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A forest in a city Biodiversity at Sunut forest, Khartoum, Sudan

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ABSTRACT

Al-Sunut is a natural forest located in the centre of Khartoum state, the capital of Sudan. Due to its unique location, Sunut forest is severely stressed by human activities, especially construction. In this paper, we provide a survey for the biodiversity at Sunut Forest. Three animal groups were investigated for density and species diversity: Birds, *Acacia nilotica* associated arthropods and ground arthropods. The aim of the study was to provide the field data required for the design of adequate management and conservation plans and to draw the popular attention to the special value of Sunut forest. The study concluded that Sunut forest hosts considerable biological diversity, particularly of birds, as 87 species were recorded. Arthropod specimens that belong to 10 different orders were collected from *A. nilotic*a trees. Likewise, specimens of ground arthropods collected from the forest represent 11 different orders.

Keywords: Habitat conservation, Birds, tree-associated arthropods, ground arthropods, *Acacia nilotica*, Khartoum

INTRODUCTION

Al-Sunut is a natural forest which borders the White Nile at the Mogran area, Khartoum. Sunut forest is a unique biotope; a poor savannah habitat impeded in the semi desert background of Northern Sudan (Shawki & Musnad, 1964). As a consequence, the forest is characterized by high density of plant cover, mainly composed of *Acacia nilotica* trees (Mohamed, 1986; Ahmed, 1998). Moreover, it represents a hot spot of bird and invertebrate diversity. It has been estimated that the forest contains at least 70 bird species (among which 26 are migrants) together with a diverse invertebrate community (Cloudsely-Thompson, 1964; Nikolaus, 1987; Elobeid, 1990; Lado, 1994; Abd-Alrahman, 1998). The major environmental factor which underlies the unusual biodiversity at Sunut forest is the annual floods of the Nile River, which supplies the site with immense amounts of water and nutrient-reach sediments. Thus, the Sunut forest is considered as an inland wetland ecosystem (Altayeb & Hamed, 2003).

Because of its unique position as a natural forest in the heart of the modern, crowded and growing capital of Sudan, Sunut forest provides a whole range of valuable services to the environment and the society of Khartoum. It is an important ground for both resident and migrating birds. It also acts as a barrier that protects the residential areas in the vicinity from the annual flooding by holding the excess water of the White Nile. Moreover, the local community exploits the forest for fishing, grazing, farming as well as recreation activities. Sunut forest is an attractive touristic site particularly for bird watchers. Because of its accessibility and proximity to academic institutions, Sunut forest was a major part in the field training of generations of Sudanese biologists (Altayeb & Hamed, 2003).

The Sunut forest is a national protected area. It is regarded as a forest reserve since 1932 and declared as a bird sanctuary since 1945. The forest attracted considerable attention at the international level as well. The management category of the International Union for the Conservation of Nature (IUCN) has listed the site as a bird sanctuary. In addition, it has been proposed as a Ramsar site (i.e. wetland of international importance) based on Ramsar convention (Altayeb & Hamed, 2003). Despite all these efforts, the level of protection that is actually applied at the site remains limited.

Being in the middle of the urban Khartoum region is the reason why Sunut forest is special in the first place, however, it is also the reason why it is extremely vulnerable to human disturbance. The forest is stressed by deforestation, habitat loss, overgrazing and waste disposal (Abushama, 1994). The most important threat, however, is the reclamation of the forest land for construction purposes; for example, about 15% of the forest area has been removed for the construction of the new White Nile Bridge (Altayeb & Hamed, 2003). As the Khartoum population continues to grow, it is expected that the threats facing the forest will increase in magnitude, unless adequate management plans are designed and thoroughly implemented.

In this paper, we provide a preliminary investigation of the biodiversity at Sunut forest, based on assessment of three key animal groups: birds, ground arthropods and *Acacia nilotica* associated arthropods. The goal is to provide a solid base of knowledge in order to guide management and conservation efforts taking place at Sunut forest.

MATERIAL AND METHODS

Study area

This study was carried out in the Sunut Forest (15°35′N, 32°30′E) (Figure 1). The site is bordered by the new White Nile Bridge from the North, the industrial area from the South, the Ghaba Street from the East and the White Nile from the West. Along the river bank there is a narrow cultivated area extending between the forest and the river bank (Figure 2).

Fig. 1: The Sunut Forest (Satellite image).

Fig. 2: The cultivated area at the edge of the Sunut forest.

Climate

The climate of Khartoum is tropical desert. There are three seasons per year, cool winter, dry summer and a rainy season. Highest temperatures (45°C or more) are recorded in summer months (May-June) while lowest temperatures (22°C or less) are recorded during winter months (December-January). The rainfall is about 150 mm per annum. The forest is flooded during the rainy season (July-October). Later, during winter and early summer, the forest becomes totally dry (Eltayeb & Hamed, 2003).

Investigation of bird diversity

The survey was carried out between October and June. Assessment of avifauna was based on bird watching. At least one visit was conducted per each month. Observation was performed during the early morning (6:45 am to 11:00 Am). Identification of bird species was made by sight using Binoculars following Stevenson & Fanshawe (2002). The numbers of individuals observed were counted when numbers were limited or estimated when numbers were huge.

Investigation of Acacia nilotica-associated arthropods

The survey was conducted in April. Based on field observations, four sampling stations were established. These are located along a transect crossing the forest from the West (River bank) to East (Ghaba street). The four stations were visited for sampling 12 times during the period of April-June 2003. Invertebrate samples were collected from *A. nilotica* trees by beating the trees with a stick and collecting organisms that fall on the beating sheet. Using the aspirator, samples were then drawn into a labeled vial containing 2ml of ethyl alcohol (70%). At each station 20 trees were sampled.

Investigation of ground arthropods

The survey was conducted in February. Ground arthropods were sampled from two different sites in Sunut forest. The first site is located at the cultivated area bordering the Nile while the second area is located about 50m from the edge of the forest, away from the river. Specimens were collected using pit fall traps. Traps were filled with water and oil and were set in burrows so that the top of the trap was leveled with the ground surface. Within each site, traps were distributed along three transects, separated by a space of 15m between every two traps. Traps were left overnight and visited daily for seven consecutive days. Specimens were collected using forceps and a sieve and were put in labeled bottles containing 70% ethanol.

Identification of arthropod specimens

Collected arthropod specimens were brought to the lab, where they were stored, identified to the lowest possible taxa and counted to estimate their density. Identification and counting were conducted under a dissecting microscope and/or a stereomicroscope. Identification was made following the literature. Specimens were sorted to morphospecies, according to size, shape and colour.

RESULTS

Bird diversity

Overall, 87 bird species were recorded in this study. Among the recorded species, 50 were Palaearctic migrants, 8 were local migrants and 29 species were resident. Species that were found in the study are listed in table (1).

Table 1: Bird species observed in the study area: where R = resident (present throughout the year), LM = local migrant (undergoing distinct seasonal movements within its distribution), PM = Palaearctic migrant (non-breeding visitors from the Palaearctic).

No.	Species Common Name	Status	Scientific Name	Family Name
1	Great White Pelican	PM	*Pelecanus onocrotalus*	Pelecanidae
2	Pink backed Pelican	R	*Pelecanus rufescens*	Pelecanidae
3	Little Grebe	LM	*Tachybaptus ruficollis*	Podicipedidae
4	Long-tailed Cormorant	LM	*Phalacrocorax africanus*	Phalacrocoracidaee
5	Cattle Egret	PM	*Bubulcus ibis*	Ardeidae
6	Common Saquacco Heron	PM	*Ardeola ralloides*	Ardeidae
7	Little Egret	PM	*Egretta garzetta*	Ardeidae
8	Great Egret	PM	*Casmerodius albus*	Ardeidae
9	Goliath Heron	R	*Ardea goliath*	Ardeidae
10	Grey Heron	PM	*Ardea cinerea*	Ardeidae
11	White Stork	PM	*Ciconia ciconia*	Ciconiidae
12	Abdims Stork	R	*Ciconia abdimii*	Ciconiidae
13	Black Stork	PM	*Ciconia nigra*	Ciconiidae
14	Saddle-billed Stork	R	*Ephippiorhynchus senegalensis*	Ciconiidae
15	Sacred Ibis	LM	*Threkiornis aethiopicus*	Threskiornithidae
16	African Spoonbill	LM	*Platalea alba*	Threskiornithidae
17	Eurasian Spoonbill	PM	*Platalea leucorodia*	Threskiornithidae
18	Greater Flamingo	PM	*Phoenicopterus ruber*	Phoenicopteridae
19	Northern Shoveler	PM	*Anas clypeata*	Anatidae
20	Black Kite	PM	*Milvus migrans*	Accipitridae
21	Arabian Bustard	LM	*Ardeotis arabs stieberi*	Otididae
22	Black-winged Stilt	PM	*Himantopus himantopus*	Recurvirostridae
23	Greater-painted Snipe	R	*Rostratula benghalensis*	Rostratulidae
24	Spotted Thick-knee	R	*Burhinus capensis*	Burhinidae
25	Senegal Thick-knee	R	*Burhinus senegalensis*	Burhinidae
26	Egyptian Plover	R	*Pluvianus aegyptius*	Glareolidae
27	Spur-winged Plover	PM	*Vanellus armatus*	Charariidae
28	Black winged Plover	PM	*Vanellus melanopterus*	Charariidae
29	Three-banded Plover	LM	*Charadrius tricollaries*	Charariidae
30	Common ringed Plover	PM	*Charadrius hiaticula*	Charariidae
31	Little ringed Plover	PM	*Charadrius dubius*	Charariidae
32	Kentish Plover	PM	*Charadrius alexandrinus*	Charariidae
33	Black-bellied Plover	PM	*Pluvialis squatarola*	Charariidae
34	Ruff	PM	*Philomachus pugnax*	Scolopacidae
35	Common Sandpiper	PM	*Actitis hypoleucos*	Scolopacidae
36	Wood Sandpiper	PM	*Tringa glareola*	Scolopacidae

Cont Table1:

No	Species Common Names	Status	*Scientific Name*	Family Name
37	Green Sandpiper	PM	*Tringa ochropus*	Scolopacidae
38	Terek Sandpiper	PM	*Xenus cinereus*	Scolopacidae
39	Common Green Shank	PM	*Tringa nebularia*	Scolopacidae
40	Marsh Sandpiper	PM	*Tringa stagnatilis*	Scolopacidae
41	Common Red Shank	PM	*Tringa tetanus*	Scolopacidae
42	Little Stint	PM	*Calidaris minuta*	Scolopacidae
43	Red-necked Stint	PM	*Calidris ruficollis*	Scolopacidae
44	Sanderling	PM	*Calidaris alba*	Scolopacidae
45	Ruddy Turnstone	PM	*Arenaria interpres*	Scolopacidae
46	Black-tailed Godwift	PM	*Limosa limosa*	Scolopacidae
47	Eurasian Curlew	PM	*Numenius arquata*	Scolopacidae
48	Common Snipe	PM	*Gallinago gallinago*	Scolopacidae
49	Common Black-headed Gull	PM	*Larus ridibundus*	Laridae
50	Lesser-crested Tern	LM	*Sterna bengalensis*	Laridae
51	Caspian Tern	PM	*Sterna caspia*	Laridae
52	Gull-billed Tern	PM	*Sterna nilotica*	Laridae
53	Common Tern	PM	*Sterna hirundo*	Laridae
54	White- winged Tern	PM	*Chlidonias leucopterus*	Laridae
55	Whiskerd Tern	PM	*Chlidonias hybridus*	Laridae
56	Namaqua Dove	PM	*Oena capensis*	Columbidae
57	African mourning Dove	R	*Streptopelia decipiens*	Columbidae
58	Laughing Dove	PM	*Sterptopelia senegalensis*	Columbidae
59	Diederik Cuckoo	R	*Chrysococcyx caprius*	Cuculidae
60	Little Swift	PM	*Apus affinis*	Apodidae
61	Alpine Swift	PM	*Apus melba*	Apodidae
62	African Palm Swift	R	*Cypsiurus parvus*	Apodidae
63	Pied Kingfisher	R	*Ceryl rudis*	Alcedinidae
64	Little Bee-eater	R	*Merops pusillus*	Meropidae
65	Little Green bee-eater	R	*Merops orientalis*	Meropidae
66	African Hoopoe	R	*Upupa africana*	Upupidae
67	Rufous-naped Lark	R	*Mirafra africana*	Alaudidae
68	Crested Lark	R	*Galerida cristata*	Alaudidae
69	Chestnut-backed Sparrow Lark	R	*Eremopterix leucotis*	Alaudidae
70	Common House Martin	PM	*Delichon urbica*	Hirundinidae
71	Ethiopian Swallow	R	*Hirundo aethiopica*	Hirundinidae
72	Grey-rumped Swallow	R	*Pseudohirundo griseopyga*	Hirundinidae
73	White Wagtail	PM	*Motacilla alba*	Motacillidae
74	Pied Wagtail	R	*Motacilla aguimp*	Motacillidae
75	Yellow Wagtail	PM	*Motacilla flava*	Motacillidae
76	Common Bulbul	R	*Pycnonotus barbatus*	Pycnonotidae
77	Isabelline Wheatear	PM	*Oenanthe isabellina*	Turdidae
78	Desert Wheatear	PM	*Oenenthe deserti*	Turdidae
79	Spotted Morning-thrush	LM	*Cichladusa guttata*	Turdidae
80	Eurasian Golden Oriole 1	R PM	*Oriolus oriolus*	Oriolidae
81	House Sparrow	R	*Passer domesticus*	Passeridae
82	Golden Sparrow	R	*Passer luteus*	Passeridae
83	Village Weaver	R	*Ploceus cucullatus*	Ploceidae
84	Little Weaver	R	*Ploceus luteolus*	Ploceidae
85	Red-billed Quelea	R	*Quelea quelea*	Ploceidae
86	Northern Red Bishop	R	*Euplectes franciscanus*	Ploceidae
87	White-rumped Seed Eater	R	*Serinus leucopygius*	Fringillidae

The variation in abundance and species composition of birds inhabiting the site during the study period is shown in table (2).

Table 2: Estimates of the numbers of individual birds observed for each species at Sunut forest during the study period (October 2011- June 2012).

		Estimated numbers of Birds in the study area								
No.	Species Common Name	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
1	Great White Pelican	19	0	0	0	0	38	74	55	57
2	Pink Blacked Pelican	0	0	0	0	0	0	0	2	3
3	Little Grebe	0	0	0	0	0	7	9	0	0
4	Long-tailed Cormorant	0	0	0	0	0	0	1	3	0
5	Cattle Egret	10	5	3	2	7	6	12	18	20
6	Common Saquacco Heron	2	0	0	0	1	2	5	3	13
7	Little Egret	25	20	17	7	9	5	15	18	26
8	Great Egret	3	1	0	0	1	0	3	3	5
9	Golaith Heron	0	0	0	0	0	0	1	0	0
10	Grey Heron	3	2	1	0	2	3	1	0	1
11	White Stork	7	0	2	0	0	0	0	0	0
12	Abdims Stork	0	0	0	0	0	0	7	1	2
13	Black Stork	4	0	0	0	0	0	0	1	1
14	Saddle-billed Stork	0	0	0	0	0	0	0	1	1
15	Sacred Ibis	3	0	0	0	3	9	10	7	0
16	African Spoonbill	0	0	0	0	0	0	2	4	5
17	Eurasian Spoonbill	0	0	0	0	0	1	2	3	2
18	Greater Flamingo	50	55	39	0	0	0	0	0	0
19	Northern Shoveler	0	0	0	0	5	3	90	5	0
20	Black Kite	17	15	12	5	4	7	9	4	3
21	Arabian Bustard	0	0	0	0	0	0	0	0	3
22	Black-winged Stilt	7	6	5	6	0	2	3	5	7
23	Greater-painted Snipe	0	0	0	0	0	0	7	0	3
24	Spotted Thick-knee	0	0	0	1	0	0	4	0	1
25	Senegal Thick-knee	0	0	0	0	0	0	0	1	0
26	Egyptian Plover	0	0	2	4	0	3	15	0	0
27	Spur-winged Plover	47	40	45	45	60	65	72	40	43
28	Black winged Plover	0	0	1	4	0	0	0	0	0
29	Three-banded Plover	0	0	0	0	0	0	0	0	2
30	Common ringed Plover	5	13	5	6	6	0	9	5	3
31	Little ringed Plover	0	15	6	4	3	1	3	0	5
32	Kentish Plover	0	0	1	2	2	1	0	1	0
33	Black-bellied Plover	0	2	0	0	0	0	0	0	0
34	Ruff	5	0	2	3	1	1	1	0	0
35	Common Sandpiper	0	7	4	10	15	11	8	1	2
36	Wood Sandpiper	0	6	10	7	0	1	1	0	0
37	Green Sandpiper	0	8	4	5	0	2	1	0	0
38	Terek Sandpiper	0	9	3	1	2	1	0	1	1
39	Common Green Shank	0	7	3	8	7	1	1	1	0
40	Marsh Sandpiper	0	0	3	8	10	0	0	0	0
41	Common Red Shank	0	3	3	8	5	1	0	2	0
42	Little Stint	0	12	5	1	4	3	6	3	0
43	Red-necked Stint	0	15	5	0	2	0	0	0	0
44	Sanderling	0	8	9	1	0	9	2	0	0

Cont: Table 2

		Estimated numbers of Birds in the study area								
No	Species Common Name	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
45	Ruddy Turnstone	0	0	0	0	0	0	2	0	0
46	Black-tailed Godwift	0	7	20	35	45	15	1	0	0
47	Eurasian Curlew	0	0	1	2	7	5	2	0	0
48	Common Snipe	3	0	0	0	0	5	7	0	0
49	Common Black-headed Gull	0	0	0	0	0	12	10	0	0
50	Lesser-crested Tern	0	0	0	0	2	5	4	0	0
51	Caspian Tern	0	0	0	0	3	4	1	0	0
52	Gull-billed Tern	0	0	0	0	1	3	1	0	0
53	Common Tern	0	0	0	5	3	8	10	2	0
54	White-winged Tern	0	0	0	0	0	2	8	5	0
55	Whiskerd Tern	0	0	0	1	1	5	6	1	0
56	Namaqua Dove	0	0	0	0	0	1	2	0	1
57	African mourning Dove	9	5	4	8	4	9	7	4	5
58	Laughing Dove	64	45	54	60	66	59	60	63	55
59	Diederik Cuckoo	0	0	0	0	0	1	3	0	0
60	Little Swift	0	40	48	35	26	0	47	30	0
61	Alpine Swift	0	39	45	50	40	43	45	33	0
62	African Palm Swift	0	0	0	0	0	0	17	0	15
63	Pied Kingfisher	2	3	2	6	2	7	4	4	2
64	Little Bee-eater	0	0	1	0	1	9	1	0	0
65	Little Green bee-eater	0	0	0	0	0	1	1	0	0
66	African Hoopoe	0	0	0	0	0	0	1	0	0
67	Rufous-naped Lark	0	0	3	0	1	1	0	0	0
68	Crested Lark	5	3	9	7	4	10	10	12	15
69	Chestnut-backed Sparrow	0	0	0	0	0	0	0	93	160
70	Common House Martin	0	0	0	0	0	44	88	153	100
71	Ethiopian Swallow	0	66	75	73	76	70	85	59	93
72	Grey-rumped Swallow	0	0	32	27	12	19	25	0	0
73	White Wagtail	15	20	18	13	23	12	1	0	0
74	Pied Wagtail	0	0	1	5	7	0	3	0	0
75	Yellow Wagtail	14	7	10	8	25	2	1	0	0
76	Common Bulbul	0	0	3	6	7	6	3	0	0
77	Isabelline Wheatear	0	2	5	4	2	0	0	0	0
78	Desert Wheatear	0	0	0	0	0	2	3	0	0
79	Spotted Morning-thrush	0	0	0	1	0	0	0	0	0
80	Eurasian Golden Oriole	0	0	5	0	9	12	0	0	0
81	House Sparrow	53	49	47	65	63	72	92	180	1000
82	Golden Sparrow	0	0	0	0	0	0	0	93	100
83	Village Weaver	0	0	0	0	0	7	45	90	1000
84	Little Weaver	0	0	0	0	0	8	4	83	300
85	Red-billed Quelea	0	0	0	0	0	0	0	47	80
86	Northern Red Bishop	0	0	0	0	1	2	5	30	900
87	White-rumped Seed Eater	0	0	0	0	0	0	260	500	600

The diversity of Acacia nilotica-associated Arthropods

A total of 465 arthropods representing 30 different morphospecies were collected. Collected specimens comprise 2 classes, 10 orders and at least 16 families. Class Insecta was dominant, represented by 7 orders and 16 families while class

Arachnida was less frequent, represented by only 3 orders. Among insects the dominant orders were Coleoptera (141 individuals), followed by Hemiptera (95 individuals). The least represented orders were Dictyoptera, Lepidoptera and Phasmida. Among Arachnida order Shizomida was dominant, represented by 114 individuals while order Amblypygi density was the bare minimum represented by only 13 individuals. The number of arthropod specimens collected from each order is illustrated in table (3).

Table 3: Density of arthropod orders collected from *Acacia nilotica* trees at four sites in the Sunut Forest during April-June 2012.

Order	Density				
	Site 1	Site 2	Site 3	Site 4	Total
Amblypygi	6	2	5	1	14
Araneae	19	7	6	6	38
Coleoptera	34	60	36	8	138
Dictyoptera	0	0	1	1	2
Hemiptera	49	20	8	18	95
Hymenoptera	7	9	6	3	25
Lepidoptera	1	1	1	0	3
Phasmida	1	0	1	1	3
Shizomida	50	26	33	27	136
Thysanoptera	2	4	0	2	8
Total	175	123	97	67	465

Four families of Coleoptera were identified, among them the Scolytidae was the most frequent. Hemipterans were represented by 7 families, from them Miridae was the dominant family. Most of the other orders were represented by only one family. The number of specimens collected from the different families of Coleoptera and Hemiptera are shown in table (4).

Table 4: Density of Coleopteran and Hemipteran families collected from *Acacia nilotica* trees at four sites in the Sunut Forest during April-June 2012.

Order	Family	Density				
		Site 1	Site 2	Site 3	Site 4	Total
Coleoptera	Coccinellidae	5	10	4	3	22
	Chrysomelidae	3	11	0	2	16
	Curculionidae	15	2	4	0	21
	Scolytidae	14	37	28	3	82
Hemiptera	Pentatomidae	0	2	3	3	8
	Miridae	40	15	4	15	74
	Lygaeidae	2	1	0	0	3
	Coreidae	2	0	0	0	2
	Coccidae	1	1	1	0	3
	Fulgoridae	2	1	0	0	3
	Aphididae	2	0	0	0	2

The diversity of ground arthropods

A total of 1286 specimens of ground arthropods, representing three classes, 11 orders and 18 morphospecies were collected (Table 5). The class Arachnida represents 14% of the total number of specimens collected. These included four morphospecies, while the class Diplopoda was represented by only 3 individuals (0.23%). Insecta was the dominant class, comprising 86% of specimens collected, including 9 orders and 13 distinct morphospecies. Among the insects Hymenoptera

was the most represented order (44%), followed by Coleoptera (25%) and Orthoptera (9%). The rest of insect orders represent only 8% of the total collection.

Table 5: Density of the different orders of ground arthropods collected at two sites in the Sunut Forest during February 2012.

		Site A	Site B	Total Number	Percentage (%)
Arachnida		150	24	174	13.53
Diplopoda		1	2	3	0.23
Insecta	Coleoptera	141	176	317	24.65
	Hymenoptera	22	545	567	44.09
	Orthoptera	69	46	115	8.94
	Dermaptera	22	0	22	1.71
	Dictyoptera	0	2	2	0.16
	Collembola	4	0	4	0.31
	Hemiptera	33	6	39	3.03
	Siphnoptera	0	3	3	0.23
	Mallophaga	0	1	1	0.08

DISCUSSION

During this study, a preliminary survey of biological diversity has been conducted at Sunut Forest. Three groups were targeted during the survey: birds, tree-associated arthropods and ground arthropods. The goal of the investigation was to provide basic data that can be used for future management and conservation activities at the forest. Overall, the study demonstrates that this site represents a hot spot for avian and arthropod diversity, as both the density and species diversity recorded there were higher than the surrounding, semi desert region of Khartoum. These findings support the view of Sudanese conservationists that Sunut forest is a valuable and unique site that should be maintained as close as possible to its natural state and protected from the severe human impact in the vicinity.

Despite the limited spatial and temporal scale of the study, 87 bird species were recorded at Sunut forest, thus demonstrating the special richness of the site with birds and, consequently, its touristic value for bird watching activities. The avifauna at Sunut forest was found to show considerable temporal fluctuations with respect to both abundance and species diversity. These variations can be attributed to two main factors (e.g. Pearson & Backhurst, 1976; Mac Nally, 1996; Yahner, 1997): first, the seasonal change in water availability that is associated with the Nile flood, this change influences both vegetation cover and insect density at the forest, and thus affects the attractiveness of the site for birds. The second factor which underlies the temporal variations is bird migrational patterns, as most of the recorded bird species (i.e. 50) were Palaearctic migrants. The annual movements of migrant birds to and from the site are likely to cause substantial temporal changes in the avifauna composition.

An outstanding feature of *Acacia nilotica* is its tolerance to prolonged periods of flood and inundation, which enables the species to flourish in periodically flooded habitats such as Sunut forest (Booth, 1966). In this study, the association between *Acacia nilotica* and arthropods was investigated. Arthropods were found to show higher density and diversity at *A. nilotica* trees than at the surrounding semi-desert Khartoum region. However, both the density and diversity appear to be somehow lower than those recorded from similar habitats (Cloudsely-Thompson, 1964; Elobeid, 1990). This may refer to the fact that the sampling period was restricted to the dry season only. However, this may also suggest a poor association of

invertebrates with *A. nilotica* trees. Indeed, some studies have reported that Sunut tress have powerful algaecidal activity due to their high tannin content. Aqueous extracts of the plant ripe pods also showed molluscicidal activity against snail vectors of Schistosomiasis (Ayoub, 1982). Such properties suggest similar effects on insects and other invertebrates, thus explaining the relatively poor density and diversity recorded in the current study. However, such conclusion could only be confirmed through conducting studies that compare invertebrate communities associated with *A. nilotica* to those associated with other tree species co-existing in the same habitat such as *A. seyal*, *A. albida*, *Balanitus egyptiaca*, *Tamarax nilotica*, *Ziziphus spinachrist*.

The structure of ground arthropod community is affected by several factors such as seasonal changes, habitat structure and land use (McIntyre *et al*., 2001). During the current investigation of ground arthropods at Sunut forest, considerable species diversity was recorded (mostly of insects). Interestingly, no clear variation was observed in ground arthropods community between the cultivated area and the forest area, despite the marked differences in the soil environment and the intensity of human influence. The observed homogeneity might result from the spatial distribution of the two sampling sites, as they were rather close to each other. The sampling site at the forest was close to the forest edge where the human impact is higher than the inner parts of the forest, due to the extensive disturbance caused by recreation activities.

The current research could be considered as pilot one towards investigation of the biodiversity at Sunut forest. Future research should adopt larger scale of sampling, both spatially and temporally; species density and diversity should be investigated during different seasons as well as from different sites in the forest. More precise taxonomical methodologies, aiming to provide identification at the species level, should be applied during surveys of arthropod diversity at the site. In addition, the diversity at the areas surrounding Sunut forest should be assessed as well, so that conclusions concerning the biodiversity status of the forest can be made on comparative basis. The ecological impact of construction, recreation and waste disposal activities on the site should also be targeted by future research.

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