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Vegetation Ecology and Taxonomy of El-Ga'ab Area, North-Western Sudan

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Abstract:

El-Ga'ab area is a dry depression situated on the western bank of the Nile River in northern Sudan. It is considered to be an old basin flooded by the Nile during Early and Mid-Holocene. The larger part of the area is an absolute desert with almost no vegetation. The aim of this study is to report on the vegetation of El-Ga'ab depression, as well as to discuss its ecology related to past settlement activities. For the purpose of this study the area was divided into four parts: Bab El-Ga'ab ,Wadi El-Hasha, Ga'abs (Oasis) and Gravel Plateau. Five different zones or habitats were recorded. These are: (i) Rock furrows and depressions, (ii) Sandy plains, (iii) Shallow depressions on annual streams and wadis in the Gravel plateau, (iv) Sand dunes, and (v) Vegetation mounds. Floristic composition and vegetation analysis which include the density, relative density and frequency were reported. For the trees and shrubs, in Northern Bab El-Ga'ab, as well

as in the Gravel plateau and Ga'ab El-Mangoor, Acacia ehrenbergiana dominated the plant communities showing both maximum frequency and higher relative density. On the other hand, Hyphaene thebiaca dominated in Ga'ab oasis. The most common annuals reported for northern Bab El-Ga'ab, and for both the upper and the lower zones of the Gravel plateau were Boerhavia repens, Senna alexandarina and Portulaca quadrifida, whereas Corchorus depressus showed a wide distribution in both Wadi El-Hasha north and Wadi El-Hasha south. The underground water level, the soil type (different chemical and physical properties) and the intensity of human activity were probably the most important factors affecting the distribution of plant species in the studied sit.

Key words: Western Desert, El-Ga'ab, ecology, vegetation, past-settlement

Introduction

El-Ga'ab area is a depression situated on the western bank of the Nile River, south of the Third Cataract in northern Sudan. It is considered to be an old basin flooded by the Nile during Early and Mid-Holocene, which is now completely dry. The surrounding vegetation is classified as being located within the desert zone of northern Sudan (Harrison and Jackson 1958), the eastern part of the North African Sahara zone (i.e. Egypt and Northern Sudan west of the Nile) being considered to be one of the most arid areas of the world (Wickens 1982). The larger part of the area is an absolute desert with almost no vegetation, the average annual precipitation being less than 0.1 mm. El-Ga'ab depression owes its importance to the fact that it is the only remote area in the Sudan Nubian desert situated away from the Nile that supports life.

El-Ga'ab depression extends for 123 km, diverging from the Nile towards the south; its width varies from 2 to 8 km. The nearest point to the river is about 6 km at its northern end and the most distant point is 60 km towards the south. (Figure1).

The northern part of El-Ga'ab known as Wadi El-Hasha is characterized by the alluvial soil deposition which is accumulated during the Early and Mid-Holocene flood seasons similar to nearby basins like Kerma El-Seliam and El-Khewi, while the southern part is a depression where the underground water is sub-surface water.

Ecological research has been largely neglected in the northern desert west of the Nile. Biological data on the study area are very scanty except for some occasional ecological notes compiled by few official visitors who published their reports on El-Ga'ab. One of the oldest reports on the area which dates back to 1905 was prepared by officers of the Sudan Government in The Anglo-Egyptian Sudan (The Anglo-Egyptian Sudan Compendium, 1905). According to this compendium A. E. Turner visited the area in 1884. He described the northern branch of Wadi Ga'ab where he saw dom palm (*Hyphaene thebaica*), date palm (*Phoenix dactylifera*), acacia tree (*Acacia* spp.) and halfa grass (*Desmostachya bipinnata*) near the wells. The report mentions that also A. Hunter visited the area in 1896. The latter recognized the effect of both wind and sand on the vegetation as he wrote: "The whole place has the appearance of a forest after a heavy storm". He added that the plant cover of the area consisted of tamarisk bushes (*Tamarix* spp.), dom palm and date palm. Recently, several wild-growing species of trees, shrubs and undershrubs were identified by Tahir (2012): *Hyphaene thebaica*, *Acacia ehrenbergiana*, *Tamarix articulata*, *Capparis decidua*, *Calotropis procera, Abutilon pannosum*, *Cassia senna*, *Panicum turgidum*, *Cynodon dactylon*, *Tribulus longipetalus* and *Cenchrus biflorus*.

The presented ecological survey was a part of the "Archaeological, Ethnographical and Ecological Project of El-Ga'ab Depression in Western Dongola (Northern Sudan)" launched by the Department of Archaeology, Faculty of Arts, University of Khartoum. The aim of this study is to report on

the vegetation of El-Ga'ab depression, as well as to discuss its ecology related to past settlement activities.

Methods

Vegetation analysis

The vegetation of selected sites was studied during two visits. Perennial vegetation was studied during the dry season in May 2014, whereas the annual plants were studied during the wet season in September 2014. Sampling plots for vegetation analysis were randomly laid in each selected site of the study area. For abundance estimation of trees, shrubs and undershrubs, quadrats 20x20 m were used, whereas for abundance estimation of the annuals, quadrats 0.5x0.5 m were used. Weeds encountered in cultivated areas around El-Ga'ab oasis were collected, identified and presented in a check list.

1. Location of sampling plots

For the purpose of the present study the area was divided into four parts (Figure 1):

Bab El-Ga'ab: A narrow channel which begins in the vicinity of Soroog village at the Nile. It runs from the terrace (covered by soil) westwards to the desert for about 6 km. The majority of the channel area is covered with gravel. Sporadic irrigation wells (*mutras* in Arabic) were encountered, but no recent human settlement .

In Bab El-Ga'ab the annuals were studied in 45 plots at the site A which is located about 8 km from the Nile. To the west of this site, about 10 km from the Nile, trees and shrubs were studied in 20 plots from a site designated as site I.

Wadi El-Hasha: An area located towards the south of the Bab El-Ga'ab. The channel expands in this area and the surface is covered with terrace and alluvial soils. Although a large

number of *mutras* was seen in these fertile agricultural lands, very little recent human settlement was encountered.

In Wadi Al Hasha few trees were encountered. The annuals were studied in 20 plots in sites B in the north, and 10 plots in site C in the south.

In both Bab El-Ga'ab and Wadi El-Hasha, the underground water is available at 5-6 meters.

Ga'abs (Oasis): To the south of the Wadi El-Hasha there is a series of oasis, where villages and hamlets for human settlement are found. The largest oasis is Ga'ab El-Lagia in the north 18 km from the Nile. Others are Ga'ab Abu Namil, Ga'ab Al Mangoor Ga'ab Um Hilal, Ga'ab El-Thowani, Ga'ab Byoda and Ga'ab Bab. Commonly villages lie in areas where underground water is available at a shallow depth (1-3 m). Cultivable and grazeable lands are present.

In El-Ga'ab oasis trees and shrubs were studied in 20 quadrats in two sites: north east of Ga'ab El-Lagia designated as site III and to the south, near Ga'ab El-Mangoor designated as site IV (Figure 2 and Figure 3).

Gravel Plateau: The Gravel plateau lies outside of El-Ga'ab depression. It extends parallel to the Nile, being bounded by the Nile to the east and by both El-Ga'ab oasis and sand stone rocky land to the west. The underground water is available at 10 -15 meters.

The vegetation on the plateau occurs on the south part where water accumulates in depressions and khors. (short watercourse). Annuals were collected from 20 plots in (a) plateau upper zone (236 above sea level) designated as site E and (b) plateau lower zone (222 m above sea level) designated as site D. Trees and shrubs were studied in 10 plots in a site referred to as site II.

2. Vegetation estimates

The following estimates were made for annuals, perennials, trees, shrubs and undershrubs according to Greig-Smith (1983):
(i) **Density**: Density inside the studied quadrat was calculated for each species as the number of individuals per unit area.
(ii) **Relative density (%):** The number of individuals of a species encountered in all quadrats expressed as percentage of the total number of individuals of all species in all quadrats.
(ii) **Frequency (%)**: The number of quadrats in which trees and shrubs were encountered, expressed as a percentage of the total number of quadrats.

3. Identification of plant species

For species identification, Andrews (1950; 1952; 1956), Sahni (1968) and El Amin (1990) were followed in most cases. Vernacular names recorded in this report were those given by the local people or those cited in Broun and Massey (1929), and Bebawi and Neugebbohrn (1991). Specimens of the plants collected are deposited in the Herbarium of the Botany Department, Faculty of Science, University of Khartoum.

Results and Discussion

1. Description of the vegetation of El-Ga'ab area

The floristic composition of plant communities identified is summarized in Table 1 and 2, expressed by the frequency index in combination with density and relative density estimate for trees and shrubs (Table 1), and annuals and perennials (Table 2). The analysis reveals that the studied sites are different in their species distribution.

As for the trees and shrubs, in Northern Bab El-Ga'ab, as well as in the Gravel plateau and Ga'ab El-Mangoor *Acacia ehrenbergiana* dominated the plant communities showing both maximum frequency and higher relative density. On the other hand, *Hyphaene thebiaca* dominated in Ga'ab oasis.

The distribution of the annuals showed, on the other hand, more complicated pattern. The most common annuals reported for northern Bab El-Ga'ab, as well as for both the upper and the lower zones of the Gravel plateau were *Boerhavia repens, Senna alexandarina* and *Portulaca quadrifida*, whereas *Corchorus depressus* showed a wide distribution in both Wadi El-Hasha north and Wadi El-Hasha south (Tables 1 and 2). The relative densities of some species such as *Haloxylon salicornicum* in Ga'ab El-Lagia and *Corchorus depressus* in the Gravel plateau were high in some sites where they formed almost pure stands, although they were not encountered in all quadrats.

The underground water level and the soil type (different chemical and physical properties) were probably the most important factors affecting the distribution of plant species in the studied sites. Another important factor was the intensity of human activity, which was, on the other hand, also strongly influenced by both above-mentioned factors. The vegetation may be divided into two main types, according to the intensity of human influence: A. The natural vegetation, and B. The vegetation (including weeds) associated with the permanent cultivation.

A. The natural vegetation:

The general characteristic of the natural vegetation is the predominance of communities with a very simple plant composition, dominated by a small number of species. The landscape pattern is strongly affected by land topography and soil water content. For convenience of description of the vegetation, five different zones or habitats were recognized: (i) Rock furrows and depressions, (ii) Sandy plains, (iii) Shallow depressions on annual streams and wadis in the Gravel plateau, (iv) Sand dunes, and (v) Vegetation mounds.

Zone (i): Rock furrows and depressions

Although extreme aridity on rocks or mountains in desert reduces the possibility for plants to grow, the furrows which are formed on the surface of the rock by run-off water provide a habitat that is favourable for ephemeral and some annuals plant growth. Depressions which accumulate thick layer of soil, become a suitable habitat for perennial acacia species. This micro-habitat is recorded in different sites of the study area. Plant species encountered in this zone are *Acacia eherenbergiana, Haloxylon salicornicum* and *Fagonia indica.*

Zone (ii): Sandy Plains

Sandy plain zone (Plate 1) represents the major zone which gives the studied area its distinctive character. The vegetation cover varies depending on the depth of the sand cover varying from a thin sheet to small-sized dunes. Plants of this zone are predominantly perennial species that are distinctly deciduous. The dominant species are *Acacia ehrenbergiana, Acacia radiana,* and *Capparis decidua.*

Zone (iii): Shallow depressions on annual streams and wadis

This zone represents the water-catchment areas or dried stream-beds (Plate 2) in which water and mineral nutrients are gradually accumulated during rainy season. Many ephemerals and few perennials were recorded. The dominant species are: *Panicum turgidum, Fagonia indica, Senna alexandarina* and *Aerva javanica.*

Zone (iv): Sand dunes

The vegetation of sand dunes (Plate 3) is usually composed of shrubs or tufts of grasses, which accumulate and stabilize sand. This feature is recorded for many sites in El-Ga'ab area especially in the transition from sandy plain to agricultural lands.

Zone (v): Vegetation mounds

The mounds formed by *Tamarix nilotica* (Plate 4), locally known as *tarbools*, are the most interesting features of this vegetation type. The *tarbools* were mostly recorded near the old settlement relics, such as graves, churches and other buildings assigned to the Christian period. The surviving shrubs of *Tamarix nilotica* are mostly the relics of the past vegetation closed to irigated agricultural schemes (Plate 5).

The phenomenon of vegetation mounds was studied in Baharyia (El-Hayz) oasis in the Western desert of Egypt (Pokorný and Pokorná 2013). Five different plants species were able to form large features of this kind: *Tamarix aphylla, T. nilotica, T. amplexicaulis, T. passerinoides*, and *Acacia nilotica*. Based on the study of topography, internal stratigraphy and radiocarbon dating of vegetation mounds Pokorný and Pokorná (2013) concluded that these features are surprisingly old, having been formed successively in the course of many hundreds of years. The hillock-forming vegetation established on ancient irrigated agricultural land and the topography of vegetation mounds is closely linked with the topography of former settlements. This is why vegetation mounds can be effectively used in spatial archaeological analysis, reconnaissance and prediction of archaeological sites. As mentioned above, this possibility has been verified again during our present study in El-Ga'ab Area.

B. The vegetation associated with permanent cultivation (Plate 5)

Weed flora associated with the permanent cultivation of El-Ga'ab area is induced by individual management practices of the land owners (Alkababeesh tribe) who cultivate many types of crops. The main crops are as follows: okra (*Abelmoschus esculentus*), onion (*Allium cepa*), coriander or cilantro (*Coriandrum sativum*), cucumber (*Cucumis sativus*), fennel (*Foeniculum vulgare*), berseem or Egyptian clover (*Trifolium*

alexandrinum), wheat (*Triticum vulgare*) and a variety of vegetables in addition to a large agricultural scheme of central pivot irrigation method. The natural vegetation has been cleared for the cultivation, although a few trees of *Hyphaene thebaica*, *Tamarix* sp. and *Acacia* spp. (usually *A. nilotica* and *A. tortilis*) could be seen within this zone.

2. Comparison with other vegetation studies in North-East Africa

Many plant species recorded in El-Ga'ab depression were also reported for similar depressions in western Egyptian Sahara such as Farafra, Dakhla, Kharga and Baharyia oases (e.g. Kassas 1971, El Hadidi 1980, Pokorný and Pokorná 2013).

The herbs reported there by Kassas (1971) are *Fagonia parviflora, Zygophyllum coccineum, Demostachya bipinnata, Tribulus mollis* and *Aristida plumosa*, while the perennials were *Phoenix dactyifera, Hyphaene thebaica, Tamarix amplexicaulis, T. nilotica, Acacia raddiana* and *A. flava.* El Hadidi (1980) reported the presence of *Phragmites australis*, *Hyphaene thebaica, Stipagrostis pungens, Acacia ehrenbergiana, Imperata cylindrica, Tamarix amplexicaulis* and *Sorghum sudanese* around wells of the eastern Sahara; *Stipagrostis ciliata* and *Astragalus vogelii* in moistened thin sand sheets; *Fagonia arabica, F. indica, Tribulus pentandrus and Euphorbia granulata* on shallow sand accumulations mixed with pebbles, and. *Panicum turgidum, Citrullus coloynthis, Aerva persica, Crotalaria thebaica, Francoeuria crispa* and *Salsola baryosoma* on thick layer of sand and silts.

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Table 1: Floristic composition (trees and shrubs) of four sites representing the vegetation of the plateau. (Site I: Bab El Ga'ab, Site II: Wadi Al Hashsha; Site III: Ga'ab El Lagia; Site IV: Ga'ab Al Mangoor)

Species	Frequency%				Density				Relative Density%			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
Acacia ehrenbergiana Hayne	55	20	10	50	4.9	0.3	0.2	2.8	64.9	75	1.14	35.4
Calotropis procera (Aiton) Dryand Ait.	20	10	0	0	0.5	0.1	0	0	6.6	25	0	0
Tamarix nilotica (Ehrenb.) Bunge	20	0	0	0	2.1	0	0	0	27.8	0	0	0
Leptadenia pyrotechnica (Forsk.) ecne.	5	10	0	0	0.05	0.1	0	0	0.66	25	0	0
Hyphaene thebaica (L.) Mart.	0	0	100	50	0	0	5.5	0.9	0	0	31.4	11.4
Haloxylon salicornicum (Moq.) Bunge ex Bioss	0	0	50	0	0	0	6.1	0	0	0	34.8	0
Acacia tortilis (Forsk.) Hayne**	0	0	60	0	0	0	2.4	0	0	0	13.7	0
Faidherbia albida (Del.) Chev	0	0	10	0	0	0	0.1	0	0	0	0.57	0
Capparis deciduas (Forssk.) Edgew.	0	0	10	0	0	0	0.1	0	0	0	0.57	0
Balanites aegyptiaca (L.) Delile	0	0	40	0	0	0	3.1	0	0	0	17.7	0
Acacia radiana Savi**	0	0	0	40	0	0	0	0.6	0	0	0	7.5
Phoenix dactilifera L	0	0	0	20	0	0	0	2.3	0	0	0	29.1
Tamarix aphylla (L.) H.Karst.	0	0	0	30	0	0	0	1.3	0	0	0	16.4

****Acacia tortilis (Forsk.) Hynes ssp. radiana (Savi) Brenan**

Table 2: Floristic composition (annuals and perennials) of five sites representing the vegetation of the plateau. (Site A: Bab El Ga'ab, Site B: Wadi Al Hashsha North; Site C: Wadi Al Hashsha South; Site D: Plateau lower zone, Site: E: Plateau upper zone .

Species	Frequency%					Density					Relative Density%				
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Boerhavia repens L.	60	10	0	0	0	1.71	0.1	0	0	0	37.3	0.66	0	0	0
Tribulus terestris L.	15	10	10	20	5	0.2	0.25	0.1	0.25	0.05	3.46	1.65	0.33	7.57	1.61
Portulaca quadrifida L.	2	0	0	0	25	0.02	0	0	0	0.35	0.38	0	0	0	11.2
Ipomoea cordofana Choisy	2	0	40	0	20	0.04	0	0.4	0	0.5	0.76	0	1.32	0	16.1
Citrullus colocyntheis (L.) Schrad	2	0	0	0	5	0.02	0	0	0	0.05	0.38	0	0	0	1.61
Euphorbia hirta L.	27	45	0	25	15	0.57	2.45	0	0.4	0.3	10	16.2	0	12.1	9.67
Zaleya pentandra (L.) C.Jeffrey	4	0	0	0	0	0.04	0	0	0	0	0.76	0	0	0	0
Fagonia indica Burm.f.	9	0	0	0	15	0.08	0	0	0	0.2	1.53	0	0	0	6.45
Senna alexandrina Mill	22	15	0	40	0	0.6	0.35	0	0.85	0	10.3	2.31	0	25.7	0
Blepharis edulis (Forsk.) Pers.	2	0	0	0	0	0.06	0	0	0	0	1.15	0	0	0	0
Panicum turgidum Forsk.	29	5	0	10	10	0.62	0.05	0	0.15	0.15	10.7	0.33	0	4.54	4.83
Aerva javanica (Burm.f.) Juss. ex Schult.	4	0	10	5	15	0.04	0	0.1	0.1	0.2	0.76	0	0.33	3.03	6.45
Corchorus depressus (L.) Christens.	51	65	100	20	20	1.73	10.2	29.4	0.65	1.1	30	67.8	97.3	19.6	35.4
Seetzenia lanata (Willd.) Bullock	0	15	0	0	0	0	1.1	0	0	0	0	7.28	0	0	0
Tephrosia purpurea (L.) Pers	0	5	0	0	0	0	0.05	0	0	0	0	0.33	0	0	0
Pulicaria undulata (L.) C.A.Mey.	0	5	0	0	0	0	0.15	0	0	0	0	0.99	0	0	0
Euphorbia aegyptiaca Boiss	0	20	20	15	0	0	0.35	0.2	0.3	0	0	2.31	0.66	9.09	0
Calotropis procera (Aiton) Dryand Ait.	0	0	0	5	0	0	0	0	0.05	0	0	0	0	1.51	0
Convolvulus arvensis L.	0	0	0	5	0	0	0	0	0.05	0	0	0	0	1.51	0
Acacia ehrenbergiana Hayne	0	0	0	20	0	0	0	0	0.5	0	0	0	0	15.1	0
Pulicaria undulata (L.) C.A.Mey.	0	0	0	0	5	0	0	0	0	0.05	0	0	0	0	1.61
Morettia philaeana DC.	0	0	0	0	5	0	0	0	0	0.05	0	0	0	0	1.61
Senna italica Mill.	0	0	0	0	10	0	0	0	0	0.1	0	0	0	0	3.22

Figures

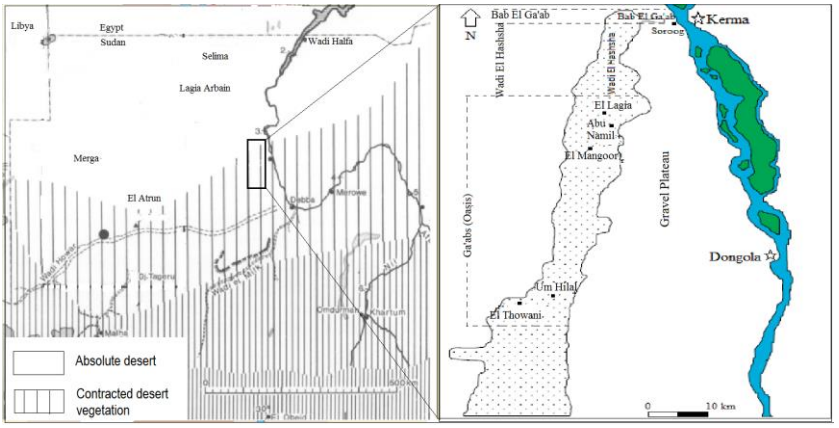

Figure 1: Location of El-Ga'ab Depression in the Eastern Sahara vegetation map (after Kassas 1971, UNESCO/AETFAT/UNSO 1983 Wickens 1982 and Katharina 1989, modified).

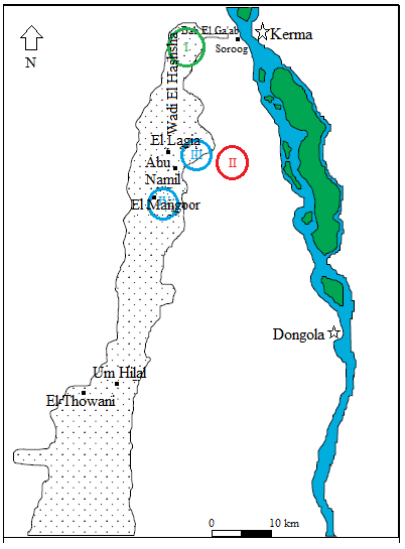

Figure 2. El-Ga'ab Depression Map showing trees and shrubs sampling locations (I-IV)

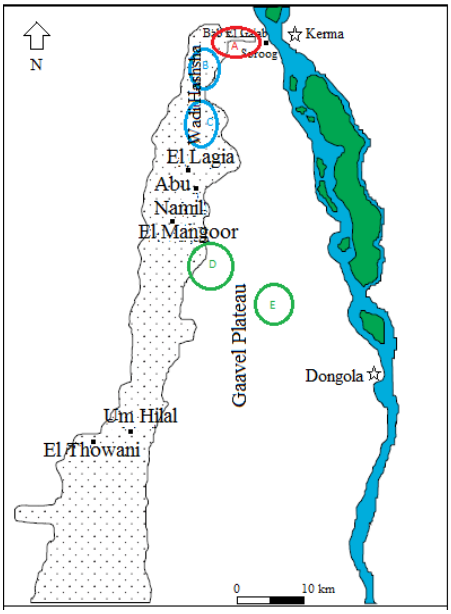

Figure 3: El-Ga'ab Depression Map showing annual herbs sampling locations (A-E)

Plate 1: Sandy plain zone dominated by *Acacia* species.

Plate2: Water-catchment areas on annual streams dominated by *Panicum turgidum*

Plate 3: Sand dunes dominated by *Pennisetum setaceum*

Plate 4: *Tamarix aphylla* mounds (near old settlements related to Christian period)

Plate 5: Satellite view of aggregation of *Tamarix aphylla* mounds

Plate 6: Artesian-wells irrigated lands