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Fish diversity in Lake Nubia in relation to water level

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Abstract
Lake Nubia came into existence as a result of construction of Aswan High Dam which began in 1960 in Egypt. The important features which largely affected fish diversity in Lake Nubia were related to construction work of the dam and the gradual transformation of the water ecosystem from riverain to lacustrine condition. Some riverain fish species such as *Heterotis niloticus* and *Heterobranchus biodorsalis* and dwarf fish species such as *Garra dembeensis* (=vineinguerre), *Andersonia leptura* and *Eleotris nanus* disappeared from the lake. Disappearance was related to change in water level at pre-impoundment, during impoundment and impoundment phases of damming, water characteristics and fish behaviour. Significant correlation (p<0.05) was found between water level and fish species disappearance.

Keywords: Fish diversity, Lake Nubia, water level

Introduction
Lake Nubia is an artificial lake created in Northern State, Sudan due to construction of Aswan High Dam in Egypt. Construction work started in 1960; completion of phase 1 and beginning of reservoir filling was in 1964 and it was completed by1970. According to Bishai [1] the reservoir reached its capacity in 1976. Pre-impoundment (Mathiasson [2]; George [3]); during impoundment (Abu Gideiri and Ali [4]; Ali [5]) and impoundment studies indicated a progressive reduction in fish diversity in Lake Nubia. Impoundment was also associated with change in fish composition (Adam, [6]; Ali [7]). The gradual transformation of the water regime from riverain to lacustrine ecosystem is a common feature in man-made lakes (Jackson[8]; Bowmaker [9]; (Jackson and Rogers [10]) and is always associated during impoundment with fish mass mortalities resulting from oxygen depletion by bacterial action on the rotten flora (Jackson [8]). Another associated feature is diminishing or disappearance of some riverain fish species. Well documented examples are *Anguilla vulgaris* which was last reported from Sudan in 1918, after construction of the old Swan dam in 1902 which prevents the fish from ascending upstream (Pekkola [11]). Disappearance of *Labeo congoro*, and *L. altivelis* (Jackson [8]); *Micralestes acutidens* (Bowmaker [9]); *Opsaridium zambesense* (Jackson and Rogers [10]) from Kariba Lake and *Mormyrus* spp. from Kamburu Dam (Dadzie [12]) are additional examples. The objective of this work is to update the list of fish species of Lake Nubia and analyze causes of fish species disappearance from the lake.

2. Material and methods
Fish crafts operating at Lake Nubia are mostly iron boats fitted with an outboard diesel engine. It is operated by two to three fishers. Two fishing gears are operating during the fishing trip. Fishing gears used by fishers are the multifilament 'Um kubok' of 64x90cm mesh size followed by 'Rmai' of 6x12cm mesh size. Cast nets (2x10cm) and long line with 50 to 300 hooks are of limited use. Monofilament nets Trammel, Drift and Seine nest of mesh size 12x18, 6x10 and 2x4cm respectively comes next to Um kubok and Rami in usage. Fish specimens were examined from randomly selected fishing camps at Lake Nubia northern and southern fisheries (Fig. 1) and from the sole fish landing station at Wadi Halfa. Fish taxonomy and nomenclature followed (Bailey [13]). The data was supplemented by examining relevant literature.

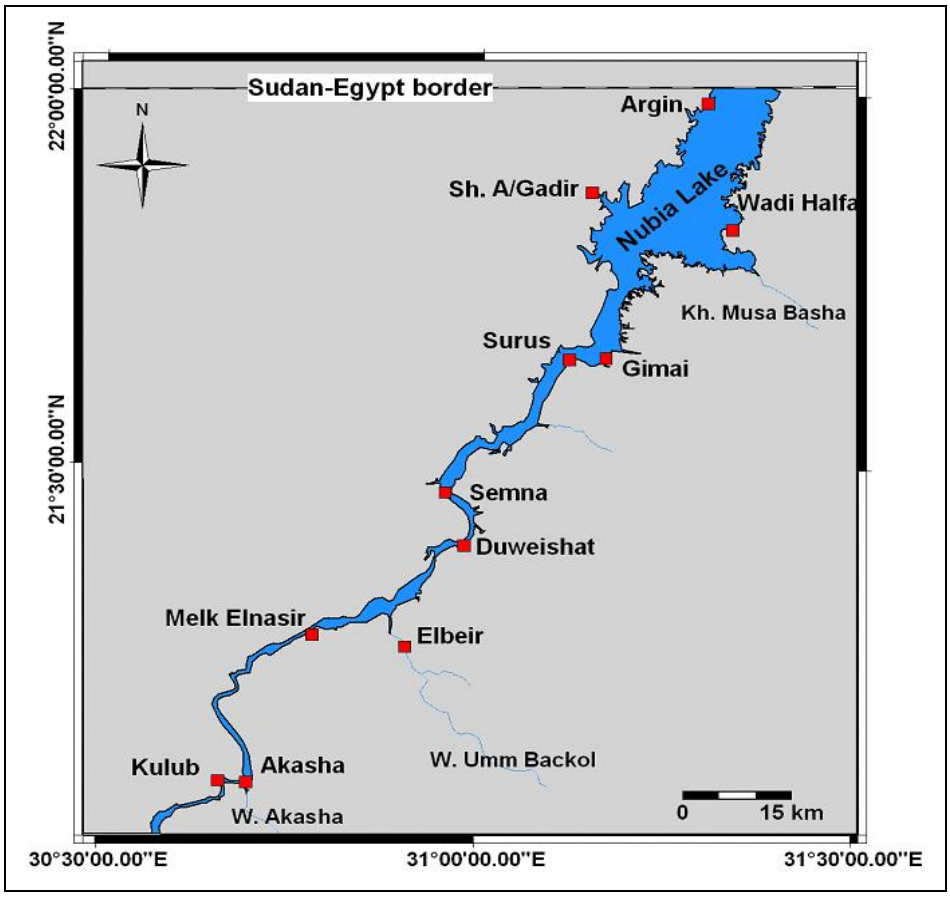

Fig 1: Fishing zones of Lake Nubia. Modified from Babiker *et al*., [14].

3. Results and discussion

3.1. Fish diversity

The list of fish species given in Table 1 indicated that over a period of 40 years, the fish families dropped from 17 to 12 and the fish species dropped from 42 to 34. The present finding revealed that Bagridae, Mormyridae and Alestiidae dominated the catch of fish species in Lake Nubia. The Cichlidae of the lake was represented by *O. niloticus, S. galilaeus* and *C. zilli*, while in the River Nile 10 cichlids were reported by (Witte *et al*., [15]). The fish species (Table 1) has a wide range of distribution in the Nile system (Abu Gideiri *et al*., [16]) with no known major natural threats except for man-made ones. This explains why the fish species given in Table 1 are registered in the Red List Category as Least Concern (ver 3.1) for eastern, northern, north eastern and western Africa. The fish species recorded by George [3], Abu Gideiri and Ali [4], Ali [5, 7] dates back to 1967/1968; 1971/1972; 1975/1976 and 1984-1987, respectively.

Table 1: List of the fish species of Lake Nubia (P= present, A= absent).

Scientific name	Local name	References*					Present Work
		1	2	3		4	
Family: Protopteridae							
Protopterus aethiopicus	Um Koro	P	A	A	A	A	A
Family: Polypteridae							
Polypterus bichir	Dabeeb Al Hout	P	A	A	A	A	A
Family: Arapaimidae							
Heterotis niloticus	Nok	P	A	A	A	A	A
Family: Mormyridae							
Hyperpisus bebe	Sawya	P	P	P	P	P	P
Marcusenius isidori	Gafadana	P	A	A	P	A	A
Moromyrops anguilloides	Taraza	P	P	P	P	P	P
Mormyrus caschive	Khashm el Banat	A	P	A	P	P	P
Mormyrus kannume	Khashm el Banat	P	P	P	P	P	P
Pterocephalus bane	Ras el Hagar	P	P	P	P	P	P
Family: Alestiidae							
Alestes baremoze	Kawara Baladi	P	P	P	P	P	P
Alestes dentex	Kawara Baladi	P	P	A	P	P	P
Brcinus nurse	Hemeela	P	P	P	P	P	P
Hydrocynus forskalii	Kass	P	P	P	P	P	P
Hydrocynus vittatus	Kass	P	A	A	P	P	P
Family: Distichodiidae							
Distichodus engycephalus	Kharsha	P	A	A	A	A	A

PDistichodus niloticus	Kharsha	P	P	P	P	P	P
PDistichodus rostratus	Kharsha	P	A	A	P	P	P
Family: Citharinidae							
Citharinus citharius	Bit Koya	P	P	P	P	A	A
Family: Cyprinidae							
Barbus bynni	Bynni	P	P	P	P	P	P
PPLabeo horie	Dabs	P	A	P	P	P	P
LaPbeo niloticus	Dabs	P	P	P	P	P	P
Labeo coubie	Kadan	P	P	P	P	A	A
Family: Bagridae							
Auchenoglanis biscutatus	Homar el Hout	P	A	A	P	P	P
Auchenoglanis occidentalis	Homar el Hout	P	A	P	P	P	P
Bagrus bajad	Bajad	P	P	P	P	P	P
Bagrus docmak	Kabarous	P	P	P	P	P	P
Chrysichthys auratus	Abo Reyala	P	P	P	P	P	P
Clarotes laticeps	Bamseeka	P	A	A	P	P	P
Family: Gmnarchidae							
Gymnarchus niloticus	Weer	P	A	A	A	A	A
Family: Schilbeidae							
Schilbe mystus	Schilbaya	P	P	A	P	P	P
Schilbe uranoscopus	Schilbaya	P	P	P	P	P	P
Eutropius niloticus	Schilbaya Arabi	P	P	P	P	P	P
Family: Clariidae							
Clarias anguillaris	Garmout	P	P	A	P	P	P
Clarias lazera	Garmout	P	P	P	P	P	P
Heterobranchus biodorsalis	Surta	P	A	A	A	A	A
Family: Malapteruridae							
Malapterurus electricus	Barada	P	A	A	P	P	P
Family: Mochokidae							
Synodontis batensoda	Gargour	P	P	A	P	P	P
Synodontis khartoumensis	Gargour	P	A	A	A	A	A
Synodontis schall	Gargour	P	P	P	P	P	P
Synodontis serratus	Gargour	P	P	P	P	P	P
Family: Latidae							
Lates niloticus	Igjl	P	P	P	P	P	P
Family: Cichlidae							
Oreochromis niloticus	Bulti	P	P	P	P	P	P
Sarotherodon galilaeus	Bulti	A	P	P	P	P	P
Coptodon zilli	Bulti	A	A	A	A	P	P
Family: Tetraodontidae							
Tetraodon lineatus	Tambera	P	P	A	P	P	A

* 1=George [3], 2=Abu Gideiri and Ali [4], 3=Ali [5], 4=Ali [7].

3.2. Causes of fish disappearance

Causes of disappearance are several and interrelated. They will be discussed under water flow, water characteristics and fish behaviour.

3.2.1. Water flow

In man-made Lakes the normal scenario is gradual change from riverain to a lacustrine and finally a typical lake condition. This typical lake condition is far beyond attainment in Lake Nubia and contributed to disappearance of some fish species. For example, the following dwarf fish species *Chelaethiops bibie* and *Garra dembeensis* (Family: Cypriniidae), *Andersonia leptura* (Family: Mochocidae), *Aplocheichtys kingi* (Family: Cyprinodotidae) and *Eleotris nanus* (Family Eleotridae) reported by Mathiasson [2] during the pre-impoundment phase were not encountered during later studies.

Heterotis niloticus, *P. aethiopicus*, *S. khartoumensis*, *D. engycephalus*, *G. niloticus*, *Polypterus* sp., and the fast running water inhabitant *H. bidorsalis* were not recorded since 1968. *Marcusenius isidori* and *C. citharius* reported by Ali [7] were not encountered during this survey. *Disticchodus rostratus*, *A. occidentalis*, *A. biscutatus* and *M. electricus* became extremely rare (Fisheries Department Wadi Halfa, personal communications). The disappearance (Table 2) is inseparable from the fact that the Lake Nubia is a reservoir, the water level of which can vary depending on the annual flood, water storage and/or release policy from Lake Nasser in Egypt. Lake Nasser entertains high transparency, high primary productivity and consequently high fish diversity compared with Lake Nubia El-Shabrawy [17]. The present study recorded *C. zilli* for the first time in Lake Nubia (Fig. 2).

Fig 2: *Coptodon zilli* in back water at Gimai

Table 2: Fish species disappearance from Lake Nubia during the past 51 years.

Date of data	Reference	No. of disappeared fish	Water level
1964	Mathiasson [2]	0	128.26 m
1967 – 1968	George [3]	5	151.16 m
1971 – 1972	Abu Gideiri and Ali [4]	18	173.76 m
1975 – 1976	Ali [5]	22	170.60 m
1984 – 1987	Ali [7]	10	162.61 m
2015	Present work	13	178.06 m

Correlation coefficient (r=0.858 at DF=4) between fish disappearance and water level (Table 2) was significant (p<0.05). The disappearance of fish species (X) or water Level (Y) at any year can be predicted from the equation:

$$Y = 138.607 + 1.953X$$

Abu Gideiri and Ali [4] reported that Lake Nubia is undergoing a continuous change from a lacustrine condition in the South to a typical lake condition in the middle and northern parts. Fifteen years later (Ali [17] stated that Lake Nubia has not attained stable condition as a lacustrine lake due to interruption of filling related to natural discharge and drought cycles. According to El-Shabrawy [18] in 2005 the water level dropped from 180m to 178.06 m. Such drops negatively impact the breeding grounds of at least tilapias and *Schilbe* spp. due to loss of shallow Khor habitat (Figs. 3 and 4).

The Grand Ethiopian Renaissance Dam (GERD) is expected to affect Lake Nubia morphology by holding back in its reservoir a tremendous amount of sediments except wash load which will be kept in suspension. In addition, continuous water release from GERD for the purpose of power generation may lead to suspension of attainment of typical lacustrine condition in Lake Nubia. Thus changes in fish biodiversity favouring riverain species is to be anticipated probably from Semna upstream Lake Nubia. It worth mentioning that the highest coefficient of similarity index (89%) in fish species was between Lake Nubia and Blue Nile (Table 3) compared with the main Nile and the White Nile (Abu Gideiri *et al*., [16]).

Table 3: Coefficient of similarity index between some major water bodies

Location	White Nile	Main Nile	Lake Nubia	Blue Nile
White Nile	-	0.69	0.60	0.53
Main Nile	0.69	-	0.85	0.76
Lake Nubia	0.60	0.85	-	0.89
Blue Nile	0.53	0.76	0.89	-

3.2.2. Water characteristics

Two aspects (transparency and dissolved oxygen) were of paramount importance.

The Nile builti (*O.* niloticus, *S. galilaeus* and *C. zilli*). The Nile builti and Schilbe spp. were found in huge amounts in shallow and protected waters with sandy bottoms especially in khors where the conditions are optimal for phytoplankton and zooplankton growth as stated by Adam [6]. This is in agreement with El-Shabrawy [18] who stated that many riverain members of the fish and tilapias in particular, prefer the still-water pools, probably due to its high water transparency and richness in dissolved oxygen. Water transparency of 11 cm in Sarra and Wadi Halfa, 10 cm in Melk Elnassir and 7 cm in Duweishat and Akasha were recorded by El-Shabrawy [18]. The depth of Lake Nubia is between 30 to 40 m on the average (Adam [6]). The dissolved oxygen is lacking below 17-18 m in Wadi Halfa, Geimi and Duweishat a condition unfavourable for bottom dwellers. This explains why molluscs eating species such *H. bebe*, *C. laticeps*, *M. electricus* and *T. lineatus* are found in few numbers in Lake Nubia.

3.2.3. Behavioural reasons

Migratory movement (Pekkola [11]; Pot [19]) are prevented by dams with no fish ladders like the Old Swan Dam. *Anguilla vulgaris* was last reported from Sudan in 1918, after construction of the Old Swan Dam in 1902 (Pekkola[11]. Breeding movements, are inhibited because the spawning and nursery areas are destructed by the rising and dropping of water level (Welcomme [20]; Zhong, and Power [21]). The riverain fish spp. such as *H. niloticus* and *H. biodoprsali* failed to survive in lacustrine waters of Lake Nubia. The peripheries of the lake in most of its parts are sandy (Fig. 3) or rocky islands (Fig. 4) devoted from mud a condition led to disappearance of mud-feeder fish species such as *H. niloticus*.

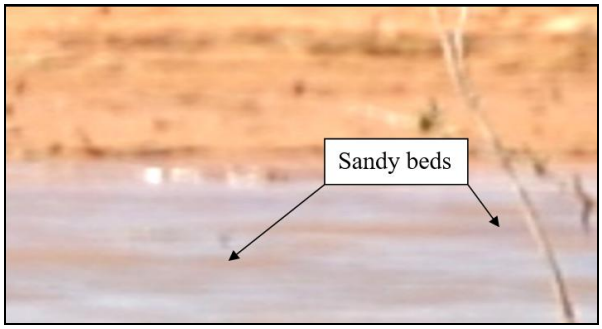

Fig 3: Typical sandy shore with sandy beds in Lake Nubia.

Fig 4: One of the numerous small islands, which were once hilltops

Pöllath *et al.*, [22] reported that Arapaimidae (Order Osteoglossiformes) Channidae (Order Perciformes) reported in the Nile North of Khartoum during Holocene were not encountered in recent times.

Conclusions

It follows from the above that there is a need to conduct a long-term study using traditional gears and modern electric fishing methods in order to update fish distribution map to latter assess the impact of TGERD on fish diversity in Lake Nubia.

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