

Flora of the sand dune ecosystems of Cyprus

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ABSTRACT: Coastal sand dunes are among the most vulnerable ecosystems in Mediterranean basin fulfilling several functions such as tourism and urbanization, agriculture, coastal defence, military activities, dune stabilization and afforestation. The flora of the sand dunes of Cyprus is examined on the basis of field observations carried out during the last five years in the psammophilous coasts of Cyprus. The flora of the sand dunes of Cyprus consists of 352 taxa belonging to 65 families and 217 genera, and represent 19 % of Cyprus flora. The three larger families in the flora of sand dunes of the country are *Leguminosae* (15 %), *Compositae* (14 %) and *Gramineae* (13 %). The life - form and the chorological spectra of the sand dunes flora are presented with the emphasis to be given to the rarities and endemism of the recorded taxa. The life form spectrum shows that therophytes predominate and make up to 56 % of the flora recorded. From chorological analysis of the sand dunes flora, the predominance of Mediterranean elements (73 %) is evident. Twenty-one taxa are endemics and 18 taxa have been included in the final list proposed for the Red Data Book of the Cyprus flora. In addition, 18 taxa are rare according to the "Flora of Cyprus". When comparing the first and unique catalogue of the flora of sand dunes of Cyprus from Holmboe in 1914 with the present floristic list, the total number of taxa occurring presently and potentially in this type of vulnerable ecosystems of Cyprus comes to 377, representing almost 20 % of the Cyprus flora.

1 INTRODUCTION

Sand dunes can be described as coastal hills formed at the back of a beach by deposits of materials, varying on their origin, amount, type and size. These hills are classified further in several dune types according to their shape and development, which are then synthesized in various biogeomorphic types of dune systems. Between sea and land, these complex geomorphotopographic ecosystems, show a notably variation of several factors such as nutrient availability, soil salinity, aerial salt deposition, water conditions, organic compound, soil texture and pH. Such factors constitute a variety of microenvironments influence the presence of the species and the vegetation type and lead to the great biodiversity on the species level of the sand dune ecosystems.

Plants established on coastal sand dunes are subject to several environmental fluctuations, affecting their growth, survival and community structure. Geomorphology seems to play an important role for the species presence. For instance, species like *Agropyron junceum* (L.) P. Beauv., *Echium angustifolium* Mill. and *Pancratium maritimum* L., were correlated with the characteristic geomorphology of the initial stages of the dune systems and not with their distance from the tide-mark (Hadjichambis et al. 2003a). The floristic diversity studies of coastal sand dunes are quite un-

common, and show that these ecosystems are generally species poor. According to Van der Maarel (2003) beaches and sand dunes are characterized by both low α - and β -diversity, although there are dune areas with high species diversity. This is the case of Wadden islands in the Netherlands with well-developed coastal dune systems bordered by salt marshes, which contain a high proportion (50%) of the flora of the Netherlands.

Along the Mediterranean basin, sand dunes, at many places, are low and the beaches narrow, mostly as a result of restricted sand supply (Meulen and Salman 1996). This is the case also for Cyprus, which is characterized by almost complete lack of river derived materials supply due to the dam construction plan of the last 20 years.

The published data related to the sand dunes of Cyprus and especially to their flora is extremely rare, since Holmboe (1914) gave the first and only catalogue on the flora of sand dunes containing 94 plant taxa. However, references of plant taxa occurring in sand dunes exist in several other published and unpublished works of other scientific scope. The current knowledge on the sand dunes flora is considered insufficient and delimited. This article aims to enhance the scientific knowledge on the sand dune flora and its diversity presenting some new floristic data.

2 METHODS

Field observations carried out during the last five years in the psammophilous coasts of Cyprus. Species identification was made according to Flora of Cyprus (Meikle 1977, 1985), on the basis of more than 1000 specimens, and comparisons with specimens in the National Herbarium of Cyprus in Agricultural Research Institute. Herbarium specimens are deposited in the private herbarium of the first author. As a rule the nomenclature follows Flora of Cyprus, and updated new data when available (Della 1999, 2000). The chorological types are identified as in Flora d' Italia (Pignatti 1982). Raunkiaer's system (1934) was followed for ranking taxa into life - form categories and the production of a life-form spectrum. The bioclimate of the 22 sand dune areas of Cyprus was determined using the Emberger's coefficient (Emberger 1955) and the ombrothermic diagrams according to the Bagnouls & Gaussen (1953) xerothermic index.

3 THE STUDY AREA

The coastal zone of Cyprus is characterized by rich wildlife of prime ecological and scientific value. The coasts are almost everywhere low and shelving. Sea cliffs of any magnitude are extremely rare. According to its substrate the shoreline is rocky (54 %) with sandy beaches and many small coves (46 %) (CAMP Cyprus 2002). Sand dunes, salt flats, salt lakes, salt marshes as well as freshwater marshes are also found in the coastal belt of Cyprus although with limited extent and in a few areas. As regards the sand dune ecosystems, along the 304 km coastline of Cyprus (free southern part), these are confined in 22 sites (Hadjichambis et al. 2003b) (Fig. 1) that presently constitute remnants mainly due to tourism and the subsequent intensive pressures and impacts affecting them during the last 30 years. Fourteen types of anthropogenic pressures and impacts have been detected in the sand dune ecosystems of Cyprus (mscr. in preparation), the majority of which are internal or activities and impacts on local scale confined to each site (e.g. trampling, driving and grazing), whilst others are external (e.g. dam construction) thus distant from the dune areas but still affecting the structure and processes of the sand dunes) (Hadjichambis et al. 2003c). The meteorological data, was supplied by the nearest to each site meteorological station, and show that the mean monthly temperature ranges from 8,1 to 28,8 °C (Akamas) and mean monthly rainfall from 0 to 131,4 mm (Akamas – Pyrgos, Limassol) (Figs. 2 & 3). According to the soil texture sand proportion ranges from 65 % to 96 % and within the sand cluster, coarse sand varies from 3 % to 99,5%.

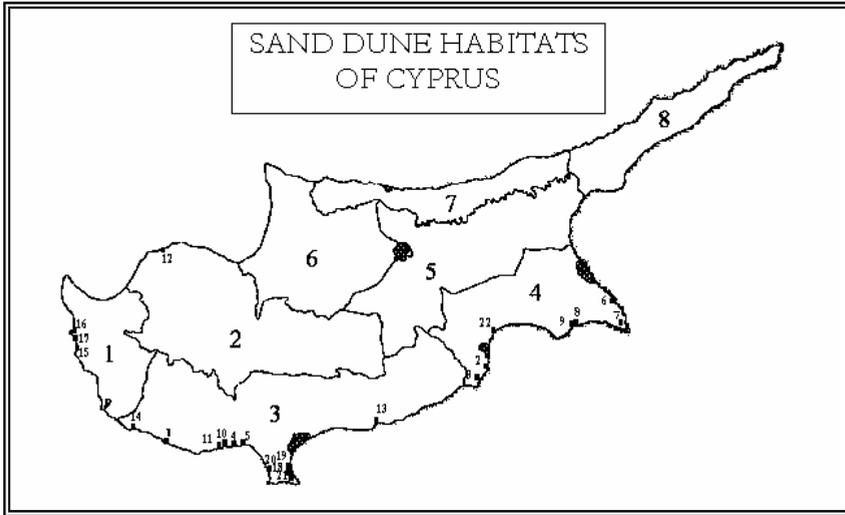


Figure 1. Map with the Phytogeographical divisions of Cyprus and the sand dune habitats (1: Akamas peninsula, 2: Troodos range, 3: The South area around Limassol, 4: Larnaca area, 5: The east part of Central plain, 6: The west part of Central plain, 7: The northern slopes and peaks of Pentadactylos, 8: Karpasia peninsula).

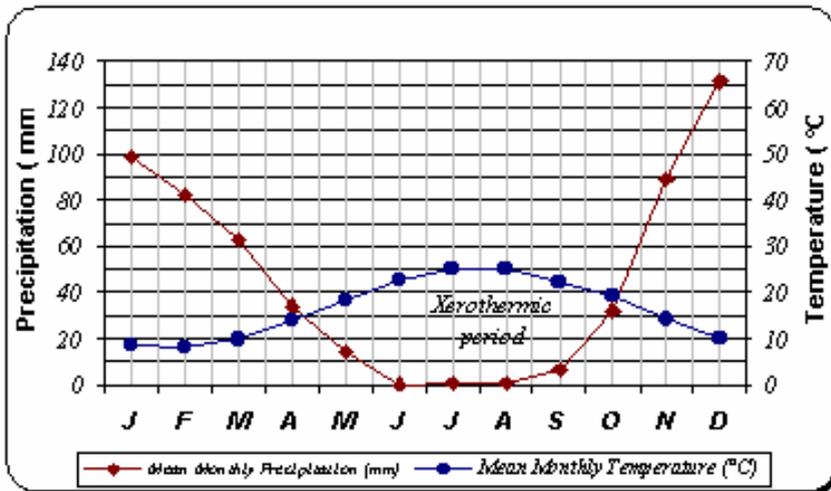


Figure 2. Ombrothermic diagram of Akamas (M.S. 32)

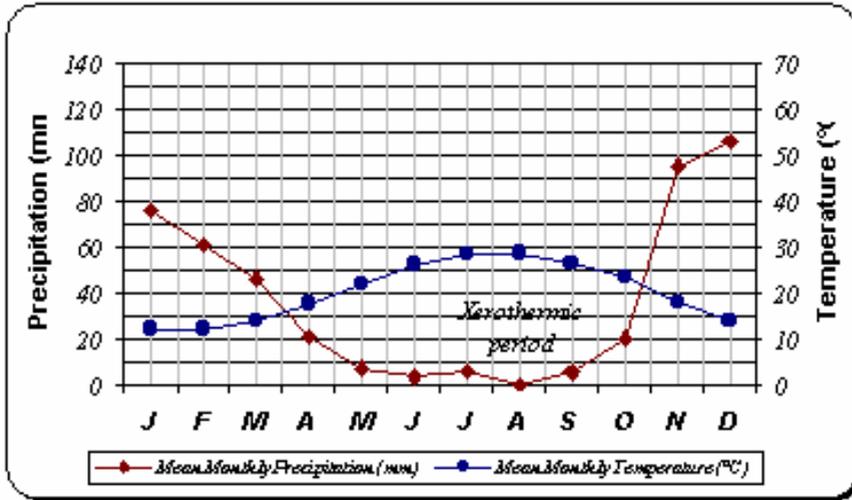


Figure 3. Ombrothermic diagram of Pyrgos (M.S. 429)

4 RESULTS

The flora of the sand dune ecosystems of Cyprus comprises 352 native taxa (including 19 subspecies and 15 varieties) representing 19 % of the flora of Cyprus. These belong to 65 families, 217 genera. Of the total recorded sand dune flora, 5 taxa are Gymnospermae (1,4 %) and 247 are Angiospermae (98,6 %) (Table 1).

Table1. Floristic analysis of the plant taxa occurring in the sand dune ecosystems of Cyprus.

Classification units	Families	Genera	Species	Subspecies	Varieties
Gymnospermae	4	4	5		
Angiospermae (Monocotyledones)	10	53	76	3	1
Angiospermae (Dicotyledones)	51	160	237	16	14
	65	217	318	19	15

Of the 65 plant families, 51 belong to the Dicotyledones and 10 to the Monocotyledones families representing 78,5 % and 21,5 % respectively of the total families richness. *Leguminosae*, *Compositae* and *Gramineae* are the richer in taxa families including as a total 147 taxa (ca. 42 % of the recorded taxa). These high proportions verify other existing studies, which suggest that these are the families best adapted to the ecological conditions of the Mediterranean region (Brofas et al. 2001).

The life-form spectrum of the studied sand dune flora (Fig. 4) shows that therophytes predominate and make up 55 % of the recorded taxa, chamaephytes follows with 13 % although hemicryptophytes, geophytes and phanerophytes are represented with 12, 11 and 9 % respectively.

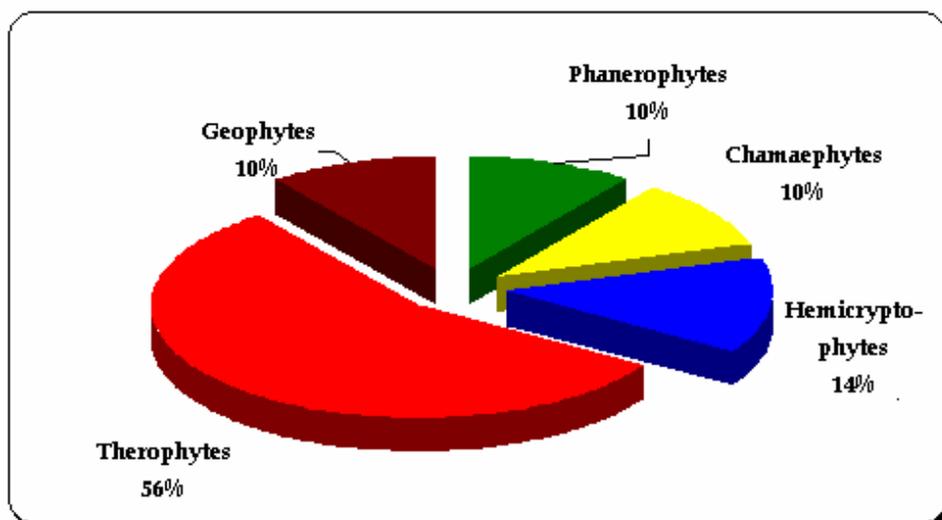


Figure 4. Total Life-form spectrum of the sand dune ecosystems studied

The endemics are also remarkably represented with 21 taxa, which are expressed in proportions up to 15 % of the endemics of Cyprus. Eighteen taxonomical units are referred as rare in the Flora of Cyprus and the *Mesembryanthemum crystallinum* L. as very rare (Table 2). It is worth notice also that twelve taxa merit some protection status in international conventions, protocols or European directives and initiatives. In addition, eighteen taxa are examined to be included in the Red Data Book of Cyprus.

Table 2. Rare taxa recorded in the sand dune ecosystems of Cyprus

<i>Ammophila arenaria</i> (L.) Link
<i>Anthemis parvifolia</i> Eig
<i>Asphodelus tenuifolius</i> Cav.
<i>Clypeola jonthlaspi</i> L. cf. var. <i>lasiocarpa</i> Guss
<i>Coronilla repanda</i> (Poir.) Guss.
<i>Crassula alata</i> (Viv.) Berger
<i>Crucianella aegyptiaca</i> L.
<i>Enarthrocarpus arcuatus</i> Labill
<i>Juncus bufonius</i> L.
<i>Limonium alpidum</i> (Guss) ssp. <i>cypricum</i> Meikle
<i>Lotus cytisoides</i> L.
<i>Medicago praecox</i> DC.
<i>Mesembryanthemum crystallinum</i> L. (very rare)
<i>Parapholis incurva</i> (L.) C.E. Hubbard
<i>Polygonum salicifolium</i> Brouss. ex Willd
<i>Reichardia intermedia</i> (Sch. Bip.) Coutinho
<i>Trifolium argutum</i> Banks et Sol.
<i>Triplanche nitens</i> (Guss.) Link

For the chorological analysis, the recorded taxa were classified in four units which include Mediterranean unit, Cosmopolitan-Subcosmopolitan unit, Endemic unit and Other which include taxa with geographical distribution not covered by the three previous categories. The Mediterra-

nean unit predominates with 73 % and is mainly consisted of steno-Mediterranean, euro-Mediterranean and S-Mediterranean elements (Fig. 5). The Cosmopolitan-Subcosmopolitan and Endemic units are represented with 7 % and 6 % respectively.

The first and unique catalogue on the sand dune flora of Cyprus (Holmboe 1914) includes 94 taxa. When comparing the floristic list from Holmboe (1914), with the present floristic list, it is concluded that 292 of the listed taxa are reported for the first time in the sand dune ecosystems of Cyprus, although 27 taxa of the old list (1914) have not been recorded during this survey. As concerns the taxa not found, some are recorded by Holmboe only in the northern coasts of Cyprus (6 taxa), some are typical of other habitats and sometimes can be found and in sand dunes as well (13 taxa) and few are characterized by Meikle (1977, 1985) as erroneous records (2 taxa). Consequently, in the floristic list of this type of vulnerable ecosystems of Cyprus can be included up to 377, which represent almost 20 % of the Cyprus flora.

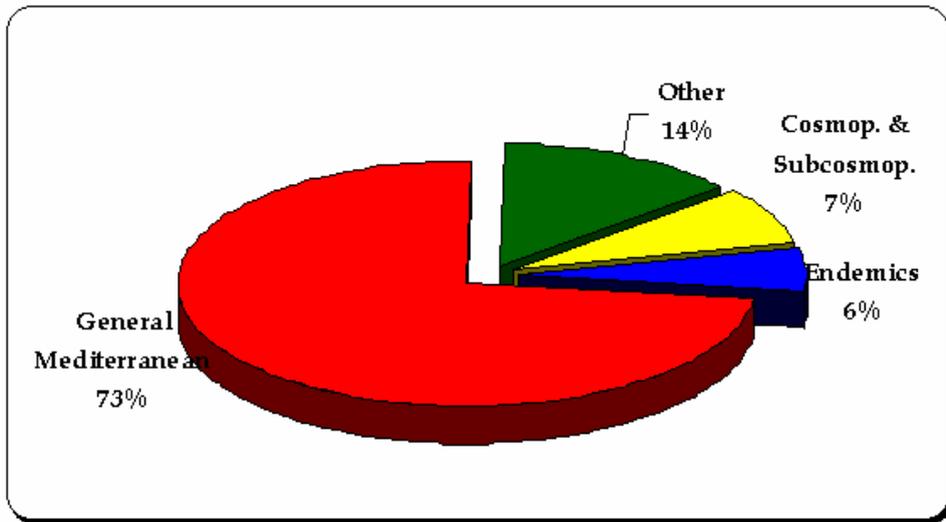


Figure 5. Chorological spectrum of the Flora recorded on the sand dune ecosystems of Cyprus

5 CONCLUSIONS

Sandy habitats are among the most vulnerable habitats of Cyprus (Hadjichambis 2003b), however, they are subject to high-intensity recreational and other uses. In a considerably small area of few km² in the southern coasts, where the most typical and representative sand dune ecosystems can be found, about 20 % of the Cyprus flora including endemic, rare and protected elements is established. Their high plant species diversity can significantly add to the conservation value of the ecosystems. The conservation and management of the sand dune ecosystems of Cyprus are necessary as ever especially for those sites included to the ecological network of protected areas "Natura 2000". Adequate measures should be taken for raising the public awareness about the values of these rare ecosystems through environmental education and other projects in order to ensure the continuations of their existence for the future generations.

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What is a Sand Dune? Sand dunes are some of nature's most scintillating creations. These eye-catching land masses are found around the globe in different climatic conditions. They are not only limited to deserts, but can form in any landscape on the earth's surface provided the conditions are right. Every sand dune is formed as a result of the interaction between the wind and soil in the form of sand grains. There are many ways thrill seekers can explore sand dunes, for example, sliding down the dunes, Bird viewing in wetlands, skiing, sand boarding or just sledging on the sand slopes. Sky div

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