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The genus Romulea in Italy: taxonomy, ecology and intraspecific variation in relation to the flora of Western Mediterranean islands.

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Abstract
Studies about genus *Romulea* underlined how this is a critical group of the Italian flora. This genus is characterized by an high level of polymorphism caused mainly by hybridization, polyploidy and peculiar climatic/edaphic conditions. In Italy are currently recognized to be 12 taxa, while 16 in the main west Mediterranean insular systems. Among them, Sardinia has the higher richness with 10 entities, followed by Corsica (8), Sicily (6), Tuscan Archipelago (5), Maltese Archipelago (5) and Balearic islands (3). Nowadays analyses about pollen, stigmas and stomata morphology, karyology and molecular biology are still in progress, in order to product a phylogentic study of this genus in Italy and to attempt solving some taxonomical doubts.

Key words: islands, phytogeography, *Romulea*, Western Mediterranean, flora.

Riassunto
Le ricerche sul genere *Romulea* hanno evidenziato come si tratti di un gruppo critico della flora italiana. Tale genere è contraddistinto da elevato grado di polimorfismo causato principalmente da fenomeni di ibridazione, poliploidia e adattamenti a particolari condizioni climatiche e/o edafiche. Allo stato attuale in Italia sono conosciuti 12 taxa, mentre sono 16 nei principali sistemi insulari del Mediterraneo occidentale. Tra questi, la Sardegna è quello che presenta la maggior ricchezza con 10 entità, seguita dalla Corsica (8), dalla Sicilia (6), l'Arcipelago toscano (5), quello maltese (5) e le isole Baleari (3). Attualmente sono in corso analisi riguardanti la morfologia pollinica, stigmatica e stomatica, la cariologia e la biologia molecolare al fine di produrre uno studio filogenetico del genere in Italia e tentare di risolvere alcuni dubbi tassonomici.

Parole chiave: isole, fitogeografia, *Romulea*, Mediterraneo occidentale, flora.

Introduction

The genus *Romulea* Maratti (family *Iridaceae* Juss.) was stated by Maratti (1772) on the basis of a species found in the surroundings of Rome and included at first in the genus *Crocus* L. and then in the genus *Ixia* L. A very patchy area of distribution and evident differentiation centres are shown by this genus; the first of them is situated in the Sub-Saharian Africa, Socotra and Arabian Peninsula where more than 70 species of *Romulea* occur; the second (about 20 species), comprises the South Mediterranean Province and the Atlantic European Province in the Holarctic kingdom, according to the phytogeographical synthesis of Takhtajan (1986) (Béguinot, 1907; 1908; 1909; Marais, 1980; Manning & Goldblatt, 2001).

Although some studies on Mediterranean species of *Romulea* are published, no accurate or exhaustive revisions of the Euro-Mediterranean species are available at present. We present an overview about the taxonomic researches of this genus in Italy and in the principal insular systems of the Western Mediterranean and his intraspecific variation in particular.

The genus *Romulea* in Italy

The distribution of genus *Romulea* in Italy seems to be related to the Mediterranean climate. In fact the *Romulea* genus results to be more spread in Italian regions with typically Mediterranean climate, with mild winters and hot, dry summers, and autumn-spring rainfall.

These conditions are particularly frequent in the coastal areas of the north and central regions of the Tyrrhenian sector and along the coasts of Adriatic sea; anyway, the most suitable climatic conditions for this genus are located in southern regions and in the islands, and in fact the species is present in the central and southern regions of the Italian peninsula, particularly in the two main islands (Sicily and Sardinia) and in the smaller insular systems. This genus is instead not found in the northern Italian regions with strong continental climate (Val d'Aosta, Piedmont, Lombardy, Friuli-Venezia Giulia, Trentino-Alto Adige and Veneto) (Conti *et al*., 2005; 2006; Frignani & Iiriti, 2008).

In succession, for every species found in Italy (Fig. 2-3) is provided a brief description of ecological and

phytosociological features and the indication of rarity in the single regions using the following abbreviations: vr = very rare; r = rare; c = common; vc = very common.

Romulea bocchierii Frignani & Iiriti

Endemic to SE Sardinia where only a population is known; this species grows in humid meadows (700-800 m a.s.l.).

Distribution in Italy: SE Sardinia (rr), on mountain massif of "Sette Fratelli" (Sarrabus).

Romulea bulbocodium (L.) Sebast. & Mauri

Species with wide distribution, spreads also in numerous European countries and in north Africa. It lives on arid grasslands, clearings and woodlands between 0 and 1200 meters a.s.l.

Distribution in Italy: Liguria (c), Tuscany (c) and Tuscan Archipelago (r), Marche (vr), Umbria (c), Abruzzo (c), Molise (c), Latium (c), Campania (c), Apulia (c), Basilicata (c), Calabria (c), Sicily (c), Sardinia (vr).

Romulea columnae subsp. *columnae* Sebast. & Mauri

Species with wide distribution, that lives on arid grasslands, clearings and pastures between 0 and 1400 meters a.s.l.

Distribution in Italy: Liguria (c), Tuscany (c) and Tuscan Archipelago (r), Marche (c), Umbria (c), Abruzzi (r), Molise (c), Latium (c), Campania (c), Apulia (c), Basilicata (c), Calabria (c), Sicily (c), Sardinia (vc).

Romulea ligustica Parl.

In Italy is present only in Liguria and Sardinia; it can be found on arid grasslands, clearings and woodlands between 0 and 1000 meters a.s.l. In west Mediterranean Sea is present also in Corsica (where is rare) and in the North Africa.

Distribution in Italy: Liguria (vr), Sardinia (vc).

Romulea linaresii subsp. *linaresii* Parl.

Endemic to west Sicily, where lives along the coast, on calcareous cliffs, shrublands and grasslands between 0 e 600 m a.s.l.

Distribution in Italy: north-west Sicily (c) and along the Agrigento coast (r).

Romulea ramiflora subsp. *ramiflora* Ten.

This species is present in several regions of the Italian peninsula, in Sicily and in Sardinia, where lives on wet clayey grasslands both along the coasts and the mountain areas, between 0 and 700 m a.s.l.

Distribution in Italy: Liguria (c), Tuscany (c) and Tuscan Archipelago (c), Molise (c), Latium (c), Apulia (r), Basilicata (c), Calabria (r), Sicily (c) e Sardinia (c).

Romulea requienii Parl.

Endemic to Sardinia and Corsica; it grows in clave coastal clearings and internal wet grasslands between 0 and 1200 m a.s.l.. The variety *etrusca* described by Chiarugi (1928; 1929) for the Tuscany coast was not recovered on field.

Distribution in Italy: Sardinia (c).

Romulea revelieri "group" Jord. & Fourr.

Two different entities, presently under study, belong to this group: *R. revelieri* s.s., endemic to Sardinia and Corsica, where lives on wet grasslands temporary flooded, between 0 and 800 m. a.s.l., and the similar *R. insularis* described by Sommier (1898) for the Capraia island in the Tuscan Archipelago; according to Diana (1991) exist some distinctive features that justify the separation between the two species. The recent finding of *R. revelieri* along the Tuscan coast (Arrigoni, 2003), should be referred to individuals with features sensibly different to both *R. revelieri* present in Sardinia and Corsica and *R. insularis* of Capraia island. Studies are still in progress to define the taxonomic position of the *R. revelieri* "group".

Distribution in Italy: Sardinia (r), Tuscany (vr) and Tuscan Archipelago (r).

Romulea rollii Parl.

Coastal species that is present in several regions of Italian peninsula, in Sardinia and in Sicily; it can be found on dunes or on wet sandy soils, between 0 and 50 m a.s.l.

Distribution in Italy: Tuscany (c) and Tuscan Archipelago (r), Abruzzo (r), Molise (r), Latium (r), Campania (c), Apulia (c), Basilicata (r), Calabria (r), Sicily (r), Sardinia (c).

Romulea limbarae Bég.

It was described as endemic to Sardinia after a finding on Monte Limbara (North Sardinia), but it was supposed by several authors (Marais, 1980; Diana Corrias, 1983) the status of natural hybrid. Studies are still in progress to define the taxonomic position of this entity (Frignani *et al*., 2009; Frignani *et* Iiriti, 2009).

Distribution in Italy: Sardinia (r).

Romulea rosea (L.) Eckl.

Exotic species coming from south Africa, found in Italy in Sardinia and Tuscany (Conti *et al*., 2005), while

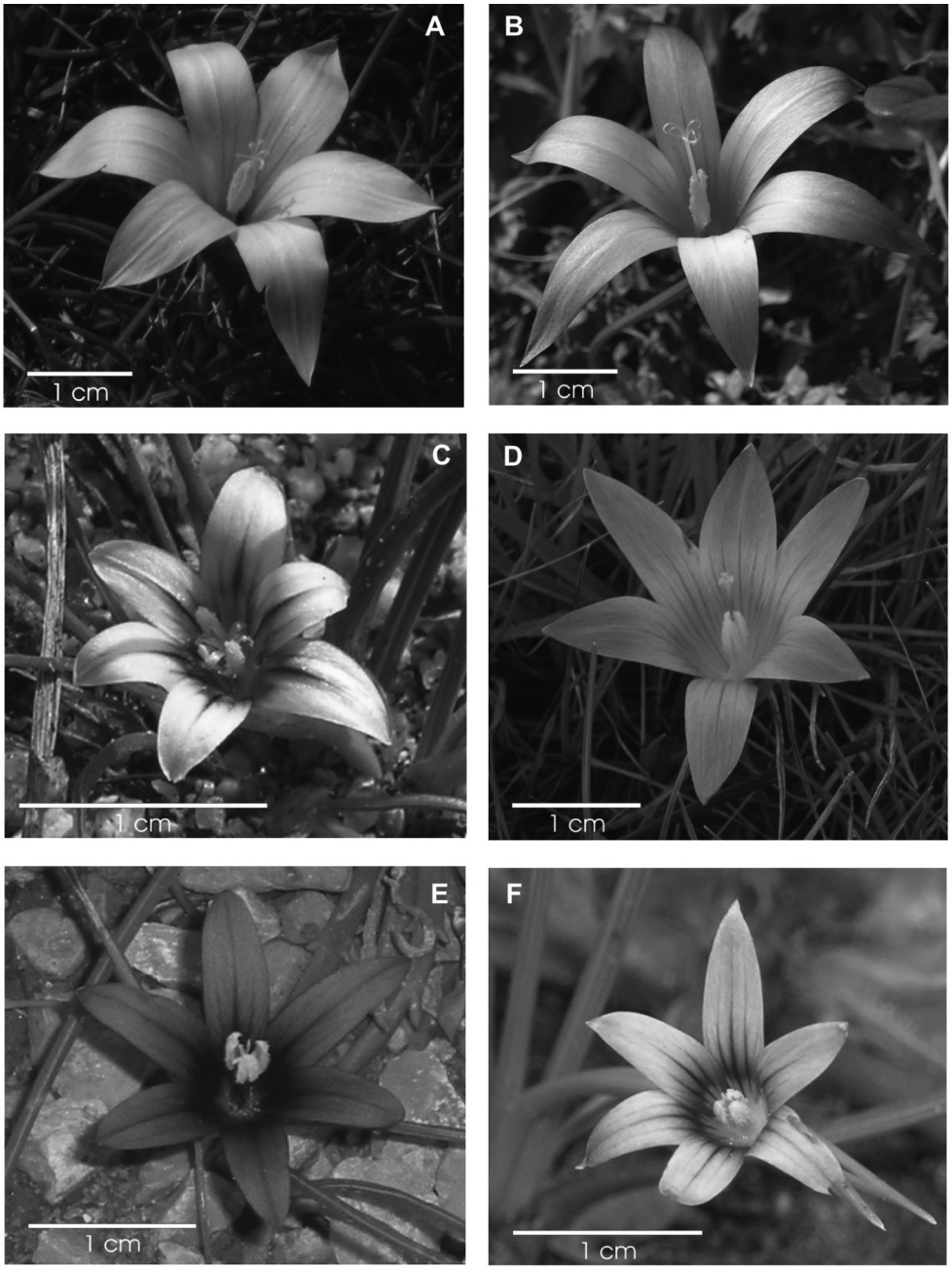

Fig. 1 - Italian species of *Romulea*: A) *R. bocchierii* Frignani & Iiriti; B) *R. bulbocodium* (L.) Sebast. & Mauri; C) *R. columnae* Sebast. & Mauri subsp. *columnae*; D) *R. ligustica* Parl.; E) *R. linaresii* Parl. subsp. *linaresii*; F) *R. ramiflora* Ten. subsp. *ramiflora*.

probably not present in Calabria since the description under the name of *R. purpurescens* (Ten.) Ten. (= *Ixia purpurescens* Ten.) was not made using spontaneous plants but instead on cultivated plants (Peruzzi L., *in verbis*). Also in Sardinia and in Tuscany the finding of this species is becoming more difficult.

Distribution in Italy: Sardinia (vr), Tuscany (vr).

The number of spcies of *Romulea* in Italy was increased by the recent finding of *R. melitensis* Bég. in the south-west sector of Sicily along the rocky coast between Sampieri and Marina di Modica in the province of Ragusa (Brullo *et al*., 2009). This finding is particularly important because not only enriches Sicily of an element until now exclusive only of the Maltese islands, but also results to be a new *taxon* of relevance for the Italian Flora.

The genus *Romulea* in Corsica, Maltese Archipelago and Balearic Archipelago

Studies still in progress have been focused particularly on the main insular (not only Italian) systems of the

Fig. 2 - Italian species of *Romulea*: A) *R. requienii* Parl.; B) *R. revelieri* Jord. & Fourr. s.s. C) *R. rollii* Parl.; D) *R. limbarae* Bég.

central-west Mediterranean basin (Frignani & Iiriti, in press), since these are territories of high interest for the *Romulea* genus (Fig. 3). In fact, in addition to consider the whole Italian territory, comprised the main insular systems as Sicily (25710 km^2), Sardinia (24090 km^2) and Tuscan Archipelago (Elba, Giglio, Capraia, Montecristo, Pianosa, Giannutri, Gorgona), a brief analysis of other insular territories such as Corsica (France), Maltese (United Kingdom) and Balearic Archipelago (Spain) was made, since they have interesting phytogeographical linkages among them and with also the continental territory of west Mediterranean basin.

Corsica

From a biogeographical point of view Corsica (8748 km^2) shows several linkages with Sardinia and with central and northern Italian coasts (mainly Tuscany and Tuscan Archipelago). The genus *Romulea* confirms these linkages; in fact he species present in Corsica (Gamisans *et al*., 1994; Jeanmonod & Gamisans, 2007) are: *R. ligustica*, *R. corsica*, *R. requienii*, *R. ramiflora* subsp. *ramiflora*, *R. columnae* subsp. *columnae*, *R. rolli* and *R. revelieri*. *R. jordani* is considered critical, while the presence of *R. bulbocodium* is excluded. With respect to Italy, the species exclusive of Corsica are *R. corsica* and *R. jordanii*. *R. Corsica* is probably an hybrid between the endemics *R. requienii* and *R. revelieri*: its finding by Mabille was in fact in the neighbourhood of the salt mines of Porto Vecchio, along the oriental coast, where there is an overlap of the populations of the two parental species (Jeanmonod & Gamisans, 2007). The perianth shows an intermediate dimension between the two species, the stylus is similar to *R. requienii*, while the greenish veins in outside tepals can be related to *R. revelieri*. About *R. jordanii,* it was described by Béguinot (1907) from an *exsiccatum* of Baeyer ("*ad litora prope Scudo*"). Now in the *locus classicus* it is no longer present, since the area is highly impacted by human activities, while it was recently found in the south part of Corsica (Jeanmonod & Gamisans, 2007).

Maltese Archipelago

Maltese Archipelago is composed by the two main islands of Malta and Gozo, in addition to some smaller

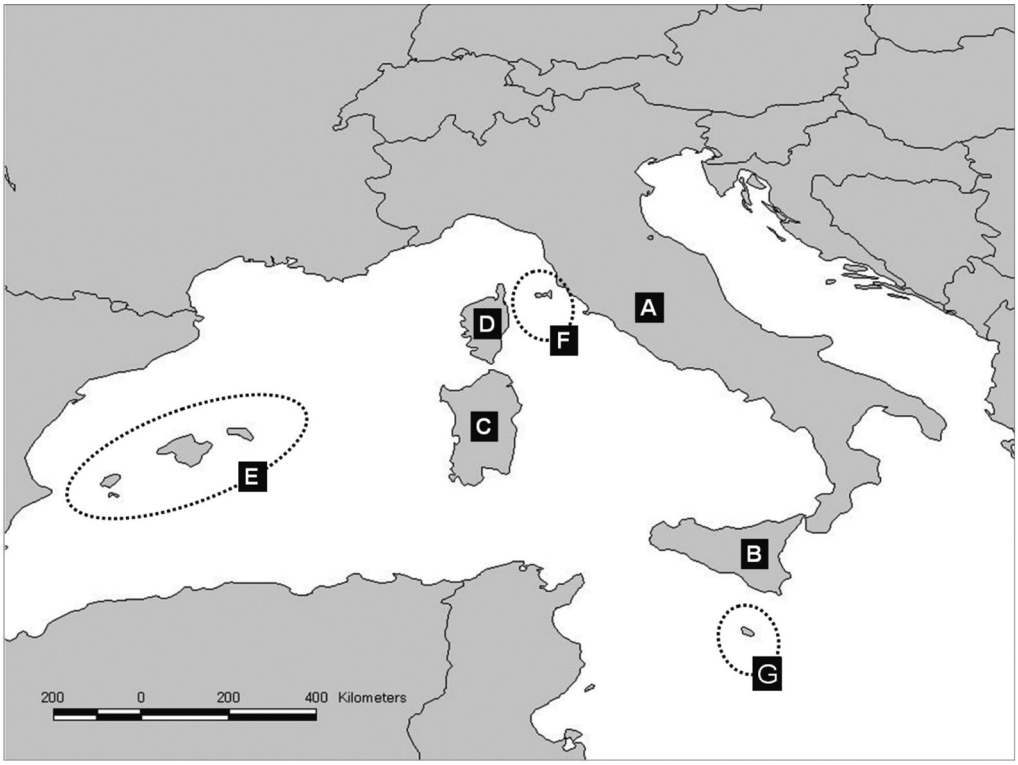

Fig. 3 - Peninsular Italy (A) and insular systems in the central-west Mediterranean basin here considered: Sicily (B), Sardinia (C), Corsica (D), Balearic Archipelago (E), Tuscan Archipelago (F) and Maltese Archipelago (G).

islands such as Comino, all made up by Miocene limestones. It has a lot of geomorphical and structural similarities with Sicily and Lampedusa island. The floristic affinities between the Maltese and Sicilian territories are underlined also by the *Romulea* genus, since all the species that are present in the Maltese Archipelago are present as well in Sicily; among these species there is also *R. melitensis,* until now exclusive of the Maltese Archipelago. The other species that are present in these islands are: *R. bulbocodium, R. columnae* subsp. *columnae*, *R. rolli* and *R. ramiflora* subsp. *ramiflora*.

Balearic Archipelago

The Balearic Archipelago (Maiorca, Minorca, Ibiza, Formentera are the main islands), located in the west sector of the Mediterranean Sea, between Spain and Sardinia, shows many floristic similarities with these territories. *Romulea* genus in these islands is less numerous with respect to other insular territories of west Mediterranean. It is probably that in the past it would be more numerous and its reduction was caused by high atrophic impact on the principal islands of the archipelago.

Romulea genus in the Balearic Archipelago is represented by the following *taxa*: *R. columnae* subsp. *columnae*, *R. columnae* subsp. *columnae* var. *immaculata*, *R. columnae* subsp. *assumptionis*.

Discussion

In Italy there are at present 12 species belonging to the *Romulea* genus, among which an alien (*R. rosea*) and one hybrid (*R. limbarae*). In the Italian insular systems (Sicily, Sardinia and Tuscan Archipelago) are present all the species that are present also in the peninsular territories, while some are endemics and exclusive of islands. After the studies (that are still in progress) about the group of *R. revelieri*, the number of species of this genus in Italy could undergo some changes.

Taking into account the other main insular systems of west Mediterranean Sea (Corsica, Balearic and Maltese Archipelago), the total number of *taxa* is 16. Among the insular systems of west Mediterranean Sea, Sardinia is the one with the higher number of *taxa* (10), followed by Corsica (8), Sicily (6), Tuscan and Maltese Archipelagos (5), Balearic islands (3) (Tab. 1).

Among the different islands and insular systems of west Mediterranean sea, Sardinia resulted to be the more interesting, since it has all the Italian species unless *R. linaresii* subsp. *linaresii* that is endemic to Sicily. *R. bocchierii* e *R. limbarae* are exclusive of Sardinia, while the position of the entities of the *R. revelieri* group is still to define.

With respect to the other insular territories, Sardinia lacks of the endemics and hybrid elements that

Taxa	Si	Sa	Co	TA	MA	BA
Romulea bocchierii Frignani & Iiriti		X				
Romulea bulbocodium (L.) Sebast. & Mauri	X	X		X	X	
Romulea columnae Sebast. & Mauri subsp. *columnae*	X	X	X	X	X	X
R. columnae Sebast. & Mauri subsp. *columnae* var. *immaculata* Maire						X
R. columnae Sebast. & Mauri subsp. *assumptionis* (Garc. Ft.) O. Bolòs *et al*.						X
Romulea corsica Jord. & Fourr.			X			
Romulea ligustica Parl.		X	X			
Romulea linaresii Parl. subsp. *linaresii*	X					
Romulea melitensis Bég.	X				X	
Romulea ramiflora Ten. subsp. *ramiflora*	X	X	X	X	X	
Romulea requienii Parl.		X	X			
Romulea revelieri Jord. & Fourr. "group"		X	X	X		
Romulea rollii Parl.	X	X	X	X	X	
Romulea rosea (L.) Eckl.		X				
Romulea limbarae Bég.		X				
Romulea jordanii Bég.			X			

Tab. 1 - Checklist of *taxa* of *Romulea* that are present in the insular territories of west Mediterranean Sea (Si=Sicily; Sa=Sardinia; Co=Corsica; TA=Tuscan Archipelago; MA=Maltese Archipelago; BA=Balearic Archipelago).

characterize the other insular territories, such as *R. corsica*, *R. jordanii* exclusive of Corsica, *R. linaresii* subsp. *linaresii* endemic to Sicily, *R. melitensis,* that was known to be only in Maltese Archipelago and instead have been recently found in south west Sicily, *R. columnae* subsp. *columnae* var. *immaculata* and *R. columnae* subsp. *assumptionis,* that are present in Balearic islands.

Relatively to the wide distribution *taxa* that are present in the peninsular Italy and in the west Mediterranean insular systems, very peculiar resulted to be the distribution of *R. bulbocodium*. This entity is in fact present in Tuscan Archipelago and in Sicily, two insular systems that, from a paleogeographical point of view, had linkages with the Italian peninsula where the species is widely spread. This species is not present in Corsica (Gamisans *et al*., 1994; Jeanmonod & Gamisans, 2007), while in Sardinia is present only in Gallura (N Sardinia), with sporadic populations confined in small clearings of woods of cork oak (*Quercus suber* L.), or along the waysides. His presence in Sardinia was excluded by Bèguinot (1905; 1908), and it was not reported also by Pignatti (1982). Probably the limited spread of *R. bulbocodium* should be linked to the wide distribution of *R. ligustica,* one of the most spread *taxa* in Sardinia (Frignani & Iiriti, 2007), that is instead rare in Corsica. Other species such as *R. columnae* subsp. *columnae*, *R. rollii*, *R. ramiflora* subsp. *ramiflora* are widely present not only in the insular systems considered, but also in the circumediterranean lands of both the west and the east sectors. Also *R. bulbocodium* resulted to be widely distributed in the eastern sector of the Mediterranean basin and in north Africa.

In Balearic islands *R. columnae* subsp. *columnae* is present with the *assumptionis* subspecies and *immaculata* variety, two *taxa* that are present along the Spanish coasts, but not still founded in other territories of west Mediterranean basin.

Polymorphism

The genus *Romulea* is distinguished from other genera of the *Iridaceae* family by its high degree of polymorphism and intraspecific variability (Frignani & Iiriti, 2008). The main critical situations emerged in this genus are: i) hybridization ii) polyploidy iii) tendency to create population with particular morphological adaptations to climatic and edaphic conditions.

Hybridization

In *Romulea* genus hybridization is quite frequent, so mach so many *taxa* described in the past as new species, later revealed to be not fixed hybrids. Examples are some individuals collected along the Sardinian coasts in which the overlap of *R. columnae*, *R. ligustica, R. ramiflora*, *R. rolli* and *R. requienii* originates individuals with intermediate habitus, and some species of the Corsica as *R.* x *jordanii* and *R. corsica*. A particular mention has to be made for the case of *R. limbarae,* described as endemic to Monte Limbara in Sardinia (Béguinot 1907) but sporadically found also in other areas always together with populations of *R. ligustica* and *R. requienii*. In these entities, nevertheless the hybrid origin can be positively determined (Tutin *et al*., 1964-1980; Pignatti, 1982; Diana Corrias, 1983), often can be observed an high intraspecific variability and the lack of pure populations. Other

cases of presumed hybridization were observed in Sicily, where wide spread populations, particularly of *R. columnae* and *R. bulbocodium,* sometimes overlap with *R. linaresii* subsp. *linaresii* thus creating individuals with intermediate features. It cannot be excluded that the specimens of *R. bulbocodium* with entirely violet tepals often found in populations of the south-west Sicily, could be due to hybridization with the Sicilian endemism. Anyway, it is not simple to define the status of hybrid from a single individual, but it is certain that specimens coming from areas where two or more entities coexist can show intermediate characters, thus creating identification troubles.

Polyploidy

Karyological studies that are still in progress concerned until now some wide distribution species (*R. bulbocodium*, *R. columnae* e *R. rollii*) and are based on material collected in Sardinia and Tuscany. The first analysis revealed a partial discordance with respect to what found in literature and different chromosome numbers have been highlighted for *R. columnae* in Tuscan Archipelago, continental Tuscany and Sardinia (Frignani *et al*., 2009).

Adaptations to climatic and edaphic conditions

By the analyses of several herbarium specimens and field observations, it can be observed an high variability in both morphological and phenological features, often leading to perplexity and wrong identifications. In the same population we can in fact observe individuals where the length of the stylus can be smaller, bigger or equal to that of anthers, with variable dimension of flowers; the tepals can take variable colors; often can be observed androsterile individuals with fully white tepals. Also the leaves are quite variable: arid condition tend to support leaves short and/or appressed to the ground, while in individuals growing in the shadow or in wet substrates the leaves tend to be erect and slender.

On the basis of what has been said above, it is easy to understand that a detailed study should be carried out on all those species growing in the Mediterranean and Atlantic area; for this reason the following studies are at the stage of completion:

a) pollen, stigmas and stomata morphology: Observations of stigmas laciniae, pollen, stomata disposition and morphology in the leaves were made using the optical microscope and the SEM. The SEM images of pollen show monosulcate and finely punctuate grains (Ciampolini & Cresti, 1981; Iiriti *et al*., 2007). There are differences in form and dimension among the species, as relieved also by stomata arrangement, that in all the species are always embedded in the four leaf ridges. The stigmas is divided in three bifurcate laciniae, each of them is provided of many cylindrical papillae; the form and length of laciniae besides the order and morphology of papillae resulted to be good diagnostic features.

b) leaf anatomy: according to Bèguinot (1907), we are studying the disposition of vascular bundles in the leaves of specimens both collected in nature and cultivated in the Botanical Gardens of Siena and Cagliari. Particularly, first results show that this feature can allow an easy distinction among the entities of *R. revelieri* group, still *sub-judice*.

c) definition of the distribution in Italy: from the control of *exsiccata* preserved in the main Italian herbaria and from data of floristical studies, it will started the editing of distributional maps for every single species, underlying – if necessary – the presence of risks for the conservation.

Conclusions

At the end of this brief text about *Romulea* genus in Italy and in the main insular systems of west Mediterranean basin, the partial results show and confirm that it is a critical genus of the Italian flora. The criticalities underlined mainly regarded hybridization, polyploidy and the adaptations to the climatic and edaphic conditions, that confer to the genus an high polymorphism. For this reason, many investigation were required relatively to pollen, stigmas, stomata and leaf morphology, with the aim to solve some problems that could lead to the definition of new *taxa*. In addition to the morphological analyses, essentials for the determination of the entity belonging to the genus, are also still in progress the karyology and molecular biology, whose results will be fundamental to understand the linkages among the different *taxa* in the case of hybridization or in the phytogeographical relations among different populations of the same species, as in the case reported above of *R. revelieri* group.

The phytogeographical study of the genus results particularly interesting since underlies, for the high number of entities, the centrality of the insular systems of west Mediterranean basin (particularly Sardinia, Sicily, Corsica and Tuscan Archipelago) about the genetic exchanges among different populations, hybridizations and speciations.

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