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Woodland Plant Growth in the Fung Area of the Sudan
I. A Survey of Plant Communities

A.M.A. Ismail*, M. Obeid and M.E. Beshir**

Departmant of Botany, Faculty of Science,
University of Khartoum, Khartoum, Sudan

ABSTRACT The composition of tree communities in the Fung-Area was assessed and sub-divisions into Riverine Associations and Clay Plain Associations were recognized. The former, with *Ziziphus spina-christi* dominating, inhabit light soils with high water table and undulating terrain. The latter are further sub-divided into: (i) *Acacia Seyal – A. senegal – Balanites aegyptiaca* associations in habitats where no cultivation is practised, (ii) *Acacia campylacantha – A. seyal – A. fistula* and *A. senegal* in intensively cultivated areas, (iii) *Acaçia mellifera* associations in depressions and catchment areas, (iv) *Acacia nubica* associations in over-grazed areas near villages and at the feet of rocky hills, and (v) *Combretum hartmannianum* associations the probable relics of the original vegetation, present in areas least influenced by man. It is concluded that the present distribution of tree species in the Fung area is largely the result of historical biotic influences, rather than stemming from environmental effects.

The Fung area is part of the central rainlands of the Sudan which extend over millions of acres on the clay plains of Kassala, Blue Nile and Upper Nile provinces. The area surveyed extends between latitudes 11° 5′ N and 13° 33′ N with the eastern boundary represented by the Blue Nile and the western boundary by a line running north to south from Jebel Moya through Jebel Dali and Mazmoum (Fig. 1).

In addition to the intermittent clearning of forest and scrub for agriculture, the area is subjected to intensive grazing by cattle, sheep, camels and goats.

* *Present address:* Department of Botany, Faculty of Science, University of Qatar, Doha, Qatar.

** *Present address:* Department of Botany, Faculty of Science, University of the Gezira, Wad Medani, Sudan.

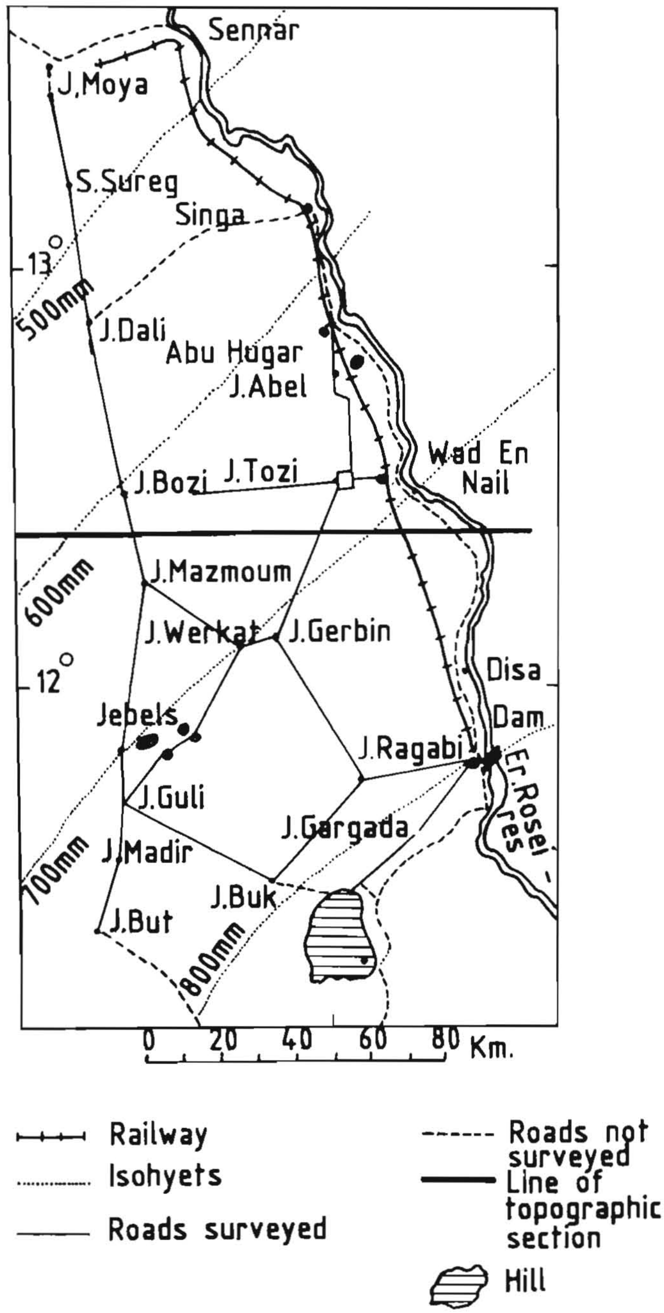


Fig. 1. The Fung area of the Sudan Republic.

Another feature of this area is *harig* cultivation system. In this system 12-15 years old forest with dense growth of grass is felled in the dry season (usually January) and by the onset of the first showers of the rainy season (usually June), when new growth is showing under the old one, is put to fire. The heat produced by the burning grass is sufficient to destroy the newly growing plant cover. This practice of timing the burning after the first showers is an effective means of weed control.

The outcome of these constant disturbances has been secondary succession, leading to the development of a series of plant communities. The aim of the present study is to evaluate the impact of these disturbances on distribution and composition of the tree plant communities.

Previous studies were concerned mainly with detailed descriptions of the vegetation, and have almost totally ignored the effects of the intensive biotic factor. This study investigates the distribution, floristic composition and types of plant communities in the Fung area in an endeavour to establish their interrelationship, and also to evaluate the impact on these communities of the system of cultivation (especially the effect of fire) and the edaphic, climatic and biotic factors prevailing in the area.

Geology and Geomorphology

The geological foundation of the area is a basement complex formation which is mainly a mixture of granite-gneiss with strong foliation and with marble on top. The basement complex is covered by unconsolidated sediments of clay, silt, sand, gravel and boulder beds attaining a maximum depth of about 60 metres (Jones 1954). In general, there is a tendency for these sediments to become coarser downwards with clay at the top. These surface deposits of clay are believed to be the weathering products of the basic rocks of the Ethiopean plateau transported by the Blue Nile.

Topography

The terrain is a flat alluvial plain with a slope of less than 2% towards the Blue Nile, but with an overall tilt towards the north. On the western border of the region, there is a north to south succession of isolated granite rock outcrops such as Jebel Dali, Bozi, Mazmoum (Fig. 1). Near the Blue Nile, the land dips in some places making troughs and grooves where silt and sand have been deposited or exposed and where small erosion channels can be seen.

Soils

Dark alkaline (pH about 9) cracking clays are the dominant soil type of the area. The clay content of the plain is over 70%. Other soil types occupy smaller fractions and include: localized grey-skeletal red and brown soils forming part of the catena developed on the scattered rock outcrops, sandy loams and clays of the slopes of the northern eroded Blue Nile and related groves and more recently deposited silts and clays of the Blue Nile trough.

Climate

The climate of the Fung, like that of the central rainlands, is semiarid and with a single rainy season (May-October). The rains are associated with the West African climatic system derived from the Atlantic and Congo Air Masses with little or no Indian Ocean influence.

The rainfall increases gradually southwards; Sennar, in the northern part of the area, has an average annual rainfall of 478 mm, whereas Roseires which lies further south has an annual average of 803 mm. There are six almost rainless months (November-April) and two months (May and October) with relatively little rainfall. The monthly, as well as the annual rainfalls totals are very variable, (El-Tom 1974, 1975). These variations do not seem to follow a particular pattern. Most of the precipitation is in July, August and September, with the peak well defined in August (Fig. 2).

During the rainy season, the maximum temperatures lie around 30°C and the minimum around 20°C. As the rains decline, the maximum rises and with the onset of the dry northerly air masses towards the end of October, the minima fall and the maxima rise (Fig. 3). The relatively cool months of December and January with mean minima below 20°C are followed by a gradual rise of temperature in February and March, the mean maxima then are about 40°C and the minima rise to 20-25°C.

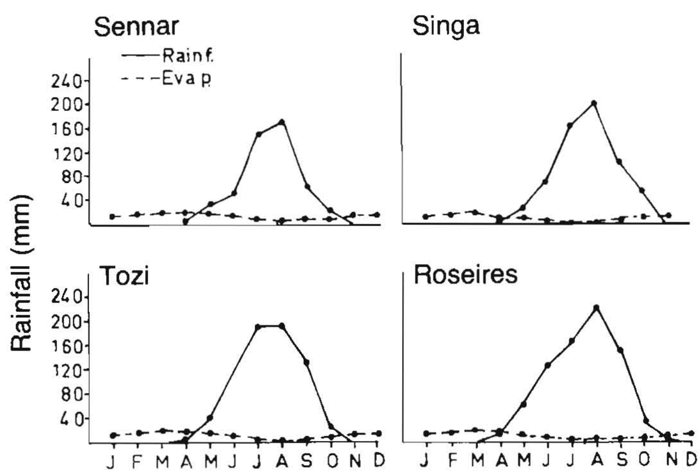


Fig. 2. Monthly rainfall and evaporation in four stations in the Fung area.

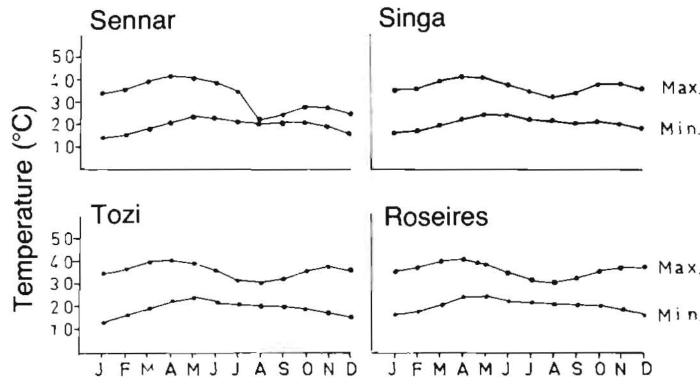


Fig. 3. Maximum and minimum temperatures of four stations in the Fung area.

Vegetation

According to Andrews (1948), two vegetation belts are recognizable in the Fung district, the *Acacia Short Grass Scrub* in the north and the *Acacia Tall Forest* in the south. Smith (1944) considered the southernmost area of the Fung as 'Mixed Deciduous Fire-Swept Country'. Harrison and Jackson (1958) presented a general classification of the vegetation of the Sudan and attempted to correlate it with systems adopted by other authors for African vegetation. In their presentation, this area belongs to the *Low Rainfall Woodland Savanna on Clay.* Bunting and Lea (1962), in their detailed description of the vegetation of the Fung area, had recognized various types including bushland and thicket, woodland, grassland and forest.

Methods

A series of preliminary surveys was carried out in the area during the dry season using the method of land traverses. On these traverses, continuous record of the vegetation were noted against distance. These records were limited species lists; also changes in vegetation and the physical environment were noted. From these traverses it was possible to recognize the following fifteen 'community types':

1. *Acacia campylacantha – A. fistula*
2. *Acacia campylacantha*
3. *Acacia seyal – Balanites aegyptiaca – A. fistula*
4. *Balanites aegyptiaca*
5. *Acacia campylacantha – A. Seyal – A. fistula – A. senegal*
6. *Acacia seyal*
7. *Balanites aegyptiaca*
8. *Acacia nubica – A. senegal*

9. *Acacia nubica*
10. *Combretum hartmannianum*
11. *Acacia mellifera – Dichrostachys glomerata – A. seyal*
12. *Ziziphus spina-christi*
13. *Acacia mellifera – Balanites aegyptiaca*
14. *Acacia mellifera*
15. *Acacia fistula*

In a site representing each of the above community types a plot of 100 × 100 m was marked for detailed vegetation survey. Because of the scarcity of access routes in the area, especially during the rainy season, random sampling over the area was not possible. Square plots (100 × 100 m) were laid out, using ranging poles for demarcation, a four-armed cross with a slit fitted on a pole for right-angles and a measuring wheel for distances. The square plots were then subdivided into 100 quadrates, each of 10 m^2 and marked out by Juxta-posts. All the tree and shrub species present in each of these quadrates were counted and crown diameters measured.

Since fire was considered an important ecological factor in the area, a field trial was carried out to test the effect of simulated heat intensity on the viability of the seeds of 5 species of *Acacia* dominant in the area, *viz., Acacia seyal, A. fistula, A. mellifera, A. campylacantha,* and *A. senegal.* The treatments tested were: (i) light burning, (ii) heavy burning and, together with a control, were laid out as three blocks. In each block, the fire treatments and control were replicated 5 times in a Latin square design.

Results and Discussion

From the data collected, the following were assessed:

1. Frequency of each species,
2. Relative density of each species,
3. Area covered by each species, and
4. 'Nodal' communities akin to Poore's nodes (1955) were established.

The findings are discussed in terms of the habitat characteristics in an endeavour to discover the relationship between the distribution of the tree species and the various environmental and biotic factors operating in the area.

Associations between species were calculated from presence or absence data in 2 × 2 contingency tables for all possible species combinations. The reciprocal of the calculated χ^2 between each species pair was used to construct a constellation diagram, (Agnew 1963) so that two species positively associated and with a large χ^2 value are positioned close to one another. Species which occurred less than five times in the total sample area were eliminated.

Table 1. The number of individuals per sample plot frequency, total cover and relative density for each species in the fifteen 'community types' recognized.

Site No.	Species	No. of indiv.	Freq. (%) (F)	Total cover (m^2)	Rel. Dens.
1	*Acacia campylacantha*	303	77	439.4	38.0
	Acacia fistula	197	77	730.9	25.0
	Cephalocroton cordofanus	235	47	23.5	29.0
	Acacia seyal	49	36	116.6	6.0
	Combretum aculeatum	3	3	0.7	0.4
	Dichrostachys glomerata	4	2	11.3	0.5
	Ziziphus spina-christi	2	1	14.6	0.2
	Acacia senegal	2	1	11.1	0.2
	Balanites aegyptiaca	1	1	14.2	0.1
	Cadaba rotundifolia	2	1	0.6	0.1
2	*Acacia campylacantha*	462	87	3668.3	68.4
	Acacia seyal	60	46	163.2	8.9
	Acacia fistula	55	41	487.9	8.2
	Dichrostachys glomerata	57	29	165.3	8.4
	Acacia senegal	35	24	15.8	5.2
	Cadaba rotundifolia	3	3	2.2	0.4
	Cephalocroton cordofanus	2	2	0.2	0.3
	Acacia mellifera	1	1	2.8	0.2
3	*Acacia seyal*	76	54	2415.3	25.0
	Balanites aegyptiaca	59	42	2056.7	20.0
	Acacia fistula	50	41	591.5	16.5
	Acacia senegal	38	31	23.2	13.0
	Cephalocroton cordofanus	44	21	3.1	14.5
	Cadaba rotundifolia	13	7	7.7	4.0
	Acacia campylacantha	7	6	18.2	2.5
	Dichrostachys glomerata	7	4	14.7	2.5
	Ziziphus spina-christi	6	3	43.9	2.0
4	*Balanites aegyptiaca*	209	64	3120.4	59.9
	Acacia seyal	71	42	3429.6	20.30
	Acacia senegal	28	21	433.7	8.0
	Acacia mellifera	26	17	24.6	7.5
	Cadaba rotundifolia	8	7	4.6	2.3
	Ziziphus spina-christi	3	2	40.3	0.9
	Acacia nubica	1	1	2.8	0.3
5	*Acacia campylacantha*	138	53	183.5	33.5
	Acacia seyal	60	48	1906.8	14.6
	Acacia fistula	55	43	954.6	13.4

Site No.	Species	No. of indiv.	Freq. (%) (F)	Total cover (m^2)	Rel. Dens.
	Acacia senegal	69	42	80.7	16.7
	Cephalocroton cordofanus	27	14	21.6	6.6
	Dichrostachys glomerata	14	9	51.4	3.4
	Ziziphus spina-christi	34	4	19.0	8.2
	Cadaba rotundifolia	7	4	4.2	1.7
	Combretum aculeatum	7	2	5.7	1.7
	Balanites aegyptiaca	1	1	21.1	0.2
6	*Acacia seyal*	269	90	6495.0	98.0
	Balanites aegyptiaca	16	15	394.2	5.0
	Cephalocroton cordofanus	14	10	12.0	4.5
	Acacia senegal	5	5	13.6	2.0
	Cadaba rotundifolia	2	2	0.6	0.5
7	*Balanites aegyptiaca*	398	92	7084.4	91.5
	Acacia seyal	21	18	62.1	4.8
	Ziziphus spina-christi	10	9	83.5	2.3
	Acacia senegal	2	2	0.4	0.5
	Acacia nubica	2	2	4.4	0.5
	Acacia campylacantha	1	1	2.0	0.2
	Dichrostachys glomerata	1	1	2.8	0.2
8	*Acacia nubica*	295	78	418.9	38.61
	Acacia senegal	116	60	2897.7	15.18
	Acacia seyal	54	45	1871.1	7.1
	Balanites aegyptiaca	34	25	166.9	4.5
	Cadaba rotundifolia	10	10	6.1	1.3
	Ziziphus spina-christi	119	6	166.6	15.6
	Dichrostachys glomerata	7	4	19.7	0.9
	Combretum aculeatum	1	1	1.5	0.1
	Capparis decidua	1	1	5.8	0.1
9	*Acacia nubica*	582	96	6056.6	79.5
	Acacia mellifera	56	43	725.2	7.7
	Acacia senegal	48	28	703.8	6.6
	Capparis decidua	15	13	35.3	2.1
	Balanites aegyptiaca	17	12	242.4	2.3
	Cadaba rotundifolia	3	3	1.7	0.4
	Ziziphus spina-christi	1	1	13.4	0.2
10	*Combretum hartmannianum*	135	85	848.2	58.4
	Acacia seyal	27	22	298.3	11.7
	Acacia senegal	18	15	130.3	7.8

Site No.	Species	No. of indiv.	Freq. (%) (F)	Total cover (m^2)	Rel. Dens.
	Cephalocroton cordofanus	37	15	31.8	16.0
	Acacia mellifera	7	6	71.2	3.0
	Balanites aegyptiaca	5	5	65.2	2.2
	Acacia fistula	2	2	20.4	0.9
11	*Acacia mellifera*	213	83	2168.3	32.0
	Dichrostachys glomerata	199	63	563.4	29.5
	Acacia seyal	115	57	1236.9	17.0
	Acacia nubica	32	27	570.0	4.8
	Cadaba rotundifolia	37	25	21.4	5.8
	Combretum aculeatum	49	24	36.0	7.0
	Acacia senegal	18	15	154.0	2.5
	Balanites aegyptiaca	9	8	724.5	1.3
	Boscia senegalensis	2	2	7.9	0.1
	Capparis decidua	1	1	12.3	0.3
12	*Ziziphus spina-christi*	900	63	8271.0	51.2
	Acacia senegal	151	58	410.4	8.6
	Grewia tenax	147	56	6.6	8.4
	Acacia nubica	241	54	530.2	13.7
	Balanites aegyptiaca	53	31	747.3	3.0
	Acacia mellifera	60	27	57.0	3.4
	Acacia seyal	27	23	288.9	1.5
	Combretum aculeatum	26	11	42.1	1.5
	Dichrostachys glomerata	6	6	22.7	0.3
	Acacia nilotica	3	2	33.9	0.2
13	*Acacia mellifera*	195	69	1989.0	13.7
	Balanites aegyptiaca	177	64	2247.9	12.2
	Acacia senegal	134	55	1118.9	9.4
	Acacia nubica	120	52	264.0	8.4
	Ziziphus spina-christi	711	39	3953.0	49.8
	Acacia seyal	36	29	385.2	2.5
	Grewia tenax	29	21	13.1	2.0
	Dichrostachys glomerata	29	12	56.4	1.4
	Acacia campylacantha	6	1	31.8	0.4
	Cadaba rotundifolia	2	1	1.2	0.4
14	*Acacia mellifera*	286	92	5176.5	65.5
	Cadaba rotundifolia	61	34	35.4	14.0
	Acacia seyal	24	19	392.2	5.5
	Dichrostachys glomerata	14	9	42.3	3.2
	Acacia senegal	12	7	175.9	2.8

Site No.	Species	No. of indiv.	Freq. (%) (F)	Total cover (m^2)	Rel. Dens.
	Boscia senegalensis	17	6	117.0	3.9
	Balanites aegyptiaca	6	6	50.1	1.4
	Ziziphus spina-christi	12	4	67.6	2.8
	Combretum aculeatum	.3	3	2.2	0.7
15	*Acacia fistula*	447	94	1269.4	38.0
	Cephalocroton cordofanus	644	64	64.4	54.8
	Acacia seyal	38	26	78.2	3.2
	Acacia campylacantha	43	15	76.1	3.6
	Acacia depranolobium	2	2	0.4	0.2
	Acacia senegal	1	1	0.3	0.1
	Balanites aegyptiaca	1	1	40.5	0.1

The result of the survey are presented in Table 1. The table contains a species list for each of the fifteen 'community types' recognized, the number of individuals per sample plot, frequency, the total cover and the relative density for each species, (Goldsmith and Harrison 1976).

Community types

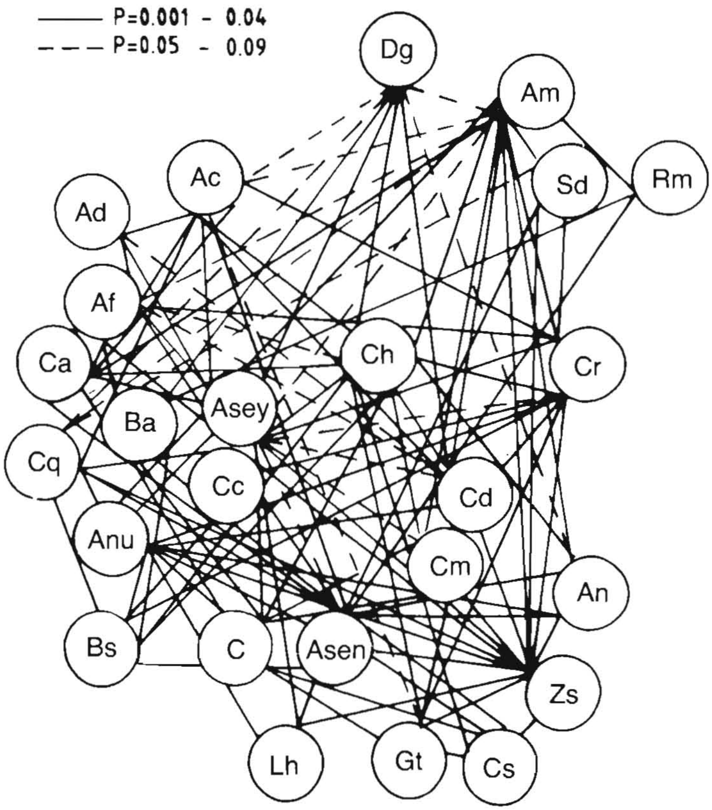
1. *Acacia campylacantha – A. fistula Community Type*

Acacia campylacantha and A. fistula are the dominant species in this community. *Cephalocroton cordofanus (F* = 47), and *A. seyal* (F = 36) are the associates which together with the dominant species constitute the main bulk of plant cover in this site. Other species present are *Combretum aculeatum*, *Dichrostachys glomerata* (F = 2) and *Ziziphus spina-christi*, *Acacia senegal*, *Balanites aegyptiaca* and *Cadaba rotundifolia* (all F = 1).

Figure 4 shows that the two dominant species, *A. campylacantha* and *A. fistula* are closely associated with each other and with *A. seyal* and *Cephalocroton cordofanus.*

This site lies halfway between Jebel Tozi and J. Gerbin (Fig. 1) where harig cultivation is extensively practised. It seems that as soon as land is abandoned after long cultivation, *A. campylacantha* regenerates either from seed or old stumps (coppice). This small (about 2.5 m high) and much branched tree appears to have a relatively high growth rate and its seed is fire-resistant (Omer 1969).

A. fistula, although represented by a smaller number of individuals in the site, has a total cover which is 60% more than that of *A. campylacantha.* This reflects



Dominant species		Intermediate species	
Ac	*Acacia campylacantha*	Bs	*Boscia senegalensis*
Ad	*A. drepanolobium*	*Cr*	*Cadaba rotundifolia*
Af	*A. fistula*	*Cs*	*Cassia senna*
Am	*A. mellifera*	*Cq*	*Cissus quadrangularis*
An	*A. nilotica*	*Ca*	*Combretum aculeatum*
Anu	*A. nubica*	*C*	*Ctenolepis sp.*
Asen	*A. senegal*	*Cm*	*Cucumis melo*
Asey	*A. seyal*	*Gt*	*Grewia tenax*
Ba	*Balanites aegyptiaca*	*Lh*	*Loranthus haemanthiflora*
Cd	*Capparis decidua*	*Rm*	*Rhynchosia memnonia*
Cc	*Cephalocroton cordofanus*	*Sd*	*Solanum dubium*
Ch	*Combretum hartmannianum*		
Dg	*Dichrostachys glomerata*		
Zs	*Ziziphus spina-christi*		

Fig. 4. The species constellation for the 15 sites based on χ^2 values and showing positive correlation.

the larger size of the former species which might render it more fire-resistant. However, its seed (Omer 1969) seems to be vulnerable to fire damage and this might account for its relatively low density. This species if often cut by the nomads to provide cattle and sheep with fresh pods and green leaves.

Cephalocroton cordofanus is a small shrub (about 1 m high) which is widely distributed in the site. Its success is probably due to its unpalatability, mechanism of seed dispersal and the readiness with which seeds germinate.

The site does not seem to be typical *Acacia seyal* country and the individuals recorded might have established from seeds brought by passing animals – the seed of almost all of these acacias can pass undigested through the alimentary canal of cattle and sheep (Kassas 1965, Halwagy 1962).

2. *Acacia campylacantha Community Type*

Acacia campylacantha (F = 87) is the dominant species in the association. *A. seyal* (F = 46) and *A. fistula* (F = 41) are codominants. Other species present in this site are *Dichrostachys glomerata* (F = 3), *Cephalocroton cordofanus* (F = 2) and *Acacia mellifera* (F = 1). The general character of the vegetation is essentially a mixture of *Acacia campylacantha*, *A. seyal*, *A. fistula and A. senegal.*

Acacia campylacantha is significantly positively associated (Fig. 4) with all species present except *Dichrostachys glomerata*.

The site seems to be similar to the previous one as far as *Acacia campylacantha* and *A. fistula* are represented, but the latter species is repeatedly cut by the local populace for domestic use. However, *A. seyal* and *A. senegal* are fairly well represented. The former is deliberately kept and encouraged to grow for its charcoal and the latter seems to have invaded the area (and been saved because of its value as gum-arabic producer) from its original country further west.

Dichrostachys glomerata, though not a usual associate in *Acacia campylacantha* sites, is represented here perhaps by virtue of being least affected by man. However, this species is single-stemmed which may render it a weak competitor and account for its disappearance (negative association) in this individual site from places where the more branching *A. campylacantha* dominates.

3. *Acacia seyal – Balanites aegyptiaca – A. fistula Community Type*

The most dominant species in this association is *A. seyal* with 54% frequency. Together with *Balanites aegyptiaca* (F = 42) and *Acacia fistula* (F = 41), it constitutes the bulk of the plant cover in this community. Other species encountered in the site are *A. senegal* (F = 31), *Cephalocroton cordofanus* (F = 21), *Cadaba rotundifolia* (F = 7), *Acacia campylacantha* (F = 6), *Dichrostachys glomerata* (F = 4) and *Ziziphus spina-christi* (F = 3).

Acacia seyal (Fig. 4) is positively associated with all the species present in this community type.

The site was clear felled in 1952 and seems to be a transitional zone between sites further north where *A. seyal* and *Balanites aegyptiaca* dominate and sites further south-west where *A. fistula*, *A. campylacantha* and *A. seyal* dominate; hence, the positive association between all the components of this community type.

A. seyal and *A. senegal* are deliberately kept for their economic values whereas *Balanites aegyptiaca* is saved as it is hard-stemmed, fire-resistant (Bunting and Lea 1962), difficult to cut and of no commercial value. *A. fistula* is larger than *A. campylacantha* and is able to compete better and hence its good representation in the site.

Cephalocroton cordofoanus is widely distributed and seems to occupy open areas, avoiding shading. *Ziziphus spina-christi* is represented by only 6 is individuals in this site associated with localized depressions where water collects. This species is mostly associated with high moisture content and a lighter type of soil such as prevails along river banks (Omer 1969).

4. *Balanites aegyptiaca Community Type*

Balanites aegyptiaca is the most dominant species in the site (F = 64) with *A. seyal* (F = 42) co-dominant. Other species include *A. senegal* (F = 21), *A. mellifera* (F = 17), *Cadaba rotundifolia* (F = 7), *Ziziphus spina-christi* (F = 2) and *A. nubica* (F = 1).

Balanites aegyptiaca (Fig. 4) is positively associated with *A. seyal*, *A. senegal* and *A. Mellifera.*

This association is heavily disturbed because of its vicinity to villages along the Nile and presence of access roads. Charcoal burning, fuel-wood and timber cutting for domestic and commercial uses are practised on a large scale. The species most affected is *A. seyal. Balanites aegyptiaca* is left because of its stem and it is not as useful as its congener *A. seyal.* The result of this practice is that, with time, *Balanites aegyptiaca* remains almost in pure stands which are not an unfamiliar scene near villages along the Blue Nile.

5. *A. campylacantha – A. seyal – A. fistula and A. senegal Community Type*

Acacia campylacantha is the dominant species in this site (F = 53). Co-dominant species are *A. seyal* (F = 48), *A. fistula* (F = 53) and *A. senegal* (F = 42). Other species present are *Cephalocroton cordofanus* (F = 14), *Dichrostachys glomerata* (F = 9), *Ziziphus spina-christi* (F = 4), *Cadaba rotundifolia* (F = 4), *Combretum aculeatum* (F = 2) and *Balanites aegyptiaca* (F = 1).

Acacia campylacantha (Fig. 4) seems to be positively associated with *A. fistula*, *A. seyal*, *A. senegal* and *Cephalocroton cordofanus* and these species appear to form a distinct grouping (clustered at the left of Fig. 4). This site lies within the area of mechanized farming schemes which are repeatedly cleared for grain cultivation.

In this site, the high efficiency of *A. campylacantha* to establish in cleared sites is exhibited as in community type 1.

Species of comparable sizes, *viz. A. seyal*, *A. fistula* and *A. senegal* (larger than *A. campylacantha*) have similar representation in this site. *Cephalocroton cordofanus*, *Dichrostachys glomerata* and *Ziziphys spina-christi* seem to be localized (low frequency) associates in this site. The first two species are weak competitors and the last is naturally localized in its distribution (*cf. Ziziphus spina-christi* community tyoe).

6. *Acacia seyal Community Type*

The clearly dominant species in this site is *A. seyal* (F = 90). Other species present are *Balanites aegyptiaca* (F = 15), *Cephalocroton cordofanus* (F = 10), *A. senegal* (F = 5) and *Cadaba rotundifolia* (F = 2).

A. seyal is positively associated (Fig. 4) with all species present in this community type.

This site lies in the clay plain and is the typical habitat for *A. seyal – Balanites aegyptiaca* association of Harrison and Jackson (1958). Here *harig* cultivation, grazing and burning are practised but there is no cutting for charcoal, owing to the long distance from villages and main roads. The elimination of the cutting factor probably accounts for the greater representation of *A. seyal*. Burning does not appear to affect this species drastically, its seed is highly-resistant (Omer 1969).

7. *Balanites aegyptiaca Community Type*

The floristic composition of this site (Table 1) shows that *Balanites aegyptiaca* is the most abundant species (F = 92). Other species in this association are *A. seyal* (F = 18), *Ziziphus spina-christi* (F = 9), *A. senegal* and *A. nubica* (F = 2) and *A. campylacantha* and *Dichrostachys glomerata* (F = 1).

Balanites aegyptiaca (Fig. 4) is highly positively associated with *A. seyal*, and less strongly (though positively) associated with *A. senegal*.

This site is near the village Shamia near Wad En Nail. The vegetation was most probably a mixture of *A. seyal – Balanites aegyptiaca* typical for the area, but lost most of its *A. seyal* through cutting. Harrison and Jackson (1958) commenting on such pure stands of *Balanites aegyptiaca* wrote '*Acacia seyal* is distributed throughout, usually more or less mixed with *Balanites*. After cultivation, the *Bala-*

nites is left pure.' Lea (1953) described these stands of pure *Balanites eagyptiaca* and wrote, 'This tree is not dominant on similar situations on the edges of *A. arabica* forest but generally increases in density near the Blue Nile.' More accurately, it increases near villages close to the Blue Nile.

The site is near to the Nile hence the presence of *Ziziphus spina-christi.*

8. *Acacia nubica – A. senegal Community Type*

Acacia nubica is the dominant species in this site (F = 78). Second in frequency comes *A. senegal* (F = 60). Other species present are *A. seyal* (F = 45), *Balanites aegyptiaca* (F = 25), *Cadaba rotundifolia* (F = 10), *Ziziphus spina-christi* (F = 6), *Dichrostachys glomerata* (F = 4) and *Combretum aculeatum* and *Capparis decidua* (both F = 1).

A. nubica (Fig. 4) seems to be positively associated only with *A. seyal, A. senegal* and *Cadaba rotundifolia. Combretum aculeatum* and *Capparis decidua* are not significant components in this site, being very rare (each is represented by only one individual).

Acacia senegal is present in large quantity mainly in the western part of the Fung Area with a tongue running in the western fringe approximately from Mazmoum through J. Bozi as far as halfway between Abu Hugar and J. Dali; here forests of *A. senegal* alternate with the thickets of *A. mellifera.* Large quantities of Gum Arabic are collected from this area.

The site seems to be typical *A. nubica* country. This species is always dominant around villages and has been graded as an indicator of over-grazing conditions, but Halwagy (1961) correlates the distribution of *A. nubica*, in the Khartoum district, with clayey soils.*

The site was probably mostly an *A. seyal – Balanites aegyptiaca* association. However, repeated cutting and grazing in addition to the protection offered to *A. senegal* seem to have changed the situation, switching the balance, in favour of the present type of vegetation.

Ziziphus spina-christi is better represented in this site than *A. senegal* but is very local. The site is not far from the river bank, again the association of this species with relatively moist habitats being evident.

From the diagram (Fig. 4) it appears that *A. senegal* and *Ziziphus spina-christi* tend to cluster in groups 'plant associations', different from, though linked with, the association of *A. Seyal – Balanites aegyptiaca.*

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* Mahmoud and Obeid (1971) found *A. nubica* to be associated with desert yellow clay deposits that form holes but do not crack as they dry.

9. *Acacia nubica Community Type*

A. nubica is a clear dominant species in this site (F = 96). Co-dominant species are *A. mellifera* (F = 43), and *A. senegal* (F = 28). Other species present are *Capparis decidua* (F = 13), *Balanites aegyptiaca* (F = 12), *Cadaba rotundifolia* (F = 3) and *Ziziphus spina-christi* (F = 1).

Acacia nubica seems to be positively associated (Fig. 4) with *A. senegal*, *A. mellifera* and *Capparis decidua*.

A. nubica occurs in dense thickets near villages and Jebels in the area. In fact, the northern part of the Fung, from J. Moya down to J. Dali and from Dali to near Singa is occupied by *A. nubica*, interrupted only a long water-courses by thickets of *A. mellifera.* Lea (1953) states that *Acacia orfota* (*nubica*) frequently forms pure communities at the base of rocky hills and on the edges of villages, but is rare on the clay plains. Domestic animals probably determine its distribution.

In the site, *Acacia mellifera* is associated with khors and depressions. Like *A. nubica* this species is throny and difficult to graze or cut. *A. senegal*, in spite of its low density, is encouraged and protected.

The presence of *Capparis decidua* seems to be associated with depressions similar to that of *A. mellifera*. Mahmoud (1968) working in Khartoum District reported stands of *C. decidua* to be found in sufficiently watered low-lying clay plains.

Thus, the association (Fig. 4) between *A. mellifera* and *A. nubica* appears to be due to their common character of resisting grazing whereas the association between *A. mellifera* and *Capparis decidua* may result from their confinement to a special type of habitat (catchment areas).

The thick cover formed by *A. nubica*, *A. mellifera* and *A. senegal* probably affects the establishment of seedlings of *Balanites aegyptiaca* and this together with repeated cutting might account for the absence of *A. seyal* from this site.

10. *Combretum hartmannianum Community Type*

Combretum hartmannianum (F = 85) is dominant and *A. seyal* (F = 22) is the close associate of this community. The other species present are *A. senegal* (F = 15), *Cephalocroton cordofanus* (F = 15), *A. mellifera* (F = 6), *Balanites aegyptiaca* (F = 5) and *A. fistula* (F = 2).

Combretum hartmannianum is positively associated (Fig. 4) with *Cephalocroton cordofanus* and *Acacia seyal.*

The vegetation in the vicinity of this site is a mixture of *A. seyal* and *Balanites aegyptiaca*. Settlements are rare in this area and hence there is no extensive cultivation; *Combretum hartmannianum* probably represents the original vegetation cover.

The site may well represent a relic of the original vegetation of the area which is believed to have been mainly composed of combretaceous species (Kassas 1968). *Acacia* species together with *Balanites aegyptiaca*, are regarded as secondary (Bunting and Lea 1962). Kassas (1968), reporting on the vegetational change in a similar area, suggested that the first fire destroys beyond recognition the original associates of *Combretum hartmannianum* but this species seems capable of coppice regeneration and may manage to retain its stand. However, repeated fire will destroy *Combretum* and the area will almost immediately be invaded by active regeneration of *A. seyal* or *A. fistula.*

The site, that is saved from human interference, retains its original vegetation. Secondary vegetation that invades the area is represented by *Acacia seyal*, *A. senegal*, *A. mellifera*, *Balanites aegyptiaca* and *A. fistula*, each of which seems to represent a separate group (Fig. 4). These groups are linked with the original *Combretum* community.

11. *Acacia mellifera – Dichrostachys glomerata – Acacia seyal Community Type*

In this site, *Acacia mellifera* is dominant (F = 83). The second most frequent species is *Dichrostachys glomerata* (F = 63). The rest of the species are *A. seyal* (F = 57), *A. nubica* (F = 27), *Cadaba rotundifolia* (F = 25), *Combretum aculeatum* (F = 24), *A. senegal* (F = 15), *Balanites aegyptiaca* (F = 8), *Boscia senegalensis* (F = 2) and *Capparis decidua* (F = 1).

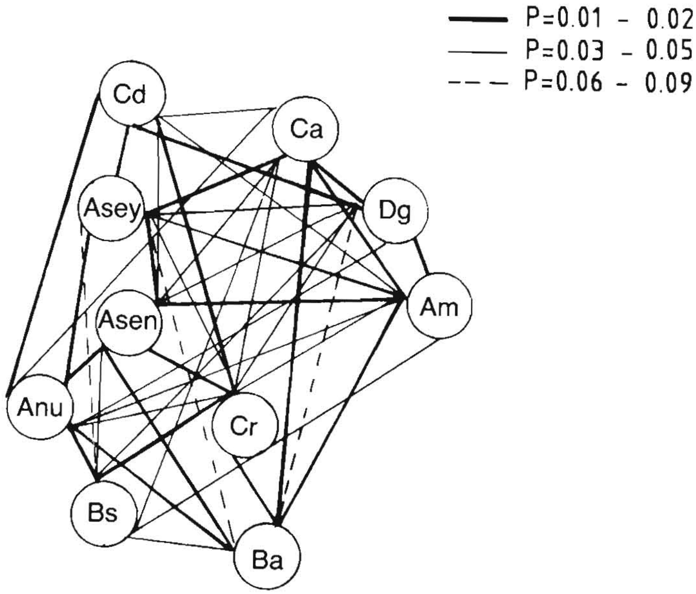
A. mellifera (Fig. 4) is positively associated with *Dichrostachys glomerata*, *A. seyal* and *Combretum aculeatum.*

The site lies more or less along the 600 mm isohyet. Intensive cultivation and grazing are practised in this area; the vegetation is composed of a thicket of *A. mellifera* and *Dichrostachys glomerata*, interspersed by *A. seyal*, *A. senegal*, *Balanites aegyptiaca* and open areas of annual grasses and herbs.

Cultivation is practised here in the open areas of annual grasses and herbs because thickets of *A. mellifera* are so dense as to be almost impenetrable. However, the cultivators enlarge the area by cutting small portions of the *A. mellifera* thicket. This is usually achieved by cutting the edges of the thicket, which would eventually be gradually eliminated. In years of low rainfall, when the grasses may not set seed and where no cultivation is practised because of the exhaustion of the soil, *Acacia seedlings* re-establish. This is the *Acacia*-grass cycle reported by Jackson (1955) and Harrison and Jackson (1958).

The species constellation diagram (Fig. 5) for this community type reveals 4 groupings or associations:

a) *A. mellifera – Dichrostachys glomerata – Combretum aculeatum* group.
b) *A. seyal – A. senegal* group.



Dominant species		Intermediate species	
Am	*A. mellifera*	Bs	*Boscia senegalensis*
Anu	*A. nubica*	*Cr*	*Cadaba rotundifolia*
Asen	*A. senegal*	*Ca*	*Combretum aculeatum*
Asey	*A. seyal*		
Ba	*Balanites aegyptiaca*		
Cd	*Capparis decidua*		
Dg	*Dichrostachys glomerata*		

Fig. 5. The species 'Constellation' based on $\varkappa^2$ values showing positive correlation.

c) *A. nubica* group.
d) *Balanites aegyptiaca* group.

These groups seem to suggest significant associations controlled by different ecological factors. *Combretum aculeatum* and *Dichrostachys glomerata* may be able to resist the competition stress of the thick growth of *A. mellifera* and can thus co-exist with this species. Indeed, *C. aculeatum* is often seen as a climber on *A. mellifera.*

A. seyal is well represented in the site and forms a group with the scattered individuals of *A. senegal.*

These two groups together with *A. nubica* and *Balanites aegyptiaca* groups are linked by correlation between member species of the respective groups and also through intermediate species, *e.g. Cadaba rotundifolia*.

12. *Ziziphus spina-christi Community Type*

Ziziphus spina-christi is strongly dominant in this site (F = 63). Abundant species are *A. senegal* (F = 58), *Grewia tenax* (F = 56) and *A. nubica* (F = 54). Other species present include *Balanites aegyptiaca* (F = 31), *A. mellifera* (F = 27), *A. seyal* (F = 23), *Combretum aculeatum* (F = 11), *Dichrostachys glomerata* (F = 6) and *A. nilotica* (F = 2).

Ziziphus spina-christi (Fig. 4) appears to be positively associated only with the abundant tree species. This site is situated near the Blue Nile on eroded soil. No cultivation is practised, but grazing by goats is common. The vegetation is a dense thicket of *Ziziphus spina-christi* and *A. mellifera* mixed with scattered *A. seyal, Balanites aegyptiaca* and localized dense thickets of *A. nubica*. This type of vegetation is found only adjacent to the Nile on eroded land and on the mouth of ephemeral water-courses.

A. nilotica is a tree of wet conditions and is not usually found far from semi-permanently moist soil condition. Obeid and Mahmoud (1971) found the species limited to two types of habitat: on river banks where it is subject to seasonal flooding for 3-4 months every year and at the mouth of valleys which pour into the Nile and receive flood water. *Ziziphus spina-christi* is associated with river banks where soils are light and moisture abundant.

Balanites aegyptiaca and *A. seyal*, the successors of the primary Combretaceous species in the area, are represented in this site by a fairly large number of individuals. The establishment of both seems to be affected by the dense tall competing tree species.

A. mellifera is confined to khors and depressions and is too thorny to be grazed. *Grewia tenax* is a shrub which is sometimes scrambling. It is widespread in central and southern Sudan. In this site, it is one of the intermediate species linking the main groups or associates. *Combretum aculeatum* and *Dichrostachys glomerata* are associates of *A. mellifera* as seen in the previous site.

13. *Acacia mellifera – Balanites aegyptiaca Community Type*

In this site, (Table 1) *Acacia mellifera* (F = 69) and *Balanites aegyptiaca* (F = 64) are the dominants. Other species present are *A. senegal* (F = 55), *A. nubica* (F = 52), *Ziziphus spina-christi* (F = 39), *A. seyal* (F = 29), *Grewia tenax* (F = 21), *Dichrostachys glomerata* (F = 12) and *A. campylacantha* and *Cadaba rotundifolia* (both F = 1).

A. mellifera (Fig. 4) is positively associated with all the species present in this site.

The vegetation is a mixed thicket of *A. mellifera* and *Ziziphus spina-christi* interspersed by *Balanites aegyptiaca*, *A. senegal*, *A. nubica* and *A. seyal.*

The same factors affecting the distribution of the tree species in the previous site appear to operate in this site. However, here *Ziziphus spina-christi* is more localized and represents a distinct group (right of Fig. 4). *A. senegal* is saved for its gum, and *A. mellifera* and *A. nubica* have the advantage of being grazing-resistant; *Balanites aegyptiaca* is cutting-resistant (being hard-stemmed) and *A. seyal* is continuously exploited. *Grewia tenax* and *Dichrostachys glomerata* are fairly distributed in the area. *A. campylacantha* being a weak competitor but a successful invader is confined to a distinct association (upper left of Fig. 4).

14. *Acacia mellifera Community Type*

A. mellifera (F = 92) is dominant in this site, *Cadaba rotundifolia* (F = 34) is also abundant and locally dominant. Other species present are: *A. seyal* (F = 19), *Dichrostachys glomerata* (F = 9), *A. senegal* (F = 7), *Boscia senegalensis* (F = 6), *Balanites aegyptiaca* (F = 6), *Ziziphus spina-christi* (F = 4) and *Combretum aculeatum* (F = 3).

A. mellifera (Fig. 4) is positively associated with all the species present in this site.

The vegetation is a dense thicket of *A. mellifera* with scattered *Balanites aegyptiaca*, *A. seyal*, *A. senegal* and open areas of grasses and herbs.

Figure 4 shows a number of distinct groupings:

A. mellifera and its associate *Dichrostachys glomerata* occupy the upper right of the diagram. The area is a catchment area (depression) for J. Abel – hence the dominance of *A. mellifera.*

Cadaba rotundifolia, the second most frequent species in this site, seems to share with *A. mellifera* resistance to grazing: the latter by being thorny, the former by being a powerful purgative. This species together with *Boscia senegalensis* represent a separate group 'association' (on the upper right of the diagram).

The limited distribution and abundance of *A. seyal*, *A. senegal* and *Balanites aegyptiaca* (a group in the mid left, Fig. 4) may result from the inability of their seedlings to establish under thick *A. mellifera.*

Ziziphus spina-christi, though represented by the same number of individuals as *A. senegal*, forms a distinct group (on the lower right of Fig. 4). The site, though not riverine, represents a deep catchment area under J. Abel. The soil is light loamy alluvial.

15. *Acacia fistula Community Type*

Acacia fistula (F = 94) dominates this association. Another dominant (local) species is *Cephalocroton cordofanus* (F = 64). Other species present are *A. seyal* (F = 26), *A. campylacantha* (F = 15), *A. drepanolobium* (F = 2) and *A. senegal* and *Balanites aegyptiaca* (both F = 1).

Acacia fistula is positively associated with all species present.

The vegetation is approaching a pure *A. fistula* stand mixed with *Cephalocroton cordofanus*, *A. seyal* and *A. campylacantha.* It is the type of association described by Harrison and Jackson (1958) as follows: 'On low-lying areas *A. campylacantha* occurs, and on areas liable to flooding *A. fistula* and *A. drepanolobium* prevail. *A. fistula* is also found on non-flooded areas in dense belts under slightly higher rainfall than is needed for *A. senegal* (*seyal*?)'. Open areas of annual grasses also occur on drier sites in the *A. seyal* – *A. fistula* woodland. They are probably relics of old clearing and cultivations.

A. campylacantha is another sub-type and may form dense communities in the absence of taller growing species of *Acacia.* Harig cultivation, grazing and burning are practised in this area on a large scale. However, no charcoal making is practised as this site is far from main roads.

That the association *A. fistula* – *A. Campylacantha* – *Cephalocroton cordofanus* (upper left of Fig. 4) is akin to that described in site 1, is very clear.

Burning Experiment

A field trial was carried out to test the effect of simulated heat intensity on the viability of seed of five species of *Acacia* dominant in the area, *viz.*, *Acacia seyal*, *A. fistula*, *A. mellifera*, *A. campylacantha* and *A. senegal.*

Two treatments were applied in this experiment, light burning and heavy burning, and no burning was used as a control.

These treatments (and control) were laid out in three plots, each representing a treatment (or control). In every plot each of the five species was replicated 5 times in a Latin Square design.

Twenty five seeds per replicate were sown at a depth of about 1 cm and dried inflammable plant material was scattered over the plots. The heavy burning plot received twice the quantity of plant material of the light burning plot and the material was set on fire. Soil surface temperature recorded a mean of 110 and 148°C for light burning and heavy burning, respectively.

The plots were watered twice daily and the sequence of the emergence of seedlings was recorded.

Results

The final mean percentage of seedlings emerged is given in Table 2.

Analysis of variance showed that between species effect is highly significant ($P < 0.001$), while the burning treatment in *Acacia nubica* and *A. fistula* is significantly different from control ($P = 0.05$).

From Table 2 the five *Acacia* species could be classified as far as their germination is concerned into the following categories.

1. Species Unaffected by Burning

Acacia campylacantha
A. senegal

Success of the first species to invade cleared (through fire or repeated cultivation) habitats and of the second to be represented in all the sites investigated could be attributed partly to heat-resistant seeds.

2. Species Stimulated by Light Burning

A. seyal

This is a species which is widely distributed in the area surveyed where different intensities of burning occur. If burning is heavy the seeds of this species do not lose their viability, whereas light burning stimulates more seed to germinate.

3. Species Stimulated by Heavy Burning

A. nubica

The hard seeds of *A. nubica* are stimulated to germinate by heavy burning causing the hard testa of these seeds to crack. In nature, this cracking or softening

Table 2. Mean percentage (arc sin scale) of seedling emergence for five species of *Acacia* under light and heavy burning and control conditions.

Species	Burning		Control
	Light	Heavy	
A. campylacantha	47.7	42.3	43.2
A. senegal	46.3	36.7	42.4
A. seyal	32.1	21.1	21.2
A. nubica	7.9	11.4	4.6
A. fistula	15.3	6.6	11.2

of the testa seems to be induced by fire, by grazing animals (pods are eaten and the seeds pass, undigested, through the alimentary canal of grazing animals) and/or by high moisture (this species being a characteristic of catchment areas, Halwagy 1961, and Obeid and Mahmoud 1971).

4. Species Stimulated by Light burning but Inhibited by Heavy Burning

A. fistula

This species is normally subjected to both early and late burning. Though its seeds are almost similar to those of *A. seyal*, heavy burning seems to reduce its viability (P = 0.05). This might account for the re-establishment of *A. fistula* noticeably later than *Acacia campylacantha* in places of old clearings and cultivation. Daubenmire (1974) reported that certain taxa of woody plants in a number of genera including *Acacia* produce large quantities of hard-coated seed that tend to be dormant in the soil until the vegetation in which they occur is burned and that fire stimulate their seedlings to appear in large numbers.

Discussion

Goldsmith and Harrison (1976) and Numata (1982) indicate that a principal characteristic of vegetation is its dynamic nature, *i.e.* the changes in the distribution and structure of components of vegetation which occur over time. Harper (1977) point out that natural ecosystems, whether structurally complex or simple, are the products of a long history of coevolution of their constituent plants and animals.

The analytic and synthetic characters of the tree vegetation of the Fung Area were described using fifteen representative sites. These ranged from the northern boundary with lower rainfall (mean annual 447 mm) to the southern part of the Fung with higher rainfall (mean annual 803 mm).

The area was settled long ago and the activities of subsistence cultivation in addition to the action of fires must have caused the destruction of the climatic vegetation. Fire is employed to clear the land which is then cultivated for a few seasons. When the land is exhausted it is left to rest for several years.

Continuous disturbance of the soil by erosion, fire and by agricultural implements leads to gradual elimination of the natural vegetation and on the ground so cleared secondary plant succession proceeds. In the Fung Area secondary succession is represented by a number of tree species – mostly acacias with *Balanites aegyptiaca* as a faithful ally.

The physical environment seems to determine the nature of this ecosystem only in a limited and specific number of sites. Riverine communities are dominated by *Ziziphus spina-christi* while overgrazed areas are dominated by *Acacia nubica*. Depressions and water catchment sites are colonized by *A. mellifera*.

However, the human factor is at least as important as the physical environment in determining the nature of this ecosystem in the majority of the sites surveyed. *Acacia* species together with *Balanites aegyptiaca* are present in various proportions. The human factor (cutting, cultivation and grazing) influences the degree of abundance of the different components of the vegetation, the change resulting being quantitative rather than qualitative.

The present classification of the vegetation of the Fung Area as summarized in Table 3 shows the following types of associations:

Table 3. The characteristic associations of the vegetation of the Fung Area.

Associations	**Riverine Assoc.**		**Clay Plain Associations**												
	I		**II a**			**II b**					**II c**		**II d**		**II e**
Sites	12	13	4	6	7	1	2	3	5	15	11	14	8	9	10
Acacia campylacantha	–	x	–	–	x	x	x	x	x	x	–	–	–	–	–
A. fistula	–	–	–	–	x	x	x	x	x	x	–	–	–	–	x
A. seyal	x	x	x	x	x	x	x	x	x	x	x	x	x	–	x
A. senegal	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Balanites aegyptiaca	x	x	x	x	x	x	–	x	x	x	x	x	x	x	x
Acacia drepanolobium	–	–	–	–	–	–	–	–	–	x	–	–	–	–	–
A. mellifera	x	x	x	–	–	–	x	–	–	–	x	x	–	x	x
A. nubica	x	x	x	–	x	–	–	–	–	–	x	–	x	x	–
Ziziphus spina-christi	x	x	x	–	x	x	–	x	x	–	–	x	x	x	–
Capparis decidua	–	–	–	–	–	–	–	–	–	–	x	–	x	x	–
Cephalocroton cordofanus	–	–	–	x	–	x	x	x	x	x	–	–	–	–	x
Combretum hartmannianum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	x
Cadaba rotundifolia	–	x	x	x	–	x	x	x	x	–	x	x	x	x	–
Dichrostachys glomerata	x	x	–	–	x	x	x	x	x	–	x	x	x	–	–
Grewia tenax	x	x	–	–	–	–	–	–	–	–	–	–	–	–	–
Boscia senegalensis	–	–	–	–	–	–	–	–	–	–	x	x	–	–	–
Combretum aculeatum	x	–	–	–	–	x	–	–	x	–	x	x	x	–	–
Acacia nilotica	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–

I. Riverine Associations

These are represented by sites 12 and 13 and to some extent by site 7, all of which lie close to the Blue Nile. The high water table, the light soil and the topography of the area are probably major factors influencing the association.

The vegetation of these sites is dense and dominated by *Ziziphus spina-christi*. Associated with this in various quantities are *Balanites aegyptiaca*, *A. seyal* and *A. senegal*. Relics of the original combretaceous species are reflected in the presence of *Combretum hartmannianum* and *Anogeissus schimperi*.

In this association, there is no shrub layer, that the dense tree cover of *Ziziphus spina-christi*, though competition, no doubt, severly limits the establishment of shrubs.

The ground vegetation (Omer 1969), although relatively rich in species, is characterized by the absence of grass species. Lack of a grass layer and hence of fierce fires, is a great advantage to tree growth. Unsuitability of land for agriculture because of generally undulating terrain greatly reduces anthropogenic interference. This association is amongst the less disturbed communities in the Fung Area.

II. Clay-plain Associations

These are represented by the rest of the sites and lie on the clay plain which characterizes the whole of the Fung Area. Here, the physical environment as well as human interference play definite roles in determining the nature of the tree associations. Accordingly, the following associations are recognized.

(a) *Acacia seyal – A. senegal – Balanites aegyptiaca Associations*

These three species have very wide distribution in the area. *A. senegal* is represented in all of the fifteen sites investigated (Table 3). *A. seyal* and *Balanites aegyptiaca* are present in 93.3% of the sites. This association dominates sites 4, 6 and 7.

Human interference includes deliberate and conscious protection of *A. senegal* from cutting. This tree is almost 'sacred' for its 'revenue' of gum arabic yield. Seif el Din and Obeid (1971) reported that, under low rainfall on clay (300-500 mm), seed germination and hence establishment are dependent upon the combined effect of the frequency of rainfall (number of rain-days per month) and the intensity of the showers. These conditions are met by the climate of the Fung Area.

Acacia seyal, unlike *A. senegal*, is regularly cut for charcoal production. Individuals of this species are saved till they are 6-8 years old and then cut.

Balanites aegyptiaca seems to be dominant and widespread in the area by virtue of being fire-resistant and hard to cut. This species does not produce a good quality charcoal.

Site 7 appears to have been a 'riverine association' that is being highly influenced by man and is gradually changing to this type of association. This shows that even the 'riverine association', which usually survives on less desirable soils, is now being encroached upon by man.

The shrub layer is almost absent in this association because of repeated cutting and frequent burning which severely limit the regeneration of shrubs.

(b) *Associations on Cultivated Areas*

These associations (represented by sites 1, 2, 3, 5 and 15) are probably controlled by the intensity of cultivation which is a direct function of population density.

All these sites are dominated in varying degrees by *Acacia campylacantha*, *A. seyal*, *A. fistula* and *A. senegal.*

A. campylacantha is a strong colonizer in areas which, as a result of repreated cultivation, have lost other tree vegetation. The small size of this tree may limit its establishment in more 'closed' associations. Nevertheless, it has a closer affinity with the relatively small *A. fistula* with which it is always associated. Lack of competition between these two species facilitates their co-existence

A. fistula on the other hand is more able to invade 'closed' sites, especially on low-lying soils. However, this species suffers human interference in being selectively cut to provide green fodder (leaves and pods) for cattle and sheep. *A. seyal* and *A. senegal*, because of their economic values, are becoming part of the cultivation cycle.

The shrub layer is represented by dense growth of *Cephalocroton cordofanus*, an unpalatable species, which appears to be very successful in invading disturbed open habitats.

The ground vegetation (Omer 1969) is dominated by a relatively small number of species. Repeated cultivation has apparently reduced the grass representation to only 16% of the total number of species.

In all of these cultivated areas, it is clear that the vegetation present is the result of a degree of population density that has so shortened the cultivation-cycle causing agriculture to become almost sedentary.

(c) *Associations on Depressions and Catchment Areas*

These associations (sites 11 and 14) are dominated by thickets and dense patches of *A. mellifera*. This species is confined to depressions and catchment areas in almost all of its habitats in the Sudan (Harrison and Jackson 1958).

Site 11 is a depression on cultivated grazed area, whereas site 14 is a catchment area of J. Abel. *A. senegal*, *A. seyal* and *Balanites aegyptiaca* are well represented in both sites, but *A. nubica* is present in the grazed site.

The shrub layer is represented by *Dichrostachys glomerata*, *Cadaba rotundifolia* and *Combretum aculeatum*. All three species seem to be associates of *A. mellifera*. *Combretum aculeatum* is a climber on *A. mellifera*, a relation giving the former a protection against grazing.

The ground vegetation is very rich particularly in site 14 (Omer 1969), where grasses are well represented. Smith (1944) noted that within the Low Rainfall Savanna on clay *A. mellifera* thickets alternate with grassland growth. He showed that these two vegetation types alternate in space and time in an apparently cyclic relationship.

(d) *Associations on Over-Grazed Areas*

These are associations usually found in the vicinity of villages (sites 8 and 9) and in which *Acacia nubica* is most dominant. Lea (1953) reported that *Acacia orfota* (*nubica*) frequently forms pure communities in the edge of villages and suggested that domestic animals probably determine its distribution. Harrison and Jackson (1958) regard the dominance of this species as an indication of over-grazing.

Acacia nubica is most commonly associated with the shallow upstream parts of the principal desert wadies (Obeid and Mahmoud 1971); this might account for its strong representation in site 11 which is a depression on a grazed area dominated by *A. mellifera*.

These two sites are relatively close to the Blue Nile and relics of the riverine vegetation are represented by *Ziziphus spina-christi*, *Capparis decidua* and *A. seyal*.

The shrub layer is represented by rich growth of *Cadaba rotundifolia* a species that escapes grazing by being a powerful purgative.

The ground vegetation is also well developed and is represented by a substantial number of species (Omer 1969).

(e) *Relics of the Original Vegetation*

The original climatic climax vegetation of the Fung Area is believed to have been composed mainly of Combretaceous species (Kassas 1968). At present, relics of this vegetation are represented only by *Combretum hartmannianum* in site 10. In the less interferred with hilly Ingessana area south of the Fung, *C. hartmannianum* is the dominant species.

In all of the Fung Area, except site 10, the activities of the cultivators together with the action of fires seems to have caused the destruction of the original vegetation. Kassas (1968) describes the situation as follows: 'The first fire destroys beyond recognition; *Pilostigma reticulata*, *Entada sudanica*, *Stereospermum kunthianum*, *Acacia sieberiana* and *Dichrostachys glomerata*. The half-burnt trees of *Combretum hartmannianum* seem capable of coppice regeneration and may manage to retain their stand. Repeated fire will destroy *Combretum* and the original forest passes to a phase of open growth of *Balanites aegyptiaca* and *A. seyal*.'

Figure 4 shows the species 'constellation' of the positive associations for the important species encountered in the 15 sites (Agnew 1961). Inspection of the diagram suggests the existence of species groups more or less same as those described above, *viz.* Riverine associations dominated by *Ziziphus spina-christi*, clay plain associations with different grades of mixtures of species and the special habitat species of *A. mellifera* and *A. nubica*.

Ziziphus spina-christi together with its riverine associate *Acacia nilotica*, occupy the lower right in Fig. 4. *Acacia seyal – Balanites aegyptiaca – Acacia senegal* appear on the lower left, whereas associations on intensively cultivated areas, *i.e.* *Acacia fistula* and *Acacia campylacantha*, are represented by separate group on the upper left of the diagram. *Acacia mellifera* together with its close associate *Dichrostachys glomerata* appear at the top of Fig. 4. The position of *Acacia nubica* is of interest, showing close association to the *Acacia seyal – Balanites aegyptiaca* and *A. senegal* group. This can be explained by the fact that through cutting and continuous grazing of these three species *Acacia nubica* is unconsciously encouraged and may invade habitats previously occupied by these species (Harper 1977). Another interesting feature is the central position of *Combretum hartmannianum* which is linked to almost all the species present.

Hence, it is clear that the grouping of the species in Fig. 4 is a useful reflection of their grouping in nature. It is equally clear that none of these groupings is sharply isolated as a distinct entity; each is linked to the adjacent groups by relationships between members of species of the respective groups or through intermediate species, *e.g. Capparis decidua*.

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العشائر والمجتمعات النباتيه فى منطقه الفونج بالسودان

أحمد محمد على إسماعيل*، محمد العبيد، ومحمد المهدى بشير**

قسم النبات - كلية العلوم - جامعة الخرطوم - الخرطوم - السودان

يختص هذا البحث بدراسة عشائر ومجتمعات الأشجار فى منطقه الفونج التى تشمل جزءاً كبيراً من ضفاف النيل الأزرق.

أوضحت الدراسة وجود مجتمعات نامية على ضفاف النيل وبالقرب منه تسودها أشجار السدر التى تفضل النمو فى الأراضى الطينية الخفيفة ذات التضاريس المتموجة والمستوى المائى الأرضى المرتفع. كذلك أوضحت الدراسة وجود مجتمعات نامية على السهول الطينية الثقيلة يمكن تقسيمها إلى مايلى:

ا - عشيرة الطلح - الهشاب - الهجليج فى أراضٍ غير مستغلة زراعيا.

ب - عشيرة السنط - الطلح - العرد والهشاب فى أراضى المشاريع الزراعية.

جـ - عشيرة الِكتر التى تنمو فى المنخفضات وأماكن تجمع مياه الأمطار.

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* العنوان الحالى: قسم النبات - كلية العلوم - جامعة قطر - قطر.

** العنوان الحالى: قسم النبات - كلية العلوم - جامعة الجزيرة - وادمدنى - السودان.

د - عشـيرة اللعـوت النـاميه فى المناطق المرعية رعياً جائراً حول القرى وعلى سطوح التلال الصخريه.

هـ - عشيرة الهييل التى يحتمل أن تكون بقايا كساء خضرى فى المناطق غيرالمتأثره بتد خل العامل البشرى.

وبيدو أن توزيع عشائر ومجموعات الأشجار فى منطقه الفونج ناتج عن التفاعلات الإحيائية أكثر من تأثير الظروف البيئية الأخرى.