Limonium korakonisicum (Plumbaginaceae), a new species from Zakynthos Island (Ionian Islands, Greece)

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Abstract

Limonium korakonisicum (Plumbaginaceae), a new species from Zakynthos Island (Ionian Islands, Greece), is described and illustrated from the only known population (locality Korakonisi) located in the southwestern coast of the island. The hexaploid chromosome number (2n=6x=51), the karyotype and the self-incompatible pollen-stigma combination A (‘A’pollen and ‘Cob’ stigma), support that L. korakonisicum is an apomictic taxon originated through hybridization. This new taxon is related to the polyploid apomictic Limonium species which are prevalent in the Aegean area and especially to the recently described Cytherian endemic L. spreitzenhoferi Erben & Brullo. The morphological differences of L. korakonisicum from L. spreitzenhoferi as well as from the sexual diploid endemic L. phitosianum, which coexists at the same locality, are discussed. Data on the ecology and conservation status of the new species are also given.

Key words: Apomictic, breeding systems, endemic, Greek flora, Ionian Islands, karyology, taxonomy

Introduction

Limonium Miller (1754: 1328) is the largest and the most widespread genus of the Plumbaginaceae family including 400–500 species (Palacios & González-Candelas 1997, Aparicio 2005, Brullo & Erben in press). The center of diversity is the Mediterranean basin (Cowan et al. 1998, Lledó et al. 2003, Palacios et al. 2000). The high taxonomic diversity and complexity of Limonium in the Mediterranean area is mainly due to its reproductive behaviour, i.e. the occurrence of both sexual and apomictic reproduction, as well as to the frequent occurrence of hybridization and polyploidy (Georgakopoulou et al. 2006). Thus, species delimitation in the genus is often a difficult task (Richards et al. 1996). This has as consequence the formation of numerous “microspecies” with local distribution.

In Greece, especially in the Aegean area, where a great number of islands and islets occurs, Limonium is represented by an high number of species. During the last 15 years, several taxonomic studies were published, increasing the number of endemic species in Greece (e.g. Artelari & Kamari 2000, Brullo & Guarino 2000, Crespo & Pena-Martín 2013). Dimopoulos et al. (2013), based in a recent paper of Brullo & Erben (in press), report 87 Limonium species most of them (79 species, 90.8%) endemic to Greece.


Four species of Limonium were known to occur in the island of Zakynthos: L. phitosianum R.Artelari (1984b: 430) and L. zacynthium R.Artelari (1984b: 429), exclusively endemic to the island, L. brevipetiolutum R.Artelari & Erben (1986: 507) endemic to W-Greece (Kerkyra, Lefkada, Kefalonia, Zakynthos, and W coast of Peloponnisos), and L.
virgatum Fourreau (1869: 41) widespread in the Mediterranean area. It is important to mention that monitoring for the two exclusively endemic taxa (*L. phitosianum* and *L. zacynthium*) has been carried out to evaluate their conservation status (Valli 2013). In September 2014, during a field investigation on Zakynthos in the southwestern coast of the island, on the locality Korakonisi a single, very interesting *Limonium* population was found. Morphological and cytological study of this population revealed that it is well differentiated and belongs to a different taxon here described as a new species for science.

**FIGURE 1.** Distribution map of sexual diploid Ionian endemic species with 2n=18 (●) and of apomictic polyploid species with 2n=34, 42, 43, 51 and 52 (◎) in Greece. Symbols represent populations in which the chromosome numbers have been counted.

**Material and methods**

This study is based on ten living plants collected from the only one *Limonium* population of the island of Zakynthos during the September of 2014 and on field observations (Fig. 2). This population was repeatedly visited for the estimation of its extention and size and for collecting mature seeds. Additionally, digital images of specimens from herbarium B as well as herbarium specimens from UPA were examined as comparative material. Voucher specimens are kept in the Herbarium UPA (acronym according to Thiers 2014+).

For the cytological study 70 seeds were germinated in Petri dishes on moistened filter paper and root tips were pretreated according to the method described in Artelari (1984a) and Artelari & Kamari (1986), while 15 metaphase plates were analyzed.

For assessing the reproductive mechanism, all reproductive mature individuals of the population were examined. Pollen and stigma type combination of the flowers were determined according to Erben (1978, 1979) and Artelari & Kamari (1986). The pollen stainability was estimated by using cotton blue as described in Artelari & Kamari (1986).
RESULTS AND DISCUSSION

Limonium korakonisicum R. Artelari & Valli sp. nov.

Type:—GREECE, Ionian Island: Zakynthos, locality Korakonisi, 37°43′08″N, 20°43′48″E, on calcareous maritime cliffs and rocks, 10 m a.s.l., 14 September 2014, leg. A.-Th. Valli no 1200 (holotype UPA!; isotype B!) (Figs. 3–4)
**FIGURE 4.** Limonium korakonisicum R.Artelari & Valli. 


**Diagnosis:**—Planta perennis, glabra, griseo-viridis, 9–25 cm alta, foliis rosulatis, densis, pulviniformis, 3.0–29.0 × (0.15–)0.3–0.6(–0.7) mm, oblanceolatis-spathulatis, obtusis, rugosis ad verrucosis, mucronulatis, 1-nervis, caulibus paucis, valde fragilis, plerumque non ramosis, scabridis, interdum proliferis, ramos sterilibus absentibus vel solo 1–3 per caulem, spicis (1–)2–6.5(–7.0) cm longis, spiculis 7–9 mm longis, (1–)2–5(–6)-floris, ad 2–4(–5) in 1 centimetro dispositis, bractea inferiore 2.0–2.9 × 1.2–2.0 mm, triangulari-ovata, apice acuta, bractea media 2.7–3.4 × 1.0–2.0 mm, bractea superiore 6.0–7.5 × 3.0–4.0 mm, obovato-elliptica, apice obtusa, margine late membranaceo, calyce (5.0–)6.0–7.0 mm longo, ex bractea superiore 1.5–2.0 mm exserto, tubo glabro vel sparsim piloso, lobis calycis 0.6–0.7 mm, acutis.

**Description:**—Perennial plant, 9–25 cm tall, glabrous, with very few and very fragile grey-green stems. Leaves 3–29 × (0.15–)0.3–0.6 (–0.7) mm on numerous small rosettes gathered to a very dense cushion-like formation up to 50 cm in diameter, uppermost leaves green at anthesis, lowermost ones brown and persistent after withering, oblanceolate-spathulate, fleshy, grey-green, flat or sometimes v-shaped in cross-section, rugose to verrucate, obtuse, without revolute margins, mucronulate with a mucro ca. 0.1 mm long sometimes curved backwards, with one central nerve, gradually tapering into a petiole shorter than lamina. Stems erect, scabrid, usually unbranched, when branched the branches begin almost from the base and form an acute angle; the branches sometimes proliferous (with small leaf rosettes); sterile branches absent or only 1–3 per stem. Inflorescence corymbose, with very fragile segments. Spikes (1.0–)2.0–6.5(–7.0) cm long, erect or slightly curved. Spikelets 7–9 mm long, composed of (1–)2–5(–6) flowers, 2–4(–5) per cm. Outer bract 2.0–2.9 × 1.2–2.0 mm, glabrous, triangular-ovate, acute, with a broad membranous margin, central part fleshy, brown, forming a point 0.4–0.5 mm. Middle bract 2.7–3.4 × 1.0–2.0 mm, glabrous, elliptical, hyaline-membranous. Inner bract 6.0–7.5 × 3.0–4.0 mm, glabrous, obovate-elliptic, obtuse, with a narrow membranous margin 0.4–0.5 mm wide; central part fleshy, forming a point 0.9–1.1 mm. Calyx (5.0–)6.0–7.0 mm long, exceeding the inner bract 1.5–2.0 mm; calyx tube glabrous or sometimes sparsely hairy; calyx lobes 0.6–0.7 mm, acute. Corolla pale lilac to white.

**Etymology:**—The specific epithet refers to Korakonisi, the type locality at the southwestern coast of the island of Zakynthos (Fig. 2).
Ecology and distribution:—*Limonium korakonisicum* is currently known only from the type locality in Korakonisi area (South-Western Zakynthos Island). Korakonisi is an isolated rock connected to the main island by a narrow land-bridge and it is characterized by impressive geological formations (Fig. 5A). The species forms a small population, which includes 100 individuals (complete census), while the 67 of them are mature (Fig. 6) according to IUCN definition (IUCN Standards and Petitions Subcommittee 2014). Flowering from August to October, fruiting from September to November. *L. korakonisicum* seems to be extremely restricted, a common feature among several agamospermus taxa, especially in the genus *Limonium* (Brullo & Pavone 1981, Artelari & Georgiou 1999). However, its occurrence in the neighbouring inaccessible rocks must not be excluded.

*FIGURE 5.* Habitat and morphological features of *Limonium korakonisicum*. A. Locality Korakonisi. B. A typical individual. C. The two local endemic taxa *L. korakonisicum* (left) and *L. phitosianum* (right) intermingled. D. spikes, spikelets and flower of *L. korakonisicum*. E. A detail of the flower. F. Grey-green leaves.

*Limonium korakonisicum* (Fig. 5B, D, E & F) grows in crevices of high, calcareous, sunny maritime cliffs and rocks with terra rossa, at an altitude of about 10 m a.s.l., together with another endemic *Limonium phitosianum*. *L. phitosianum* forms a larger population in the area of Korakonisi which includes 245 individuals, 183 (74.7%) of them are mature. The two local endemic *Limonium* taxa not only coexist but sometimes are intermingled, producing an amazing sight (Fig. 5C).

Other cohabiting taxa in the area are *Crithmum maritimum* L., *Hypericum aegypticum* L. subsp. *webbii* (Spach) N. Robson and *Sarcocornia fruticosa* (L.) A. J. Scott.

**Conservation status:**—According to IUCN (2014), *Limonium korakonisicum* fulfills Criterion D, mainly due to its very limited expansion/restricted distribution (Extent of Occurrence less than 100 km² and Area of Occupancy less than 10 km²), as well as its low number of mature individuals (less than 250). Thus, is here assessed as Endangered (EN). Moreover, in case of further touristic development in the area in the future, the species may be classified as Critically Endangered (CR). All the above reasons necessitate the long term monitoring of *L. korakonisicum*. Long term monitoring is essential so that required management measures can be taken to ensure the survivability of the species.
**Taxonomic relationships:**—*Limonium korakonisicum* belongs to the subgenus *Limonium* (sensu Lledó et al. 2005). It is well differentiated from the group of the sexual diploid Ionian endemics with $2n=18$, which dominate in the Ionian Islands and the western coasts of the Greek mainland (Fig. 1), as well as from all the other *Limonium* taxa which are known so far from the same area. On the contrary, it is related to the polyploid apomorphic *Limonium* species occurring in the Aegean area and the eastern coasts of the Greek mainland (Fig. 1). Among them, *L. korakonisicum* is more closely related to the recently described Cytherian endemic *L. spreitzenhoferi* Erben & Brullo (Brullo & Erben in press). *L. spreitzenhoferi* has as type a specimen of G.C. Spreitzenhofer (Iter Jonicum IV num. 18: Cerigo, auf den Felsen bei den Häusern im Hafen von Kapsali, 15 June 1880, holotype B photo! no. 10-0294995), which as it seems from the label, was originally identified as *Statice sieberi* Boiss. Based on this, material which we have collected from the same locality of Kithira Island treated in a previous paper as *L. sieberi* Kunze (Artelari & Georgiou 2003: 495) is considered now as *L. spreitzenhoferi*. From the morphological point of view *L. korakonisicum* (Fig. 5B, D, E & F) clearly differs from *L. spreitzenhoferi* in having leaves on numerous small rosettes gathered to a very dense cushion-like formation up to 50 cm in diameter, fewer and very fragile stems all of them reaching at about the same height, denser spikes, shorter spikelets with more flowers per spikelet, as well as shorter outer bracts and calyces.

![FIGURE 6](image_url). Population structure of *Limonium korakonisicum*.

The coexisting species in the area, *L. phitosianum*, also has small leaf rosettes gathered to dense cushion-like formations which are much smaller (not more than 20 cm) than those of *L. korakonisicum*. The two taxa are readily distinguished (Fig. 5C) as *L. korakonisicum* has grey-green stems, grey-green leaves without revolute margins and with petiole shorter than lamina, segments of the inflorescence not articulate, fewer sterile branches, longer spikes and spikelets, shorter outer and middle bracts, longer and obtuse inner bracts, and shorter calyx lobes. Furthermore, *L. korakonisicum* is found to be an apomictic polyploid species with $2n=6x=51$ (see cytology and breeding system below), while *L. phitosianum* is a sexual diploid with $2n=2x=18$. The main morphological diagnostic characters of *L. korakonisicum*, *L. spreitzenhoferi* and *L. phitosianum* are given in Table 1.

**Chromosome number:**—$2n=6x=51$

**Cytology and breeding system:**—*Limonium korakonisicum* was found to be hexaploid with $2n=6x=51$. The karyotype (Fig. 7) possesses three long metacentric ‘marker’ chromosomes which, according to Erben (1978, 1979) are characteristic for the karyotypes of the taxa of the subgenus *Limonium* with the basic number $x=8$ and are missing in the taxa with $x=9$. Their occurrence indicates that the above chromosome number derived from the combination of $3 \times 8 + 3 \times 9$ genomes (Erben 1978, 1979), therefore it can be assumed that *L. korakonisicum* has a hybrid origin.

The study of breeding system of *L. korakonisicum* was carried out on all 67 mature individuals of the known population of the species. The analysis of pollen and stigma combinations revealed that the population of this taxon is monomorphic. All studied plants have the self-incompatible ‘A’ combination, i.e. ‘A’pollen and ‘Cob’ stigma (Baker 1948, 1953, Erben 1978, 1979) indicating self-sterility. Pollen stainability values are very low (0–2%) and pollen grains are irregular in size. Stainable pollen grains are well-shaped and much larger than the unstainable ones, which are small and misshaped. Such pollen and stigma features characterize apomictic species (Baker 1953). Although pollen stainability values are very low, relative reproductive success (RRS) of the species is high enough (75.6%). RRS
is defined as the percentage of all ovules maturing into seeds (Wiens 1984). The above data together with the hexaploid chromosome number support that *L. korakonisicum* is an apomictic species.

### TABLE 1. Main morphological diagnostic characters of *L. korakonisicum*, *L. spreitzenhoferi* and *L. phitosianum* (measurements in mm).

<table>
<thead>
<tr>
<th>Character</th>
<th><em>L. korakonisicum</em></th>
<th><em>L. spreitzenhoferi</em></th>
<th><em>L. phitosianum</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf size</td>
<td>3.0−29.0 × (0.15−)0.3−0.6(−0.7)</td>
<td>12−35 × 4−7</td>
<td>6.5−30 × 2.5−6.5</td>
</tr>
<tr>
<td>Leaf shape</td>
<td>oblongate-spathulate, without revolute margins</td>
<td>oblongate-subspathulate, without revolute margins</td>
<td>spatulate-oblongate, with revolute margins</td>
</tr>
<tr>
<td>Leaf apex</td>
<td>mucronate</td>
<td>rounded</td>
<td>obtuse, sometimes emarginate</td>
</tr>
<tr>
<td>Leaves on numerous small rosettes gathered to a cushion like formation</td>
<td>yes, with the formation reaching up to 50 cm in diameter</td>
<td>no</td>
<td>yes, with the formation reaching up to 20 cm in diameter</td>
</tr>
<tr>
<td>Sterile branches/individual</td>
<td>0−3</td>
<td>0−2</td>
<td>numerous</td>
</tr>
<tr>
<td>Spike length</td>
<td>(10−)20−65(−70)</td>
<td>(20)−40−100</td>
<td>0.7−10.0</td>
</tr>
<tr>
<td>Spikelet length</td>
<td>7.0−9.0</td>
<td>8.5−10.0</td>
<td>6.0−7.0</td>
</tr>
<tr>
<td>Spikelets per cm</td>
<td>2−4(−5)</td>
<td>1−2</td>
<td>2−4(−6)</td>
</tr>
<tr>
<td>Outer bract length</td>
<td>2.0−2.9</td>
<td>3.0−3.6</td>
<td>1.0−1.8(−2.0)</td>
</tr>
<tr>
<td>Middle bract length</td>
<td>2.7−3.4</td>
<td>3.0−4.0</td>
<td>(1.7−)1.9−2.6</td>
</tr>
<tr>
<td>Inner bract length</td>
<td>6.0−7.5</td>
<td>6.5−7.5</td>
<td>(3.7−)4.0−5.0(−5.7)</td>
</tr>
<tr>
<td>Inner bract shape</td>
<td>oblong-elliptic, obtuse</td>
<td>oblong-obovate, obtuse</td>
<td>elliptic, slightly curved, slightly acute to acute</td>
</tr>
<tr>
<td>Calyx length</td>
<td>(5.0−)6.0−7.0</td>
<td>7.0−8.0</td>
<td>5.0−5.8(−6.0)</td>
</tr>
<tr>
<td>Calyx indumentum</td>
<td>glabrous/ sometimes sparsely hairy</td>
<td>glabrous</td>
<td>very sparsely hairy</td>
</tr>
<tr>
<td>Calyx limb</td>
<td>slightly lacerate after anthesis</td>
<td>not or slightly lacerate after anthesis</td>
<td>lacerate after anthesis</td>
</tr>
</tbody>
</table>

It is important to note here the discovery, for the first time in the Ionian area, of an apomictic polyploid taxon with a chromosome number derived from the combination of *x*=8 and *x*=9. According to our data so far such taxa are found in the Aegean area. A distribution map of the group of sexual diploid Ionian endemic species with 2n=18 and of apomictic polyploid species with 2n=34, 42, 43, 51 and 52 is presented in Fig. 1. This map is based on known data (Papatsou & Phitos 1975, Artelari 1984b, 1989a–c, 1992, Artelari & Kamari 1986, 1995, 2000, Artelari & Georgiou 1999, 2000, 2003, Georgakopoulou & al. 2006) as well as on other available data (Artelari & Georgiou unpublished).

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FIGURE 7. Mitotic metaphase plate of *Limonium korakonisicum* with 2n=6x=51. Scale bar = 10 μm.

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A NEW SPECIES FROM ZAKYNTOS ISLAND

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