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Paleozoology of Sudan: 2. Amphibians, Reptiles and Aves fossils

Zuheir N Mahmoud[1]* and Muna A Mohmed[2]

[1]*Department of Zoology, University of Khartoum, Sudan*

[2]*Institute of Environmental Studies, University of Khartoum, Sudan*

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***Corresponding author:** Zuheir N Mahmoud, Department of Zoology, Faculty of Science, University of Khartoum, Sudan

Abstract

Fossilized remains of amphibians, reptiles, and birds have been classified into 94 distinct taxa. Among the amphibians, five species were identified, including the extant Sclerophrys regularis, an extinct new genus named Kababisha which includes two new species -Kababisha humarensis and Kababisha sudanensis- both considered extinct, as well as several indeterminate caecilian specimens. The reptilian assemblage includes several extinct taxa, such as Coniophis dabiebus, Nubianophis afaahus, and Krebsophis thobanus. Crocodylian remains are represented by Crocodylus sudani and Hyposaurus sp. Additionally, the fossil record includes multiple extinct dinosaur taxa within the reptilian group, including members of the Hypsilophodontid, Iguanodontid, Dromaeosaurid, and Theropod, as well as representatives of Carcharodontosaurus, Ouranosaurus sp., and Titanosaurus spp. Avian fossils are represented by ten species, all of which are currently recognized as extant.

Keywords: Sudan; Fossils; Amphibians; Reptiles; Aves

Introduction

Numerous fossils remain of amphibians, reptiles and birds have been recorded from some wadis and geological formations from northern Sudan. Werner [1] reported the first evidence of Gymnophiona (Amphibia) from the Cretaceous-aged Wadi Al Milk Formation, Sudan. Subsequently, Evans et al. [2] recovered fossilized amphibian vertebrate and described *two new salamander species: Kababisha humarensis gen. et sp. nov., Kababisha sudanensis gen. et sp. nov.,* in addition to unidentified caecilian remains.

Reptilian fossils in Sudan are highly diverse. Fossil Testudines have been described in several [3-9]. Fossilized remains of Crocodylia, including fragmented skeletal material, have been documented by multiple sources [3,7,9-11,13]. *Hyposaurus* gen. et, was described by [12] and *Crocodylus sudani* gen. et sp. nov., was described by [14]. Paleonile [15] & Werner C et al. described a fossil crocodile tooth, from Singa on the Blue Nile. Fossil snakes (Serpentes) were identified in studies made by [9,13,16,17]. Remains of *Varanus niloticus* were described by Suková et al. [9,13], whereas indeterminate *Varanus* material was reported in [3,6]. Dinosaurian faunal remains from the Upper Cretaceous of northern Sudan have been described by [4,18].

Globally, avian fossils are relatively rare due to the lightweight and pneumatic nature of bird bones, which reduces their potential for fossilization. However, fossil bird remains from Sudan have been documented in several studies [3,5,9,11,13,17,19,20].

The primary objectives of this study are to: Compile and synthesize existing paleontological data on fossilized amphibians, reptiles, and bird focusing on significant paleontological contributions, such as the first records and newly described species. It also aimed to provide a consolidated reference for future research on the vertebrate paleofauna of Sudan.

Methods

The information presented here was based on deskwork, in addition to two new locality records. The following are the acronyms used: Ex=Extinct, L. Ex=Extinct from the study site but extant elsewhere in Sudan, Ext=Extant at the study and elsewhere in Sudan, gen. et. =New genus, nov. sp. =New species, Indet=The taxon is unknowable beyond a certain taxonomic level, Cf.=Indicates to be compared with, MYA=Million years ago.

Findings

Amphibians study sites and findings

Werner [1] investigated fossil material from the Cretaceous-aged (145-66 million years ago) Wadi Al Milk Formation, Sudan. Evans et al. [2] reported indeterminate frog (Anura indet.) vertebrae, deposits (100.5–93.9 million years ago) within the same formation. *Pöllath et al. [21]* during Holocene (11,700 years ago to present) excavations in Wadi Howar, recovered a bone attributed to an unidentified amphibian. Additionally, Sukova et al. [13] excavated the Sphinx site (SBK.W-60) 3.5km north west of the Sabaloka cataract (the 6th cataract) 80km North of Khartoum. They reported fossilized frog material.

Class Amphibia: Gray,1825

Order Anura: Duneril, 1806

Anura Indet recorded by [18].

Sclerophrys (=*Bufo*) *regularis* from Wadi Howar was described by [7].

Frog Indet found by [1,13,21].

Order Caudata: Duneril, 1806.

Kababisha humarensis gen. et. sp. nov.

Kababisha sudanensis gen. et. sp. nov.

Evans et al. [2] reported both *new fossil genus and the two new species.*

Order Gymnophiona: Müller, 1832

Gymnophiona Indet.

Caecilian Indet.

The first documented occurrence of Gymnophiona (Amphibia) from the Cretaceous Wadi Al Milk Formation in Sudan was reported by [1]. The recovered material included indeterminate specimens of frogs (Anura indet.) and caecilians (Gymnophiona indet.). Subsequent work by Evans et al. [2] yielded additional vertebrate remains from the Cenomanian-aged deposits (approximately 100.5–93.9 million years ago) of the same formation, comprising representatives of Anura, Urodela, and Gymnophiona. Among these, two species of Sirenidae (salamanders), *Kenyasiren humarensis* and *Kenyasiren sudanensis*, were described. According to Werner & Gayet [22], these specimens represent the earliest known sirenids outside of North America.

Reptilians study sites and findings

Bufferaut et al. [4] described a new vertebrate fauna from the Upper Cretaceous deposits of northern Sudan. Müller et al. [5] investigated reptilian assemblages from the studied the reptiles of Late Cretaceous Wadi Al Milk and Shendi formations in the same region. Dunne et al. [9] reported reptile fossils from Al-Khiday situated approximately 25km south of Omdurman and 3km west of the White Nile. From the Upper Cretaceous Wadi Al Milk Formation, Evans et al. [10] described a new Peirosaurid crocodyliform based on articulated right and left anterior dentary, associated splenial segments, two complete teeth and several broken tooth bases, and an almost complete, fused frontal complex. In the Shendi Formation, Salih et al. [12] reported the first record of *Hyposaurus* sp. as a new Dyrosaurid crocodyliform genus. Their identification was based on an incomplete, but associated skull, comprising associated a partial mandible, posterior portion of the upper jaw, and a fused frontal complex. *Crocodylus sudani* g. nov. and sp. nov. was described by [14] from Late Pleistocene deposits of the Middle Atbara River in eastern Sudan. The fossil material is currently on loan to the Institut für Paläontologie, Free University of Berlin.

Dinosaurs first appeared during the Triassic Period, approximately 243 to 233.2 million years ago. According to [18,23], the Late Cretaceous of Sudan exhibits notable dinosaur diversity, with at least nine distinct taxa identified. The fossil material is currently housed in the collections of the Institut für Paläontologie, Free University of Berlin.

Class Reptilia: Laurenti, 1768

Order Testudines: Batsch, 1788

Turtle Chelonia was described by [4,5].

Trionyx sp. from Khartoum Hospital by [3].

Testudo hermanni from Esh Shaheinab by [3].

Testudo sp. from Esh Shaheinab by [3].

Marks et al. [6] from Late Pleistocene and Early Holocene in the Upper Atbara River Valley, revealed the following four testudians:

Kinixys belliana (Bell's eastern hinged tortoise)

Kinixys sp. (Hinged tortoise).

Pelusios sp. (Terrapin).

Cyclanorbis elegans (Cyclanorbine turtle).

From Al-Khiday [9] identified:

Trionychidae Indet.

Pelusios adansonii (Softshell turtle).

Geochelne pardalis (tortoise) from Wadi Howar by [7].

Klein et al. [8] described the following from Wadi Al Milk Formation (Upper Cretaceous) and Wadi Abu Hashim region in northern Sudan:

Pelomedusoid Indet.

Three Podocnemididae Indet.

Bothremydidae Indet

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Order Crocodilia: Owen, 1842

Crocodylia Dyrosauridae Indet.? *Crocodylus* (Dyrosauridae) by Bufferaut *et al*. [4]

Crocodiles Indet was described by [5].

Crocodylus niloticus, fossils were observed at Al-Khiday by [9], Ga'ab Allagia by [11], and from Sabaloka by [13].

Crocodylus sudani sp. nov., was described from Late Pleistocene deposits of the Middle Atbara River in eastern Sudan, by [14].

Crocodylus sp., were described by [3] from Khartoum Hospital and Esh Shaeinab fossils material deposited at the British Natural History Museum; and from Wadi Howar by [7].

Hyposaurus from the Late Cretaceous Shendi Formation, was defined by [12].

Crocodyliform Indet from the Late Cretaceous of Sudan was described by [10].

Order Squmata: Oppel, 1811

Family Varanidae:

Varanus niloticus by [9,13].

Varanus sp. from Late Pleistocene and Early Holocene in the Upper Atbara River Valley, was described by [6], and by [3] from Khartoum Hospital site.

Lacertilia Indet were recorded by [20] from the eastern bank of the 6th cataract.

Lizards Indet. from Sabaloka by [13] from the western bank of the 6th cataract.

Snake Indet was by [5], and from Al-Khiday by [9].

Rage & Werner [17] described a number of fossilized snakes from Wadi Abu Hashim. These are:

lapparentophiid-grade snake A.

lapparentophiid-grade snake B.

Madtsoiidae.

?Palaeophiidae (aquatic forms).

?Aniliidae.

Octopodidae *Coniophis dabiebus* gen. et. sp. nov., and *Coniophis* cf. *C. dabiebus*.

Nigerophiidae *Nubianophis afaahus* gen. et. sp. nov., *Nubianophis* cf. *N. afaahus* (aquatic forms).

Russellophiidae *Krebsophis thobanus* gen. et. sp. nov.

Colubroidea.

Other snakes described included:

Python sebae from Sabaloka by [13].

Order Dinosauria: Owen, 1842

All members of this order are Ex. Dinosaur assemblage from the upper Late Cretaceous of Sudan, is reflected by the occurrence of as shown by [18,23]:

Two *Titanosaurs* spp.

Sauropod Indet (gen. et., Titanosaurid?).

Charcharodontosaurs?

Hypsilophodontid Indet.

Ouranosaurus sp.

Iguanodontid Indet.

Dromaeosaurid Indet.

Theropod Indet.

Saurapoda Theropoda Titanosuridae described by [4].

Dinosaurs Indet by [5].

Aves study sites and findings

Avian fossil fragments from Khartoum Hospital excavations and Esh Shaheinab were reexamined by Peters [3]. Marks et al. [6] reported fossilized faunal remains, including avian elements from Late Pleistocene and Early Holocene in the Upper Atbara River Valley. Peters [19] also identified avian remains among the faunal assemblage from Shaqadud site. Additional avian fossils were recovered from the Al-Khiday locality by Dunne et al. [9] found bird fossils from Al-Khiday site. Fragments of *Struthio camelus* (ostrich) eggshells have been recorded from multiple sites in Sudan, including the Al Ga'ab Depression [11], west of the Sixth Cataract [13], Shaqadud [19], and east of the Sixth Cataract [20].

Class Aves: Linnaeus, 1758

Peters [3] recorded the following from Khartoum Hospital fossil collection:

Aves Indet 1.

From Esh Shaheinab he recorded:

The Helmeted Guinea Fowl (*Numida meleagris*).

Plectropterus gambensis.

Anatids Indet.

Buzzard Indet.

Vulture Indet.

Clapperton's Francolin (*Francolinus clappertoni*).

Crocodile Bird (*Pluvianus aegyptius*).

Bustard Indet.

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Bird of prey, Accipitridae Indet by [6].

Ostrich, *Struthio camelus* by [6].

Birds' fossils found at Shaqadud by [19] included:

Aves Indet (Birds).

Pelecanis sp. (Pelpcan).

Franclinus clappertoni (Clapperton's Francolin).

Nimidia meleagris (Helmeted Guinea Fowl).

Sterotoplia sp. (Dove).

Strigidae Indet (Owl).

Corvus sp. (Crow).

Dunne et al. [9] revealed the following from Al-Khiday:

Aves Indet.

Ciconiidae (Stork) Indet.

Anas crecca.

Anas platyrynchus.

Goose Indet.

Discussion

The early climatic history of Sudan was marked by alternating phases of environmental conditions, including episodes of extremely low temperatures, periods of relatively high humidity and warmth, intense rainfall, and subsequent aridification accompanied by the development of sand dune systems. These climatic fluctuations played a significant role in the extinction and preservation of various organisms, particularly in northern Sudanese regions such as Wadi Howar, Wadi Al Milk, Wadi Firja, Wadi Al Mogaddam, and Wadi Abu Hashim.

Research on the Cretaceous vertebrate assemblages of northern Sudan have been notably advanced through the efforts of numerous scholars [1,2,4,5,8,9,12,16,18,21,22]. Evans et al. [10] described a new Peirosaurid crocodyliform from the Upper Cretaceous Wadi Al Milk Formation. Dinosaur remains from the same formation and time period have been reported by Buffetaut et al. [4] and Klein et al. [18] Additional vertebrate material from both the Wadi Al Milk Formation and the Wadi Abu Hashim area was documented by [8].

Salih et al. [12] documented the first occurrence of *Hyposaurus* sp. a dyrosaurid crocodyliform, from the Late Cretaceous Shendi Formation. Both the Wadi Al Milk and Shendi Formations are notable for their rich vertebrate fossil records [5]. According to [18,23], these formations exhibit a remarkable dinosaur diversity. A Crocodyliform Indeterminate specimen from the Late Cretaceous of Sudan was described by [10].

The Wadi Al Milk Formation contains diverse faunal elements, including actinopterygians (ray-finned fishes), snakes, lissamphibians, turtles, crocodiles, and dinosaurs. These discoveries have significantly enriched the understanding of Late Cretaceous vertebrate assemblages in northeastern Africa and northern Gondwana [23]. Among the Cenomanian vertebrate assemblages from Wadi Al Milk is the genus *Kababisha* [2], marking the first sirenid found outside North America and the first fossil salamander genus identified in Africa [22].

New genera and new species

The study identified five new genera and six new species, including: gen. et sp. nov. (Titanosaurid?) [18,23], *Kababisha humarensis* gen. et sp. nov., *Kababisha sudanensis* gen. et sp. nov., *Coniophis dabiebus* gen. et sp. nov., *Nubianophis afaahus* gen. et sp. nov. (Nigerophiidae) and *Krebsophis thobanus* gen. et sp. nov. [17]. *Crocodylus sudani* gen. et sp. nov., was described by [14].

Thirty taxa were identified as Indet (), including 4 amphibians, 17 reptiles, and 9 birds.

a) Amphibian Indet:

Gymnophiona (Amphibia) Indet [1], *Anura* Indet [18], Frog Indet [1,13,21] and Caecilian Indet [1].

b) Reptilian Indet:

Varanus Indet [3,6]; *Chelonia* (turtle) Indet [4,5]; *Trionychidae* Indet [9]; *Pelomedusoid* Indet, Three *Podocnemididae* Indet and *Bothremydidae* Indet [8]; *Crocodyliform* Indet [10]; Crocodiles Indet [5]; *Crocodylia* (Dyrosauridae) Indet, possibly *Crocodylus* (Dyrosauridae) [4]; *Lacertilia* Indet [20]; Lizards Indet [13]; Snakes Indet [5,9]; Dinosaurs Indet [5], including *Hypsilophodontid*, *Iguanodontid*, *Dromaeosaurid*, and *Theropod* Indet [18,23].

c) Avian Indet:

Aves Indet [3,9,19]; Anatids Indet, Buzzard Indet, Vulture Indet, Bustard Indet [3]; *Accipitridae* Indet [6]; *Ciconiidae* (stork) Indet, Goose Indet [9] and *Strigidae* (owl) Indet [19].

d) cf. (to be compared with.

The following two taxa *Coniophis cf. C. dabiebus* and *Nubianophis cf. N. afaahus* (aquatic forms) [17] were assigned as "cf."

e) ?Questionable indentation:

Seven taxa had tentative identifications, including: ?*Crocodylus* (Dyrosauridae) [4], ?*Palaeophiidae*, ?*Aniliidae* [17], ?*Titanosaurid*, ?*Carcharodontosaurus* [18,23], and ?*Lapparentophiidae* (A and B forms) [16,17].

f) Extinct taxa:

Twelve taxa are extinct, including: *Kababisha humarensis*, *K. sudanensis*, [2], a fossil caecilian; [18,23], Crocodylia: *Hyposaurus* sp. [12] and *C. sudani* [14], and Dinosaur species [4],

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Hypsilophodontid, Iguanodontid, Dromaeosaurid, Theropod, Carcharodontosaurus, Ouranosaurus sp., and Titanosaurus spp. [18,23,24].

Extant fossil species

Twenty-five fossil species are extant in modern Sudan, including: An Amphibian: *Sclerophrys regularis.*

Fourteen Reptiles: *Trionyx* sp., *Testudo* sp., *T. hermanni*, *Kinixys* sp., *K. belliana*, *Pelusios* sp., *P. adansonii*, *Chamaeleo elegans*, *Geochelone pardalis*, *Crocodylus* sp., *C. niloticus*, *Varanus* sp., *V. niloticus*, *P. sebae.*

Ten Birds: *P. gambensis*, *F. clappertoni*, *P. aegyptius*, *S. camelus*, *Pelecanus* sp., *N. meleagris*, *Streptopelia* sp., *Corvus* sp., *A. crecca*, and *A. platyrhynchos.*

Conclusion and Recommendations

Wadi Howar, Wadi Al Milk, Wadi Abu Hashim, the Upper Atbara River Valley, Shaqadud, and Al-Khiday are rich archaeozoological sites that have yielded a substantial amount of material, classified into 93 taxa—excluding fish and mammals. Other promising sites, such as Wadi Firja, Wadi Al Mogaddam, Wadi Abu Dom, and the Khor Abu Habil fan, still await excavation.

It is now crucial to establish a National Archaeological Institute to license, supervise, and coordinate collaborative excavation efforts across the country. Additionally, efforts should be made to repatriate Sudanese fossil collections currently housed in institutions such as the British Natural History Museum and the Institut für Paläontologie at the Free University of Berlin, among others, to support the creation of a National Paleontological Museum.

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