

ECOLOGICAL ASSESSMENT OF SPATIAL PATTERNS OF HYPHAENE THEBAICA AND ZIZIPHUS SPINA-CHRISTI IN A SUDANESE FOREST RESERVE

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Abstract: Dinder National Park (DNP) harbors diverse tree species and rich wildlife. This study aimed to analyze the spatial distribution patterns of two key tree species, Hyphaene thebaica and Ziziphus spina-christi, within the park. Using the Morisita's index method, vegetation sampling was conducted across 60 plots to assess the distribution pattern of both species. Results revealed that Ziziphus spina-christi exhibited a clumped distribution pattern with an index value of 1.4, while Hyphaene thebaica showed a stronger clumped pattern with an index of 3.03. The correlation between the two species was calculated as -0.3, indicating a slight negative association in their spatial occurrence. The study suggests that the clumped distribution of these species is primarily influenced by water availability in the riverine environment. These findings reject the null hypothesis of random distribution and highlight the ecological significance of water sources in shaping tree species distribution within DNP. Understanding these spatial patterns can inform conservation and management strategies for sustaining the park's biodiversity.

Keywords: Hyphaene thebaica, Ziziphus spina-christi, Morisita's index, spatial distribution

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INTRODUCTION

Sudan is an African country located within the tropical region (particularly occupying the Sahara and equatorial zones) owing to Hassan (2003) ecological classification of the vegetation of Sudan. Sudan has a great variety of climate and ecosystem including the sub-Sahara, savannah, wooded savannah, lakes, rivers, hills and coastal regions, each with a distinct group of faunal and floral composition creating diverse ecosystem and as a result a good representation of the African wild species which are consider to be of a great economic, scientific, recreational, biological and cultural values. Most of the vegetation plays a great significant role in maintaining the natural ecosystem and preservation of the wild species fauna and flora (Hassan 2003). Savannah is divided into different types according to various characteristic and certain community and species that they have. Along moisture grade is a wet savannah, this part can be recognized in a various types of species composition, vegetation structure and key ecological processes (Vogt 1995).

Desman (1972), has classified the vegetation of Dinder National Park into four categories- woodland, grassland, open grass land and wooded riverine forest. Hakim et al. (1978) and Abel Hameed (1996) classified it into three types of ecosystems: Acacia seyal - Balanites, Reverie Forest and Mayas (meadows) ecosystems.

Hyphaene thebachia and Ziziphus spina Christi serve as a vital habitat for terrestrial migrator species which spend the dry season in the park and they provide food, cover to wild animals such as baboons, bush bucks and green monkeys and many bird species. Also they protect the environment from the degradation. The objective of this study is to determine the distribution pattern of Hyphaene thebachia and Ziziphus spina Christi and the correlation and association of the two species.

MATERIALS AND METHODS

The study area

This study was conducted in Dinder National Park, established in 1935 (Anonymous, 2003). The park which embraces 650,000 ha of land lies between latitude 11° 45' National-Park retrieved on 4/22/2017).



Figure 1. The Dinder National Park (Source: <https://www.britannica.com/place/Dinder> E, 12° 50' N and longitude 34° 30' E 36° 00' N at the south eastern part of Sudan against the Ethiopian frontier (Figure 1). The area of the park principally consists of a low-lying flood plain that slopes gently from the Ethiopian highlands with few rocky hills at its southern corner (Anonymous, 2003). The Rahad and Dinder rivers flow north-westerly through the park area. Tributary streams form seasonally flooded lowlands, known as Mayas (marches) in much of the area adjacent to the Ethiopian border. The park comprises three ecosystems: Maya, Riverine and Dahara (Hakim et al., 1978). Vegetation in the ecosystems consists of grasslands, wooded land and riparian forest.

Along seasonal streams, the vegetation consists of *Hyphaene thebaica*, *Acacia sieberiana*, *Tamarindus indica* and *Ficus* spp. The under stream vegetation consisting of *Ziziphus spina Christi* and *Mimosa pigra*. The herbaceous layer comprises coarse grasses, including *Sorghum* spp. and *Brachiaria* spp. Thorn-bush savanna (*Acacia seyal*–*Balanites aegyptiaca* association) with tall grasses dominates the north, while *Combretum aculeatum* woodland is found in the moister south.

Nymphaea and Ipomoea spp. are common in Mayas with shallow lakes, while the open grass plains are covered by Themeda triandra, Panicum, Hyparrhenia and Cynodon spp. The Mayas, the main source of water and green fodder during the dry season (November to June) are dominated by Echinochloa spp (Hakim et al., 1978).

Dinder National Park has a mean annual rainfall of 600 to 1,000 mm, falling between May and November. When the area of the park was extended by adding 2630 km², ten villages consequently fell inside the park and there are 38 villages outside its boundary. These villages lie at a distance of less than one kilometer from the boundaries of the park (Anonymous, 2003).

A great variety of species occur within the park and this include Reedbuck (*Redunca redunca*), Bushbuck (*Tragelaphus scriptus*), Water buck (*Kobus defassa*), and warthog (*Phacocheirus aethiopicus*). The dominant predators include Lion (*Panthera leo*), and Hyena (*Hyena hyena*). The primates are represented by olive Baboon (*Papio anubis*), Green monkey (*Cercopithecus aethiops*), and patas monkey (*Erythrocebus patas*). There is also great variety of birds' species in the park ranging from Egyptian goose, Guinea fowl, Ostrich, Pelicans, Marabou stork, Bustards, Heron, Starling, Rollers and Raptors species (Anonymous, 2003).

Materials

Materials used were 50 and 20 m steel tape for measuring the distances, data sheet and pen for recording data.

Data collection

Data collection took place during the daylight hour from 7 am to 5 pm, three days a week from January to February in Dinder National Park, during the dry season of 2017. A 50 meter steel tape was used for determining straight transact line. The length of line transact was one km. The data was systematically collected twice from the different directions of khor Galagu riverine forest. 20 plots were taken at the riverine forest in the western part of the park. The second 20 plots were taken at the southern part of khor Galagu riverine forest and the last 20 plots were taken at the northern part of khor Galagu riverine forest making it a total of 60 plots.

Data analysis

Moristas (1959) index (ID) of dispersion was used to determine the dispersion and distribution pattern of tree species.

$$ID = n \times \frac{\sum x^2 - N}{\sum x^2 - N}$$

Where: ID= index of dispersion, n = number of all plots, N= number of individual counted in all plots and $\sum x^2$ = summation over all plots the square of the number of individual per plots

If: ID = 1 it means random

ID ≤ 1 it means even

ID ≥ 1 it means clumpy or patchy

Chi- square test was used to test the significance:

$$\chi^2 = \frac{k \sum x^2}{N}$$

Where: χ^2 = Chi-square, k = number of plots, $\sum x^2$ = summation over all plots the square of the number of individual per plots and N = Total number of individuals counted in plots.

Spearman rank correlation coefficient (SRCC) was used for association of two species:

$$R = 1 - \frac{6 \sum d^2}{n^3 - n}$$

Where: d^2 = different between two ranks of *Hyphaene thebachia* and *Ziziphuss pina Christi* and n = number of pairs of *Hyphaene thebachia* and *Ziziphus spina Christi*

If: $R = +1$, it means the ranking have perfect positive association.

$R = 0$, it means the ranking have no correlation or association.

$R = -1$, it means the ranking have perfect negative association.

RESULTS AND DISCUSSION

In all types of savannah along the Dinder river most of *Hyphaene thebaica* and *Ziziphus spina Christi* found mix with other species of *Acacia sibiriana* along the riverine forest.

The index of dispersion for *Ziziphus spina Christi* is found to be 1.4 while the distribution along the riverine forest of the Dinder National Park is clumpy because the ID is greater than 1 and tested with Chi-square test under the degree of freedom ($n-1$) and it is significant because the calculated value of Chi-square test is 83.56*, is greater than the tabulated value which is greater than 1% level of significant. In clumped distribution the distance between neighboring individuals is minimize. This type of distribution is found in environments that are characterized by patchy resources. Clumpy distribution is the most common type of dispersion found in nature because animals need certain resources to survive and when these resources become rare during certain time of the year animals tend to clump together around these crucial resources (Table 1).

The distribution of riverine woodland of DNP was found to be 3.03 for *Hyphaene thebaica* and clearly indicated that they are clumpy distributed in riverine wood of DNP because the index of dispersion is greater than 1 ($ID \geq 1$). Also the Chi-square test is highly significant because the calculated value is greater than 1% level of significant (Table 2).

The correlation between the of *Hyphaene thebaica* and *Ziziphus spina Christi* correlation coefficient of two species, interpreted total summation of d^2 and calculation of SRCC with it clear very low resulted to the value of $r = -0.3$ and tabulated value of simple linear correlation coefficient at the 5% and 1% level of significant. This indicated that the correlation is negative (Table 3).

The two species and association number of species summation of x^2 , value of ID, value of chi-square x^2 is highly significant for each tree but the type of distribution were found for both trees to be clumpy distribution. The correlation of both tree species was negative and null hypothesis of Chi-square of two species are rejected.

These tree species in three directions has no correlation

Table 1. Collection and calculation data of *Ziziphus spina -christi*, in riverine forest of Dinder National Park, during the dry season 2017.

Tota No. of individual in one plot(x)	3	2	2	1	2	2	3	1	5	1	4	1	3	2	1	2	4	1	2	1	4	3	3	6	1	1
2 4	2	2	1	6	1	7	9																			
Sum of x^2 or $\sum x^2$	9	4	4	1									44	91	25	16	1	94	1	41	6	1	41	16	1	41

ID= 1.4, $X^2 = 83.65$, $P 0.05 = 46.19$, $P 0.01 = 53.5$, DF= 33.

Table 2. Collection and calculation data of *Hyphaene thebaica*, in riverine forest of Dinder National Park, during the dry season 2017.

Tota No. of individual in one plot(x)	6	1	4	2	3	1	4	4	10	4	1	4	5	1	4	2	1
Sum of x^2 or $\sum x^2$	36	1	16	4	9	1	16	16	100	16	1	16	25	1	16	4	1

ID= 3.03, $X^2 = 170.9^{**}$, DF=20, $P 0.05 = 31.4$, $P 0.01 = 37.6$.

Table 3. The correlation between *Hyphaenethebacia* and *ZiziphusspinaChristi* in riverine forest of Dinder National Park, during the dry season 2017.

<i>Ziziphusspinachristi</i>	R1	<i>Hyphaenethebacia</i>	R2	d	d 2
3	31	0	10	21	441
2	23.5	6	39	-15.5	240.25
0	4	1	24	-20	400
2	23.5	4	34.5	-11	121
1	13	2	29.5	-16.5	272.25
2	23.5	3	31	-7.5	56.25
2	23.5	1	24	-0.5	0.25
0	4	4	34.5	-30.5	930.25
0	4	4	34.5	-30.5	930.5
0	4	10	40	-36	1296
0	4	4	34.5	-30.5	930.25
3	31	1	24	7	49
1	13	4	34.5	-21.5	462.25
5	38	5	38	0	0
0	4	1	24	-20	400
1	13	4	34.5	-25.5	462.25
0	4	2	29.5	-21.5	650.25
4	35.5	0	10	25.5	650.25
3	31	0	10	21	441
1	13	1	24	-11	121
2	23.5	1	24	-0.5	0.25

Table 3. Contd.

1	13	1	24	-11	121
2	23.5	0	10	13.5	182.25
4	35.5	0	10	25.5	650.25
1	13	0	10	3	9
2	23.5	0	10	13.5	182.25
1	13	0	10	3	9
4	35.5	0	10	25.5	650.25
3	31	0	10	21	441
3	31	1	24	7	49
6	39.5	0	10	29.5	870.25
1	13	0	10	3	9
1	13	1	24	-11	121
2	23.5	0	10	13.5	182.25
4	35.5	0	10	25.5	650.25
2	23.5	0	10	13.5	182.25

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2	23.5	0	10	13.5	182.25
1	13	0	10	3	9
6	39.5	0	10	29.5	870.25
1	13	0	10	3	9

Sum square 13993.2

R= -0.3*, Po.05= 0.312, Po.01= 0.403.

Table 4. Results calculated in in riverine forest of Dinder National Park, during the dry season 2017.

Species	No. of trees	Sum of x ²	Value of ID	Value of Chi- square (x ²)	Distribution	type
Po.05	SRCC					

Ziziphus spinachristi	79	257	1.4	83.65*	Clumpy	46.2 53.5 -0.3
Hyphaenethebacia	61	283	3.03	170.9**	Clumpy	31.4 37.5 Negative

Where: *= significant, **= highly significant, Po.05= probability at 5% level of significant, Po.01= probability at 1% level of significant, SRCC= spearman rank correlation coefficient.

They occur due to climatic factors such as soil or habitat requirement of the species (Table 4).

Conclusion

The total number of tree species was found to be 79 and 61 and sum of x is 257, 283, value of ID is 1.4 and 3.3, value of x² is 83.65*, 170** respectively for Ziziphus spinachristi and Hyphaene thebacia. The type of dispersion is clumpy for the two species and correlation is negative SRCC (-0.3).

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