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## ***Limonium ammochoistianum*, *L. karpasiticum* and *L. paralimniticum* (*Plumbaginaceae*), three new endemic species from the eastern part of Cyprus**

### **Abstract**

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*Limonium ammochoistianum*, *L. karpasiticum* and *L. paralimniticum* (*Plumbaginaceae*) are described as new to science. The former species was long time known in Cyprus under the misapplied name *L. ocymifolium* subsp. *bellidifolium*. The three species occur in a few coastal stretches in the east of the island. The new taxa show strong morphological similarities and can be considered as segregates of a *L. ammochoistianum* species group. All hitherto known populations of the species group make up about 6000 individuals. *L. ammochoistianum* and *L. paralimniticum* should be classified as “Endangered”, whereas *L. karpasiticum* as a “Data Deficient” taxon.

*Key words*: micro-endemism, chromosome numbers, species group, coastal habitat.

### **Introduction**

The *Limonium* flora of Cyprus, the third largest island of the Mediterranean, is rather poor in species compared to areas with similar size located more to the west of the basin. Currently, eight species are known to occur, two of them, *Limonium cypricum* (Meikle) Hand & Buttler and *L. mucronulatum* (H. Lindb.) Greuter & Burdet, are endemic to the island (Hand & al. 2021). Karyological research considering the majority of taxa has been dealt with recently by Kouzali & al. (2012). At the southeast tip of the island, known as Kavo Gkreko (or Cavo Greco, Cape Greco, Akrotirio Gkreko), a rare taxon was first found in 1958 by Macdonald, which was named as *L. ocymifolium* subsp. *bellidifolium* (Sm.) Meikle in the “Flora of Cyprus” (Meikle 1985). Nowadays, most authors prefer the heterotypic species name *L. aucheri* (Girard) Greuter & Burdet. Few authors, e. g. Strid (2016), advocate lumping *L. aucheri* with *L. ocymifolium* (Poir.) Kuntze. There is also a short summary about the nomenclature of this *L. aucheri* by Kouzali & al. (2012). However, both names used in Cyprus are based on material collected in the Aegean region. Furthermore, not much is

known about the phylogenetic relationship of all discussed taxa. *L. aucheri* and *L. ocymifolium* have not been included into the analysis by Malekmohammadi & al. (2017) but were integrated in the study by Koutroumpa & al. (2018). The latter study used accessions of *L. aucheri* and *L. ocymifolium* from Greece and Turkey respectively, which, according to the results, proved to be surprisingly remotely related. A recent paper by Koutroumpa & al. (2021) adds general aspects of origin and diversification of Mediterranean *Limonium* taxa.

Intensive field and herbarium studies revealed that the Cypriot plants differ considerably from plants collected in Greece as well as from all known taxa of the wider East Mediterranean region. As a result, we describe a new species group comprising three microspecies.

## Material and methods

The current study is based on fieldwork at all known sites of the new taxa, as well as on studies of herbarium material in various collections (B, CYP, M).

Chromosome numbers have been counted according to the protocol described by Brullo & Erben (2011: 11). Taxonomy and nomenclature of taxa mentioned in the text follow Hand & al. (2021). Georeferenced data for all locations is stored in the database on endemic and endangered vascular plants of Cyprus kept at the Department of Forests (Lefkosia).

## Results

The three new species share many morphological characters. A diagnosis for the species group is therefore first given to help distinguish it from other E Mediterranean taxa.

### *Limonium ammochostianum* species group

Diagnosis: **Plants** perennial, glabrous, forming a sub-shrub 12–40 cm tall, with many ascending to erect stems and robust tap-root. **Caudices** 2–15 cm long, branched and densely spirally leafy in the upper half, living leaves in the upper third or in rosettes at apices of caudices. **Leaves** 6–45 × 9–10 mm, fleshy, dark green or glaucous, flat, v-shaped or caniculate in cross-section, apex rounded to obtuse or slightly emarginated, sometimes shortly mucronate, with one central nerve, gradually tapering into the petiole. **Stems** slender, 10–30 cm long, rugose, flexuous. **Sterile branches** absent or only 1–5 per stem, 5–40 mm long, straight, unbranched. **Fertile branches** 2–5 cm long, straight, obliquely directed upwards. **Spikes** 10–50 mm long, straight to slightly arched. **Spikelets** 7–10 mm long, composed of 1–8 flowers, remotely arranged with 1–6 flowers per 2 cm. **Outer bract** 1.9–3.5 × 1.6–2.6 mm, narrowly to broadly triangular-ovate. **Middle bract** 2.0–3.8 × 1.7–2.5 mm, oblong-elliptic, rounded or emarginate. **Inner bract** 5.8–7.9 × 3.0–4.3 mm, elliptic to obovate, rounded to obtuse, narrowly to broadly membranous, central part fleshy, 4.0–6.5 × 2.0–3.5 mm, elliptic to oblong-obovate, acuminate, forming a triangular tip 0.5–1.5 mm long, not reaching the upper margin. **Calyx** 5.0–6.6 mm long, calyx tube glabrous or sparsely to densely long hairy. **Corolla** pinkish to lilac-mauve.

Key to the species including diagnostic characters:

1. Leaves acute to obtuse, shortly mucronate, spikelets 8.5–10 mm long, inner bract 7.2–7.9 mm long ..... *L. karpasiticum*
1. Leaves emarginated to obtuse, spikelets 7.0–8.5 mm long, inner bract 5.8–6.8 mm long ..... 2
2. Leaves cuneate-spathulate, apice emarginated, calyx 5.0–5.8 mm long, calyx tube densely long hairy ..... *L. ammochostianum*
2. Leaves narrowly spathulate, apice rounded to obtuse, sometimes slightly emarginated, calyx 5.8–6.6 mm long, normally glabrous ..... *L. paralimniticum*

*Limonium ammochostianum* Erben, Christodoulou, Hand & Kefalas, **spec. nova**

– *L. aucheri* sensu auct. cypr., non (Girard) Greuter & Burdet

– *L. ocymifolium* subsp. *bellidifolium* sensu auct. cypr. non (Sm.) Meikle

Holotypus: Cyprus: Cavo Gkreko (Somera station), maritime rocks, 27.10.2017, C. S. Christodoulou (M-0244416, isotype: M-0244417).

Diagnosis: **Leaves** 20–45 × 7–10 mm, dark green, cuneate-spathulate, apex slightly emarginated to obtuse, lamina canalculated to slightly v-shaped in cross-section, living leaves more or less in rosettes at apices of caudices. **Spikes** with 2–3 spikelets per 1 cm. **Spikelets** 7.0–8.5 mm long, composed of 2–8 flowers. **Outer bract** 1.9–2.5 × 1.9–2.4 mm, triangular-ovate. **Middle bract** 2.0–2.9 × 1.9–2.2 mm, oblong-elliptic. **Inner bract** 5.8–6.8 × 3.1–4.2 mm, elliptic to obovate, rounded to obtuse. **Calyx** 5.0–5.8 mm long, calyx tube with dense, long hairs in the lower half. **Corolla** pale lilac-mauve.

*Limonium karpasiticum* Kefalas, Erben, Christodoulou & Hand, **spec. nova**

Holotypus: Cyprus: Rizokarpaso, Mora Psaria, maritime rocks, sea level, 3.7.2017, K. Kefalas 3 (M-0244415).

Diagnosis: **Leaves** 20–40 × 3–7 mm, glaucous, cuneate-spathulate, apex acute to obtuse, shortly mucronate, lamina flat, living leaves more or less in rosettes at the apices of caudices. **Spikes** with 0.5–1 spikelets per 1 cm. **Spikelets** 8.5–10.0 mm long, composed of 2–3 flowers. **Outer bract** 3.0–3.5 × 2.0–2.8 mm, narrowly triangular-ovate. **Middle bract** 3.1–3.8 × 2.0–2.5 mm, oblong-elliptic. **Inner bract** 7.2–7.9 × 3.6–4.3 mm, obovate-elliptic, obtuse. **Calyx** 5.5–6.5 mm long, calyx tube sparsely long hairy in the lower half. **Corolla** pinkish.

*Limonium paralimniticum* Christodoulou, Erben, Hand & Kefalas, **spec. nova**

Holotypus: Cyprus: Protaras, sea level, maritime rocks, 15.7.2007, C. S. Christodoulou (M-0275002, isotypes B, CYP, PAL).

Diagnosis: **Leaves** 22–40 × 3–7 mm, glaucous in maturity, narrowly spathulate to lanceolate-spathulate, apex rounded to obtuse or sometimes slightly emarginate, lamina flat or slightly v-shaped in cross-section, living leaves in the upper part of caudices; leaves usually with salt secretions. **Spikes** with 0.5–2 spikelets per 1 cm. **Spikelets** 7.0–8.5

mm, composed of 1–2 flowers. **Outer bract** 2.0–2.5 × 1.8–2.0 mm, narrowly triangular-ovate. **Middle bract** 2.2–3.2 × 1.7–2.1 mm, oblong-elliptic. **Inner bract** 5.8–6.5 × 3.0–3.9 mm, elliptic-obovate, obtuse to rounded. **Calyx** 5.8–6.6 mm long, normally glabrous, sometimes with some hairs in the lower half of the calyx. **Corolla** pale pink.

Illustrations: Fig. 1–10; for further photo documentation see Hand & al. (2021).

Phenology: *L. ammochostinianum* flowers earlier than the other two species, usually from (March–) April to early June; *L. paralimniticum* and *L. karpasiticum* flower from (April–) May to July.

Etymology: The epithet of the new species *L. ammochostinianum* refers to Ammochostos district in the eastern part of Cyprus. The eponymous district capital, a few kilometers away from the type locality, is also well known under its colonial name Famagusta. The species *L. paralimniticum* is named after Paralimni municipality where its distribution area is confined. The name of *L. karpasiticum* is based on the Karpasia peninsula, the characteristic “panhandle” in the northeast of Cyprus.

Chromosome numbers: Kouzali & al. (2012) published three chromosome counts based on Cypriot material, two from the type region of *L. paralimniticum* in the Protaras area (Paralimni municipality) and one from Kavos Gkreko area, the type locality of the species *L. ammochostinianum*. In all three cases they revealed the pentaploid number  $2n=43$ . We have not seen the corresponding specimens, so that the identity with the newly circumscribed taxa needs to be clarified, especially as regards the latter case. However, our own countings based on plants grown from seeds of the type specimens (performed by ME) confirmed the pentaploid number  $2n=43$  for *L. paralimniticum*. In the other cases plants proved to be hexaploids with  $2n=51$  (type material of *L. ammochostinianum* and *L. karpasiticum*, also plants from Galounia near Davlos).

Additional specimens examined (all from Cyprus, divisions sensu Meikle 1985):

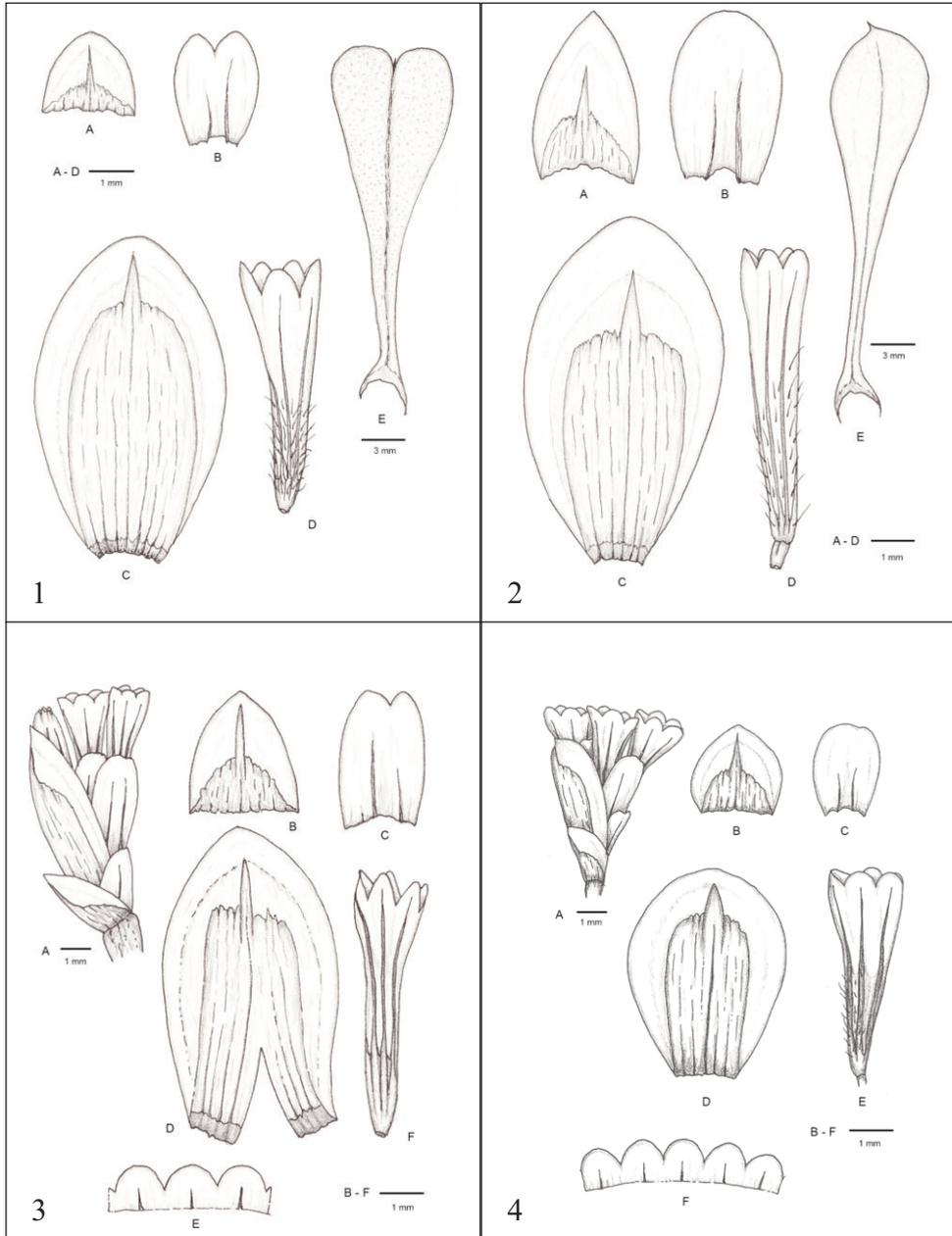
*L. ammochostinianum*

Division 4, Cape Greco (Larnaca), calcaires coralliens du Miocène inférieur, et sables, alt. 10–20 m, 12.4.1991, G. Alziar & al., *Iter Medit. 4, 0169* (B). – Capo Greco, 10.10.1988, Brullo & Pavone (CAT, M-0274985, M-0274986, M-0274991). – Akrotirio Gkreko, neck of the peninsula, S of the road near to its end, rocky coastal phrygana, alt. c. 10 m, 11.5.2005, R. Hand 4925 (B). – Kavos Gkreko, SSE Agioi Anargyroi, rocky coast, alt. 15 m, 3.4.2014, R. Hand 6361 (B, PAL).

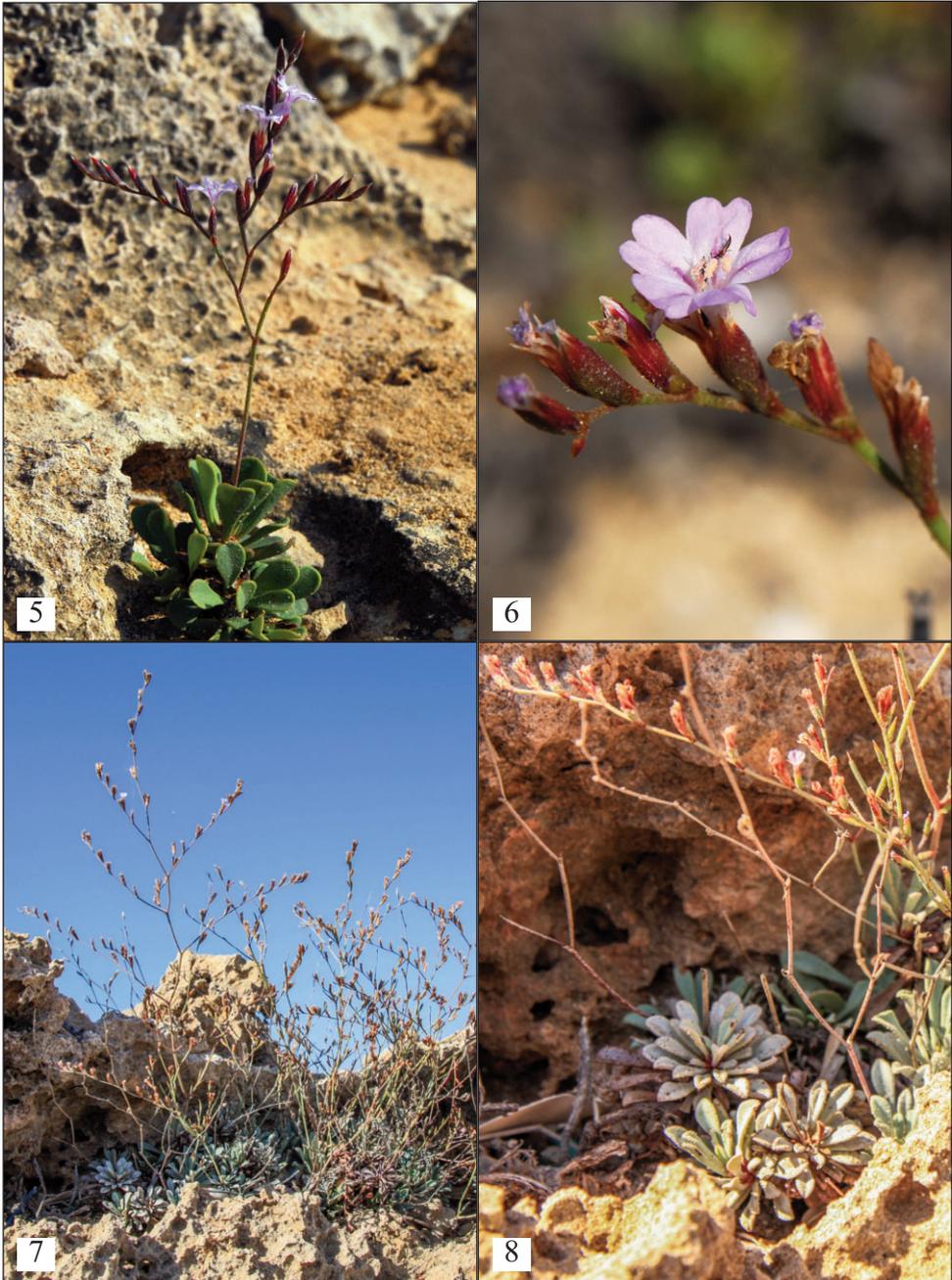
Division 8, Davlos, Galounia, rocky coast, 5 m, 11.8.2017, *Kefalas 5* (M-0274993).

*L. karpasiticum*

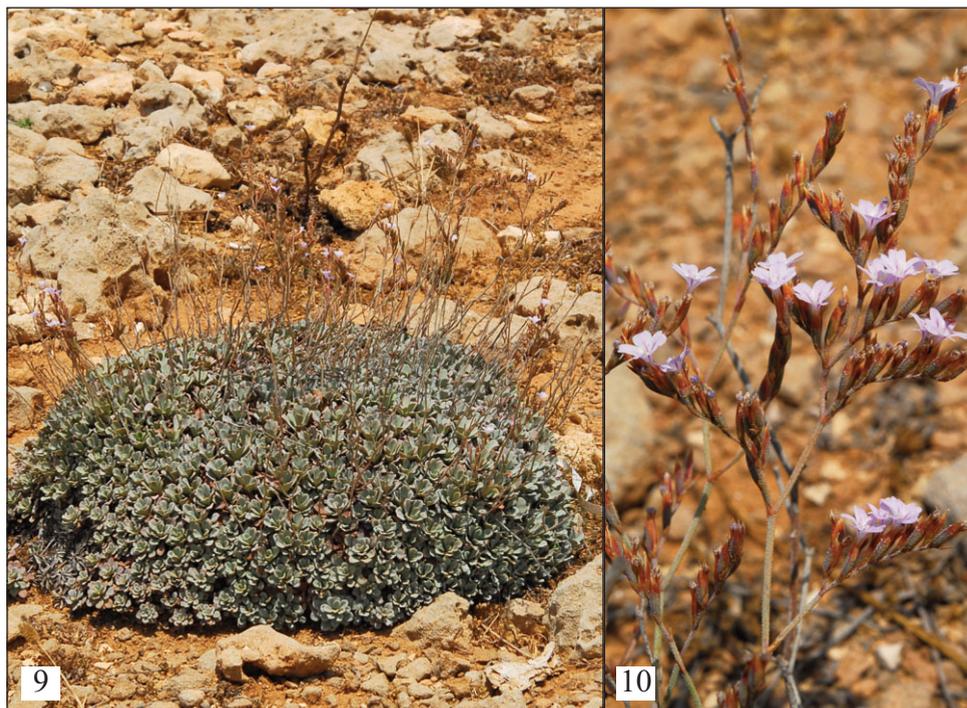
Division 4, Cape Greco, rochers calcaires, 19.4.1992, *Lambinon no. 92/CY/473 & Rousselle* (M-0275001).



Figs. 1-4. **1)** *Limonium ammochoistianum*: A) outer bract; B) middle bract; C) inner bract; D) calyx; E) leaf; based on the holotype (M-0244416); **2)** *L. karpaticum*: A) outer bract; B) middle bract; C) inner bract; D) calyx; E) leaf; based on the holotype (M-0244415); **3)** *L. paralimniticum*: A) spikelet; B) outer bract; C) middle bract; D) inner bract; E) calyx lobes; F) calyx; based on the holotype (M-0275002); **4)** *L. aucheri*: A) spikelet; B) outer bract; C) middle bract; D) inner bract; E) calyx; F) calyx lobes; based on specimen Greece, Kos, Agios Stefanos, 19.9.1997, Schwarz (herb. Erben). – Drawings: M. Erben.



Figs. 5-8. **5)** *Limonium ammochostianum*, habit, Cyprus, Kavο Gkreko, 7 May 2011; **6)** *L. ammochostianum*, flowers, Cyprus, Kavο Gkreko, 8 June 2010. – Photos by C. S. Christodoulou; **7 & 8)** *L. karpatiticum*, habit and typical habitat, Cyprus, Rizokarpaso, Mora Psaria, 3 July 2017. – Photos by K. Kefalas.



Figs. 9-10. **9)** *Limonium paralimniticum*, habit and typical habitat, Cyprus, Protaras, near Fig Tree bay, 13 June 2010; **10)** *L. paralimniticum*, flowers, Cyprus, Protaras, near Fig Tree bay, 13 June 2010. – Photos by C. S. Christodoulou.

#### *L. paralimniticum*

Division 4, Protaras, small peninsula SE of Fig Tree Bay, coastal rocks, alt. 2 m, 21.9.2010, *R. Hand 5719* & *C. S. Christodoulou* (B, PAL), also grown from seed of this gathering, 8.5.2013, *M. Cubr 49121* (B, garden herbarium). – Protaras, east of Fig Tree, maritime rocks, 27.10.2017, *C. S. Christodoulou* (M-0274988). – Protaras, near Skoutarospilioi, maritime rocks, 27.10.2017, *C. S. Christodoulou* (M-274990). – Protaras, Kapparis, rocky coast, sea level, 10.6.2012, *K. Kefalas 492* (B).

Intermediate plants (with presumed parentage):

#### *L. ammochostianum* × *L. karpasiticum*

Division 8, Davlos, Galounia, rocky coast, 5 m, 11.8.2017, *Kefalas 6* (M-0274997).

#### *L. ammochostianum* × *L. paralimniticum*

Division 8, Davlos, Galounia, 11.08.2017, rocky coast, 5 m, *Kefalas 1* (M-0275000), 2 (M-0274998), 4 (M-0274996) and 7 (M-0274987).

## Distribution

All three new taxa are rare species of Cyprus, known so far from four small coastal stretches in the eastern part of the island (Fig. 11). In the past two decades, the coastline of Cyprus has been studied relatively intensively regarding the occurrence and distribution of *Limonium*. This resulted in the mapping of many new sites of *L. cyprium*, formerly thought to be rare along the northern coast (summary of records in Hand & al. 2021). Hitherto, the southeast coast of Cyprus has been intensively studied. *L. ammochostianum* is restricted to the coastline of Kavο Gkreko from “Palatia” sea caves to “Agiοi Anargyroi” chapel, where the taxon has been known since more than 60 years. *L. paralimniticum* is known to occur along the Protaras coastline (Paralimni municipality). Because of the presence of extensive stretches of sandy beaches, no additional occurrences are to be expected in the Ammochostos gulf between Protaras and Bogazi. In the Karpasia peninsula, which follows to the northeast, *L. karpasiticum* has been found on the northern coast near the tip (Mora Psaria) and another location at the base of the peninsula (Galounia, Davlos), where also *L. ammochostianum* occurs sympatrically. In one case *L. karpasiticum* material has also been identified from Kavο Gkreko area.

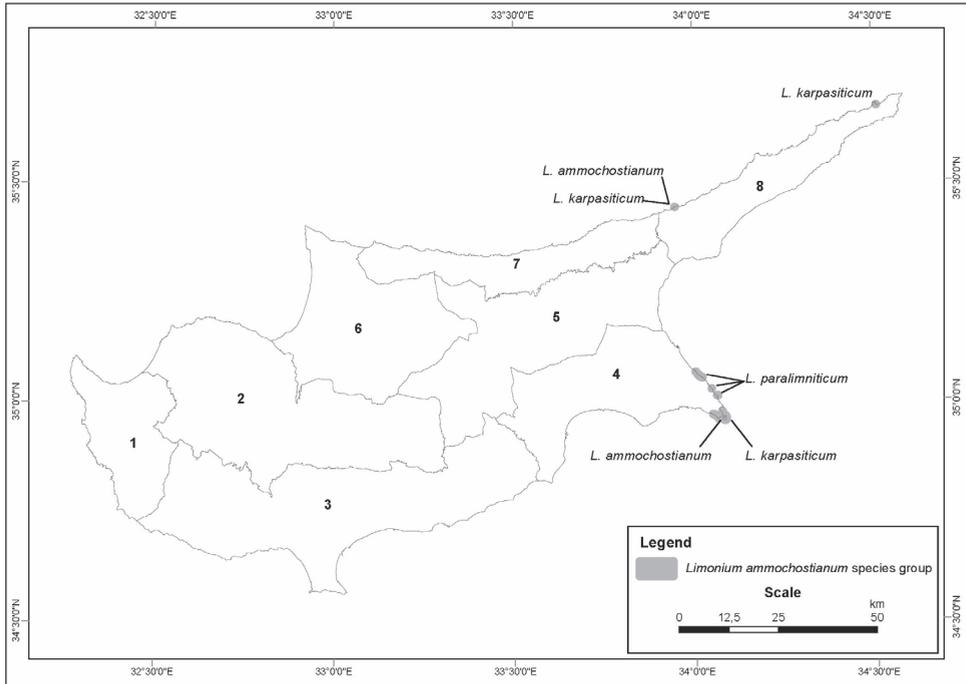


Fig. 11. *Limonium ammochostianum* species group, distribution in Cyprus; phytogeographical divisions sensu Meikle 1985. – Map design: K. Papasavvas.

## Habitat

All three species inhabit maritime calcareous rocks, which correspond to habitat type 1240: Vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* sp. pl. (sensu Annex I of the EU Directive 92/43/EEC). Other accompanying species are *Limonium virgatum* (Willd.) Fourr., *Frankenia hirsuta* L., *Crithmum maritimum* L., *Silene sedoides* Poir., *Atriplex portulacoides* L. and sporadically *Tetraena alba* (L. f.) Beier & Thulin. In the wider Kavο Gkreko area, *L. ammochostianum* is mainly found on Quaternary marine terrace calcarenite and to a lesser extent on Quaternary marine terrace calcarenite with Tera Member limestone in places; *L. paralimniticum*, along Protaras coasts, grows on Quaternary marine terrace calcarenite as well as on Pachna Formation chalk and marl, in some places topped by Quaternary marine terrace calcarenite. In the north coast of Karpasia peninsula, *L. karpasiticum* colonises Kythrea formation sandstones and Quaternary marine terrace calcarenite (Geological Survey Department 1995).

## Conservation

Undoubtedly, the *L. ammochostianum* species group is a rare taxon encompassing three species with restricted and fragmented distribution, small population and threatened habitat. The estimated population of the species group is around 6000 individuals (*L. ammochostianum* 4000, *L. paralimniticum* 1700 and *L. karpasiticum* 200 individuals respectively). Considering the current knowledge, the *L. ammochostianum* species group could be assessed as Vulnerable: B1ab(iii+v)&2ab(iii+v), because the Extent of Occurrence (EOO) is 116 km<sup>2</sup>, the Area of Occupancy (AOO) is 21 km<sup>2</sup> and the taxa of the species group occur at 6 locations; also, the quality of habitat has been degraded, at least at three of the locations, and as a result the population declined.

However, *L. ammochostianum* can be classified as Endangered: B1ab(iii+v)&2ab(iii+v) due to the number of locations (three), EOO (116 km<sup>2</sup>), AOO (11 km<sup>2</sup>) and the quality of habitat, which has been degraded at one location resulting in reduction of the population. Similarly, in the “Red Data Book of the Flora of Cyprus” (Tsintides & al. 2007), *L. ammochostianum* (= *L. aucheri*, including part of the population of *L. paralimniticum*) has been assessed as Endangered: B1ab(iii+v)&2ab(iii+v); this classification is still valid, although *L. ammochostianum* occurs almost entirely within a protected area, since Kavο Gkreko is a National Forest Park as well as a designated Natura 2000 site. *L. paralimniticum* could be also classified as Endangered: (B1ab(iii+v)&2ab(iii+v) based on the EOO (13 km<sup>2</sup>), the AOO (7 km<sup>2</sup>), the number of locations (2) and the continuing decline in area/extent and quality of habitat, resulting also in population decline; habitat degradation is due to extensive touristic development along the coastal zone of Protaras (Paralimni municipality). *L. karpasiticum* is hitherto known from two locations with a population of about 200 individuals, thus it could be also characterised as Endangered under criterion D (number of mature individuals <250) (IUCN Standards and Petitions Subcommittee 2014). However, owing to its recent discovery, the insufficient survey and one collection without exact locality, we believe it is more appropriate to be classified as Data Deficient.

## Discussion

The new species are similar in habit, leaves and inflorescences to *L. aucheri*, a species which is frequent on many islands of the central and southern Aegean region and rare in Attika and Peloponnese (Greece; see also fig. 4). They differ from *L. aucheri* first of all by having fleshy, canaliculate in cross-section leaves (vs. flat leaves), larger (vs. 5.5–6.3 mm), more remotely arranged spikelets, greater bracts (vs. inner bract 4.3–5.2 × 3.2–3.9 mm) and often longer calyces (vs. 4.3–5.4 mm).

The known populations of the 3 new species differ slightly in morphological characters from each other but also in their flowering periods. Furthermore, in one of the four known coastal stretches, where the species occur, transitional plants have been identified. Most probably, the new taxa represent cases of rather recent speciation events. The differences between the three taxa are small, but they are easily diagnosable. Also, because of the almost parapatric distribution, classification as subspecies would be a viable solution, but in view of the current preferred practice in the Mediterranean area, we have opted for microspecies. Additional future fieldwork in some remote coastal areas of the Karpasia peninsula may improve the chorological knowledge as will do additional karyological work. The somewhat complicated known distribution patterns, e. g. in *L. ammochostianum* which “brackets” the other species occurrences as well as the occurrence of transitional plants with or without the postulated parental taxa may be explained by relictual sites or long-distance dispersal by coastal currents in the past.

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