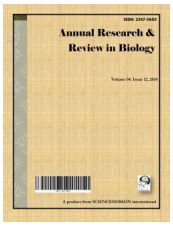

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Plant Diversity of the Coastal Regions of Gulf of Aqaba, Saudi Arabia

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Floristic diversity of the coastal regions of Gulf of Aqaba has been compiled based on the vegetation survey with consultation of literature and herbarium collections during two spring seasons of 2016 and 2017. A total of 109 species belonging to 86 genera in 36 families are recorded in the study area; of which above 50% of the taxa falling in 6 dominant families. Amaranthaceae 23% is the dominant family followed by Poaceae 17%, Fabaceae 7 and 3% Asteraceae. Various vegetation units belonging to three major habitats such as sabkhas, wadis and hilly areas, three life-forms and chorological units have been identified. Based on the physiognomic study the climate of the study area is classified as a transition zone between Mediterranean and sub-Saharan arid zone. A high number of ephemerals in the area indicate dry climate prevailing in these areas. Halophytes dominate along the coastal zone, ephemerals in wadi-bed and chamaephytes in foothills and slopes.

Keywords: Chorotypes; ephemerals; floristic diversity; Northern Hijaz; Sabkhas.

1. INTRODUCTION

Studies related to the vegetation of saline areas, particularly of sea shore have received much attention among ecologists and conservationists in Saudi Arabia. However, coastal ecosystems are relentlessly threatened all over the Tropics due to their perfect locations for recreation and

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summer resorts [1]. The vegetation of the coastal zone in the northern parts of Red Sea area (coastal regions of Gulf of Aqaba on the Arabian side are equally significant when compared with coastal region along the African side. The presence of several endemic plants and other Mediterranean elements in the Northern Hijaz Mountains makes the area important among other important plant areas in the Kingdom. The salinity level of the coastal saline soil in Gulf of Aqaba is one of the highest in the world [2]. The area is significant both for the flora and fauna due to its growing interest as an ecological system that supports coral reefs and endangered floristic elements [3]. One of the characteristic topographical zones of the western Arabia is the presence of an extensive coastal strip extending from southern tip of Saudi Arabia that borders with Jazan to Haql Town in the north bordering Jordan. The Tihama region in the south is the widest in the entire western side and narrow as one approach towards north. In the study area, the Tihama zone is virtually nil as the hilly area is almost merging with coastal zone.

The present study explores the distribution of plant communities and flora along with floral elements ecological relationships and various factors affecting their distribution. However, enhanced human influences have resulted in the swift decrease in the ecosystem resulting to a decline in floristic diversity. Urban developments and habitat fragmentation are considered to be one of the primary reasons for plant population decline [4].

The survey aims to disseminate more knowledge on to this region by analysing a detailed study of the northern portion of the Red Sea coast. The outcome of the research will be utilized to develop a framework for the conservation of the coastal region Gulf of Aqaba.

2. MATERIALS AND METHODS

The study area (Fig. 1) is a narrow stretch of land in northern Red Sea coast extending between 28° 00' 15.64"N 34° 38' 53.21"E and Haql (29° 13' 26.58"N 34° 14' 34.04"E). The coastal zone of Gulf of Aqaba on Saudi Arabian side is about 160 km long. The parts of the study area are located in Tabuk Province. It is part of the Syrian –African rift valley bordered by a combination of low altitude mountains [5]. The western shore line is somewhat undulate with a few incursions like Al- Majawah Bay and several other wadi mouths such as at Wasil and Humidah. Salt marshes are subject to periodic inundation by tides or high waves. Other coastal zones are a gravel-covered plain traversed by the downstream extremities of the main wadis and is dissected by smaller drainage runnels [6]. Wadi mouths are terminal points of several wadis criss-crossing the entire breadth of the study area. These wadis are originating from the Northern Hijaz Mountains and sloping from east to west, cutting through the hillocks to join the Gulf of Aqaba. Major wadies of this area, from north to south are Mubarak Valley, Al-Humaidah Valley, Al Wasal Valley, Al Sharih Valley, Dabar Valley, Nakhla Valley, Al Safina Valley, Tayyib al-Ism Valley, Maqana Valley etc. Several wadi mouths have extensive salt marshes (sabkhas) which support a number of halophytes. Among these, Al Majawah is one of the prominent one in the region. Located just north of Ras Hamid, it is a pear-shaped bay with a bar of sand heaped up by tidal waves.

The main climatic factors reflecting the vegetation growth e.g. temperature and rainfall are shown in Fig. 2. The area is characterised by dry Mediterranean climate. The mean monthly air temperature ranges between 11.2°C in January to 31.3°C during July. The mean monthly relative humidity varies from 21% during June and 49% during December-January. The mean annual rainfall varies from 6.4 mm in January to almost 0 mm between June-September periods.

The area consists of three main habitats, such as coastal salt marshes, wadis and coastal rocky- mountains. Wadies, covering a narrow distance extending from the rocky slopes and ending in Gulf of Aqaba are dry for most of the year. Coastal salt marshes extend from the coastal salt marshes and coastal mountains on the inland side. Coastal mountains comprise an almost continuous range of mountains of various altitudes, formed of crystalline and metamorphic basement as well as volcanic rocks [7].

For the purpose a floristic survey, samples have been collected and collections have been made all the extent of the study area at different seasons of the year. Detailed survey has been carried out in each of the habitats such as sabkhas, wadis, rocky mountains, etc. Dominant plants and their associated species were

recorded as part of recording the vegetation structure of the study area. Herbarium samples were processed, identified and kept at the Herbarium (KSU) of the Dept. of Botany and Microbiology, King Saud University and Herbarium of the Department of Biology, University Faculty -Haql, University of Tabuk. Identification of the species were carried out with the help of various National and regional Floras [8]. The analysis of plant geographical regions of the plant species as described in recent article [9].

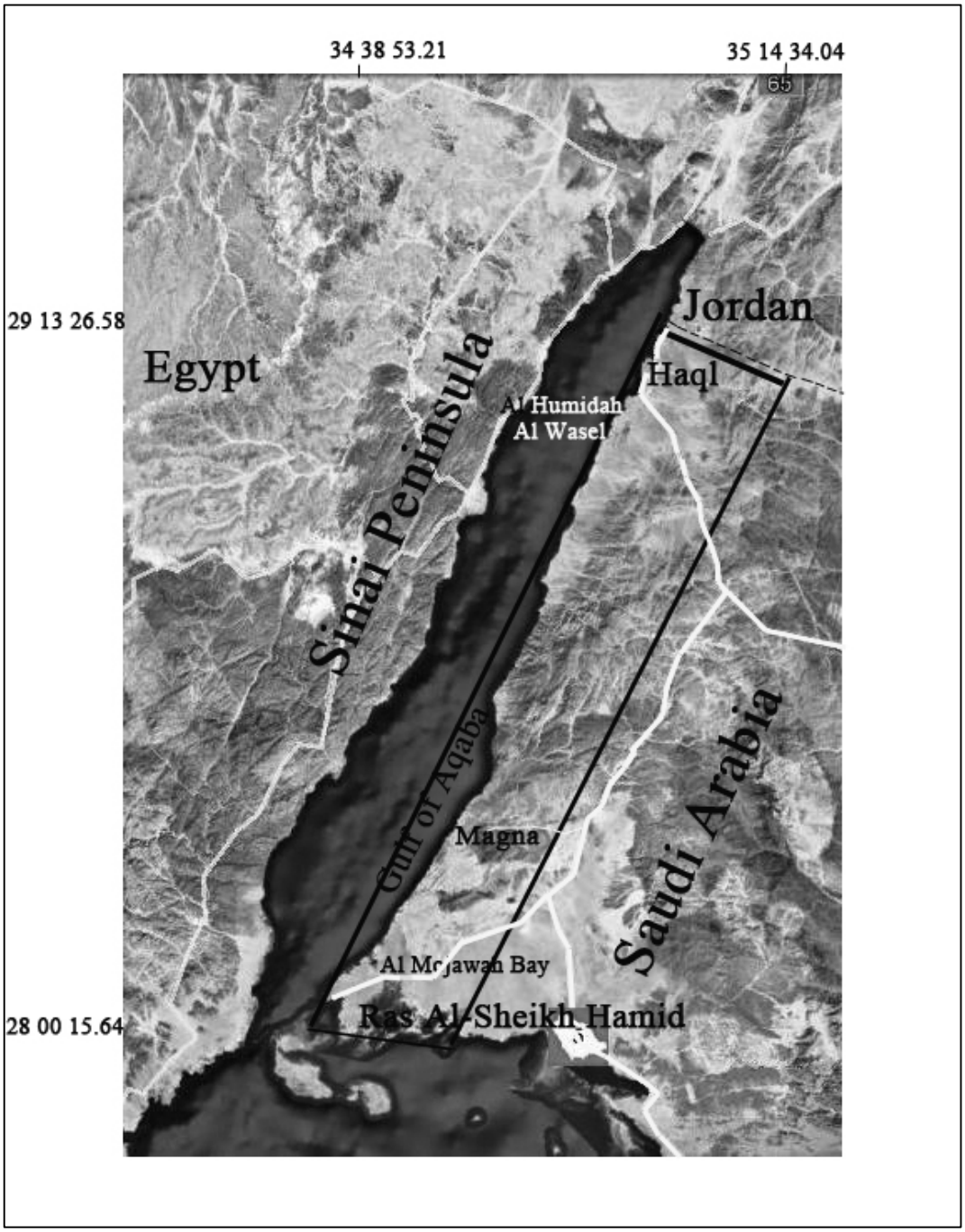

Fig. 1. Map of Gulf of Aqaba covering the study area

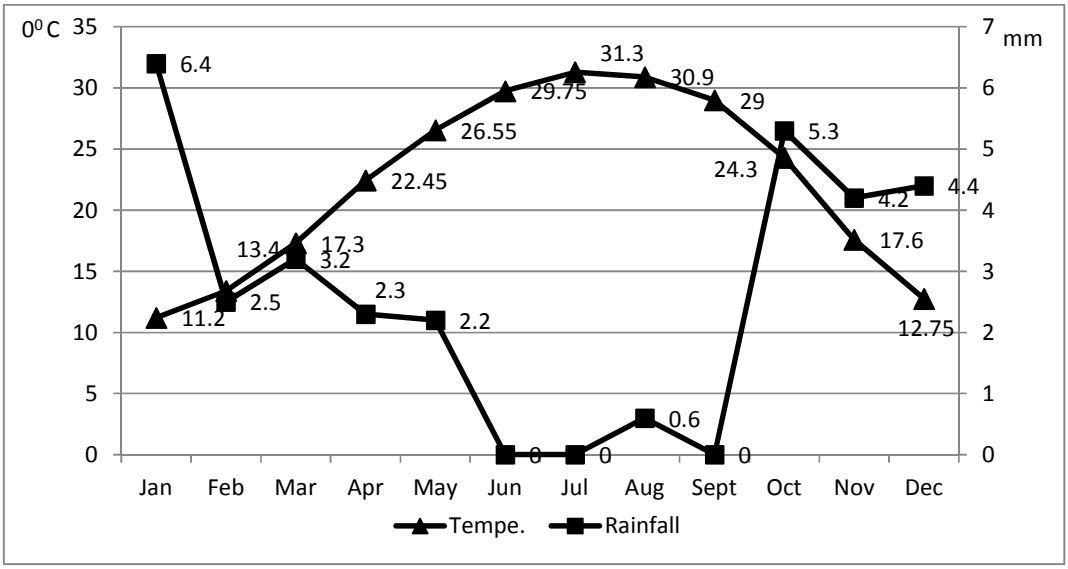

Fig. 2. Relation between temperature and rainfall with time monthly

3. RESULTS

A total of 109 species of woody and herbaceous plants (Trees, Shrubs, Subshrubs, Herbs and Grasses) were found in the coastal region of the Gulf of Aqaba. These species belong to 86 genera in 36 families. The families with a highest number of species in their decreasing order were Amaranthaceae (including Chenopodiaceae), Poaceae, Fabaceae and Asteraceae. Among the species recorded 16 (14.67%) were monocots and 93 (85.32%) species were dicots. The species-generic ratio in the study area is not significantly high except for a few genera such as *Acacia, Amaranthus, Cleome, Launaea* and *Tetraena*, containing each with 3 species. Among the species, 66 species are perennials and 43 are annuals (Fig. 3 A). The collected species were composed of 38.53 % Chamaephytes, 36.69% Therophytes, 13.76% Phanerophytes, 8.25% Hemicryptophytes and 2.75% Cryptophytes (Fig. 3 B). As per the analysis on the phytogeographical distributions, the largest share recorded from the elements belonging to Saharo Arabian chorological unit (30 spp.), followed by Saharo Arabia – Sudano Zambezian, Mediterranean –Irano Turanian, and Sudano-Zambezian regions (Fig. 4). Mediterranean elements in the study area are not significantly high despite the region's close proximity with other Mediterranean floras in the neighbouring countries. Vegetation analysis and major dominant communities in 3 major habitats as follows:

A. Sabkha vegetation: Except wadi mouths, the vegetation of sea shores is scanty and composed of Chenopods, sedges, rushes and members of Zygophyllaceae. Among the halophytes, the most widespread species is *Tetraena coccineum*. Other species frequently seen along with *T. coccineum* is *Aeluropus lagopoides, T. simplex*, etc. All sabkhas are situated along the coastal zones, mostly at the mouths of the wadis. The largest among these is the Al Majawah salt marsh. The largest population in such areas is found to be of *Arthrocnemum macrostachyum*. This population appears to be seen in a large area and as a pure stand of continuous mat in the sand bank formed by the tidal and wave actions. Other major populations in the area are *Cressa cretica, Suaeda vermiculata, Nitraria retusa, Aeluropus lagopoides* and *Tetraena coccineum* along with associated species such as *Aeluropus lagopoides, Tetraena simplex, Haloxylon salicornicum, Sevada schimperi, T. propinqua, Leptochloa fusca*, etc.

B. Wadi communities: Wadis are sparsely vegetated. The study area contains several small and big wadis sloping from east to west, cutting through small hillocks and ending in Gulf of Aqaba. Not less than 9 wadies are present in the area, all of them drain water from the surrounding hillocks and support a xeromorphic vegetation dominated by *Acacia tortilis* and several sclerophyllous dwarf shurblands.

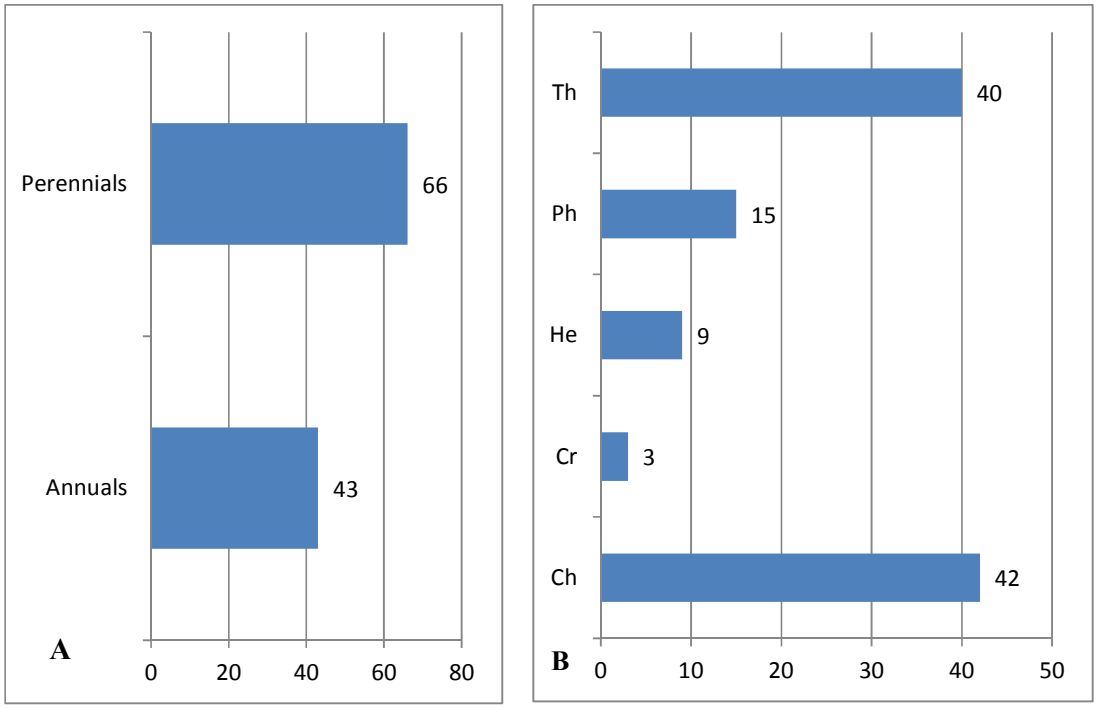

Fig. 3. A. and B. various life forms in the study area

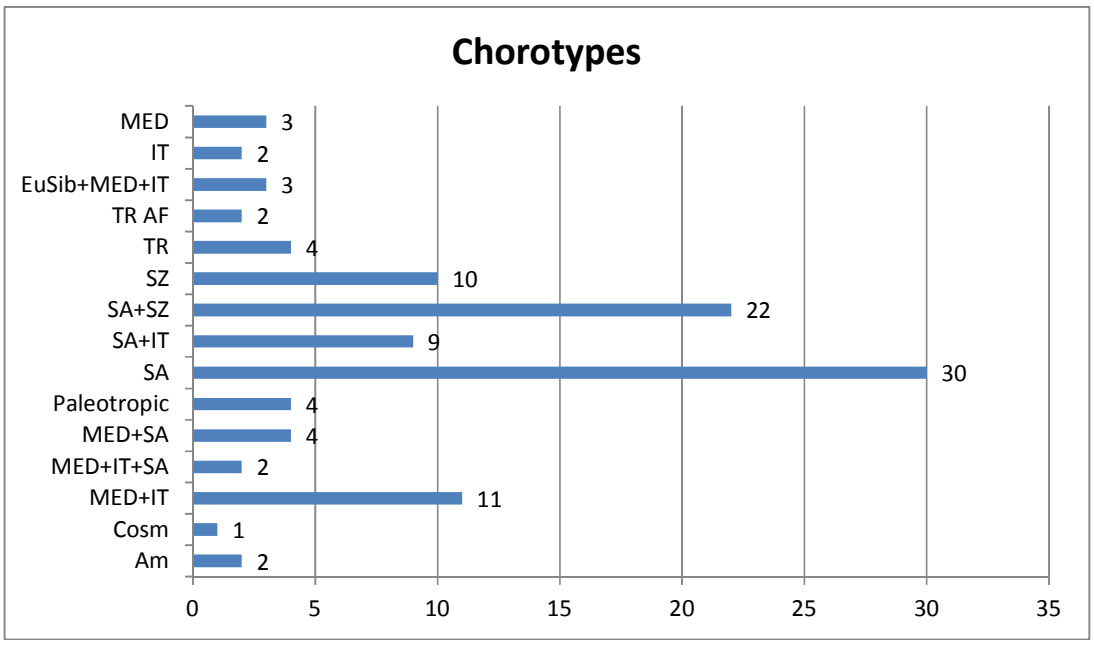

Fig. 4. Share of phytogeographical elements in the study area

The soil wadi bed, composed of gravel and silt, permits the growth of subshrubs and shrubs. During spring, a significant number of annuals appears in wadi bed and along the banks. Though no perennial streams present in the entire study area, seasonal streams develop during rainy seasons and water may remain logged in along the course of wadi stretch particularly in depressions. Some of these ditches may contain water for several months

and support vegetation dominated by several semi aquatic plants such as *Phragmites australis, Juncus rigidus, Bacopa monnieri*, etc. Various wadies and the dominant and associated species of their flora are as follows.

C. Mubarak Wadi: *Acacia tortilis and Haloxylon salicornicum*

D. Al – Humaidah Wadi: *Acacia tortilis, Haloxylon salicornicum, Tetraena simplex Tetraena coccineum, Tetraena simplex Mesembryanthemum forskali Fagonia glutinosa*

E. Al Wasl Wadi: *Acacia tortilis, Haloxylon salicornicum, Zilla spinosa, Tetraena coccineum Sclerocephalus arabicus, Neurada procumbens,*

F. Al Sharih Wadi and Dabar Wadi: *Acacia tortilis* dominate in most of the areas. A number of ephemerals also present along the wadi bed as associated species, such as *Aizoon canariense, Bassia muricata, Launaea angustifolia, Cleome amblyocarpa, Neurada procumbens, Rumex vesicarius, Reseda muricata, Asphodelus fistulosus*, etc. and a number of perennials such as *Pergularia tomentosa, Senna italica, Trichodesma africanum*, etc.

G. Al -Nakhla Wadi: *Nitraria retusa, Tamarix aucheriana, Acacia ehrenbergiana, T. coccineum, T. simplex Cleome droserifolia, Iphiona scabra, Cressa cretica, Lycium shawii, Zilla spinoa, Convolvulus hystrix, Acacia tortilis*

H. Al-Safina Wadi: *A. tortilis* (Dominent), *Ochradenus baccatus Iphiona scabra Cressa cretica, Lycium shawii, Zilla spinoa, Hyoscyamus muticus, Senna italic, Lasiurus scindicus, Citrullus colocynthis, Cucumis prophetarum, Fagonia bruguieri, Kickxia pseudoscoparia, Convolvulus hystrix, Acacia tortilis, T. simplex, T. coccineum, Nitraria retusa*

I. Tayyib al-Ism Wadi: *Phoenix dactylifera*, *Acacia tortilis, Cleome droserifolia, Cynodon dactylon, Phragmites australis, Pulicaria incisa, T. nilotica, T. coccineum, Heliotropium aegyptiacum, Juncus rigidus*

J. South Tayyib al-Ism Wadi: *Anabasis setifera (Dominant), Capparis sinaica, Nitraria retusa*

K. North of Maqana Wadi: *Anabasis setifera* (Dominant), *Hyphaene thebaica, Phoenix dactylifera L., Acacia tortilis, Nitraria retusa*

L. Rocky Mountains: This part of the study area is a low altitude mountain range. Vegetation is sparse in most of the areas, except the foot hills and runnels. Some of the dominant species in the area are *Cleome* dorserifolia and Forsskaolea *tenacissima* at higher altitude and *Nitraria retusa, Lycium shawii* and *Withania somnifera* at lower altitudes. Majority of vegetation is found between large boulders and in pockets where silt and sand accumulate. Other associated species found along the slopes and gullies are *Blepharis ciliaris, Aerva javanica, Iphiona scabra, Pulicaria incisa, Farsetia stylosa, Capparis cartilaginea, Scleorocephalus arabicus, Convolvulus hystrix, Ochradenus baccataus*, etc.

4. DISCUSSION

The Gulf of Aqaba is of growing interest because it hosts an ecological system that includes coral reefs and another tropical biota that are unique at such latitudinal positions [10]. Rainfall is the most crucial factor controlling plant distribution and overall stature of plant life in the study area. Since habitats such as wadi beds, slopes etc. accumulate maximum moisture; plant associations that inhabit such habitats possess the highest species richness and species turnover [11]. Gulf of Aqaba is of great significant from a biological point of view, due to its geographic location at the junction of two climatic zones (Mediterranean and arid) and three phytogeographical units such as Saharo Arabian, Mediterranean and Irano-Turanian. The study area has a unique combination of physical, chemical and biological features. Despite of its unique nature comprised of coastal saline zone, wadis and rocky hillocks, the region have attracted little consideration concerning their floristic composition and ecological processes. The study area is one of the plant diversity centers of chenopods [8] and the number of chenopods recorded from the study area showed that the habitats of the study area are conducive for the growth of such species. Though the study area is close to the coastal zones of Mediterranean countries, the halophytes of the area are more closely related to the desert flora than the Mediterranean coastal sabkha. Coastal estuaries are mostly bounded by saline muddy flats or small dune of coral sand rocks. Halophytes often form small to big populations, sometimes forming as a mono stand. However, the dominance changes within one area due to the chemical composition of the soil, compactness, type of rain water drainage. Among the halophytes, the succulent shrub

Arthrocnemum macrostachyum has extensive distribution range followed by *Nitraria retusa, Suaeda vermiculata* and *Tetraena coccineum*. Unlike the coastal zone of Gulf of Aqaba on the Sinai side of Egypt, Common reed, *Phragmites australis* and rhizomatous perennial rush *Juncus rigidus* do not have extensive distribution range [12]. Unlike the coastal zones of southern Hijaz, the density of halophytes is more in northern Tihama coast [13]. *T. coccineum* and *T. album* association along with other halophytes which inhabits salt marshes, and sand flats near sea shores are similar to that of the coastal regions of Sinai Peninsula [11]. Size of the flora, diversity and density of species are much higher on the Sinai Peninsula side, probably due to higher moisture content [14].

There is a consistency in the presence of dominant plants in the entire coastal zone of the northwestern region. The common species along the entire stretch are *Arthrocnemum macrostachyum, Halocnemum strobilaceum, T. coccineum, T. album*. Creeks with muddy flats often support the common mangrove, *Avicennia marina* [15]. The high percentage of chamaephytes and therophytes is characteristic of the climate of both Mediterranean and Saharo Arabian zone (arid zone). The presence of these two categories in wadis and sabkhas seems to play a significant role in ecological and evolutionary dynamics of extra arid habitats.

Distribution of species in the study area is consistent and even. Several recorded species have both low abundance and restricted distribution range. A significant number of species showed only one occurrence and has very abundance. Such species are at risk of continued existence due to abiotic stress, human interference and adverse climate [6]. Unlike other regions, particularly southwestern region, invasions of major exotic species in the Kingdom such as *Prosopis juliflora, Opuntia* spp., *Argemone*, etc. in the study area are very limited. However, at a few locations, thin strands of *P. juliflora* could be noticed. None of these stands, however, have any immediate effect on the existence of native populations [10].

The pattern in life forms enlightens the appearance of plant populations and also indicates the biotic influence in disturbed plant communities. In many plant explorations, it is not possible to categorize all species, but they can be classified according to life forms. The sea water in the area does not have any thermal pollution and mostly well oxygenated. Moreover, no significant variations in the pH and salinity values, relatively low levels of nitrogen, phosphorus and reactive silicate are also observed [3]. A high percentage of annuals in the study area indicate the dry climate prevailing in the area, the physiognomic analysis of the floristic components in the study area reflects the general nature of the plant such as size form, herbaceous or woody and the position of the buds in the dormant season. Overall various life forms like trees, shrubs, subshrubs and annuals are primary methodology in adjudging the climate of this narrow region.

Halophytic populations in the salt marsh areas appear to be caused by a complex factors of tidal inundation, differences of soil moisture, differences of ground level, distance from coastal areas, elevation above water table, salinity levels, etc. *A. macrostachyum* population is seen close to the shoreline as it requires more moisture. Majority of populations of *A. macrostachyum* in other parts of the coastal areas are also seen very close to the shorelines. Growth of this species is always initiated during winter and accelerated during summer. However, plants that are exposed to continuously inundated habitats show uninterrupted growth [16]. *A. macrostachyum* requires high salinity in its habitats. The presence of large population in the vicinity of the shoreline of the study area indicated that the area is highly saline, particularly the saline habitats of Magawah salt pans.

Habitats of the coastal region of Gulf of Aqaba support natural resources with great ecological and social importance due to their decisive role in the progress of rural areas. Rangelands support forages for domesticated animals; offer various openings for outdoor entertaining events [17]. However, unsustainable utilization impend the continued existence of rangeland resources and thereby enhances its degradation. According to conservationists, setting up exclusion zones in densely populated areas may be a positive solution for restoring vegetation and conservation of plant diversity of degraded lands.

5. CONCLUSION

This study includes the work of a comprehensive survey of the vegetation cover of the Gulf of Aqaba - Saudi Arabia, extending from Ras al-Sheikh Humaid in the south to the port of Durra border with Jordan in the north, Tabuk

governorate. To identify their wild plants, from the beginning of 2016 to the end of 2017. 109 plant species belonging to 86 species belonging to 36 families were registered. More than 50% of the plant species belong to dominant species (dominant), the dominant species Amaranthaceae, followed by Poaceae, followed by Fabaceae, followed by the Asteraceae. The picture of life is 43 species, 66 species. Various plant environments belonging to three main habitats were studied: sabkhat - valleys - mountains. The study showed that Saharo-Arabian plants are the most prevalent (30%), followed by the plants of the geographical region Saharo Arabia - Sudano Zambezian (22%), followed by the region's Mediterranean-IranoTuranian plants (11%), followed by Sudano-Zambezian 10%), followed by the plants of the geographical region IranoTuranian Saharo Arabia - (10%).

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COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Araujo DSD, Pereira MCA. Sandy coastal vegetation. Encyclopedia of life support systems. Auspices of the UNESCO, Eolss Publishers, Oxford, UK; 2008.
2. Klinker J, Reiss Z, Kropach C, Levanon I, Harpaz H, Halicz E, Assaf G. Observation on the circulation pattern in the Gulf of Aqaba, Red Sea. Israel Journal of Earth Sciences. 1976;25(9):85– 103.
3. Batayneh A, Elawadi E, Zaman H, Al-Taani AA, Nazza Y, Ghrefat H. Environmental assessment of the gulf of aqaba coastal surface waters, Saudi Arabia, Journal of Coastal Research. 2014;30(2): 283-290.
4. Hegazy A, Lovett-Doust J. Plant ecology in the Middle East. Oxford University Press. U.K; 2016.
5. Berman T, Paldor N, Brenner S. Simulation of winddriven circulation in the gulf of Aqaba. Journal of Marine Systems. 2000; 263(4):349–365.
6. Lovett-Doust J, Hegazy AK, Hammouda O, Gomaa NH. Abundance-occupancy relationships and implications for conservation of desert plants in the northwestern Red Sea region. Community Ecology. 2009;10(1):91-98.
7. Abd El–Ghani MM. Vegetation along a transect in the Hijaz mountains (Saudi Arabia). J. Arid Environment. 1996;32(6): 289–304.
8. Al-Hassan HO. Wild plants of the Northern Region, Camel and range research center in collaboration with FAO, Al-Jouf; 2006.
9. Zohary M. Geobotanical foundations of the Middle East. Stuttgart: Gustav Fischer Verlag. 1973;739:67-78.
10. Thomas J. Plant diversity of Saudi Arabia; 2011.
Available:http://plantdiversityofsaudiarabia.info/Biodiversity-Saudi-Arabia/Vegetation/Northern%20Province.htm> continuously updated
(Accessed on 21/06/2017).
11. Hatim MZ, Shaltout KH, Schamine´e JH, El-Kady HF, Janssen J, El-Sheikh MA. VegEgypt ecoinformatics: Contribution to Sinai flora and vegetation. Rendiconti Lincei. 2015;27(2):383-399
12. El-Bana MI. Floristic composition of a threatened Mediterranean sabkhat of Sinai in Khan, et al. (eds) Sabkha ecosystems,: West and Central Asia, Springer. 2006;II
13. Vesey-Fitzgerald DF. The vegetation of the Red Sea coast, north of Jeddah, Saudi Arabia. Jour. Ecol. 1957;45(3): 547-562.
14. El-Kady HF, Henidy SZ, El-Demerdash MA. Vegetation analysis of the Northern Aqaba Gulf coastal land Egypt. J Union Arab Biol Cairo. 1998;6:B: 319–338.
15. Hegazy AK, Lovett-Doust J, Hammouda O, Gomaa NH. Vegetation distribution along the altitudinal gradient in the northwestern Red Sea region. Community Ecology. 2007;8(2):151-162.
16. Mahmoud A, El-Sheikh AM, Youssef MM. Al-Tom M. Ecology of the littoral salt marsh vegetation at al-Magawah, on the Gulf of Aqaba, Saudi Arabia. Arab Gulf J. Sci. Res. 1985;3:145-163.
17. Al-Rowaily S, El-Bana MI, Al-Bakre DA, Assaeed AM, Hegazy AK, Basharat Ali M. Effects of open grazing and livestock exclusion on floristic composition and diversity in natural ecosystem of Western Saudi Arabia. Saudi J. Bio. Sci. 2015;22(4): 430–437

APPENDIX

Families	Species	Vegetation type	Life form	Chorotype
Acanthaceae	*Blepharis ciliaris (L.) B.L. Burtt.*	Annual	Th	SA
Aizoaceae	*Aizoon canariense L.*	Perrennial	Th	SA+SZ
	Mesembryanthemum forskalii	Annual	Th	SA
Amaranthaceae	*Aerva javanica (Burm.f.) Juss. ex Schultes*	Perrennial	Ch	SA+SZ
	Amaranthus graecizans L.	Annual	Th	Paleotropic
	Amaranthus hybridus L.	Annual	Th	Am
	Amaranthus viridis L.	Annual	Th	TR
	Anabasis setifera Moq.	Perrennial	Ch	SA
	Arthrocnemum macrostachyum (Moric.) K.Koch	Perennial	Ch	MED+SA
	Bassia muricata (L.) Asch.	Annual	Th	SA+IT
	Chenopodium album L.	Annual	Th	Paleotropic
	Chenopodium murale L.	Annual	Th	Paleotropic
	Haloxylon salicornicum (Moq.) Bunge ex Boiss.	Perrennial	Ch	SA+IT
	Salsola imbricata Forssk.	Perennial	Ch	SA
	Salsola spinescens Moq.	Perennial	Ch	SA+SZ
	Sevada schimperi	Perennial	Ch	SA
	Suaeda vermiculata Forssk. ex J.F.Gmel.	Perennial	Ch	SA
	Traganum nudatum Delile	Perennial	Ch	SA
Apocynaceae	*Blyttia fruticulosum (Decne.) D.V. Field*	Perennial	Ch	IT
	Calotropis procera (Ait.) Ait.f.	Perrennial	Ph	SA+SZ
	Pergularia tomentosa L.	Perennial	Ch	SA
Arecaceae	*Hyphaene thebaica (L.) M art.*	Perrennial	Ph	SA+SZ
	Phoenix dactylifera L.	Perrennial	Ph	SA
Asteraceae	*Iphiona scabra DC.*	Perrennial	Ch	SA
	Launaea angustifolia (Desf.) Kuntze	Annual	Th	SA
	Launaea mucronata (Forssk.) Muschl	Annual	Ch	MED+SA
	Launaea nudicaulis (L.) Hook.f.	Annual	Th	SA
	Pulicaria guestii Rech.f. & Rawi	Perennial	Ch	SA+SZ
	Pulicaria incisa (Lam.) DC.	Annual	Th	SA
	Sonchus oleraceus L.	Annual	Th	EuSib+MED+IT
	Matricaria aurea (Loefl.) Svhultz Bip.	Annual	Th	MED+IT
Boraginaceae	*Arnebia decumbens (Vent.) Coss. & Kralik*	Annual	Th	SA+IT
	Arnebia hispidissima (Lehm.) A.DC	Annual	Th	SA
	Heliotropium aegyptiacum Lehm.	Perennial	Ch	SA+SZ
	Heliotropium bacciferum Forssk.	Perennial	Ch	SA+SZ
	Trichodesma africanum (L.) Sm.	Annual	Th	SA+SZ
Brassicaceae	*Eremobium lineare (Delile) Boiss.*	Annual	Th	SA
	Farsetia linearis Decne. ex Boiss.	Perennial	Ch	SA+SZ
	Morettia parviflora Boiss.	Perrennial	Th	SZ
	Sinapis arvensis L.	Annual	Th	MED+IT
	Zilla spinosa (L.) Prantl	Perrennial	Ch	SA
Capparaceae	*Capparis cartilaginea Delile*	Perennial	Ch	SZ
	Cleome droserifolia (Forssk.) Delile	Perennial	Ch	SA
	Cleome amblyocarpa Barratte & Murb.	Annual	Ch	SA+SZ
	Cleome brachycarpa (Forssk.) Vahl ex DC.	Perennial	Ch	SA+SZ
Caryophyllaceae	*Polycarpaea repens (Forssk.) Asch. & Schweinf.*	Perennial	Ch	SA
	Sclerocephalus arabicus Boiss.	Annual	Th	SA
Convolvulaceae	*Convolvulus hystrix Vahl*	Perennial	Ch	MED+IT
	Cressa cretica L.	Annual	Th	MED+IT
Cucurbitaceae	*Citrullus colocynthis (L.) Schrad.*	Perrennial	He	MED+SA
	Cucumis prophetarum L.	Annual	He	SA+SZ

Families	Species	Vegetation type	Life form	Chorotype
Cyperaceae	*Cyperus conglomeratus Rottb.*	Perennial	Ch	SA
Euphorbiaceae	*Chrozophora tinctoria (L.) Raf.*	Annual	Ch	MED+IT
	Euphorbia granulata Forssk.	Perrennial	He	SA+SZ
Fabaceae	*Acacia ehrenbergiana Hayne*	Perrennial	Ph	SZ
	Acacia tortilis (Forssk.) Hayne subsp. raddiana (Savi)	Perrennial	Ph	SZ
	Acacia tortilis (Forssk.) Hayne subsp. tortilis	Perrennial	Ph	SZ
	Astragalus eremophilus Boiss.	Annual	Ch	SA+MED+ IT
	Astragalus schimperi Boiss.	Annual	Th	SA+IT
	Prosopis juliflora (Sw.) DC.	Perennial	Th	Am
	Retama raetam (Forssk.) Webb	Perrennial	Ph	SA
	Senna italica Mill.	Perrennial	Ch	SA+SZ
Gentianaceae	*Erodium laciniatum (Cav.) Willd.*	Annual	Th	MED+IT
Juncaceae	*Juncus rigidus Desf.*	Perennial	Ch	SA+IT
Lamiaceae	*Teucrium polium L.*	Perrennial	He	IT
Loranthaceae	*Plicosepalus acaciae (Zucc.) Wiens & Polhill*	Perennial	Ch	SZ
Malvaceae	*Malva parviflora L.*	Annual	Th	MED+IT
Menispermaceae	*Cocculus pendulus (J. R. Forst. & G. Forst.) Diels*	Perennial	Ph	Paleotropic
Neuradaceae	*Neurada procumbens L.*	Annual	Th	SA
Nitrariaceae	*Nitraria retusa (Forssk.) Asch*	Perennial	Ph	SA+IT
Nyctaginaceae	*Commicarpus grandiflorus (A. Rich.) Standley*	Perennial	Ch	SZ
Orobanchaceae	*Cistanche phelypaea (L.) Cout.*	Perennial	He	SA
Plantaginaceae	*Bacopa monnieri (L.) Wettst.*	Perennial	Ch	TR
	Kickxia floribunda (Boiss.) Taeckh. & Boulos	Perrennial	Ch	SA
	Kickxia pseudoscoparia (Spreng.) kunkel.	Perennial	Ch	SZ
	Plantago boissieri Hausskn. & Bornm.	Annual	Th	SA
	Plantago ciliata Desf.	Annual	Th	MED+IT
Poacea	*Aeluropus lagopoides (L.) Thwaites*	Perennial	Cr	EuSib+MED+IT
	Chloris barbata Sw.	Annual	Th	TR AF
	Echinochloa colona (L.) Link	Perennial	Cr	MED+IT
	Lasiurus scindicus Henrard	Perennial	Ch	SA+SZ
	Leptochloa fusca (L.) Kunth	Perennial	He	TR
	Panicum turgidum Forssk.	Annual	Ch	SA+SZ
	Phragmites australis (Cav.) Trin. ex Steud.	Perrennial	Cr	MED
	Polypogon monspeliensis (L.) Desf.	Annual	Th	MED+IT+SA
	Setaria verticillata (L.) P.Beauv.	Annual	Th	TR
	Stipa capensis Thunb	Perrennial	Th	SA+IT
	Stipagrostis obtusa (Del.) Nees	Perrennial	Th	SA+SZ
Portulacaceae	*Portulaca oleracea L.*	Annual	He	Cosm.
Polygonaceae	*Rumex vesicarius L.*	Annual	Th	SA
Resedaceae	*Ochradenus baccatus Delile*	Perrennial	Ph	SA+SZ
	Reseda lutea L.	Annual	Th	EuSib+MED+IT
	Reseda muricata C.Presl	Perrennial	Th	SA+IT
Rhamnaceae	*Ziziphus spina-christi (L.) Willd*	Perennial	Ph	SZ
Solanaceae	*Hyoscyamus muticus L.*	Perennial	Ch	MED
	Lycium shawii Roem. & Schult.	Perennial	Ph	SA+SZ
	Withania somnifera (L.) Dunal	Perennial	Ph	TR AF
Tamaricaceae	*Tamarix aucheriana (Decne. ex Walp.) B.R. Baum*	Perennial	Ph	SA
	Tamarix nilotica (Ehrenb.) Bunge	Perrennial	Ph	SA+MED
Urticaceae	*Forsskaolea tenacissima L.*	Annual	Ch	SA+SZ

Families	Species	Vegetation type	Life form	Chorotype
Xanthorrhoeaceae	*Aloe officinalis Forssk.*	Perennial	Ch	SZ
	Asphodelus fistulosus L.	Annual	Th	MED
Zygophyllaceae	*Fagonia bruguieri DC.*	Perrennial	He	SA+IT
	Fagonia glutinosa Delile	Perrennial	He	SA
	Tetraena coccinea (L.) Beier & Thulin	Perrennial	Ch	SA+SZ
	Tetraena propinqua Decne.	Perennial	Ch	SA
	Tetraena simplex (L.) Beier & Thulin	Annual	Ch	SA
	Tribulus macropterus Boiss.	Annual	Th	MED+IT
	Tribulus Terrestris L.	Annual	Th	MED+IT

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