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Review

A Review of Parasites of Freshwater Fishes of the Sudan from 1902 to 2020

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Abstract

Background

This review was conducted from 1996 to 2020 aiming to compile the findings of parasites of freshwater fishes of Sudan in a single document.

Methods

The present review was based on 105 scientific paper, 3 conferences abstracts, 3 graduation dissertation, 7 master and 2 Ph.D. theses, one unpublished reports, 10 books, and one technical report. The work covered the period from 1902 to 2020.

Results

Some thousands of freshwater fish specimens were examined for their ecto-parasites and/or endo-parasites. Fifty-eight fish species were reported infected and 162 parasitic species including 32 new species were collected. The parasites found were three bacterial and three fungal species collected from *Oreochromis niloticus*. From 10 species of fish, 19 protozoans were described. From 10 species of fish, 22 Monogenean species were found including 7 new species. One new Aspidogastrean species was collected from *Labeobarbus bynni*. From 29 fish species 23 Digenean species were collected including five new ones. From 41 species of fish, 44 species of cestodes parasites were collected including 11 species new to science. Twenty parasitic Nematodes species including seven new ones were collected from 32 fish species. From 12 fish species 9 Crustacean were described. Nine Acanthocephalans including one new species from *Ichthyborus besse* were collected from 11 fish species. Co-infection was observed.

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***Conclusions*:**

The collected parasites included 31 new species to science. One new subfamily Sandonellinae from *Heterotis niloticus* was erected; and 10 new genera, *Brevicaecum*, *Sandonia*, *Afromacroderoides* (Digenea); *Wenyonia*, *Sandonella*, *Amirthalingamia*, *Barsonella lafoni* (Cestoda) and *Dichelyne*, *Nilonema*, (Nematoda) were described. Revision of parasitic species designated as *CithariniellaTrypanosoma* type 1, 2, 3; *Dactylogyrus* species type 1, 2, 3, 4, 5; *Dogielius* sp. 1;*Amplicaecum* type 1 and *Amplicaecum* type 2; *Contracaecum* sp. Third stage-larvae Type 2; Procamallanustype 1, 2, 3 and those parasites identified to the genus level should be given due attention. Some recommendations for further research were offered.

Keywords: Freshwater fishes, Parasites, Sudan, Sandonellinae, *Heterotis niloticus.*

Introduction

Parasitism is a biological phenomenon caused by parasites at various levels in the food chain in any ecosystem. It is a life strategy for several forms of biota. Parasites range in size from microscopic forms to macroscopic ones. Examples are *Trypanosoma mukasai*in the blood of *O. niloticus* [1] and the ectoparasitic sea lampreys *Petromyzon marinus* on the minke whales *Balaenoptera acutorostrata* [2, 3], beside fishes, whales, dugong and sea turtles. This ecto-parasite is large enough to be seen by the naked eyes from several meters.

A fundamental feature associated with parasitism in fishes is the negative impact cost by some parasite on its host affecting behavioral response in some cases. This cost included but not limited to loss of blood, intestinal fluid and of energy in defensive mechanisms against the parasites. Irritability, attracting secondary infection to establish, skin necrosis and anemia are also associated with parasitism. Some parasites act as a blood sucking ecto-parasites (*Mothocya belonae* an isopod parasite of the marine garfish *Belone* [4]. Parasites can deprive the host from sizable quantities of intestinal fluids as reported by [5, 6] in *Clarias gariepinus* infected bythe intestinecestodes *Polyunchobothrium polypteri* Leydig, 1853. According to [7] anemia in goldfish *Carassius auratus* is the resultant of infection with *Trypanosoma danilewskyi.* Parasitism was reported by [8] to affect courtship dance in the three spine sticklebacks (*Gasterosteus aculeatus*).

Fishes (Class: Pisces)are indeed superior in number of individuals and species to other vertebrates. Probably more than 25,000 different species of fish are extant and many new forms are discovered every year [9]. Parasites wise, new fish species are usually followed by new species or new fish hosts or new parasite localities records. In the River Nile and its tributaries in Sudan there are about 123 fish species belong to 22 families [10], but only about 50 of these fish species are of economic importance and are recognized as a source of animal protein [11]. In the aquatic environment the fish is subjected to viruses, fungi, bacteria, protozoa, helminthes, crustacean, and acanthocephalan some of which are potentially infectious. Fish diseases and parasites are detrimental for proper utilization of some of these valuable food resources. Studies of captive freshwater fishes have provided much information about fish parasites [5] and diseases [6]. Fish parasites and hence diseases are being understood as longtime factors, and various methods are being probed to control them especially when fish are kept in confinements such as fish ponds or aquaria. The first step is always the proper isolation, identification and description of existing parasites [12]. In Sudan studies on freshwater fish parasites probably dates back to the pioneer work of Jagerskiold and his collaborators in 1902). According to [5] helminthes are very common in freshwater fishes of Sudan and cause few lesions by the intestinal ones.

Although the history of parasitological studies on freshwater fishes' dates back to 1902, the fauna of these parasites in Sudan is still little known. Khalil from 1960 to 1997 published 18 papers on helminthes parasites from freshwater fishes and described seven species new to science and made 30 new records to the Sudan. Khalil [13] reported 15 species of adult digenetic trematodes, three species of larval trematodes, 16 species of adult cestodes, 13 species of adult nematodes, two species of larval nematodes and three species of acanthocephalans. Four species of adults and four species of larval worms are recorded

for the first time in the Sudan and 30 new hosts were listed by [13].

In his update of parasites, infections and diseases of fishes in Africa [14] repeatedly referred to Khalil's work. The checklists on fish parasites in Africa produced by [15, 16] were criticized by [17] on basis of being out of date and do not provide reliable information on the current state of species diversity of these fish parasites. A monogenean *Macrogyrodactylus polypteri* was described by [5, 18, 19, 20, 21] from *Polypterus* sp. To the parasites of freshwater fish of Sudan, [22, 23, 24] added 19 monogenean species including six new to science and six under evaluation for their taxonomic status.

It is unfortunate that the theses of [1, 5, 25, 26, 27] were not published and are looked upon as grey research, despite the useful information therein about parasites of freshwater fishes of Sudan.

Objectives

This article used the existing literature to create a new knowledge. The objective of this literature review is to compile the available information about parasites of freshwater fishes of Sudan embodied in dissertations, thesis, books, conferences abstracts and scientific articles in a single document. Fish parasites, the fish species infected the infected organs or tissues and the references were given in appropriate tables. This review which is by no means complete covered the period from 1902 to 2020. It is hoped that

Table 1. New parasitic species recorded from freshwater fishes of Sudan (* new genus)		
Taxon	Fish (type) host	Author(s)_
Monogenia		
Afrogyrodactylus *girgifae*	*Brycinus* [*Alestes*] *nurse*	[30]#
Quadriacanthus fornicates	*Clarias gariepinus*[*lazera*]	[22]#
Quadriacanthus pravus	*Clarias gariepinus*	[22]#
Quadriacanthus zuheiri	*Clarias gariepinus*	[22]#
Quadriacanthus mandibulatus	*Heterobranchus bidorsalis*	[22]#
Dogielius sennarensis	*Labeo niloticus*	[23]#
Characidotrema pollex	*Brycinus nurse*	[24]#
Aspidogastrea		
Allocreadium sudanensis	*Labeobarbus* [*Barbus*] *bynni*	[31]
Digenea		
Aspidogaster africanus	*Labeobarbus bynni*	[32]
*Brevicaecum niloticum**	*Citharinus citharus*	[33]
*Sandonia sudanensis**	*Synodontis schall*	[33]
Orientocreadium lazeri	*Clarias gariepinus*	[34]
*Afromacroderoides lazerae**	*Clarias gariepinus*	[35]
Cestoda		
*Wenyonia virilis**	*Synodontis schall*	[37]
Wenyonia minuta	*Chrysichthys auratus*	[37]
Wenyonia accuminuta	*Synodontis membranaceaus*	[38]
Proteocephalus synodontis	*Synodontis schall*	[37]
Proteocephalus sandoni	*Heterotis niloticus*	[39]
Lytocestus alesstesi	*Alestes* sp.	[40]
*Sandonella sandoni**	*Heterotis niloticus*	[41]
Bothriocephalus prudhoei	*Clarias anguillaris*	[42]
Ichthybothrium ichthybori	*Ichthyborus besse*	[15]
Amirthalingamia macracantha	*Oreochromis niloticus*	[43]
*Barsonella lafoni**	*Clarias gariepinus*	[44]#
Nematoda		
*Dichelyne fossor**	*Lates niloticus*	[29]
*Nilonema gymnarchi**	*Gymnarchus niloticus*	[45]
Raphidascaroides bishaii	*Gymnarchus niloticus*	[46]
Falcaustra hexapapillata	***Distichodus nefasch***	[47]
*Chathariniella citharini**	*Citharinus citharus*	[48]
Cucullanus mormyri	*Mormyrus caschive*	[17]#
Procamallanus pseudospiralis.	*Synodontis schall*	[17]#
Acanthocephala		
Neochinorhynchus ichthyobori	*Ichthyborus besse*	[49]

researchers in fish parasites and their related pathology find this article of relevance and useful in formulating future research projects.

Desk Work

The present review was based on 105 scientific papers, 3 conferences abstracts, 3

graduation dissertations, 7 masters and 2 Ph.D. thesis, one unpublished reports, 10 books, and one technical report. The systematic of these parasites is based on some electronic sites and some taxonomic papers. The names of fish hosts recorded were those provided in FishBase as valid names [28]. Generic/species names used in the original description are retained in square brackets as synonyms when first mentioned

A Quick Glimpse

Perhaps the first authenticated work on parasites fr.om freshwater fishes in the Sudan was that of the Swedish Zoological Expedition to Egypt and the White Nile from1901 to 1910, which was led by Prof. Jagerskiold. The parasites collected, some of which were prototypes, were deposited at the Department of Zoology, Uppsala University. A new genus was erected and a new nematode species (*Dichelyne fossor* Jagerskiold, 1902) was described from the intestine of *lates niloticus* from the White Nile by [29]. Since then one new subfamily Sandonellinae and several new genera and species were recorded form freshwater fishes of the Sudan. Significant contribution was made by Lotfi Fakhori Kahlil (1960-1979). Tomas Scholz (Institute of Parasitology CAS CR, Czech Republic) and Alain de Chambrier (Natural History Museum, Geneva, Switzerland) in (2006-2008) in collaboration with Zuheir N. Mahmoud made an extensive field surveys. The survey is part of a project aimed at revising the morphology and verifying the taxonomic status of poorly known African Cestodes of the orders Proteocephalidea, Caryophyllidea and Pseudophyllidea, and other helminthes parasites of freshwater fish, as a prerequisite for phylogenetic studies on the evolution of these parasites and their fish hosts. The interesting findings encouraged the collaboration of the Institute of Parasitology, Biology Centre of the CAS, the Department of Botany and Zoology, Faculty of Science, Masaryk University, Czech Republic and Sudan Institute of Natural Sciences to carry out more field work in Sudan. This fruitful collaboration led to description of one new genus and 10 new parasitic species to Science. These were indicated by[#] after the author(s) in Table 1.

Findings and Discussion

Parasitic bacteria

Bacterial infection may cause heavy losses of fish from natural water bodies or species reared in ponds. The first to study bacteria of freshwater fishes of the Sudan was [25] who revealed the presence of *Bacillus* sp. and *Diplococcus* sp. from the blood of *O. niloticus*. It was not made clear by [25] whether these are due to secondary infection or not? In many cases fish injuries act as a pathway facilitating viral and/or bacterial infections.Bacterial infection usually induces morphological and physiological changes in fish. *Aeromonas hydrophile* infecting the mouth of *O. niloticus* and

causing fin deformity were reported from several specimens collected from Al Azozab White Nile by [50].

Parasitic fungi

Fungi are associated with injuries causing diseases of freshwater fishes [51]. Infection of fish skin by fungi is manifested by appearance of cotton wool cover over the epidermis damaging it as it spreads causing extensive necrosis [52]. Body injuries in fish facilitates invasion by integument parasitic fungal species. *Soprolegnia* sp., *Achlya* sp. and *Aureobasidium* sp., *w*ere collected from the skin and mouth of *O. niloticus*by [25]. The fungus *Aureobasidium* sp., was reported for the first time as a fish pathogen in Sudan by [25]. According to [25] whenever fungal infections were found in *O. niloticus*, myxosporeans were also detected. The relationship between the natural seasonal occurrence of *Saprolegnia* sp.in the freshwater and the periodicity of the fungal infections recorded on *O. niloticus* was demonstrated by [25].

Parasitic protozoa

According to [12] the internal protozoan parasites, like Myxosporidions a serious internal fish pathogen, stuck in the fish tissue and either kill the host or persist for long periods of time deteriorating fish health and quality. Protozoan parasites have attracted the attention of various researchers. Paperna [14] wrote "in 1841 what was either a Trypanosome or probably a *Trypanopolasm* species was recorded by Valentin from the blood of the trout *Salmo fario*". He added in the following year "1842" Remok found what seemed definitely to have been a Trypanosome in the blood of the pike (*Esox* sp.). Since then a long list of findings in various parts of the world were published in periodicals or incorporated in theses and/or technical reports. Some of these were new to science. According to [53] a total of 153 species of trypanosomes have been described from freshwater and marine fishes. In addition, 33 unnamed records from various fish hosts exist. According to [14] about ten forms of trypanosomes were reported from fish in Africa, out of which five or six were accepted as valid species. In Sudan only two species were found (*T. mukasai* from *O. niloticus* and *Trypanosoma alhusaini* from *Clarias gariepinus*) and the rest were designated cautiously by investigators as *Trypanosoma* Type 1, *Trypanosoma* Type 2, or *Trypanosoma* sp.

Protozoan fish relationship may be of no relation, commensalism or parasitism. In fish hatcheries and field situations some infections of the fish by protozoan are recognized as normal and pose no health and/or economic problem. Protozoan ecto-parasites such as *Costia* spp. and *Trichodina* spp. are among the genera which may infect fish causing suffering, death in fish populations and consequently serious economic losses if it happened in fish ponds. According to [12] epidermal tissue destruction caused by protozoan usually attracts viral, bacterial and fungal infections. Very little work on protozoa of Sudanese freshwater fishes had been done compared with the work done in the region. Three categories of protozoan's: trypanosomes, myxosporeans and ciliates were reported. According to [26] impression smears of liver and spleen revealed the presence of *Myxobolus* sp. Bütschli, 1882 and *M. heterospora* Baker, 1963; in 2% of the studied fishes. Investigations of body cavity and viscera revealed that 72% of fishes were infected with one or both parasites [26].

Fish trypanosomes are more than 190 species [54]. The first report of fish trypanosomes from Sudan was due to [55] who noted the presence of a *Trypanosoma* sp. in the blood of *S.* [*Lynodontis*] *schall*, *Bagrus bajad* [*bayad*] and *Mugil* species but

gave no description of the parasite. *Trypanosoma* spp. in the blood of *Mugil* sp., *B. bayad*, *S. schall*, *Chrysichthys auratus* [*auratii*], *Coptodon* [*Tilapia*] *zillii*, *Clarias anguillarias* and *Polypterus* sp. from the Nile in Sudan was found by [56]. It is likely that *Mugil* sp. is a misidentified cyprinid species, as *Mugil* sp. has never been recorded among freshwater fishes of Sudan [57, 58]. Four protozoan species were reported from *O. niloticus* and *Sartherodon galilaeus* [*Tilapia galilaea*] fishes in the Sudan (Table 4) by [1]. Those were *Trypanosoma mukasi* Hoare, 1932, *Myxosoma heterospora* Baker, 1963, *Myxosoma brachyspora* Baker, 1963 and a *Myxosoma* identified to the genus level. The host-parasites relationship for *O. niloticus* and *S. galilaeus* was investigated by [1]. This trait was improved by rigorous statistical analysis carried by [5, 26]. *Trypanosoma alhusaini* Mohamed, 1978 from *C. gariepinus* and a *Trypanosoma* sp. from *Polypterus senegalus* and *S. schall* were reported by [5]. The occurrence of *T. alhusaini* was reported only by [5]. Unfortunately, the extensive measurements on trypanosomes from *P. senegalus* and *S. schall* were not compared to find out whether there is specific variation? Or whether there are one or more forms of the *Trypanosom* sp? The presence of *T. mukasi* in *O. niloticus* was confirmed by [25, 51]. Based on multiple regressions analysis of six measured characters against total body length excluding the free flagellum, three distinct length groups of trypanosomes were found by [25]. These were *T. mukasi* (27.21±4.09), *Trypanosoma* Type 1 (46.55±3.59) and *Trypanosoma* Type 2 (59.71±2.64). The clear cut differences in length made this grouping valid and of relevance in any comparative study of blood trypanosomes of fishes. The advancement in molecular biology and sequencing can determine the validity of this designation as Type 1 or Type 2 and even defining the species. According to [59] isoenzymes and molecular sequencing are useful in resolving the confusion regarding the synonymy of species and naming the valid species.

A total of seven Myxosporean parasites (*Myxosoma heterospora*, *Myxosoma brachyspora*, *Myxosoma equatoriali*, *Myxosoma sarigi*, *Myxobolus agolus*, *Myxobolus galilaeus* and *Myxobolus* sp.) were recorded by [1, 5, 25, 26] from *O. niloticus*, *S. galilaeus* and *C. gariepinus* (Table 2). All these were reported as first record to Sudan. Shamat [25] produced transmission and scanning electron photomicrographs for the studies Myxosporean species and based the identification on similarities and differences in spore size, 11 morphological measurements and site of infection.

The ecto-parasitic ciliate *Trichodina* sp. from *O. niloticus* was reported by [1, 51]. *Trichodina heterodentata* Duncan, 1977 were collected from the skin and gill lamellae of *O. niloticus* by [25].

Most of the fish specimens examined for their protozoa were collected from the White Nile and fish ponds in Khartoum. No attempts were made to quantify the prevalence rates in infected fish species. *Trypanosoma* species are transmitted to fish through a blood-sucking vector, usually a species of leech, but isopod crustaceans can also be potential vectors of Trypanosomiasis in fish. This needs further investigation. The Apicomplexa, *Cyrilia nili* [syn. *Haemogregarina nili*, Wenyon, 1909] infect fresh water fish and are transmitted by the African fish leech Batracobdelloides tricarinata Blanchard, 1897, [14] it was found in blood smear of *Parachanna obscura*.

The detection of these vectors attacking freshwater fish in Sudan should be given due attention as trypanosomes were found in a number of fish species including *O.*

niloticus, S. galilaeus, C. zillii, C. gariepinus, B. bajad, C. auratus and *Polypterus* sp., see Table 2.

Table 2. Protozoa parasites of freshwater fishes from Sudan

Parasites	*Infected organ / tissue*	*References*
Parachanna obscura		
Cyrilia nili Wenyon, 1909	*Blood*	*[60]*
Oreochromis niloticus		
Trypanosoma mukasai Hoare, 1932	*Blood*	*[1, 25, 51, 61, 62]*
Trypanosoma type 1	*Blood*	*[25]*
Trypanosoma type 2	*Blood*	*[25]*
Myxosoma heterospora Baker, 1963	*Hepatopancreas, brain, heart*	*[1, 25, 51, 61]*
Myxosoma brachyspora Baker, 1963	*Hepatopancreas, brain, heart, spleen*	*[1, 25, 26]*
Myxosoma sarigi Landsberg, 1985	*Hepatopancreas, brain, heart*	*[1, 25]*
Myxosoma equatorialis Landsberg, 1985	*Hepatopancreas, brain, heart*	*[1, 25]*
Myxobolus agolus Landsberg,1985	*Hepatopancreas, brain, heart*	*[25]*
Myxobolus galilaeus Landsberg, 1985	*Hepatopancreas, brain, heart*	*[25]*
Myxobolus sp. Bütschli, 1882	*Hepatopancreas, brain, heart, liver, kidney, ovaries*	*[1, 25, 54]*
Cryptobia sp. Leidy, 1856	*Liver*	*[61, 62]*
Trichodina heterodentata Duncan, 1977	*Skin and gill lamellae*	*[25, 61]*
Myxospora sp. Butschli, 1882	*Gill lamellae*	*[50]*
Trichodina sp. Ehrenberg, 1831	*Skin and gill lamellae*	*[1]*
Sartherodon galilaeus		
Trypanosoma sp. Gruby, 1843	*Blood*	*[55]*
Trypanosoma mukasai Hoare, 1932	*Blood*	*[1]*
Myxosoma heterospora Baker, 1963	*Hepatopancreas*	*[36]*
Myxosoma brachyspora Baker, 1963.	*Hepatopancreas*	*[36]*
Myxosoma sp. Thélohan, 1892	*Hepatopancreas*	*[36]*
Coptodon zillii		
Trypanosoma sp. Gruby, 1843	*Blood*	*[55]*
Clarias gariepinus		
Trypanosoma alhusaini Mohamed, 1978	*Blood*	*[5]*
Myxosoma sp. Bykhovskaya-Pavlouskaya, 1964	*Hepatopancreas*	*[5]*
Trypanosoma sp. Gruby, 1843	*Blood, Liver*	*[62]*
Haemogregarine sp. Danilewsky, 1885	*Blood*	*[62]*
Myxobolus sp. Bütschli, 1882.	*Liver, kidney, ovaries*	*[26, 54]*
Synodontis schall		
Trypanosoma sp. Gruby, 1843	*Blood*	*[5, 55, 56]*
	Liver	*[26]*
Labeobrabus bynni		
Myxosoma heterospora Baker, 1963	*Spleen*	*[26]*
Bagrus bajad		

Trypanosoma sp. Gruby, 1843	*Blood*	*[55]*
Chrysichthys auratus		
Trypanosoma sp. Gruby, 1843	*Blood*	*[55]*
Polypterus sp.		
Trypanosoma sp. Gruby, 1843	*Blood*	*[55]*

Parasitic Trematoda

The knowledge of trematode fauna remains highly incomplete [63, 64]. Current estimates of trematode species in African freshwater fishes revealed the presence of 66 species (based on adults) allocated in 33 genera of 20 families reported from 59 freshwater fish species [64].

The earliest study on trematodes of freshwater fishes of the Sudan was probably the historic work of the Swedish Zoological Expedition to Egypt and the White Nile from 1901 to 1910. Odhner, a member of the expedition, in 1902 described two digeneans (*Callodistomum diaphanmun*)from *Polypterns senegalus* and *Cheloptes ovofractas* from *S. schal.* His work was published nine years later by [65] Table 3. The majority of African Monogenea species are ecto-parasites found on gill lamellae, skin and fins, and rarely in mouth cavity and nostrils; a few species are endo-parasitic in foregut, stomach and urinary bladder [24, 60].

Macrogyrodactylus polypteri Malmberg, 1957 is a viviparous monogenetic described from the skin of *C. citharinus* and from gill lamellae of *P. senegalus* by [18, 19] and from the skin and fins of *P. senegalus* by [5, 20,21]. *Macrogyrodactylus polypteri* was also described from *Polypterus bichir* by [21]. According to [19] *M. polypteri*, which is likely confined to African fishes, feeds on epidermal cells and mucous when young and upon the blood of its host, at least in part, when adult. A detailed description of its life cycle was given by [19]. To the physiology, biology and morphology of *M. polypteri* [5] made very useful contribution and reported that heavy parasitaemia by *M. polypteri* causes anemia in *P. senegalus* as well as significant drop in the level of Hb, PCV, RBC, WBC, total protein, albumen, globulin and glucose levels. The chemical investigation of the gut contents of *M. polypteri* carried out by [5] established a blood feeding habit for this parasite. According to [5] warm water is the best medium for induction of birth of *M. polypteri*. The ultra-structure of *M. polypteri* was revealed by using scanning electron microscopy by [5]. *Allocreadium sudanensis* sp. nov., was described and compared with five African species of the genus *Allocreadium* and produced a key for their identification by [31]. *Allocreadium sudanensis* is the first member of Subclass Aspidogastrea to be collected from freshwater fishes of Sudan.

A systematic survey of the monogeneans parasitizing freshwater fishes in Africa was carried by ichthyo-parasiologist of the Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, Czech Republic [66]. Their taxonomic evaluation of the monogeneans found was based on macro and ultra-structural, molecular and phylogeny studies. Their collection resulted in a catalogue of 482 monogenean species parasitizing African freshwater fishes [66]. *Afrogyrodactylus girgifae* sp. n. was described from the fins of *Brycinus nurse* (type host) from Sinnar (type locality), Blue Nile, Sudan by [30].The specific name is derived from ‘girgifa’, common name for *B.nurse* in Nubian, old Sudanese. Significant addition to the monogenean of Sudan was made by [22, 23, 24] who described six new monogeneans species to science from Sudan and several locality records of monogenea to Sudan.

Seven *Quadriacanthus* species from the gill lamellae of three catfishes for the first time in Sudan. These were *Q. aegypticus*, *Q. clariadis*, *Quadriacanthus fornicatus* n. sp., *Quadriacanthus pravus* n. sp., and *Quadriacanthus zuheiri* n. sp. from *Clarias gariepinus* (type host); *Quadriacanthus mandibulatus* n. sp. from *Heterobranchus bidorsalis* (type host); and *Q. bagrae* from *Bagrus docmak* (type host) were described by [22]. In addition, they made taxonomic evaluation of the monogeneans found on basis of morphometric mesurements and molecular biology methods usingtwo nuclear ribosomal DNA fragments. The interspecific relationships among *Quadriacanthus* spp., were investigated for the first time [22]. According to [22] for both 18S-ITS1 and 28S, *Q. clariadis* was found to be most closely related to *Q. bagrae*. *Quadriacanthus mandibulatus* was observed to be the most distant species from others [22]. The separation of *Q. mandibulatus* from the other species corresponds with the different morphology of its copulatory tube [22]. The copulatory tube is terminally enlarged and with sub terminal flange in *Q. mandibulatus*, while the tube in all other congeners studied is comparatively small and with oblique tapering termination [22]. *Quadriacanthus clariadis* from a clariid fish is sister species to *Q. bagrae* from a bagrid host indicating a possible host-switching event in the evolutionary history of the genus [22]. TheDactylogyrids (Platyhelminthes: Monogenea) from Sudanese *Labeo* spp was studied by [23]. Based on a morphometric evaluation of the sclerotised structures [23] reported the presence of ten *Dactylogyrus* spp., and three *Dogielius* spp. These were *Dactylogyrus nathaliae* from *L. niloticus*, *D. rastellus* and *D. retroversus* from *Labeo horie*; *D. senegalensis* and *D. yassensis* from *L. horie* and *L. niloticus* from Kosti, White Nile [23]. Five *Dactylogyrus* sp., and designated them as *Dactylogyrus* sp. 1 from *L. horie*, *Dactylogyrus* sp. 2, *Dactylogyrus* sp. 3, *Dactylogyrus* sp. 4 and *Dactylogyrus* sp. 5 the last 4 ones were from *L.niloticus* and were rigorously investigated by [23]. *Dogielius fl osculus* from *L horie*, a new species to science *Dogielius sennarensis* n. sp., from *L. niloticus* from Sinnar were described by [23], who also reported *Dogielius* sp. 1 from *L. horie* from Sinnar, Blue Nile and *L niloticus* from Kosti, White Nile. Completion of characterization of *Dactylogyrus* sp1- 5 and *Dogielius* sp. 1 spp., will add to science and the parasites of freshwater fishes of Sudan.

Characidotrema (Monogenea: Dactylogyridae) ***from B. nurse***fishes from Kosti and Sinnar, Sudan was studied by [24]. They described ***Characidotrema pollex*** as a new species to science, they also recorded ***C. brevipenis***, *C.**nurse***, *C.**spinivaginus*** and *C.* ***zelotes. All collections were made from*** *B. nurse* from Kosti and Sinnar [24]. According to [24, 66]species identification was based on morphological analysis of the sclerotized structures supported by the genetic relationships among these species using nuclear ribosomal DNA (partial 18S rDNA, ITS1, and *28S* rDNA) sequence data. Morphological analysis confirmed that the most apparent character distinguishing species in the genus is the morphology of the male copulatory organ and vagina [24, 66].

The digenetic parasites recorded so far from the freshwater fish of Sudan are 24 out of 57 trematodes species (Table 3). The presence of the digenetic *Clinostomum complanatum* larva, from *H. niloticus* from Khartoum were listed by Scholz and de Chambrier in an unpublished report on their 2006 and 2008 freshwater fish parasitological expedition to Sudan**.**

Sandonia sudanensis gen. et sp. nov., was described from the intestine of *Synodontis*

schall (type host) and *Distichodus niloticus* collected from the Nile near Khartoum by [33]. Its affinities with members of the subfamily Schizamphistomainae was discussed by [33]. Its presence in the type host and the type locality was confirmed by [5]. Additional hosts were *B. docmak, Distichodus nefasch, D. rostratus, Synodontis batensoda, S. clarias, S. membranaceus, S. nigrita, S. sorex* and *Synodontis* sp., added by [64].

A detailed description of *Diplostomulum tregenna* Nazi Gohor, 1932 a trematode of the fat tissue in the cranial cavity of *C. gariepinus* was given by [36] who in addition demonstrated experimentally part of its life cycle. The presence of *D. tregenna* in the type host was confirmed by [5]. A new species of Trematodes*Orientocreadium lazeri* from the intestine of *C. gariepinus* (Table 1) was described by [33]. *Brevicaecum niloticum* gen. et sp. nov., was described from the intestine of *Citharinus citharus* (type host) collected from the Nile near Khartoum by [33]. It was placed by McClelland (1957) in the subfamily Kalitrematinae. *Brevicaecum niloticum* (Trematoda, Paramphistomidae) was redscribed from the intestine of *C. citharus* by [33] who amended the characters of the genus and erected a new subfamily Brevicaecinae to accommodate the genus. *Aspidogaster africanus* was redscribed as a new species from *Labeobarbus bynni* by [31]. The description was based on detailed morphological features such as the position of the ovary in relation to testis. *Glossidium lazerae* [*Afromacroderoides lazerae*] gen. et. sp. nov. (Allocreadiidae; Walliniinae) was collected, described and figuredfrom specimens found in the intestine of the African freshwater fish *C. gariepinus* from the White Nile near Khartoum, Sudan, by [35]. The new genus is distinguished by the shape of its cirrus sac, the presence of a bipartite seminal vesicle and a spiny cirrus from the related genera Paramacroderoides and Pseudoparamacroderoides [35]. According to [67] *Glossidiumpedatum* Loss, 1899 was first reported from *B. bajad* and *B*agrus *docmak* from the lower reaches of the River Nile. *Glossidiumpedatum* was collected and described from the intestine of *Clarias mossambicus*from Lake Haik in Ethiopia by [68] and from *C. gariepinus* from South Africa by [69]. Both authors noted similarities between *G. pedatum* and *A. lazerae* [35] and synonymized it with *G. pedatum* [67]. However, [70] based on his diagnoses of genus *Glossidium*, did not considered the synonyms between *G. pedatum* and *A. lazerae* thus he made the new combination *Glossidium lazerae.*

The trematodes described by [1] were *Euclinostomum heterostomum*, *Clinostomum tilapiae* and *Clinostomum phalacrocorcis* in different tissues in *O. niloticus*. *Clinostomum tilapiae* Ukoli, 1966 was found in the bucco-pharynged cavity of *O.niloticus* by [26]. The occurrence of a parasite in different tissues of a host is probably a strategy to avoid competition.

One monogenean (*M. polypteri*) and seven digeneans (*Basidiodiscus ectorchis, S. sudanensis, Callodistomum diaphanum, C. ovofractas,* and *Diplostomulum tregenna* (Metacercaria); and two unidentified adult digeneans were reported by [5] Table 3. The hemorrhage in *C. gariepinus* infected by *D. tregenna* was noticed by [5, 34] who related the extent of hemorrhage to the intensity of infection. *Callodistomum diaphanum* Odhner 1902 was reported from *S. schall* by [5], and from *S. schall, P*. bichir and *P. endlichheri* by [64]. The parasites of *O. niloticus* and *H. forskalii* collected from Khartoum fish market were studied by [71]. From the investigated fish specimens three metacercaria, *Euclinostomum heterostomum, Clinostomum tilapiae* and C. *phalacrocoracis* with the parasitic incidence of 78% in O. *niloticus* and 61% with

females exhibiting higher percentage of infection than males [71]. Ahmed [6] worked on two freshwater fish, *O. niloticus* and *C. gariepinus* collected from Jebel Aulia reservoir and the sewage ponds South of Khartoum. He reported *C. tilapiae* and *Clinostomum* sp. from *O. niloticus* from the reservoir. Metacercaria of *C. tilapiae* and of *C. phalacrocoracis* from *O. niloticus* were reported by [26].

Nemathobothrium labeonis McClelland, 1955 was collected from a *Labeo* sp by [13]. Later, [72] collected *N. labeonis* from *Labeo coubie*, *L. forskalii*, *L. horie* and *L. niloticus*. From some freshwater fishes of Sudan [64] recorded *Sanguinicola chalmersi* Odhner, 1924 from *Auchenoglanis occidentalis* and *S. schall*; *Cholepotes ovofarctus* (Odhner, 1902) from *S. schall* and *Synodontis* sp., *Thaparotrema piscicola* (Odhner, 1902) from *G. niloticus*. Description of *Sanguinicola* sp. Plehn, 1905 as an exraintestinal parasite from *S. schall* and *A. occidentalis* was made by [13]. For *Nematobothrium* sp., [64] listed two hosts *Labeo coubie* and, *L. senegalensis*

A summary of trematodes of freshwater fish of Sudan collected from organs/tissues by different investigators were given in Table 3.

Table 3. Trematodes of freshwater fishes from Sudan.		
Parasites	**Infected organ /tissue**	**References**
Class Monogenea		
Polypterns senegalus		
Macrogyrodactylus polypteri Malmberg,1957	Skin, fins	[5, 18, 19, 20, 21]
Polypterus bichir		
Macrogyrodactylus polypteri Malmberg,1957	Skin, fins	[21]
Clarias gariepinus		
Quadriacanthus aegypticus El-Naggar and Serag, 1986.	Gill lamellae	[22]
Quadriacanthus clariadis Paperna, 1961.	Gill lamellae	[22]
Quadriacanthus fornicatus Francová and Řehulková, 2017	Gill lamellae	[22]
Quadriacanthus pravus Francová and Řehulková, 2017	Gill lamellae	[22]
Quadriacanthus zuheiri Francová and Řehulková, 2017	Gill lamellae	[22]
Heterobranchus bidorsalis		
Quadriacanthus mandibulatus Francová and Řehulková, 2017	Gill lamellae	[22]
Bagrus docmak		
Quadriacanthus bagrae Paperna, 1979	Gill lamellae	[22]
Labeo niloticus		
Dactylogyrus nathaliae Guégan, Lambert & Euzet, 1988	Gill lamellae	[23]
Dactylogyrus spp.	Gill lamellae	[23]
Dogielius sennarensis Pardova *et al*.,2018	Gill lamellae	[23]
Labeo horie		
Dactylogyrus rastellus Guégan, Lambert & Euzet, 1988	Gill lamellae	[23]
Dactylogyrus retroversus Guégan, Lambert & Euzet, 1988	Gill lamellae	[23]
Dactylogyrus senegalensis Paperna, 1969	Gill lamellae	[23]
Dactylogyrus yassensis Musilová, Řehulková and Gelnar, 2009	Gill lamellae	[23]
Dogielius osculus Guégan, Lambert and Euzet, 1989	Gill lamellae	[23]
Dogielius sp.	Gill lamellae	[23]
Brycinus nurse		
Characidotrema pollex Kičinjaová and Řehulková, 20109	Gill lamellae	[24]
Characidotrema brevipenis Paperna, 1969	Gill lamellae	[24]
Characidotrema nursei Ergens, 1973	Gill lamellae	[24]
Characidotrema spinivaginus Paperna, 1973	Gill lamellae	[24]
Characidotrema zelotes Kritsky, Kulo & Boeger, 1987	Gill lamellae	[24]

Subclass Aspidogastrea Faust et Tang, 1936		
Labeobarbus bynni		
Allocreadium sudanensis Saoud, Abdel-Hamid and Ibrahim, 1974	Intestine	[31]
Subclass Digenea Carus, 1863		
Oreochromis niloticus		
Euclinostomum heterostomum Rudolphi, 1809	Kidney	[1, 71]
Clinostomum tilapiae Ukoli, 1966	Operculum muscle, buccal cavity	[1, 6, 26, 71]
Clinostomum phalacoracis Dubois, 1931	Buccopharyngeal	[1, 26]
Clinostomum sp. Leidy, 1856	Buccal cavity	[6]
Sartherodon galilaeus		
Euclinostomum heterostomum Rudolphi, 1809	Kidney	[1]
Clinostomum tilapiae Ukoli (1966)	Operculum muscle	[1]
Clinostomum phalacoracis Dubois, 1931	Buccopharyngeal cavity	[1]
Clarias gariepinus		
Orientocreadium lazeri Khalil, 1961		[33]
Diplostomum tregenna Nazmi Gohor, 1932	Fat tissue in the cranial cavity	[5, 34]
Diplostomum spathaceum Rudolphi, 1819	Intestine	[36]
Diplostomum mashonense Dubois, 1961	Intestine	[36]
Glossidium lazerae Khalil, 1972	Intestine	[35]
Labeobarbus bynni		
Aspidogaster africanus Saoud, Mohamed et Abdel-Hamid, 1974	Intestine	[31]
Polypterns senegalus		
Callodistomum diaphanmun Odhner, 1902	Gall bladder	[5]
Callodistomum diaphanmun Odhner 1902	Intestine	[5]
Synodontis schall		
Sanguinicola sp. Plehn, 1905	Exraintestinal	[13]
Basidiodiscus ectorchis Fischthal & Kuntz 1959	Stomach, upper intestine	[5]
Sandonia sudanensis McClelland,1957	Stomach, upper intestine	[5]
Cheloptes ovofractas Odhner, 1902	Gall bladder	[5, 58]
Callodistomum diaphanum Odhner 1902	Intestine	[5, 58]
Bagrus docmak		
Phyllodistomum sp. Braum, 1899	Intestine	[26]
Hydrocynus forskalii		
Euchinostomum heterostomum Rudolphi, 1809	Buccal cavity	[71]
Clinostomum tilapiae Ukoli, 1966	Buccal cavity	[71]
Clinostomum phalacoracis Dubois, 1931	Buccal cavity	[71]
Phyllodistomum sp. Braum, 1899		[26]
Citharinus citharus		

Brevicaecum niloticum McClelland, 1957	Intestine	[73]
Auchenoglaris occidentalis		
Sanguinicola sp. Plehn, 1905	Exraintestinal	[13]
Heterotis niloticus		
Clinostomum complanatum Rudolphi, 1814	Intestine	*
*Allocreadium sudanensis*Saoud, Abdel-Hamid and Ibrahim, 1974	Intestine	[31]
Labeo spp.		
Nemathobothrium labeonis McClelland, 1955	Eye orbit	[13, 68]
Gymnarchus niloticus		
Acanthostomum gymnarchi Dollfus, 1950	Intestine	[58, 69]
Thaparotrema piscicola Odhner, 1902	Intestine	[64]

*Scholz, T. and de Chambrier, A. two unpublished reports on their 2006 and 2008 freshwater fish parasitological expedition to Sudan.

It is apparent from Table 3 that:
Trematodes species were found parasitizing 16 fish species.

1. The following 11 trematodes were new species to science: *Brevicaecum niloticum*; *Sandonia sudanensis; Orientocreadium lazeri*; *Aspidogaster africanus; Allocreadium sudanensis*; *Afrogyrodactylus girgifae; Quadriacanthus fornicatus*; *Quadriacanthus pravus*; *Quadriacanthus zuheiri*; *Quadriacanthus mandibulatus* and *Dogielius sennarensis*.
2. Three *Diplostomum* spp. were collected from *Clarias gariepinus*
3. *Euclinostomum heterostomum, C. tilapiae, C. phalacoracis* and *Clinostomum* spp. are of common occurrence in *O. niloticus, S. galilaeus, S. schall* and *H. forskalii.*
4. *Clinostomum* spp., *Anguinicola* sp. and *Phyllodistomum* sp. needs redescription to the species level.
5. *Macrogyrodactylus polypteri* was extensively studied compared with other trematodes.

Parasitic Cestodes

Some cestodes, collected by Dr. Franz Werner from freshwater fishes in the Sudan and North Uganda in 1905 were described by [74]. The collection made by C. M. Wenyon and A. J. Chalmers from the Sudan, was examined by [35, 36]. In 1925, Woodland reported on some new *Monticellia* like '*Proteocephalus synodontis*' and other cestodes from Sudanese Siluroids and also *Marsypocephalus heterobranchus* from *H. bidorsalis.* The fish cestodes collected by the Swedish Zoological Expedition to Egypt and the White Nile were examined by [75], who described *Proteocephalus glanduligerus* of *Clarias anguilaris*. The parasitological collection made by H. Sandon and S. El Marash and deposited at London School of Hygiene and Tropical Medicine, United Kingdom, was cautiously revised by [40]; who described from the intestine of *H. niloticus, B. bajad* and *B. docmak* a proteocephalidean tapeworm *Proteocephalus sandoni* n. sp. Lynadale, 1956. Some Proteocephalid cestodes from freshwater fishes mostly from around Khartoum were described by [77]. These were *Proteocephalus sulcatus* Klaptocz, 1906 from the intestine of *Clarotes laticeps*; *Proteocephalus beauchampi* Fuhrmann and Bare, 1925) from *Chrysichthys* sp. *Synodontis schall* was

added as a new host for *P. beauchampi* by [5]. Other Proteocephalids collected by [77] included *Corallobothrium solidum* Fritsch, 1886 and *Electrotaenia malopteruri* Frisch, 1886 from *Malapterurus electricus* in addition [77] reported on a ProteocephaIid worm, *M. heterobranchus* Woodland, 1925 collected from the intestine of *H. bidorsalis*. A redescription of *Proteocephalus glanduligerus* from *Clarias* catfishes including material from Sudan and some African countries was made by [78]. According to [78] *P. glanduligerus* was described as *Ichthyotaenia glanduligera* by [75] from *C. anguillaris* from the Nile River in Cairo, Egypt. *Proteocephalus sulcatus* a poorly known parasite of *C. laticeps* was redescriped by [79] who added the following fish hosts *Clarias anguillaris, C. gariepinus, C. laticeps, Polypterus endlicheri*. A redescription of *Proteocephalus synodontis* Woodland, 1925 was made by [79]. The investigtors included taxonomically and phylogenetically important features for *P. synodontis* from *S. schall* (type species) from the Nile River in Khartoum (Type host) and added *S. caudovittatus, S. eupterus, S. frontosus, S. nigrita, S. serratus, S. batensoda* as a new host records from the Nile near Khartoum, Kosti Sinnar and Khashm el Girba was made by [79]

The genus *Wenyonia* was established by [37] to accommodate three new species from the River Nile at Khartoum, Sudan**.** These were *Wenyonia virilis* Woodland, 1923 (type-species) n. gen.; n. sp., from *S. schall*; *Wenyonia acuminata* Woodland, 1923 n.sp., from *S. membranaceaus* and *Wenyonia minuta* Woodland, 1923 n.sp., from *C. auratus*. Subsequent studies by [37] added *Wenyonia* species, new fish host and locality records. To the *Wenyonia* of Sudan, a *Wenyonia* sp. Woodland, 1923 was collected from the stomach and intestine of *C. gariepinus*and *C. anguilaris* from Khartoum by [5]. *Wenyoniayoudeoweii* Ukoli, 1972 were collected from *S. frontosus* and *S. serratus* by [27, 77]. *Wenyonia synodontis* Ukoli, 1972 was added by [27] and *Wenyonia kainjii* Ukoli, 1972 was added by [84]. *Wenyonia virilis* Woodland, 1923, were collected from *S. schall* by [5, 26] from Khartoum. *Wenyonia virilis* from *Synodontis eupterus, S. frontosus, S. nigrita* and *S. schall* from Khashm El Girba (Atbara River); from *S. caudovittatus*, *S. nigrita* and *S. schall* from Kostı (White Nile) and from *S. schall* from Sinnar (Blue Nile) were collected and described by [82]. *Wenyonia virilis c*ollection made by [27] was from Jebel Aulia, Um Shaba, Alkawa and Kosti on the White Nile and from Lake Roseries, Blue Nile. *Wenyonia acuminata* Woodland, 1923, were collected from *C. gariepinus and S. schall* (new fish hosts from Khartoum) by [5]. The prevalence and intensity of *W.minuta* Woodland, 1923 in *S. frontosus* from Khashm El Girba (Atbara River), in *S. nigrita* and *S.schall* from Kostı (White Nile) and in *S. caudovittatus, S. serratus* and *S. schall* Sinnar (Blue Nile) was studied by [82]. *Wenyonia* youdeoweii Ukoli, 1972 prevalence and intensity was studied from S. caudovittatus, *S. schall* and *S. serrata* from the White Nile (Kosti, Sudan) by [82].*Wenyonia* youdeoweii was also collected from*S. serrata*and *S. nigrita* by [27] form same localities as *W. virilis*. *Wenyonia synodontis* Ukoli, 1972 was described from *Synodontis nigrita* and *Synodontis serratus* by [27] form the same localities of *W. virilis*. The contribution of [27, 77] to new fish host and locality records of *Wenyonia* of Sudan is clearly apparent. *Wenyonia kainjii* Ukoli, 1972 from *Synodontis batensoda, S. caudovittatus, S. clarias, S. eupterus, S. frontosus, S. nigrita, S. schall* was reported by [82] in their guide to the parasites of African freshwater fish.

From the collection made by Sandon and El Marash two cestodes: *Lytocestus alestesi* n. sp. Lynadale, 1956 from and *Lytocestus*

filiformis Woodland, 1923 from *Alestes* sp., were described by [38]. On the basis of other Sudanese specimens (Table 4), [85] re-examined the original material of *L. alestesi* Lynsdale, 1956 and concluded that it should be considered as synonym of *Lytocestus filiformis* Woodland, 1923. The presence of *L. filiformis* in the type host was confirmed by [84]. *Lytocestus longicollis* Devi, 1973 an intestinal of *C. gariepinus*, *S. schall*, *A. occidentalis* and *Auchenoglanisbiscutatus* was recorded by [27].

A new genus, *Sandonella* Khalil, 1960 was described by [41]. On basis of additional morphological data, revision of the taxonomy of the genus and diagnostic character [41] erected a new subfamily Sandonellinae. Hemodified the key to the subfamilies of Proteocephalidae and erected a new genus, *Sandonella*, to accommodate *sandoni* species. The improved description of *S. sandoni* (an enigmatic and morphologically unique Cestode parasitic in the Osteoglossiform fish *H. niloticus* in Africa) by adding detailed rediscription of morphological characters based on scanning electron microscopy was made by [83]. The validity of the monotypic subfamily Sandonellinae and its placement in the Proteocephalidea by [83] has since been widely accepted.

Amirthalingamia Bray, 1974 a ng., was erected as new genus to replace *Paradilepis* by [43]. *Amirthalingamia* (=*Paradilepis*) *macracantha*, was redescribed, as a larval form from the liver and intestinal wall of *O. niloticus* and as an adult form from*Phalacrocorax carbo*a fish-eating bird, from the Green Belt, Sudan by [43]. According to [43], *A. macracantha* differs from other Dilepididae in having 20 large rostellar hooks of three sizes, in two rows, arranged in a bilaterally symmetrical pattern. Two other dilepidid larvae, believed to belong to the genera *Paradilepis* and *Parvitaenia* were also found in *O. niloticus* [43]**.** The Green Belt was demolished after construction on the new sewage treatment plant south of Khartoum.

From the parasites of tilapiasaround Khartoum *Contracaecum* larvae from the intestinal wall, *Paraspidodera* speciesfrom the rectum and *Acanthosentis tilapia* Baylis, 1948 were reported as first record for Sudan by [1], who found a proportional relation between the intensity of infection and the total length of the fish.

Twelve cestodes species from *C. gariepinus*, *P. senegalus*, *S. schall* and *S. serratus* were reported by [5]. These were *Garyophyllaeus* sp., *Stocksia* sp.(reported for the first time from the Sudan, *W. virillis, W. acuminata*, *Wenyonia* sp. *Polyonchobothrium clarias, P. polypteri, Marsypocephalus recangulus, Proteocephalus beuchampi, P. pentantoma, P. synodontis,* unidentified larval cestodes and a Proteocephalid cestode larva. According to [5] *Stocksia* sp. is highly host specific as it has so far been found only in *C. gariepinus*.

Ahmed [6] examined *O. niloticus* and *C. gariepinus* collected from Jebel Aulia reservoir and the sewage treated water ponds South of Khartoum and reported *Polyonchobithrium polypteri* and *Polyonchobithrium clarias* in *C. gariepinus* from Lake Jebel Aulia.

A *Cyclophyllidean* cestode larva from the intestine of *O. niloticus* and *W. virilis* from the intestine of *S. schall* were added by [26] fom fish specimens collected from Al Kalakla Alqubba, 12km south of Khartoum White Nile.Since the publication of the checklist by [16], a number of new genera, new species, new fish hosts and new locality records from African freshwater fish including Sudan have been published (Tables 1 and 4).

Scholz and de Chambrier in 2006 and 2008 examined freshwater fishes from Khartoum (Nile), Kosti (White Nile), Sinnar (Blue Nile) and Khashm el Girbar (Atbara River)

for their cestodes and nematodes. All parasites collected from outside Khartoum were new locality records. To the Sudan cestodes detailed redescription including electron microscopic studies were made for some species. *Barsonella lafoni* was added as a new genus and few species of Proteocephalidean from *Clarias* catfishes based on material from Wadi Halfa, Lake Nubia, Sudan and Tarkana Lake Kenya by [44].

Bothriocephalidean tapeworms (Cestoda) of freshwater fish in Africa including four species from Sudan were redescribed by [72]. Detailed description of *I. ichthybori* from *I. besse* based on 3 mature and 6 immature specimens from Kosti was made by [72]. A redescribtion of *Kirstenella gordoni* from *H. biodorsalis* from Kosti and *Polyunchobothrium polypteri* from *A. occidentalis, P. senegalus* and *P. endlichheri* from Kosti and *P. bichir* from Sinnar was due to [72]. Their description of *Tetracampos ciliotheca* was based on material collected from *C. anguilaris* from Khartoum, Al Kawa, Kosti and Sinnar as well as material collected from *Clarias* sp. from Khartoum, Lake Nubia and Sinnar. They added *C. gariepinus* and *C. auratus* as additional hosts. Based on material from Sudan and other African countries a key to the freshwater Bothriocephalideans larvae from Africa was set by [72]. As the type material of *T. ciliotheca* was not found, the specimen from *Clarias* sp. from Sinnar was designated as neotype and was deposited in IPCAS (No. C-466) by [72]. The presence of the cestode *Monobothrioides tchadensis,* from *Auchenoglanis* sp. from Kosti was listed by Scholz and de Chambrier in an unpublished report on their 2006 and 2008 freshwater fish parasitological expedition to Sudan. The findings of *C. solidum* Fritsch, 1886 and *E. malapterui* Fritsch, 1886 from the intestine of *M. electricus* and *P. sulcatus* Klaptocz, 1906 from *C. laticeps* were confirmed by [27, 67].

Several redescription of cestodes from freshwater fiishes of Sudan were made. Parasites rediscribed included *Brevicaecum niloticumby* by [73]; Acanthostomum *gymnarchi*, with notes on the genera. *Acanthostomum,Atrophacaecum* and *Gymnajotrema* and *Haplocaecum* Simha, [76], Protocephalid cestodes [77]; *Proteocephalus glanduligerus* from *Clarias* catfishes [78]; *Proteocephalus sulcatus* from *Clarotes laticeps* [79]; Tapeworms (Cestoda: Proteocephalidea) of *Synodontis* spp. [80]; *Proteocephalus pentastoma* and *Polyonchobothrium polypteri* from species of *Polypterus* [81] *Wenyonia* from catfishes [82]; the enigmatic and morphologically unique *Sandonella sandoni* from *Heterotis niloticus* [83]. The work of [74] and [75] is pioneer for parasites of freshwater fishes of Sudan. The chapter on cestodes in the guide to the parasites of African freshwater fish by [84] and the systematic position of *Caryophyllaeus fuhrmani* and *Lytocestus alestesi* by [85] are of significance.

Scholz and de Chambrier in 2006 and 2008 confirmed from collection in Kosti area the presence of six cestodes from fish species. These were *Wenyonia chalmersius* and *M. rectangulus* in *Clarias gariepinus* which was reported by [5]; *Polyonchobothrium polypteri* in *Polypterus* sp.by [81] and in *C. gariepinus* by [6]; *Corallobothrium solidum* and *Electrotaenia malopteruri* in *Malapterurus electricus* and *Marsypocephalus heterobranchu* in *Heterobranchus* sp. which was reported by [77].

A detailed description of *Cyclophyllidean* sp.parasitizing the intestine of *O. niloticus* collected from the White Nile near Khartoum was made by [26]. A new genus, *Ichthyologist* (Cyclophyllidea: Dilepididae) was erected by [86] to accommodate *Ichthyolepis africana* n. sp.,

from *Marcusenius macrolepidotus* (type host) from South Africa. The new species parasitizes several freshwater Mormyridae including *Mormyrus caschive*, *M. niloticus* and *Pollimyrus isodori* in the Sudan [79]. According to [86] *I. Africana* represent a unique example of host switching of a tapeworm from birds to teleost fish in Africa and is the first cyclophyllidean tapeworm that sexually matures in teleost fishes.

Scholz and de Chambrier in 2006 and 2008 stuies showed that there is a need to carry out exhaustive morphological and taxonomic revision, DNA sequencing and re-descriptions of Proteocephalus sp. juv. (?*P. synodontis*) from *Synodontis*; *Acanthostomum* sp. from *Bagrus* spp.; Amphistomidae gen. sp. from *Synodontis* and Digenea gen. sp. from *Synodontis*; to verify their taxonomic status.

All cestodes of freshwater fish of Sudan were found in the intestine, except *Amirthalingamiamacracantha*, *Paradilepis* larva and *Dilepidid* larva which were found in liver and intestine of *O. niloticus* [43]; *Cysticercus* larva from the hepatopancreas of *O. niloticus* and *S. galiliaeus* by [1] and *Wenyonia* sp. which was found in the intestine and stomach of *C. gariepinus* by [5]. A summary of cestodes collected from freshwater fish of Sudan by different investigators were given in Table 4.

Table 4. Cestodes of freshwater fishes from Sudan	
Parasites	**References**
Oreochromis niloticus	
*Amirthalingamia macracantha*Bray, 1974	[43]
Paradilepis larva Hsü, 1935	[43]
Parvitaenia larva Burt,1940	[43]
Dilepidid larva Railliet and Henry, 1909	[1]
Polyonchobothrium clariai, Woodland, 1925	[6]
Polyunchobothrium polypteri Leydig, 1853	[6]
Cysticercus Larva Gmelin, 1800	[1]
Cyclophyllidean sp. van Beneden in Braun, 1900	[26]
Sarotherodon galiliaeus	
Polyonchobothrium clariai, Woodland, 1925	[6]
Polyunchobothrium polypteri Leydig, 1853	[6]
Dilepidid larva Railliet and Henry, 1909	[1]
Cysticercus LarvaGmelin, 1800	[1]
Clarias gariepinus	
Proteocephalus beauchampi Fuhrmann and Baer, 1925	[13]
Proteocephalus glanduligerus Janicki, 1928	[77]
Polyonchobothrium polypteriLeydig, 1853	[6]
Bothriocephalus cuspidatus Cooper, 1917	[27]
Tetracampos ciliotheca Wedl. 1861	[72]
Polyunchobothrium clariai Woodland, 1925	[5, 6]
Polyunchobothrium polypteri Leydig, 1853	[5, 6, 83]
Marsypocphalus rectangulus Wedl, 1861	[5, 27, *]
Wenyonia sp. Woodland, 1923	[5]
Wenyonia acuminate Woodland, 1923	[5]
Stocksia sp. Woodland, 1937	[5]
Lytocestus longicollis Devi, 1973	[27]
Clarias anguilaris	
Proteocephalus glanduligerus Janicki, 1928	[72]
Polyonchobothrium clarias, Woodland, 1925	[5, 84]
Wenyonia sp. Woodland, 1923	[5]
Monobothrioides chalmersius Woodland, 1924	[84]
Clarias sp.	
Barsonella lafoni de Chambrier, Scholz, Beletew and Mariaux, 2009	[44]
Tetracampos ciliotheca Wedl. 1861	[72]
Polypterus senegalus	
Proteocephalus pentastoma Klaptoaz, 1906	[5]
Polyunchobothrium polypteri Leydig, 1853	[5, 68, 83]
Polypterus bichir	
Polyunchobothrium polypteri Leydig, 1853	[68, 83]
Proteocephalus pentastomus Klaptocz, 1906	[84]

Polypterus endlicheri	
Polyunchobothrium polypteri Leydig, 1853	[68, 83]
Polypterus sp.	
Proteocephalus pentastoma Klaptoaz, 1906	[81]
Polyonchobothrium polypteri Leydig, 1853	[81]
Synodontis schall	
Wenyonia virilis Woodland, 1923	[5, 26, 35, 77]
Wenyonia acuminata Woodland, 1923	[5]
Proteocephalus synodontis Woodland, 1925	[5, 36, 76]
Proteocephalus beuchampi Fuhrmann and Baer, 1925	[5]
Lytocestus longicollis Devi, 1973	[27]
Synodontis caudovittatus	
Proteocephalus synodontis Woodland, 1925	[79]
Synodontis eupterus	
Proteocephalus synodontis Woodland, 1925	[79]
Synodontis frontosus	
Proteocephalus synodontis Woodland, 1925	[79]
Wenyonia virilis Woodland, 1923	[27]
Synodontis nigrita	
Proteocephalus synodontis Woodland, 1925	[79]
Wenyonia synodontis Ukoli, 1972	[27]
Synodontis serratus	
Proteocephalus synodontis Woodland, 1925	[79]
Wenyonia virilis Woodland, 1923	[27]
Wenyonia youdeoweii Ukoli, 1972	[27]
Spironoura sp. Leidy, 1856	[5, 45]
Synodontis membranaceus	
Wenyonia acuminata Woodland, 1923	[35, 77]
Synodontis batensoda	
Wenyonia kainjii Ukoli, 1972	[84]
Hydrocynus forskalii	
Proteocephalus sp. Weinland, 1858	[71]
Brycinusnurse	
Lytocestus alestesi Lynadale, 1956	[40]
Lytocestus filotormis Woodland, 1923	[40]
Malapterurus electricus	
Corallobothrium solidum Fritsch, 1886	[27, 73]
Electrotaenia malapteruri Fritsch, 1886	[27, 73]
Heterobranchus biodorsalis	
Marsypocephalus heterobranchus Woodland, 1925	[27, 73]
Kirstenella gordoni Woodland, 1937	[72]
Heterotis niloticus	
Proteocephalus sandoni Lynsdale, 1960	[41]
Sandonella sandoni Khalil, 1960	[39, *]

Clarotes laticeps	
Proteocephalus sulcatus Klaptocz, 1906	[27, 73]
Chrysichthys auratus	
Proteocephalus beauchampi Fuhrmann and Baer, 1925	[*]
Ichthyborus besse	
Ichthybothrium ichthybori Khalil, 1971	[15, 68]
Auchenoglanis cf. *acuticeps*	
Monobothrioides tchadensis Troncy, 1978	[*]
Proteocephalus synodontis Woodland, 1925	[79]
Auchenoglanis occidentalis	
Lytocestus longicollis Devi, 1973	[27]
Polyunchobothrium polypteri Leydig, 1853	[72]
Auchenoglanisbiscutatus	
Lytocestus longicollis Devi, 1973	[27]
Mormyrus caschive	
Lytocestus filiformis Woodland, 1923	[72]
Ichthyolepis africana Scholz, Tavakol, Luus-Powell, 2020	*[86]*
Chrysichthys auratus	
Wenyonia minuta Woodland, 1923	[35, 77]

*Scholz, T. and de Chambrier, A. two unpublished reports on their 2006 and 2008 freshwater fish parasitological expedition to Sudan.

It is apparent from Table 4 that:

1. Forty-four Cestode species were found in 26 fish species.
2. Three Clarid catfish species were infected by 10 genera of cestodes 8 of which were identified to the species level.
3. Eight Mochidae harbour 12 species and one cestode identified at the genus level.
4. *Proteocephalus synodontis* were recorded from eight fish species.
5. Eight *Proteocephalus* sp were collected from 15 fish species.
6. *Lytocestus alestesi* and *Lytocestus filotormis* were collected from *Brycinusnurse*.
7. *Corallobothrium solidum*and *Electrotaenia malapterui* from *M. electricus* seems to be host specific.
8. *Clarias* spp. harboured at least six parasitic species. Proteocephalidea is represented by nine species of parasites, with the genus *Proteocephalus* being represented by four species.
9. *Barsonella lafoni* a new genus and a new species was described from material collected from Africa including Wadi Halfa, Lake Nubia.

Parasitic Nematoda

Probably the first freshwater fish parasite recorded from Sudan was *Dichelyne fossor* described by [29] as a new genus (n. gen.); and new species) n. sp., nematode from *Lates niloticus* (type host) and from Bagrus *bajad*. More details on the nematodes collected from Egypt and the White Nile by the Swedish Zoological Expedition was given by [87]. From 1902 to 2020, 12 nematodes species were described from Sudan including n. gen. and/or n. sp in addition to seven nematodes identified to the genus level.

Cucullanus clarotis Baylis, 1923 was recorded from *S. schall* by [13] and from *C. laticeps*by [93]from Khartoum. A recent

study on nematodes of Sudan and Ethiopia by [17] recorded and redescribed in detail *Cucullanus baylisi*Campana-Rouget, 1961. The material was collected from intestine of*Synodontis schall* (Kosti White Nile) and *Synodontis* sp. (Sinnar, Blue Nile). Based on light and scanning electron microscope investigations, they revealed that *Cucullanus baylisi* was erroneously reported by [13, 71] as *C.clarotis*.*Cucullanus baylisi* was re-named '*Cucullanus dubius* nom. n.' by [17] due to its poor and questionable description. It was designated as a species inquirenda by [17].

A new nematode species *Nilonema gymnarchi* n. sp [45] was described from the freshwater fish *G. niloticus*. The described species was a female collected from the lung-like air bladder.

Raphidascaroides bishaii Khalil, 1961 was described as a n. sp. from *G. niloticus*, by [46].

Falcaustra sudanensis from *Distichodus brevipinnis***(from Khartoum, White Nile)** and *Spironoura hexapapillata* from*Distichodus nefasch***(from Kosti, White Nile)** were described in 1962 by [47] as two new nematode species to science from Sudan. *Falcaustrasudanensis* was collected from the intestine of *D. brevipnnis* by [47]. Its presence in *D. brevipnnis* and from *D. niloticus* was confirmed by [26]. A redescription of *F. sudanensis* in 2017 by [17] led to modification of its valid name to read *Spironoura sudanensis*.*Spironoura hexapapillata* Khalil, 1962 was restudied from its type host and type locality by [17]. The authors concluded that*Falcaustra hexapapillata* Khalil, 1962 is a senior to [syns. *Spironoura hexapapillata* Khalil, 1962]. *Spironura* sp. Leidy, 1856was collected from the intestine of *Synodontis batensoda*,*D. brevipennis* and *Distichodus* sp [13] andfromthe intestine of *S. schall* by [5, 13].

Diplostomulum tregenna Nazmi Gohor, 1932 from the Nile fish *C. gariepinus* was described from the fat tissue in the cranial cavity by [36] who experimentally demonstrated part of its life cycle. *Chitariniella citharini* Khalil, 1963 was described as n. gen. and n. sp., of oxyurid from a freshwater fish, *C. citharus* in the Sudan [48]. The material was collected from the rectum of several specimens of *C. citharus*. *Chitariniella citharini* was the only Pharyngodonidae from Sudan freshwater fishes [48].*Distichodus brevipinnis*, *S. schall* and *S. serratus* were added by [91] as additional hosts for *Citharinus* from Sudan. *Philometra bagri*n. sp. Khalil, 1969 was collected from the subcutaneous tissue of *B. bajad* by [13].

Procamallanus laeviconchus Wedl, 1861 [Syn. *Cucullanuslaeviconchus* Wedl, 1861] was collected from the esophagus, stomach, intestine and gill lamellae of *C. gariepinus* by [13]; from *S. schall* by [5, 26, 17]; from *S. serratus* Sy [5] and from *B. bajad*, *B. docmak*, *D. niloticus*, *D. brevipennis*, from *H.forskalii* by [26] and from *Schilbe intermedius* by [17]. All these fish hosts were collected from the White Nile near Khartoum, Sudan. *Procamallanus icyathopharynx* Wedl, 1862 was found in the esophagus, stomach, intestine and gill lamellae of *C. gariepinus* by [13]. A new species to science, *Procamallanus* (=*Spirocamallanus*) *pseudospiralis*Moravec and Scholz, 2017 was collected from the intestine of *S. schall* (type host) from River Nile in Khartoum (type locality) by [17]. An additional locality was Khashm el Girba, Dam Lake. Other hosts were *S. frontosus* and *S. nigrita*. A Key to Procamallanus spp. parasitic in freshwater fishes in Africa was included. From the intestine and stomach of *S. schall* [92] described three *Procamallanus* Olsen, 1952 and designated them as*Procamallanus* type 1, 2 and 3.

Procamallanus spiralis Baylis, 1923 was collected from the intestine of *Clarias anguillaris*, *Auchincglanis occidentalis*, *S. schall* and *S. batensoda* by [13]; from the stomach and intestine of *S. schall* by [5, 13, 26]; from *S. serratus* by [5] and from *B. docmak* by [26].

Cucullanus barbi n. sp. Baylis, 1923 was redescribed from *Labeobarbus binnyi* from Khartoum by[93]. It was rediscribed from the types host collected from White Nile in Kostí and Blue Nile in Sinnar, Sudan by [17].

An adult nematode *Gendrid tilapiae* Baylis, 1930 was reported for the first time in Sudan from the rectum of a single specimen of *O. niloticus* by [1] who also described *Acanthosentis tilapiae* Bolyis, 1948 from the intestine of *O. niloticus* and *S. galilaeus*. *Amphicaecum* sp. Baylis, 1920 was collected from mesenteries surface of stomach and intestine, and from sinus venosus of *O. niloticus* by [13, 26]; from *C. gariepinus* by [6]; from *L. niloticus* by [92]; and from *B. bajad, H. forskalii, L. niloticus* and *S. mystus* by [26].

Contracaecum sp. Reilliet and Henary, 1912 was collected from the intestine and sinus venosus of *O. niloticus* by [1, 26, 87, 88]; from *S. galilaeus* by [1, 89]; from *C. zillii* by [90]; from the visceral cavity and stomach wall of *C. gariepinus* by [5, 6] from *P. senegalus* by [5] and from *B. bajad*, *H. forskalii, L. niloticus*,and *Schilbe mystus* by [26].An *in vitro* experiments made by [89] demonstrated part of the life cycle of *Contracaecum* sp., and revealed that molting in small larval nematodes takes 2 to 3 days.

Rhabdochona sp. Raillet, 1916 was collected from the intestine of *G. niloticus* by [89] and from *H. forskalii* by [26]. *Metaquimperia* sp, Karve, 1941 was collected from the stomach of *P. senegalus* by [5]. *Porrocaecum* sp. Railliet and Henry, 1912 was collected from the intestine of *O. niloticus* and *L. niloticus* by [92].

A new species of nematode, *Cucullanus mormyri* sp. n. Moravec et Scholz, 2017 was collected from the intestine of *M. caschive* (Type host) from Kosti on the White Nile (type locality); other hosts were a *Mormyrus* sp. and *Marcusenius cyprinoides* (both belong to Mormyridae) [17].

From the sinus venosus of *O. niloticus*, *S. galilaeus* and *C. zillii* larvae of *Amplicaecum* Baylis, 1920 were collected by [13] who designated them as *Amplicaecum* type 1 and *Amplicaecum* type 2.

Cucullanus sp. Muller, 1877 was collected from the intestine, occasionally gill lamellae of *S. schall* by [5, 26], from *L. bynni* by [26] and from the intestine of *S.serratus* by [5].

Dujardinascaris malapteruri Baylis, 1923 was collected from *Malapterurus electricus* by [91].

Other nematodes collected and described by [17]were:

1. *Falcaustra similis*Moravec et Van As, 2004 was collected from *S. frontosus*, *S. serratus* (Sinnar, Blue Nile), *S. frontosus*, *S. nigrita*, *S. schall* (Khashm el Girba).
2. *Falcaustra guiersi*Vassiliadès, 1973 (considered a junior synonym of *F. hexapapillata* Khalil, 1962) was collected from *D. brevipinnis* and *D. nefasch.*
3. ***Citharіniella khalili*** Petter, Vassiliades et Troncy, 1972 was collected from the intestine of *S. membranaceus* and*S. serratus* from White Nile River in Kostí and Blue Nile in Sinnar.
4. *Multicaecum heterotis*Petter, Vassiliades and Marchand, 1979 was collected and rediscribed from the intestine of*H. niloticus* (type host) from Khartoum and Kosti.
5. ***Camallanus longicaudatus Moravec, 1973 was collected*** and rediscribed from the intestine of *Labeo niloticus* from Nile River *L. niloticus* from Khartoum**.**
6. *Paracamallanus cyathopharynx* Baylis, 1923 from *C. gariepinus* (type host) was

collected from the intestine of *Clarias* sp. from Sinnar (Blue Nile).

7. ***To the*** larval nematodes [17] added: Records of *Contracaecum* sp. Third stage-larvae Type 2 of Moravec *et al*. 1993 ***from the body cavity of*** *B. nurse*, *C. gariepinus*, *Clarias* sp. and *O. niloticus* (River Nile in Khartoum) and *B. nurse* in Khashm el Girba Dam Lake. Both *B. nurse**and** C. gariepinus **are new host and ranges for** Contracaecum* sp. Third stage-larvae Type 2. The body length of third stage-larvae Type 2 was about 10 mm from *B. nurse* and about 30–50 mm from *O. niloticus*.
8. ***Capillariidae*** gen. sp Raillet, 1815 was collected from the intestine of *Auchenoglanis* sp. from Kosti. The collection was a single gravid female nematode**.**
9. ***Spinitectus polli Campana-Rouget, 1961*** was collected from the intestine of *S. schall* from Khartoum.

The nematodes of freshwater fishes encountered so far from Sudan, were given in Table 5.

Table 5. Nematode of freshwater fishes from Sudan		
Parasites	**Infected organ / tissue**	**References**
Oreochromis niloticus		
Gendrid tilapiae Baylis, 1930	Rectum	[1]
Acanthosentis tilapiae Bolyis, 1948	Intestine	[1]
Contracaecum sp. Reilliet and Henary, 1912	Mesenteries of stomach and intestine, sinus venosus	[1, 26, 87, 88]
Amphicaecum sp. Baylis, 1920	Mesenteries of stomach and intestine, sinus venosus	[13, 26]
Porrocaecum sp. Railliet and Henry, 1912	Intestine	[92]
Sarotherodon galilaeus		
Acanthosentis tilapiae Bolyis, 1948	Intestine	[1]
Contracaecum sp. Reilliet and Henary, 1912	Intestine, sinus venosus	[1, 89]
Coptodon zillii		
Contracaecum sp.Reilliet and Henary, 1912	Sinus venosus	[90]
Clarias gariepinus		
Procamallanus laeviconchus Wedl,1861	Esophagus, stomach, intestine and gill lamellae	[13]
Procamallanus icyathopharynx Wedl, 1861	Esophagus, stomach, intestine and gill lamellae	[13]
Amphicaecum sp. Baylis, 1920	Intestine	[6]
Contracaecum sp. Reilliet and Henary, 1912	Visceral cavity, stomach wall	[5 , 6]
Clarias anguillaris		
Procamallanus spiralis Baylis, 1923	Intestine	[13]
Clarias sp.		
Procamallanus spiralis Baylis, 1923		[13]
Synodontis schall		
Procamallanus spiralis Baylis, 1923	Stomach, intestine	[5, 13, 26]
Cucullanus sp. Mueller, 1877	Intestine, Gill lamellae	[5, 26]
Procamallanus laeviconchus Wedl, 1861	Esophagus, stomach, gill lamellae	[5, 26]
Procamallanus type 1	Intestine and stomach	[92]
Procamallanus type 2	Intestine and stomach	[92]
Procamallanus type 3	Intestine and stomach	[92]
Spironoura sp. Leidy, 1856	Intestine	[5, 13]
Cucullanus clarotis Baylis, 1923	Intestine	[13**, 71]
Synodontis batensoda		
Procamallanus spiralis Baylis, 1923	Intestine	[13]
Spironoura sp. Leidy, 1856	Intestine	[13]
Synodontis serratus		

Procamallanus laeviconchus Wedl, 1861	Stomach	[5]
Procamallanus spiralis Baylis, 1923	Intestine	[5]
Cucullanus sp. Muller, 1877	Intestine	[5]
Synodontis frontosus		
*Falcaustra similis*Moravec et Van As, 2004		[17]
Synodontis membranaceus		
Cithariniella khalili Petter, Vassiliadès et Troncy, 1972		[17]
Labeobarbus bjnni		
Cucullanus brati Baylis, 1923		[93]
Cucullanus sp. Muller, 1877	Intestine occasionally Gill lamellae	[26]
Distichodus brevipinnis		
Spironoura sudanensis Khalil, 1962	Intestine	[26, 45]
*Falcaustra guiersi*Vassiliadès, 1973		[17]
Spironoura sp. Leidy, 1856	Intestine.	[13]
Distichodus niloticus		
Spironoura sudanensis Khalil, 1962	Intestine	[26]
Procamallanus laveiconchus Wedl (1862)	Esophagus, stomach, intestine	[26]
Spironoura sp. Leidy, 1856	Intestine.	[13]
Citharinus citharus		
Cithariniella citharini Khalil, 1963	Intestine	[48]
Polypterus senegalus		
Metaquimperia sp. Karve, 1941	Stomach	[5]
Contracaecum sp. Reilliet and Henary, 1912	Visceral cavity, stomach wall	[5]
Bagrus docmak		
Procamallanus spiralis Baylis, 1923	Stomach and intestine	[26]
Procamallanus laeviconchus Wedl (1862)	Stomach	[26]
Bagrus bajad		
Amphicaecum sp. Baylis, 1920	Mesenteries, surfaces of stomach and intestine, sinus venosus	[26]
Procamallanus laeviconchus Wedl,1862	only larvae in the esophagus, stomach, and intestine	[26]
*Philometra bagri*Khalil, 1969	Subcutaneous tissue	[13]
Thwaite Bagri Khalil, 1965		[95]
Hydrocynus forskalii		
Procamallanus laeviconchus Wedl, 1861	Gill lamellae	[26]
Amphicaecum sp. Baylis, 1920	Mesenteries of stomach and intestine, sinus venosus	[26]
Contracaecum sp. Reilliet and Henary, 1912	Mesenteries of stomach and intestine, sinus venosus	[26]
Rhabdochona sp.	Intestine	[26]
Lates niloticus		

Contracaecum sp. Reilliet and Henary, 1912	Mesenteries of stomach and intestine, sinus venosus	[26]
Amphicaecum sp. Baylis, 1920	Mesenteries of stomach and intestine, sinus venosus	[26]
Schilbe mystus		
Amphicaecum sp. Baylis, 1920	Mesenteries of stomach and intestine, sinus venosus	[26]
Gymnarchus niloticus		
Nilonema gymnarchi Khalil, 1960	Swim bladder	[45]
Rhabdochona sp,		[89]
Labeo niloticus		
Amphicaecum sp.Baylis, 1920	Intestine	[92]
Porrocaecum sp.	Intestine	[92]
Auchincglanis occidentalis		
Procamallanus spiralis Baylis, 1923	Intestine	[13]
Malapterurus electricus		
Dujardinascaris malapteruri Baylis, 1923		[91]

** According to [17]*Cucullanus clarotis* was erroneously named by [13, 93]. Its correct name is *Cucullanus baylisi*.

From Table 5 it is apparent that:

1. The nematode *P. laeviconchus* seems to have no preference to a specific host.
2. Omer (1999) studied the parasites of *O.niloticus* from Khartoum, recorded their prevalence rate and concluded that no histological evidence of ill-effect.
3. T***o the nematodes of Sudan 12*** adult and two larval belonging to the Ascaridoidea, Camallanoidea, Cosmocercoidea, Habronematoidea, Oxyuroidea, Seuratoidea and TT
4. The findings of [17] represented several new host and geographical records for example *F. sudanensis*from*D. brevipennis* and *D. niloticus* was collected from Khartoum and *C. barbi* from Kosti (White Nile) and Sinnar (Blue Nile).
5. Scholz and de Chambrier in 2006 and 2008 confirmed from *Clarias* sp. collected from Kosti the presence of *Procamallanus spiralis* previously reported from Khartoum from *Clarias gariepinus* by [13]; from *S. schallS. schall* and *Synodontis sirratus* by [5] and by [26] from *B. docmak*.

Parasitic Crustacea

Parasitic Copepodsof freshwater fishes of Sudan received very little attention. *Lemaea laphiara* Harding, 1950, *Opistholemaea laterobrachialis nilotica* Fryer, 1965 and *Lamprogiena mondi* Caport, 1944 were recorded by [1] from gill lamellae, fins and scales of *O. niloticus* and *S. galilaeus* as first record to Sudan. In 1986 [5] added *Lemaea haphocephala* (Cunnuhngton, 1914) from the skin around anal finof *P. senegalus*. The ecto-parasites *Lamproglena mondi*, Capart, 1944 from *O. niloticus*; *Lamproglena* sp. von Nordmann, 1832 from *H. forskalii* and *Ergasilus* sp. von Nordmann, 1832 from the gill lamellae of *B. bayad* and *B. docmak* were collected by [26] who found an overall prevalence rate of 18.6%. A recent study by [96] reported the occurrence of five crustaceans from freshwaterfishes of Sudan. These were *Dysphorus torquatus* Kurtz, 1924 from *H. niloticus*; *Lamproglena elongata* Capart, 1956 from *C. citharus*, *Lernaeocera werneri* Kurtz, 1922 from *C.*

gariepinus, *D. nefasch*, *M. electricus*; *Lernaeocera senegali* Zimmermann, 1922 from *P. senegalus* and *Ergasilus nodosus* Wilson, 1924 from *B. bajad*.

Acanthocephala parasites

According to [13] Acanthocephala found in the Sudan were *Tenuisentis niloticus* Meyer, 1932 from *H. niloticus*, *Neoechinorhynchus* sp. (Günther, 1864) in *C. citharus* and 2–5 unidentified acanthocephala in *S. batensoda*. In a subsequent study [76] added*Acanthostomum abscoditum*Looss, 1901and*Acanthostomum spiniceps*Looss, 1901 from *B. bajad* and *B. docmak* and *Acanthostomum gymnarchi*Dollfus, 1950 from *G. niloticus*. The first record of *Polyacanthorhynchus kenyensis* Schmidit and Canaris, 1967 in Sudan from the kidney of *O. niloticus* was made by [97]. According to [97] this spiny-headed worm added to the list of faunal similarities between Africa and South America. *Neochinorhynchus ichthyobori*Saoud, El-Naffar and Abu-Sinna, 1974 was described as a new species by [49] from the intestine of *I. besse*. They stated that it is the first species of the genus *Neochinorhynchus* to be recorded from Africa. *Neochinorhynchus ichthyobori*differs from the 6 other species of the genus in trunk length, in the measurements of the proboscis, its hooks, the lemnisci, and in lacking sexual dimorphism [49].Three species of *Polyacanthorhynchus* are parasitic of caiman in South America and their occurrence in *Crocodylus niloticus*, *Varanus niloticus* and/or *Trionyx* spp., as definite host in Sudan should not be excluded [97]. *Acanthogyrus* (=*Acanthosentis*) *tilapiae* Baylis, 1948 was found in the intestine of *O. niloticus* and *S. galilaeus* by [1, 26]. Their occurrence in both species probably represent a case of co-evolution and multiple infections at the same time.From *O. niloticus* [94] identified an *Acanthogyrus* sp., while from *Labeo niloticus*,[92] found an *Acanthocephala* sp.

Conclusions

A couple thousand of freshwater fish specimens were examined for their ecto-parasites and/or end-parasites. Fifty-eight fish species were reported infected and 162 parasitic species including 32 new species were collected. These were three bacterial and three fungal species collected from *O. niloticus*. From 10 species of fish, 19 protozoans were described. From 10 species of fish, 22 Monogenean species were found including 7 new species. One new Aspidogastrean species was collected from *Labeobarbus bynni*. From 29 fish species 23 Digeneans species were collected including five new ones. From 41 species of fish, 44 species of cestods parasites were collected including 11 species new to science. Twenty parasitic Nematodes species including seven new ones were collected from 32 fish species. From 12 fish species 9 Crustacean were described. Nine Acanthocephalans including one new species from *Ichthyborus besse* were collected from 11 fish species (Appendix 1).

One new subfamily Sandonellinae from *Heterotis niloticus* was erected; and 10 new genera, *Brevicaecum*, *Sandonia*, *Afromacroderoides* (Digenia); *Wenyonia*, *Sandonella*, *Amirthalingamia*, *Barsonella lafoni* (Cestoda) and *Dichelyne*, *Nilonema*, (Nematoda) were described. Revision of *Trypanosoma* species type 1, 2, 3 [25]; *Dactylogyrus* species type 1, 2, 3, 4, 5; *Dogielius* sp. 1 [23]; *Amplicaecum* type 1 and *Amplicaecum* type 2 [13]; *Contracaecum* sp. Third stage-larvae Type 2 [17],*Procamallanus* type 1, 2, 3 [92] and those parasites identified to the genus level shouds be given due attention.

Scholz and de Chambrier in 2006 and 2008 study showed that there is a need to carry

out exhaustive morphological and taxonomic revision, DNA sequencing and re-descriptions of Nematoda gen. sp. 1 from *Distichodus*; Nematoda gen. sp. 2 from *H. niloticu*s to verify their taxonomic status.This notion carried out forward the subsequent studies made by the Institute of Parasitology, Biology Centre of the CAS, the Department of Botany and Zoology, Faculty of Science, Masaryk University, Czech Republic and Sudan Institute of Natural Sciences which led to description of one new genus and 10 new parasitic species and more material are yet in the verification tube.

Many parasites of freshwater fish described in Ethiopia and Egypt [100, 101, 102, 103, 104, 105] are likely to be found in Sudan. An example is *Bothriocephalus acheilognathi* Yamaguti, 1934 (a Bothriocephalidean tapeworms, Cestoda) reported by [72] from both countries.

Despite the extensive surveys made by [27] at Jebel Aulia, Um Shaba, Alkawa and Kosti on the White Nile and from Lake Roseries no digenias, cestodes, nematodes, crustaceans and acanthocepha parasites were found in *B. bayad*, *B. docmak* and *C. auratus* (see appendix 1). The negative findings by [27] might be a matter of chance but probing the presence of an antibody complement system secreted into the intestine to prevent the establishment of parasites should be investigated.

Several parasites species were recorded from same fish genus probably indicating a co-evolution of the fish genus and the parasites genus. Examples included *Acanthostomum abscoditum* and *Acanthostomum spiniceps* reported from *Bagrus bayad* and *Bagrus docmak* by [76]. *Spironoura sudanensis* from *D. niloticus* and *D. brevipennis* [26]. *Proteocephalus synodontis* from *Synodontis eupterus*, *S. frontosus*, *S. nigrita* and *S. serratus* [27, 76]. The trematode *Macrogyrodactylus polypteri* from *Polypterns senegalus* [5, 18, 19, 20] and *P. bichir* [21].

A guide to the parasites of African freshwater fish [98]; a systematic survey of the Monogenea parasites of freshwater fishes in Africa [66] and Parasitic crustaceans of African freshwater fishes from the Nile and Niger systems [99] beside this review are milestone for future research in freshwater fish parasitology.

The review showed that there is a need to launch a genuine international project with multi-nations team to study in details the parasites of fishes of Sudan from the Nile and non-Nilotic inland water bodies. Such project is expected to cover:

1. The fish parasites of freshwater fishes of Sudan, their description and systematics.
2. Establishment of life cycles of each parasite especially those infecting commercial fishes.
3. Host-parasite relationship, correlation between parasites and the health status of fish and their histopathological consequences.
4. The impact of single or multiple infections by parasitic species on fish species reared in earthen ponds, floating cages and/or pen culture.
5. The fish parasites of Dinder River and Rahad River is an area of interest because both rivers belong to Nilo- Sudanic and highland East African fish regions.
6. The role of piscvorous birds in diversity of fish parasites.
7. Capacity development by enhancing research facilities, promoting technician skills, and avail scholarships for postgraduate students.

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Annex 1. Parasites infecting different freshwater fish species in Sudan.

Fish species	**Bacteria**	**fungi**	**Protozoa**	**Monogenea**	**Aspido-Gastrea**	**Digenea**	**Cestoda**	**Nematoda**	**Crustacea**	**Acantho-cephala**
Polypterns senegalus				√		√	√	√	√	
Polypterus bichir				√		√	√			
Polypterus endlicheri						√	√			
Polypterus sp.			√				√			
Heterotis niloticus						√	√		√	√
Gymnarchus niloticus						√		√		
Mormyrus caschive							√	√		
Mormyrus niloticus							√			
Mormyrus sp.								√		
Marcuseniu s macrolepid otus							√			
Marcuseni us cyprinoide s								√		
Pollimyrus isodori							√			
Labeobarb us bynni			√		√	√	√	√		
Labeo niloticus				√		√	√	√		√
Labeo				√		√				

horie										
Labeo coubie						√				
Labeo senegalensis						√				
Labeo sp.						√				
Distichodus nefasch						√		√	√	
Distichodus brevipinnis								√		
Distichodus niloticus							√	√		
Distichodus rostratus						√				
Ichthyborus besse							√			√
Citharinus citharus				√		√		√	√	√
Brycinus nurse				√			√			
Hydrocynus forskalii						√	√	√	√	
Bagrus bajad			√			√	√	√	√	√
Bagrus docmak				√		√	√	√	√	√
Auchenoglaris occidentalis						√	√	√	√	
Auchenoglanis acuticeps							√			
Auchenoglanis biscutatus							√			
Auchenoglanis sp.							√			
Chrysichthys auratus			√				√			
Chrysichthys sp.							√			
Clarotes laticeps							√	√		
Schilbe mystus							√	√		
Schilbe intermedius								√		

Clarias gariepinus			√	√		√	√	√	√	√
Clarias anguilaris							√	√		
Clarias sp.							√	√		
Heterobranchus bidorsalis				√			√			
Synodontis schall			√			√	√	√		
Synodontis batensoda						√	√	√		√
Synodontis clarias						√				
Synodontis caudovittata							√			
Synodontis frontosus							√	√		
Synodontis membranaceus						√	√	√		
Synodontis nigrita						√	√	√		
Synodontis serratus							√	√		
Synodontis sorex						√				
Synodontis eupterus							√			
Synodontis sp.						√	√			
Malapterurus electricus							√	√	√	
Lates niloticus								√		
Parachanna obscura			√			√				√
Oreochromis niloticus	√	√	√			√	√	√	√	√
Sartherodon galilaeus			√			√	√	√	√	√
Coptodon zillii			√					√		
No. of infected fish species= 58	**1**	**1**	**10**	**9**	**1**	**29**	**41**	**32**	**12**	**11**
No. of	**3**	**3**	**10**	**22**	**1**	**23**	**44**	**20**	**9**	**9**

parasite species=162										
No. of new parasite species=32	**0**	**0**	**0**	**7**	**1**	**5**	**11**	**7**	**0**	**1**