasing the probability of local extinction (Pellegrino and Bellusci 2014). Sardinia is the second largest island in the Mediterranean Basin and Cagliari, its capital city, has a multimillennian history. The urban landscape is shaped by seven calcareous hills and the native flora is confined to the

garrigues. Although there is no comprehensive checklist of the flora of the city so far, several endemites such as *Genista corsica* (Loisel.) DC. and *Helichrysum italicum* (Roth) G. Don subsp. *tyrrhenicum* (Bacch., Brullo & Giusso) Herrando, J.M. Blanco, L. Sáez & Galbany are recorded. Given the need to update the botanical knowledge in urban ecosystems, the aim of this thirteen-year study is to perform an inventory of the orchid flora of Cagliari and discuss the ecology of these organisms in urban areas. Specifically, I investigate: i) the species richness and ii) the flowering and vegetative phenologies of the native orchids of Cagliari.

MATERIALS AND METHODS

This study was performed in Cagliari, Sardinia, Italy (WGS84 coordinates: 39.2236, 9.1181) (Figure 1). The city is located in the southern part of the island of Sardinia in the middle of the Golfo degli Angeli. The territory has a thermo-



Figure 1. Map of the research area and its location in Sardinia.

mediterranean climate (Canu et al. 2014) and the urban landscape is shaped by seven calcareous hills formed by the intrusion of the sea. They are named: Castello, Tuvumannu/Tuixeddu, Monte Claro, Monte Urpinu, Colle di Bonaria, Colle di San Michele, Calamosca/Capo Sant'Elia. The current city extends into the flat areas among the hills. The hills of Cagliari form the terminal part of the Campidano plain.

Plant communities show a Mediterranean-eastern floristic contingent characterized by the presence of *Satureja thymbra* L., *Thymbra capitata* (L.) Cav., *Poterium spinosum* L. This inventory was based on fieldwork carried out from 2008 to 2021. In 2020, sampling was not possible from March to April due to restrictions caused by the pandemic of coronavirus disease (COVID-19). The inventory was compiled covering every type of habitat. Nomenclature follows The International Plant Name Index and, in the floristic list, species are arranged in alphabetical order. For each species the following information are provided: 1) accepted name; 2) number of stations and 3) flowering and vegetative phenologies. The calculation of species richness was performed for the municipality of Cagliari but also for each hill. The final list was compared with the previous notes on the orchid flora of Cagliari (Martinoli 1950).

RESULTS

In total 17 species, two subspecies and three hybrids belonging to six orchid genera were found in Cagliari between 2008 and 2021. The genera represented by the highest number of taxa are *Ophrys* including ten species among which the endemic *Ophrys exaltata* subsp. *morisii* (Martelli) Del Prete and three hybrids (*Ophrys x sommierii*, *O. x tavignanensis* and *O. x cosana*), and *Anacamptis* with two species and one subspecies. The complete list of orchid taxa recorded is shown in Table 1. The most common orchids were: *Himantoglossum robertianum*, *Ophrys lutea*, *Ophrys speculum*, *Serapias lingua*, *Serapias parviflora*. *Ophrys x sommierii*,

Ophrys x tavignanensis and *Neotinea maculata* have not be found since 2014, 2010 and 2017 respectively. *Ophrys exaltata* subsp. *morisii* disappeared in 2014 and was found again in

Table 1. List of orchid species occurring in the municipality of Cagliari and number of stations encountered.

Species	Number of stations
<i>Anacamptis collina</i> (Banks & Sol. Ex Russell) R.M. Bateman, Pridgeon & M.W. Chase	4
<i>Anacamptis fragrans</i> (Pollini) R.M. Bateman	1
<i>Anacamptis papilionacea</i> subsp. <i>grandiflora</i> (Boiss.) Kreutz, Ber. Arbeitskreis	3
<i>Himantoglossum robertianum</i> (Loisel.) P. Delforge	1
<i>Neotinea maculata</i> (Desf.) Stearn	1
<i>Ophrys apifera</i> Huds.	3
<i>Ophrys bombyliflora</i> Link	4
<i>Ophrys eleonorae</i> Devillers-Tersch. & Devillers,	3
<i>Ophrys exaltata</i> subsp. <i>morisii</i> (Martelli) Del Prete	1
<i>Ophrys fusca</i> Link	2
<i>Ophrys incubacea</i> Bianca	1
<i>Ophrys lutea</i> Cav.	4
<i>Ophrys speculum</i> Link	6
<i>Ophrys tenthredinifera</i> Wild.	1
<i>Orchis anthropophora</i> (L.)	1
<i>Serapias lingua</i> L.	4
<i>Serapias parviflora</i> Parl.	4
<i>Spiranthes aestivalis</i> (Poir.) Rich.	2
Hybrids	
<i>Ophrys x sommierii</i> Tyteca	1
<i>Ophrys x tavignanensis</i> H. Mathé, J.M. Mathé & M. Pena	1
<i>Ophrys x cosana</i> H. Baumann & Künkele	1

2021. In 2021 *Ophrys tenthredinifera* was found for the very first time as a single flowering plant in Capo Sant’Elia. The hill that accounts for the highest species richness is San Michele with 15 taxa followed by Tuvumannu/Tuvixeddu with 13 and Calamosca/Capo Sant’Elia with 10 taxa. Species richness for each hill is reported in Table 2. Comparative analysis shows that *Anacamptis laxiflora* is missing from my species list.

All the taxa found except *Spiranthes aestivalis* (Poir.) Rich. produce leaves in late summer and fall (Figure 2). The first orchids to bloom are *Himantoglossum robertianum* and *Anacamptis collina* in January. While the flowering season reaches a peak between March and April with 15 taxa blooming simultaneously, vegetative season starts in late summer and it

reaches the peak between October and March (Figure 2).

Table 2. Hills forming the city of Cagliari and the corresponding number of recorded orchid taxa.

Hill	Number of taxa
San Michele	15
Tuvumannu/Tuvixeddu	13
Calamosca/Capo Sant’Elia	11
Monte Claro	4
Monte Urpinu	3
Castello	3
Bonaria	0

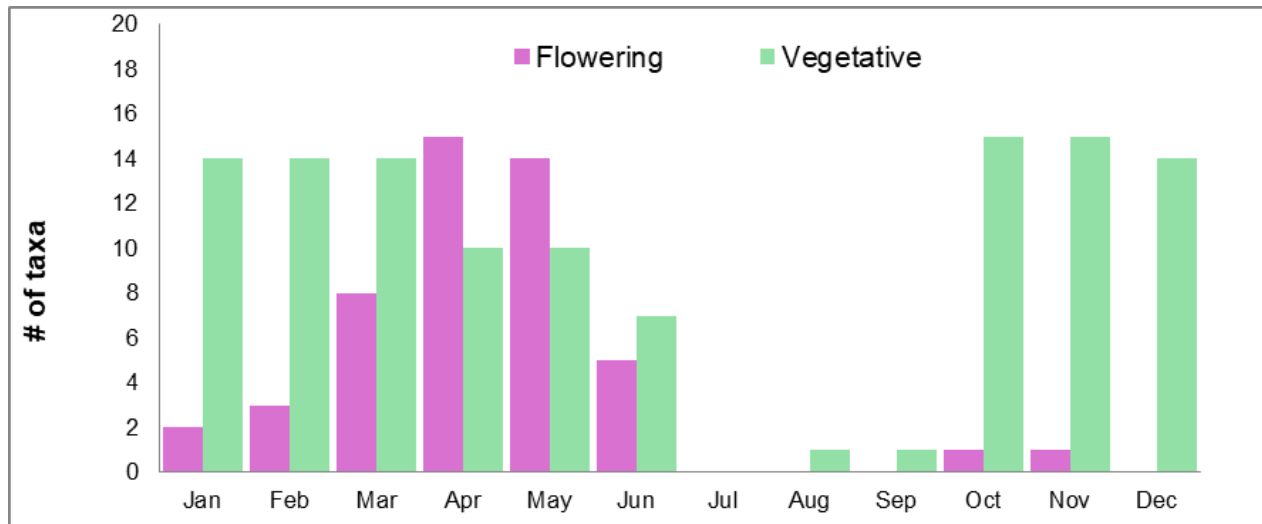


Figure 2. Flowering and vegetative phenology of the orchid flora of Cagliari.

DISCUSSION

A quarter of the species recorded in Sardinia live in Cagliari (Lussu et al. 2020). These species show typical Mediterranean traits: preference for calcareous soil and resistance for hot and dry summers. Compared to the previous notes on the orchid flora of Cagliari (Martinoli 1950), *Anacamptis laxiflora* was not found during my research, probably because of the reduction of wetlands in the last decades. In contrast, *Neotinea maculata*, *Ophrys x sommieri* and

Ophrys x tavignanensis were no longer encountered. The first two taxa were represented by a single population of very few flowering plants. *Neotinea maculata* is an autogamous self-pollinating species and, although it grows in a wide range of habitats, is susceptible to local environmental changes (Duffy et al. 2009). In Cagliari, this orchid vegetated in moist, cool, alkaline and mid-shade soils on the north-facing slopes of San Michele hill dominated by *Arbutus unedo* L and *Pistacia lentiscus* L.. The growth of

the basal branches of these two species has considerably reduced the light and space availability, leading to the disappearance of the few orchid specimens. In contrast, the role of pollinators is crucial for the persistence of sexually deceptive species of the genus *Ophrys*, since the two parental species of *Ophrys x sommieri*, *O. bombyliflora* and *O. tenthredinifera*, have different pollinators, the extinction of *O. x sommieri* can be associated not only with the limited frequency of hybridization events, but also to the low ability of *Ophrys* hybrids to define their own pollinator niche (Vereecken et al. 2010). The only known population of *O. x tavignanensis* was destroyed by an unsuccessful urbanization program. The greater richness of species found in the hills of San Michele and Tuvumannu / Tuvixeddu may be due to different factors. In San Michele hill, its rough topology probably has discouraged building construction, protecting biodiversity. Most of this hill consists of an urban park which hosts several semi-natural areas regularly mowed in late spring indirectly promoting orchid persistence. However, in fall 2015, two entire populations of *Ophrys eleonora* and *H. robertianum* were devastated by an attempt to enhance the area and dozens of dormant tubers were uprooted. During this event, dozens of *Quercus ilex* L., *Arbutus unedo* L. and *Salvia rosmarinus* Schleid. were planted instead. In contrast, the orchid richness of Tuvumannu hill may be due to the abandonment in 1953 of the great limestone quarry. The area is today a totally abandoned and degraded suburban area favouring orchid establishment and persistence. However, here, between 2008 and 2009 a road construction irreparably defaced the area causing the disappearance of *O. x tavignanensis*. Personal observation on the general and rapid decline of orchid populations in parks might be because of the introduction of ornamental birds such as ducks, chickens and peacocks. In fact, the few surviving specimens still persist in the garrigues far from foraging areas and aviaries. Different studies have been carried out on the fitness of wild Sardinian orchids (e.g. Cozzolino et al. 2021), and further comparative analysis on

the demography of urban vs non-urban communities are needed to define population's health and prevent local extinction. Such research might also reveal the network of relationships in which orchids are involved, for instance, insect occurrence and their pollination ability. My findings emphasize that specialized organisms might find in urban ecosystems a niche where they prosper but I also provide evidence that little is still known about their ecological and demographic patterns. In conclusion, the city of Cagliari hosts an interesting but suffering orchid community. Identifying which anthropogenic factor or which combination of factors is responsible for this decline requires more analyses. In the management of public green spaces it is therefore crucial to consider both the vegetation and blooming stages of local species to promote the persistence of local biodiversity and avoid the loss of species. Considering that all the orchid species recorded in the urban area of Cagliari are assessed as least concern (Lussu et al. 2020), plants with a biology as complex as orchids can be adopted to raise awareness among citizens and politicians but also they can be seen as umbrella species in order to preserve other taxa that do not enjoy the same notoriety but that equally contribute to the urban biodiversity.

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