PLANT SPECIES DIVERSITY WITHIN AN IMPORTANT UNITED ARAB EMIRATES ECOSYSTEM

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RÉSUMÉ.— *Diversité spécifique végétale dans un important écosystème des Émirats Arabes Unis*.— Le but de la présente étude est d'évaluer l'effet de la protection contre le pâturage sur la diversité des espèces dans la zone protégée de Wadi Tarabat, Al Ain, Émirats Arabes Unis. Cette étude a été menée au printemps et en été afin d'identifier la diversité des espèces à l'aide des indices de Shannon-Wiener, Brillouin et Simpson, ainsi que la valeur d'importance (I.V.). Un total de 106 espèces différentes a été enregistré. L'indice de Shannon-Wiener s'est avéré plus élevé en zone protégée qu'en zone non protégée (2,64 et 2,15; respectivement) et au printemps plus qu'en été (2,50 et 2,28; respectivement). L'indice de Simpson n'a fait que révéler l'effet de la protection ($P < 0,001$). Les indices de Shannon-Wiener et de Brillouin sont préconisés comme les plus appropriés pour exprimer la diversité dans les sites d'étude. *Acacia tortilis*, *Cenchrus ciliaris* et *Pennisetum divisum* avaient la plus forte I.V. tant dans les zones protégées que non protégées au cours du printemps et en été. Les I.V. pour *A. tortilis* variaient entre 38,9%, dans des zones protégées au cours du printemps, à 44,3% dans les zones non protégées pendant l'été.

SUMMARY.— The aim of the present study was to assess the effect of protection from grazing on species diversity in Wadi Tarabat protected area, Al Ain, United Arab Emirates. This study was conducted during spring and summer to identify the species diversity using Shannon-Wiener, Brillouin and Simpson species diversity indices in addition to the importance value (IV). A total of 106 different species was recorded. Shannon-Wiener index was significantly higher in the protected area in comparison to the unprotected one (2.64 and 2.15; respectively) and during spring than summer seasons (2.50 and 2.28; respectively). The Simpson index did only reveal significant protection effect ($P<0.001$). Shannon-Wiener and Brillouin indices are suggested to be more appropriate to express diversity in the study sites. *Acacia tortilis, Cenchrus ciliaris* and *Pennisetum divisum* had the highest IV in both protected and unprotected areas during spring and summer. The IV values for *A. tortilis* ranged between 38.9%, in protected areas during spring, to 44.3% in unprotected areas during summer.

Desert ecosystems are fragile and require extra care in order to be sustainably managed. A good understanding of arid rangelands is essential to properly manage them (Retzer, 2006). Often, overgrazing coupled with the extreme environmental conditions presents serious challenges to management and monitoring. Overgrazing leads to the loss of vegetation cover and ultimately to the loss of biodiversity especially in areas where grazing is open. Faunal diversity sharply declines as well with increased grazing pressure (Seymour & Dean, 1999). Unfortuna-

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tely, quantifying trends in species diversity in desert ecosystems is challenging. Various diversity indices have been developed over the years. Shannon-Wiener index has been used with contradicting responses, while Brillouin and Simpson indices were not contradictory. Species diversity may be affected by factors such as level of disturbances (Rabatin & Stinner, 1989). The medium disturbance theory states that neither low nor high disturbances improve species diversity (Connell, 1978).

With groundwater overexploitation, overgrazing is considered as the main harmful anthropogenic effect in desert ecosystems. Arid lands such as those dominating the United Arab Emirates (hereafter "UAE") land area are facing extreme levels of overgrazing, especially by camels (Gallacher & Hill, 2006). Jebel Hafit, a mountain massif at the border between the UAE and Oman has been severely affected by overgrazing (Brown & Sakkir, 2004). Fortunately, some restricted areas which have been protected show an interesting variety of floral as well as faunal species (Drew & Al-Dhaheri, 2003). Nevertheless, the number of plant species recorded declined between 1998 to 2003 from 129 species down to 93 species (Drew & Al-Dhaheri, 2003) highlighting the need for a proper monitoring and protection.

The impact of grazing on species diversity has been the subject of debates for many decades. Grazing has been said to enhance plant diversity (McNaughton, 1985; Crawley, 1997; Hobbs & Huenneke, 1992). Protection from grazing, however, has been overwhelmingly considered as a positive sign of recovery in desert ecosystems (El-Keblawy, 2003; Waser & Price, 1981; Ayyad & Elkadi, 1982; Ayyad & Fakhry, 1996; Omar, 1991). Moreover, protection from grazing in deserts has been suggested as a feasible approach to slow down land degradation (Ayyad *et al.*, 1990; Omar, 1991; Ayyad, 2003). The season of rest and grazing are extremely important in deciding the speed of desert vegetation recovery. During rainy seasons, any grazing may result in undesired consequences in plant growth and diversity. The objectives of our study were (1) to estimate the plant diversity in Wadi Tarabat, Jebel Hafit, within both protected and unprotected areas, (2) to determine the floral species with the highest importance value in Wadi Tarabat and (3) to evaluate the seasonal variations of species diversity in Wadi Tarabat.

MATERIALS AND METHODS

Study area

Jebel Hafit (23.50N and 55.50E) or Hafit Mountain is a large hill located in the south of Al Ain, about 160 km east of Abu Dhabi town. Jebel Hafit is described as an isolated structure measuring about 17 km long by 4 km wide. It is nearly 4000 feet high at the center. It is a foreland anticline developed by gravity folding in response to the uplift of the Oman Mountains and extends for some 10 km in a north-south direction. The Jebel is deeply incised with wadis and eroded faces. The Jebel itself area is composed of tertiary sedimentary rocks of limestone. It is an anticlinal feature that is actually the southernmost element of a small collection of anticlines which reach into Al Ain. Inclusive details on the geology of Jabel Hafit are described elsewhere (Kirkham, 1998, 2004).

Wadi Tarabat is a wide area on the northeastern side of Jebel Hafit. Historically it was easily reached to both camel and goat grazing (Brown & Sakkir, 2004). Livestock grazing was recognized as the most critical threat to the vegetation in the wadi (Brown & Sakkir, 2004) and as a consequence, parts of the area were fenced-off (referred to as protected thereafter) during the year 2005. The protected area is located in the upper part of wadi Tarabat and surrounded by Jebel Hafit. The unprotected area is located in the lower part of the wadi and about 60% of it lies on the alluvial plain not surrounded by the mountain. The reason for the protection has been the presence of the endangered Arabian Tahr (*Arabitragus jayakari*). It has been reported that fewer than 2500 adults survive in the wild (ENS, 2009). The soils were recorded to be extremely poor in organic matter and nitrogen but rich in some other nutrients (Brown & Sakkir, 2004).

The climate is arid and the bare appearance of the Jebel Hafit is possibly attributed to the nature of its flanks which are steep and heavily eroded (Brown & Sakkir, 2004). In August, the air temperature may be high and reaches 45° C (Tab. I). Rainfall is limited with flash storms in spring and occasional storms between July and September. Very little water is collected on the hill; most rainfalls run off extremely quickly and rapidly dissipate into the alluvial plains. Even within a given region, rainfall is most effective for the vegetation when it occurs during the winter and spring. The average relative humidity in Al Ain is 60%. In 1996, ten meteorological stations were established in the UAE, equipped with more than 60 devices to measure sea and land temperatures, humidity, direction and force of wind, and rainfall. One of these stations is established in Al Ain nearest to the study area at Jebel Hafit.

TABLE I

Monthly variation in the air temperature (°C), the annual rainfall (mm) and the relative humidity (%) during 1965-2001 of ten meteorological stations in Al-Ain. (Ministry of Agriculture and Fisheries UAE, 1965-2001)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Air temperature (°C)													
Minimum	14.8	14.9	18.5	20.4	23.9	27.1	30	30.2	26.6	23	18.9	15.8	22.0
Maximum	23.3	26.9	30.8	35.4	40.4	43.5	43.5	44.9	42.0	37.6	32.4	28.8	35.8
Annual rainfall (mm)	68.1	45.7	2.7	Trace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	9.9
Relative humidity (%)	66	64	59	53	50	53	53	54	56	58	63	66	58

VEGETATION ANALYSIS

During September 2009 (before the onset of the rainy season), and March 2010 (after the onset of the rainy season), a total of thirty one plots were randomly selected in the two areas: sixteen plots within the unprotected area and fifteen plots within the protected area.

Thirty one sampling quadrates (10 m ×10 m) were laid out to record vegetation data within each plot of the study area. In each quadrat, the following plant community attributes were assessed: density, relative density, frequency, relative frequency and percent cover. The importance was then calculated as the sum of relative frequency, relative density and relative cover. Three diversity indices were also generated using an Excel add-in (SSC, 2007). The species diversity indices (Simpson, Shannon-Wiener and Brillouin) for each occurring species were calculated (Krebs, 1999).

The nomenclature of plant species followed Jongbloed, (2003) and Karim & Fawzi (2007). A two-way analysis of variance (ANOVA) was used to evaluate the effect of protection and season on species diversity within each area. ANOVA was used to compare between the main effects (protection and season) and their interactions. The following formulas were used to calculate some parameters of vegetation analysis (Mueller-Dombois & Ellenberg, 1974) of the communities in each site of the study area:

Frequency = (Number of quadrates where a species occurs / Total number of quadrates analysed) x 100

Relative Frequency = (Frequency of a species / Total frequencies of all species) x 100

Density per quadrat = (Number of individuals of a species / Total number of quadrats analysed) x 100

Relative density = (Number of individuals of a species / Total number of individuals of all species) x 100

Cover = (Total area covered by a species / Total area sampled) x 100

Relative Cover = (Cover of a species (m^2) / Total cover of all species (m^2)) x 100

Importance value (IV) = Relative frequency + Relative density + Relative Cover

Finally, we used SPSS (PASW Statistics 18) program to calculate the community similarity in the protected and unprotected areas in spring and summer; based on presence or absence of the plant species.

RESULTS

Within the whole study area, regardless of protection status and season, 106 species were recorded (Annex) belonging to 39 families and 98 genera, including 42 herbs, 41 shrubs, 18 grasses and 5 trees. The recorded species were grouped as perennials (71 species), annuals (31 species) and facultative perennials (4 species).

DIVERSITY INDICES

The ANOVA output for the Shannon index of diversity revealed a strong significance of the main effects of protection and season at $P < 0.01$ (Fig. 1). Shannon index was higher for the protected area when compared to the unprotected area (2.64 ± 0.06 and 2.15 ± 0.055; respectively). The species diversity was higher during spring than during summer (2.50 ± 0.37 and 2.28 ± 0.42; respectively).

ANOVA for Brillouin's index showed significant main effects of protection and season at $P < 0.002$ (Fig. 2). The Brillouin's index was higher in the protected area compared to the unprotected area (2.17 ± 0.05 and 1.77±0.05 respectively). The average Brillouin index was higher during spring when compared to summer (2.07 ± 0.05 vs 1.86 ± 0.05, respectively).

The Simpson index of diversity showed a significant effect of protection ($P < 0.001$) while no effect was detected for season at $P > 0.05$ (Fig. 3). The Simpson index was higher for the protected area compared to the unprotected area (0.92 ± 0.01 and 0.83 ± 0.01; respectively).

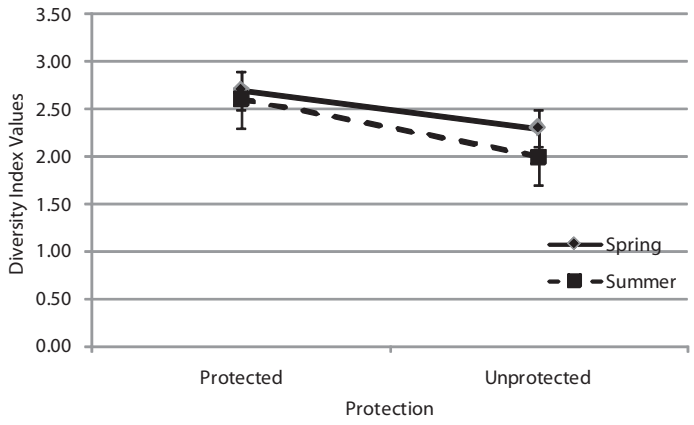

Figure 1.— Variations in the Shannon index of diversity during Summer and Spring for protected and unprotected areas in Wadi Tarabat.

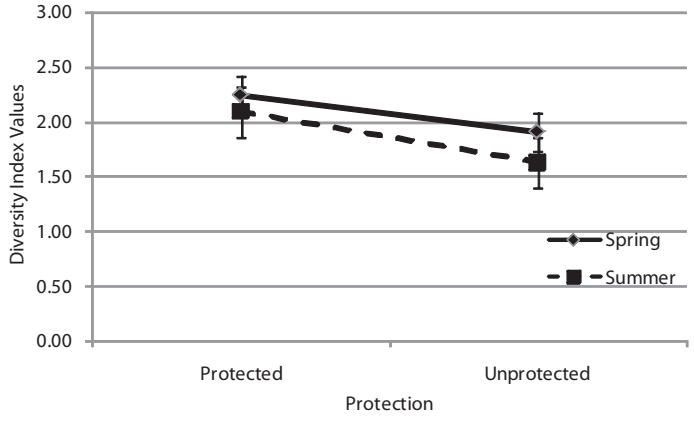

Figure 2.— Variations in the Brillouin index of diversity during Summer and Spring for protected and unprotected areas in Wadi Tarabat.

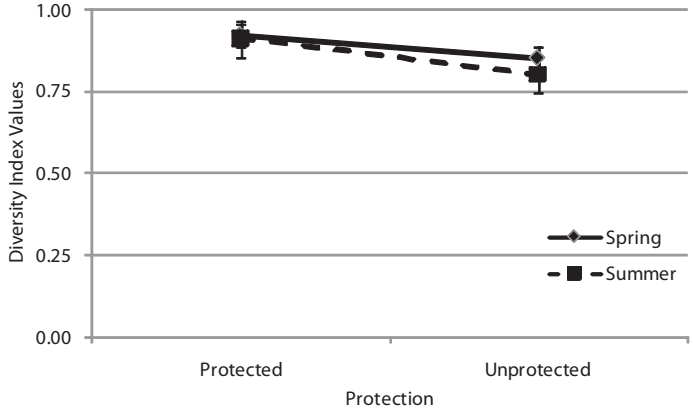

Figure 3.— Variations in the Simpson index of diversity during Summer and Spring for protected and unprotected areas in Wadi Tarabat.

IMPORTANCE VALUE (IV)

Within the protected area of Wadi Tarabat ecosystem, the number of species ranged from 61 to 77 during summer and spring seasons respectively (Annex). In the unprotected area the number of species was higher than in the protected area, being 83 species in spring and declined to 55 species in summer.

During spring and summer, *Acacia tortilis, Cenchrus ciliaris* and *Pennisetum divisum* had the highest IV in protected and unprotected areas (Tab. II). The IV values for *A. tortilis* ranged

TABLE II

Importance values (IV) for the most and least important five species recorded in the protected and unprotected areas during both Spring and Summer seasons in Wadi Tarabat ecosystem

Species Status	Protection	Season	Species	IV
Most Important 5 Species	Protected	Spring	*Acacia tortilis*	38.99
			Cenchrus ciliaris	21.49
			Acridocarpus orientalis	19.74
			Aristida adscensionis	17.56
			Pennisetum divisum	13.50
Least Important 5 Species			*Diplotaxis hara*	0.43
			Euphorbia granulata	0.43
			Orobanche cernua	0.43
			Polygala erioptera	0.44
			Arnebia hispidissima	0.45
Most Important 5 Species		Summer	*Acacia tortilis*	41.73
			Cenchrus ciliaris	26.85
			Acridocarpus orientalis	21.19
			Pennisetum divisum	15.41
			Physorrhynchus chamaerapistrum	14.05
Least Important 5 Species			*Euphorbia granulata*	0.53
			Orobanche cernua	0.53
			Polygala erioptera	0.54
			Reseda aucheri	0.56
			Asclepias curassavica	0.57
Most Important 5 Species	Unprotected	Spring	*Acacia tortilis*	40.61
			Cenchrus ciliaris	31.59
			Ziziphus spina-christi	14.31
			Zygophyllum qatarense	12.35
			Pennisetum divisum	11.89
Least Important 5 Species			*Ifloga spicata*	0.49
			Diplotaxis hara	0.50
			Euphorbia granulata	0.50
			Hippocrepis constricta	0.50
			Medicago polymorpha	0.50
Most Important 5 Species		Summer	*Acacia tortilis*	44.39
			Cenchrus ciliaris	40.04
			Ziziphus spina-christi	15.32
			Zygophyllum qatarense	15.10
			Pennisetum divisum	13.87
Least Important 5 Species			*Euphorbia granulata*	0.66
			Polygala erioptera	0.66
			Cleome rupicola	0.67
			Cleome dolichostyla	0.67
			Sporobolus spicatus	0.69

between 38.9% during spring in protected area to 44.3% in unprotected area during summer. For *C. ciliaris* the IV ranged from 21.4% to 40%, in protected area during spring, and unprotected area during summer; respectively. In summer, the observed high IV of the most important 3 species was attributed to the disappearance of annual plant species and this is true for most top five perennial species.

Examination of the protected and unprotected areas revealed that *Acridocarpus orientalis*, a rare species in the UAE, was only recorded in the protected area. *Ziziphus spina-christi* was recorded as one of the 5 most important species in the unprotected area and was not present in the protected area. Its local common use for human food rather than animal feed may be an explanation for its absence in the protected areas.

For the least important species, only *Euphorbia granulata* was recorded in both areas during spring and summer. The IV values ranged between 0.4% and 0.6% in the protected area during spring and in the unprotected area during summer; respectively. All species listed as least important were annuals except *Sporobolus spicatus*, which is a perennial grass important for grazing. *S. spicatus* was recorded in unprotected area during summer with an average IV of 0.7%.

At the study area (Wadi Tarabat) level, the number of species that were recorded once showed some substantial variations especially because of seasonal effects. The total number of species recorded once in the spring was much higher than that recorded during summer (44 vs 28 species; respectively).

Community similarity

The community similarity values based on the Jaccard Measure varied between 38.5% and 79.2% (Tab. III). The highest similarity (79.2%) was recorded between the protected area in spring and in summer, and followed by 67.5% between the unprotected area in spring and in summer. The dendrogram showed two clusters, one grouping the protected area in spring and in summer and the second grouping the unprotected area in spring and in summer (Fig. 4).

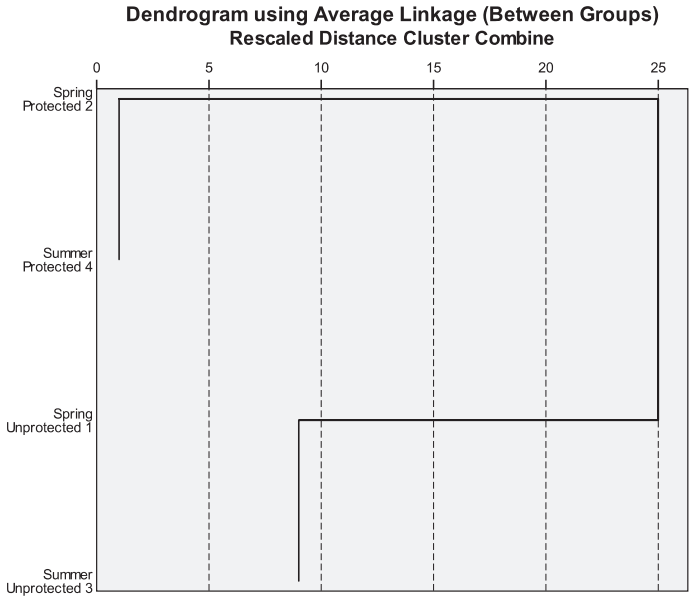

Figure 4.— Clustering of communities based on presence or absence of the plant species.

TABLE III

The community similarity in the protected and unprotected areas in spring and summer; based on presence or absence of the plant species

Proximity Matrix				
	Jaccard Measure			
	Spring Unprotected	Spring Protected	Summer Unprotected	Summer Protected
Spring Unprotected		50.9%	67.5%	38.5%
Spring Protected			43.0%	79.2%
Summer Unprotected				51.9%
Summer Protected				

DISCUSSION

The present study revealed that contrary to Simpson index, Shannon-Wiener and Brillouin's indices showed nearly similar values. This type of discrepancies was also reported by Ejtehadi *et al.* (2007) when they found inconsistencies between Shannon and Simpson within the same community. Moreover, appropriate ways to measure changes in species diversity in some ecosystems is unclear (Pueyo *et al.*, 2006). The results of our study suggest that Shannon's and Brillouin's indices are more appropriate to assess plant species diversity in UAE desert ecosystems.

Our results on protection from grazing support previous findings of its critical role in preserving species diversity in desert ecosystems (Ayyad *et al.*, 1990; El-Keblawy, 2003). Protection from grazing for shorter periods such as the case in our study (i.e. 5 years) improves ecosystem productivity. In Kuwait, however, extended protection from grazing resulted in ecosystem decline (Omar, 1991).

The protection of Wadi Tarabat from grazing is relatively new (ca 5 years). Therefore, we cannot exclude the issue of ecosystem disturbances and their effects on species diversity in our study. Many studies (Peet *et al.*, 1983; Huston, 1979) agree with the idea that moderate ecosystem disturbance improves species diversity. Neither low nor high disturbances increase species diversity (Connel, 1978).

For *Acacia tortilis, Cenchrus ciliaris* and *Pennisetum divisum* to have high IV values in the protected and in the unprotected areas in spring and summer reflects a possible adaptation of these species to grazing. Our observations agree with Kozlowski (1982), Ibrahim (1995) and Kummerow (1980).

The perennial species had higher IV values in summer than in spring because of the absence of annual species. In Indian grassland, for instance, species diversity ranged between 2.5 in September and 1.7 in December (Mukesh, 1995) on the basis of live shoots biomass.

Moreover, most above-ground production occurring during the rainy season at the study area (Wadi Tarabat), levels. The total number of species recorded once was much higher during spring than during summer (44 vs 28 species; respectively). The majority of species recorded once were annuals (Annex). The annual *Aristida adscensionis* which was listed among the most important five species within the protected area during spring was not listed among the most important five species within the unprotected area. Grazing is believed to be the main reason for the absence of *Aristida adscensionis* from the most important five species in the unprotected area.

The importance of ecosystems, such as Wadi Tarabat, in deserts could include floral species protection and preservation. Recently there have been attempts in retaining parts of some ecosystems based on their vulnerability to the threatening processes (Cowling *et al.*, 1999). The case of *Acridocarpus orientalis*, a rare species in the UAE, is an excellent example of such benefits.

A good way to compare communities in different places or at different times is to examine community similarity (Brower & Zar, 1984). The plant community within the protected area in spring and summer grouped together and showed the highest similarity, although of the absence of the annual species in summer. Moreover, the similarities between protected and unprotected areas in spring and summer are the lowest values. These indicate that protection is efficient and caused significant alteration between the plant communities within the protected area comparing with the unprotected area.

One of the very important findings in the present study is the presence of *Asclepias curassavica* which is the first record of this species. *Asclepias curassavica* has not been previously listed in the flora of the UAE (Western 1989; Jongbloed 2003; Karim & Fawzi 2007a,b; etc.). Moreover, two other species were reported to be only restricted to Wadi Tarabat, namely *Acridocarpus orientalis* and *Anvillea garcinii*. In a current study, Ksiksi (unpublished) found 123 individuals of *A. orientalis* species. Brown & Sakkir (2004) classified this plant as a rare species.

The high frequency of *A. orientalis* in the protected area may be attributed to the presence of mountain cliffs in the surroundings which create a micro-environment that may suit many plant species which are not adapted to the arid environment. *Acacia tortilis*, for instance, is much more adapted to the local environment since it is present at high frequencies in both protected and unprotected areas.

In conclusion, protection from grazing, even for short periods, improved species diversity in Wadi Tarabat ecosystem. As it is the case in the present project, Arabian Tahr grazing has been very low because of low number of individuals and light grazing intensity observed in the site. Additionally, plant species diversity increased during spring, within both protected and unprotected areas. As spring season is considered favorable for plant growth in this part of the world, growth outcomes from the above average rains during winter may become more apparent during spring, when temperatures become warmer. Protection from grazing, even for limited times, is essential in order to preserve species diversity in desert ecosystems. Moreover, ecosystem environmental characteristics have been shown to impact species diversity more than protection from grazing.

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ANNEX

Detailed list of species recorded as present (+) or absent (-) in protected (P) and unprotected (U) areas within Wadi Tarabat ecosystem during Spring and Summer

S.N.	Family	Species	Life form	Life cycle	Spring		Summer	
					U	**P**	**U**	**P**
1	Acanthaceae	*Blepharis ciliaris*	Herb	Perennial	+	+	+	+
2	Amaranthaceae	*Aerva javanica*	Shrub	Perennial	+	+	+	+
3	Amaranthaceae	*Amaranthus graecizans*	Herb	Annual	+	-	-	-
4	Amaranthaceae	*Amaranthus viridis*	Herb	Annual	+	+	-	-
5	Apiaceae	*Ducrosia anethifolia*	Herb	Annual	+	-	-	-
6	Asclepiadaceae	*Asclepias curassavica*	Shrub	Perennial	-	+	-	+
7	Asclepiadaceae	*Calotropis procera*	Shrub	Perennial	+	-	+	-
8	Asclepiadaceae	*Leptadenia pyrotechnica*	Shrub	Perennial	-	+	-	+
9	Asclepiadaceae	*Pentatropis spiralis*	Shrub	Perennial	-	+	-	+
10	Asclepiadaceae	*Periploca aphylla*	Shrub	Perennial	-	+	-	+
11	Asteraceae	*Anvillea garcinii*	Shrub	Perennial	+	+	+	+
12	Asteraceae	*Centaurea pseudosinaica*	Herb	Annual	+	+	-	-
13	Asteraceae	*Conyza bonariensis*	Herb	Annual	+	-	-	-
14	Asteraceae	*Grantia aucheri*	Herb	Facultative	+	+	+	+
15	Asteraceae	*Ifloga spicata*	Herb	Annual	+	+	-	-
16	Asteraceae	*Iphiona scabra*	Shrub	Perennial	-	+	-	+
17	Asteraceae	*Pulicaria edmondsonii*	Shrub	Perennial	-	+	-	+
18	Asteraceae	*Pulicaria glutinosa*	Shrub	Perennial	+	+	+	+
19	Asteraceae	*Reichardia tingitana*	Herb	Annual	-	+	-	-
20	Asteraceae	*Rhanterium epapposum*	Shrub	Perennial	+	+	+	+
21	Asteraceae	*Senecio flavus*	Herb	Annual	+	+	-	-
22	Boraginaceae	*Arnebia hispidissima*	Herb	Annual	+	+	-	-
23	Boraginaceae	*Echiochilon persicum*	Shrub	Perennial	+	+	+	+
24	Boraginaceae	*Heliotropium bacciferum*	Shrub	Perennial	+	-	+	-
25	Boraginaceae	*Heliotropium calcareum*	Herb	Perennial	+	+	+	+
26	Boraginaceae	*Heliotropium europaeum*	Herb	Annual	+	-	-	-
27	Boraginaceae	*Heliotropium rariflorum*	Shrub	Perennial	+	+	-	-
28	Brassicaceae	*Diplotaxis hara*	Herb	Annual	+	+	-	-
29	Brassicaceae	*Farsetia aegyptiaca*	Shrub	Perennial	+	+	+	+
30	Brassicaceae	*Morettia parviflora*	Herb	Perennial	+	+	+	+
31	Brassicaceae	*Physorrhynchus chamaerapistrum*	Herb	Perennial	+	+	+	+
32	Brassicaceae	*Savignya parviflora*	Herb	Annual	+	+	-	-
33	Brassicaceae	*Sisymbrium irio*	Herb	Annual	+	+	-	-
34	Caesalpiniaceae	*Senna italica*	Shrub	Perennial	+	-	+	-
35	Capparaceae	*Capparis cartilaginea*	Shrub	Perennial	-	+	-	+
36	Capparaceae	*Cleome dolichostyla*	Herb	Annual	+	+	+	+
37	Capparaceae	*Cleome rupicola*	Herb	Annual	+	-	+	-
38	Caryophyllaceae	*Gymnocarpos decandrus*	Shrub	Perennial	+	-	+	-
39	Caryophyllaceae	*Paronychia arabica*	Herb	Annual	+	-	-	-
40	Caryophyllaceae	*Sclerocephalus arabicus*	Herb	Annual	+	-	-	-
41	Chenopodiaceae	*Haloxylon salicornicum*	Shrub	Perennial	+	+	+	+
42	Chenopodiaceae	*Salsola imbricata*	Shrub	Facultative	+	-	+	-
43	Chenopodiaceae	*Salsola rubescens*	Shrub	Perennial	+	+	+	+
44	Convolvulaceae	*Convolvulus deserti*	Shrub	Perennial	+	+	+	+

S.N.	Family	Species	Life form	Life cycle	Spring		Summer	
					U	P	U	P
45	Convolvulaceae	*Convolvulus virgatus*	Shrub	Perennial	+	+	+	+
46	Cucurbitaceae	*Citrullus colocynthis*	Herb	Perennial	+	+	+	+
47	Cucurbitaceae	*Cucumis prophetarum*	Herb	Perennial	-	+	-	+
48	Cuscutaceae	*Cuscuta planiflora*	Herb	Annual	+	+	-	-
49	Ephedraceae	*Ephedra foliata*	Shrub	Perennial	+	+	+	+
50	Euphorbiaceae	*Euphorbia granulata*	Herb	Annual	+	+	+	+
51	Euphorbiaceae	*Euphorbia larica*	Shrub	Perennial	+	+	+	+
52	Fabaceae	*Crotalaria aegyptiaca*	Shrub	Perennial	+	+	+	+
53	Fabaceae	*Hippocrepis constricta*	Herb	Annual	+	-	-	-
54	Fabaceae	*Indigofera arabica*	Shrub	Perennial	+	-	+	-
55	Fabaceae	*Medicago polymorpha*	Herb	Annual	+	-	-	-
56	Fabaceae	*Taverniera glabra*	Shrub	Perennial	+	-	+	-
57	Fabaceae	*Tephrosia apollinea*	Shrub	Perennial	+	+	+	+
58	Fabaceae	*Tephrosia nubica*	Shrub	Perennial	+	-	+	-
59	Geraniaceae	*Monsonia nivea*	Herb	Perennial	+	-	-	-
60	Lamiaceae	*Leucas inflata*	Shrub	Perennial	-	+	-	+
61	Malvaceae	*Hibiscus micranthus*	Shrub	Perennial	-	+	-	+
62	Malpighiaceae	*Acridocarpus orientalis*	Shrub	Perennial	-	+	-	+
63	Mimosaceae	*Acacia tortilis*	Tree	Perennial	+	+	+	+
64	Mimosaceae	*Prosopis cineraria*	Tree	Perennial	+	+	+	+
65	Mimosaceae	*Prosopis juliflora*	Shrub	Perennial	+	+	+	+
66	Moringaceae	*Moringa peregrina*	Tree	Perennial	-	+	-	+
67	Nyctaginaceae	*Boerhavia elegans*	Herb	Perennial	+	+	+	+
68	Orobanchaceae	*Orobanche cernua*	Herb	Perennial	-	+	-	+
69	Plantagoniaceae	*Plantago ciliata*	Herb	Annual	+	+	-	-
70	Plantagoniaceae	*Plantago ovata*	Herb	Annual	+	+	-	-
71	Poaceae	*Aristida adscensionis*	Grass	Annual	+	+	-	-
72	Poaceae	*Arundo donax*	Grass	Perennial	+	-	+	-
73	Poaceae	*Cenchrus ciliaris*	Grass	Perennial	+	+	+	+
74	Poaceae	*Cymbopogon parkeri*	Grass	Perennial	+	+	+	+
75	Poaceae	*Dichanthium foveolatum*	Grass	Perennial	+	+	+	+
76	Poaceae	*Digitaria sanguinalis*	Grass	Annual	+	-	+	-
77	Poaceae	*Echinochloa colona*	Grass	Annual	-	+	-	+
78	Poaceae	*Eleusine compressa*	Grass	Perennial	-	+	-	+
79	Poaceae	*Eragrostis barrelieri*	Grass	Annual	-	+	-	-
80	Poaceae	*Lasiurus scindicus*	Grass	Perennial	+	-	-	-
81	Poaceae	*Panicum antidotale*	Grass	Perennial	+	+	+	+
82	Poaceae	*Pennisetum divisum*	Grass	Perennial	+	+	+	+
83	Poaceae	*Schismus barbatus*	Grass	Annual	+	+	+	+
84	Poaceae	*Sporobolus spicatus*	Grass	Perennial	+	-	+	-
85	Poaceae	*Stipa capensis*	Grass	Annual	+	+	-	-
86	Poaceae	*Stipagrostis plumosa*	Grass	Perennial	+	-	+	-
87	Poaceae	*Tricholaena teneriffae*	Grass	Perennial	+	-	-	-
88	Portulacaceae	*Portulaca oleracea*	Herb	Annual	+	-	-	-
89	Polygalaceae	*Polygala erioptera*	Herb	Facultative	+	+	+	+
90	Rahmanaceae	*Ziziphus spina-christi*	Tree	Perennial	+	-	+	-
91	Resedaceae	*Ochradenus arabicus*	Shrub	Perennial	+	+	+	+
92	Resedaceae	*Ochradenus aucheri*	Shrub	Perennial	+	-	+	-
93	Resedaceae	*Reseda aucheri*	Herb	Perennial	-	+	-	+

S.N.	Family	Species	Life form	Life cycle	Spring		Summer	
					U	**P**	**U**	**P**
94	Rubiaceae	*Gaillonia aucheri*	Shrub	Perennial	+	+	+	+
95	Rubiaceae	*Kohautia retrorsa*	Herb	Facultative	-	+	-	+
96	Rubiaceae	*Pseudogaillonia hymenostephana*	Herb	Perennial	-	+	-	+
97	Rutaceae	*Haplophyllum tuberculatum*	Herb	Perennial	+	+	+	+
98	Scrophulariaceae	*Scrophularia desertii*	Herb	Perennial	-	+	-	+
99	Solanaceae	*Lycium shawii*	Shrub	Perennial	+	+	+	+
100	Tamaricaeae	*Tamarix sp.*	Tree	Perennial	+	-	+	-
101	Tiliaceae	*Corchorus depressus*	Grass	Annual	+	-	-	-
102	Tiliaceae	*Grewia erythraea*	Shrub	Perennial	-	+	-	+
103	Urticaceae	*Forsskaolea tenacissima*	Herb	Perennial	-	+	-	+
104	Zygophyllaceae	*Fagonia indica*	Shrub	Perennial	+	+	+	+
105	Zygophyllaceae	*Tribulus omanensis*	Herb	Perennial	+	+	+	+
106	Zygophyllaceae	*Zygophyllum qatarense*	Shrub	Perennial	+	+	+	+