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Endemic flora of Codula di Luna (Gulf of Orosei, Central Eastern Sardinia)

Abstract

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In the framework of floristic research programs carried out in the limestone mountain range of the Gulf of Orosei (Province of Nuoro- Central Eastern Sardinia), the authors wish to highlight the rich endemic component present at Codula di Luna. Fifty-eight floristic entities belonging to 28 families and 49 genera were found. Of these, 21 are exclusive to Sardinia, 13 are Sardinian-Corsican, 7 in common with Corsica and the Tuscan archipelago and 3 with Sicily, whereas the others exhibit a wider distribution area. The most widely represented families are *Asteraceae*, *Lamiaceae*, *Scrophulariaceae* and *Fabaceae*. Following our field observations, we present details on their ecology, distribution and rarity.

Introduction

This paper examines the endemic component of Codula di Luna, an area in which ongoing studies on flora and the vegetation landscape are in progress (Bocchieri & al. 2003a, 2003b). Previous works on the limestone mountains of the Gulf of Orosei report on vegetation (Arrigoni 1996; Arrigoni & Di Tommaso 1991; Arrigoni & al. 1985; 1990) and endemic flora surveys (Arrigoni & al. 1977-1991; Fridlender 1999; Fridlender & Raynal-Roques 1998; Giotta & al. 2002) from which we have taken data on Codula di Luna.

Codula di Luna is one of the main tourist attractions of the Gulf of Orosei, a sector whose naturalistic interest is due to the processes of erosion and tectonic movements which have made the limestone mountains of central eastern Sardinia particularly rugged.

The local name “Codula” (meaning a heap of stones or boulders) is given to the karst valleys found exclusively in this area of Sardinia, whereas the word “luna” (moon) refers to the light colour of the rounded granite and limestone boulders strewn along the river banks.

The wider area has been targeted by numerous local, regional, national and Community programs aiming at ecosystem protection, and sustainable use and management of natural

resources. The floristic component, with particular reference to endemic and rare species, can be considered a benchmark for evaluating the choices made for the enhancement, management and conservation of the territory.

The territory

Codula di Luna, included in IGM (Italian Military Geographic Institute) Map n. 500 sec. II Dorgali and n. 517 sec. I Cantoniera Genna Silana, crosses diagonally for some 20 Km the eastern plate of the limestone mountains of central eastern Sardinia, sloping down to the sea from an elevation of about 500 m. This area belongs to the municipalities of Baunei, Urzulei and Dorgali, all of which fall within the Province of Nuoro (Fig. 1). The lateral reliefs encircling the Codula reach maximum elevation of 990 m with the peaks of Monte Oseli.

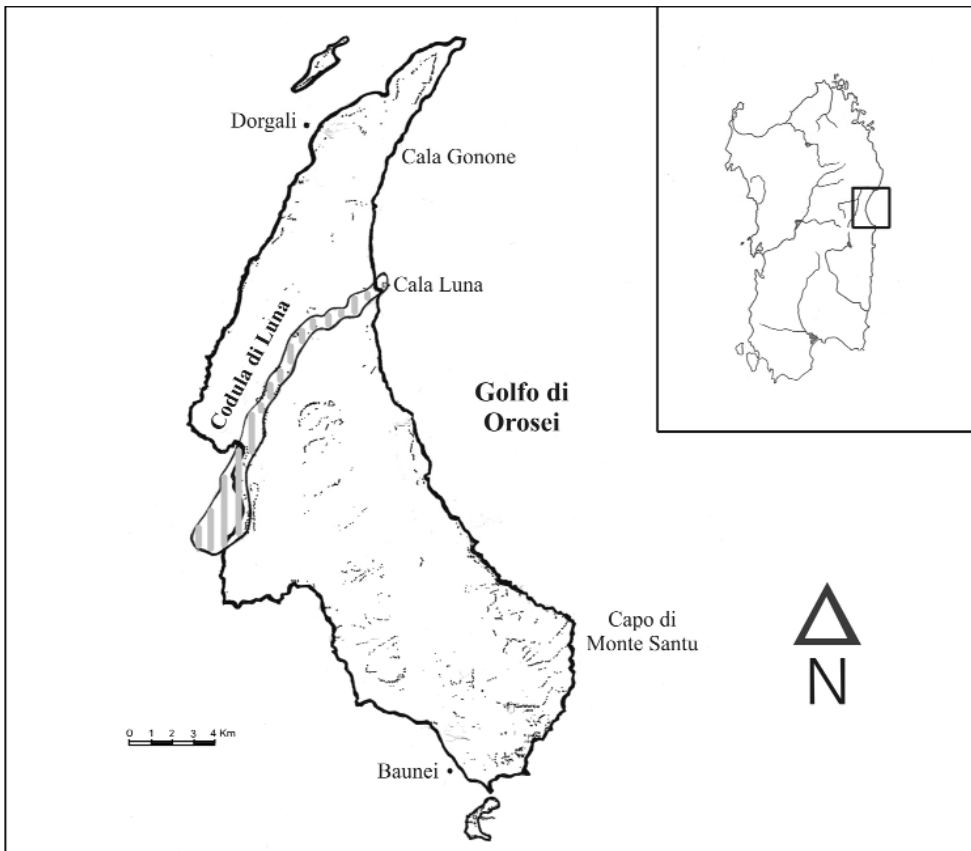


Fig. 1. The study area and its geographical position.

The geology and structure of the surveyed area include a basement with alternating terrigenous and crystalline components. On the granite substratum we find large, discordant carbonatic layers, dolomites and dolomitic limestone dating back to the Jurassic (Dieni & Massari 1966). As to its geo-morphology, the coastal area of the Gulf of Orosei is characterized by steep carbonatic cliffs (with advanced karst phenomena) cut by karst valleys ending with small sandy bays. In particular, Cala Luna has a sandy cordon which closes the mouth of the stream creating a small marshy area to the back of the beach (Orrù & Ulzega 1987).

The Palaeozoic and Mesozoic stone formations found along Codula di Luna offer ideal conditions for differential erosion. Indeed, in the areas with less resistant rocks we find the main streams, separated by crests of more resistant rocks (Bartolini 1992).

The Codula di Luna stream flows in the main over a granite and schist bed, also marked by abundant deposit of limestone detritus from the lateral cliffs, which in some sections reach considerable height, creating a narrow canyon. The absence of granite outcrops leads to the flowing of water underground.

Since no temperature and rainfall data were available specifically for this area, we used the recordings from the Orosei station, located 18 km distant at 20 m ASL, in order to provide climatic details, albeit not detailed. Mean annual temperature is 17°C, with an average for the hottest month of 25°C and for the coldest of 10°C. Mean annual rainfall is 550 mm, although there are several years when rainfall exceeded 1000 mm. The high flow rate of the Codula di Luna stream is explained by its watershed, which reaches the eastern slopes of Genna Silana, an area with one of the highest rainfalls in Sardinia.

The sparse historical data on Codula di Luna are linked to the numerous karst caves located in the rocky walls; they were inhabited almost constantly by groups of shepherds from pre-Nuragic to Roman times, and right up to the early Middle Ages (Colomo & Ticca 1985).

Flora

Botanical studies on this sector of Sardinia carried out in past years provide a somewhat patchy picture as regards the flora of Codula di Luna and in particular of its endemic component. Our researches, often hampered by unfavourable environmental conditions, started in Autumn 1995 and proceeded with regular, planned field surveys.

For identification of the samples collected and for nomenclature, we utilized the works by Arrigoni & al. (1977-1991), Gamsans & Marzocchi (1996) as well as Moris (1837-1859), Fiori (1923-1927), Pignatti (1982) and Tutin & al. (1964-1980; 1993). Moreover, for systematic, taxonomic and distributive purposes we consulted some other specific works.

For each entity we indicate: family, biological form and distribution area, utilizing the following abbreviations: AT = Tuscan Archipelago, BL = Balearic Islands, CAL = Calabria, CO = Corsica, Cr = Island of Crete, H = Hyeres Islands, ITm = locality in mainland Italy, SA = Sardinia, SI = Sicily; locality, date of collection and abundance. Moreover, when available, we also provide bibliographical data.

Floristic List

Allium parviflorum Viv. - *Liliaceae* - G – SA-CO

In the vicinity of the Grotta de Mocco, 27.VIII.2002; rare. Arrigoni & Di Tommaso (1991).

Arenaria balearica L. - *Caryophyllaceae* – H – SA-CO-AT-BL

Near Monte Andau, 23.IV.2003; sporadic.

Aristolochia insularis Nardi & Arrigoni – *Aristolochiaceae* - G – SA-CO

Near Bacu Su Palu, 01.VI.2003; extremely rare. Arrigoni & al. (1977-1991); Arrigoni & Di Tommaso (1991).

Aristolochia tyrrhena Nardi & Arrigoni – *Aristolochiaceae* – G – SA

Teletottes, 08.III.2003; common. Arrigoni & al. (1977-1991).

Arum pictum L. fil. – *Araceae* – G – SA-CO-AT-BL

Su Murtargiu and Teletottes, 08.III.2003; sporadic.

Bellium bellidioides L. – *Asteraceae* – H – SA-CO-BL

Throughout the area under study, 08.III.2003; very common. Arrigoni & al. (1977-1991).

Biscutella morisiana Raffaelli – *Brassicaceae* – T – SA-CO.

Perda Molina, 08.III.2003; sporadic. Arrigoni & al. (1977-1991).

Bituminaria morisiana (L.) Stirton – *Fabaceae* – Ch – SA. Arrigoni & Di Tommaso (1991).

Brassica tyrrhena Giotta, Piccitto & Arrigoni – *Brassicaceae* – Ch – SA

Between Campu Esone and Sa Palumbrosa Baunei, 08.III.2003; sporadic.

Bryonia marmorata Petit – *Cucurbitaceae* – G – SA-CO

S'Arcada Sozzastro, 27.VIII.2002; common. Arrigoni & al. (1977-1991); Arrigoni & Di Tommaso (1991).

Carex microcarpa Bertol ex Moris – *Cyperaceae* – H – SA-CO-AT

Near Funtana Terriarbino, 27.III.2003; rare.

Carex panormitana Guss. – *Cyperaceae* – H – SA-SI

In the vicinity of Teletottes, 21.VIII.2003; extremely rare. Arrigoni & al. (1977-1991).

Note: this species is included in the Red and Blue Lists of Italian flora (Bacchetta in Pignatti & al. 2001). In the Codula area, clusters always consist of just a few individuals, as in the other Sardinian and Sicilian populations; this fact confirms its status as a seriously endangered species CR (Conti & al. 1997).

Centaurea filiformis Viv. subsp. *filiformis* – *Asteraceae* – Ch – SA

Under Sa Palumbrosa, 19.IV.2003; common. Arrigoni & al. (1977-1991); Arrigoni & Di Tommaso (1991).

Centaurea filiformis subsp. *ferulacea* (Martelli) Arrigoni – *Asteraceae* – Ch – SA

In the vicinity of Campu Esone, 04.V.2003; rare.

Note: throughout the area undergoing study we found exemplars with morphological characteristics intermediate between the two sub-specific entities.

Centranthus amazonum Fridlender & A. Raynal – *Valerianaceae* – Ch – SA

In the vicinity of Teletottes, 01.IV.2003; extremely rare. Arrigoni & al. (1977-1991); Fridlender and Raynal-Roques (1998).

Note: a chasmo-chomophyte, sciaphilous, calcicolous, rupicolous species, observed by us in the same locality, is included in the Red and Blue Lists of Italian flora (Bacchetta in Pignatti & al. 2001). The conservation status of the Codula di Luna population is difficult to define since only few elements were found growing together while we found several isolated ones scattered over the cliffs and among the rocks of the Codula, between the localities of Teletottes and Pedra Molina. We confirm its status as a seriously endangered species CR (Conti & al. 1997).

Cephalaria mediterranea (Viv.) Szabò – *Dipsacaceae* – Ch – SA-CO

Between Campu Esone and Monte Andau, 21.VIII.2003; rare. Arrigoni & al. (1977-1991); Arrigoni & Di Tommaso (1991).

Colchicum actupii Fridlender – *Liliaceae* – G – SA

S'Arcada S'ozzastru, 23.IX.2003; rare. Fridlender (1999).

Cymbalaria aequitriloba (Viv.) A. Chevalier – *Scrophulariaceae* – H – SA-CO-AT-BL

Teletottes, 19.IV.2003; common. Arrigoni & al. (1977-1991).

Crocus minimus DC. – *Iridaceae* – G – SA-CO-AT

In the area of Cuile Nidu 'e Porcheddos, 27.III.2003; rare.

Delphinium pictum Willd. – *Ranunculaceae* – H – SA-CO-BL-H

In the area of Campu Esone, 28.IV.2003; area to the back of Cala Luna, 27.VII.2002; sporadic.

Dianthus cyathophorus Moris – *Caryophyllaceae* – Ch – SA-SI

Between Campu Esone and Sa Palumbrosa, 01.VI.2003; rare.

Note: this entity was described by Moris (1853): “*In montanis Sardiniae orientalis, circa Dorgali, inter fissuras rupium calcarearum, legit Dominicus Lisa*”. Only recently has it been re-assessed as a species of Sardinian and Sicilian flora and included in the work on the genus *Dianthus* of Sardinia, Sicily and southern Italy (Bacchetta & al. 2004; Arrigoni 2006).

Digitalis purpurea L. var. *gyspergerae* (Rouy) Fiori – *Scrophulariaceae* – H – SA-CO

Area to the rear of Cala Luna, 25.V.2003; sporadic.

Euphorbia cupanii Guss. ex Bertol. – *Euphorbiaceae* – G – SA-CO-SI

Scartari, 29.VI.2003; rare. Arrigoni & Di Tommaso (1991).

Euphorbia semiperfoliata Viv. – *Euphorbiaceae* – Ch – SA-CO

The upper portion of the Codula and in the vicinity of Cala Luna, 19.X.2002; common. Arrigoni & al. (1977-1991).

Galium schmidii Arrigoni – *Rubiaceae* – H – SA

In the vicinity of Campu Esone, 19.IV.2003; sporadic.

Genista aetnensis (Raf.) DC. – *Fabaceae* – P – SA-SI

In the vicinity of Serra Oseli, 19.IV.2003; sporadic. Arrigoni & al. (1977-1991).

Genista cadasonensis Vals. – *Fabaceae* – NP – SA

In the area of Cresta Tittiddai, 03.V.2003; rare.

Genista corsica (Loisel.) DC. – *Fabaceae* – NP – SA-CO

Serra Oseli, 19.IV.2003; rare.

Note: Along the Codula this species is little evident, whereas it is widespread in other sectors of the Gulf of Orosei. The fresh damp environmental conditions of the area under consideration might well be a limiting factor for this species which favors arid sunny areas.

- Glechoma sardoa* (Bég.) Bég. – *Lamiaceae* – H – SA
Teletottes, 28.III.2003; sporadic.
- Helichrysum italicum* subsp. *microphyllum* (Willd.) Nyman – *Asteraceae* – Ch – SA-CO-BL-Cr
Area to the back of Cala Luna 25.V.2003; sporadic. Arrigoni & Di Tommaso (1991).
Note: Bacchetta *et. al.* (2003) report the presence of this species also on the island of Crete.
- Helichrysum saxatile* Moris – *Asteraceae* – Ch – SA
Along the Codula and in the area of Cala Luna, 03.V.2003; common. Arrigoni & al. (1977-1991); Arrigoni & Di Tommaso (1991).
Note: in Sardinia we find two sub-specific entities, *H. saxatile* subsp. *saxatile* with a distribution area including the limestone mountains of central eastern Sardinia, Monte Tuttavista and the area of the Tacchi, whereas *H. saxatile* subsp. *morisianum* is widespread only in southern Sardinia (Bacchetta & al. 2003).
- Helleborus argutifolius* Viv. – *Ranunculaceae* – G – SA-CO
Between Scartari and Su Murtargiu, 08.III.2003; very common. Arrigoni & Di Tommaso (1991).
- Hieracium supramontanum* Arrigoni – *Asteraceae* – H – SA
Serra Oseli, Arrigoni & al. (1977-1991).
- Hypericum annulatum* Moris – *Hypericaceae* – H – SA
In the area of Bacu su Palu, 01.VI.2003; Teletottes, 07.XI.2003; sporadic.
- Hypericum hircinum* L. – *Hypericaceae* – Ch – SA-CO-AT
Throughout the area under examination, 19.IV.2002; very common. Arrigoni & al. (1977-1991); Arrigoni & Di Tommaso (1991).
- Lactuca longidentata* Moris – *Asteraceae* – H – SA
In the area of Punta Pigas, 01.XI.2002; sporadic. Arrigoni & al. (1977-1991).
- Limonium hermaeum* (Pignatti) Pignatti – *Plumbaginaceae* – Ch – SA
Cala Luna, 25.V.2003; common. Arrigoni & al. (1977-1991); Arrigoni & Di Tommaso (1991).
- Mentha insularis* Requier – *Lamiaceae* – H – SA-CO-AT-BL
Teletottes, 21.VIII.2003; area to the rear of the beach, 25.V.2003; sporadic.
- Mercurialis corsica* Cosson – *Euphorbiaceae* – Ch – SA-CO
In the area of Serra Oseli, 01.VI.2003; sporadic. Arrigoni & al. (1977-1991).
- Micromeria cordata* Moris – *Lamiaceae* – Ch – SA
Between Teletottes and Cala Luna, 08.III.2003; rare. Arrigoni & al. (1977-1991).
- Orobancha rigens* Loisel. – *Orobanchaceae* – G – SA-CO
In the vicinity of Genna Ostuno, 25.V.2003; sporadic.
- Pancratium illyricum* L. – *Amaryllidaceae* – G – SA-CO-AT
Su Masongiu, 19.IV.2003; common.
- Potentilla caulescens* subsp. *nebrodensis* (Zimm.) Arrigoni – *Rosaceae* – Ch – SA-SI-ITm
Serra Oseli, 19.X.2002; rare. Arrigoni & al. (1977-1991).
- Ptilostemon casabonae* (L.) Greuter – *Asteraceae* – Ch – SA-CO-AT-H
Upper areas of the Codula, 14.III.2003; very common.
- Ptychotis sardoa* Pignatti & Metlesics – *Apiaceae* – H – SA
Arrigoni & Di Tommaso (1991).

- Ribes sandalioticum* (Arrigoni) Arrigoni – *Saxifragaceae* – NP – SA
 Rio Su Cardu Pintu at its confluence with the Codula, 19.X.2002; extremely rare.
 Note: the presence of this species is probably fortuitous since only one tiny exemplar was noted in a cool area between rocky boulders. Transportation of seeds could be a result of hydrochory and/or pollination by birds.
- Robertia taraxacoides* (Loisel.) DC. – *Asteraceae* – H – SA-CO-SI-ITm
 In the area of Serra Oseli, 07.XI.2003; sporadic.
- Rumex scutatus* subsp. *glaucescens* (Guss.) Brullo, Scelsi & Spampinato – *Polygonaceae* – H – SA-SI-CAL
 In the area of Genna Ostuno, 07.XI.2003; common.
- Santolina insularis* (Gennari ex Fiori) Arrigoni – *Asteraceae* – NP – SA
 Area to the back of Cala Luna, 25.V.2003; extremely rare.
 Note: this represents the lowest altitude locality hitherto discovered.
- Scrophularia trifoliata* L. – *Scrophulariaceae* – H – SA-CO-AT
 Along the whole of the Codula, 19.X.2002; common.
- Seseli bocconi* subsp. *praecox* Gamisans – *Apiaceae* – Ch – SA-CO
 In the area of Monte Pizzigheddu, 01.XI.2002; sporadic. Arrigoni & al. (1977-1991); Arrigoni & Di Tommaso (1991).
- Sesleria insularis* subsp. *barbaricina* Arrigoni – *Poaceae* – H – SA
 Arrigoni & al. (1977-1991).
- Stachys corsica* Pers. – *Lamiaceae* – H – SA-CO
 Confluence of the Rio Ferrarda and the Codula, 08.III.2003; common. Arrigoni & al. (1977-1991).
- Stachys glutinosa* L. – *Lamiaceae* – Ch – SA-CO-AT
 Throughout the area under examination, 08.III.2003; very common. Arrigoni & al. (1977-1991); Arrigoni & Di Tommaso (1991).
- Teucrium marum* L. – *Lamiaceae* – Ch – SA-CO-AT-BL-H
 Throughout the area under examination, 19.IV.03; very common. Arrigoni & Di Tommaso (1991).
- Thesium italicum* A. DC. in DC. – *Santalaceae* – G – SA
 Arrigoni & al. (1977-1991).
- Urtica atrovirens* Requier ex Loisel. – *Urticaceae* – H – SA-CO-AT-BL
 Teletottes and the area to the rear of Cala Luna, 14.II.2003; sporadic.
- Verbascum conocarpum* Moris – *Scrophulariaceae* – H – SA-CO-AT
 Along the road to Teletottes, 01.VI.2003; sporadic. Arrigoni & Di Tommaso (1991).

Conclusions

The floristic list consists of 58 taxa (50 species, 7 sub-species and 1 variety) belonging to 49 genera of 28 families. The most numerous families are: *Asteraceae* (10), *Lamiaceae* (6), *Scrophulariaceae* (4), *Fabaceae* (4) and *Euphorbiaceae* (3). The dominant biological forms, accounting respectively for 36.2 % and 32.8 %, are hemicryptophytes and chamaephytes, whereas 20.4% are geophytes (Tab. 1).

The endemic component is made up as follows: 36.3 % are entities exclusive to

Table 1. Biological spectrum.

Biological form	N° <i>Taxa</i>	%
Hemicryptophytes (H)	21	36.2
Chamaephytes (Ch)	19	32.8
Geophytes (G)	12	20.7
Phanerophytes (P) and Nanophanerophytes (NP)	5	8.6
Therophytes (T)	1	1.7
Total	58	100

Sardinia, while 22.4% have a distribution area including Sardinia and Corsica; a sizeable 12.2% are taxa occurring in Sardinia, Corsica and the Tuscan archipelago; while 8.6% of entities are found in Sardinia, Corsica, the Tuscan archipelago and the Balearic Islands. As shown in Tab. 2, some entities have a wider distribution area which at times includes other specific localities of the Italian peninsula, the island of Crete and the Hyeres islands.

Among the taxa exclusive to Sardinia, we find considerable abundance of chasmophilous flora growing on the rocky walls of the deep crevasses caused by erosion along the Codula. Already Arrigoni, back in 1983, when speaking of the limestone mountains of central eastern Sardinia, highlighted the fact that the great age of the limestone reliefs and the frequency of rocky outcrops have assisted in a long process of floristic evolution which has favoured the origin of several chasmophytes specialised for growth on limestone cliffs.

Table 2. Chorological spectrum (AT = Tuscan archipelago, BL = Balearic Islands, CAL = Calabria, CO = Corsica, Cr = Island of Crete, H = Hyeres Islands, ITm = locality in mainland Italy, SA = Sardinia, SI = Sicily).

Chorological form	N. of <i>Taxa</i>	%
SA	21	36.3
SA-CO	13	22.4
SA-CO-AT	7	12.2
SA-CO-AT-BL	5	8.6
SA-SI	3	5.2
SA-SI-ITm	1	1.7
SA-CO-SI	1	1.7
SA-CO-BL	1	1.7
SA-SI-CAL	1	1.7
SA-CO-SI-ITm	1	1.7
SA-CO-BL-H	1	1.7
SA-CO-BL-Cr	1	1.7
SA-CO-AT-H	1	1.7
SA-CO-AT-BL-H	1	1.7
Total	58	100

Some of these are endemisms exclusive to the limestone habitat and they constitute the element which most differentiates the flora of Sardinia from that of Corsica. A contribution to the high density of endemic flora along the Codula di Luna is also made by the presence of two rock types - sandstone and granite - which allow the settlement of a larger number of species.

During our surveys we observed 24 endemics which were not mentioned in previous works covering Codula di Luna; amongst these, significant importance should be assigned to *Dianthus cyathophorus* Moris, *Ribes sandalioticum* (Arrigoni) Arrigoni and *Santolina insularis* (Gennari ex Fiori) Arrigoni; in particular, the last two are species belonging to mountain vegetation formations as is shown by their rare presence and the absence of extensive populations in the area under study.

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Golfo di Orosei - La parte terminale della "Codula di Luna", seguendo il corso del fiume che sbocca sulla spiaggia di Cala Luna. (Con polarizzatore). Gulf of Orosei - The final part of "Codula di Luna" trekking, following the river as far as Cala Luna Beach (polarized image). vimeo.com/70355157. . Please don't use my images on websites, blogs or other media without my explicit permission. Native to Corsica, Sardinia and Balearic Islands. Golfo di Orosei - Province of Ogliastra (Eastern Sardinia). Cala Goloritz  by Matteo Paolo Tauriello. 3. 3. Golfo di Orosei - Province of Ogliastra (Eastern Sardinia). Cala Goloritz  by Matteo Paolo Tauriello. 2. Genna Silana and Codula di Luna, Urzulei- their long generation time (BACCHETTA & PONTECORVO, 2005). OG), *Morisia monanthos* and *Cerastium palustre* (loc. Mare The therophytes value (Fig. Endemic flora of FRIEDLENDER, A. (1999). Description d'une esp ce nouvelle de *Codula di Luna* (Gulf of Orosei, Central Eastern Sardinia). *colchique* (*Colchicum*, Liliaceae) en Sardaigne: *Colchicum Bocconea* 19: 233-242. *actupii* Fridlender. Bull. Mens. The Gulf of Orosei is located on Sardinia's eastern coast. It is a symmetrical arch extending from Capo Nero on the north to Capo Monte Santo on the south. In their Guida alla Natura della Sardegna (Natural Guide to Sardinia), Fulco Pratesi e Franco Tassi call the Gulf of Orosei "...probably the most beautiful stretch of Italian coast and without a shadow of a doubt, the wildest and steepest." On the bottom of the codula is a stream, often dry in summer: along its banks or sides, beautiful oleander and elder gorges extend down to the beach, as at Cala Luna. The Gulf of Orosei is the seafront of the Supramonte: a vast, wild mountain region full of woods and lunar landscapes.