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Biodiversity of the coastal flora of Tripoli Province

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Abstract. This study aims to investigate the coastal plant biodiversity status of Tripoli Province. The result of the survey led to a collection and identification of 130 plant species belonging to 36 families and 105 genera, of which 29 species represented monocotyledons and 101 dicotyledons. Floristic analysis revealed the dominance of the family Asteraceae (24 species) followed by the family Poaceae (22 species). The results have also showed the predominance of the genera *Juncus* and *Lotus* with 4 species each. Life form and chorological spectra analyses showed the prevalence of therophytes, represented by 77 species, and the Mediterranean chorotypes with 46 species. Categorization of collected plant species according to their ecological types, revealed a variety of ecological types, with the prevalence of psammophytes, represented by 50 species.

Key words: flora, biodiversity, halophytes, sabkha, coast, psammophytes, xerohalophytes

1. Introduction

There are many definitions of halophytes, but often they are defined as those species that can survive and reproduce in environments where the salt concentration of soil solution is around 200 mM or more (Flowers & Colmer 2008; Grigore *et al.* 2010).

Nowadays, salt stress is the most intensely studied of all abiotic stress types, because the salinity is considered the main constraint for crop plants worldwide (Mittler 2006; Bartel & Sunkar 2005). Drought and salinity are the two major environmental factors determining plant productivity and plant distribution (Grigore *et al*. 2010.). Salinity reduces the ability of plants to take up water, and this quickly induces a reduction in growth rate, along with a suite of metabolic changes identical with those caused by water stress. Halophytes represent a polymorphous ecological group of plants; they include species with a complex set of anatomical and physiological adaptations that allow them to survive in high soil salinity conditions (Grigore & Toma 2014).

The total sea coastline of Libya is about 1975 km long, with numerous salt marsh habitats (sabkhas) distributed along the coast. Sabkhas cover a very large area and majority of them are completely dry during the summer season. These highly saline habitats are natural biotopes with specific poor vegetation cover, composed mainly of halophytes and desert plant taxa (xerophytes) due to coarse sand texture and prevailing semiarid to arid conditions (El-Magsodi & Haddoud 2010). Sabkha habitats along the Libyan coastline are characterized mostly by halophytic vegetation. One of large sabkhas is known as the Abu Kammash salt marsh (Abu Kammash Sabkha). It is located in the western coastal part of Libya, about 150 km west of Tripoli, in Abu Kammash area near the Tunisian border. It extends along the Libyan coastal highway. Another large sabkha is the great sabkhat of Tawurgha area. It extends along the coast, behind sand dunes, between Musratah and Ebu`ayrat el Ehsun, stretching for 100 km. Other salt pans, some of considerable extent, occur inland on the Plain of Sirte, in Sabkhat el Qunayyin, and behind the coastal dunes of Ajdabiya area (Mahklouf & Al-Sghair 2016). In addition to the coastal salt marshes, there are also several oases and wetlands in the southern parts of the country, such as the oases of the Ghat-al Uwaynat region, the Sebha district, al Kufrah and the lakes of Waw En-Namus, Gabr Oun and others. All of these saline wetlands are characterized by specific halophytic and xerophytic desert vegetation (El-Magsodi & Haddoud 2010). The number of halophytic taxa distributed in the world counts around 3000 species (Guvensen *et al.* 2006; Altay & Ozturk 2012). Nearly 700 species are distributed in the Mediterranean climatic zone (Choukr-

Fig. 1. The study area (basemap: Google Earth)
Explanations: Zanzour (32°50'09.41″ N, 13°00'10.43″ E), Al-Seyaheiya (32°51'33.17" N, 13°4'24.39" E), Al-Sendibad resort (32°53'01.67″ N, 13°09'21.62″ E), Shat Al-Hinsheer (32°54'34.41″ N, 13°14'51.26″ E), Mitiga (32°53'52.23″ N, 13°19'16.69″ E), Sidi Al-Andulusi (32°53'45.15″ N, 13°22'10.64″ E), Tajura (32°52'21.29″ N, 13°24'37.79″ E)

Allah 1991; Ozturk & Guvensen 2002; Ozturk *et al.* 2011).

The area of the present study lies in the Mediterranean climatic zone. Since the floristic and inventory studies of saline habitats in this area are scanty and limited, except for Kikili & Erteeb (2008) and Mahklouf & El-Sghair (2016), the purpose of this work is to focus on coastal halophytic and associated vegetation of Tripoli district.

2. The study area

The survey covers the coast of the Tripoli district, between the Tajura area (east of Tripoli) to Janzour area (west of Tripoli), about 49 km long. Seven localities were chosen for plant collection: Janzour, Al-Seyaheiya, Al-Sendibad resort, Shat Al-Hinsheer, Mitiga, Sidi Al-Andulusi, and Tajura. The study area is bordered by the Mediterranean sea to the North, Tajura to the east, Janzour to the west and Tripoli city to the south (Fig. 1). This area is characterized by differences in topography and soil characteristics along the seashore – from sandy to rocky surface, which results in the presence of different ecological types of halophytic species. The Tripoli Province has the Mediterranean climate, characterized by cold, rainy winter with an annual average rainfall between 200-250 mm (Mahklouf & Etayeb 2019), and hot dry summer with a mean day temperatures of 18°C (Mahklouf *et al.* 2018).

3. Methods

Floristic and vegetation survey of the selected localities within the area of study was conducted in February and October 2018, including both moist and dry seasons, with one survey trip per week.

Collected plant specimens were brought to the herbarium and subjected to routine herbarium procedures (pressing, drying, mounting, labeling and identification). Identification of species was authenticated by the author with the aid of the data from the following literature: Jafri & El-Gadi (1977-1989), Davis (1962, 1982), Zohary (1966, 1972, 1978), Feinbrun-Dothan (1986), Moutterde (1966, 1970, 1983). The collected and identified plant species were finally deposited at the National Herbarium, Botany Department, Faculty of Sciences, University of Tripoli.

4. Results and discussion

4.1. Taxonomic composition of the costal flora

By the end of the survey, a total of 130 plant species belonging to 105 genera and 36 families were collected and identified, of which 31 families and 101 species represented dicotyledons, while 5 families and 29 species belonged to monocotyledons (Tables 1-2).

Floristic and quantitative analyses showed the dominance of the family Asteraceae, followed by the families

Table 1. Families and species of dicotyledon plants found in the studied area of Tripoli Province, with information on ecological types, life forms and chorotypes

No	Family	Species	Ecological type	Life form	Chorotype
1	Aizoaceae	*Carpobrotus edulis* (L.) Brown in Rhilip	PH	Ch	Med
2		*Mesembryanthemum nodiflorum* L.	XH	Th	Med/Eru-Si/Sah-Ara
3		*Mesembryanthemum crystallinum* L.	XH	Th	Med/Eru-Si
4	Apiaceae	*Daucus capillifolius* Gilli.	PH	H	Med
5		*Daucus carota* L.	PH	H	Med/Ir-Tu
6		*Eryngium maritimum* L.	PH	H	Med
7	Apocynaceae	*Calotropis procera* (Ait.) Ait.	X	NP	Sud/Sah-Ara
8	Asteraceae	*Aetheorhiza bulbosa* (L.) Cass.	W	G	Med
9		*Amberboa libyca* (Viv.) Alavi.	Chm	Th	Med
10		*Artemisia campestris* L.	PH	H	Med/Eru-Si
11		*Atractylis serratuloides* Cass.	PH	Ch	Sah-Ara
12		*Calendula arvensis* L.	PH	Th	Med/Ir-Tu
13		*Carduus argentatus* L.	PH	Th	Med.
14		*Centaurea dimorpha* Viv.	PH	Th	Med/Ir-Tu
15		*Chrysanthemum coronarium* L.	PH	Th	Med
16		*Conyza bonariensis* (L.) Cronq.	PH	Th	Med
17		*Echinops spinosissimus* DC.	PH	H	Med
18		*Helichrysum stoechas* (L.) Moench.	Chm	Ch	Med
19		*Hypochoeris achyrophoprus* L.	W	Th	Med
20		*Hypochoeris glabra* L.	W	Th	Med/Ir-Tu/Eru-Si
21		*Launaea resedifolia* (L.) Kuntze.	PH	H	Med
22		*Leontodon simplex* (Viv.) Widder	W	Th	Med/Eru-Si
23		*Leucanthemopsis trifurcata* (Giroux)	PH	H	Med
24		*Phagnalon rupestre* (L.) DC.	Chm	Ch	Med/Ir-Tu
25		*Reichardia tingitana* (L.) Roth.	X	Th	Sah-Ar/Ir-Tu
26		*Senecio gallicus* Chiax	W	Th	Med
27		*Senecio vulgaris* L.	W	Th	Med/Ir-Tu/Eru-Si
28		*Silybum marianum* (L.) Gaertner.	Chm	Th	Med/Ir-Tu/Eru-Si
29		*Sonchus oleraceus* L.	X	Th	Cos
30		*Sonchus tenerrimus* L.	X	Th	Med
31		*Urospermum picroides* (L.) F.W. Schmidt	X	Th	Med/Ir-Tu
32	Boraginaceae	*Echium humile* Desf.	PH	H	Med
33		*Echium angustifolium* Mill.	PH	H	Med
34		*Heliotropium curassavicum* L.	H	H	Cos
35		*Heliotropium europaeum* L.	PH	Th	Med
36		*Brassica tournefortii* Goun.	PH	Th	Med/Sah-Ara
37		*Cakile aegyptiaca* (L.) Wild.	PH	Th	Med/Eru-Si
38		*Sisymbrium irio* L.	W	Th	Med/Ir-Tu
39	Caryophyllaceae	*Silene gallica* L.	W	Th	Cos
40		*Silene succrulenta* Forks.	PH	H	Med
41		*Spergularia marina* (L.) Griseb.	XH	Th	Plu
42		*Arthrocnemum macrostachyum* (Moric.) Koch	H	Ch	Med
43	Chenopodiaceae	*Atriplex rosea* L.	XH	Th	Med
44		*Beta vulgaris* L.	XH	H	Med/Ir-Tu/Eru-Si
45		*Blackiella inflata* (F.Muell) Aellen in Engler.	PH	Th	Australian
46		*Chenopodium album* L.	X	Th	Plu
47		*Chenopodium murale* L.	W	Th	Plu
48		*Kochia indica* Wight.	X	Th	Med/Ir-Tu
49		*Salsola kali* auct. non L.	PH	Th	Plu
50		*Suaeda vera* Forssk. ex J.F.Gmel.	H	Ch	Med/Sah-Ara
51	Convolvulaceae	*Convolvulus arvensis* L.	P	H	Cos
52		*Ipomoea cairica* (L.) Sweet	PH	H	Trop
53	Euphorbiaceae	*Euphorbia forsskalii* Gay in Webb & Berth.	W	Th	Sud
54		*Euphorbia paralias* L.	PH	H	Med
55		*Euphorbia terracina* L.	PH	H	Med/Eru-Si
56		*Ricinus communis* L.	P	NP	Ir-Tu

No	Family	Species	Ecological type	Life form	Chorotype
57	Fabaceae	*Anthyllis vulneraria* L.	W	H	Med
58		*Astragalus stella* L.	W	Th	Med
59		*Hippocrepis bicontorta* Loisel.	W	Th	Sah-Ara
60		*Hippocrepis multisiliquosa* L.	W	Th	Med
61		*Lotus creticus* L .	P	H	Med
62		*Lotus cytisoides* L.	P	H	Med
63		*Lotus edulis* L.	P	Th	Med
64		*Lotus halophilus* Boiss. & Spruner	PH	Th	Med
65		*Medicago polymorpha* L.	W	Th	Med/Ir-Tu
66		*Melilotus sulcatus* Desf.	Chm	Th	Med
67		*Retama raetam* (Forssk.) Webb	P	NP	Sah-Ara
68		*Scorpiurus muricatus* L.	W	Th	Med
69		*Trigonella maritima* Delile ex Poir.	XH	Th	Med
70	Geraniaceae	*Erodium arborescens* (Desf) Willd.	PH	H	Med
71		*Erodium glaucophyllum* (L.) L'Her.	PH	H	Sah-Ara
72		*Erodium laciniatum* (Cav.) Willd.	CH	Th	Med
73	Gentianaceae	*Centaurium pulchellum* (Swartz.) Druce.	X	Th	Med
74	Illcebraceae	*Herniaria glabra* L.	X	Th	Med/Ir-Tu/ Eru-Si
75	Lythraceae	*Lythrum junceum* Banks & Sol.	H	H	Med
76	Malvaceae	*Lavatera* sp.	PH	Th	Med/Ir-Tu
77		*Malva parviflora* L.	W	Th	Med/Eru-Si
78		*Malva sylvestris* L.	W	H	Med/Ir-Tu
79	Mimosaceae	*Acacia cyanophylla* Lindl.	X	Ph	Au
80		*Acacia karroo* Hayne	X	Ph	Plu
81	Neuradaceae	*Neurada procumbens* L.	P	Th	Sah-Ara
82	Oxalidaceae	*Oxalis pes-caprae* L.	Chm	G	Plu
83	Papveraceae	*Glaucium flavum* Cranz.	P	H	Med/Eru-Si
84	Plantaginaceae	*Plantago coronopus* L.	H	Th	Med/Eru-Tu/Sah-Ar
85		*Plantago lagopus* L.	W	Th	Med/Ir-Tu
86	Plumbaginaceae	*Limonium sibthorpianum* (Guss.) Kuntze	H	H	Med
87	Polygonaceae	*Polygonum equisetiforme* L.	X	H	Plu
88		*Polygonum maritimum* L.	X	H	Med
89		*Rumex vesicarius* L.	X	Th	Sah-Ara
90	Primulaceae	*Anagallis arvensis* L.	W	Th	Med/Ir-Tu/Eru-Si
91	Scrophulariaceae	*Kickxia aegyptiaca* (Benth. ex Reich.) Fritsch.	X	Ch	Med
92	Solanaceae	*Datura innoxia* Mill.	P	Th	Plu
93		*Hyoscyamus albus* L.	X	Th	Med
94		*Lycium schweinfurthii* Dammer.	X	NP	Med
95		*Nicotiana glauca* Graham.	X	NP	Plu
96		*Solanum nigrum* L.	Chm	Th	Cos
97	Tamaricaceae	*Tamarix aphylla* (L.) Karsten	XH	Ph	Sud/Sah-Ara
98	Tetragoniaceae	*Tetragonia tetragonioides* (Pallas.) O. Kuntz	PH	Th	Plu
99	Thymelaeaceae	*Thymelaea hirsuta* (L.) Endl.	XH	Ch	Med
100	Verbenaceae	*Lantana camara* L.	P	NP	Trop
101	Zygophyllaceae	*Tribulus terrestris* L.	W	Th	Cos

Explanations: Chm – chasmophytes, H – halophytes, P – psammophytes, PH – psammohalophytes, W – weeds, X – xerophytes, XH – xerohalophytes; CH – chamaephytes, G – geophytes, H – hemicryptophytes, NP – nanophanerophytes, Ph – phanerophytes, Th – therophytes; Au – Australian, Cos – Cosmopolitan, Eru-Si – Euro-Siberian, Eru-Tu – Euro-Turanian, Ir-Tu – Irano-Turanian, Med – Mediterranean, Plu – Pluri-regional, Sah-Ar – Saharo-Arabian, Sud – Sudanian, Trop – Tropical

of Poaceae and Fabaceae. The other families found are presented in Table 3. The results have also shown the dominance of the genera *Juncus* and *Lotus*, followed by *Bromus*, *Euphorbia* and *Erodium* (Table 4).

4.2. Life forms

Life form spectrum of the collected species was analyzed according to Raunkiaer (1934), as modified

Table 2. Families and species of monocotyledon plants found in the studied area of Tripoli Province, with information on ecological types, life forms and chorotypes

No	Family	Species	Ecological type	Life form	Chorotype
1	Alliaceae	*Allium ampeloprasum* L.	Chm	G	Med/Ir-Tu
2	Amaryllidaceae	*Pancratium maritimum* L.	XH	G	Med/Eru-Si
3	Juncaceae	*Juncus acutus* L.	XH	G	Med/Ir-Tu
4		*Juncus bufonius* L.	H	Th	Cos
5		*Juncus maritimus* Lam.	XH	G	Med/Eru-Si
6		*Juncus subulatus* Lam.	H	G	Med
7	Liliaceae	*Asphodellus festulosus* L.	Chm	G	Med
8	Poaceae	*Arundo donax* L.	H	G	Med/Ir-Tu/Eru-Si
9		*Avena barbata* Pott ex Link.	W	Th	Med
10		*Bromus diandrus* Roth.	W	Th	Med
11		*Bromus molliformis* Lloyd	W	Th	Med/Eru-Si
12		*Bromus rigidus* Roth.	W	Th	Med/Eru-Si
13		*Cenchrus ciliaris* L.	X	H	Sah-Ar
14		*Chloris gayana* Kunth	W	Ch	Trop
15		*Cutandia maritima* (L.) Barbey.	PH	Th	Med
16		*Cynodon dactylon* (L.)Pers.	PH	G	Plu
17		*Elytrigia juncea* (L.) Nevskli in Acta.	PH	G	Med/Eru-Si
18		*Hordeum marinum* Huds	PH	Th	Plu
19		*Hyparrhenia hirta* (L.) Stapf.	Chm	Ch	Med/Ir-Tu/Sah-Ar
20		*Lagurus ovatus* L.	Chm	Th	Med/Eru-Si
21		*Lophochloa cristata* (L.) Hyl.	X	Th	Plu
22		*Parapholis incurva* (L.) C. E. Hubbard	P	Th	Med/Ir-Tu/Eru-Si
23		*Phalaris minor* Retz.	W	Th	Med/Ir-Tu
24		*Phragmitis australis* (Cav.) Trin ex Steud.	W	G	Cos
25		*Piptatherum miliaceum* (L.) Coss.	Chm	Ch	Med/Ir-Tu/ Sah-Ar
26		*Polypogon monspeliensis* (L.) Desf.	XH	Th	Plu
27		*Psilurus incurvus* (Gouan.) Schinz & Thell.	W	Th	Med/Ir-Tu
28		*Setaria adhaerens* (Forsk.) Chiov.	P	Th	Plu
29		*Stipa capensis* Thunb	X	Th	Med/Ir-Tu/Sah-Ar

Explanations: see Table 1

by Govaerts *et al.* (2000). The obtained results showed the absolute dominance of therophytes, followed by hemicryptophytes and geophytes, while other life forms were less numerously represented (Tables 1-2, 5).

4.3. Geographical elements at species level (chorotypes)

Chorological spectrum of collected and identified plant species was studied and analyzed. The results

Table 3. Dominating families found in the studied area of Tripoli Province

Family	No. of species
Asteraceae	24
Poaceae	22
Fabaceae	13
Chenopodiaceae	8
Solanaceae	5
Boraginaceae	4
Euphorbiaceae	4
Juncaceae	4
Apiaceae	3
Aizoaceae	3
Brassicaceae	3
Geraniaceae	3
Malvaceae	3
Polygonaceae	3

Table 4. Dominating genera found in the studied area of Tripoli Province

Genus	No. of species
Plantago	10
Silene	8
Medicago	7
Helianthemum	7
Euphorbia	7
Erodium	7
Centaurea	7
Astragalus	6
Ononis	6
Convolvulus	6
Bupleurum	6
Trifolium	5
Galium	5
Bromus	5

Table 5. The number of species found in the studied area of Tripoli Province according to their life forms

Life form	No. of species
Therophytes	70
Hemicryptophytes	28
Geophytes	12
Chaemephytes	11
Nanophanerophytes	6
Phanerophytes	3

Table 6. The number of plant species found in the studied area of Tripoli Province according to their chorotypes

Chorotype	No. of species
Med	46
Plu	16
Med/Ir-Tu	15
Med/Eru-Si	13
Cos	9
Med/Ir-Tu/Eru-Si	8
Sah-Ara	7
Med/Sah-Ara	2
Trop	2
Sud/Sah-Ara	2
Med/Eru-Si/ Sah-Ara	1
Ir-Tu	1
Med/Eru-Tu/Sah-Ar	1
Sah-Ar/Ir-Tu	1
Sud	1

Explanations: see Table 1

showed the absolute dominance of the Mediterranean plants, followed by Pluri-regional, Mediterranean/Irano-Turanian and Mediterranean/Euro-Siberian species, while other chorological types were less numerously represented (Tables 1-2).

Table 7. The number of species found in the studied area of Tripoli Province according to their ecological types

Ecological type	No. of species
Psammohalophytes	46
Weeds	29
Xerophytes	21
Chasmophytes	13
Xerohalophytes	12
Halophytes	9

4.4. Ecological types

Identified plant species were classified according to their ecological types. The results have shown the dominance of psammophytes, followed by weedy plants, xerophytes, halophytes, chasmophytes, and, finally, xerohalophytes (Tables 1-2, 7).

5. Conclusion

The dominance of the families Asteraceae, Fabaceae and Poaceae was expected, because these families are dominating in the Mediterranean climate. Furthermore, these families are among the largest families in the world and have cosmopolitan distribution. The dominance of therophytes and Mediterranean chorotypes was expected as well, because the study area is located within the coastal Mediterranean region, in which therophytes are dominating (Altay *et al.* 2010; Osma *et al.* 2010); moreover, therophytes are adapted to drought and saline environment (Asaadi 2009; Mahklouf & Al-Sghair 2016).

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