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Storks' Diversity, Flock Characteristic, Roosting Ecology and Fluctuation in Numbers in Some *Mayas* at Dinder National Park, Sudan, During the Dry Seasons 2009 and 2010*

Omer M. Meina and Ibrahim M. Hashim[1]

Wildlife Research Centre, Shambat, Sudan

Abstract: Storks were studied by directly observing them in the *Maya* (meadow) ecosystem of Dinder National Park (DNP) during the dry seasons of 2009 and 2010. The objective was to determine their diversity, flock characteristics, roosting ecology and the annual fluctuation in their numbers. The numbers were ascertained by the double sampling procedure in which the number of each stork species in a flock was estimated and was then directly counted. A predictive model was developed from the relationship between the counted and the estimated variables. Subsequently, the number was only estimated and the actual count was predicted from the regression model. The tree density was determined by the nearest neighbour method. The crown diameters of the trees were measured, and the crown areas were calculated. Eight species of storks; namely, the black (*Ciconia nigra*), the white (*Ciconia ciconia*), the Abdim's (*Ciconia abdimii*), the yellow-billed (*Mycteria ibis*), the African open bill (*Anastomus lamelligerus*), the woolly-necked (*Ciconia episcopus*), the marabou (*Leptoptilos crumeniferus*) and the saddle bill (*Ephippiorhynchus senegalensis*), occurred in DNP. The black and the white storks are Palearctic migrants, whereas the Abdim's, the woolly-necked, the African open bill and the yellow-billed are local migrants; the marabou and the saddle bill are resident. The three species that occurred in large flocks were the yellow-billed, the marabou and the open bill. The total number of storks in 2010 was lower than that in 2009. This decline was attributed to severe drought that struck the DNP in 2010.

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[1] Corresponding author, e-mail: ibramaha35@hotmail.com

Juvenile/female ratio of the African open bill was relatively high but was about equal for the yellow-billed and the marabou. The yellow-billed is polygamous, the African open bill and marabou are monogamous. Marabou, the only stork that roosts in DNP, preferred *Balanites aegyptiaca* for roosting.

Key words: Storks; flock; roosting; polygamous; monogamous; Dinder National Park

INTRODUCTION

Storks (Ciconiidae) are large, long-legged, long-necked, wading birds with long, stout bills. They occur in the warmer regions of the world. They lack the powder underneath their bodies that are used for cleaning off fish slime. They are mute, giving no bird call; bill clattering is the only mode of communication in the nest (Stork from Wikipedia 2009). Storks are found in a wide variety of lowland habitats, but many species prefer to be in or near wetlands, although some, such as the marabou (*Leptoptilos crumeniferus*), occur in drier areas. The one with possibly the most atypical habitat is the black stork (*Ciconia nigra*). In the summer, this bird inhabits the extensive forests of Eastern Europe and Asia, albeit within easy reach of small pools and rivers for feeding (Jeffynotes 2010). Storks are found in all continents except Antarctica, their greatest diversity being in the tropical region. North America has the least diversity, with the wood stork (*Mycteria americana*) the region only representative (Jeffynotes 2010).

There are 19 species of storks in six genera (Elliott 1992). Among these, eight species in five genera occur in Africa, mainly tropical in their distribution (Kahl 1971; Brown *et al*. 1982). All the African species occur in Sudan. These are the white, marabou, Abdim's, the yellow-billed, the black, the woolly-necked, the African open bill and the saddle bill. The white and the black storks are Palearctic migrants, while the other six species are locally migrant (Nikolaus 1987).

Storks occur in flocks. The white stork, marabou, Abdim's, African open bill, yellow-billed, and the black stork are gregarious although the latter species is occasionally solitary; woolly-necked and saddle bill are

normally solitary (Brown *et al.* 1982). Most storks roost solely in trees, but the Abdim's and the black stork sometimes roost on cliffs; the yellow-billed roosts on the ground (Brown *et al*. 1982).

Many species of storks are suffering regional decline in the face of the ever-increasing pressure on land for agriculture and buildings. The numbers of marabou, however, are increasing, perhaps in part due to their fondness for feeding around human garbage (Jiffynotes 2010).

The objective of this study was to determine the storks' diversity, variation in numbers, flock characteristics and roosting ecology in Dinder National Park (DNP).

METHODS

The Study area

This study was conducted in DNP (Fig. 1) which lies between latitudes 11°55' and 12°48'N and between longitudes 35°44' and 35°42'E. Established in 1935, the park embraces about 10 000 Km², lying mostly in Sinnar State and to some extent in the Blue Nile and Gedarif States. It was proclaimed a Biosphere Reserve in 1979. The Dinder and Rahad rivers and *Khor* Galegu, which originate from the Ethiopian plateau, are seasonal, constituting the main drainage system of the park. The park is classified into the riverine, the *Maya* and the *Dehra* ecosystems (Mahgoub 2004; Ibrahim and Hashim 2011). The *Dehra* is mainly the hinterland (*dehra*) that covers most of the park area; the riverine consists of the main rivers and their tributaries, and the *Maya* comprises the numerous *mayas* (meadows) lying along the riverine ecosystem (Hashim and Mahgoub 2007). Detailed description of reptiles in the park was given by Sulaiman (2006), birds by Hamed (1998) and vegetation and Mammals by Mahgoub (2004).

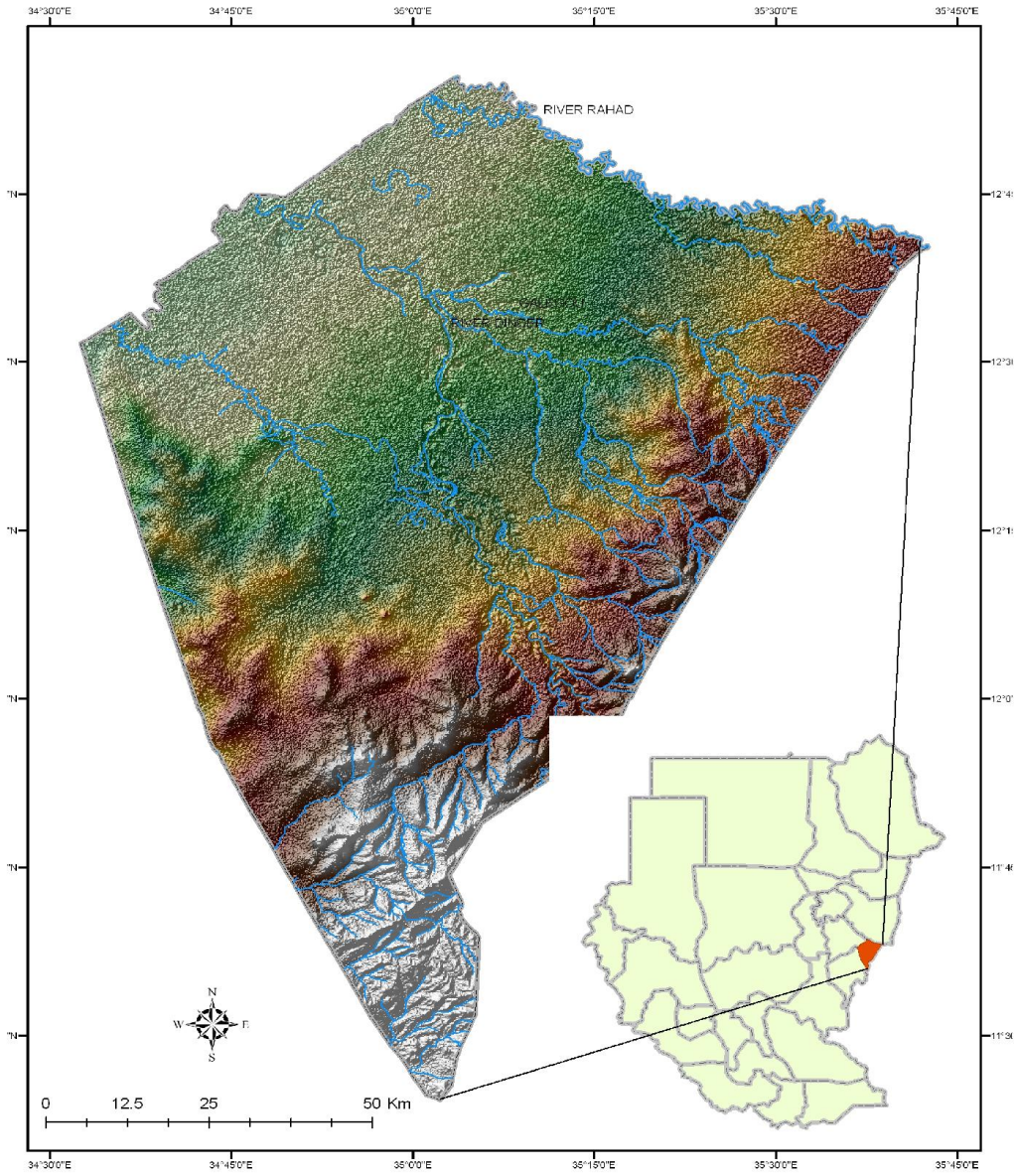

Fig. 1. Dinder National Park (Source: Lubna M. A. Hassan, personal communication)

Data collection

Storks were studied in various *mayas* of the park during the dry seasons of 2009 and 2010. Their numbers were ascertained by the double sampling procedure (Pechance and Pickford 1937; Ibrahim and Hashim 2011). First, the number of each stork species in a flock was estimated and then directly counted. This was repeated for at least 30 flocks until the actual count was equal to or very close to the estimated number. Subsequently, a linear regression model was developed in which the direct count was the independent variable and the estimated count the dependent variable. The number of the stork species was then only an estimate, and its actual number was predicted from the regression model.

The numbers of storks were estimated weekly every two months (December-January, February-March and April-May), and the variations in the species and the numbers were recorded to determine when the storks visited and left the park. By so doing, resident, locally migrant and Palearctic species were identified. Habitat characteristics of resident storks (marabou only) were studied. The density of trees was determined by the nearest neighbour method (Clark and Evans 1954). A 500-m long line transects that began at the bark of the roosting tree and ran north, south, east and west were traversed, and the distance of the nearest neighbour tree was recorded at 50-m intervals along the lines (Ibrahim and Hashim 2011).

Tree density/ha was calculated as $10\ 000 \div (x^2 \times 1.67)$, where x is the mean distance and 1.67 is a constant.

RESULTS AND DISCUSSION

Storks' diversity

There were eight species of storks in Dinder National Park (Table 1). The white and_black storks were Palearctic migrants, whereas Abdim's, the yellow-billed, the African open bill, and the woolly necked were locally migrants; marabou and the saddle bill were resident. This agrees with Nikolaus (1987) findings.

The numbers of marabou, the yellow-billed and the open bill were relatively high in winter and summer, with marked variations in 2009 and

2010 (Table 1). In 2010, however, the numbers were very low, which could be attributed to the severe drought (Meina 2011); the *mayas* were dry and only limited sources of water were available in waterholes along the Dinder river bed. Generally, the total number of storks varied between seasons and years. The total number in winter was slightly more than that in summer due to the arrival of the Palearctic migrants.

Table 1. Total number of storks counted at *mayas** of the Dinder National Park in two years

Stork	2009		2010	
	Summer	Winter	Summer	Winter
Black	0	8	0	0
White	18	8	0	0
Abdim's	44	0	129	0
Yellow-billed	1250	1322	5	2
African open bill	3338	2759	62	84
Woolly-necked	119	426	5	0
Marabou	3277	3840	157	479
Saddle bill	7	17	2	12
Total	8053	8380	360	589

**Maya* = Meadow

The number of woolly-necked was very low as the bird was solitary and sometimes it occurred in pairs, but a group of five birds was frequently seen on the grassland near the *mayas*. Normally, the numbers of woolly-necked and the black and white storks were high in winter compared with summer. Because of the drought in 2010 (Meina 2011), the three bird species did not visit the park. Abdim's stork visited the park in summer before the onset of the rains and left to the south at the end of autumn. The saddle bill was resident, and it was either solitary or in pairs throughout the dry season.

Evidently, the drought has varying effects on storks. While marabou, some yellow-billed and African open bill tolerate the drought conditions of summer and winter, the white and black storks do not. On the other hand, drought has no influence on the Abdim's stork as the bird visits the park only in summer.

The predictive model

The linear relationship between the direct count and the estimated count was predictive for marabou ($\hat{y} = 2.452 + 0.982x$; $r^2 = 0.982$, $P < 0.0001$), open bill ($\hat{y}=0.838 + 0.985x$; $r^2 = 0.985$, $P < 0.001$) and yellow-billed ($\hat{y} = 1.081 + 0.969x$; $r^2 = 0.969$, $P < 0.001$). It is worth mentioning that these birds occur in large flocks. The model did not work for the woolly-necked, the saddle bill, the white, black and the Abdim's storks, because they either occur singly, in pairs or in small flocks. It is more practical to count them directly. Ibrahim and Hashim (2011), who developed a similar predictive model for guinea fowl (*Numida meleagris*) in Dinder National Park, argued that such a model is applicable for birds occurring in large flocks or animals in large groups that make it difficult and cumbersome to count them every now and then.

Roosting ecology

Only the marabou stork roosted exclusively in the riverine and *Maya* ecosystems where it preferred certain tree species. Among the twelve trees species, with varying densities (Table 2), crown areas and distances from the *mayas* (Table 3), only four species were preferred for roosting; namely, *Balanites aegyptiaca*, *Acacia siebberiana*, *Stereospermum kunthianum* and *A. seyal*. However, there was an indication that the marabou was very selective of the roosting tree species. Among the eight *mayas* and/or sites studied, 70% of the roosting trees was *B. aegyptiaca*. In roosting sites, such as Beit el Wahash and Berkat Tomsah, where no *B. aegyptiaca* was found, the marabou roosted on *A. sieberiana* and *A. seyal*. There was, however, some deviation from this trend. In El Sama'aya, marabou preferred *Stereospermum kunthianum* although *B. aegyptiaca* was available. This suggests that *S. kunthianum* would have been preferred if it was available surrounding the *mayas*.

Table 2. Density of trees/ha at marabou stork (*Leptoptilos crumeniferus*) roosting sites surrounding *mayas* in the Dinder National Park (2009 and 2010)

Taxon	*Maya**							
	El Samaaya	Ein Es Shams	Ras Amir	Galegu	Beit el Wahash	Gererrisa	Abdel Ghani	Berkat Tomsah
Balanites aegyptiaca	1.8	78.4	154.6	67.3	-	136.2	742.2	-
Combretum hartmanianum	151.7	227.0	84.6	-	742.0	28.7	70.2	-
Acacia seyal	330.0	131.2	132.7	146.3	-	95.2	82.5	42.8
Ziziphus-Spina-christi	29.8	371.0	26.7	265.7	1670.0	14.6	177.7	104.4
Acacia sieberiama	185.6	26.1	-	66.8	18.5	82.5	23.1	-
Acacia polyacantha	-	108.2	742.2	1670.0	-	-	55.2	1.4
Piliostigma reticulatum	153.2	-	-	39.5	36.6	2.3	104.4	742.2
Hyphaene thebiaca	-	-	-	1159.3	-	1670.0	-	104.4
Crateva adnsonii	-	-	-	1670.6	-	-	185.6	45.4
Acacia. nilotica	-	-	-	-	-	68.6	82.5	118.8
Stereospermum kunthianum	-	-	-	-	-	13.3	-	118.8
Gardeinia lutea	-	-	-	-	-	-	-	742.2

**Maya* = Meadow

Table 3. Crown area and distance of roosting tree from *maya** in Dinder National Park (2009 and 2010)

Maya	Roosting tree	Crown area (m²)	Distance (m)
Ein Es shams	*Balanites aegyptiaca*	424.6	195.0
Beit el wahash	*Acacia seiberana*	378.7	195.0
Gererrisa	*B. aegyptiaca*	451.0	81.5
Galegu	*B. aegyptiaca*	144.9	149.0
Ras Amir	*B. aegyptiaca*	427.2	240.0
El Sama'aya	*Stereospermum kunthianum*	82.6	200.0
Abdel Ghani	*B. aegyptiaca*	473.3	300.0
Berkat Tomsah	*Acacia seyal*	433.9	46.0

**Maya* = Meadow

Flock characteristics

The yellow-billed, the African open bill and the marabou are gregarious. Respective numbers of flocks reported for these storks in some *mayas* were 3, 16 and 17 with respective 361, 668, and 1094 birds. The mean flock size of the yellow-billed was 120.33, the open bill 41.75 and the marabou 64.35.The African open bill visited the *mayas* singly or in pairs in the morning, and it gradually formed flocks afterwards.

Literature about storks' flock sizes is meagre. Brown *et al*. (1982) reported that the marabou is less gregarious compared with the other storks, and sometimes it is solitary, but the African open bill is highly gregarious, the yellow-billed less so.

The number of eggs laid/female is used to measure the potential productivity, which is not available for storks except the yellow-billed, the open bill and the marabou (Meina 2011). The juveniles/female measures the realized productivity and male/female the sexual relationships, i.e. if the birds are polygamous or monogamous (Bolen and Robinson 1998). Since the yellow-billed, the open bill and the marabou lay 3, 4, and 3 eggs, respectively (Kahl 1972), their respective potential productivity (juvenile/female) is 3, 4, and 3. Accordingly, the open bill had slightly higher potential productivity compared with the yellow-billed and the marabou.

The mean number of females in the yellow-billed flock was almost twice the number of the males (Table 4), and the sexes were about equal in the

flocks of the open bill and the marabou. This suggests that the former stork is polygamous; the latter two are monogamous.

Table 4. Productivity and sex relationship parameters of three storks in Dinder National Park (2009)

Ratio	Yellow-billed	Open bill	Marabou
Eggs laid/females*	3.00	4.00	3.00
Juvenile /females	0.29	0.47	0.32
Male/females	0.51	0.99	1.03
N	3.00	16.00	17.00

N = Flock size; *Kahl (1972)

In conclusion, the black, the white, the Abdim's, the yellow-billed, the African open bill, the wooly-necked, the marabou and the saddle bill storks occur in Dinder National Park. The largest flock is formed by the marabou, followed by the African open bill and least by the yellow-billed. The yellow-billed is polygamous and the African open bill and the marabou are monogamous. The marabou, the only stork that roosts in Dinder National Park, prefers *Balanites aegyptiaca* for roosting.

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مجلة جامعة الخرطوم للعلوم الزراعية : المجلد العشرين – العدد الثانى ، 2012م

تعدد اللقالق وخصائص أسرابها وإيكولجيا مبيتها وتذبذب أعدادها الموسمي فى فترة الصيف بمحمية الدندر الوطنية – السودان

عمر محمد مينا وإبراهيم محمد هاشم

مركز بحوث الحياة البرية ، شمبات – السودان

المستخلص: درست اللقالق فى نظام الميعات بمحمية الدندر القومية أثناء موسم الصيف فى عامى 2009 و2010 ، لتحديد تعددها وخصائص أسرابها وإيكولوجيا مبيتها وتذبذب أعدادها السنوي . حددت الأعداد ، عن طريق أخذ العينات المزدوج ، بتقدير أعداد أنواع اللقالق فى كل سرب أولاً ثم عدها مباشرة . طور نموذج إحصائى طردي بين متغيرات الأعداد المقدرة والمعدودة للتنبوء بالمعدودة ومن ثم قدرت الأعداد فقط. حددت كثافة الأشجار بطريقة أقرب جار وقيست أقطار تيجانها ثم حسبت مساحات التيجان . وجدت ثمانية أنواع من اللقالق بمحمية الدندر– تحديداً الباجبار الأسود (*Ciconia nigra*) والباجار الأبيض (*Ciconia ciconia*) والسمبر (*Ciconia abdimii*) والباجبار أصفر المنقار (*Mycteria ibis*) وأم قرقور (*Anastomus lamelligerus*) وأبو رقيبة (*Ciconia episcopus*) وأبو السعن(*Leptoptilos crumeniferus*) وأبوميير (*Ephippiorhynchus senegalensis*. اللقلاقان الأبيض والأسود تهاجران من منطقة الباليركتيك ، والسمبر وأبورقية والقرقور والبجبار أصفر المنقار تهاجر محلياً ، وأبوالسعن والميرم مستقران فى المحمية . الباجبار أصفر المنقار وأبوالسعن وأبوقرقور تقع فى أسراب كبيرة . كان العدد الكلى للقالق فى 2009 أقل منها فى 2010 . نسبة الصغار/ الأناث فى أبوقرقور كانت عالية مقارنة مع نفس النسبة فى البجبار أصفر المنقار وأبوالسعن. إن البجبار أصفر المنقار متعدد الزوجية ، وأبوقرقور وأبوالسعن أحاديا الزوجية . أبوالسعن ، وهو اللقلاق الوحيد الذى يبيت قرب الميعات ، يفضل شجرة الهجليج (*Balanites aegyptiaca*) للمبيت.