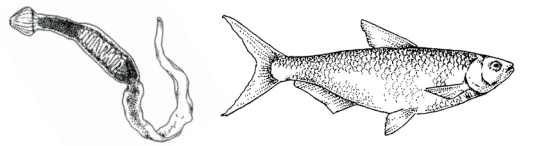
PART 4

A SYSTEMATIC SURVEY OF THE PARASITES OF FRESHWATER FISHES IN AFRICA



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Chapter 4.1.

KEY TO THE PRINCIPAL GROUPS OF THE PARASITES OF FRESHWATER FISHES IN AFRICA*

Roman KUCHTA

1 (2) Microscopic organisms, mostly unicellular, may form cysts containing spores that are not visible to the naked eye, cysts sometimes macroscopic…….**Protista and Myxozoa** (see key in Chapter 3.3.1)

2 (1) Organisms visible to the naked eye (may nonetheless be quite small and larvae may be microscopic), multicellular, may or may not be aggregated into clusters of individuals ..……3

3 (4) Worm-like organism, lacking an articulated exoskeleton with segmented appendages…….....5

4 (3) Organisms with articulated exoskeleton and segmented appendages (appendages may be minute requiring a microscope to be observed)……15

5 (6) Organisms with dorsoventrally flattened body, not round in cross-section……...7

6 (5) Organisms not dorsoventrally flattened, round in cross-section, endoparasitic ……13

7 (8) Organisms with the anterior and posterior attachment organ……..…9

8 (7) Organisms without the posterior attachment organ, usually proglottised [Fig. 4.1F]……**Cestoda** (see Chapter 4.6)

9 (10) Anterior and posterior attachment organs sucker-like, without armatures……...11

10 (9) The posterior attachment organ (haptor) comprising various sclerotised structures (hooks, clamps, squamodiscs) present [Fig. 4.1A, B]……**Monogenea** (see Chapter 4.4)

11 (12) Anterior and posterior attachment organs present with well-defined posterior sucker; intestine not bifurcate; always ectoparasites [Fig. 4.1E] …….**Hirudinea** (see Chapter 4.10)

* The key does not include encysted helminth larvae; these larvae have to be taken out from the cyst before identification or fixation, usually using fine preparation.

12 (11) Posterior attachment organ usually not present, circumoral and ventral suckers present (except for blood-dwelling species and Aspidogastrea); intestine mostly bifurcate; always endoparasitic [Fig. 4.1C, D]……..**Trematoda** (see Chapter 4.5)

13 (14) Anterior end with retractable spined proboscis; intestine absent [Fig. 4.1G] ……...**Acanthocephala** (see Chapter 4.7)

14 (13) Anterior spined retractable proboscis absent; intestine present [Fig. 4.1H] ……..**Nematoda** (see Chapter 4.8)

15 (16) Body not covered by carapace……17

16 (15) Almost whole body covered by carapace; four swimming legs [Fig. 4.1I] ……**Branchiura** (see Chapter 4.9)

17 (18) Organisms with two compound eyes; body dorsoventrally flattened, segmented; more than 4 legs [Fig. 4.1J]……**Isopoda** (see Chapter 4.9)

18 (17) Organisms with one compound eye; body shape variable [Fig. 4.1K] ……..**Copepoda** (see Chapter 4.9)

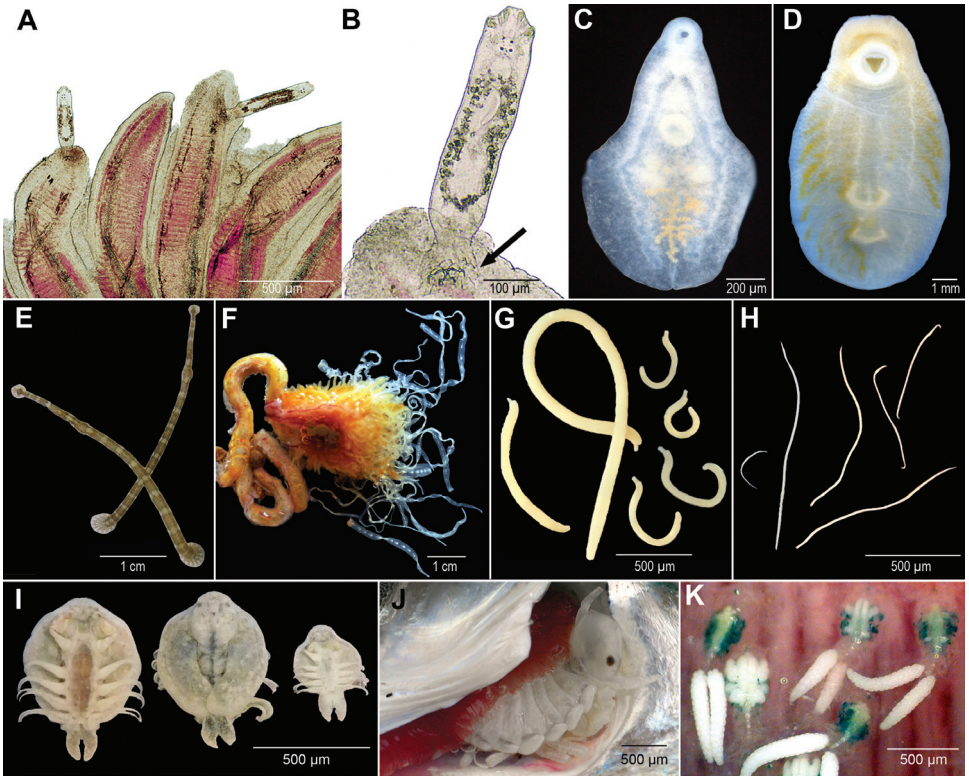

Fig. 4.1. Principal groups of metazoan fish parasites. **A, B.** Monogenea – *Thylacicleidus serendipitus* Wheeler et Klassen, 1988 from *Dichotomyctere nigroviridis*; arrow indicates position of the haptor; **C.** Digenea – *Phyllodistomum* sp.; **D.** Digenea – *Euclinostomum* sp., metacercaria; both from *Clarias gariepinus*; **E.** Hirudinea – *Piscicola geometra* Linnaeus, 1761 from *Cyprinus carpio*; **F.** Cestoda – *Ichthybothrium* sp. in the intestine of *Mesoborus crocodilus*; **G.** Acanthocephala – *Echinorhynchus* cf. *gadi* Zoega in Müller, 1776 from *Microgadus proximus*; **H.** Nematoda – *Procamallanus* sp. from *C. gariepinus*; **I.** Branchiura – *Dolops ranarum* (Stuhlmann, 1892); **J.** Isopoda – *Mothocya renardi* (Bleeker, 1857) from *Strongylura leiura*; **K.** Copepoda – *Ergasilus* sp. on the gills of *C. carpio*. (Photographs by R. Kuchta, O. Kudlai, D. Modrý & E. Řehulková).

Chapter 4.2.

PROTISTA

Linda BASSON & Courtney COOK

Protists parasitising freshwater fishes – basic characteristics, life cycles, classification and principal diagnostic features

Protists do not represent a distinct and monophyletic group of organisms. According to Adl *et al.* (2005) Haeckel's taxon Protista (Haeckel 1866) is no longer formally recognised. However, the popular term "protist" is retained to describe eukaryotes with a unicellular level of organisation (eukaryotic microorganisms or EMs; see Chapter 3.3.1). Therefore, this term will be used throughout this chapter, but with no taxonomic validity. The various groups discussed below belong to supergroups as proposed by Adl *et al.* (2012). The only characteristic these organisms share is the fact that they are all unicellular. Very scant information on protist fish parasites in Africa exists.

Each taxonomic group is discussed separately throughout. Host names are presented according to Froese & Pauly (2017). For the purpose of this chapter, the classification system proposed by Adl *et al.* (2012) has been followed. A brief outline of this system is presented in Table 4.2.1, limited to groups of parasites recorded from African freshwater fishes. A generalised key to major groups is presented in Chapter 3.3.1.

In cases where a representative species for every genus could be obtained from the relevant African literature, these species are presented in diagrammatic drawings. However, in several instances only records of genera are provided, with no species identification and/or micrographs or diagrams. In these cases, a representative species from elsewhere in the world was selected and diagrammatically presented.

Practical key for preliminary determination of fish-infecting EMs in freshly prepared material

1 (2) Protists detectable as macroscopic whitish aggregations, from tiny dots to cyst-like structures of several millimetres in size; on skin, gills, in or on internal organs……3

2 (1) No macroscopic changes visible; protists only detectable by light microscopy……17

3 (4) Microorganisms visible as tiny dots on the body surface and gills, under the microscope dot proves to be one or several large (up to 1 mm) slowly rotating cells, uniformly covered with beating cilia; smaller cells may be

present, next to large ones; cytoplasm full of granules, containing large macronucleus [Fig. 4.2.4E]……***Ichthyophthirius multifiliis***

4 (3) Dot-, nodule-, or cyst-like structures composed of mass of small, uniform, refractile bodies (spores or oocysts)……5

5 (6) Spores very small, typically 3-10 µm in size, usually ovoid and often showing prominent vacuole in posterior part (Microsporidia)……9

6 (5) Spores spherical or ellipsoid-spherical……7

7 (8) Spherical spores with a large central vacuole/light refracting bodies [Fig. 4.2.2B]……***Dermocystidium***

8 (7) Organisms spherical or ellipsoidal bodies of about 10-20 µm in size, each with 4 sharply delimited (coccidian oocysts)…… 15

9 (10) Microsporidian not directly associated with fish, hyperparasite [Fig. 4.2.2F] ……..***Unikaryon***

10 (9) Microsporidians associated directly with fish……11

11 (12) First merogony stages with diplokarya [Fig. 4.2.2D]……***Neonosemoides***

12 (11) No diplokaryon in the developmental series……13

13 (14) Xenoma wall consists of granulo-fibrillar layer, spores throughout xenoma [Fig. 4.2.2C]…… ***Loma***

14 (13) Merogony and sporogony stages with conspicuous envelope [Fig. 4.2.2E] ……***Pleistophora***

15 (16) One pole of sporocyst bearing special structure (Stieda body) [Fig. 4.2.2I] …….. ***Eimeria***

16 (15) Sporocyst without Stieda body [Fig. 4.2.2J]……..***Goussia***

17 (18) Protists infecting surface (skin, fins, nasal pits or gills)…….. 19

18 (17) Protists infecting intestine, other internal organs or blood……55

19 (12) Organisms that move……21

20 (11) Sessile or motionless organisms attached to surface……29

21 (14) Protists with flagella or cilia on the cell surface ……23

22 (13) Cells with amoeboid movement and changes of body shape [Fig. 4.2.2A] ……***Entamoeba***

23 (16) Protists possessing 2 flagella, moving with jerky, creeping motion or swimming spirally forward (flagellates)……..25

24 (15) Protists 20 µm and larger, either covered uniformly with cilia or with several ciliary belts or circular ciliary wreath; they move directly forward, glide over the surface, or roll on the spot (ciliophorans)……..…41

25 (26) No mitochondrion present [Fig. 4.2.5F] ……..***Hexamita***

26 (25) Mitochondrion present …… 27

27 (28) Long tubular mitochondrion contains numerous nucleoids so that there are many small kinetoplasts throughout the body [Fig. 4.2.5G]…… ……. ***Ichthyobodo***

28 (27) Single branched mitochondrial ribbon forms massive, elongate kinetoplast on the ventral surface [Fig. 4.2.5H]…… ***Cryptobia***

29 (30) Refractile granules in cytoplasm……31

30 (29) Goblet-like or cylindrical, each with wide free end and encircled by wreaths of beating cilia; cells may contract a little (sessilines)…… 33

31 (32) Pyriform or sack-like flagellated protist, cytoplasm yellowish or greenish (parasitic dinoflagellates) [Fig. 4.2.2H]……***Piscinoodinium***

32 (31) Cytoplasm dark due to refractile granules, with bundles of tubules ending in knob-like shapes (suctorians) [Fig. 4.2.4D]……..***Capriniana***

33 (34) Sessilines attach directly to substrate via scopula……35

34 (33) Sessilines attach to substrate via a stalk……39

35 (36) Permanent locomotory equatorial fringe present [Fig. 4.2.5D]…… ……***Ambiphrya***

36 (35) Locomotory fringe of cilia only present in free-swimming larval stage …… ……..…….. 37

37 (38) Body elongate, macronucleus compact, conical or ellipsoidal [Fig. 4.2.5B] ……..***Apiosoma***

38 (37) Body cylindrical, macronucleus sausage-shaped [Fig. 4.2.5C]…… ……..***Riboscyphidia***

39 (40) Stalk highly contractile and unbranched [Fig. 4.2.5E]……***Vorticella***

40 (39) Stalk non-contractile, bearing a small colony of several zooids [Fig. 4.2.5A] ……***Epistylis***

41 (42) Cilia in distinct rows……43

42 (41) Cilia limited to aboral wreath (around concave adhesive disc) and an adoral spiral of cilia (feeding organelles at the opposite side of adhesive disc); aboral side with distinct adhesive disc consisting of prominent interlinking

denticles (mobilines)……45

43 (44) Ciliary rows limited to one surface of the organism……53

44 (43) Pyriform ciliophorans with 2-30 meridional kineties [Fig. 4.2.4F]…… ……***Tetrahymena***

45 (46) Adoral spiral makes a full turn or slightly more……47

46 (45) Adoral spiral makes less than one full turn……49

47 (48) Denticles have well-developed rays and blades [Fig. 4.2.6C]…… ……***Trichodina***

48 (47) Denticles have stunted blades [Fig. 4.2.6A]……***Hemitrichodina***

49 (50) Denticles have well-developed rays……51

50 (49) Denticles have rays that merely form small hooks [Fig. 4.2.6D]…… ……***Trichodinella***

51 (52) Denticles interlinked only by central parts [Fig. 4.2.6B]…… ……. ***Paratrichodina***

52 (51) Denticles interlinked by central parts, as well as by a prominent anterior projection of blades, fitting tightly into corresponding notches in blades of preceding denticles [Fig. 4.2.6E]……***Tripartiella***

53 (54) One side bears longitudinal or strongly arched ciliary rows [Fig. 4.2.4B] ……***Amphileptus***

54 (53) Ventral ciliature reduced to two longitudinal belts close to body margins [Fig. 4.2.4C]…….. ***Chilodonella***

55 (56) Protists in internal organs or urinary tract……57

56 (55) Protists in blood……..63

57 (58) Microsporidia (see 5; in any organ), coccidian oocysts (see 8; in intestine), or amoebae (see 22)

58 (57) Protists with surface showing cilia…… 59

59 (60) Cilia uniformly covering body of ciliophoran……..61

60 (59) Cilia limited to aboral wreath as well as an adoral spiral of cilia. The aboral side with distinct adhesive disc consisting of denticles (endoparasitic trichodinids) [Fig. 4.2.6C]…… ***Trichodina***

61 (62) Spindle-shaped cells, with both ends pointed, showing sluggish movement; two to many monomorphic nuclei [Fig. 4.2.2G]……***Protoopalina***

62 (61) Ciliophorans covered uniformly in longitudinal rows of cilia; single elongate macronucleus and single spherical micronucleus [Fig. 4.2.4A]…… …….. ***Balantidium***

63 (64) Motile protists, slender cells, typically 10-15 µm long, moving with a wriggling or undulating motion, with 1 or 2 flagella [Fig. 4.2.3D]…… ……...***Trypanosoma***

64 (63) Non-motile protists only visible in stained blood smears, found within blood cells…… 65

65 (66) Intraerythrocytic meronts (division stage showing more than one nuclei) and gamonts (sexual stage showing a single nucleus)…….. 67

66 (65) Intraerythrocytic gamonts only [Fig. 4.2.3C]…….***Desseria***

67 (68) Intraerythrocytic meronts rounded [Fig. 4.2.3A]……..***Babesiosoma***

68 (67) Intraerythrocytic meronts vermicular (wormlike) [Fig. 4.2.3B]……***Cyrilia***

Fig. 4.2.1. A. Life cycles of the ciliophoran *Ichthyophthirius multifiliis* Fouquet, 1876 (direct life cycle without intermediate hosts); **B.** The blood kinetoplastid *Trypanosoma* sp. (indirect life cycle where leeches serve as intermediate hosts). (Illustration by M. Luo.)

Table 4.2.1. Classification system for the protists according to Adl *et al.* (2012).

Supergroup	First rank	Second rank – examples
AMOEBOZOA	Archamoebae	Entamoebidae (*Entamoeba*)
OPISTHOKONTA	Holozoa	Ichthyosporea (*Dermocystidium*)
	Nucletmycea	Fungi (*Eimeria*, *Glugea*, *Loma*, *Neonosemoides*, *Pleistophora*, *Unikaryon*)
EXCAVATA	Diplomonanida	Hexamitinae (*Hexamita*)
	Euglenozoa	Prokinetoplastina (*Cryptobia*, *Ichthyobodo*, *Trypanosoma*)
SAR	Stramenopiles	Opalinata (*Protoopalina*)
	Alveolata	Dinoflagellata (*Piscinoodinium*)
		Apicomplexa (*Babesiosoma*, *Cyrilia*, *Desseria*, *Eimeria*, *Goussia*, haemogregarines)
SAR	Alveolata	Ciliophora; Trichostomatia* (*Amphiletus*, *Balantidium*) Phyllopharyngea* (*Chilodonella*) Suctoria** (*Capriniana*), Oligohymenophorea*; Hymenostomatia** (*Ichthyophthirius*, *Tetrahymena*) Oligohymenophorea*; Peritrichia** (*Ambiphrya*, *Apiosoma*, *Epistylis*, *Hemitrichodina*, *Paratrichodina*, *Riboscyphydia*, *Trichodina*, *Trichodinella*, *Tripartiella*, *Vorticella*)

* fifth rank; ** sixth rank

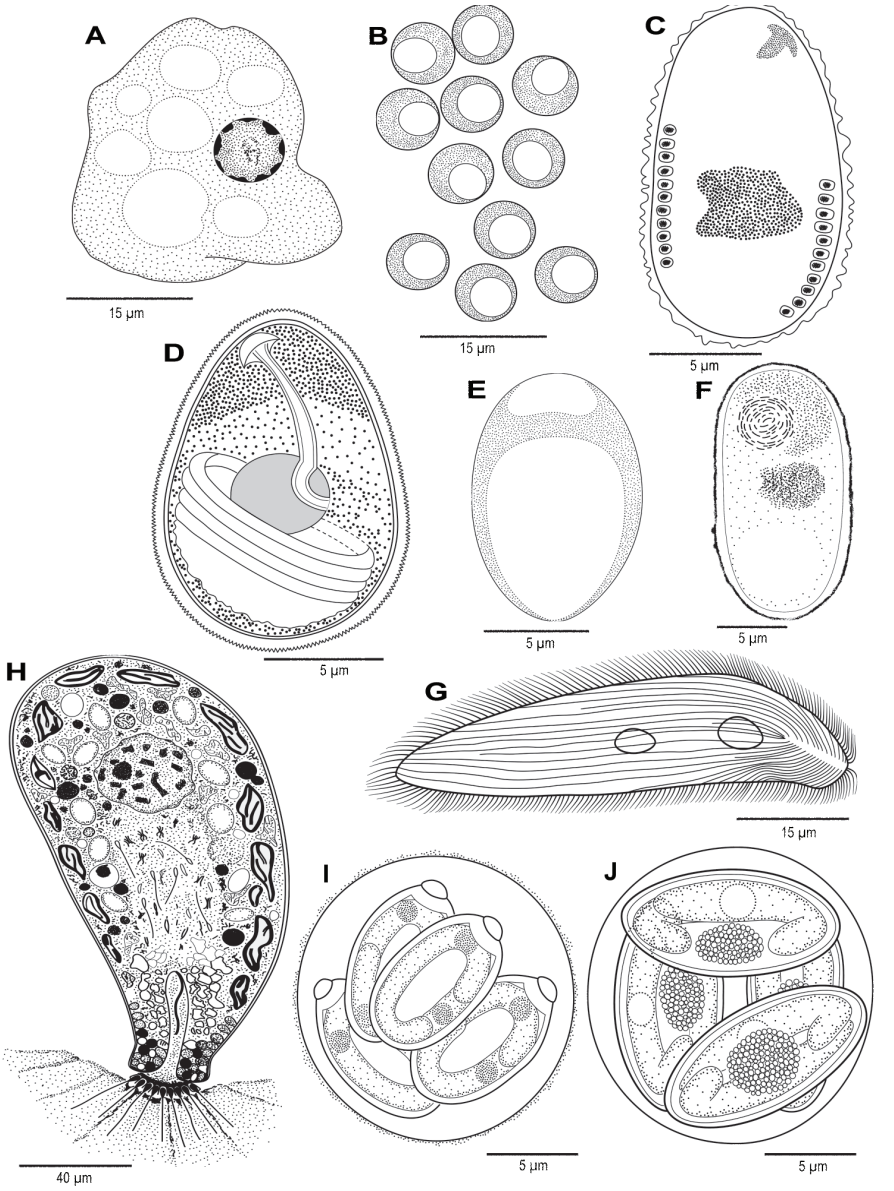

Fig. 4.2.2. Schematic line drawings of fish-infecting eukaryotic microorganisms (EMs). **A.** *Entamoeba salpae* (Alexeieff, 1912) from *Boops salpa*; **B.** *Dermocystidium branchiale* Léger, 1914 from *Salmo trutta*; **C.** *Loma camerounensis* Fomena, Coste et Bouix, 1992 from *Oreochromis niloticus*; **D.** *Neonosemoides* sp. from *Chrysichthys auratus*; **E.** *Pleistophora elegans* Auerbach, 1910 from *Alburnus alburnus*; **F.** *Unikaryon nomimoscolexi* Sene, Ba, Marchand et Toguebaye, 1997 from *Clarotes laticeps*; **G.** *Protoopalina symphysodonis* Foissner, Schubert et Wilbert, 1974 from *Symphysodon aequifasciata*; **H.** *Piscinoodinium pillulare* (Schäperclaus, 1954) from *Poecilia reticulata*; **I.** *Eimeria variabilis* (Thélohan, 1893) from *Cottus bubalis*; **J.** *Goussia anopli* Molnár, Avenant-Oldewage et Székely, 2004 from *Enteromius anoplus*. (Modified from Davies 1978; Fomena *et al.* 1992; Lom & Dyková 1992; Sene *et al.* 1997; Molnár *et al.* 2004; Reda 2010.)

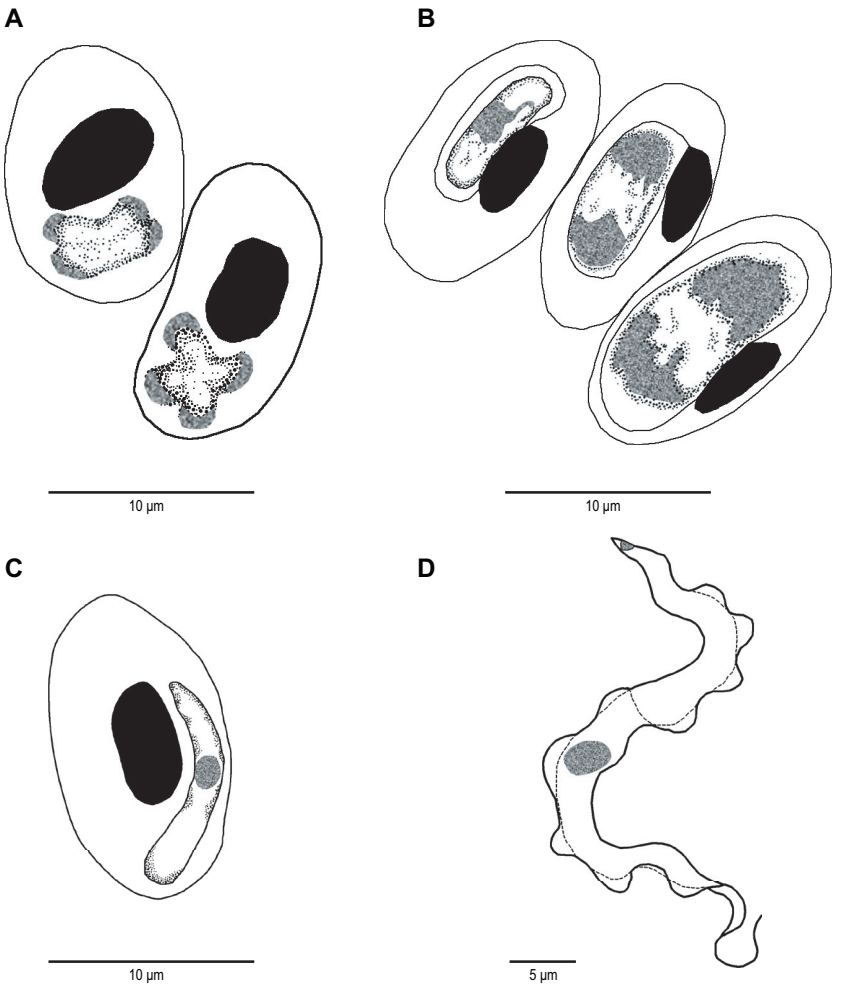

Fig. 4.2.3. Schematic line drawings of blood parasites reported from the peripheral blood of African freshwater fishes; **A.** Left to right: young meront in division and characteristic mature cruciform meront with four merozoites of *Babesiosoma mariae* (Hoare, 1930) from various freshwater fish species; **B.** Left to right: gamont, young meront and mature meront stage of *Cyrilia gomesi* (Neiva et Pinto, 1926) from *Synbranchus marmoratus*; **C.** Gamont stage of *Desseria* sp. from *Mugil cephalus*; **D.** Trypomastigote stage of *Trypanosoma mukasai* Hoare, 1932 from a freshwater fish. (Modified from Hoare 1930, 1932; Lainson 1981; Smit *et al.* 2002.)

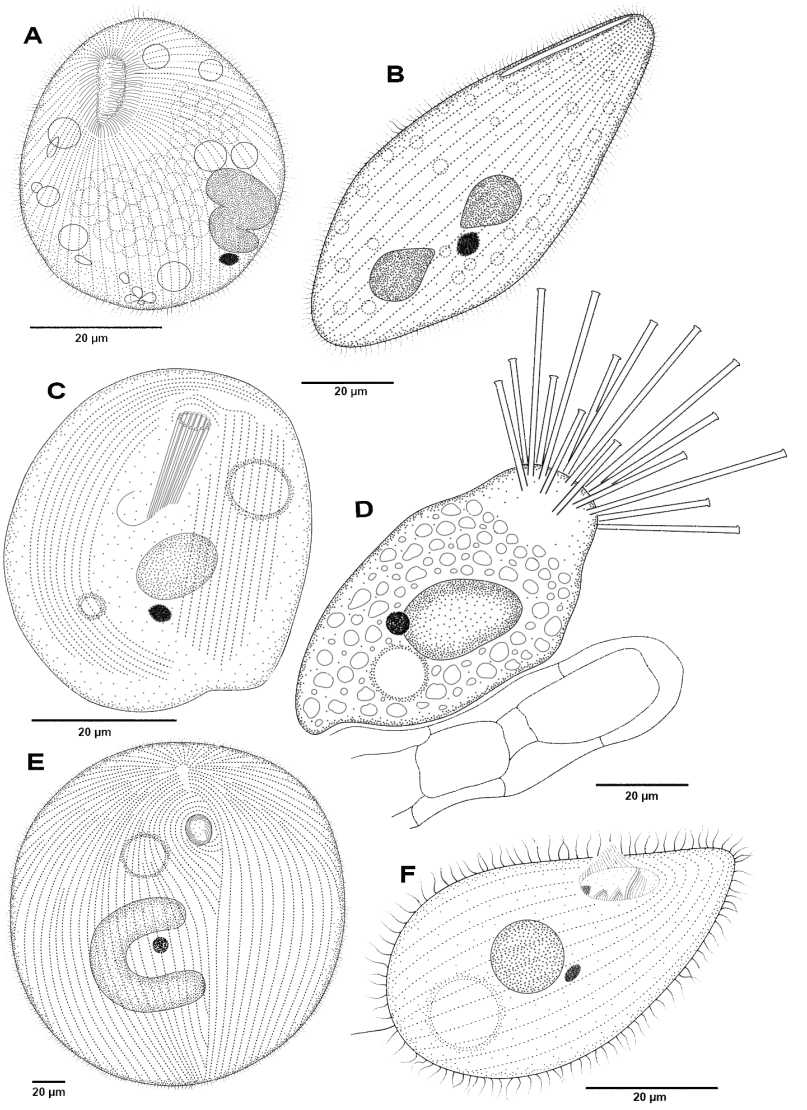

Fig. 4.2.4. Schematic line drawings of ciliophorans. **A.** *Balantidium polyvacuolum* Li, 1963 from *Xenocypris argentea*; **B.** *Amphileptus branchiarum* Wenrich, 1924 from a freshwater fish; **C.** *Chilodonella piscicola* (Zacharias, 1894) from *Tilapia sparrmanii*; **D.** *Capriniana piscium* (Buetschli, 1889) from *Perca fluviatilis*; **E.** *Ichthyophthirius multifiliis* Fouquet, 1876 from *Oreochromis mossambicus*; **F.** *Tetrahymena corlissi* Thompson, 1955 from a freshwater fish. (Modified from Li 1963; Lom & Dyková 1992.)

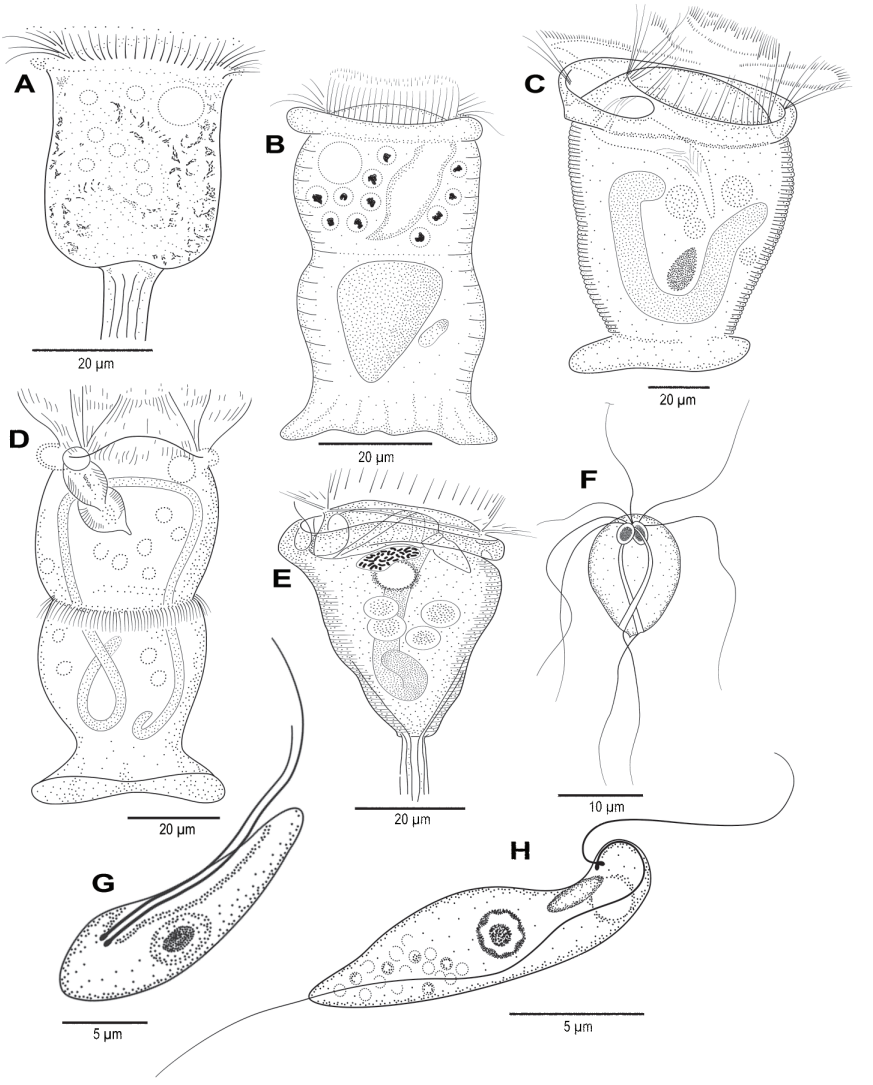

Fig. 4.2.5. Schematic line drawings. **A.** *Epistylis transvaalensis* Viljoen et Van As, 1983 from *Pseudocrenilabrus philander*; **B.** *Apiosoma dermatum* Viljoen et Van As, 1983 from *Oreochromis mossambicus*; **C.** *Riboscyphidia arctica* (Zhukov, 1962) from *Liparis* sp.; **D.** *Ambiphrya neobolae* Viljoen et Van As, 1985 from *Neobola brevianalis*; **E.** *Vorticella* sp. from a freshwater fish; **F.** *Hexamita salmonis* (Moore, 1923) from *Salmo trutta*; **G.** *Ichthyobodo necator* (Henneguy, 1883) from *Cyprinus carpio*; **H.** *Cryptobia branchialis* Nie in Chen, 1955 from *Clarias gariepinus*. (Modified from Viljoen & Van As 1983, 1985; Lom & Dyková 1992; Lom & de Puytorac 1994.)

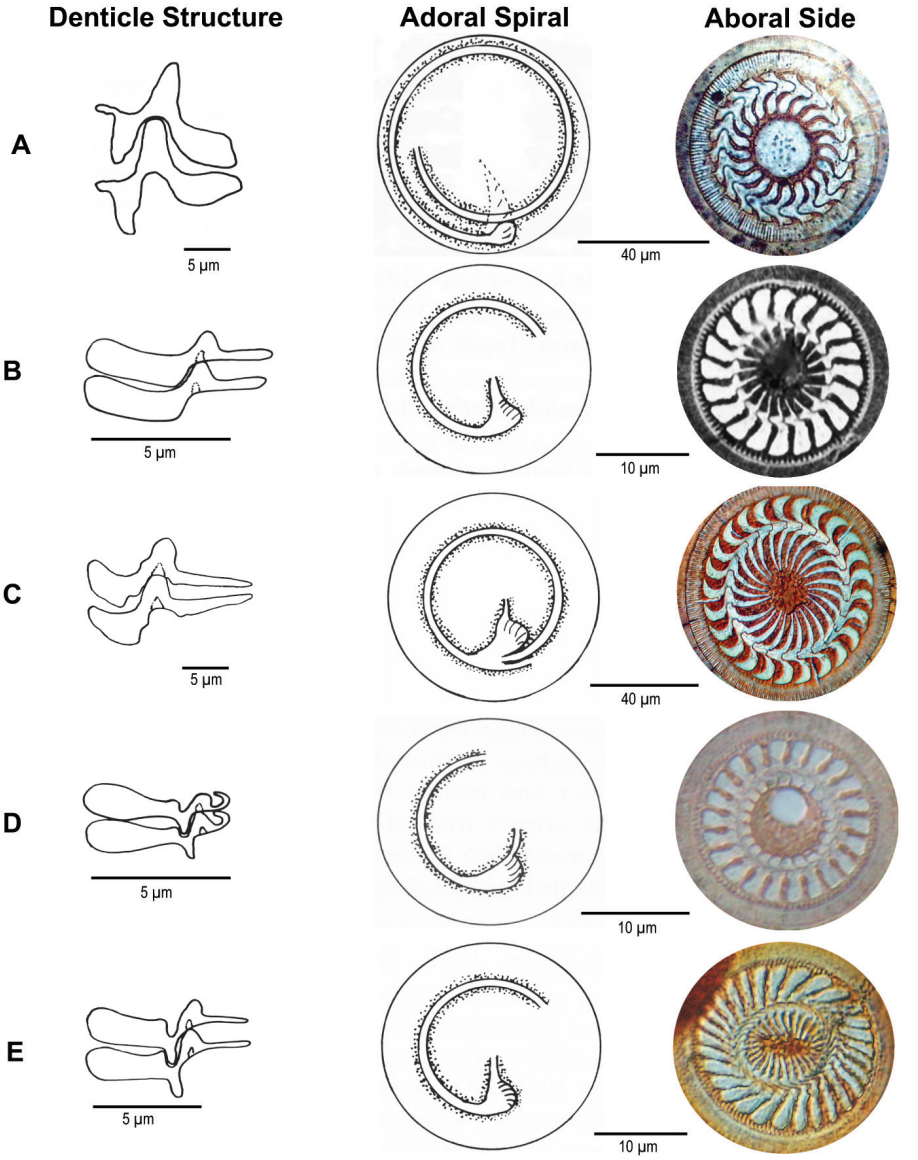

Fig. 4.2.6. Schematic line drawings and silver impregnated adhesives discs of five genera of trichodinids. **A.** *Hemitrichodina robusta* Basson et Van As, 1989 from *Marcusenius macrolepidotus*; **B.** *Paratrichodina corlissi* Lom et Haldar, 1977 from *Gobio* sp.; **C.** *Trichodina magna* Van As et Basson, 1989 from *Oreochromis mossambicus*; **D.** *Trichodinella epizootica* (Raabe, 1950) from *Enteromius paludinosus*; **E.** *Tripartiella ctenopomae* Basson et Van As, 2002 from *Ctenopoma multispine*. (Modified from Basson & Van As, 1989; micrographs by L. Basson except for B, which was provided by the late J. Lom.)

AMOEBOZOA Lühe, 1913

Archaomoebae Cavalier-Smith, 1983 – **Entamoebidae** Chatton, 1925

Amoeboid organisms – basic characteristics

- amoebae infecting fish either specific endocommensals or free-living (see Dyková 2008)
- only species of *Entamoeba* reported from African fishes
- cilia and centrioles absent
- contain mitosomes instead of classical mitochondria
- peroxisome-absent
- mitosis closed with endonuclear centrosomes and spindle
- reduced Golgi dictyosome

List of amoeboid protists in African freshwater fishes

Note: Dyková *et al.* (2005) characterised 17 strains of flattened amoebae from fishes obtained from various sources and deposited at the Institute of Parasitology, Biology Centre of the Czech Academy of Sciences. Mention is made of two freshwater strains imported from Africa, both from the gills of *Clarias angolensis* that formed part of the analyses in their study.

Entamoeba Cassagrandi et Barbagallo, 1895

Entamoeba synodontis Imam, Ramadan and Derahlli, 1987 from ***Synodontis schall*** (Egypt)*

Entamoeba sp. on the skin and gills of *Clarias gariepinus* [Fig. 4.2.2A]

OPISTHOKONTA Cavalier-Smith, 1987

Ichthyosporea Cavalier-Smith, 1998 – **Rhinosporidaceae** Mendoza *et al.*, 2001

Ichthyosporeans – basic characteristics

- posterior cilia, if cilia present
- flat mitochondrial cristae present (folds of mitochondrial inner membrane)
- parasitic forms spherical phenotypes with several endospores 2-20 µm in diameter eventually released, becoming mature cells with endospores to continue with the parasitic cycle

List of ichthyosporeans from African freshwater fishes

Dermocystidium Pérez, 1908

Dermocystidium sp. on the skin of *Carassius auratus* and *Cyprinus carpio* [Fig. 4.2.2B]

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*The type species of parasite genera and type host of species are highlighted in bold. The country where the type locality lies is also provided if known.

Fungi Moore, 1980 – **Microsporidia** Balbiani, 1882

Microsporidia – basic characteristics

- parasites of nearly all animal phyla, with the majority of species associated with arthropods and fishes
- obligate intracellular parasites, usually of animals
- mitochondria reduced to mitosomes
- spores with inner chitin walls and outer proteinaceous walls
- without kinetosomes, centrioles or cilia
- centrosomal plaque
- extrusive specialised polar tube for host penetration
- reproduction sexual, asexual or both
- systematic subdivisions uncertain at this time
- many of those genera that are found as parasites in fishes exhibit a complex coexistence with their host cell that includes a special type of hypertrophy, forming structures known as xenomas
- about 100 microsporidian species known from fishes (see Lom 2002)

List of microsporidians from African freshwater fishes

Loma Morrison et Sprague, 1981

Loma camerounensis Fomena, Coste et Bouix, 1992 in subepithelial connective tissue of the intestine of ***Oreochromis niloticus*** (Cameroon) [Fig. 4.2.2C]

Neonosemoides Faye, Toguebaye et Bouix, 1996

Neonosemoides tilapiae Faye, Toguebaye et Bouix, 1996 in the stomach of ***Coptodon guineensis*** (Senegal)

Neonosemoides sp. in the gills of *Chrysichthys auratus* [Fig. 4.2.2D]

Pleistophora Gurley, 1893

Pleistophora-like species in the swim-bladder of *Haplochromis angustifrons* and *H. elegans* [Fig. 4.2.2E]

Unikaryon Canning, Lai et Lie, 1974

Unikaryon nomimoscolexi Sene, Ba, Marcand et Toguebaye, 1997 in the cestode *Nomimoscolex* sp. from ***Clarotes laticeps*** (Senegal), *i.e.*, hyperparasite [Fig. 4.2.1F] [the cestode was certainly misidentified as species of *Nomimoscolex* occur in the Neotropical region; it was most likely *Proteocephalus sulcatus* – see Chapter 4.6]

Unidentified microsporidia

Microsporidia gen. sp. from *Clarias gariepinus* (cystozoic), *Oreochromis niloticus* (skin and gills), *Parachanna obscura*, *Synodontis schall*, *S. ocellifer* (both in stomach and intestine)

SAR (Alveolata, Rhizaria and Stramenopiles)

Stramenopiles Patterson, 1989 – **Opalinata** Wenyon, 1926

Opalins – basic characteristics

- slowly swimming large protists
- covered with numerous cilia arranged in longitudinal, or slightly helicoidal, densely spaced rows
- multiciliated cells with cilia originating from anterior morphogenetic centre, the falx, forming oblique longitudinal rows or files
- microtubular ribbons supporting longitudinal pellicular ridges between ciliary rows
- two to many monomorphic nuclei
- life cycle complex, with sexual processes induced by hormones of host and linked to host's life cycle
- endobionts in amphibians and some fishes (Adl *et al.* 2012).

List of opalins from African freshwater fishes

Protoopalina Metcalf, 1918

Protoopalina sp. in the intestine of *Clarias gariepinus* [Fig. 4.2.2G]

Alveolata Cavalier-Smith, 1991 – **Dinoflagellata** Bütschli, 1885

Dinoflagellates – basic characteristics

- dinoflagellates in fishes with the parasitic stage in the life cycle predominating over the dinospore stage
- cells with two cilia in motile stage
- nucleus typically a dinokaryon (nucleus where chromosomes are fibrillar in appearance and condensed)
- closed dinomitosis (mitosis specifically involving dinokaryon) with extra nuclear spindle

List of dinoflagellates from African freshwater fishes

Piscinoodinium Lom, 1981

Piscinoodinium sp. in the skin and gills of *Clarias gariepinus* [Fig. 4.2.2H]

Apicomplexa Levine, 1980 **– Coccidia** Leuckart, 1879 **(Eimeriorina** Léger, 1911**)**

Coccidia – basic characteristics

- elaborate and intricate apical complex always present
- oocysts always formed

- sporozoites with a three-layered pellicle
- micro- and macrogametes develop independently
- microgamonts produce large numbers of ciliated microgametes
- zygote nonmotile
- sporozoites always enclosed in sporocyst within oocysts

List of coccidia from African freshwater fishes

Eimeria Schneider, 1875

Eimeria sp. from *Clarias* spp. (intestine) and *Synodontis schall* [Fig. 4.2.2I]

Goussia Labbé, 1896

Goussia anopli Molnár, Avenant-Oldewage et Székely, 2004 in mucus and epithelium of the foregut of ***Enteromius anoplus*** (South Africa) [Fig. 4.2.2J]

Goussia cichlidarum Landsberg et Paperna, 1985 in the swim bladder of *Coptodon zillii*, *Oreochromis aureus*, *O. niloticus*, ***Oreochromis* sp.** (Uganda)

Goussia molnarica El-Mansy, 2008 in the intestine of ***Clarias gariepinus*** (Egypt)

Goussia vanasi (Landsberg et Paperna, 1987) [syn. *Eimeria vanasi* Landsberg and Paperna, 1987] in the intestine of *Oreochromis mossambicus*, *Pseudocrenilabrus philander*, *Tilapia sparrmanii* (South Africa)

Coccidia sp. in the intestine of *Chrysichthys nigrodigitatus*

Apicomplexa Levine, 1980 **– Coccidia** Leuckart, 1879 **(Adeleorina** Léger, 1911**)**

Haemogregarines – basic characteristics

- obligate endoparasitic intracellular protists in the blood of a range of vertebrates
- transmitted by invertebrate haematophagous vectors (flies, bugs, ticks and leeches)
- around 400 species recorded globally in vertebrates and invertebrate vectors
- apical complex in infective stages (merozoites, sporozoites)
- heteroxenous, asexual development (including merogony and gamogony) in vertebrate host
- sexual development (including gametogenesis, syngamy, ookinete formation and sporogony) in invertebrate vector
- transfer of infective stages to and from the invertebrate vector presumed to be inoculative
- leeches implicated as the invertebrate vector for most African genera

List of haemogregarines from African freshwater fishes

Babesiosoma Jakowski et Nigrelli, 1956

Babesiosoma hannesi (Paperna, 1981) from *Chelon dumerili*, *Chelon richardsonii*, ***Mugil cephalus*** (South Africa) [Fish inhabiting marine, freshwater and brackish systems.]

Babesiosoma mariae (Hoare, 1930) [syn. *Dactylosoma mariae* Hoare, 1930] from *Astatoreochromis alluaudi*, *Haplochromis cinereus*, *H. nubilus*, *H. serranus*, ***Haplochromis* spp**. (Uganda), *Labeo victorianus*, *Oreochromis esculentus*, *O. niloticus*, *O. variabilis*, *Serranochromis angusticeps* [Fig. 4.2.3A]

Cyrilia Lainson, 1981

Cyrilia nili (Wenyon, 1909) [syn. *Haemogregarina nili*] from ***Parachanna obscura*** (Sudan) [Fig. 4.2.3B]

Desseria Siddall, 1995

Desseria sp. from *Mugil cephalus* [This species was described in detail by Smit *et al.* (2002), but not named. As such it has been provisionally included here.] [Fig. 4.2.3C]

Haemogregarine gen. sp. from *Synodontis schall*

Ciliophora Doflein, 1901

Ciliophorans – basic characteristics

- among the most common and widely distributed symbionts of fishes, whether as parasites or as ecto- and endocommensals
- monograph by Lynn (2008) gives an overview of these organisms
- highly organised protists with a pellicle covering cell body
- pellicle covered by cilia, may be grouped to form compound ciliary organelles
- ciliature may be reduced in some groups, or completely absent
- infraciliature (complex fibrillar network) associated with cilia's basal bodies
- one to several diploid macronuclei and one to several polyploid macronuclei
- transverse (homothetogenic) binary fission, rarely budding or multiple fission
- conjugation occurs as sexual reproduction process
- complex buccal apparatus used for feeding, but some groups secondarily astome
- found on the surface or inside animal hosts (variety of symbiotic associations with hosts)

List of ciliophorans from African freshwater fishes

In the following survey, ciliophorans are listed according to their 5th and 6th taxonomic rank (see Table 4.2.1), *i.e.*, Trichostomatia (genera *Amphileptus* and *Balantidium*), Phyllopharyngea (*Chilodonella*), Suctoria (*Capriniana*), Oligohymenophorea – Hymenostomatia (*Ichthyophthirius* and *Tetrahymena*), Oligohymenophorea – Peritrichia (Sessilida: *Ambiphrya*, *Apiosoma*, *Epistylis*, *Riboscyphidia*, *Vorticella*), and Oligohymenophorea – Peritrichia (Mobilida: *Hemitrichodina*, *Paratrichodina*, *Trichodina*, *Trichodinella*, *Tripartiella*).

Trichostomatia Bütschli, 1889

Amphileptus Ehrenberg, 1830

Amphileptus niloticus El-Tantawy, Abdel-Aziz, Abou El-Nour, Samn, Shaldoum et Rady, 2016 on the skin and gills of ***Lates niloticus*** (Egypt)

Amphileptus sp. on the gills of *Clarias gariepinus*, *Lates niloticus*, *Sarotherodon galilaeus* [Fig. 4.2.4B]

Balantidium Claparède et Lachmann, 1858

Balantidium sp. from *Clarias gariepinus* and *Synodontis schall* [Fig. 4.2.4A]

Phyllopharyngea de Puytorac *et al.*, 1974

Chilodonella Strand, 1926

Chilodonella hexasticha (Kiernik, 1909) on the skin, fins and gills of *Carassius auratus*, *Clarias gariepinus*, *Coptodon rendalli*, *C. zillii*, *Enteromius paludinosus*, *Oreochromis mossambicus*, *O. niloticus*, *Pseudocrenilabrus philander*, *Sarotherodon galilaeus*, *Tilapia sparrmanii*

Chilodonella piscicola (Zacharias, 1894) [syn. *C. cyprini* (Moroff, 1902)] from *Coptodon rendalli*, *Oreochromis mossambicus*, *Pseudocrenilabrus philander*, *Tilapia sparrmanii* [Fig. 4.2.4C]

Chilodonella sp. on the skin and gills of *Clarias gariepinus*, *Clarias* sp., *Cyprinus carpio*, *Heterobranchus bidorsalis*, *H. longifilis*, *Oreochromis mossambicus*, *O. niloticus*, *Synodontis schall*

Suctoria Claparède et Lachmann, 1858

Capriniana Mazzarelli, 1906 [syn. *Trichophrya* Claparède et Lachmann, 1858]

Capriniana sp. on the skin and gills of *Clarias gariepinus* [Fig. 4.2.4D]

Oligohymenophorea de Puytorac *et al.*, 1974 – **Hymenostomatia** Delage et Hérouard, 1896

Ichthyophthirius Fouquet, 1876

Ichthyophthirius multifiliis Fouquet, 1876 on the skin, fins and gills of *Anguilla mossambica*, *Carassius auratus*, *Chrysichthys auratus*, *Clarias gariepinus*, *Cyprinus carpio*, *Enteromius paludinosus*, *Heterobranchus longifilis*, *Labeobarbus aeneus*,

Oncorhynchus mykiss, *Oreochromis mossambicus*, *O. niloticus*, *Poecilia reticulata*, *Salmo trutta* [Fig. 4.2.4E]

Ichthyophthirius sp. on the skin and gills of *Carassius auratus*, *Clarias gariepinus*, *Oreochromis niloticus*, *Synodontis schall*

Tetrahymena Furgason, 1940

Tetrahymena corlissi Thompson, 1955 on the skin of *Sarotherodon galilaeus* [Fig. 4.2.4F]

Tetrahymena pyriformis (Ehrenberg, 1830) on the skin and gills of *Coptodon zillii*, *Cyprinus carpio*, *Enteromius paludinosus*, *Oreochromis leucostictus*

Tetrahymena sp. on the skin and gills of *Clarias gariepinus*, *Lates niloticus*

Oligohymenophorea de Puytorac *et al.*, 1974 – **Peritrichia** Stein, 1859 (Sessilida Kahl, 1935)

Ambiphrya Raabe, 1952

Ambiphrya ameiuri Davis, 1947 on the skin and gills of *Lates niloticus*, *Sarotherodon galilaeus*

Ambiphrya neobolae Viljoen et Van As, 1985 on the skin of ***Mesobola brevianalis*** (South Africa) [Fig. 4.2.5D]

Ambiphrya sp. on the skin and gills of *Clarias gariepinus*, *Lates niloticus*

Apiosoma Blanchard, 1885 [syns *Glossatella* Bütschli, 1889; *Scopulata* Viljoen and Van As, 1985]

Apiosoma amoebae (Grenfell, 1887) [syn. *Glossatella amoebae* Grenfell, 1887] on the gills of *Lates niloticus*

Apiosoma caulata Viljoen et Van As, 1985 on the skin and gills of ***Mesobola brevianalis*** (South Africa)

Apiosoma conica Shulman, 1984 on the gills of *Coptodon zillii*

Apiosoma constricta (Viljoen et Van As, 1985) [syn. *Scopulata constricta* Viljoen et Van As, 1985] on the skin of *Coptodon rendalli*, *Enteromius trimaculatus*, *Marcusenius macrolepidotus*, *Micralestes acutidens*, ***Oreochromis mossambicus*** (South Africa)**,** *Pseudocrenilabrus philander*, *Tilapia sparrmanii*

Apiosoma curvinucleata Viljoen et Van As, 1985 on the skin of ***Oreochromis mossambicus*** (South Africa)

Apiosoma dermatum (Viljoen et Van As, 1983) [syn. *Scopulata dermata* Viljoen et Van As, 1983] on the skin of *Coptodon rendalli, Enteromius trimaculatus*, *Marcusenius macrolepidotus*, *Micralestes acutidens*, ***Oreochromis mossambicus*** (South Africa), *Pseudocrenilabrus philander*, *Tilapia sparrmanii* [Fig. 4.2.5B]

Apiosoma doliaris Timofeev, 1962 on the gills of *Lates niloticus*

Apiosoma epibranchialis (Viljoen et Van As, 1983) [syn. *Scopulata epibranchialis* Viljoen et Van As, 1983] on the skin of *Lates niloticus*, *Micropterus dolomieu*, *Oreochromis mossambicus*, ***Pseudocrenilabrus philander*** (South Africa), *Sarotherodon galilaeus*

Apiosoma micralesti Viljoen et Van As, 1985 on the skin of ***Micralestes acutidens*** (South Africa)

Apiosoma mothlapitsis Viljoen et Van As, 1985 on the skin of ***Labeobarbus marequensis*** (South Africa)

Apiosoma nasalis (Timofeev, 1962) [syn. *Glossatella nasalis* Timofeev, 1962] on the skin and gills of *Pseudocrenilabrus philander*

Apiosoma obliqua Viljoen et Van As, 1985 on the skin of ***Labeo cylindricus*** (South Africa)

Apiosoma phiala Viljoen et Van As, 1985 on the skin of ***Enteromius trimaculatus*** (South Africa), *E. marequensis*, *E. paludinosus*, *E. unitaeniatus*, *Labeo capensis*, *L. cylindricus*, *Mesobola brevianalis*, *Oreochromis mossambicus*, *Pseudocrenilabrus philander*

Apiosoma piscicola Blanchard, 1885 on the skin and gills of *Coptodon rendalli*, *C. zillii*, *Enteromius paludinosus*, *E. trimaculatus*, *Labeo cylindricus*, *Lates niloticus*, *Marcusenius macrolepidotus*, *Micropterus dolomieu*, *Oreochromis mossambicus*, *Pseudocrenilabrus philander*

Apiosoma poteriformis (Timofeev, 1962) [syn. *Glossatella poteriformis* Timofeev, 1962] on the gills of *Lates niloticus*

Apiosoma viridis Viljoen et Van As, 1985 on the skin of *Chetia flaviventris*, *Coptodon rendalli*, *Oreochromis mossambicus*, ***Pseudocrenilabrus philander*** (South Africa), *Tilapia sparrmanii*

Apiosoma sp. on the skin and gills of *Oncorhynchus mykiss*, *Synodontis schall*

Epistylis Ehrenberg, 1830

Epistylis transvaalensis Viljoen et Van As, 1983 on the skin of ***Pseudocrenilabrus philander*** (South Africa)

Epistylis sp. on the skin and gills of *Clarias gariepinus*, *Enteromius paludinosus*, *Oreochromis leucostictus*, *O. niloticus* [Fig. 4.2.5A]

Riboscyphidia Jankovski, 1985 (syn. *Scyphidia* Dujardin, 1841, *partim*)

Riboscyphidia doliaris (Chernova, 1977) [syn. *Scyphidia doliaris* Chernova, 1977] on the skin and gills of *Lates niloticus*

Riboscyphidia globularis (Solomatova, 1977) [syn. *Scyphidia globularis* Solomatova, 1977] on the skin and gills of *Lates niloticus*

Riboscyphidia mansourensis (El-Tantawy, Abdel-Aziz, Abou El-Nour, Samn, Shaldoum et Rady, 2016) [syn. *Scyphidia mansourensis* El-Tantawy, Abdel-Aziz, Abou El-Nour, Samn, Shaldoum et Rady, 2016] on the skin and gills of ***Lates niloticus*** (Egypt)

Riboscyphidia sp. on the gills and skin of *Chrysichthys auratus*, *Lates niloticus* [Fig. 4.2.5C]

Vorticella Linnaeus, 1767

Vorticella sp. on the gills and skin of *Clarias gariepinus*, *Sarotherodon galilaeus* [Fig. 4.2.5E]

Oligohymenophorea de Puytorac *et al.*, 1974 – **Peritrichia** Stein, 1859 (order Mobilida Kahl, 1933)

List of trichodinids (Mobilida) in African freshwater fishes

Hemitrichodina Basson et Van As, 1989

Hemitrichodina robusta Basson et Van As, 1989 on the skin and fins, occasionally gills of *Hepsetus cuvieri*, ***Marcusenius macrolepidotus*** (South Africa), *Micralestes acutidens* [Fig. 4.2.6A]

Paratrichodina Lom, 1963

Paratrichodina africana Kazubski et El-Tantawy, 1986 on the gills, rarely body surface of *Lates niloticus*, ***Oreochromis niloticus*** (Egypt), *Sarotherodon galilaeus*, *Tilapia* sp. [Fig. 4.2.6B]

Trichodina Ehrenberg, 1838

Trichodina acuta Lom, 1961 on the skin of *Oncorhynchus mykiss*

Trichodina anabantidarum Basson et Van As, 2002 on the gills, sometimes skin and fins of *Ctenopoma multispine*, ***Microctenopoma intermedium*** (Botswana)

Trichodina centrostrigeata Basson, Van As et Paperna, 1983 on the gills, sometimes skin and fins of *Brycinus lateralis*, *Coptodon rendalli*, *Cyprinus carpio*, *Enteromius* sp., *Hemichromis elongatus*, *Labeo cylindricus*, *Lates niloticus*, *Oreochromis andersonii*, *O. mossambicus*, *O. niloticus*, ***Pseudocrenilabrus philander*** (South Africa), *Serranochromis angusticeps*, *Synodontis leopardinus*, *Tilapia sparrmanii*

Trichodina compacta Van As et Basson, 1989 on the skin and fins of *Chetia flaviventris*, *Chiloglanis pretoriae*, ***Coptodon rendalli*** (South Africa)**,** *Cyprinus carpio*, *Enteromius eutaenia*, *E. radiatus*, *E. trimaculatus*, *Labeo cylindricus*, *Labeobarbus kimberleyensis*, *L. marequensis*, *Lates niloticus*, *Marcusenius macrolepidotus*, *Mesobola brevianalis*, *Micropanchax johnstoni*, *Nannocharax multifasciatus*, *Oreochromis andersonii*, *O. mossambicus*, *Petrocephalus catostoma*, *Pharyngochromis darlingi*, *Pseudocrenilabrus philander*, *Sarotherodon galilaeus*, *Serranochromis angusticeps*, *Tilapia sparrmanii*

Trichodina equatorialis Kazubski, 1986 on the gills of ***Tilapia* sp**. (Kenya)

Trichodina fahaka Al-Rasheid, Ali, Sakran, Abdel-Baki et Abdel Ghaffar, 2000 on the gills of ***Tetraodon lineatus*** [syn. *Tetraodon fahaka*] (Egypt)

Trichodina frenata Van As et Basson, 1992 on the gills of *Lates niloticus*, ***Mastacembelus frenatus*** (Namibia), *Sarotherodon galilaeus*

Trichodina heterodentata Duncan, 1977 on the skin, fins and gills of *Chetia flaviventris*, *Coptodon rendalli*, *Cyprinus carpio*, *Enteromius eutaenia*, *E. paludinosus*, *E. trimaculatus*, *Glossogobius giuris*, *Hydrocynus forskahlii*, *Labeo cylindricus*, *Labeobarbus marequensis*, *Marcusenius macrolepidotus*, *Mesobola brevianalis*, *Micralestes acutidens*, *Micropanchax johnstoni*, *Micropterus salmoides*, *Oreochromis*

mossambicus, *O. niloticus, Petrocephalus catostoma*, *Pseudocrenilabrus philander*, *Synodontis zambezensis*, *Tilapia sparrmanii*

Trichodina kalimbeza Van As et Basson, 1992 on the skin and fins of ***Enteromius fasciolatus*** (Namibia)

Trichodina kazubski Van As et Basson, 1989 on the skin, fins and gills of ***Enteromius paludinosus*** (South Africa), *E. trimaculatus*

Trichodina kwando Van As et Basson, 1992 on the gills, rarely skin and fins of ***Brycinus lateralis*** (Namibia), *Micralestes acutidens*

Trichodina labyrinthipicis Basson et Van As, 2002 on the gills, rarely skin of *Ctenopoma multispine*, ***Microctenopoma intermedium*** (Botswana)

Trichodina lepsii Lom, 1962 from *Lates niloticus*

Trichodina linyanta Van As et Basson, 1992 on the skin and gills of *Hemichromis elongatus*, ***Oreochromis andersonii*** (Namibia)

Trichodina magna Van As et Basson, 1989 on the skin and fins, occasionally gills of *Clarias gariepinus*, ***Coptodon rendalli*** (South Africa), *C. zillii*, *Hepsetus cuvieri*, *Lates niloticus*, *Marcusenius macrolepidotus*, *Mesobola brevianalis*, *Micropanchax johnstoni*, *Micropterus salmoides*, *Oreochromis andersonii*, *O. mossambicus*, *O. niloticus*, *Petrocephalus catostoma*, *Pseudocrenilabrus philander*, *Sarotherodon galilaeus*, *Schilbe mystus*, *Serranochromis angusticeps*, *Tilapia sparrmanii* [Fig. 4.2.6C]

Trichodina maritinkae Basson et Van As, 1991 on the gills of *Clarias stappersii*, ***C. gariepinus*** (South Africa), *Heterobranchus longifilis*

Trichodina matsu Basson et Van As, 1994 on the gills of *Clarias gariepinus*

Trichodina microspina Van As et Basson, 1992 on the skin and fins, occasionally gills of ***Ctenopoma multispine*** (Namibia), *Microctenopoma intermedium*

Trichodina minuta Basson, Van As et Paperna, 1983 from the skin, fins and gills of *Enteromius trimaculatus*, *Hemichromis elongatus*, ***Oreochromis mossambicus*** (South Africa), *Pseudocrenilabrus philander*, *Tilapia sparrmanii*

Trichodina mutabilis Kazubski et Migala, 1968 on the skin and gills of *Carassius auratus*, *Oreochromis niloticus*

Trichodina ngoma Van As et Basson, 1992 on the skin, fins and gills of ***Nannocharax multifasciatus*** (Namibia)

Trichodina nigra Lom, 1961 on the skin, fins and gills of *Enteromius paludinosus*, *Oreochromis mossambicus*, *Pseudocrenilabrus philander*, *Tilapia sparrmanii*

Trichodina nkasa Van As et Basson, 1992 on the gills of *Synodontis leopardinus*, ***S. macrostigma*** (Namibia)

Trichodina nobilis Chen, 1963 on the skin and gills of *Cyprinus carpio*

Trichodina rectuncinata Raabe, 1958 from *Clarias gariepinus*, *Lates niloticus*, *Oreochromis niloticus*

Note: this species was probably misidentified because it is a marine trichodinid, described from various parts of the world from the gills of various marine fish hosts. The identification of this record cannot be verified as none of the authors provided any morphological data or micrographs.

Trichodina reticulata Hirschmann et Partsch, 1955 on the skin and gills of *Carassius auratus*, *Cyprinus carpio*, *Oreochromis niloticus*

Trichodina sangwala Van As et Basson, 1992 on the gills of *Clarias gariepinus*, ***Schilbe mystus*** (South Africa)

Trichodina uniforma Van As et Basson, 1989 on the skin, fins and gills of ***Carassius auratus*** (South Africa)

Trichodina uretra Basson, 1989 in the urinary bladder and ureters of ***Enteromius trimaculatus*** (South Africa)

Trichodina sp. on the skin and gills of *Clarias gariepinus*, *Coptodon zillii*, *Cyprinus carpio*, *Enteromius paludinosus*, *Heterobranchus bidorsalis*, *H. longifilis*, *Oncorhynchus mykiss*, *Oreochromis leucostictus*, *O. niloticus*, *Protopterus annectens*, *Salmo trutta*, *Synodontis schall*

Trichodinella Raabe, 1950

Trichodinella crennulata Basson et Van As, 1987 on the gills of ***Micralestes acutidens*** (South Africa)

Trichodinella epizootica (Raabe, 1950) on the gills of *Anguilla anguilla*, *Coptodon rendalli*, *C. zillii*, *Ctenopharyngodon idella*, *Cyprinus carpio*, *Enteromius paludinosus*, *E. trimaculatus*, *Mesobola brevianalis*, *Mormyrus kannume*, *Oreochromis mossambicus*, *Pseudocrenilabrus philander* [Fig. 4.2.6D]

Trichodinella sp. on the skin and gills of *Coptodon zillii*, *Cyprinus carpio*, *Enteromius paludinosus*, *Oreochromis leucostictus*

Tripartiella Lom, 1959

Tripartiella clavodonta Basson et Van As, 1987 on the gills of *Mesobola brevianalis*, ***Oreochromis mossambicus*** (South Africa), *Pseudocrenilabrus philander*

Tripartiella ctenopomae Basson et Van As, 2002 on the gills of ***Ctenopoma multispine*** (Botswana) [Fig. 4.2.6E]

Tripartiella dactylodentata Al-Rasheid, Ali, Sakran, Abdel-Baki et Ghaffar, 2000 on the gills of ***Mormyrus kannume*** (Egypt)

Tripartiella lechridens Basson et Van As, 1987 on the gills of *Cyprinus carpio*, *Enteromius paludinosus*, *E. trimaculatus*, ***Labeo cylindricus*** (South Africa), *Mesobola brevianalis*, *Micralestes acutidens*, *Oreochromis mossambicus*

Tripartiella leptospina Basson et Van As, 1987 on the gills of ***Oreochromis mossambicus*** (South Africa)

Tripartiella macrosoma Basson et Van As, 1987 on the gills of ***Enteromius eutaenia*** (South Africa)

Tripartiella microctenopomae Basson et Van As, 2002 on the gills of ***Microctenopoma intermedium*** (Botswana)

Tripartiella nana Basson et Van As, 1987 on the gills of ***Oreochromis mossambicus*** (South Africa)

Tripartiella orthodens Basson et Van As, 1987 on the gills of ***Coptodon rendalli*** (South Africa), *Sarotherodon galilaeus*

EXCAVATA Cavalier-Smith, 2002

Diplomonadida Wenyon, 1926 – **Hexamitinae** Kent, 1880

Diplomonadids – basic characteristics

- with a pair of kinetids and two nuclei, each kinetid usually with four kinetosomes and flagella (sometimes three or two), or uncommonly, one kinetid and nucleus
- with a pair of kinetids and two nuclei, each kinetid usually with four kinetosomes and flagella (sometimes three or two), or uncommonly, one kinetid and nucleus
- at least one flagellum per kinetid directed posteriorly, associated with a cytopharyngeal tube or groove, or lying axially within the cell
- various non-microtubular fibres supporting nucleus and cytopharyngeal apparatus
- free-living or endobiotic, often parasitic
- with functional feeding apparatuses
- with an alternate genetic code (TAR codon for glutamine)

List of diplomonadids from African freshwater fishes

Hexamita Dujardin, 1838

Hexamita africanus Imam, Ramadan et Derahli, 1987 from ***Synodontis schall*** (Egypt)

Hexamita sp. in the stomach and intestine of *Clarias gariepinus*, *Coptodon rendalli*, *Heterobranchus longifilis*, *Oreochromis niloticus*, *Sarotherodon galilaeus*, *Synodontis schall* [Fig. 4.2.5F]

Euglenozoa Cavalier-Smith, 1981 – **Prokinetoplastina** Vickerman in Moreira *et al.*, 2004

Prokinetoplastins – basic characteristics

- cells with two (occasionally one, rarely more) flagella, inserted into an apical/subapical flagellar pocket

- with rare exception, emergent flagella with paraxonemal rods
- usually with tubular feeding apparatus associated with flagellar apparatus
- basic flagellar apparatus pattern consisting of two functional kinetosomes and three asymmetrical arranged microtubular roots
- mostly with discoidal cristae

List of prokinetoplastins from African freshwater fishes

Ichthyobodo Pinto, 1928

Ichthyobodo necator (Henneguy, 1883) on the skin and gills of *Cyprinus carpio*, *Oreochromis mossambicus*, *Pseudocrenilabrus philander*, *Tilapia sparrmanii* [Fig. 4.2.5G]

Ichthyobodo sp. on the skin and gills of *Clarias gariepinus*, *Cyprinus carpio*, *Heterobranchus longifilis*, *Labeobarbus* sp., *Oreochromis niloticus*, *Synodontis schall*

Euglenozoa Cavalier-Smith, 1981 **– Metakinetoplastina** Vickerman in Moreira *et al.*, 2004

List of metakinetoplastins from African freshwater fishes

Cryptobia Leidy, 1846

Cryptobia iubilans Nohynková, 1948 in the stomach and intestine of *Clarias gariepinus*, *Heterobrachus longifilis*

Cryptobia sp. in the intestine, liver, gills and blood of *Clarias gariepinus*, *Coptodon rendalli*, *Enteromius paludinosus*, *Oreochromis niloticus*, *Sarotherodon galilaeus*, *Synodontis schall* [Fig. 4.2.5H]

Trypanosoma Gruby, 1843

Trypanosoma alhussaini Mohamed, 1978 from ***Clarias gariepinus*** (Egypt)

Trypanosoma cyanophilum Mohamed, 1978 from ***Coptodon zillii*** (Egypt)

Trypanosoma mansouri Mohamed, 1978 from ***Coptodon zillii*** (Egypt)

Trypanosoma cf. *mugilicola* Becker et Overstreet, 1979 from *Mugil cephalus*

Note: this fish inhabits marine, freshwater and brackish water systems.

Trypanosoma mukasai Hoare, 1932 from *Astatoreochromis alluaudi*, *Bagrus docmak*, *Clarias gariepinus*, *C. theodorae*, *Haplochromis cinereus*, *H. humilior*, *H. nubilus*, *H. serranus*, ***Haplochromis* spp**. (Uganda), *Mormyrus kannume*, *Oreochromis andersonii*, *O. esculentus*, *O. mossambicus*, *O. niloticus*, *O. variabilis*, *Parauchenoglanis ngamensis*, *Schilbe intermedius*, *Serranochromis angusticeps*, *S. macrocephalus*, *S. robustus*, *Synodontis nigromaculatus*, *S. vanderwaali*, *Tilapia sparrmanii* [Fig. 4.2.3D]

Trypanosoma tobeyi Dias, 1952 from ***Clarias angolensis*** (Mozambique)

Trypanosoma toddi Bouet, 1909 from *Clarias angolensis*, ***C. anguillaris*** (French West Africa)

Trypanosoma sp. from *Coptodon zillii* (Egypt)

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Chapter 4.3.
MYXOZOA

Ivan FIALA & Pavla BARTOŠOVÁ-SOJKOVÁ

Myxozoa – basic characteristics, life cycles, classification and principal diagnostic features

- parasitic cnidarians (Cnidaria: Myxozoa) with about 2,400 species classified in 67 genera with a worldwide distribution
- endoparasites of fish, annelids and bryozoans, less frequently in amphibians and reptiles; exceptionally in birds, mammals and sipunculids
- two-host life cycle: an invertebrate (annelid or bryozoan) definitive host produces actinospores or malacospores and a vertebrate (mostly fish) intermediate host produces myxospores or fish malacospores (Fig. 4.3.1)
- a vertebrate-derived spore consists mostly of two valves, 1-4 polar capsules and an infectious sporoplasm
- spores microscopic (typically 10-20 µm in size)
- spores develop in vegetative stages (trophozoites, plasmodia) which are histozoic (between tissue cells, *e.g.*, muscles, gills, skin, brain, kidney, liver and spleen) or coelozoic (in cavities, *e.g.*, gall bladder, urinary bladder, lumen of renal tubules and renal corpuscles)
- vegetative stages vary greatly in dimensions, histozoic ones may be macroscopic (up to several cm in diameter)
- trophozoites characterised by cell-within-cell organisation
- species belonging to *Myxobolus* are the most common freshwater myxozoans
- myxozoans from freshwater fishes cluster within the malacosporean clade (*Buddenbrockia*, *Tetracapsuloides*), *Sphaerospora* sensu stricto clade (*Sphaerospora*) and the freshwater (oligochaete) myxosporean lineage (all other genera, *e.g.*, *Myxobolus*).
- causative agents of serious fish diseases, *e.g.*, whirling disease and proliferative kidney disease (PKD)

The classification of the Myxozoa is based on myxospore morphology. The shape of the spore, number of shell valves and polar capsules and the position of the polar capsules within the spore are the most important features for the definition of myxozoan genera (Fiala *et al.* 2015; Fig. 4.3.2). Classification at the species level is based on other spore characteristics such as spore and polar capsule dimensions, spore surface structures, the number of polar filament coils, etc.

The subphylum Myxozoa consists of two classes, the Malacosporea (*Buddenbrockia* and *Tetracapsuloides*) and the Myxosporea with two orders, Bivalvulida and Multivalvulida (mostly marine species, *e.g.*, *Kudoa*). Bivalvulida includes two suborders: Variisporina (*e.g.*, *Myxidium*, *Zschokkella*, *Sphaerospora*, *Hoferellus*, *Chloromyxum* and *Myxobilatus*) and Platysporina (*e.g.*, *Myxobolus*, *Henneguya*, *Thelohanellus* and *Unicauda*) (Fig. 4.3.2).

Key to the genera of the Myxozoa from freshwater fishes (modified from Fiala *et al.* 2015)

The taxonomic key includes myxozoan genera reported from freshwater fishes from all continents (Lom & Dyková 2006) with the genera previously reported in Africa in bold.

1 (2) Spores with soft (unhardened) shell valves (Malacosporea)……3

2 (1) Spores with hardened shell valves (Myxosporea)…… 5

3 (4) Fish malacospores with two shell valves, two spherical polar capsules, one sporoplasm; bryozoan-related trophozoites sac- or worm-like; sacs irregularly shaped, elongate, ellipsoid or constricted; myxoworms with triploblast organisation……..*Buddenbrockia*

4 (3) Fish malacospores with two shell valves, two spherical polar capsules, one sporoplasm; bryozoan-related stages mostly sac-like of regular spherical shape……*Tetracapsuloides*

5 (6) Mature spore contains only one polar capsule……7

6 (5) Mature spore contains two or more polar capsules……11

7 (8) Spore with a bifurcate caudal process……*Phlogospora*

8 (7) Spore without a caudal process……9

9 (10) Spores with polar capsule discharging apically and axially [Fig. 4.3.2B] ……..***Thelohanellus***

10 (9) Spores with polar capsule discharging subapically and to the side ……..*Neothelohanellus*

11 (12) Mature spore contains two polar capsules……13

12 (11) Mature spore contains four or more polar capsules……51

13 (14) Polar capsules set apart from each other……15

14 (13) Polar capsules located close to each other……..25

15 (16) Polar capsules each located separately at spore ends……...17

16 (15) Polar capsules located not terminally and set widely apart in the sutural plane……...19

17 (18) Spores fusiform, straight or slightly crescent or sigmoid-shaped with more or less pointed ends, usually pyriform polar capsules; mostly coelozoic [Fig. 4.3.2K]……. ***Myxidium***

18 (17) Spores usually ellipsoidal, slightly bent or semicircular, with rounded or bluntly pointed ends and almost spherical polar capsules; mostly coelozoic [Fig. 4.3.2L]……. ***Zschokkella***

19 (20) Spores spherical or subspherical [Fig. 4.3.2F]…….***Ortholinea***

20 (19) Spores ovoid or triangular……... 21

21 (22) Spores triangular with rounded corners, flattened parallel to sutural plane, without projections [Fig. 4.3.2G]……***Triangula***

22 (21) Spores ovoid……..23

23 (24) Spores flattened parallel to the sutural plane without sutural markings …….. *Neomyxobolus*

24 (23) Spores spindle-shaped in sutural view with sutural markings along the posterior border…….*Cardimyxobolus*

25 (26) Spores asymmetrical with two caudal projections……*Hennegoides*

26 (25) Spores bilaterally symmetrical…….27

27 (28) Polar capsules at distance from the spore apex……. 29

28 (27) Polar capsules in the apex of the spore…….31

29 (30) Spindle-shaped spores with two spherical polar capsules positioned in tandem at a distance from the anterior end and two projections at both spore ends……..*Neohenneguya*

30 (29) Large spherical polar capsules in the centre of an oval spore in valvular view and with triangular shape in sutural view…….*Wardia*

31 (32) Polar capsules set in a plane perpendicular to the sutural line……33

32 (31) Polar capsules set in the sutural plane……..39

33 (34) Spores without projections……..35

34 (33) Spores with projections……37

35 (36) Spores spherical, subspherical or slightly elongate in the direction perpendicular to the sutural plane; mostly coelozoic in the excretory system [Fig 4.3.2E]……..***Sphaerospora***

36 (35) Spores pyriform or mitre-like with ridged valves…….*Acauda*

37 (38) Spores spindle-shaped, with a pair of long posterior projections [Fig. 4.3.2I] ……..***Myxobilatus***

38 (37) Spores pointed, mitre-like or rounded in valvular view with numerous stiff filaments at the posterior end [Fig. 4.3.2J]…….***Hoferellus***

39 (40) Spores without projections……...41

40 (39) Spores with projections……43

41 (42) Sutural line strongly sinuous……..*Spirosuturia*

42 (41) Sutural line straight, spores ellipsoidal, ovoid or rounded [Fig. 4.3.2A] …… ***Myxobolus***

43 (44) Spores with a single caudal projection [Fig. 4.3.2C]……..…***Unicauda***

44 (43) Spores with more than one caudal projection……45

45 (46) Spores with two caudal projections……47

46 (45) Spores with four posterolateral projections……..*Tetrauronema*

47 (48) Spores with two laterally extending projections……49

48 (47) Spores with two slightly divergent projections [Fig. 4.3.2D]…..***Henneguya***

49 (50) Lateral projections extend from one side of the posterior spore end ……*Laterocaudata*

50 (49) Lateral projections extend in opposite directions……...*Dicauda*

51 (52) Spores with two shell valves……53

52 (51) Spores with four shell valves…….. 55

53 (54) Spores spherical [Fig. 4.3.2H]……..***Chloromyxum***

54 (53) Spores almost spherical with one or two caudal projections…… *Caudomyxum*

55 (56) Spores stout spindle-shaped with the sutural ridge extending both spore ends as a spine, coelozoic…… *Octospina*

56 (55) Spores stellate, quadrate, subspherical to ovoid in apical view; histozoic [Fig. 4.3.2M]…….……..***Kudoa***

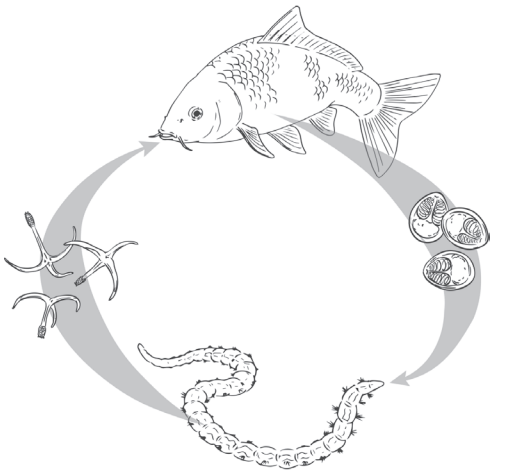

Fig. 4.3.1. Myxozoan life cycle with an annelid definitive host releasing actinospores and a fish intermediate host releasing myxospores. (Illustration by M. Luo.)

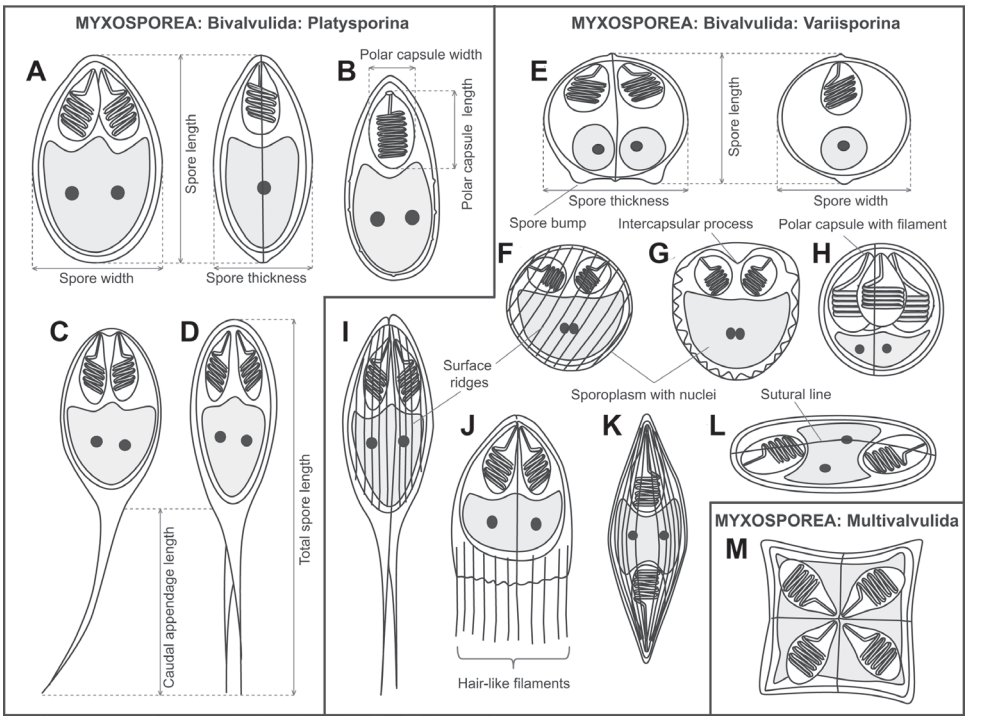

Fig. 4.3.2. Schematic line drawings of myxospores representing myxosporean genera reported from African freshwater fishes with instructions on spore measurements and indicating the most important spore features. **A.** *Myxobolus*, frontal and sutural view; **B.** *Thelohanellus*; **C.** *Unicauda*; **D.** *Henneguya*; **E.** *Sphaerospora*, sutural and lateral view; **F.** *Ortholinea*; **G.** *Triangula*; **H.** *Chloromyxum*; **I.** *Myxobilatus*; **J.** *Hoferellus*; **K.** *Myxidium*; **L.** *Zschokkella*; **M.** *Kudoa*.

List of the Myxozoa in African freshwater fishes

Species are listed alphabetically according to individual myxozoan genera with information about infection site and type host species (in bold) and country of origin if described from Africa. The systematic survey is based on Fomena & Bouix (1997), Eiras (2002), Eiras *et al.* (2005, 2011, 2012, 2014), Abdel-Ghaffar *et al.* (2008), Eiras & Adriano (2012), Zhang *et al.* (2013), and Alama-Bermejo *et al.* (2016).

Cnidaria Hatschek, 1888

MYXOZOA Grassé, 1970

Myxosporea Bütschli, 1881

Bivalvulida Shulman, 1959

PLATYSPORINA Kudo, 1919

Henneguya Thélohan, 1892

Henneguya auchenoglanii Kostoïngué, Diebakate, Faye et Toguebaye, 2001 in the base of primary gill lamellae of ***Auchenoglanis occidentalis*** (Chad)

Henneguya bopeleti Fomena et Bouix, 1987 in the gills of ***Chrysichthys nigrodigitatus*** (Cameroon)

Henneguya branchialis Ashmawy, Abu-Elwafa, Imam et El-Otifi, 1989 in the gills and intestine of *Clarias anguillaris*, ***C. gariepinus*** (Egypt), *Coptodon zillii*, *Sarotherodon galilaeus*

Henneguya camerounensis Fomena et Bouix, 1987 in the gills of *Schilbe multitaeniatus*, ***Synodontis batesii*** (Cameroon)

Henneguya chrysichthyi Obiekezie et Enyenihi, 1988 in the gills of ***Chrysichthys nigrodigitatus*** (Nigeria)

Henneguya clariae Abolarin, 1971 in the gills of ***Clarias gariepinus*** (Nigeria)

Henneguya ctenopomae Fomena et Bouix, 1996 in the gills of ***Microctenopoma nanum*** (Cameroon)

Henneguya dini Kabre, Sakiti, Marquès et Sawadogo, 1997 in the gills of ***Heterotis niloticus*** (Burkina Faso)

Henneguya fusiformis Kostoïngué, Fall, Faye et Toguebaye, 1999 in the gills of ***Clarias anguillaris*** (Chad), *C. gariepinus*.

Henneguya ghaffari Ali, 1999 in the intestine, pyloric caeca and gills of ***Lates niloticus*** (Egypt)

Henneguya laterocapsulata Landsberg, 1987 in the skin of *Clarias gariepinus*, ***C. gariepinus*** × ***Heterobranchus bidorsalis***

Henneguya logonensis Kostoïngué, Diebakate, Faye et Toguebaye, 2001 in the primary gill lamellae of ***Citharinus citharus*** (Chad)

Henneguya mailaoensis Kostoïngué, Diebakate, Faye et Toguebaye, 2001 in the primary gill lamellae of ***Mormyrus caschive*** (Chad)

Henneguya malapteruri Fomena et Bouix, 1996 in the skin and muscles of ***Malapterurus electricus*** (Cameroon)

Henneguya mandouri Rabie, Mohammed, Hussein et Hussein, 2009 in the middle and base of gill filaments of ***Lates niloticus*** (Egypt)

Henneguya maraensis Kostoïngué, 1997 in the gills and intestine of ***Lates niloticus*** (Chad)

Henneguya massii Kostoïngué, Diebakate, Faye et Toguebaye, 2001 in the primary gill lamellae of ***Lates niloticus*** (Chad)

Henneguya mbakaouensis Fomena et Bouix, 2000 in the gills of ***Lates niloticus*** (Cameroon)

Henneguya mormyri Kostoïngué, Diebakate, Faye et Toguebaye, 2001 in the primary gill lamellae of ***Mormyrus caschive*** (Chad)

Henneguya nkamensis Fomena, Folefack et Bouix, 2008 in the secondary gill lamellae of ***Hepsetus odoe*** (Cameroon)

Henneguya ntemensis Fomena et Bouix, 1996 in the gall bladder, kidney and spleen of ***Brienomyrus brachyistius*** (Cameroon)

Henneguya ntondei Fomena, Folefack et Bouix, 2008 in the secondary gill lamellae of ***Schilbe mystus*** (Cameroon)

Henneguya nyongensis Fomena et Bouix, 1996 in the gills and muscles of ***Marcusenius moorii*** (Cameroon)

Henneguya odzai Fomena et Bouix, 1996 in the gills of *Brevimyrus niger*, *Hyperopisus bebe*, ***Marcusenius moorii*** (Cameroon), *M. senegalensis*, *Mormyrus rume*

Henneguya pethericii Fomena, Folefack et Bouix, 2008 in the secondary gill lamellae of ***Ctenopoma petherici*** (Cameroon)

Henneguya samochimensis Reed, Basson et Van As, 2003 in the primary gill filaments of ***Clarias gariepinus*** (Botswana)

Henneguya sarotherodoni Fall, Fomena, Kostoïngué, Diebakate, Faye et Toguebaye, 2000 in the intestine of ***Sarotherodon galilaeus*** (Chad)

Henneguya somahiensis Sakiti, 1997 in the gills of ***Ctenopoma kingsleyae*** (Benin)

Henneguya suprabranchiae Landsberg, 1987 in the accessory breathing organ of *Clarias anguillaris*, ***C. gariepinus***, *Oreochromis niloticus*

Myxobolus Bütschli, 1882

Myxobolus africanus Fomena, Bouix et Birgi, 1989 in the brain, gill adductor muscle, muscles of the operculum, bile duct and gall bladder wall of ***Hepsetus odoe*** (Cameroon)

Myxobolus agolus Landsberg, 1985 [syn. *Myxobolus melenensis* Fomena, Bouix et Birgi, 1985] in the kidney, spleen and gills of *Coptodon guineensis*, *Hemichromis fasciatus*, *Oreochromis niloticus*, *Sarotherodon galilaeus*

Myxobolus amieti Fomena, Bouix et Birgi, 1989 in the gills, eye, superficial mandibular muscles, muscles of the operculum and pharyngeal wall and connective tissue covering the gill arches of ***Microctenopoma nanum*** (Cameroon)

Myxobolus bagri Negm-Eldin, Govedich et Davies, 1999 in the gills of ***Bagrus bajad*** (Egypt)

Myxobolus beninensis Sakiti, Blanc, Marquès et Bouix, 1991 in the gills of ***Sarotherodon melanotheron*** (Benin)

Myxobolus bilongi Fomena, Marquès, Bouix et Njiné, 1994 in the gills and fins of ***Labeo* sp.** (Cameroon)

Myxobolus bizerti Bahri et Marquès, 1996 in the gills of ***Mugil cephalus*** (Tunisia)

Myxobolus bouixi Fomena, Folefack et Tang, 2007 in the gills of ***Chrysichthys nigrodigitatus*** (Cameroon)

Myxobolus brachysporus (Baker, 1963) in the spleen and kidney of *Coptodon guineensis*, ***Oreochromis esculentus*** (Uganda), *O. niloticus*, *O. niloticus* × *S. galilaeus*, *O. variabilis*, *Sarotherodon galilaeus*

Myxobolus branchiophilus Abdel-Ghaffar, El-Toukhy, Al-Quarishy, Al-Rashid, Abdel-Baki, Hegazy et Bashtar, 2008 in the gill filaments of ***Oreochromis niloticus*** (Egypt)

Myxobolus burkinei Kabré, 1995 in the gills and fins of ***Labeo coubie*** (Burkina Faso)

Myxobolus camerounensis Fomena, Marquès et Bouix, 1993 in the gills, eyes and muscles of ***Oreochromis niloticus*** (Cameroon)

Myxobolus caudatus Ali, Al-Rasheid, Sakran, Abdel-Baki et Abdel-Ghaffar, 2002 in the tail and fins of ***Labeobarbus bynni*** (Egypt)

Myxobolus charii Fomena, 2004 in the skin of ***Citharinus citharus*** (Chad)

Myxobolus chrysichthyi Negm-Eldin, Govedich et Davies, 1999 in the gills of ***Chrysichthys auratus*** (Egypt)

Myxobolus clarias Negm-Eldin, Govedich et Davies, 1999 in the gills of ***Chrysichthys auratus*** (Egypt)

Myxobolus comoei Kabre, Sakiti, Marquès et Sawadogo, 1995 in the fins and gills of ***Clarias anguillaris*** (Burkina Faso)

Myxobolus dahomeyensis (Siau, 1971) in the ovaries of *Coptodon zillii*, *Oreochromis niloticus*, *O. mossambicus* × *O. niloticus*, *Sarotherodon melanotheron*, ***Synodontis ansorgii*** (Benin)

Myxobolus diamaensis Diamanka, Faye, Fall et Toguebaye, 2007 in the gill filaments of ***Sarotherodon melanotheron*** (Senegal)

Myxobolus distichodi Kostoingué et Toguebaye, 1994 in the gills, intestine and liver of ***Distichodus engycephalus*** (Chad)

Myxobolus djoudjensis Diamanka, Faye, Fall et Toguebaye, 2007 in the ovaries of ***Coptodon guineensis*** (Senegal)

Myxobolus dossoui Sakiti, Blanc, Marquès et Bouix, 1991 in the gill arches and cartilage of ***Coptodon zillii*** (Benin), *Hemichromis fasciatus*, *Oreochromis mossambicus* x *O. niloticus*

Myxobolus egypticus (Ali, Al-Rasheid, Sakran, Abdel-Baki et Abdel-Ghaffar, 2002) [syn. *M. intestinalis* Ali, Al-Rasheid, Sakran, Abdel-Baki et Abdel-Ghaffar, 2002] in the intestine of ***Labeobarbus bynni*** (Egypt)

Myxobolus equatorialis (Landsberg, 1985) in the spleen and kidney of *Coptodon guineensis, Oreochromis niloticus*, *Sarotherodon galilaeus*

Myxobolus etsataensis Reed, Basson et Van As, 2002 in the gills of ***Enteromius thamalakanensis*** (Botswana)

Myxobolus exiguous Thélohan, 1895 in the scales of *Chelon aurata*, *Mugil cephalus*

Myxobolus fahmii Ali, Al-Rasheid, Sakran, Abdel-Baki et Abdel-Ghaffar, 2002 in the gills of ***Labeobarbus bynni*** (Egypt)

Myxobolus fobobi (Fomena, 1985) [syn. *Myxobolus barbi* Fomena, 1985] in the gills of ***Enteromius aspilus*** (Cameroon), *E. camptacanthus*, *E. jae*, *E. guirali*, *E. martorelli*

Myxobolus fomenai Abdel-Ghaffar, El-Toukhy, Al-Quarishy, Al-Rashid, Abdel-Baki, Hegazy et Bashtar, 2008 in the muscles, intestine and kidney of ***Oreochromis niloticus*** (Egypt)

Myxobolus fotoi Fomena, Marquès and Bouix, 1993 in the gills of ***Oreochromis niloticus*** (Cameroon)

Myxobolus galilaeus Landsberg, 1985 in the kidney, spleen, eyes, gills and intestine of *Coptodon guineensis*, *Oreochromis niloticus*, *O. niloticus* × *S. galilaeus*, ***Sarotherodon galilaeus***

Myxobolus gandiolensis Fall, Fomena, Kostoïngué, Diebakate, Faye et Toguebaye, 2000 in the kidney of ***Coptodon guineensis*** (Senegal)

Myxobolus gariepinus Reed, Basson et Van As, 2003 in the ovaries of ***Clarias gariepinus*** (Botswana)

Myxobolus heterosporus (Baker, 1963) [syn. *Myxosoma heterospora* Baker, 1963] in the kidney, liver, spleen, gills, intestine and gall bladder of *Coptodon zillii*, *Hemichromis fasciatus, Oreochromis niloticus*, *Sarotherodon melanotheron*

Myxobolus heterotisi Bongou, Kabré, Sakiti, Marquès et Sawadogo, 2006 in the primary gill filaments of ***Heterotis niloticus*** (Burkina Faso)

Myxobolus homeosporus (Baker, 1963) in the muscles and cornea of *Coptodon zillii*, ***Oreochromis esculentus*** (Uganda), *O. niloticus*, *O. variabilis*, *Sarotherodon galilaeus*

Myxobolus hydrocyni Kostoïngué et Toguebaye, 1994 in the gills of ***Hydrocynus forskahlii*** (Chad)

Myxobolus imami Ali, Al-Rasheid, Sakran, Abdel-Baki et Abdel-Ghaffar, 2002 in the kidney of ***Labeo niloticus*** (Egypt), *Labeobarbus bynni*

Myxobolus israelensis Landsberg, 1985 in the kidney, spleen and gills of *Coptodon cameronensis*, *C. guineensis*, *Oreochromis niloticus*, ***O. niloticus* × *O. aureus***, *Sarotherodon galilaeus*, *S. mvogoi*

Myxobolus kainjiae (Obiekezie et Okaeme, 1990) [syn. *M. ovariae* Paperna, 1973] in the ovaries and urinary bladder of *Coptodon nyongana*, ***Haplochromis angustifrons*** (Uganda), *H. elegans*, *Oreochromis niloticus*, *Sarotherodon galilaeus*

Myxobolus kouoptamoensis Nchoutpouen et Fomena, 2011 in the gills, spleen and kidney of ***Labeo parvus*** (Cameroon)

Myxobolus kribiensis Fomena et Bouix, 1994 in the skin, eye sclera and kidney of ***Brycinus longipinnis*** (Cameroon)

Myxobolus labeoi Boungou, Kabré, Sakiti, Marquès et Sawadogo, 2006 in the fin rays of ***Labeo coubie*** (Burkina Faso)

Myxobolus labiae Negm-Eldin, Govedich et Davies, 1999 in the gills of ***Labeo niloticus*** (Egypt)

Myxobolus latesi Kostoïngué et Toguebaye, 1994 in the gills and intestine of ***Lates niloticus*** (Chad)

Myxobolus latis Negm-Eldin, Govedich et Davies, 1999 in the gills of ***Lates niloticus*** (Egypt)

Myxobolus lazera (Mandour, Galal et Abed, 1993) [syn. *M. clarii* Mandour, Galal et Abed, 1993] in the testes of ***Clarias gariepinus*** (Egypt)

Myxobolus mbailaoi Fomena, 2004 in the operculum, skin and intestine of ***Citharinus citharus*** (Chad)

Myxobolus naffari Ghaffar, Ibrahiem, Bashtar et Ali, 1998 in the gills of ***Labeo niloticus*** (Egypt) and *Labeobarbus bynni*

Myxobolus nchoutnounensis Nchoutpouen et Fomena, 2011 in the gills, scales, liver, fins, spleen, kidney and eyes of ***Labeo parvus*** (Cameroon)

Myxobolus negmgoda (Negm-Eldin, Govedich et Davies, 1999) [syn. *M. synodontis* Negm-Eldin, Govedich et Davies, 1999] in the gills of ***Synodontis schall*** (Egypt)

Myxobolus ngassami Lekeufack Folefack, Defoueng et Fomena 2017 in the fins, operculum, skin and sclera of the eye of ***Enteromius callipterus*** (Cameroon)

Myxobolus nilei (Faisal et Shalaby, 1987) [syn. *Myxosoma tilapiae* Faisal et Shalaby, 1987] in the gills, skin, eyes, kidney and pancreas of ***Oreochromis niloticus*** (Egypt)

Myxobolus niloticus Fahmy, Mandour et El-Naffar, 1971 in the tail fin rays and operculum of ***Labeo niloticus*** (Egypt)

Myxobolus njinei Fomena, Bouix et Birgi, 1985 in the gill arch of ***Enteromius camptacanthus*** (Cameroon), *E. guirali*, *E. martorelli*

Myxobolus njoyai Nchoutpouen et Fomena, 2011 in the gills, scales, fins, spleen and kidney of ***Labeo parvus*** (Cameroon)

Myxobolus nkolyaensis Fomena et Bouix, 1994 in the gills and caudal muscles of ***Enteromius jae*** (Cameroon)

Myxobolus nokoueensis Sakiti, 1991 in the gills of ***Sarotherodon melanotheron*** (Benin)

Myxobolus nounensis Fomena et Bouix, 2000 in the kidney and spleen of ***Sarotherodon galilaeus*** (Cameroon)

Myxobolus nyongana (Fomena, Bouix et Birgi, 1985) [syn. *Myxobolus barbi* Fomena, Bouix et Birgi, 1985] in the gills and eyes of *Alestes dentex*, *Enteromius aspilus*, *E. camptacanthus*, *E. guirali*, ***E. jae*** (Cameroon), *E. martorelli*, *Labeo parvus*, *Sarotherodon melanotheron*

Myxobolus occularis Abu-El-Wafa, 1988 in the eyes of ***Tilapia* sp.** (Egypt)

Myxobolus oloi Fomena et Bouix, 1994 in the gill arch epithelium, kidney and heart of ***Enteromius aspilus*** (Cameroon), *E. camptacanthus*, *E. guirali, E. martorelli*

Myxobolus ovoidalis Fantham, 1930 in the subcutaneous tissue of *Barbus* sp., ***Cyprinus carpio*** (South Africa), *Salvelinus fontinalis*

Myxobolus paludinosus Reed, Basson et Van As, 2002 in the gills of ***Enteromius paludinosus*** (Botswana)

Myxobolus perforata Ali, Al-Rasheid, Sakran, Abdel-Baki et Abdel-Ghaffar, 2002 in the internal surface of operculum of ***Hydrocynus forskahlii*** (Egypt)

Myxobolus pethericii Fomena, Folefack et Tang, 2007 in the gills, fins, stomach wall, liver, small intestine, operculum and kidney of ***Ctenopoma petherici*** (Cameroon)

Myxobolus polycentropsi Fomena, Bouix et Birgi 1985 [syn. *M. microcapsularis* Sakiti, Blanc, Marquès et Bouix, 1991] in the gills arch cartilage of ***Polycentropsis abbreviata*** (Cameroon), *Coptodon zillii*

Myxobolus saintlouisiensis Diamanka, Faye, Fall et Toguebaye, 2007 in the gill filaments of ***Oreochromis niloticus*** (Senegal)

Myxobolus sanagaensis Lekeufack Folefack, Defoueng et Fomena 2017 in the heart auricles of ***Enteromius callipterus*** (Cameroon)

Myxobolus sangei Fomena, Folefack et Tang, 2007 in the gills, skin, kidney of ***Brycinus macrolepidotus*** (Cameroon)

Myxobolus sarigi (Landsberg, 1985) in the kidney and spleen of *Coptodon margaritacea*, *C. guineensis*, *Oreochromis niloticus*, *O. niloticus* × *Sarotherodon galilaeus*, *S. galilaeus*

Myxobolus sarotherodoni Sakiti, Blanc, Marquès et Bouix, 1991 in the gills of ***Sarotherodon melanotheron*** (Benin)

Myxobolus sessabai Lekeufack Folefack, Defoueng et Fomena, 2017 in the skin of ***Enteromius callipterus*** (Cameroon)

Myxobolus sheroidalis Abu-El-Wafa, 1988 in the viscera of *Clarias* sp., ***Tilapia* sp.** (Egypt)

Myxobolus sourouensis Bongou, Kabré, Sakiti, Marquès et Sawadogo, 2006 in the primary gill filaments of ***Heterotis niloticus*** (Burkina Faso)

Myxobolus stenosus Paperna, 1973 in the gills and kidney of *Synodontis clarias*, ***S. schall*** (Uganda)

Myxobolus synodonti Fomena, Bouix et Birgi, 1985 in the stomach wall of ***Synodontis batesii*** (Cameroon)

Myxobolus tilapiae Abolarin, 1974 in the buccal cavity, gills, fins, kidney and spleen of *Coptodon margaritacea*, *C. rendalli*, *C. zillii*, ***Oreochromis niloticus*** (Nigeria), *Sarotherodon galilaeus*, *S. mvogoi*

Myxobolus tingrelaensi Bongou, Kabré, Sakiti, Marquès et Sawadogo, 2006 in the fin rays of ***Sarotherodon galilaeus*** (Burkina Faso)

Myxobolus zillii Sakiti, Blanc, Marquès et Bouix, 1991 [syn. *Myxobolus latesi* Kostoïngué et Toguebaye 1994] in the gills and intestine of ***C. zillii*** (Benin), *Lates niloticus*

Thelohanellus Kudo, 1933

Thelohanellus assambai Fomena, Marquès, Bouix et Njine, 1994 in the gills and fins of ***Labeo* sp.** (Cameroon)

Thelohanellus bicornei Kabre, Sakiti, Marquès et Sawadogo, 2002 in the gills of ***Labeo coubie*** (Burkina Faso)

Thelohanellus citharini Kostoïngué, Fall, Faye et Toguebaye, 1999 in the heart of ***Citharinus citharus*** (Chad)

Thelohanellus costeae Sakiti, 1997 in the gills of ***Labeo senegalensis*** (Benin)

Thelohanellus lagdoensis Fomena, Farikou-Oumarou, Tang et Bouix, 2007 in from the intestine of ***Citharinus citharus*** (Cameroon)

Thelohanellus ndjamenaensis Kostoïngué, Fall, Faye et Toguebaye, 1999 in the gills of ***Labeo parvus*** (Chad)

Thelohanellus niloticus Abdel-Ghaffar, Morsy, Bashtar, El-Ganainy et Gamal, 2013 [syn. *Myxobolus unicapsulatus* Gurley, 1893] in the gills of ***Labeo niloticus*** (Egypt)

Thelohanellus njinei Fomena, Farikou-Oumarou, Tang et Bouix, 2007 in the intestine of ***Schilbe mystus*** (Cameroon)

Thelohanellus rhabdalestus Azevedo, Samuel, Saveia, Delgado et Casal, 2011 in the liver and heart of ***Rhabdalestes maunensis*** (Angola)

Thelohanellus sanagaensis Fomena, Marquès, Bouix et Njine, 1994 in the gills and fins of ***Labeo* sp.** (Cameroon)

Thelohanellus taguii Fomena, Abakar-Ousman, Ngassam et Bouix, 2004 in the gills, liver, opercular muscles and intestine of ***Citharinus citharus*** (Chad)

Thelohanellus valeti Fomena et Bouix, 1987 in the stomach wall, gill filaments, muscles and operculum of *Enteromius aspilus*, ***E. jae*** (Cameroon), *Oreochromis niloticus*

Unicauda Davis, 1944

Unicauda strongylura (Gurley, 1893) [syn. *Henneguya strongylura* (Gurey, 1893) Labbé, 1899] in the tissues of ***Synodontis schall*** (Egypt)

VARIISPORINA Lom et Noble, 1984

Chloromyxum Mingazzini, 1890

Chloromyxum alii Abdel-Baki, 2007 in the gall bladder of ***Schilbe mystus*** (Egypt)

Chloromyxum birgii Fomena et Bouix, 1994 in the gall bladder of *Amphilius longirostris*, *Enteromius aspilus*, ***E. martorelli*** (Cameroon)

Chloromyxum vanasi Ali, 1998 in the gall bladder of ***Bagrus bajad*** (Egypt)

Hoferellus Berg, 1898

Hoferellus gnathonemi Alama-Bermejo, Jirků, Kodádková, Pecková, Fiala et Holzer, 2016 in the kidney of ***Gnathonemus petersii*** (Nigeria)

Myxidium Bütschli, 1882

Myxidium beninensis Sakiti, 1997 in the gall bladder of *Chrysichthys auratus*, ***C. nigrodigitatus*** (Benin)

Myxidium birgii Fomena et Bouix, 1986 in the gall bladder of ***Aphyosemion bivittatum*** (Cameroon)

Myxidium bouixi Siau, 1971 in the gall bladder of ***Synodontis ansorgii*** (Benin)

Myxidium brienomyri Fomena et Bouix, 1986 in the gall bladder of ***Brienomyrus brachyistius*** (Cameroon)

Myxidium camerounense Fomena et Bouix, 1986 in the gall bladder of ***Neolebias ansorgii*** (Cameroon)

Myxidium distichodi Kostoïngué, Faye et Toguebaye, 1998 in the gall bladder of ***Distichodus engycephalus*** (Chad), *Parachanna obscura*

Myxidium latesi Kostoïngué, Faye et Toguebaye, 1998 in the gall bladder of ***Lates niloticus*** (Chad)

Myxidium mendehi Fomena et Bouix, 1994 in the kidney of ***Enteromius guirali*** (Cameroon), *E. martorelli*

Myxidium nkamense Fomena, Folefack et Bouix, 2010 in the gall bladder of ***Clarias pachynema*** (Cameroon)

Myxidium nyongense Fomena et Bouix, 1986 in the gall bladder of *Enteromius aspilus*, *E. camptacanthus*, *E. guirali*, ***E. jae*** (Cameroon), *E. martorelli*

Myxidium parachannae Sakiti, 1997 in the gall bladder of ***Parachanna obscura*** (Benin)

Myxidium petrocephali Fomena et Bouix, 1986 in the gall bladder of *Ctenopoma petherici*, ***Petrocephalus simus*** (Cameroon)

Myxidium sangei Fomena, Folefack et Bouix, 2010 in the gall bladder of ***Parachanna obscura*** (Cameroon)

Myxidium schalli Abdel Ghaffar, El-Shahawi et Naas, 1995 in the gall bladder of ***Synodontis schall*** (Egypt)

Myxidium schilba Ali, Sakran et Abdel-Baki, 1999 in the gall bladder of ***Schilbe mystus*** (Egypt)

Myxidium shamama Ali, Sakran et Abdel-Baki, 1999 in the kidney of ***Labeo niloticus*** (Egypt)

Myxobilatus Davis, 1944

Myxobilatus accessobranchialis Obiekezie et Okaeme, 1987 in the accessory breathing organs of ***Heterobranchus bidorsalis*** (Nigeria)

Myxobilatus synodontis Siau, 1971 in the gills of ***Synodontis ansorgii*** (Benin)

Ortholinea Shulman, 1962

Ortholinea africanus Abdel-Ghaffar, El-Toukhy, Al-Quraishy, Al-Rasheid, Abdel-Baki, Hegazy et Bashtar, 2008 in the urinary bladder of ***Oreochromis niloticus*** (Egypt)

Sphaerospora Thélohan, 1892

Sphaerospora melenensis Fomena, Marquès et Bouix, 1993 in the kidney of ***Oreochromis niloticus***

Sphaerospora sangmelimaensis Fomena, Marquès et Bouix, 1993 in the kidney of ***Brienomyrus brachyistius*** (Cameroon), *Hepsetus odoe*, *Petrocephalus simus*

Sphaerospora tilapiae Fomena, Marquès et Bouix, 1993 in the kidney and spleen of ***Oreochromis niloticus*** (Cameroon)

Triangula Chen et Hsieh, 1984

Triangula egyptica Abdel-Ghaffar, El-Toukhy, Al-Quraishy, Al-Rasheid, Abdel-Baki, Hegazy et Bashtar, 2008 in the kidney of ***Oreochromis niloticus*** (Egypt)

Zschokkella Auerbach, 1910

Zschokkella nilei Abdel-Ghaffar, El-Toukhy, Al-Quraishy, Al-Rasheid, Abdel-Baki, Hegazy et Bashtar, 2008 in the kidney of ***Oreochromis niloticus*** (Egypt)

MULTIVALVULIDA Shulman, 1959

Kudoa Meglitsch, 1947

Kudoa eleotrici Siau, 1971 in the gills of ***Kribia kribensis*** (Benin). Note: this is a very exceptional finding as species of *Kudoa* are typically parasites of marine fishes.

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Chapter 4.4.
MONOGENEA

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Monogenea – basic characteristics, life cycles, classification and principal diagnostic features

- parasitic flatworms with a syncytial tegument (Platyhelminthes: Neodermata)
- over 5,500 species allocated to more than 750 genera
- mostly parasites of freshwater, brackish water and marine fishes; a number of species parasitise crustaceans, cephalopods, amphibians, reptiles and a mammal
- majority of African species found on external surfaces (gills, skin, fins, rarely mouth cavity and nostrils); a few species are endoparasitic (*Enterogyrus* – foregut and stomach, *Urogyrus* – urinary bladder)
- body dorsoventrally flattened, varying in size from *ca.* 100 µm up to 4 cm long (typically 0.3-10 mm)
- main attachment organ on the posterior end called haptor (or opisthaptor) houses a variable array of sclerotised (hard) structures; number, shape and configuration of the haptoral structures are key to species identification and classification
- simple digestive system consisting of mouth, pharynx and intestine with no terminal opening (anus)
- intestine usually with two simple or branched stems often fusing (anastomosing) posteriorly
- hermaphroditic (commonly protandrous), usually with cross-fertilisation
- distal parts of the male and female reproductive system (male copulatory organ, vagina) may contain sclerotised elements (*e.g.*, copulatory tube, accessory piece) that help in species identification
- direct life cycles (no intermediate host required) (Fig. 4.4.1)
- oviparous (oncomiracidium larva), viviparous (sequential polyembryony)
- a high degree of host and site (microhabitat) specificity

The classification of monogeneans is still under discussion. Even the name of the class, Monogenea (used by the majority of workers) or Monogenoidea, is controversial (Wheeler & Chisholm 1995). There are several classifications of monogeneans that are based on morphology, ontogeny and spermatology (Bychowsky 1957; Yamaguti 1963; Lebedev 1988; Malmberg 1990; Justine 1991; Boeger & Kritsky 1993, 2001). The system of Boeger and Kritsky (1993,

Fig. 4.4.1. Life cycles of monogeneans (no intermediate host required). **A.** Oviparous life cycle (*Dactylogyrus* sp.); **B.** Viviparous life cycle (*Macrogyrodactylus* sp.). (Illustrations by M. Luo.)

2001) is followed here for the higher taxonomical levels, based on a variety of anatomical and ultrastructural characters. The subclasses as listed below are now well accepted, as is the division of Heteronchoinea into two infrasubclasses (*i.e.*, Oligonchoinea and Polystomatoinea).

Generic classification of monogeneans is based mainly on characters associated with the attachment structures. However, information on the internal anatomy and sclerotised distal parts of the male and female reproductive system is also important, as an integral part of the generic definition.

Species identification of monogeneans (especially so-called lower monogeneans – Polyonchoinea) is based on the morphology of the sclerotised structures of the haptor and distal parts of the reproductive systems (*i.e.*, male copulatory organ

and vagina). However, details on the arrangement of internal structures may also supplement the taxonomical evaluation, and should ideally be a part of the species description.

The unique and characteristic morphological feature of the Monogenea is the presence of the posterior attachment organ called the haptor (or opisthaptor). It is a complex organ composed of the attachment disc and various sclerotised structures (Fig. 4.4.2). The terminology of the haptoral structures is not unified and some researchers use these terms differently. Here, the following terms are used in keying out these parasites:

Anchors (hamuli, grypi, large hooks, central hooks, Mittelhakens) are paired trifid structures situated on the ventral and/or dorsal surface of the central part of the haptor. One or two pairs of anchors may be present, but in some monogeneans (*e.g.*, species of *Heteronchocleidus*, *Trianchoratus*, *Urogyrus*) one of the anchors may not be fully developed, *i.e.*, it is much reduced in size and shape. In a typical case, the anchor consists of inner root (superficial root, ventral root, guard), outer root (deep root, dorsal root, shaft), base, shaft (blade) and point; the membranous structures arising from the convex surface of the shaft are termed anchor filaments (wings, filament loops). The anchors of some genera may possess accessory sclerites (patch, cuneus) associated with the tip of the inner root (*e.g.*, species of *Birgiellus*, *Paraquadriacanthus*, *Quadriacanthus*).

Bars (connecting bars, transverse bars) are one or two-piece structures connecting the basis of individual members of a pair of anchors. Generally, each pair of anchors has a bar and together they form the so-called ventral and/or dorsal anchor-bar complex. In a number of genera with two pairs of anchors, only one pair has a bar (*e.g.*, species of *Enterogyrus*, *Eutrianchoratus*). Conversely, two bars (ventral and dorsal) may be present in some monogeneans with one pair of anchors (*e.g.*, species of *Dactylogyrus*, *Gyrodactylus*).

Needles (4A hooks) are paired delicate (usually poorly detectable) splinter-like structures of which the nature and origin have not yet been clearly documented. Mostly they are considered to be vestigial anchors or vestigial hooks (*e.g.*, species of *Dactylogyrus*, *Dogielius*, *Schilbetrematoides*).

Hooks (marginal hooks, uncinuli) are bilaterally arranged pairs of small sickle-shaped structures. In a typical case, each hook consists of a sickle (with sickle-filament loop or FH loop) and a handle. There are two types of hooks called unhinged and hinged hooks. The sickle of a hinged hook is movable in relation to the handle. The number of hooks is 14 in species with unhinged hooks (Dactylogyridae, Diplectanidae) and 16 in species with hinged hooks (Gyrodactylidae). There are several types of numbering systems for hook pairs; here the system of Mizelle (1936) is adopted, because it is the only currently used method that considers both the anteroposterior and dorsoventral positions of the respective hook pairs in the adult haptor.

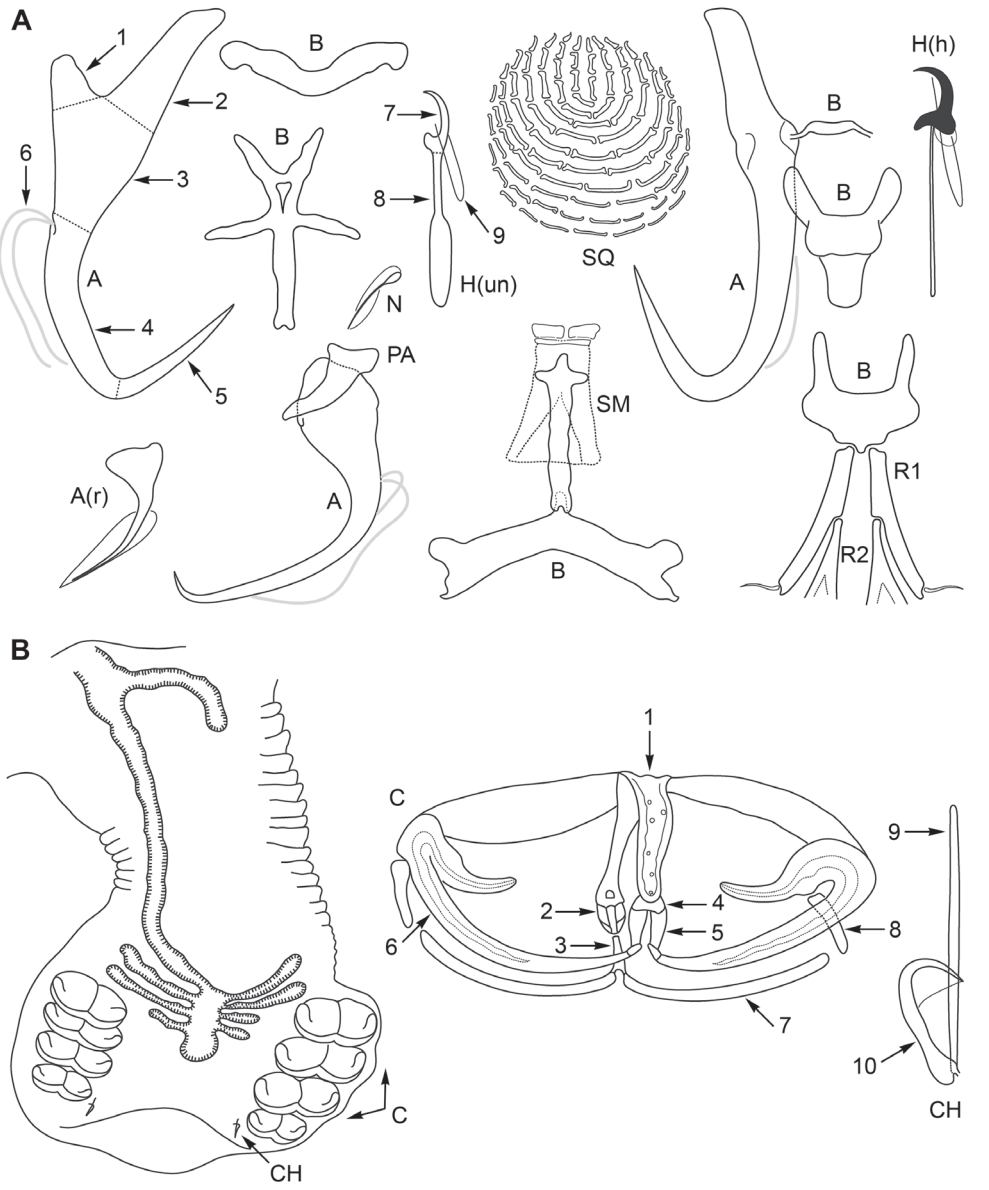

Fig. 4.4.2. Examples of haptoral attachment structures, as typically seen in papers describing new species. **A.** Polyonchoinea. A = anchor, A(r) = anchor (rudimentary), B = bar, H(h) = hook (hinged), H(un) = hook (unhinged), N = needle, Pa = patch, R = rods, SM = supporting membrane, SQ = squamodisc, 1 = outer root, 2 = inner root, 3 = base, 4 = shaft, 5 = point, 6 = filament, 7 = sickle, 8 = handle, 9 = FH loop; **B.** Oligonchoinea. (Modified after Khotenovsky 1985.) C = clamps, CH = central hook, 1 = median plate, 2 = proximal additional sclerite, 3 = distal additional sclerite, 4 = trapeze spur, 5 = anterior joining sclerites, 6 = anterior jaw, 7 = posterior jaw (median sclerite), 8 = posterior jaw (lateral sclerite), 9 = handle, 10 = sickle.

Squamodiscs are circular or oval plate-like formations, which are found only in certain monogeneans of the Diplectanidae. There are, typically, two squamodiscs (one ventral and one dorsal) located anteriorly to the anchor-bar complexes. Each disc possesses scales embedded in the tegument, which appear under the microscope as rootlets arranged in rows.

Clamps are metamorphosed suckers characteristic of higher monogeneans (Oligonchoinea). They are highly specialised structures, often armed with sclerotised elements. The number of clamps varies from two to many; they are distributed symmetrically or asymmetrically. The number and arrangement of clamps as well as the number, shape and size of clamp sclerites are of taxonomic importance in differentiating taxa.

4.4.1. Identification keys for monogeneans (adults)

The guide to the monogeneans parasitising African freshwater fishes is presented here as keys to individual genera and higher-level taxa. Every step in the keys refers to a corresponding figure for a better understanding of identifying feature(s). Figures are labelled to illustrate the used terminology of the sclerotised structures; taxonomically important characters indicated by arrows. In case of hooks, only half of them is depicted in the key to the Dactylogyridae. The genus *Ancyrocephalus* is not included in the keys. Following the emendation of the generic diagnosis for *Ancyrocephalus* of Bychowsky and Nagibina (1970), *A. barilli*, *A. claveaui*, *A. limnotrissae* and *A. pellonulae* do not belong to the genus *sensu stricto*. Nevertheless, we retain them in *Ancyrocephalus* until their generic status is formally resolved. Thus, these species are listed below under *Ancyrocephalus sensu lato*.

Key to the subclasses/infrasubclasses of monogeneans

1 (2) Hook-like sclerites with various connecting and supporting sclerites (*e.g.*, bars, squamodiscs) are main attachment structures of haptor [Fig. 4.4.2A]……**Polyonchoinea**

2 (1) Main attachment structures of haptor are morphologically and functionally changed suckers – clamps [Fig. 4.4.2B]……**Oligonchoinea**

Key to the families of the Oligonchoinea Bychowsky, 1937

1 (2) Haptor with 4 + 4 clamps; male copulatory organ armed with a circle of spines, present in anterior part of the body (just behind pharynx); no fused (concrescent) individuals occur [Fig. 4.4.3]……**Diclidophoridae**

2 (1) Haptor with 4 + 4 and more clamps; one pair of posteriorly situated hooks (central hooks) usually present; male copulatory organ absent; already in juvenile stage, two individuals (diporpae) permanently fused forming an X-shape [Fig. 4.4.4]……**Diplozoidae**

Key to the genera of the Diplozoidae Tripathi, 1959

1 (2) Haptor with 4 + 4 laterally situated clamps and one pair of small central hooks; gill parasites of *Brycinus macrolepidotus* (Alestidae) and Cyprinidae [Fig. 4.4.4A]…….***Paradiplozoon***

2 (1) Haptor with more than 4 + 4 laterally situated clamps (up to 15 pairs) and one pair of small central hooks; gill parasites of *Alestes baremoze* (Alestidae) and Cyprinidae [Fig. 4.4.4B]…….***Afrodiplozoon***

Key to the families of the Polyonchoinea Bychowsky, 1937

1 (2) Oviparous, usually with two pairs of eye spots; haptor with unhinged (dactylogyrid) hooks [Fig. 4.4.5A]……..……3

2 (1) Viviparous or oviparous, eye spots are lacking; haptor with hinged (gyrodactylid) 8 + 8 hooks [Fig. 4.4.5B]……..**Gyrodactylidae**

3 (4) Haptor with 7 + 7 unhinged hooks, two pairs of anchors (one or two anchors may be rudimentary), two bars (one may be rudimentary or absent) [Fig. 4.4.6A]……...**Dactylogyridae**

4 (3) Haptor with 7 + 7 unhinged hooks, two pairs of anchors, two bars (dorsal bar two-pieced); accessory adhesive organs (squamodiscs) present [Fig. 4.4.6B] ..... **Diplectanidae**

Key to the genera of the Dactylogyridae Bychowsky, 1933

1 (2) Dactylogyrids parasitising internal organs……3

2 (1) Dactylogyrids parasitising external organs……..5

3 (4) In stomach; haptor with two pairs of anchors; ventral anchors associated with the ventral bar (*i.e.*, ventral anchor-bar complex present); dorsal anchors with recurved inner root, elongate outer root; dorsal bar absent; male copulatory organ a spirally coiled tube; in Cichlidae [Fig. 4.4.7A]…… ***Enterogyrus***

4 (3) In urinary bladder; haptor with one pair of ventral anchors associated with the ventral bar; right anchor rudimentary (reduced in size and shape); dorsal anchor-bar complex absent; in Cichlidae [Fig. 4.4.7B]……***Urogyrus***

5 (6) Haptor with two developed anchors (ventral or dorsal pair) and two anchors reduced or replaced by needles (poorly defined)……7

6 (5) Haptor with more than two developed anchors……13

7 (8) Ventral anchor-bar complex developed; dorsal anchors modified into spike-like sclerites; dorsal bar absent; gill parasites of *Citharinus citharus*

(Citharinidae) [Fig. 4.4.8A]…….……***Nanotrema***

8 (7) One pair of delicate splinter-like structures (needles) located near hook pair V present……...9

9 (10) Only one bar present; anchors with short roots (inner root often with basal fold) of similar size, poorly differentiated shafts and points (with subterminal curvature and strongly recurved tip) directing towards each other (like a pair of pincers); gill parasites of Cyprinidae [Fig. 4.4.8B]…… ……...***Dogielius***

10 (9) One or two bars present……11

11 (12) Dorsal bar present; ventral bar usually smaller than the dorsal one, rudimentary or absent; dorsal anchors often with roots of unequal size, well-differentiated shaft and point; mostly on gills of Cyprinidae [Fig. 4.4.9A] ……***Dactylogyrus***

12 (11) Ventral bar simple, rod-shaped; dorsal bar complex, comprising bar proper and massive shield-like structure posteriorly serving as a guide for anchor points; dorsal anchors with elongate inner root having a superficial protuberance near mid-length; gill parasites of *Schilbe* (Schilbeidae) [Fig. 4.4.9B]……...***Schilbetrematoides***

13 (14) Three developed and one (ventral) rudimentary (*i.e.*, markedly reduced in size and shape) anchors present……15

14 (13) Four (two pairs) developed anchors present……17

15 (16) Two bars present; developed anchors (two dorsal, one ventral) with well-differentiated roots; dorsal anchors usually differ from each other in size and shape; gill parasites of *Ctenopoma* (Anabantidae) [Fig. 4.4.10A] ……***Heteronchocleidus***

16 (15) One bar present; developed anchors (two left, one right) in a claw-like position, each with stout inner root and poorly developed outer root; a circular muscle attached terminally to the inner root of the left ventral anchor detectable; gill parasites of *Parachanna obscura* (Channidae) [Fig.4.4.10B]……***Eutrianchoratus***

17 (18) One or both pairs of anchors associated with a two-piece bar……19

18 (17) Each anchor pair associated with a one-piece (solid) bar……25

19 (20) Both bars two-pieced; ventral and dorsal anchors similar in shape and size; base of copulatory tube delicate, usually with finger-like processes; gill parasites of Mormyridae [Fig. 4.4.11A…… ***Bouixella***

20 (19) Ventral bar two-pieced; dorsal bar solid……21

21 (22) Ventral bar comprising two well-separated components; ventral anchors

markedly smaller than dorsal anchors; dorsal bar straight, broadly V- or M-shaped; gill parasites of Cichlidae [Fig. 4.4.11B]……***Onchobdella***

22 (21) Ventral bar comprising two components articulating medially……23

23 (24) Anchors with patches, rootless; dorsal bar T-shaped, with bilateral arms and expanded mid-region with posterior process; gill parasites of Clariidae, *Bagrus* (Bagridae), and *Papyrocranus afer* (Notopteridae) [Fig. 4.4.12A] ……...***Quadriacanthus***

24 (23) Anchors without patches; dorsal anchors with inner root terminally curled; ventral anchors with thickened ridge extending from outer root across base to shaft; pouch-like structure (onchium), through which dorsal extrinsic muscles extend, present in the anterior region of haptor; gill parasites of *Chrysichthys* (Claroteidae) and *Malapterurus electricus* (Malapteruridae) [Fig. 4.4.13]……..***Protoancylodiscoides***

25 (26) Anchors with patches……27

26 (25) Anchors without patches……..31

27 (28) Patches on ventral anchors only; anchors large, with poorly developed outer root; bars simple in shape; gill parasites of *Heterotis niloticus* (Arapaimidae) [Fig. 4.4.12B]……...***Heterotesia***

28 (27) Patches on both dorsal and ventral anchors……29

29 (30) Ventral and dorsal anchors rootless; patches small; dorsal anchors with shaft sharply (at about 90º) bent proximally; dorsal bar cross-shaped; ventral bar triangular or three-armed; gill parasites of *Clarias* (Clariidae) [Fig. 4.4.14A]……***Birgiellus***

30 (29) Dorsal anchors robust, with flange on superficial surface of base, large patch (wings unequal); ventral anchors small, with delicate patch; dorsal bar complex, with anterior shield and posterior arrow- or T-shaped process; ventral bar broadly U-shaped; in the nasal cavity of *Clarias gariepinus* (Clariidae) [Fig. 4.4.14B]……***Paraquadriacanthus***

31 (32) Dorsal bar with two submedial auricles ……33

32 (31) Dorsal bar lacking auricles……35

33 (34) Dorsal bar with long auricles and lateral wing-shaped enlargements; ventral bar associated with supporting membrane marked by fan-shaped median thickenings; gill parasites of Cichlidae [Fig. 4.4.15A…… ……***Scutogyrus***

34 (33) Dorsal bar with auricles variable in length; ventral bar not associated with supporting membrane, V-shaped, usually with a medial portion reduced in diameter; an auxiliary plate lying in close proximity of the male copulato-

ry organ sometimes present; gill parasites of *Aphyosemion cameronense* (Nothobranchiidae), Cichlidae and *Polycentropsis abbreviata* (Nandidae) [Fig. 4.4.15B]……...***Cichlidogyrus***

35 (36) Both ventral and dorsal bar associated with lightly sclerotised (sometimes poorly defined) supporting membrane; ventral bar often with median process; anchors with inner roots having recurved (erect) terminal half, elongate shaft and short point; gill parasites of Alestidae [Fig. 4.4.16A]…….***Annulotrema***

36 (35) Supporting membrane absent or associated with only one bar……37

37 (38) Bar(s) with a median projection and/or two bilateral anterior arms (*i.e.*, bar ends bent at about 90° anteriorly)……39

38 (37) Bars lacking median projection and such bilateral anterior arms……47

39 (40) Median projection articulated to the ventral bar and associated with lightly sclerotised skirt-like supporting membrane; dorsal bar yoke-shaped with a posterior shield; gill parasites of *Auchenoglanis occidentalis* (Claroteidae) [Fig. 4.4.16B]……..***Bagrobdella***

40 (39) Median projection arising (not articulated) from the ventral bar……41

41 (42) Ventral anchors modified in shape……43

42 (41) Ventral anchors with basal surface protuberance……45

43 (44) Ventral anchors with recurved inner root, elongate (erected) outer root, and diagonally truncate point; ventral bar with two bilateral anterior arms, small/delicate posteromedial projection usually present; dorsal bar simple, rod-shaped; gill parasites of Alestidae [Fig. 4.4.17A]…… ……...***Characidotrema***

44 (43) Ventral anchors with prominent superficial knob on base near its union with the shaft, shaft sharply (usually at about 90º) bent proximally, roots variable in shape; bars usually with lateral, subterminal (often horn-shaped) and medial anterior projections; accessory sclerite associated with anteromedial projection of the ventral bar may be present; gill parasites of Schilbeidae [Fig. 4.4.17B]……***Schilbetrema***

45 (46) Ventral anchors with pestle-shaped protuberance diagonally extending from outer root to inner side of proximal part of the shaft; ventral bar with lobed ends and medial projection; dorsal anchors with small to reduced outer root; dorsal bar simple, with indistinct supporting membrane; gill parasites of *Synodontis* (Mochokidae) [Fig. 4.4.18A]…… …… ***Synodontella***

46 (45) Ventral anchors robust, with leaf-shaped protuberance extending along medial part of base; ventral bar with lobed ends and medial projection;

dorsal anchors with shaft slightly swollen at its union with base; dorsal bar with two subterminal joint-like thickenings; gill parasites of *Gnathonemus petersii* (Mormyridae) [Fig. 4.4.18B]…….***Archidiplectanum***

47 (48) Bars (primarily ventral bar) with recurved ends, subterminal constrictions; dorsal bar with indistinct supporting membrane; ventral anchors with wide base; gill parasites of Cichlidae in Madagascar [Fig. 4.4.19A]…… ……***Insulacleidus***

48 (47) Ventral bar saddle-shaped, with enlarged (bulbous) terminations and rectangular enlargement of anteromedial margin; dorsal bar rod- or broadly U-shaped; anchors with enlarged roots and relatively delicate shaft; gill parasites of *Distichodus* (Distichodontidae) [Fig. 4.4.19B]…… ……***Afrocleidodiscus***

Key to the genera of the Gyrodactylidae van Beneden et Hesse, 1863

1 (2) Haptor with 16 hooks of the same type; ventral and dorsal bar present……3

2 (1) Haptor with 16 hooks of two different types (ten hooks with large falculate sickles, six smaller hooks with well-articulated sickles), a pair of muscular adhesive discs situated on the side of anchors; no dorsal bar present; gill parasites of *Polypterus senegalus* (Polypteridae) [Fig. 4.4.20A]…… ……..***Diplogyrodactylus***

3 (4) Hooks evenly distributed along the edge of haptor……5

4 (3) Hooks distributed unevenly; 14 hooks arranged in a row along the posterior margin of haptor; two hooks located on anterolateral lobes, reflected forwards; peg-like tegumental extensions (supporting struts) present on lateral and anterior margins of haptor; inner roots of anchors associated with accessory bars; ventral bar associated with two pairs of supporting rods (not incorporated in the bar); gill, skin/fin parasites of Clariidae, *Ctenopoma muriei* (Anabantidae), *Lates niloticus* (Latidae) and Polypteridae [Fig. 4.4.20B]…….***Macrogyrodactylus***

5 (6) Haptor with four pairs of accessory bars; three (two lateral, one central) supporting rods incorporated in ventral bar present; skin/fin parasites of *Marcusenius macrolepidotus* (Mormyridae) [Fig. 4.4.21A]…….***Mormyrogyrodactylus***

6 (5) Haptor lacking accessory bars……7

7 (8) Anchors with two developed roots; outer root conspicuous, approximately half-length of inner root; ventral bar without membrane and anterolateral processes; gill, skin/fin parasites of Alestidae [Fig. 4.4.21B] ……***Afrogyrodactylus***

8 (7) Anchors with only one (inner) developed root……9

9 (10) Ventral bar with membrane, anterolateral processes may be present; male copulatory organ bulbous, equipped with one apical spine and row(s) of small spines; gill, skin/fin parasites of various host families [Fig. 4.4.22A] ……***Gyrodactylus***

10 (9) Anchors with a constriction between shaft and point; ventral bar with membrane, anterolateral processes lacking; male copulatory organ muscular, consists of a central curved cone and a muscular pouch armed with numerous small spines; gill parasites of *Citharinus citharus* (Citharinidae) [Fig. 4.4.22B]……***Citharodactylus***

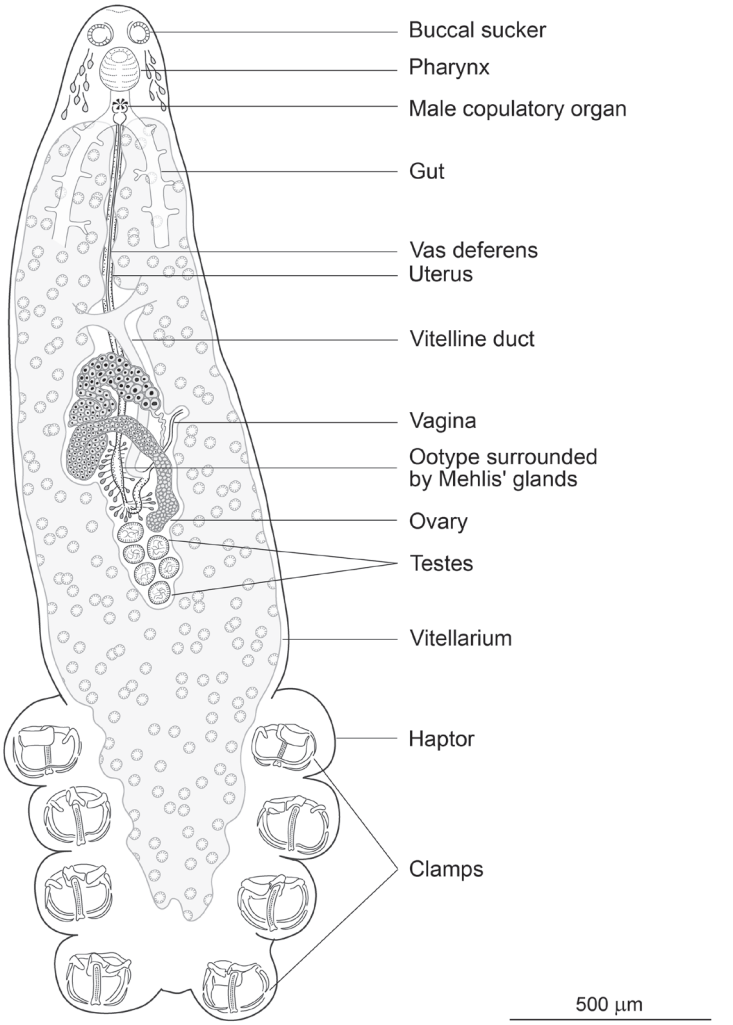

Fig. 4.4.3. Monogenea (Diclidophoridae). *Heterobothrium fluviatilis* Euzet et Birgi, 1975 from *Tetraodon lineatus*. (Modified from Euzet & Birgi 1975.)

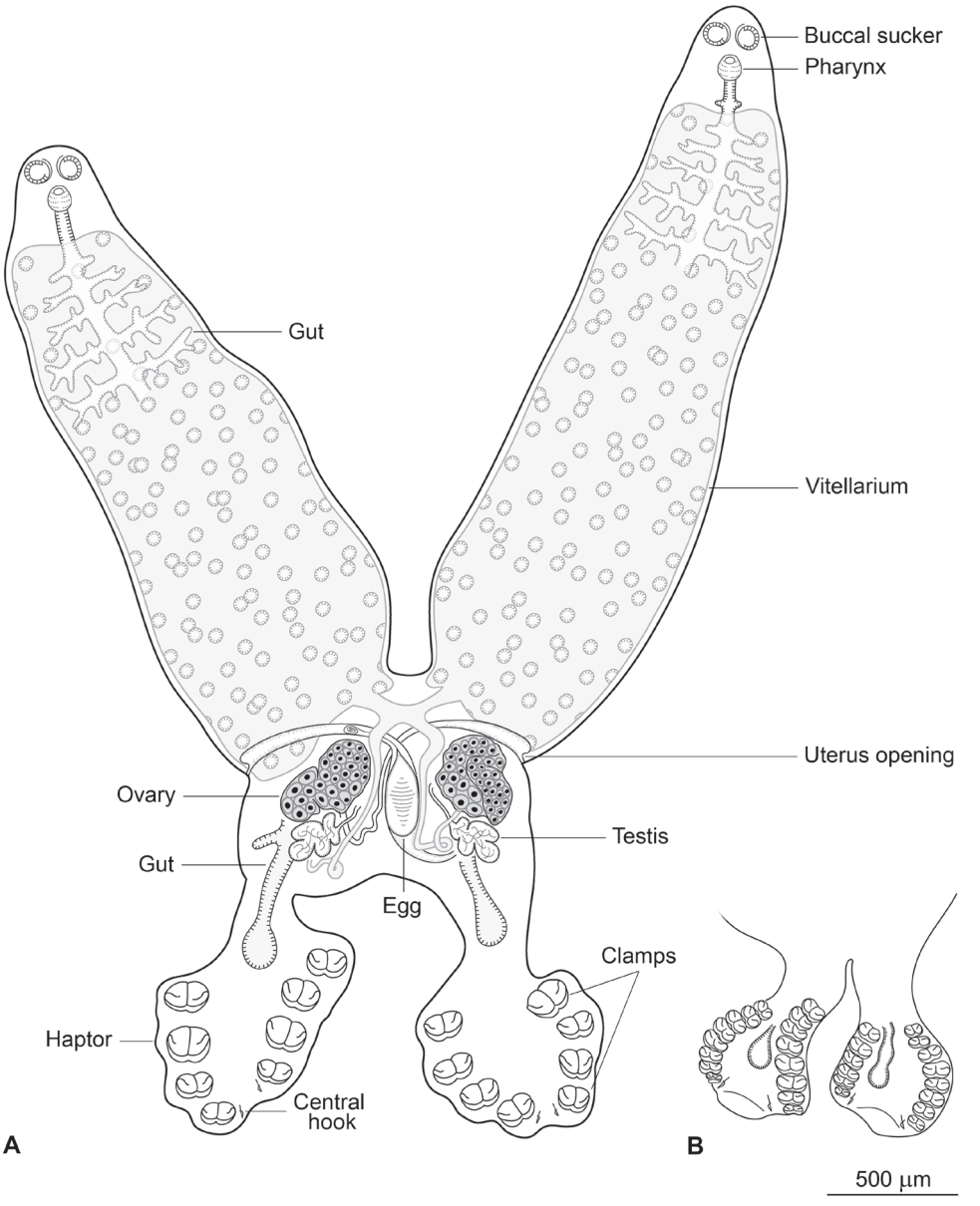

Fig. 4.4.4. Monogenea (Diplozoidae). **A.** *Paradiplozoon ghanense* (Thomas, 1957) from *Brycinus macrolepidotus*; **B.** *Afrodiplozoon polycotyleus* (Paperna, 1973) from *Enteromius cercops*. (Modified from Khotenovsky 1985.)

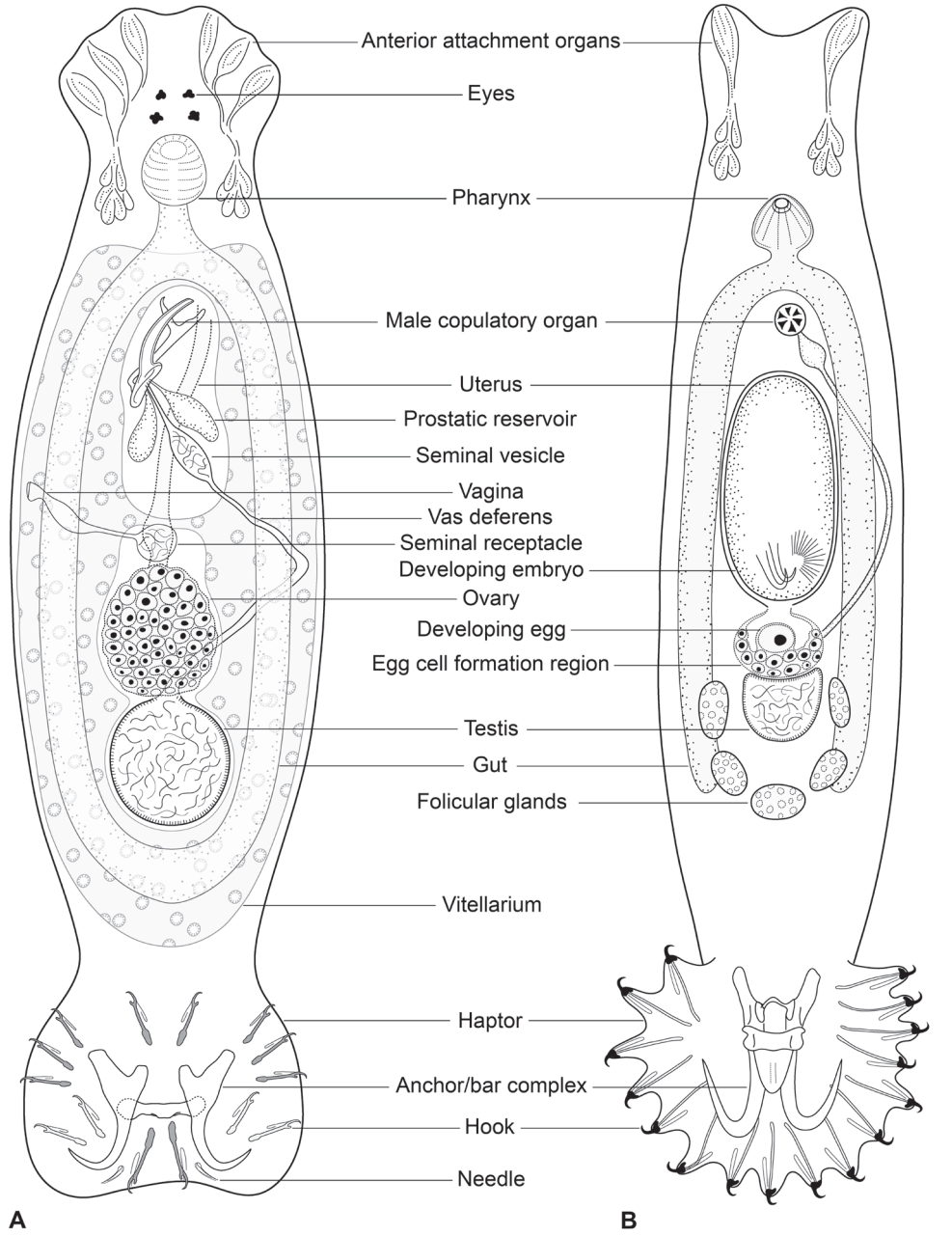

Fig. 4.4.5. Monogenea (Polyonchoinea). **A.** Generalised anatomy of oviparous *Dactylogyrus* sp., ventral view; **B.** Generalised anatomy of viviparous *Gyrodactylus* sp., ventral view. (Modified from Roberts *et al.* 2013.)

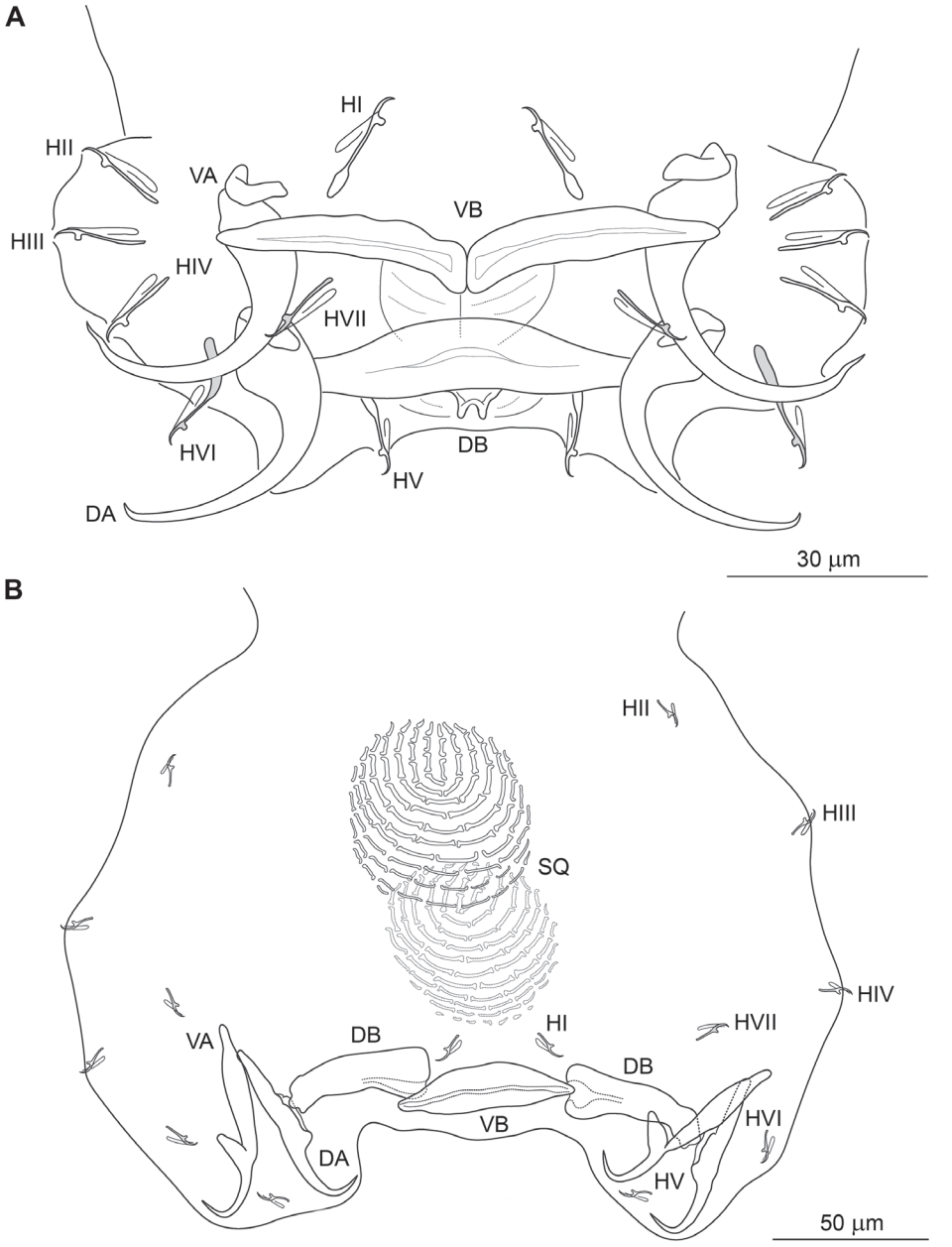

Fig. 4.4.6. Monogenea (Polyonchoinea). **A.** Haptor of *Quadriacanthus ashuri* Kritsky et Kulo, 1988 (Dactylogyridae) from *Clarias gariepinus*. **B.** Haptor of *Diplectanum lacustre* Thurston et Paperna, 1969 (Diplectanidae) from *Lates niloticus*. (Modified from Kritsky & Kulo 1988.) VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; HI-VII = hooks; SQ = squamodiscs.

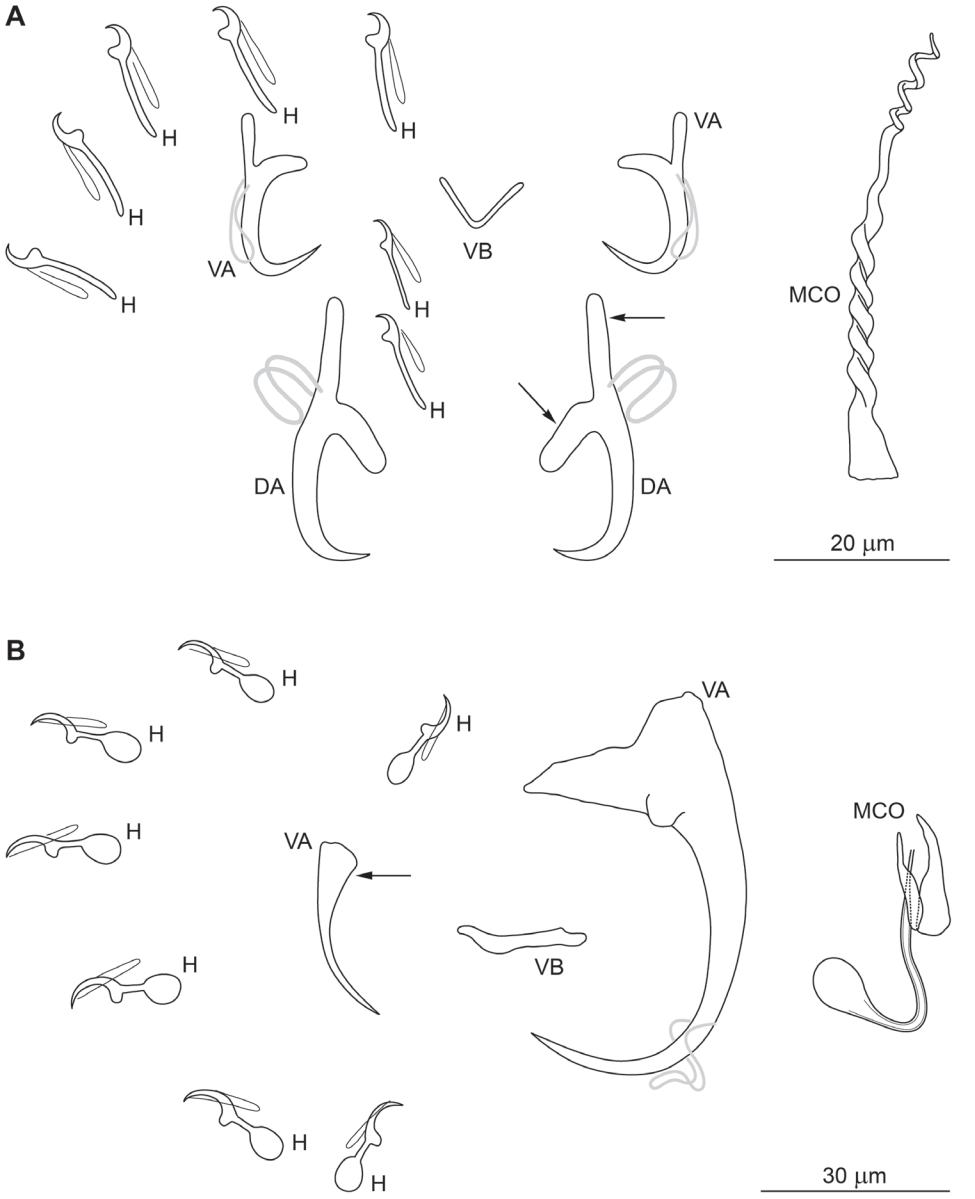

Fig. 4.4.7. Monogenea (Dactylogyridae). **A.** *Enterogyrus amieti* Bilong Bilong, Euzet et Birgi, 1996 from *Sarotherodon galilaeus*; **B.** *Urogyrus cichlidarum* Bilong Bilong, Birgi et Euzet, 1994 from *Benitochromis batesii*. (Modified from Bilong Bilong *et al.* 1994, 1996.) VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; H = hook; MCO = male copulatory organ.

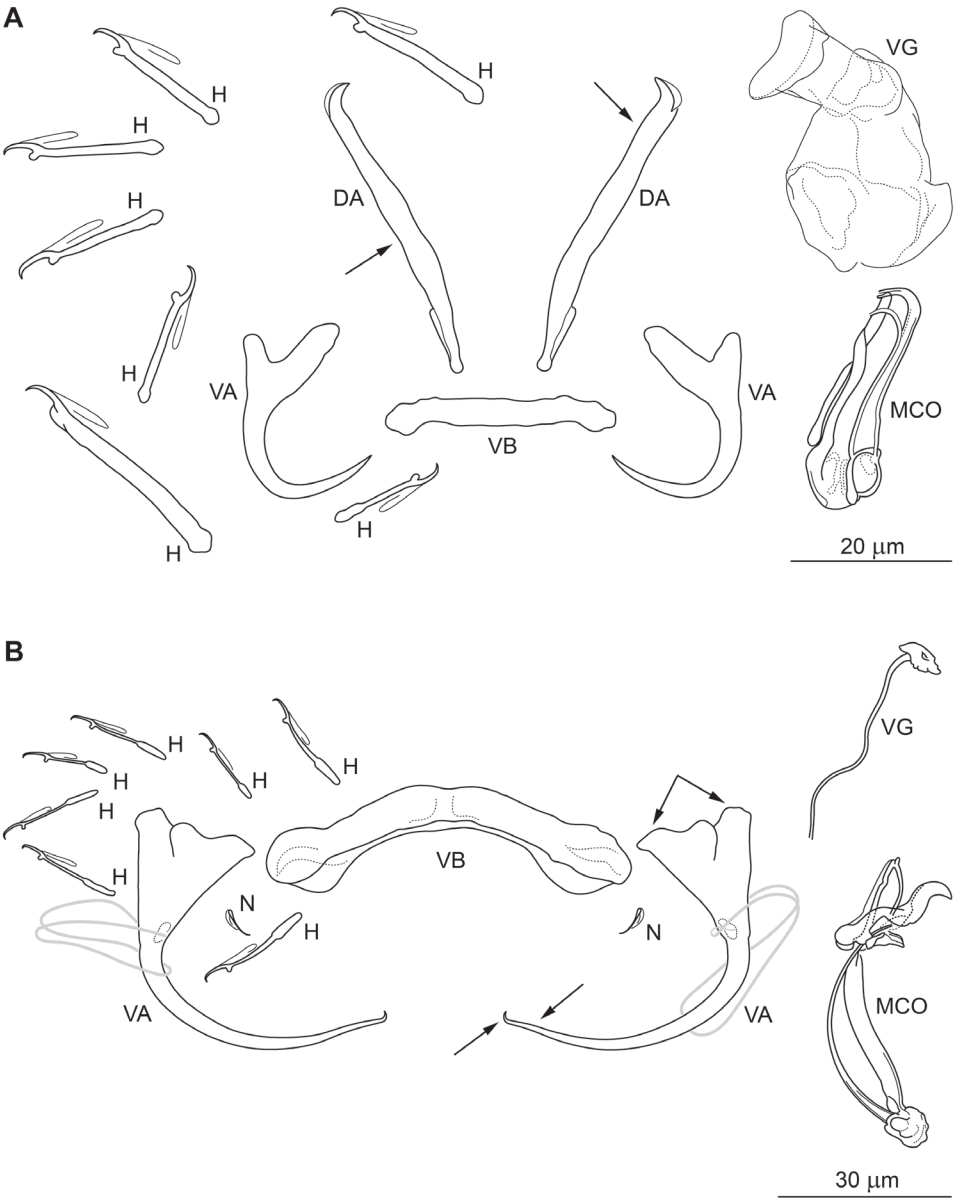

Fig. 4.4.8. Monogenea (Dactylogyridae). **A.** *Nanotrema citharini* Paperna, 1969 from *Citharinus citharus*; **B.** *Dogielius anthocolpos* Guégan, Lambert et Euzet, 1989 from *Labeo coubie*. VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; N = needle; H = hook; VG = vagina; MCO = male copulatory organ.

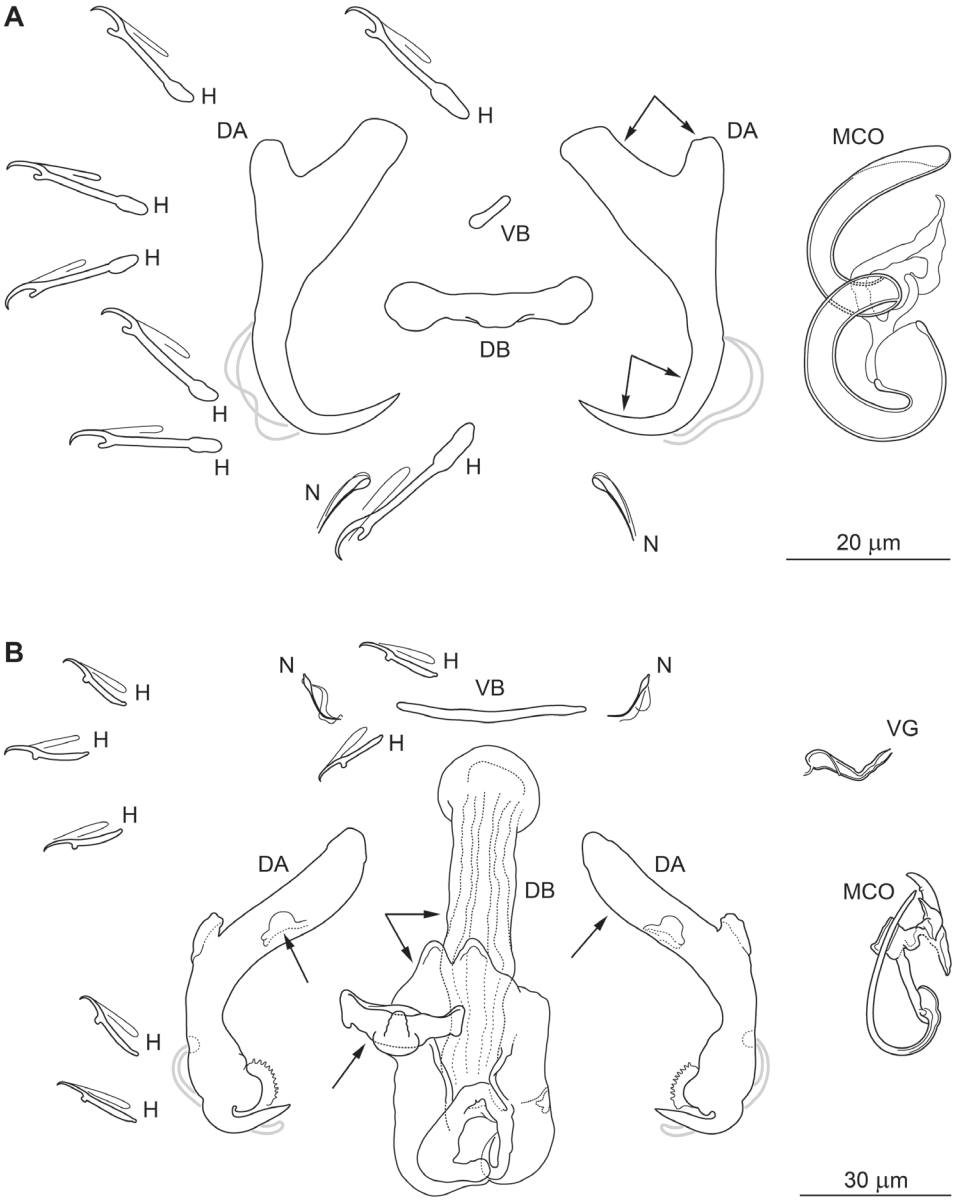

Fig. 4.4.9. Monogenea (Dactylogyridae). **A.** *Dactylogyrus yassensis* Musilová, Řehulková et Gelnar, 2009 from *Labeo coubie*. **B.** *Schilbetrematoides manizani* N'Douba, Lambert, Pariselle et Euzet, 2000 from *Schilbe intermedius*. (Modified from Musilová *et al.* 2009.) VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; N = needle; H = hook; VG = vagina; MCO = male copulatory organ.

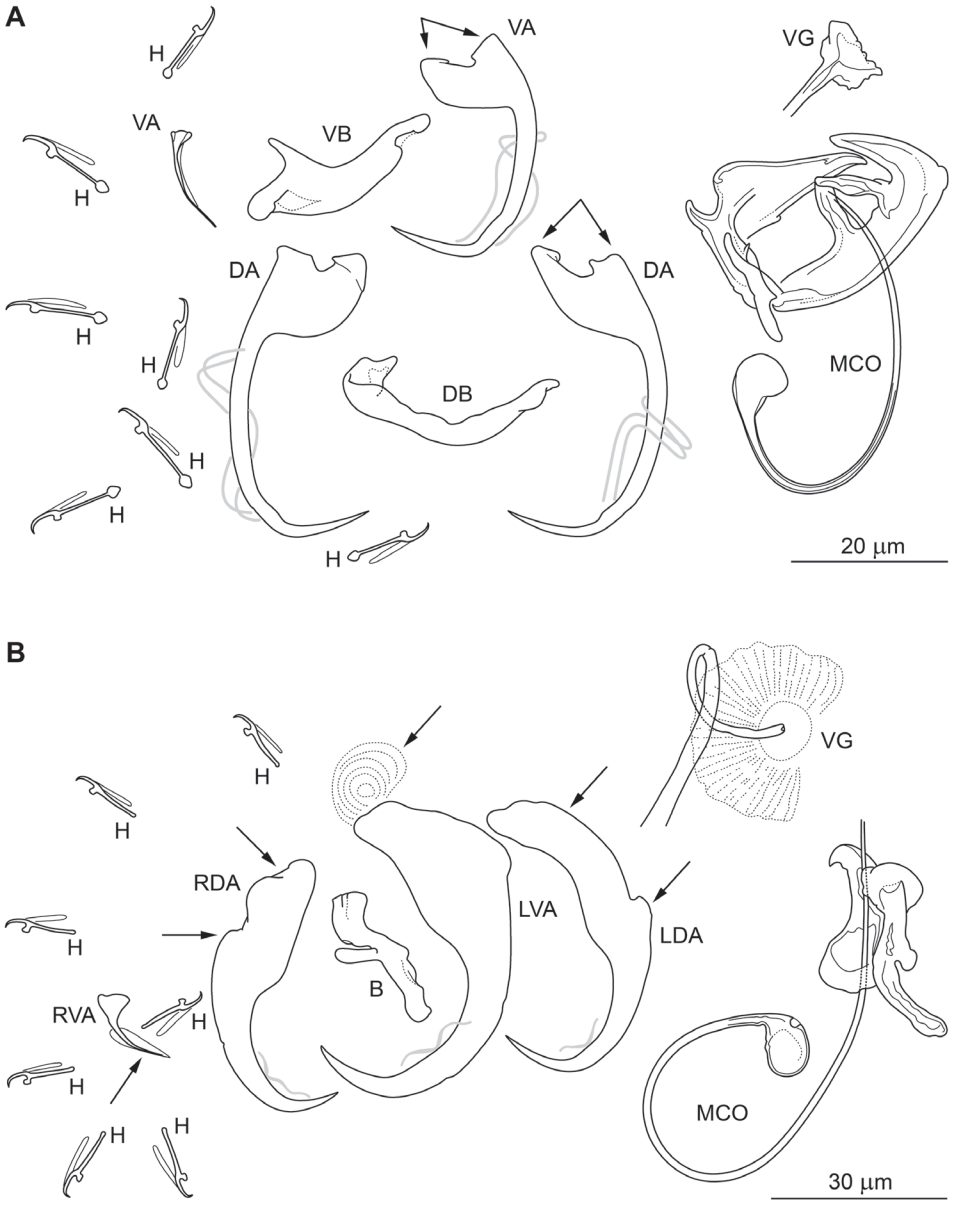

Fig. 4.4.10. Monogenea (Dactylogyridae). **A.** *Heteronchocleidus adjanohouni* Euzet et Dossou, 1975 from *Ctenopoma petherici*; **B.** *Eutrianchoratus malleus* Bilong Bilong, Euzet et Birgi, 1994 from *Parachanna obscura*. VA = ventral anchor; LVA = left ventral anchor; RVA = right ventral anchor; VB = ventral bar; DA = dorsal anchor; LDA = left dorsal anchor; RDA = right dorsal anchor; DB = dorsal bar; B = bar; H = hook; VG = vagina; MCO = male copulatory organ.

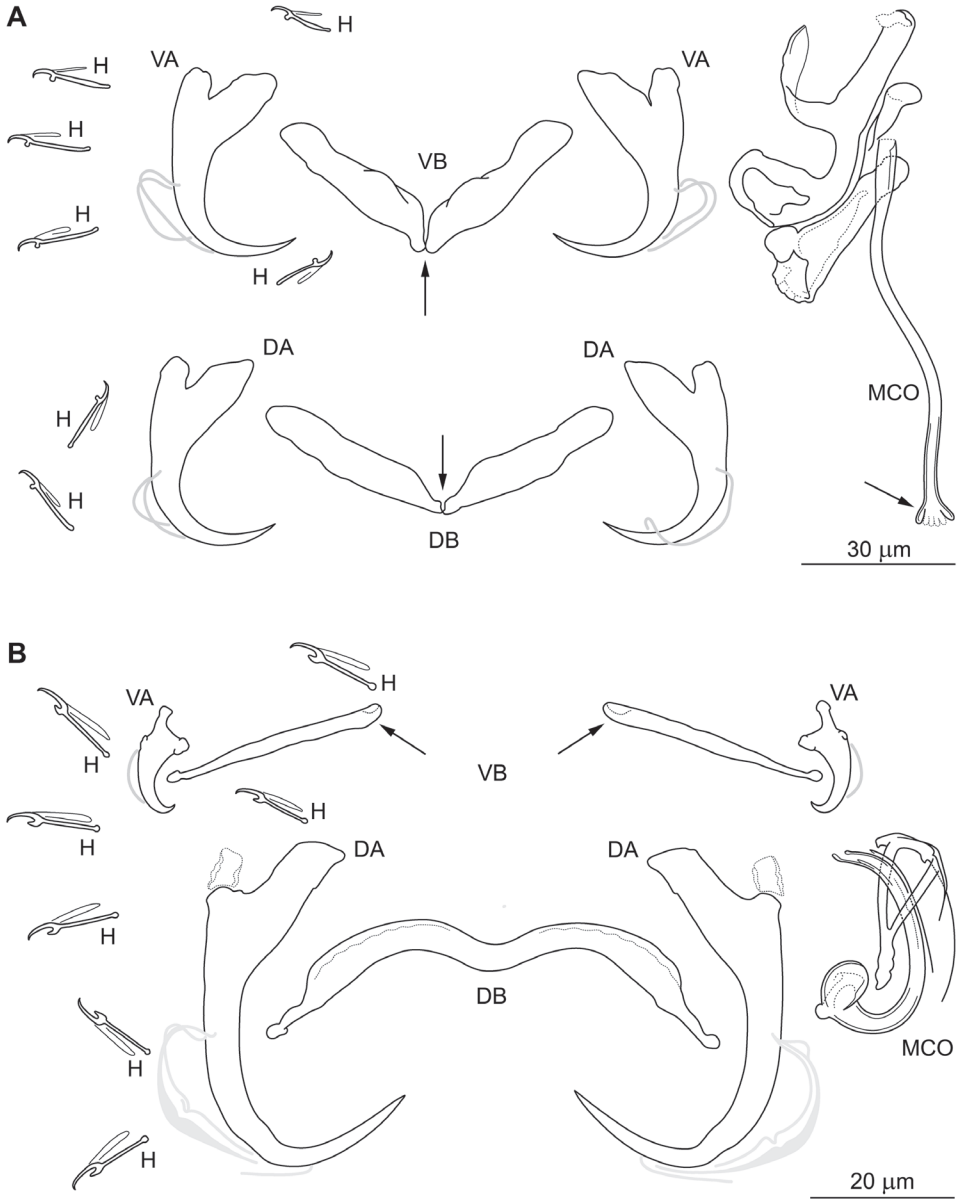

Fig. 4.4.11. Monogenea (Dactylogyridae). **A.** *Bouixella mormyrume* Euzet et Dossou, 1976 from *Mormyrus kannume*; **B.** *Onchobdella voltensis* Paperna, 1968 from *Hemichromis fasciatus*. VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; H = hook; MCO = male copulatory organ.

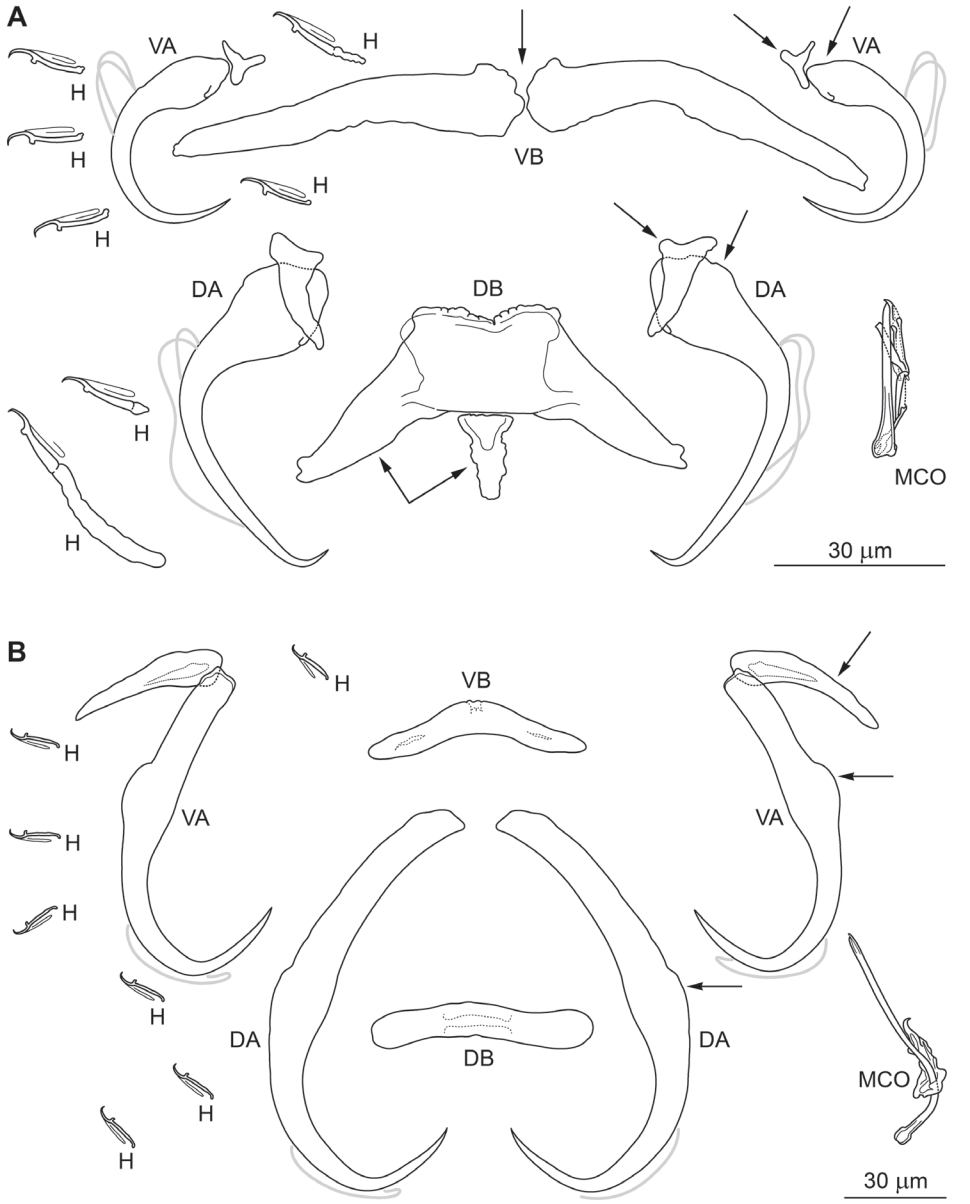

Fig. 4.4.12. Monogenea (Dactylogyridae). **A.** *Quadriacanthus clariadis* Paperna, 1961 from *Clarias gariepinus*; **B.** *Heterotesia voltae* Paperna, 1969 from *Heterotis niloticus*. VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; H = hook; MCO = male copulatory organ.

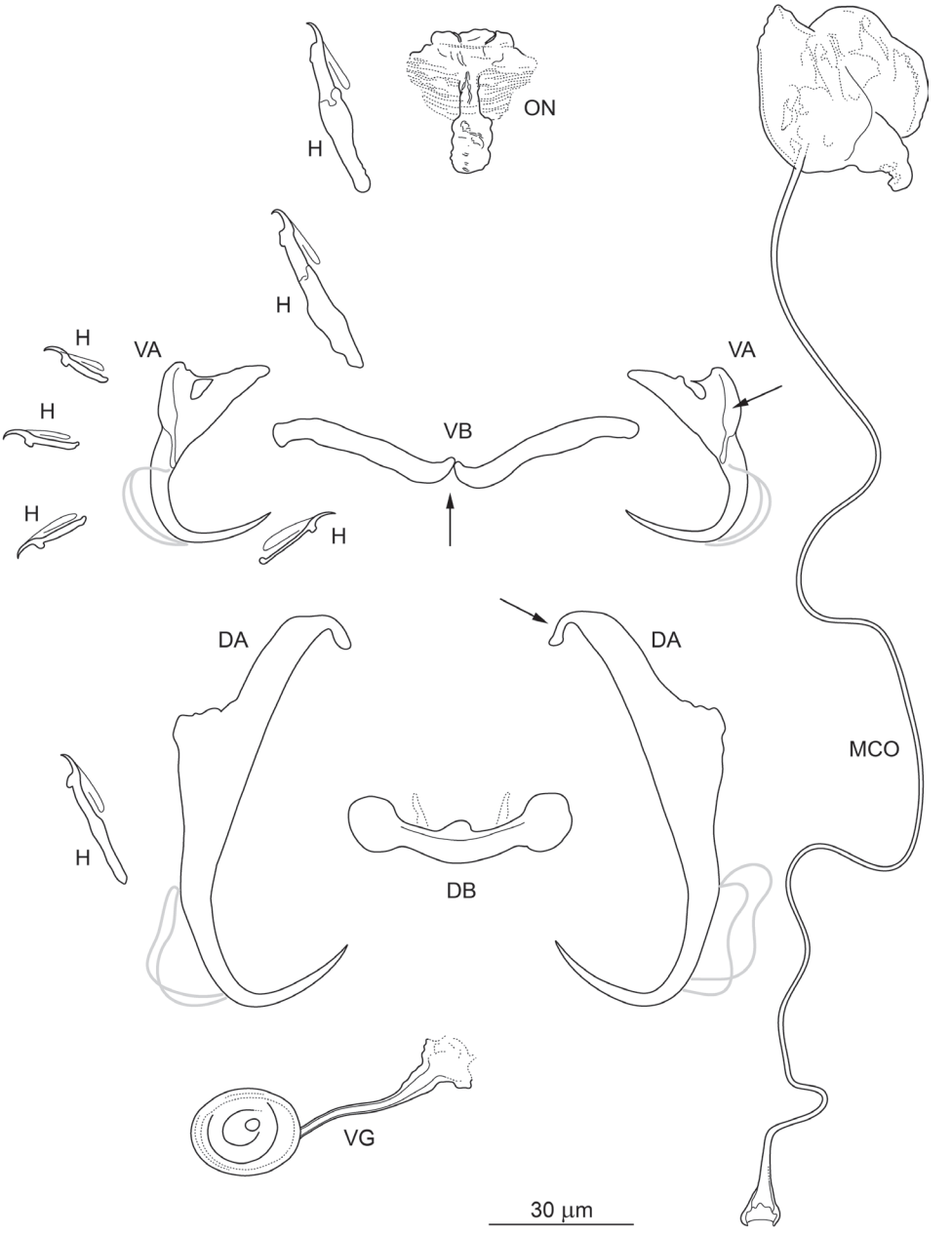

Fig. 4.4.13. Monogenea (Dactylogyridae). *Protoancylodiscoides mansourensis* El-Naggar, 1987 from *Chrysichthys auratus*. VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; H = hook; ON = onchium; VG = vagina; MCO = male copulatory organ.

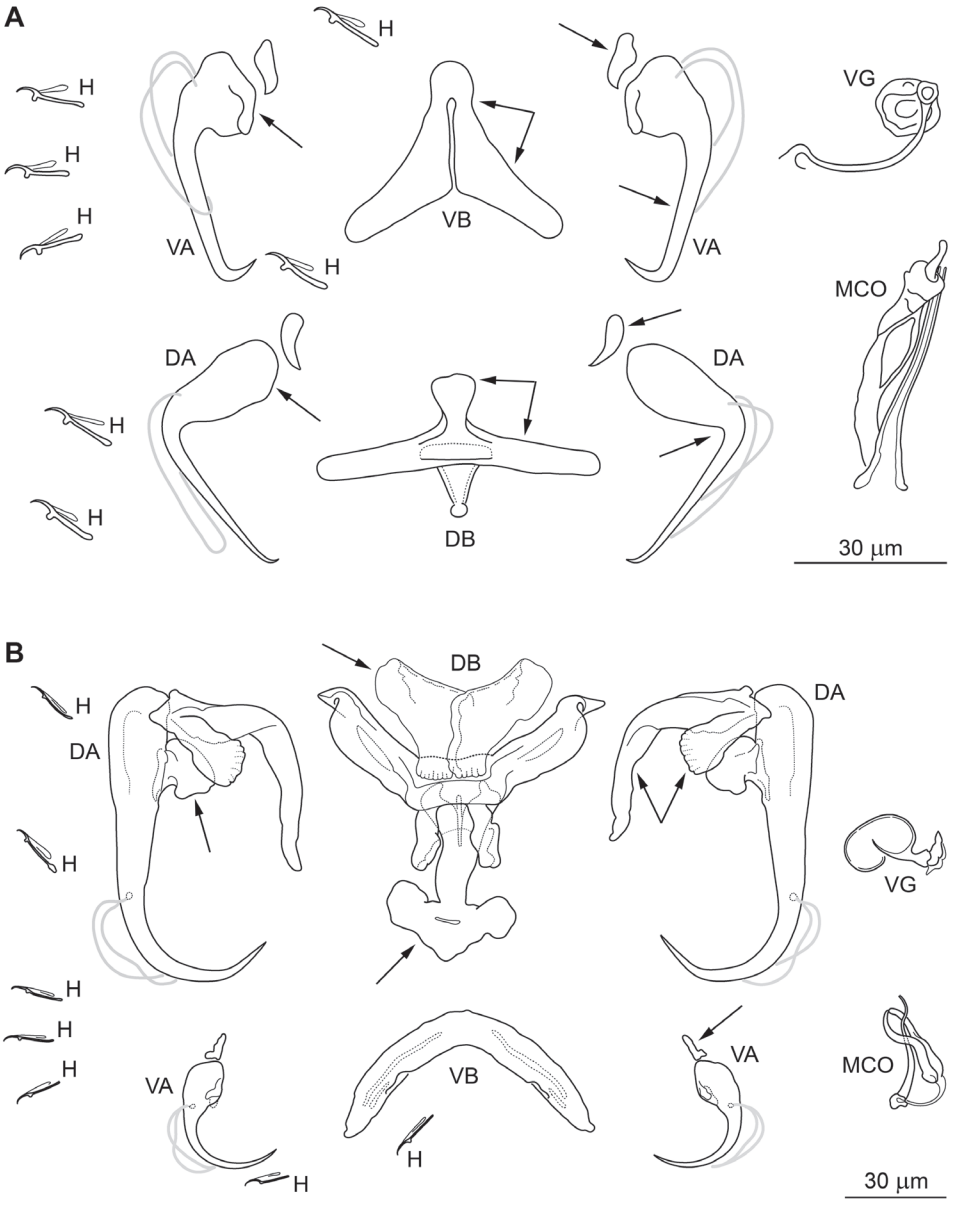

Fig. 4.4.14. Monogenea (Dactylogyridae). **A.** *Birgiellus mutatus* Bilong Bilong, Nack et Euzet, 2007 from *Clarias pachynema*. **B.** *Paraquadriacanthus nasalis* Ergens, 1988 from *Clarias gariepinus*. (Modified from Bilong Bilong *et al.* 2007.) VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; H = hook; VG = vagina; MCO = male copulatory organ.

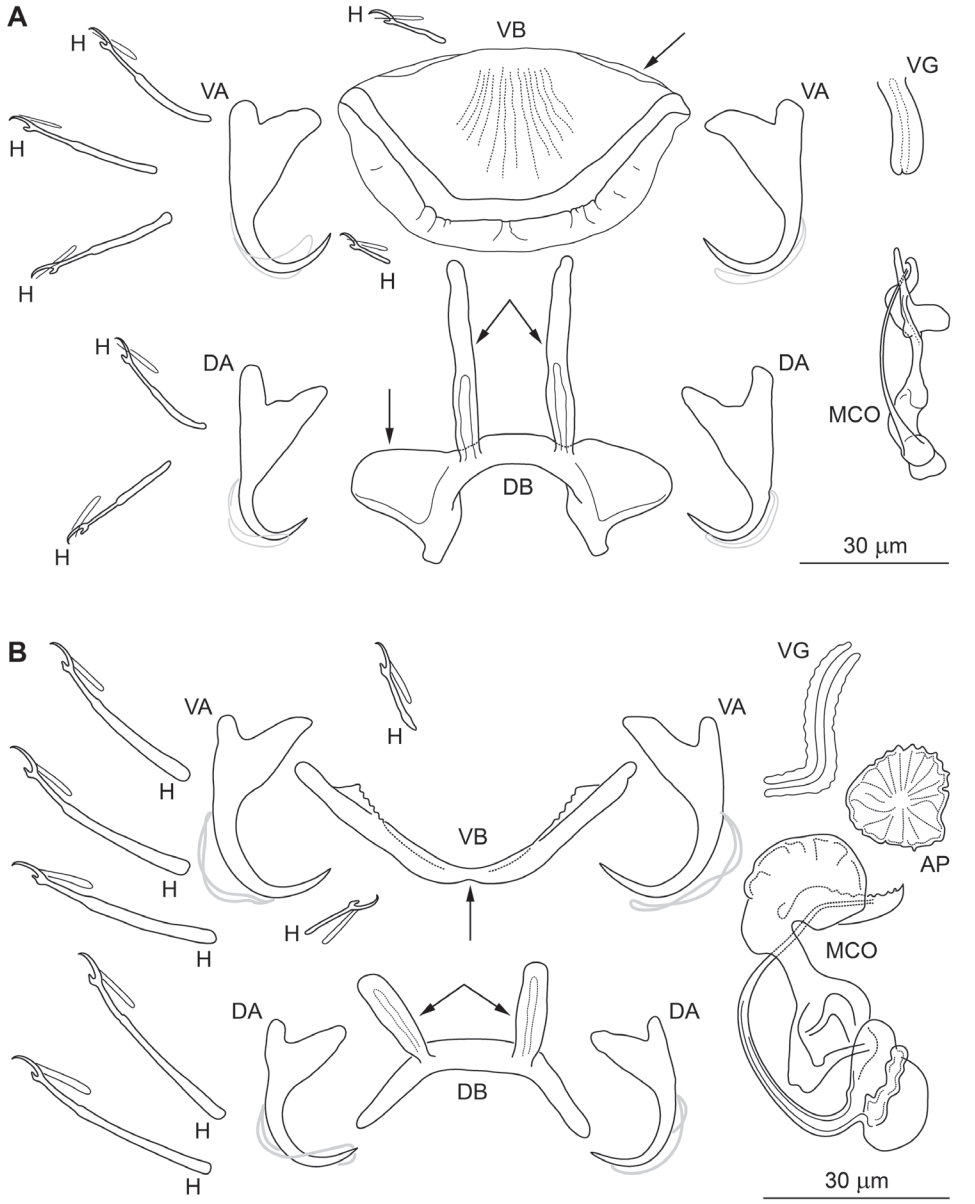

Fig. 4.4.15. Monogenea (Dactylogyridae). **A.** *Scutogyrus minus* (Dossou, 1982) from *Oreochromis niloticus*; **B.** *Cichlidogyrus gallus* Pariselle et Euzet, 1995 from *Coptodon guineensis*. (Modified from Pariselle & Euzet, 1995a,b.) VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; H = hook; VG = vagina; MCO = male copulatory organ; AP = accessory plate.

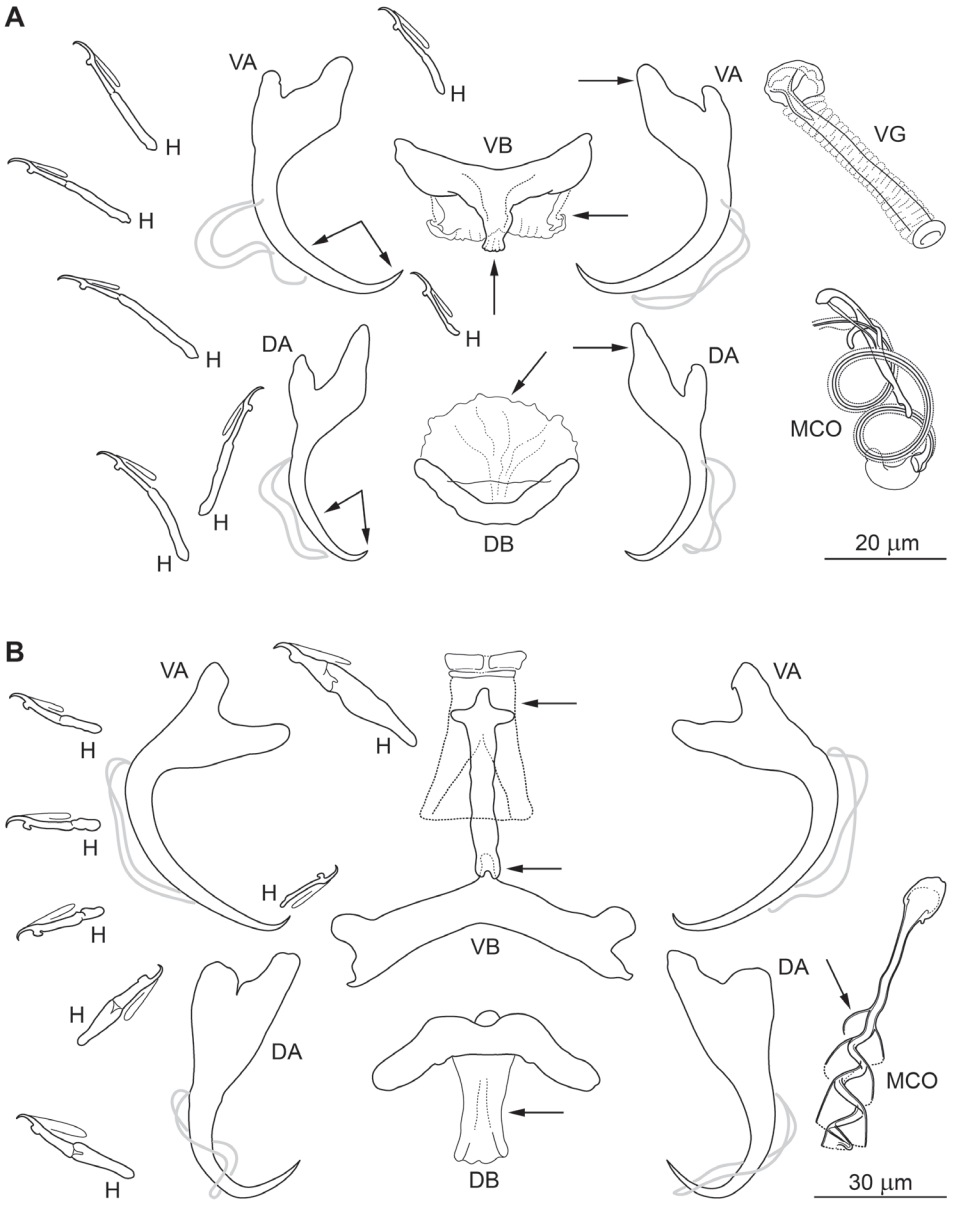

Fig. 4.4.16. Monogenea (Dactylogyridae). **A.** *Annulotrema uncata* Řehulková, Musilová et Gelnar, 2014 from *Hydrocynus brevis*. **B.** *Bagrobdella auchenoglanii* Paperna, 1969 from *Auchenoglanis occidentalis*. (Modified from Řehulková *et al.* 2014.) VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; H = hook; VG = vagina; MCO = male copulatory organ.

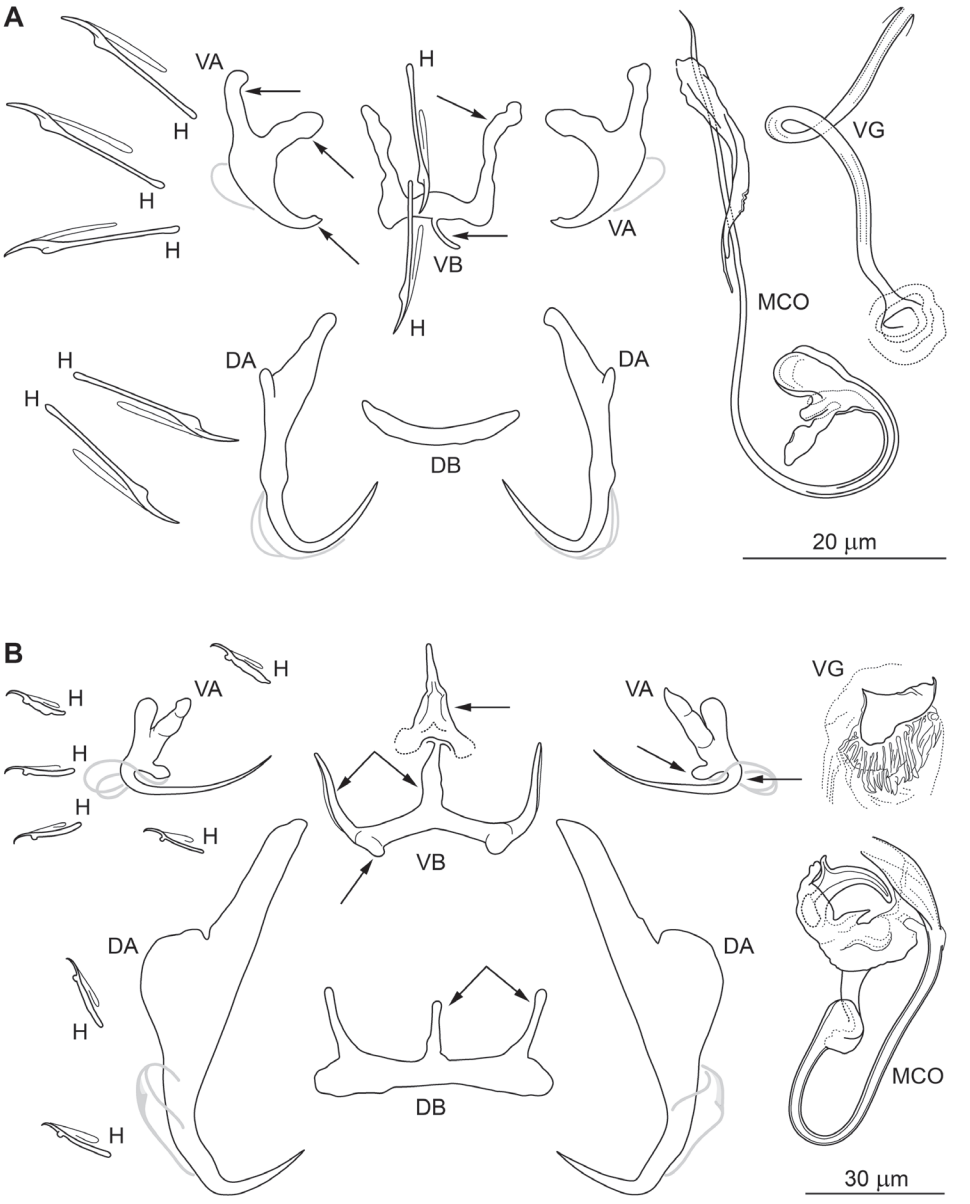

Fig. 4.4.17. Monogenea (Dactylogyridae). **A.** *Characidotrema nursei* Ergens, 1973 from *Brycinus nurse*; **B.** *Schilbetrema hexacornis* Paperna, 1969 from *Schilbe mystus*. VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; H = hook; VG = vagina; MCO = male copulatory organ.

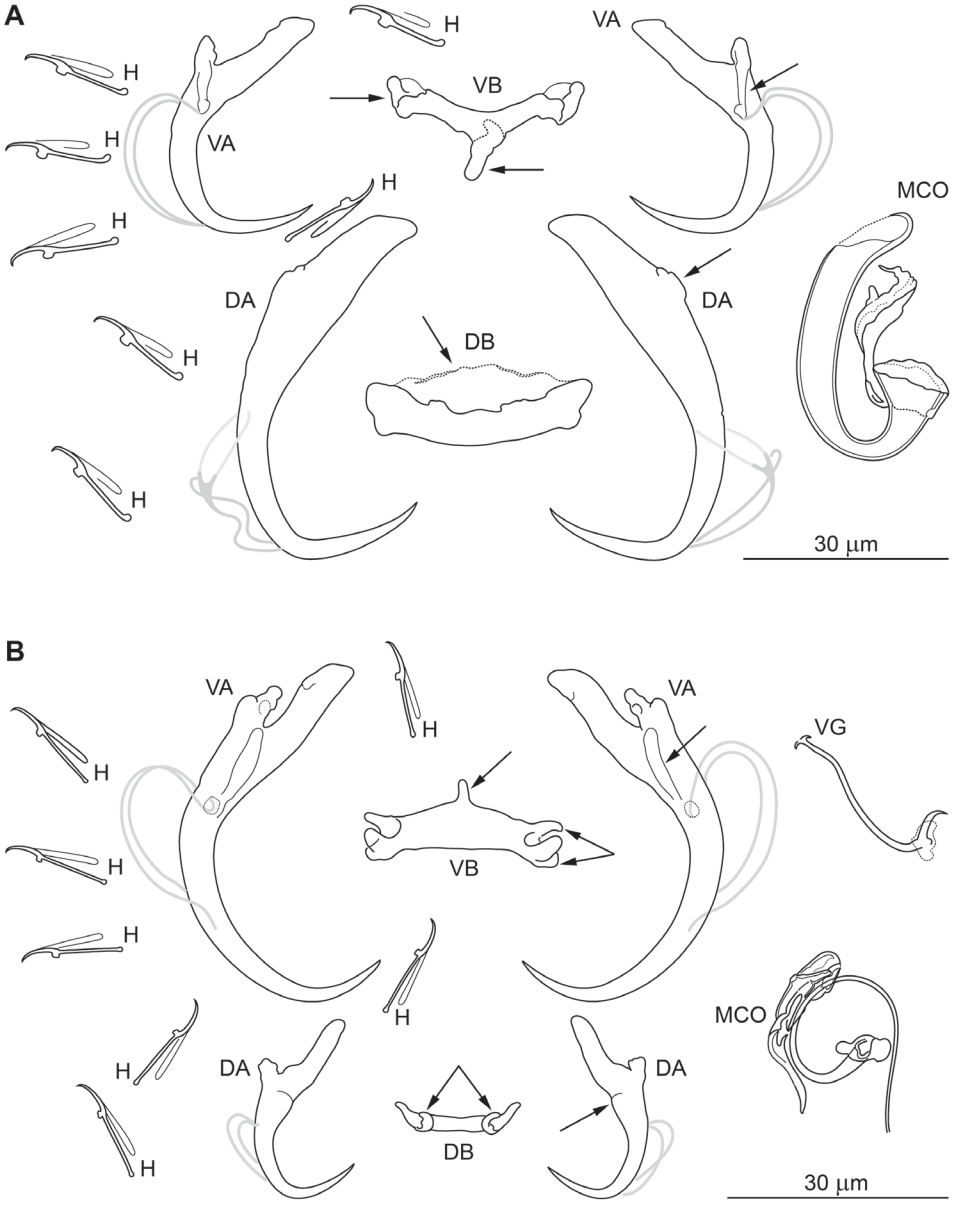

Fig. 4.4.18. Monogenea (Dactylogyridae). **A.** *Synodontella melanoptera* Dossou et Euzet, 1993 from *Synodontis melanopterus*; **B.** *Archidiplectanum archidiplectanum* Mizelle et Kritsky, 1969 from *Gnathonemus petersii*. VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; H = hook; VG = vagina; MCO = male copulatory organ.

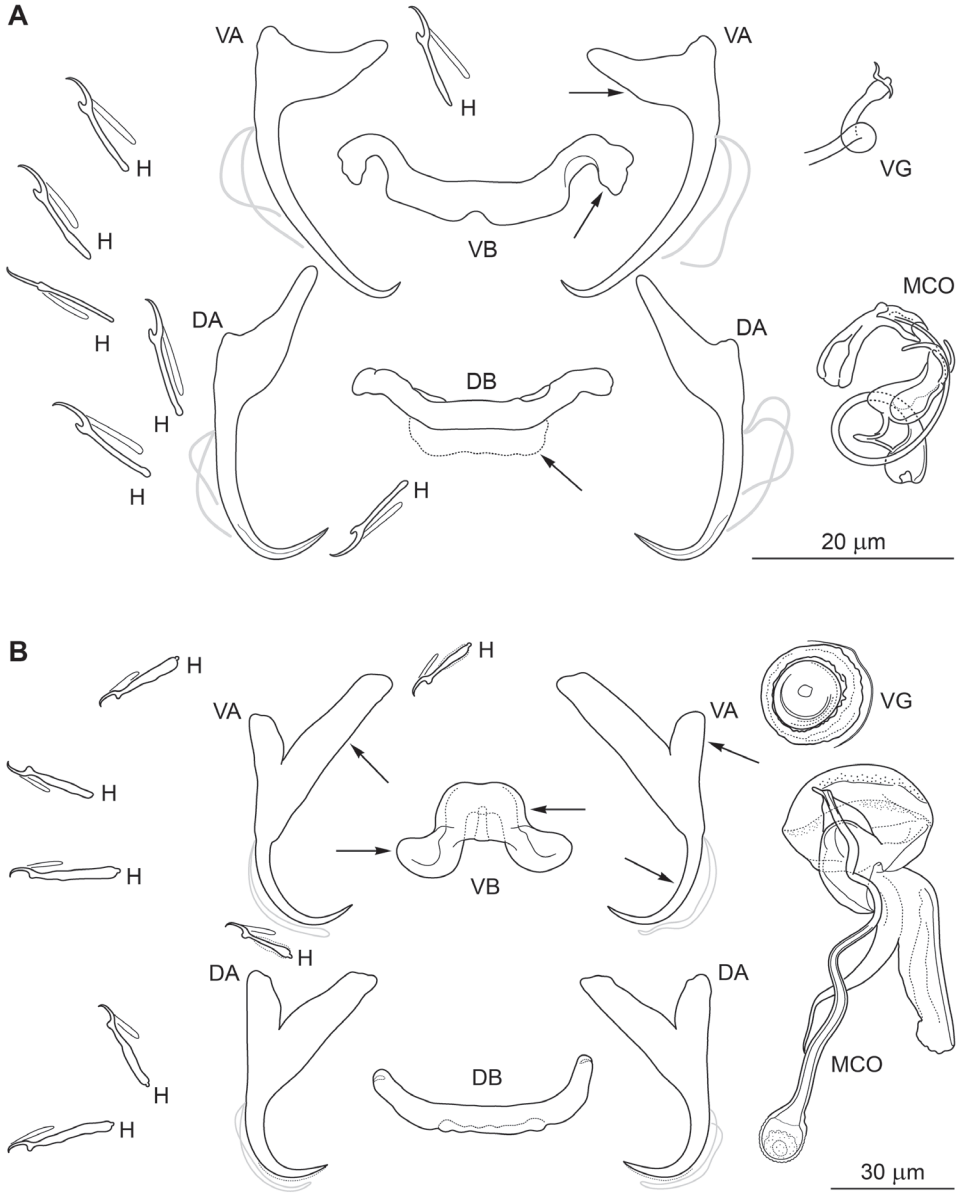

Fig. 4.4.19. Monogenea (Dactylogyridae). **A.** *Insulacleidus paratilapiae* Rakotofiringa et Euzet, 1983 from *Paratilapia polleni*; **B.** *Afrocleidodiscus paracleidodiscus* Paperna, 1973 from *Distichodus nefasch*. VA = ventral anchor; VB = ventral bar; DA = dorsal anchor; DB = dorsal bar; H = hook; VG = vagina; MCO = male copulatory organ.

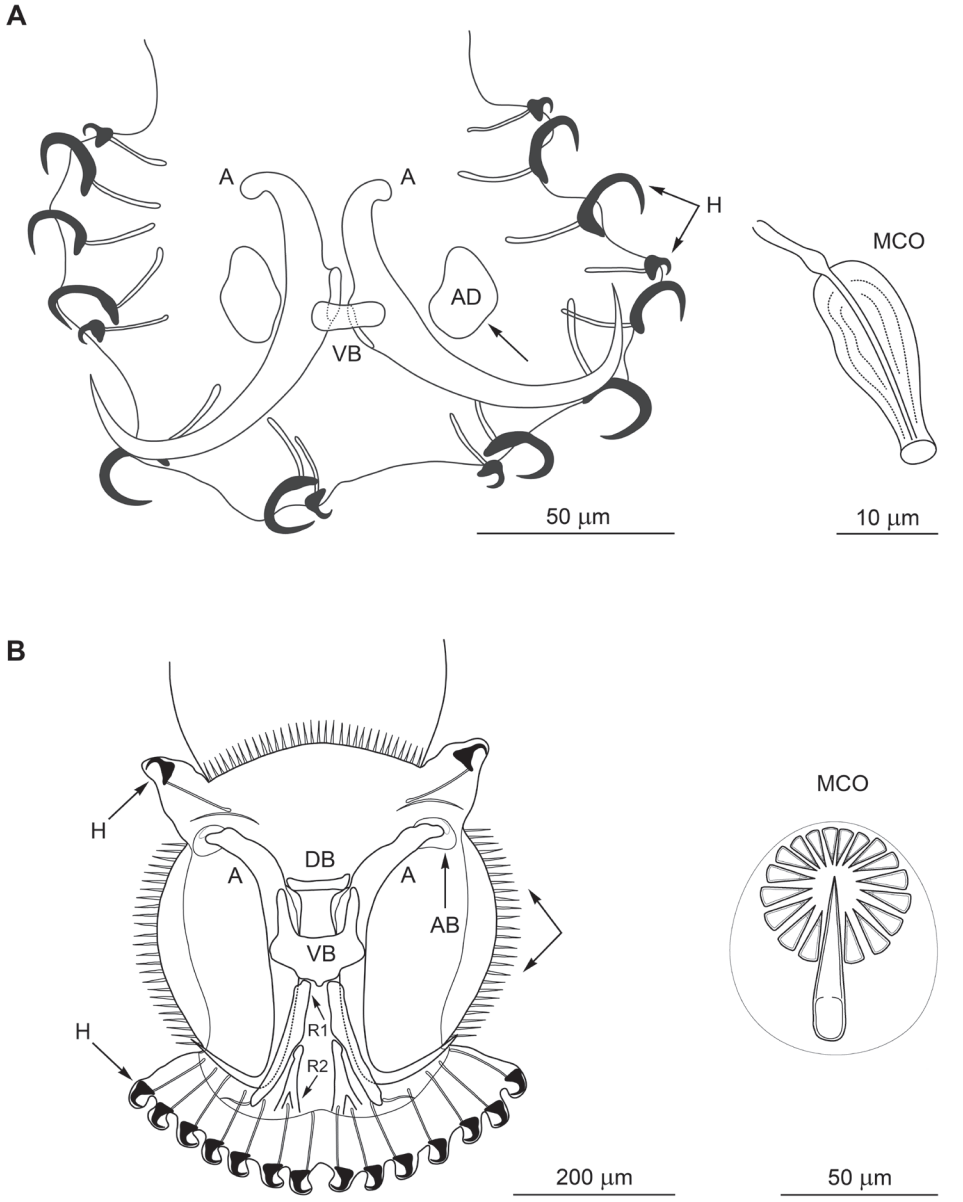

Fig. 4.4.20. Monogenea (Gyrodactylidae). **A.** *Diplogyrodactylus martini* Přikrylová, Matějusová, Musilová, Gelnar et Harris, 2009 from *Polypterus senegalus*; **B.** *Macrogyrodactylus congolensis* (Prudhoe, 1957) from *Clarias gariepinus*. (Modified from El-Naggar *et al.* 1999; Přikrylová *et al.* 2009.) A = anchor; AB = accessory bar, VB = ventral bar; R1, R2 = ventral bar rods; DB = dorsal bar; H = hook; AD = adhesive disc, MCO = male copulatory organ.

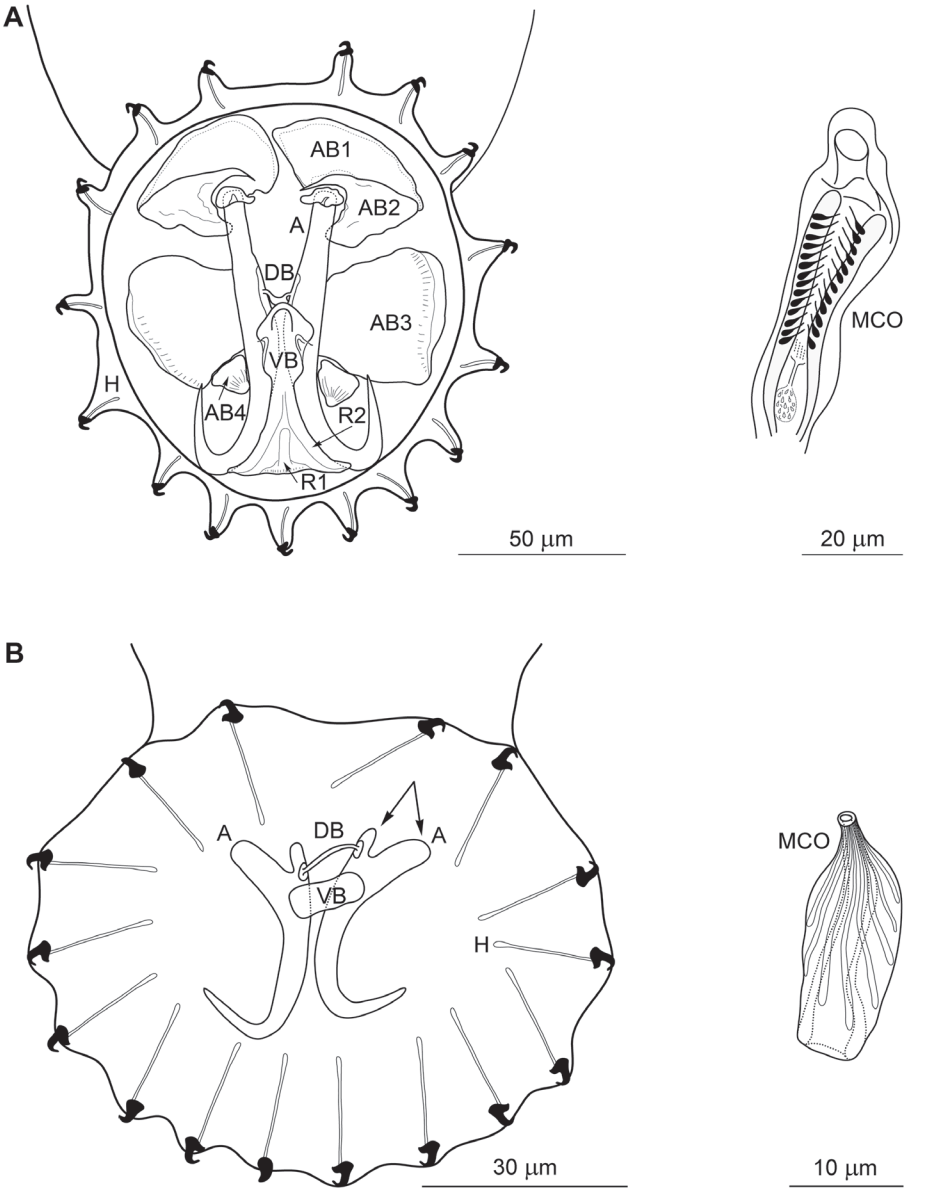

Fig. 4.4.21. Monogenea (Gyrodactylidae). **A.** *Mormyrogyrodactylus gemini* Luus-Powell, Mashego et Khalil, 2003 from *Marcusenius macrolepidotus*; **B.** *Afrogyrodactylus kingi* Přikrylová et Luus-Powell, 2014 from *Micralestes acutidens*. (Modified from Luus-Powell *et al.* 2003; Vianna *et al.* 2007; Přikrylová & Luus-Powell 2014.) A = anchor; VB = ventral bar; R1, R2 = ventral bar rods; DB = dorsal bar; H = hook; AB1–AB4 = accessory bars; MCO = male copulatory organ.

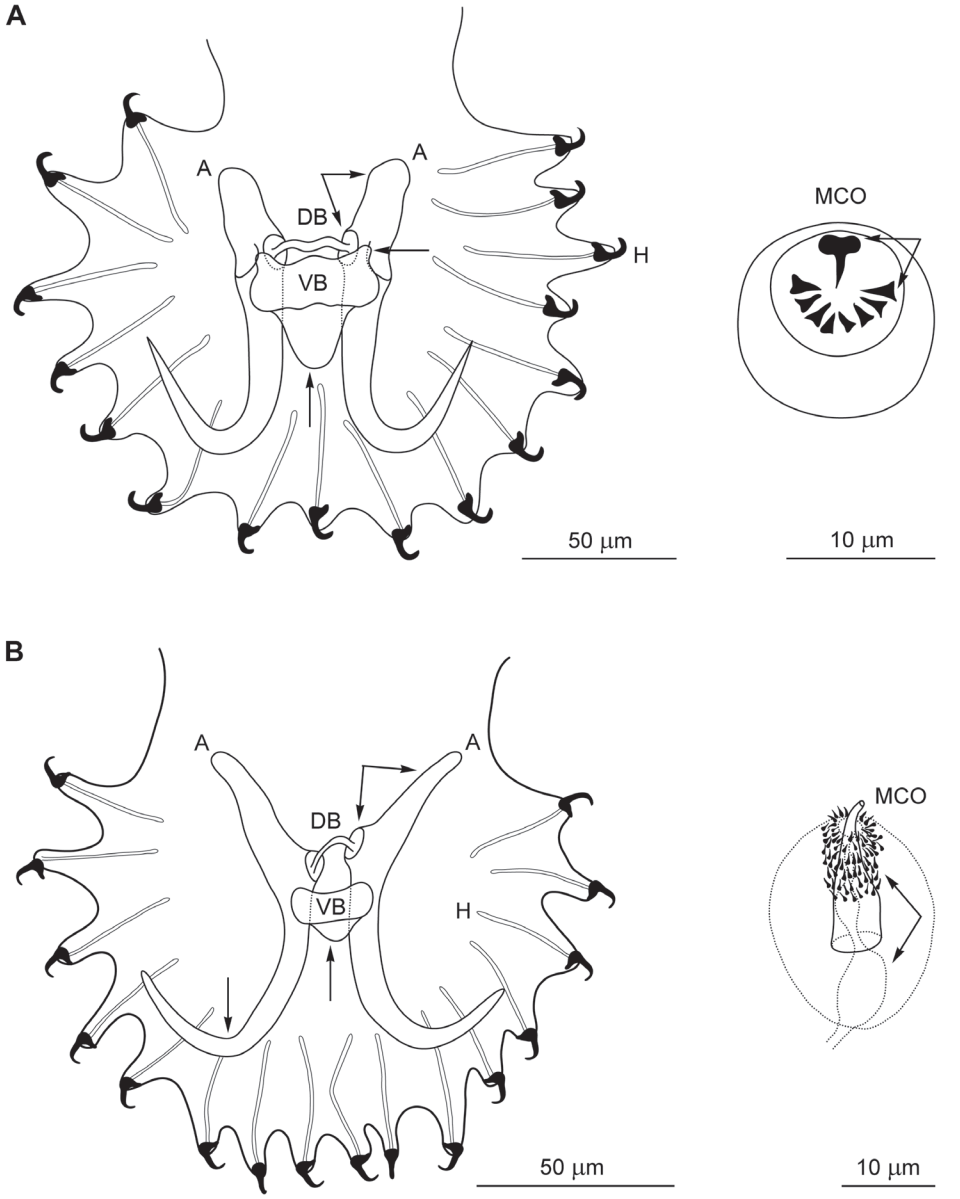

Fig. 4.4.22. Monogenea (Gyrodactylidae). **A.** *Gyrodactylus derjavini* Mikailov, 1975 from *Oncorhynchus mykiss*; **B.** *Citharodactylus gagei* Přikrylová, Shinn et Paladini, 2017 from *Citharinus citharus*. (Modified from Přikrylová *et al.* 2017.) A = anchor; VB = ventral bar; DB = dorsal bar; H = hook; MCO = male copulatory organ.

4.4.2. A systematic survey of monogeneans on/in African freshwater fishes

Knowledge of monogeneans in Africa is incomplete and the present numbers of these parasites on/in fishes in the region are likely to be an underestimate, as relatively few species of fishes have been examined. Today, more than twenty years since the last compilation (Khalil & Polling 1997), a total of 475 species of polyonchoineans (33 genera in 3 families) and 7 species of oligonchoineans (3 genera in 2 families) have been described. Given the high diversity of freshwater fish species in Africa (more than 3,200 spp.), monogeneans are therefore still poorly known. At the family level, the Dactylogyridae are represented currently by the greatest number of species (423 spp.) belonging to 26 genera: *Afrocleidodiscus* (3), *Ancyrocephalus* (s.l.) (4), *Annulotrema* (48), *Archidiplectanum* (1), *Bagrobdella* (4), *Birgiellus* (3), *Bouixella* (10), *Characidotrema* (10), *Cichlidogyrus* (112), *Dactylogyrus* (100), *Dogielius* (21), *Enterogyrus* (8), *Eutrianchoratus* (5), *Heteronchocleidus* (5), *Heterotesia* (1), *Insulacleidus* (3), *Nanotrema* (2), *Onchobdella* (8), *Paraquadriacanthus* (1), *Protoancylodiscoides* (9), *Quadriacanthus* (34), *Schilbetrema* (14), *Schilbetrematoides* (2), *Scutogyrus* (7), *Synodontella* (7), and *Urogyrus* (1). Only a single species of diplectanids, *Diplectanum lacustre*, has been reported from *Lates niloticus*. The viviparous gyrodactylids are the second-largest family, with 51 species attributed to 6 genera, *i.e.*, *Afrogyrodactylus* (4), *Citharodactylus* (1), *Diplogyrodactylus* (1), *Gyrodactylus* (35), *Macrogyrodactylus* (9), and *Mormyrogyrodactylus* (1). The only representatives of the Oligonchoinea are 7 species belonging to *Paradiplozoon* (5), *Afrodiplozoon* (1) (Diplozoidae) and one species of *Heterobothrium* (Diclidophoridae).

The catalogue of monogenean species described from freshwater fishes in Africa has been compiled from various sources (*e.g.*, Paperna 1979; Khalil & Polling 1997; Lim *et al.* 2001; Pariselle & Euzet 2009). Mention of the monogenean species in the list does not imply that the authors agree with their validity or taxonomy. Species are listed alphabetically according to individual monogenean genera. The type species of genera and type host of parasite species are highlighted in bold. The country where the type locality lies is also provided if known. Names of hosts recorded here are those provided in FishBase (Froese & Pauly 2017); names used in the original description are retained in square brackets as synonyms.

HETERONCHOINEA: OLIGONCHOINEA Bychowsky, 1937

DICLIDOPHORIDAE Cerfontaine, 1895

Heterobothrium Cerfontaine, 1895

Heterobothrium fluviatilis Euzet et Birgi, 1975 from ***Tetraodon lineatus*** [syn. *Tetraodon fahaka*] (Chad) [Fig. 4.4.3]

DIPLOZOIDAE Tripathi, 1959

Afrodiplozoon Khotenovsky, 1981

Afrodiplozoon polycotyleus (Paperna, 1973) [syn. *Neodiplozoon polycotyleus* Paperna, 1973] from *Alestes baremoze*, *Enteromius cercops*, *E. kerstenii*, *E. neefi*, *E. neumayeri*, *E. paludinosus*, *E. trimaculatus*, ***Labeo victorianus*** (Kenya), *Labeobarbus macrolepis*, *L. marequensis* [Fig. 4.4.4B]

Paradiplozoon Akhmerov, 1974

Paradiplozoon aegyptense (Fischthal et Kuntz, 1963) [syn. *Diplozoon aegyptensis* Fischthal et Kuntz, 1963] from *Brycinus macrolepidotus*, *Enteromius paludinosus*, *Labeo coubie*, *L. cylindricus*, ***L. forskalii*** (Egypt), *L. victorianus*, *Raiamas senegalensis* [syn. *Barilius loati*]

Paradiplozoon ghanense (Thomas, 1957) [syn. *Diplozoon ghanense* Thomas, 1957] from *Alestes baremoze*, ***Brycinus macrolepidotus*** (Ghana) [Fig. 4.4.4A]

Paradiplozoon ichthyoxanthon Avenant-Oldewage 2014 from ***Labeobarbus aeneus*** (South Africa)

Paradiplozoon krugerense Dos Santos et Avenant-Oldewage, 2016 from ***Labeo congoro*** (South Africa), *L. rosae*

Paradiplozoon vaalense Dos Santos, Jansen van Vuuren et Avenant-Oldewage, 2015 from *Labeo capensis*, ***L. umbratus*** (South Africa)

POLYONCHOINEA Bychowsky, 1937

DACTYLOGYRIDAE Bychowsky, 1933

Afrocleidodiscus Paperna, 1969

Afrocleidodiscus distichodis Paperna, 1969 from ***Distichodus rostratus*** (Ghana)

Afrocleidodiscus hydrocynuous Paperna, 1969 from ***Hydrocynus*** sp. (Ghana)

Afrocleidodiscus paracleidodiscus Paperna, 1973 from ***Distichodus nefasch*** [syn. *Distichodus niloticus*] (Uganda) [Fig. 4.4.19B]

Ancyrocephalus Creplin, 1839 *sensu lato*

Ancyrocephalus barilii Paperna, 1973 from ***Raiamas senegalensis*** [syn. *Barilius loati*] (Uganda), *Barilius* sp.

Ancyrocephalus claveaui Birgi, 1988 from ***Poropanchax luxophthalmus*** [syn. *Aplocheilichthys macrophthalmus*] (Cameroon)

Ancyrocephalus limnotrissae Paperna, 1973 from ***Limnothrissa miodon*** (Tanzania)

Ancyrocephalus pellonulae Paperna, 1969 from ***Pellonula leonensis*** [syn. *Pellonula afzeliusi*] (Ghana)

Annulotrema Paperna et Thurston, 1969

Annulotrema alberti Paperna, 1973 from ***Brycinus macrolepidotus*** (Uganda)

Annulotrema alestesimberi Paperna, 1973 from ***Brycinus imberi*** Tanzania)

Annulotrema alestesnursi Paperna, 1973 from ***Brycinus nurse*** (Uganda)

Annulotrema allogravis Paperna, 1973 from ***Brycinus imberi*** (Tanzania)

Annulotrema amieti Birgi, 1988 from *Hemigrammopetersius pulcher*, ***Phenacogrammus major*** (Cameroon)

Annulotrema ansatum Kičinjaová et Řehulková, 2015 from ***Hydrocynus forskahlii*** (Kenya)

Annulotrema besalis Řehulková, Musilová et Gelnar, 2014 from ***Hydrocynus brevis*** (Senegal), *H. forskahlii*

Annulotrema biaensis N'Douba, Pariselle et Euzet, 1997 from ***Hepsetus odoe*** (Ivory Coast)

Annulotrema bilongi Birgi, 1988 from ***Neolebias trewavasae*** (Cameroon)

Annulotrema bipatens Kičinjaová, Řehulková et Blažek, 2015 from ***Hydrocynus forskahlii*** (Kenya)

Annulotrema bouixi Birgi, 1988 from ***Brycinus kingsleyae*** (Cameroon)

Annulotrema bracteatum Kinčinjaová et Řehulková, 2018 from ***Hydrocynus vittatus*** (Zimbabwe)

Annulotrema combesi Birgi, 1988 from ***Brycinus kingsleyae*** (Cameroon)

Annulotrema cryptophallus Paperna, 1973 from ***Hydrocynus forskahlii*** (Uganda)

Annulotrema cucullatum Kičinjaová, Řehulková et Blažek, 2015 from ***Hydrocynus forskahlii*** (Kenya)

Annulotrema curvipenis Paperna, 1969 from ***Alestes baremoze*** (Ghana), *Hydrocynus forskahlii*

Annulotrema delta Paperna, 1973 from ***Brycinus nurse*** (Uganda)

Annulotrema edeensis Birgi, 1988 from ***Micralestes*** sp. (Cameroon)

Annulotrema elongata Paperna et Thurston, 1969 from ***Alestes baremoze*** (Uganda), *A. dentex*, *Brycinus macrolepidotus*

Annulotrema endjami Birgi, 1988 from ***Neolebias trewavasae*** (Cameroon)

Annulotrema fomenai Birgi, 1988 from ***Neolebias trewavasae*** (Cameroon)

Annulotrema gabrioni Birgi, 1988 from *Hemigrammopetersius pulcher*, ***Phenacogrammus major*** (Cameroon)

Annulotrema gracilis (Wedl, 1861) [syns *Dactylogyrus gracilis* Wedl, 1861; *Neodactylogyrus gracilis* (Wedl, 1861)] from ***Hydrocynus forskahlii*** [syn. *Hydrocyon dentex*] (Egypt)

Annulotrema gravis Paperna et Thurston, 1969 from *Brycinus jacksonii*, ***B. nurse*** (Uganda)

Annulotrema helicocirra Paperna, 1973 from ***Brycinus macrolepidotus*** (Uganda)

Annulotrema hepseti Paperna et Thurston, 1969 from *Hepsetus cuvieri*, ***H. odoe*** (Ghana)

Annulotrema hydrocynusi Paperna, 1973 from ***Hydrocynus forskahlii*** (Uganda)

Annulotrema kribiensis Birgi, 1988 from ***Brycinus longipinnis*** (Cameroon)

Annulotrema lamberti Birgi, 1988 from ***Brycinus longipinnis*** (Cameroon)

Annulotrema longipenis Paperna, 1969 from *Alestes baremoze*, ***Brycinus macrolepidotus*** (Ghana), *Hydrocynus brevis*, *H. forskahlii*, *H. vittatus*

Annulotrema macropenis N'Douba, Pariselle et Euzet, 1997 from ***Hepsetus odoe*** (Ivory Coast)

Annulotrema magna Paperna, 1973 from ***Hydrocynus vittatus*** (Tanzania)

Annulotrema magnihamula Paperna, 1973 from ***Hydrocynus forskahlii*** (Uganda)

Annulotrema maillardi Birgi, 1988 from ***Brycinus kingsleyae*** (Cameroon)

Annulotrema moanko Birgi, 1988 from ***Brycinus longipinnis*** (Cameroon)

Annulotrema nannaethiopis Birgi, 1988 from ***Nannaethiops unitaeniatus*** (Cameroon)

Annulotrema nili Paperna, 1973 from *Hydrocynus brevis*, ***H. forskahlii*** (Uganda), *H. vittatus*

Annulotrema noyongensis Birgi, 1988 from ***Brycinus kingsleyae*** (Cameroon)

Annulotrema pikei (Price, Peebles et Bamford, 1969) [syns *Cleidodiscus pikei* Price, Peebles et Bamford, 1969; *Annulotrema armorata* Paperna, 1969] from *Hydrocynus forskahlii*, ***H. vittatus*** (South Africa)

Annulotrema pikoides Guégan, Lambert et Birgi, 1988 from ***Hydrocynus vittatus*** (Mali)

Annulotrema pontile Kičinjaová et Řehulková, 2015 [syn. *Annulotrema pikei* of Paperna (1979)] from ***Hydrocynus forskahlii*** (Kenya)

Annulotrema pseudonili Kičinjaová et Řehulková, 2018 from ***Hydrocynus vittatus*** (Zimbabwe)

Annulotrema robusta Paperna, 1969 from ***Brycinus leuciscus*** (Ghana)

Annulotrema ruahae Paperna, 1973 from ***Hydrocynus vittatus*** (Tanzania)

Annulotrema sangmelinensis Birgi, 1988 from ***Micralestes humilis*** (Cameroon)

Annulotrema spiropenis Paperna, 1969 from ***Brycinus nurse*** (Ghana), *Hydrocynus forskahlii*

Annulotrema tenuicirra Paperna, 1973 from ***Brycinus macrolepidotus*** (Uganda)

Annulotrema uncata Řehulková, Musilová et Gelnar, 2014 from ***Hydrocynus brevis*** (Senegal) [Fig. 4.4.16A]

Archidiplectanum Mizelle et Kritsky, 1969

Archidiplectanum archidiplectanum Mizelle et Kritsky, 1969 from ***Gnathonemus petersii*** (Western Africa) [Fig. 4.4.18B]

Bagrobdella Paperna, 1969

Bagrobdella anthopenis Euzet et Le Brun, 1990 from ***Auchenoglanis occidentalis*** (Mali)

Bagrobdella auchenoglanii Paperna, 1969 from ***Auchenoglanis occidentalis*** (Ghana) [Fig. 4.4.16B]

Bagrobdella fraudulenta Euzet et Le Brun, 1990 [syn. *Bagrobdella auchenoglanii* of Paperna, 1971] from ***Auchenoglanis occidentalis*** (Mali or Uganda; type locality not indicated)

Bagrobdella parauchenoglanii Akoumba, Pariselle et Tombi, 2017 from ***Parauchenoglanis monkei*** (Cameroon)

Birgiellus Bilong Bilong, Nack et Euzet 2007

Birgiellus calaris Bilong Bilong, Nack et Euzet, 2007 from ***Clarias jaensis*** (Cameroon)

Birgiellus kellensis Bilong Bilong, Nack et Euzet, 2007 from ***Clarias camerunensis*** (Cameroon)

Birgiellus mutatus Bilong Bilong, Nack et Euzet, 2007 from ***Clarias pachynema*** (Cameroon) [Fig. 4.4.14A]

Bouixella Euzet et Dossou, 1976

Bouixella beninensis Euzet et Dossou, 1976 from ***Mormyrus rume*** (Benin)

Bouixella deliciosa Dossou et Euzet, 1984 from ***Mormyrops anguilloides*** [syn. *Mormyrops deliciosus*] (Benin)

Bouixella furcillata Dossou et Euzet, 1984 from ***Marcusenius senegalensis*** (Benin)

Bouixella gorei Blahoua, Pariselle, N'Douba, Kone et Kouassi, 2009 from ***Mormyrus rume*** (Ivory Coast)

Bouixella koutouani Blahoua, Pariselle, N'Douba, Kone et Kouassi, 2009 from ***Mormyrus rume*** (Ivory Coast)

Bouixella mormyris (Paperna, 1973) [syn. *Ancyrocephalus mormyris* Paperna, 1973] from ***Mormyrus niloticus*** (Uganda)

Bouixella mormyrume Euzet et Dossou, 1976 from *Mormyrus kannume* (new host record), ***M. rume*** (Benin) [Fig. 4.4.11A]

Bouixella pusilla Dossou et Euzet, 1984 from ***Brienomyrus brachyistius*** (Benin)

Bouixella torta Dossou et Euzet, 1984 from ***Mormyrops anguilloides*** [syn. *Mormyrops deliciosus*] (Benin)

Bouixella yaoi Blahoua, Pariselle, N'Douba, Kone et Kouassi, 2009 from ***Mormyrus rume*** (Ivory Coast)

Characidotrema Paperna et Thurston, 1968

Characidotrema brevipenis Paperna, 1969 [syn. *Jainus brevipenis* (Paperna, 1969) Paperna, 1979] from *Alestes baremoze*, ***Brycinus nurse*** (Ghana)

Characidotrema elongata Paperna et Thurston, 1968 [syn. *Jainus elongatus* (Paperna et Thurston, 1968) Paperna, 1979] from ***Brycinus jacksonii*** (Uganda), *Brycinus leuciscus*

Characidotrema nursei Ergens, 1973 [syns *Jainus longipenis* Paperna, 1973; *Jainus nursei* (Ergens, 1973) Paperna, 1979] from *Alestes dentex*, *Brycinus leuciscus*, ***Brycinus nurse*** (Egypt) [Fig. 4.4.17A]

Characidotrema nzoiae (Paperna, 1979) [syn. *Jainus brevipenis nzoiae* Paperna, 1979] from ***Brycinus jacksonii*** (Kenya)

Characidotrema regia Birgi, 1988 from ***Brycinus kingsleyae*** (Cameroon)

Characidotrema ruahae (Paperna, 1979) [syn. *Jainus brevipenis ruahae* Paperna, 1979] from ***Brycinus imberi*** (Tanzania)

Characidotrema spinivaginus (Paperna, 1973) [syn. *Jainus spinivaginus* Paperna, 1973] from ***Brycinus nurse*** (Uganda)

Characidotrema spiropenis Birgi, 1988 from *Phenacogrammus major*, *P. urotaenia, Hemigrammopetersius pulcher* (Cameroon; type host not indicated)

Characidotrema undifera Kritsky, Kulo et Boeger, 1987 from ***Brycinus* cf. *nurse*** (Togo)

Characidotrema zelotes Kritsky, Kulo et Boeger, 1987 from ***Brycinus* cf. *nurse*** (Togo)

Cichlidogyrus Paperna, 1960

Cichlidogyrus acerbus Dossou, 1982 from *Sarotherodon galilaeus*, ***S. melanotheron*** (Benin)

Cichlidogyrus aegypticus Ergens, 1981 from *Coptodon camerunensis*, *C. dageti*, *C. guineensis*, *C. gutturosa*, *C. kottae*, *C. louka*, *C. walteri*, ***C. zillii*** (Egypt), *Oreochromis niloticus*, *Sarotherodon galilaeus*

Cichlidogyrus agnesi Pariselle et Euzet, 1995 from ***Coptodon guineensis*** (Ivory Coast)

Cichlidogyrus albareti Pariselle et Euzet, 1998 from ***Tilapia brevimanus*** (Guinea)

Cichlidogyrus amieti Birgi et Euzet, 1983 from ***Aphyosemion cameronense*** [syn. *Aphyosemion obscurum*] (Cameroon), *A. exiguum*

Cichlidogyrus amphoratus Pariselle et Euzet, 1996 from *Coptodon guineensis*, ***C. louka*** (Guinea)

Cichlidogyrus anthemocolpos Dossou, 1982 from *Coptodon camerunensis*, *C. guineensis*, ***C. zillii*** (Benin)

Cichlidogyrus arfii Pariselle et Euzet, 1995 [syn. *Cichlidogyrus dionchus* Paperna, 1968 (*partim*)] from ***Pelmatochromis buettikoferi*** (Guinea)

Cichlidogyrus arthracanthus Paperna, 1960 from *Coptodon camerunensis*, *C. coffea*, *C. dageti*, *C. deckerti*, *C. guineensis*, *C. gutturosa*, *C. kottae*, *C. walteri*, ***C. zillii***, *Oreochromis niloticus*, *Sarotherodon galilaeus*, *Tilapia* sp.

Cichlidogyrus aspiralis Rahmouni, Vanhove et Šimková, 2017 from ***Ophthalmotilapia nasuta*** (Burundi)

Cichlidogyrus attenboroughi Kmentová, Gelnar, Koblmüller et Vanhove, 2016 from ***Benthochromis horii*** (Burundi)

Cichlidogyrus banyankimbonai Pariselle et Vanhove, 2015 from ***Simochromis diagramma*** (Democratic Republic of the Congo)

Cichlidogyrus berminensis Pariselle, Bitja Nyom et Bilong Bilong, 2013 from *Coptodon bakossiorum*, ***C. bemini*** (Cameroon), *C. gutturosa*, *C. thysi*

Cichlidogyrus berradae Pariselle et Euzet, 2003 from *Coptodon camerunensis*, *C. guineensis*, ***Pelmatolapia cabrae*** (Cabinda, Angola)

Cichlidogyrus berrebii Pariselle et Euzet, 1994 from ***Tylochromis jentinki*** (Ivory Coast)

Cichlidogyrus bifurcatus Paperna, 1960 from *Haplochromis aeneocolor*, *H. elegans*, *H. limax*, *H. squamipinnis*, *Oreochromis aureus*, *Pseudocrenilabrus multicolor*

Cichlidogyrus bilongi Pariselle et Euzet, 1995 from *Coptodon camerunensis*, ***C. guineensis*** (Guinea)

Cichlidogyrus bonhommei Pariselle et Euzet, 1998 from ***Heterotilapia buttikoferi*** (Sierra Leone)

Cichlidogyrus bouvii Pariselle et Euzet, 1997 from ***Sarotherodon occidentalis*** (Guinea)

Cichlidogyrus brunnensis Kmentová, Gelnar, Koblmüller et Vanhove, 2016 from ***Trematocara unimaculatum*** (Burundi)

Cichlidogyrus buescheri Pariselle et Vanhove, 2015 from ***Interochromis loocki*** (Zambia)

Cichlidogyrus bychowskii (Markevich, 1934) [syn. *Ancyrocephalus bychowskii* Markevitch, 1934] from ***Hemichromis bimaculatus***, *H. fasciatus*, *Sarotherodon galilaeus*

Cichlidogyrus casuarinus Pariselle, Muterezi Bukinga et Vanhove, 2015 from *Bathybates fasciatus*, *B. hornii*, *B. leo*, ***B. minor*** (Democratic Republic of the Congo), *B. vittatus*, *Hemibates stenosoma*

Cichlidogyrus centesimus Vanhove, Volckaert et Pariselle, 2011 from *Ophthalmotilapia boops*, *O. nasuta*, ***O. ventralis*** (Zambia)

Cichlidogyrus chrysopiformis Pariselle, Bitja Nyom et Bilong Bilong, 2014 from ***Tylochromis sudanensis*** (Cameroon)

Cichlidogyrus cirratus Paperna, 1964 [syn. *Cichlidogyrus nematocirrus* Paperna, 1969] from *Coptodon zillii*, *Oreochromis esculentus*, *O. mweruensis*, *O. niloticus*, *O. variabilis*, ***Sarotherodon galilaeus***

Cichlidogyrus consobrini Jorissen, Pariselle et Vanhove, 2018 from *Orthochromis katumbii*, ***Sargochromis mellandi*** (Democratic Republic of the Congo)

Cichlidogyrus cubitus Dossou, 1982 from *Coptodon camerunensis*, *C. dageti*, *C. guineensis*, *C. louka*, *C. walteri*, ***C. zillii*** (Benin)

Cichlidogyrus dageti Dossou et Birgi, 1984 from ***Hemichromis fasciatus*** (Benin or Cameroon; type locality not indicated)

Cichlidogyrus digitatus Dossou, 1982 [syns *Cichlidogyrus* cf. *brevicirrus* of Paperna (1969); *Cichlidogyrus halinus* Paperna, 1969 (*partim*)] from *Coptodon camerunensis*, *C. dageti*, *C. discolor*, *C. guineensis*, *C. louka*, *C. walteri*, ***C. zillii*** (Benin), *Pelmatolapia mariae*, *Tilapia brevimanus*

Cichlidogyrus dionchus Paperna, 1968 [syn. *Cichlidogyrus brevicirrus* Paperna et Thurston, 1969] from *Chromidotilapia guntheri*, *Coptodon discolor*, *C. zillii*, *Haplochromis guiarti*, *H. longirostris*, *H. obesus*, *H. obliquidens*, *H. retrodens*, *Hemichromis fasciatus*, ***Sarotherodon galilaeus*** (Ghana)

Cichlidogyrus discophonum Rahmouni, Vanhove et Šimková, 2017 from ***Aulonocranus dewindti*** (Burundi)

Cichlidogyrus djietoi Pariselle, Bitja Nyom et Bilong Bilong, 2014 from ***Tylochromis sudanensis*** (Cameroon)

Cichlidogyrus dossoui Douëllou, 1993 from *Coptodon camerunensis*, *C. guineensis*, ***C. rendalli*** (Zimbabwe), *Oreochromis mortimeri*, *O. mossambicus*, *O. mweruensis*, *Serranochromis macrocephalus*, *Tilapia sparrmanii*

Cichlidogyrus douellouae Pariselle, Bilong Bilong et Euzet, 2003 from ***Sarotherodon galilaeus*** (Nigeria)

Cichlidogyrus dracolemma Řehulková, Mendlová et Šimková, 2013 from ***Hemichromis letourneuxi*** (Senegal)

Cichlidogyrus ergensi Dossou, 1982 from *Coptodon camerunensis*, *C. guineensis*, ***C. zillii*** (Benin), *Pelmatolapia mariae*

Cichlidogyrus euzeti Dossou et Birgi, 1984 from ***Hemichromis fasciatus*** (Benin or Cameroon; type locality not indicated)

Cichlidogyrus evikae Rahmouni, Vanhove et Šimková, 2017 from ***Tanganicodus irsacae*** (Burundi)

Cichlidogyrus falcifer Dossou et Birgi, 1984 [syn. *Cichlidogyrus dionchus* Paperna, 1968 (*partim*)] from ***Hemichromis fasciatus*** (Benin or Cameroon; type locality not indicated)

Cichlidogyrus flexicolpos Pariselle et Euzet, 1995 from *Coptodon dageti*, ***C. guineensis*** (Ivory Coast), *Pelmatolapia mariae*

Cichlidogyrus fontanai Pariselle et Euzet, 1997 from ***Sarotherodon occidentalis*** (Guinea)

Cichlidogyrus frankwillemsi Pariselle et Vanhove, 2015 from ***Pseudosimochromis curvifrons*** (Zambia)

Cichlidogyrus franswittei Pariselle et Vanhove, 2015 from *Pseudosimochromis curvifrons*, ***P. marginatus*** (Democratic Republic of the Congo)

Cichlidogyrus gallus Pariselle et Euzet, 1995 [syn. *Cichlidogyrus aegypticus* Ergens, 1981 (*partim*)] from ***Coptodon guineensis*** (Ivory Coast), *C. walteri*, *C. zillii* [Fig. 4.4.15B]

Cichlidogyrus georgesmertensi Pariselle et Vanhove, 2015 from ***Pseudosimochromis babaulti*** (Democratic Republic of the Congo)

Cichlidogyrus gillardinae Muterezi Bukinga, Vanhove, Van Steenberge et Pariselle, 2012 from ***Astatotilapia burtoni*** (Democratic Republic of the Congo)

Cichlidogyrus gillesi Pariselle, Bitja Nyom et Bilong Bilong, 2013 from ***Coptodon guineensis*** (Cameroon)

Cichlidogyrus giostrai Pariselle, Bilong Bilong et Euzet, 2003 from ***Sarotherodon caudomarginatus*** (Guinea)

Cichlidogyrus gistelincki Gillardin, Vanhove, Pariselle, Huyse et Volckaert, 2012 from ***Ctenochromis horei*** (Zambia)

Cichlidogyrus glacicremoratus Rahmouni, Vanhove et Šimková, 2017 from ***Ophthalmotilapia nasuta*** (Burundi)

Cichlidogyrus guirali Pariselle et Euzet, 1997 from ***Sarotherodon occidentalis*** (Guinea)

Cichlidogyrus halinus Paperna, 1969 [syn. *Cichlidogyrus erectus* Dossou, 1982] from *Coptodon guineensis*, ***Sarotherodon melanotheron*** [syn. *Tilapia heudeloti*] (Ghana)

Cichlidogyrus halli (Price et Kirk, 1967) [syns *Cleidodiscus halli* Price et Kirk, 1967; *Cichlidogyrus tubicirrus magnus* Paperna et Thurston, 1969; *Cichlidogyrus magnus* Paperna et Thurston, 1969; *Cichlidogyrus halli typicus* Paperna, 1979; *Cichlidogyrus halli victorianus* Paperna, 1979] from *Oreochromis esculentus*, *O. leucostictus*, *O. mortimeri*, *O. mweruensis*, *O. niloticus* x *mweruensis*, ***O. shiranus*** (Malawi), *O. spilurus*, *O. tanganicae*, *O. variabilis*, *Sarotherodon galilaeus*, *S. melanotheron*, *S. occidentalis*, *Serranochromis macrocephalus*

Cichlidogyrus haplochromii Paperna et Thurston, 1969 [*Cichlidogyrus dionchus* Paperna, 1968 (*partim*); *Cichlidogyrus tubicirrus minutus* Paperna et Thurston, 1969 (*partim*); *Cichlidogyrus tubicirrus* Paperna et Thurston, 1969 (*partim*)] from *Haplochromis aeneocolor*, *H. angustifrons*, *H. bicolor*, *H. degeni*, *H. elegans*, ***H. guiarti*** (Uganda), *H. limax*, *H. longirostris*, *H. macrognathus*, *H. macrops*, *H. nigripinnis*, *H. nubilus*, *H. obesus*, *H. obliquidens*, *H. petronius*, *H. retrodens*, *H. schubotzi*, *H. squamipinnis*, *Oreochromis leucostictus*, *Pharyngochromis darlingi*, *Thoracochromis wingatii*

Cichlidogyrus hemi Pariselle et Euzet, 1998 from ***Tilapia brevimanus*** (Guinea)

Cichlidogyrus inconsultans Birgi et Lambert, 1987 [syn. *Cichlidogyrus euzeti* Birgi et Lambert, 1986 renamed] from ***Polycentropsis abbreviata*** (Cameroon)

Cichlidogyrus irenae Gillardin, Vanhove, Pariselle, Huyse et Volckaert, 2012 from ***Gnathochromis pfefferi*** (Zambia)

Chichlidogyrus jeanloujustinei Rahmouni, Vanhove et Šimková, 2017 from ***Eretmodus marksmithi*** (Burundi)

Cichlidogyrus karibae Douëllou, 1993 from *Oreochromis mortimeri*, ***Sargochromis codringtonii*** (Zimbabwe)

Cichlidogyrus kothiasi Pariselle et Euzet, 1994 from ***Tylochromis jentinki*** (Ivory Coast)

Cichlidogyrus kouassii N'Douba, Thys van den Audenaerde et Pariselle, 1997 from ***Coptodon guineensis*** (Ivory Coast)

Cichlidogyrus lagoonaris Paperna, 1969 [syn. *Cichlidogyrus gibbus* Dossou, 1982] from *Coptodon guineensis*, ***Sarotherodon melanotheron*** (Ghana)

Cichlidogyrus legendrei Pariselle et Euzet, 2003 from ***Pelmatolapia cabrae*** (Cabinda, Angola)

Cichlidogyrus lemoallei Pariselle et Euzet, 2003 from ***Pelmatolapia cabrae*** (Republic of the Congo), *P. mariae*

Cichlidogyrus levequei Pariselle et Euzet, 1996 from ***Coptodon coffea*** (Guinea)

Cichlidogyrus longicirrus Paperna, 1965 from *Chromidotilapia guntheri*, ***Hemichromis fasciatus*** (Ghana)

Cichlidogyrus longipenis Paperna et Thurston, 1969 [syn. *Cichlidogyrus tubicirrus longipenis* Paperna et Thurston, 1969] from ***Astatoreochromis alluaudi*** (Uganda)

Cichlidogyrus louipaysani Pariselle et Euzet, 1995 from ***Coptodon guineensis*** (Guinea)

Cichlidogyrus makasai Vanhove, Volckaert et Pariselle, 2011 from *Ophthalmotilapia boops*, *O. nasuta*, ***O. ventralis*** (Zambia)

Cichlidogyrus mbirizei Muterezi Bukinga, Vanhove, Van Steenberge et Pariselle, 2012 from *Oreochromis niloticus*, *O. niloticus* × *mossambicus*, *O. niloticus* × *mweruensis*, ***O. tanganicae*** (Democratic Republic of the Congo)

Cichlidogyrus microscutus Pariselle et Euzet, 1996 from *Coptodon camerunensis*, *C. dageti*, ***C. guineensis*** (Republic of the Congo)

Cichlidogyrus milangelnari Rahmouni, Vanhove et Šimková, 2017 from ***Cyprichromis microlepidotus*** (Burundi)

Cichlidogyrus mulimbwai Muterezi Bukinga, Vanhove, Van Steenberge et Pariselle, 2012 from ***Tylochromis polylepis*** (Democratic Republic of the Congo)

Cichlidogyrus muterezii Pariselle et Vanhove, 2015 from ***Simochromis diagramma*** (Democratic Republic of the Congo)

Cichlidogyrus muzumanii Muterezi Bukinga, Vanhove, Van Steenberge et Pariselle, 2012 from ***Tylochromis polylepis*** (Democratic Republic of the Congo)

Cichlidogyrus mvogoi Pariselle, Bitja Nyom et Bilong Bilong, 2014 from ***Sarotherodon mvogoi*** (Cameroon)

Cichlidogyrus nageus Řehulková, Mendlová et Šimková, 2013 from *Coptodon guineensis*, ***Sarotherodon galilaeus*** (Senegal)

Cichlidogyrus nandidae Birgi et Lambert, 1986 from ***Polycentropsis abbreviata*** (Cameroon)

Cichlidogyrus njinei Pariselle, Bilong Bilong et Euzet, 2003 from ***Sarotherodon galilaeus*** (Cameroon)

Cichlidogyrus nshomboi Muterezi Bukinga, Vanhove, Van Steenberge et Pariselle, 2012 from ***Boulengerochromis microlepis*** (Democratic Republic of the Congo)

Cichlidogyrus nuniezi Pariselle et Euzet, 1998 from *Heterotilapia buttikoferi*, ***H. cessiana*** (Ivory Coast)

Cichlidogyrus ornatus Pariselle et Euzet, 1996 from *Coptodon camerunensis*, *C. dageti*, ***C. zillii*** (Ivory Coast)

Cichlidogyrus ouedraogoi Pariselle et Euzet, 1996 from ***Coptodon coffea*** (Guinea), *C. guineensis*, *C. kottae*, *Pelmatolapia mariae*

Cichlidogyrus paganoi Pariselle et Euzet, 1997 from ***Sarotherodon occidentalis*** (Guinea)

Cichlidogyrus papernastrema Price, Peebles et Bamford, 1969 from *Coptodon rendalli*, *Oreochromis mweruensis*, ***Tilapia sparrmanii*** (South Africa)

Cichlidogyrus philander Douëllou, 1993 from ***Pseudocrenilabrus philander*** (Zimbabwe)

Cichlidogyrus pouyaudi Pariselle et Euzet, 1994 from *Tylochromis intermedius*, ***T. jentinki*** (Ivory Coast)

Cichlidogyrus pseudoaspiralis Rahmouni, Vanhove et Šimková, 2017 from ***Aulonocranus dewindti*** (Burundi)

Cichlidogyrus quaestio Douëllou, 1993 from ***Coptodon rendalli*** (Zimbabwe), *Sargochromis codringtonii*, *Serranochromis macrocephalus*, *Tilapia sparrmanii*

Cichlidogyrus raeymaekersi Pariselle et Vanhove, 2015 from ***Simochromis diagramma*** (Democratic Republic of the Congo)

Cichlidogyrus rectangulus Rahmouni, Vanhove et Šimková, 2017 from ***Ophthalmotilapia nasuta*** (Burundi)

Cichlidogyrus reversati Pariselle et Euzet, 2003 from ***Pelmatolapia cabrae*** (Republic of the Congo)

Cichlidogyrus rognoni Pariselle, Bilong Bilong et Euzet, 2003 from ***Oreochromis niloticus*** (Senegal)

Cichlidogyrus sanjeani Pariselle et Euzet, 1997 from ***Sarotherodon occidentalis*** (Guinea)

Cichlidogyrus sanseoi Pariselle et Euzet, 2004 from ***Hemichromis fasciatus*** (Ivory Coast)

Cichlidogyrus schreyenbrichardorum Pariselle et Vanhove, 2015 from ***Interochromis loocki*** (Zambia)

Cichlidogyrus sclerosus Paperna et Thurston, 1969 [syn. *Cichlidogyrus bangladeshi* Ferdousi et Chandra, 2002] from *Coptodon zillii*, *Haplochromis* sp., *Oreochromis leucostictus*, *O. mortimeri*, ***O. mossambicus*** (Uganda), *O. mweruensis*, *O. niloticus*, *O. spilurus*, *Sarotherodon galilaeus*, *Serranochromis macrocephalus*

Cichlidogyrus sigmocirrus Pariselle, Bitja Nyom et Bilong Bilong, 2014 from ***Tylochromis sudanensis*** (Cameroon)

Cichlidogyrus slembroucki Pariselle et Euzet, 1998 from ***Heterotilapia buttikoferi*** (Guinea), *Pelmatolapia mariae*

Cichlidogyrus steenbergei Gillardin, Vanhove, Pariselle, Huyse et Volckaert, 2012 from ***Limnotilapia dardennii*** (Zambia)

Cichlidogyrus sturmbaueri Vanhove, Volckaert et Pariselle, 2011 from *Ophthalmotilapia nasuta*, ***O. ventralis*** (Zambia)

Cichlidogyrus testificatus Dossou, 1982 from ***Pelmatolapia mariae*** (Benin)

Cichlidogyrus teugelsi Pariselle et Euzet, 2004 from ***Hemichromis fasciatus*** (Ivory Coast)

Cichlidogyrus thurstonae Ergens, 1981 [syns *Cichlidogyrus tiberianus* Paperna, 1960 (*partim*); *Cichlidogyrus gilli* Ferdousi et Chandra, 2002] from *Haplochromis longirostris*, *Oreochromis esculentus*, ***O. niloticus*** (Egypt), *O. variabilis*, *Sarotherodon galilaeus*

Cichlidogyrus tiberianus Paperna, 1960 from *Coptodon bakossiorum*, *C. coffea*, *C. dageti*, *C. guineensis*, *C. gutturosa*, *C. kottae*, *C. rendalli*, *C. walteri*, ***C. zillii***, *Oreochromis mweruensis*, *Pelmatolapia mariae*, *Tilapia sparrmanii*

Cichlidogyrus tilapiae Paperna, 1960 [syns *Cleidodiscus tilapiae* Price et Géry, 1967; *Cichlidogyrus tubicirrus minutus* Paperna et Thurston, 1969 (*partim*); *Cichlidogyrus tubicirrus* Paperna et Thurston, 1969 (*partim*); *Cichlidogyrus chandrai* Ferdousi et Chandra, 2002] from *Chromidotilapia guntheri*, *Coptodon camerunensis*, *C. guineensis*, *C. gutturosa*, *C. kottae*, *C. zillii*, *Haplochromis macrognathus*, *Hemichromis fasciatus, Oreochromis aureus*, *O. leucostictus*, *O. mortimeri*, *O. mossambicus*, *O. mweruensis*, *O. niloticus*, *O. spilurus*, *O. urolepis*, *O. variabilis*, *Pelmatolapia mariae*, ***Sarotherodon galilaeus***, *Tilapia busumana*

Cichlidogyrus vandekerkhovei Vanhove, Volckaert et Pariselle, 2011 from *Ophthalmotilapia boops*, *O. nasuta*, ***O. ventralis*** (Zambia)

Cichlidogyrus vealli Pariselle et Vanhove, 2015 from ***Interochromis loocki*** (Zambia)

Cichlidogyrus vexus Pariselle et Euzet, 1995 from ***Coptodon guineensis*** (Ivory Coast), *C. zillii*

Cichlidogyrus yanni Pariselle et Euzet, 1996 from *Coptodon camerunensis*, *C. dageti*, *C. guineensis*, *C. louka*, *C. walteri*, ***C. zillii*** (Guinea)

Cichlidogyrus zambezensis Douëllou, 1993 from *Oreochromis mortimeri*, *Sargochromis mellandi*, *Serranochromis angusticeps*, ***S. macrocephalus*** (Zimbabwe), *S. robustus*, *S. stappersi*, *S. thumbergi*

Dactylogyrus Diesing, 1850 [syn. *Neodactylogyrus* Price, 1938]

Dactylogyrus afer Price et Géry, 1968 from ***Labeobarbus batesii*** (Gabon)

Dactylogyrus aferoides Guégan et Lambert, 1990 from ***Labeobarbus bynni*** [syns *Barbus occidentalis*, *B. waldroni*] (Mali), *L. parawaldroni*, *L. petitjeani*

Dactylogyrus afrobarbae Paperna, 1968 from *Enteromius ablabes*, *E. sublineatus*, *E. trispilopleura* (Ghana; type host not indicated)

Dactylogyrus afrochelatus Paperna, 1973 from ***Enteromius paludinosus*** [syn. *Barbus amphigramma*] (Kenya)

Dactylogyrus afrofluviatilis Paperna, 1973 from ***Barbus*** sp. (Kenya), *Enteromius neglectus*, *E. perince*

Dactylogyrus afrolongicornis Paperna, 1973 from ***Enteromius kerstenii*** (Uganda), *E. perince*, *E. trimaculatus*

Dactylogyrus afropsilovaginus Paperna, 1973 from *Enteromius kerstenii*, ***E. paludinosus*** [syn. *Barbus amphigramma*] (Uganda), *E. perince*

Dactylogyrus afroruahae Paperna, 1973 from ***Barbus*** sp. (Tanzania)

Dactylogyrus afrosclerovaginus Paperna, 1973 from *Enteromius magdalenae*, ***E. neglectus*** (Uganda), *E. paludinosus*, *E. perince*

Dactylogyrus afrotoxopous Paperna, 1973 from ***Enteromius kerstenii*** (Uganda)

Dactylogyrus allolongionchus Paperna, 1973 from ***Enteromius perince*** (Uganda), *E. trimaculatus*

Dactylogyrus amieti Birgi et Lambert, 1987 from ***Enteromius camptacanthus*** (Cameroon)

Dactylogyrus archaeopenis Guégan et Lambert, 1990 from ***Labeobarbus parawaldroni*** (Guinea), *L. petitjeani*, *L. sacratus*

Dactylogyrus aspili Birgi et Lambert, 1987 from ***Enteromius aspilus*** (Cameroon)

Dactylogyrus atlasensis El Gharbi, Birgi et Lambert, 1994 from ***Luciobarbus pallaryi*** (Morocco)

Dactylogyrus barbus Price et Géry, 1968 from ***Barbus*** sp. (*brichardi* aff.) (Gabon)

Dactylogyrus batesii Birgi et Euzet, 1983 from ***Aphyosemion batesii*** (Cameroon)

Dactylogyrus benhoussai Rahmouni, Řehulková et Šimková, 2017 from ***Luciobarbus moulouyensis*** (Morocco)

Dactylogyrus biradius Birgi et Lambert, 1987 from ***Enteromius jae*** (Cameroon)

Dactylogyrus birgii Timofeeva, Gerasev et Gibson, 1996 [syn. *Dactylogyrus simplex* Birgi et Lambert, 1987] from ***Enteromius martorelli*** (Cameroon)

Dactylogyrus bopeleti Birgi et Lambert, 1987 from ***Enteromius martorelli*** (Cameroon)

Dactylogyrus borjensis El Gharbi, Birgi et Lambert, 1994 from ***Luciobarbus nasus*** (Morocco)

Dactylogyrus brachydiscus Paperna, 1973 from ***Labeo victorianus*** (Kenya)

Dactylogyrus brevicirrus Paperna, 1973 from *Enteromius kerstenii*, *E. neglectus*, *E. perince*, *Labeo cylindricus*, *L. forskalii*, *L. parvus*, ***L. victorianus*** (Uganda), *Labeobarbus altianalis*, *Leptocypris niloticus*

Dactylogyrus brevicornis Paperna, 1973 from ***Enteromius kerstenii*** (Uganda)

Dactylogyrus clani Guégan et Lambert, 1990 from ***Labeobarbus petitjeani*** (Guinea)

Dactylogyrus clavatovaginus Paperna, 1973 from *Enteromius nyanzae*, ***E. paludinosus*** [syn. *Barbus amphigramma*] (Uganda)

Dactylogyrus cyclocirrus Paperna, 1973 from *Labeo coubie*, ***L. cylindricus*** (Tanzania), *L. senegalensis*, *L. victorianus*

Dactylogyrus decaspirus Guégan, Lambert et Euzet, 1988 [syns *Dactylogyrus senegalensis* Paperna, 1969 (*partim*); *Dactylogyrus* cf. *senegalensis* Paperna, 1979] from ***Labeo coubie*** (Ghana)

Dactylogyrus dembae Musilová, Řehulková et Gelnar, 2009 [syn. *Dactylogyrus* cf. *labeous* Paperna, 1979 (*partim*)] from ***Labeo coubie*** (Senegal)

Dactylogyrus digitalis Paperna, 1969 from ***Labeo coubie*** (Ghana)

Dactylogyrus dominici Mashego, 1983 from ***Enteromius paludinosus*** (South Africa)

Dactylogyrus draaensis El Gharbi, Birgi et Lambert, 1994 from ***Luciobarbus pallaryi*** (Morocco)

Dactylogyrus enidae Mashego, 1983 from ***Enteromius neefi*** (South Africa)

Dactylogyrus falcilocus Guégan, Lambert et Euzet, 1988 from ***Labeo coubie*** (Mali), *L. parvus*, *Labeobarbus wurtzi*

Dactylogyrus falsiphallus Rahmouni, Řehulková et Šimková, 2017 from ***Luciobarbus maghrebensis*** (Morocco)

Dactylogyrus fimbriphallus El Gharbi, Birgi et Lambert, 1994 from *Carasobarbus moulouyensis*, ***Luciobarbus callensis*** [syns *Barbus figuiensis*, *B. issenensis*, *B. massaensis*] (Morocco), *L. pallaryi* [syn. *Barbus lepineyi*]

Dactylogyrus gabonensis Price et Géry, 1968 from ***Barbus*** sp. (*occidentalis* aff.) (Gabon)

Dactylogyrus guirensis El Gharbi, Birgi et Lambert, 1994 from ***Luciobarbus pallaryi*** (Morocco)

Dactylogyrus helicophallus Paperna, 1973 from ***Labeo forskalii*** (Uganda), *L. victorianus*

Dactylogyrus heteromorphus El Gharbi, Birgi et Lambert, 1994 from ***Luciobarbus callensis*** (Tunisia)

Dactylogyrus insolitus Birgi et Lambert, 1987 from ***Enteromius martorelli*** (Cameroon)

Dactylogyrus iwani Crafford, Luus-Powell et Avenant-Oldewage, 2012 from ***Labeo capensis*** (South Africa), *L. umbratus*

Dactylogyrus jaculus Guégan, Lambert et Euzet, 1988 [syn. *Dactylogyrus* cf. *labeous* Paperna, 1979 (*partim*)] from ***Labeo coubie*** (Mali)

Dactylogyrus jaei Birgi et Lambert, 1987 from ***Enteromius jae*** (Cameroon)

Dactylogyrus jubbstrema Price, Korach et McPott, 1969 from ***Glossogobius giuris*** (South Africa)

Dactylogyrus jucundus Guégan et Lambert, 1991 from *Labeo parvus*, ***L. rouaneti*** (Guinea)

Dactylogyrus kii Birgi et Lambert, 1987 from ***Enteromius jae*** (Cameroon)

Dactylogyrus ksibii El Gharbi, Birgi et Lambert, 1994 from ***Luciobarbus callensis*** [syn. *Barbus ksibi*] (Morocco), *L. magniatlantis*, *L. setivimensis*

Dactylogyrus ksibioides El Gharbi, Birgi et Lambert, 1994 from *Carasobarbus moulouyensis*, ***Luciobarbus setivimensis*** (Morocco)

Dactylogyrus kulindrii El Gharbi, Birgi et Lambert, 1994 from *Carasobarbus fritschii*, *Labeobarbus reinii* (Morocco; type host not indicated)

Dactylogyrus labeous Paperna, 1969 from *Labeo coubie*, *L. senegalensis* (Ghana; type host not indicated)

Dactylogyrus larindae Crafford, Luus-Powell et Avenant-Oldewage, 2012 from *Labeo capensis*, ***L. umbratus*** (South Africa)

Dactylogyrus leonis Musilová, Řehulková et Gelnar, 2009 from ***Labeo coubie*** (Senegal)

Dactylogyrus longionchus Paperna, 1973 from ***Enteromius kerstenii*** (Uganda)

Dactylogyrus longiphalloides Guégan et Lambert, 1991 from ***Labeo alluaudi*** (Sierra Leone)

Dactylogyrus longiphallus Paperna, 1973 from *Enteromius kerstenii*, *Labeo forskalii*, *L. parvus*, ***L. victorianus*** (Kenya), *Labeobarbus altianalis*

Dactylogyrus macrocleithrum Price et Géry, 1968 from ***Barbus*** sp. (*holotaenia* aff.) (Gabon)

Dactylogyrus maillardi Birgi et Lambert, 1987 from ***Enteromius martorelli*** (Cameroon)

Dactylogyrus marocanus El Gharbi, Birgi et Lambert, 1994 from ***Carasobarbus fritschii*** [syn. *Barbus paytonii*] (Morocco), *C. harterti*, *Labeobarbus reinii*, *Luciobarbus callensis* [syn. *B. ksibi*], *L. nasus*, *L. setivimensis*

Dactylogyrus mawli Paperna, 1969 from ***Enteromius macrops*** (Ghana)

Dactylogyrus mendehei Birgi et Lambert, 1987 from ***Enteromius aspilus*** (Cameroon), *E. guirali*

Dactylogyrus myersi Price, McClellan, Druckenmiller et Jacobs, 1969 from *Enteromius perince*, ***E. trimaculatus*** (South Africa)

Dactylogyrus nanocirrus Paperna, 1973 from *Enteromius apleurogramma*, *E. neglectus*, *E. perince*, ***E. trispilos*** (Ghana), *E. sublineatus*

Dactylogyrus nathaliae Guégan, Lambert et Euzet, 1988 from ***Labeo*** sp. (Mali)

Dactylogyrus nicolettae Crafford, Luus-Powell et Avenant-Oldewage, 2012 from ***Labeo capensis*** (South Africa)

Dactylogyrus njinei Birgi et Lambert, 1987 from ***Enteromius camptacanthus*** (Cameroon)

Dactylogyrus nyongensis Birgi et Lambert, 1987 from *Enteromius aspilus*, *E. guirali* (Cameroon; type host not indicated)

Dactylogyrus oligospirophallus Paperna, 1973 [syn. *Dactylogyrus afrobarbae* Paperna, 1968 (*partim*)] from ***Labeo coubie*** (Ghana)

Dactylogyrus omega Guegan et Lambert, 1991 from *Labeo parvus*, ***L. rouaneti*** (Guinea)

Dactylogyrus oumiensis El Gharbi, Birgi et Lambert, 1994 from *Carasobarbus fritschii* [syn. *Barbus paytonii*], *C. harterti*, *Labeobarbus reinii* (Morocco; type host not indicated)

Dactylogyrus papernai Timofeeva, Gerasev et Gibson, 1996 [*D. magnum* Paperna, 1973 renamed] from ***Labeobarbus macrolepis*** (Tanzania)

Dactylogyrus parawaldronii Guégan et Lambert, 1990 from ***Labeobarbus parawaldroni*** (Guinea)

Dactylogyrus parviphallus Paperna, 1973 from *Enteromius apleurogramma*, *E. kerstenii* (Uganda; type host not indicated)

Dactylogyrus petitjeani Guégan et Lambert, 1990 from ***Labeobarbus petitjeani*** (Guinea)

Dactylogyrus pienaari Price, Korach et McPott, 1969 from ***Labeo rosae*** (South Africa)

Dactylogyrus pokoase Paperna, 1973 from ***Enteromius ablabes*** (Ghana)

Dactylogyrus pseudanchoratus Price et Géry, 1968 from ***Labeobarbus bynni*** [syns *Barbus occidentalis*, *B. waldroni*] (Gabon), *L. macrolepis*, *L. parawaldroni*, *L. petitjeani*, *L. sacratus*, *L. wurtzi*

Dactylogyrus rastellus Guégan, Lambert et Euzet, 1988 from ***Labeo senegalensis*** (Mali)

Dactylogyrus reinii El Gharbi, Birgi et Lambert, 1994 from ***Labeobarbus reinii*** (Morocco)

Dactylogyrus retroversus Guégan, Lambert et Euzet, 1988 from ***Labeo coubie*** (Mali)

Dactylogyrus ruahae Paperna, 1973 from ***Labeobarbus macrolepis*** (Tanzania), *L. parawaldroni*, *L. sacratus*, *L. wurtzi*

Dactylogyrus rufijii Paperna, 1973 from ***Labeobarbus macrolepis*** (Tanzania)

Dactylogyrus sacrati Guégan et Lambert, 1990 from ***Labeobarbus sacratus*** (Guinea)

Dactylogyrus sahelensis Guégan et Lambert, 1990 from ***Labeobarbus bynni*** [syns *Barbus occidentalis*, *B. waldroni*] (Mali), *L. petitjeani*

Dactylogyrus scorpius Rahmouni, Řehulková et Šimková, 2017 from ***Luciobarbus rifensis*** (Morocco)

Dactylogyrus sematus Guégan et Lambert, 1991 from ***Labeo rouaneti*** (Guinea)

Dactylogyrus senegalensis Paperna, 1969 from ***Labeo senegalensis*** (Ghana)

Dactylogyrus spinicirrus (Paperna et Thurston, 1968) [syn. *Neodactylogyrus spinicirrus* Paperna et Thurston, 1968] from *Enteromius nyanzae*, *E. radiatus*, *E. trimaculatus*, ***Labeobarbus altianalis*** (Uganda), *L. marequensis*, *L. somereni*

Dactylogyrus teresae Mashego, 1983 from ***Enteromius paludinosus*** (South Africa)

Dactylogyrus titus Guégan, Lambert et Euzet, 1988 from ***Labeo coubie*** (Mali)

Dactylogyrus tubarius Guégan, Lambert et Euzet, 1988 from ***Labeo senegalensis*** (Mali)

Dactylogyrus tunisiensis El Gharbi, Birgi et Lambert, 1994 from ***Luciobarbus callensis*** (Tunisia)

Dactylogyrus valeti Birgi et Lambert, 1987 from ***Enteromius camptacanthus*** (Cameroon)

Dactylogyrus varicorhini Bychowsky, 1958 from ***Labeobarbus kimberleyensis*** (South Africa)

Dactylogyrus varius Rahmouni, Řehulková et Šimková, 2017 from ***Luciobarbus maghrebensis*** (Morocco)

Dactylogyrus volutus El Gharbi, Birgi et Lambert, 1994 from ***Carasobarbus fritschii*** (Morocco)

Dactylogyrus wurtzii Guégan et Lambert, 1990 from ***Labeobarbus wurtzi*** (Guinea)

Dactylogyrus yassensis Musilová, Řehulková et Gelnar, 2009 from ***Labeo coubie*** (Senegal) [Fig. 4.4.9A]

Dactylogyrus zatensis El Gharbi, Birgi et Lambert, 1994 from ***Carasobarbus fritschii*** (Morocco)

Dogielius Bychowsky, 1936

Dogielius anthocolpos Guégan, Lambert et Euzet, 1989 from ***Labeo coubie*** (Mali) [Fig. 4.4.8B]

Dogielius clavipenis Guégan, Lambert et Euzet, 1989 from ***Labeo coubie*** (Mali)

Dogielius complicitus Guégan, Lambert et Euzet, 1989 from ***Labeo coubie*** (Mali)

Dogielius djolibaensis Guégan et Lambert, 1990 from ***Labeobarbus bynni*** [syns *Barbus occidentalis*, *B. waldroni*] (Mali), *L. petitjeani*

Dogielius dublicornis Paperna, 1973 from ***Labeo cylindricus*** (Tanzania)

Dogielius flagellatus Guégan, Lambert et Euzet, 1989 from ***Labeo coubie*** (Mali)

Dogielius flosculus Guégan, Lambert et Euzet, 1989 from ***Labeo senegalensis*** (Mali)

Dogielius grandijugus Guégan, Lambert et Euzet, 1989 from ***Labeo*** sp. (Mali)

Dogielius grandiphallus Paperna, 1973 from ***Labeobarbus macrolepis*** (Tanzania)

Dogielius harpagatus Guégan, Lambert et Euzet, 1989 from ***Labeo coubie*** (Mali)

Dogielius intorquens Crafford, Luus-Powell et Avenant-Oldewage, 2012 from *Enteromius paludinosus*, *Labeo capensis*, ***L. umbratus*** (South Africa)

Dogielius junorstrema Price et Yurkiewicz, 1968 from ***Labeo ruddi*** (Zimbabwe)

Dogielius kabaensis Guégan et Lambert, 1991 from *Labeo alluaudi*, ***L. parvus*** (Guinea)

Dogielius martorellii Birgi et Lambert, 1987 from ***Enteromius martorelli*** (Cameroon)

Dogielius njinei Birgi et Lambert, 1987 from ***Enteromius camptacanthus*** (Cameroon)

Dogielius parvus Guégan, Lambert et Euzet, 1989 from ***Labeo parvus*** (Mali)

Dogielius pedaloe Guégan et Lambert, 1990 from ***Labeobarbus parawaldroni*** (Guinea), *L. wurtzi*

Dogielius phrygieus Guégan et Lambert, 1990 from ***Labeobarbus sacratus*** (Guinea)

Dogielius rosumplicatus Guégan et Lambert, 1991 from *Labeo parvus*, ***L. rouaneti*** (Guinea)

Dogielius tropicus Paperna, 1969 from *Labeo coubie*, *L. senegalensis* (Ghana; type host not indicated)

Dogielius vexillus Guégan et Lambert, 1990 from ***Labeobarbus wurtzi*** (Ivory Coast)

Enterogyrus Paperna, 1963

Enterogyrus amieti Bilong Bilong, Euzet et Birgi, 1996 from ***Sarotherodon galilaeus*** (Cameroon) [Fig. 4.4.7A]

Enterogyrus barombiensis Bilong Bilong, Birgi et Euzet, 1991 from *Konia eisentrauti*, ***Pungu maclareni*** (Cameroon), *Stomatepia pindu*

Enterogyrus cichlidarum Paperna, 1963 [syn. *Enterogyrus niloticus* Eid et Negm, 1987] from *Coptodon nyongana*, ***C. zillii***, *Oreochromis mossambicus*, *O. niloticus*, *Pseudocrenilabrus philander*, *Sarotherodon galilaeus*

Enterogyrus coronatus Pariselle, Lambert et Euzet, 1991 from *Coptodon dageti*, ***C. guineensis*** (Ivory Coast), *Pseudocrenilabrus philander*

Enterogyrus crassus Bilong Bilong, Euzet et Birgi, 1996 from ***Coptodon nyongana*** (Cameroon)

Enterogyrus foratus Pariselle, Lambert et Euzet, 1991 from ***Sarotherodon melanotheron*** (Senegal or Ivory Coast; type locality not indicated)

Enterogyrus malmbergi Bilong Bilong, 1988 from ***Oreochromis niloticus*** (Cameroon)

Enterogyrus melenensis Bilong Bilong, Birgi et Lambert, 1989 from ***Hemichromis fasciatus*** (Cameroon)

Eutrianchoratus Paperna, 1969

Eutrianchoratus chibami Bilong Bilong, Euzet et Birgi, 1994 from ***Parachanna obscura*** (Cameroon)

Eutrianchoratus imbachi Dossou et Euzet, 1984 from ***Parachanna obscura*** (Benin)

Eutrianchoratus magnus Paperna, 1969 from ***Parachanna obscura*** (Ghana)

Eutrianchoratus malleus Bilong Bilong, Euzet et Birgi, 1994 from ***Parachanna obscura*** (Cameroon) [Fig. 4.4.10B]

Eutrianchoratus minutus Paperna, 1969 from ***Parachanna obscura*** (Ghana)

Heteronchocleidus Bychowsky, 1957

Heteronchocleidus adjanohouni Euzet et Dossou, 1975 from *Ctenopoma kingsleyae*, *C. petherici* (Benin; type host not indicated) [Fig. 4.4.10A]

Heteronchocleidus ctenopomae Paperna, 1969 from ***Ctenopoma kingsleyae*** (Ghana), *C. petherici*

Heteronchocleidus niloticus Paperna, 1973 from ***Ctenopoma muriei*** (Uganda)

Heteronchocleidus ouemensis Euzet et Dossou, 1975 from *Ctenopoma kingsleyae*, *C. petherici* (Benin; type host not indicated)

Heteronchocleidus tuzetae Euzet et Dossou, 1975 from *Ctenopoma kingsleyae*, *C. petherici* (Benin; type host not indicated)

Heterotesia Paperna, 1969

Heterotesia voltae Paperna, 1969 from ***Heterotis niloticus*** (Ghana) [Fig. 4.4.12B]

Insulacleidus Rakotofiringa et Euzet, 1983

Insulacleidus paratilapiae Rakotofiringa et Euzet, 1983 from ***Paratilapia polleni*** (Madagascar) [Fig. 4.4.19A]

Insulacleidus paretropli Rakotofiringa et Euzet, 1983 from ***Paretroplus polyactis*** (Madagascar)

Insulacleidus ptychochromidis Rakotofiringa et Euzet, 1983 from ***Ptychochromis oligacanthus*** (Madagascar)

Nanotrema Paperna, 1969

Nanotrema citharini Paperna, 1969 from ***Citharinus citharus*** (Ghana) [Fig. 4.4.8A]

Nanotrema niokoloensis Musilová, Řehulková et Gelnar, 2011 from ***Citharinus citharus*** (Senegal)

Onchobdella Paperna, 1968

Onchobdella aframae Paperna, 1968 from ***Hemichromis fasciatus*** (Ghana)

Onchobdella bopeleti Bilong Bilong et Euzet, 1995 from ***Hemichromis fasciatus*** (Cameroon or Mali; type locality not indicated)

Onchobdella krachii Paperna, 1968 from ***Chromidotilapia guntheri*** (Ghana)

Onchobdella melissa Pariselle et Euzet, 1995 from ***Pelmatochromis buettikoferi*** (Guinea)

Onchobdella pterigyalis Paperna, 1968 from ***Hemichromis bimaculatus*** (Ghana)

Onchobdella spirocirra Paperna, 1968 from ***Hemichromis bimaculatus*** (Ghana)

Onchobdella sylverai Pariselle et Euzet, 1995 from ***Pelmatochromis buettikoferi*** (Guinea)

Onchobdella voltensis Paperna, 1968 from *Hemichromis bimaculatus*, ***H. fasciatus*** (Ghana) [Fig. 4.4.11B]

Paraquadriacanthus Ergens, 1988 [syn. *Quadriacanthoides* Kritsky et Kulo, 1988]

Paraquadriacanthus nasalis Ergens, 1988 [syn. *Quadriacanthoides andersoni* Kritsky et Kulo, 1988] from ***Clarias gariepinus*** [syn. *Clarias lazera*] (Egypt) [Fig. 4.4.14B]

Protoancylodiscoides Paperna, 1969

Protoancylodiscoides aurratum Bassock Bayiha, Nack et Pariselle, 2016 from ***Chrysichthys auratus*** (Cameroon)

Protoancylodiscoides chrysichthes Paperna, 1969 from *Chrysichthys auratus*, ***C. nigrodigitatus*** (Togo)

Protoancylodiscoides combesi Bassock Bayiha, Nack et Pariselle, 2016 from ***Chrysichthys auratus*** (Cameroon), *C. longidorsalis*, *C. nigrodigitatus*

Protoancylodiscoides katii N'Douba et Lambert, 1999 from ***Malapterurus electricus*** (Ivory Coast)

Protoancylodiscoides malapteruri Bilong Bilong, Birgi et Le Brun, 1997 from ***Malapterurus electricus*** (Cameroon)

Protoancylodiscoides mansourensis El-Naggar, 1987 from ***Chrysichthys auratus*** (Egypt) [Fig. 4.4.13]

Protoancylodiscoides sanagaensis Bassock Bayiha, Nack et Pariselle, 2017 from *Chrysichthys longidorsalis*, ***C. nigrodigitatus*** (Cameroon)

Protoancylodiscoides spirovagina Bassock Bayiha, Nack et Pariselle, 2017 from ***Chrysichthys nigrodigitatus*** (Cameroon)

Protoancylodiscoides valentini Bassock Bayiha, Nack et Pariselle, 2017 from *Chrysichthys longidorsalis*, ***C. nigrodigitatus*** (Cameroon)

Quadriacanthus Paperna, 1961 [syn. *Anacornuatus* Dubey, Gupta et Agarwal, 1992]

Quadriacanthus aegypticus El-Naggar et Serag, 1986 [syns *Anacornuatus aegypticus* (El-Naggar et Serag, 1986) Dubey, Gupta et Agarwal, 1992; *Quadriacanthus clariadis* Paperna, 1961 (*partim*)] from ***Clarias gariepinus*** [syn. *Clarias lazera*] (Egypt)

Quadriacanthus agnebiensis N'Douba, Lambert et Euzet, 1999 from ***Heterobranchus isopterus*** (Ivory Coast)

Quadriacanthus allobychowskiella Paperna, 1979 [syns *Quadriacanthus clariadis allobychowskiella* Paperna, 1979; *Quadriacanthus kearni* El-Naggar et Serag, 1985] from ***Clarias gariepinus*** [syn. *Clarias lazera*] (Uganda)

Quadriacanthus anaspidoglanii Akoumba, Pariselle et Tombi, 2017 from ***Notoglanidium macrostoma*** (Cameroon)

Quadriacanthus ashuri Kritsky et Kulo, 1988 from ***Clarias gariepinus*** [syn. *Clarias lazera*] (Egypt)

Quadriacanthus ayameensis N'Douba, Lambert et Euzet, 1999 from ***Heterobranchus isopterus*** (Ivory Coast)

Quadriacanthus bagrae Paperna, 1979 [syn. *Quadriacanthus clariadis bagrae* Paperna, 1979] from *Bagrus bajad*, ***B. docmak*** (Uganda), *B. orientalis*, *Clarias gariepinus* [syn. *Clarias lazera*]

Quadriacanthus clariadis Paperna, 1961 [syns *Quadriacanthus clariadis clariadis* Paperna, 1979; *Quadriacanthus bagrae* Paperna, 1979 (*partim*)] from ***Clarias gariepinus*** [syn. *Clarias lazera*] [Fig. 4.4.12A]

Quadriacanthus dageti Birgi, 1988 from ***Clarias jaensis*** (Cameroon)

Quadriacanthus eboreus N'Douba et Lambert, 2001 from ***Clarias ebriensis*** (Ivory Coast)

Quadriacanthus euzeti Nack, Pariselle et Bilong Bilong, 2016 from ***Papyrocranus afer*** (Cameroon)

Quadriacanthus fornicatus Francová et Řehulková, 2017 from ***Clarias gariepinus*** (Sudan)

Quadriacanthus gourenei N'Douba, Lambert et Euzet, 1999 from ***Heterobranchus isopterus*** (Ivory Coast)

Quadriacanthus ivoiriensis N'Douba et Lambert, 2001 from ***Clarias ebriensis*** (Ivory Coast)

Quadriacanthus levequei Birgi, 1988 from ***Clarias pachynema*** (Cameroon)

Quadriacanthus longifilisi N'Douba, Lambert et Euzet, 1999 from ***Heterobranchus longifilis*** (Ivory Coast)

Quadriacanthus macrocirrus N'Douba, Lambert et Euzet, 1999 from ***Heterobranchus isopterus*** (Ivory Coast)

Quadriacanthus macruncus Bahanak, Nack et Pariselle, 2016 from ***Clarias submarginatus*** (Cameroon)

Quadriacanthus mandibulatus Francová et Řehulková, 2017 from ***Heterobranchus bidorsalis*** (Sudan)

Quadriacanthus ndoubai Bahanak, Pariselle et Bilong Bilong, 2017 from ***Heterobranchus longifilis*** (Cameroon)

Quadriacanthus numidus Kritsky et Kulo, 1988 from ***Clarias gariepinus*** [syn. *Clarias lazera*] (Egypt)

Quadriacanthus nyongensis Birgi, 1988 from *Clarias jaensis*, *C. pachynema* (Cameroon; type host not indicated)

Quadriacanthus ossaensis Bahanak, Nack et Pariselle, 2016 from ***Clarias submarginatus*** (Cameroon)

Quadriacanthus papernai Kritsky et Kulo, 1988 from ***Clarias gariepinus*** [syn. *Clarias lazera*] (Egypt)

Quadriacanthus pravus Francová et Řehulková, 2017 from ***Clarias gariepinus*** (Sudan)

Quadriacanthus simplex N'Douba, Lambert et Euzet, 1999 from ***Heterobranchus isopterus*** (Ivory Coast)

Quadriacanthus submarginati Bahanak, Nack et Pariselle, 2016 from ***Clarias submarginatus*** (Cameroon)

Quadriacanthus teugelsi Birgi, 1988 from *Clarias jaensis*, *C. pachynema* (Cameroon; type host not indicated)

Quadriacanthus thysi N'Douba, Lambert et Euzet, 1999 from ***Heterobranchus longifilis*** (Ivory Coast)

Quadriacanthus tilapiae Paperna, 1973 from ***Oreochromis esculentus*** (Uganda)

Quadriacanthus tricorniculai Bahanak, Pariselle et Bilong Bilong, 2017 from ***Heterobranchus longifilis*** (Cameroon)

Quadriacanthus triunguisi Bahanak, Pariselle et Bilong Bilong, 2017 from ***Heterobranchus longifilis*** (Cameroon)

Quadriacanthus voltaensis Paperna, 1965 from ***Clarias gariepinus*** [syn. *Clarias lazera*] (Ghana), *C. camerunensis* [syn. *C. walkeri*]

Quadriacanthus zuheiri Francová et Řehulková, 2017 from ***Clarias gariepinus*** (Sudan)

Schilbetrema Paperna et Thurston, 1968

Schilbetrema acornis Paperna et Thurston, 1968 from ***Schilbe intermedius*** [syn. *Schilbe mystus*] (Uganda)

Schilbetrema aegyptica El-Naggar, 1985 from ***Schilbe intermedius*** [syn. *Schilbe mystus*] (Egypt)

Schilbetrema biclavula N'Douba, Pariselle, Thys van den Audenaerde et Euzet, 1997 from ***Schilbe mandibularis*** (Ivory Coast)

Schilbetrema bicornis Paperna, 1969 – *species inquirenda* (Kritsky and Kulo 1992) from ***Parailia pellucida*** (Ghana)

Schilbetrema calamocleithrum Kritsky et Kulo, 1992 from ***Schilbe intermedius*** (Togo)

Schilbetrema dissimilis N'Douba, Pariselle, Thys van den Audenaerde et Euzet, 1997 from ***Schilbe mandibularis*** (Ivory Coast)

Schilbetrema eutropii Paperna, 1969 [syn. *Schilbetrema quadricornis eutropii* Paperna, 1969] from ***Schilbe mystus*** [syn. *Eutropius niloticus*] (Ghana)

Schilbetrema hexacornis Paperna, 1969 from ***Schilbe mystus*** [syn. *Eutropius niloticus*] (Ghana) [Fig. 4.4.17B]

Schilbetrema quadricornis Paperna et Thurston, 1968 [syn. *Schilbetrema quadricornis schilbae* Paperna, 1969] from ***Schilbe intermedius*** [syn. *Schilbe mystus*] (Uganda)

Schilbetrema spirocirra Paperna, 1969 from ***Schilbe mystus*** [syn. *Eutropius niloticus*] (Ghana)

Schilbetrema torula Kritsky et Kulo, 1992 from ***Schilbe mystus*** (Togo)

Schilbetrema tricera Paperna, 1973 from ***Schilbe*** sp. (Tanzania)

Schilbetrema undinula Kritsky et Kulo, 1992 from ***Schilbe intermedius*** (Togo)

Schilbetrema vacillans Kritsky et Kulo, 1992 from ***Schilbe intermedius*** (Togo)

Schilbetrematoides Kritsky et Kulo, 1992

Schilbetrematoides manizani N'Douba, Lambert, Pariselle et Euzet, 2000 from *Schilbe intermedius* (new host record), ***S. mandibularis*** (Ivory Coast) [Fig. 4.4.9B]

Schilbetrematoides pseudodactylogyrus Kritsky et Kulo, 1992 from ***Schilbe intermedius*** (Togo)

Scutogyrus Pariselle et Euzet, 1995

Scutogyrus bailloni Pariselle et Euzet, 1995 from ***Sarotherodon galilaeus*** (Niger)

Scutogyrus chikhii Pariselle et Euzet, 1995 from ***Oreochromis mossambicus*** (Republic of the Congo)

Scutogyrus ecoutini Pariselle et Euzet, 1995 from ***Sarotherodon occidentalis*** (Guinea)

Scutogyrus gravivaginus (Paperna et Thurston, 1969) [syns *Cichlidogyrus longicornis gravivaginus* Paperna et Thurston, 1969; *Cichlidogyrus gravivaginus* Paperna et

Thurston, 1969 of Douëllou (1993)] from ***Oreochromis leucostictus*** (Uganda), *O. mortimeri*, *O. mweruensis*, *O. tanganicae*, *O. variabilis*

Scutogyrus longicornis (Paperna et Thurston, 1969) [syns *Cichlidogyrus longicornis longicornis* Paperna et Thurston, 1969; *Cichlidogyrus longicornis* of Douëllou (1993); *Actinocleidus muelleri* Ferdousi et Chandra, 2002] from *Coptodon zillii*, *Oreochromis aureus*, *O. mortimeri*, *O. mossambicus*, *O. niloticus*, ***Sarotherodon galilaeus*** (Ghana)

Scutogyrus minus (Dossou, 1982) [syns *Cichlidogyrus longicornis minus* Dossou, 1982; *Cichlidogyrus minus* of Pariselle & Euzet, 1995] from *Oreochromis niloticus,* ***Sarotherodon melanotheron*** (Benin) [Fig. 4.4.15A]

Scutogyrus vanhovei Pariselle, Bitja Nyom et Bilong Bilong, 2013 from ***Pelmatolapia mariae*** (Cameroon)

Synodontella Dossou et Euzet, 1993

Synodontella apertipenis Mbondo, Nack et Pariselle, 2017 from ***Synodontis rebeli*** (Cameroon)

Synodontella arcopenis Dossou et Euzet, 1993 from ***Synodontis sorex*** (Benin or Mali; type locality not indicated)

Synodontella davidi Dossou et Euzet, 1993 from ***Synodontis membranaceus*** (Mali)

Synodontella melanoptera Dossou et Euzet, 1993 from ***Synodontis melanopterus*** (Benin), *S. obesus*, *S. rebeli* [Fig. 4.4.18A]

Synodontella sanagaensis Mbondo, Nack et Pariselle, 2017 from ***Synodontis rebeli*** (Cameroon)

Synodontella synodontii (Paperna et Thurston, 1968) [syns *Ancyrocephalus synodontii* Paperna et Thurston, 1968; *Schilbetrema synodontii* (Paperna et Thurston, 1968)] from *Synodontis membranaceus*, ***S. victoriae*** (Uganda), *S. zambezensis*

Synodontella zambezensis Douëllou et Chishawa, 1995 from ***Synodontis zambezensis*** (Zimbabwe)

Urogyrus Bilong Bilong, Birgi et Euzet, 1994

Urogyrus cichlidarum Bilong Bilong, Birgi et Euzet, 1994 from ***Benitochromis batesii*** (Cameroon), *Parananochromis caudifasciatus*, *Pungu maclareni*, *Stomatepia pindu*, *Tilapia* sp. [Fig. 4.4.7B]

DIPLECTANIDAE Monticelli, 1903

Diplectanum Diesing, 1858

Diplectanum lacustre Thurston et Paperna, 1969 – *incertae sedis* (Domingues and Boeger 2008) from ***Lates niloticus*** [syn. *Lates albertianus*] (Ghana) [Fig. 4.4.6B]

GYRODACTYLIDAE van Beneden et Hesse, 1863

Afrogyrodactylus Paperna, 1968

Afrogyrodactylus ardae Přikrylová, Smit et Gelnar 2017 from ***Rhabdalestes septentrionalis*** (Senegal)

Afrogyrodactylus characinis Paperna, 1968 from ***Micralestes*** sp. (Ghana)

Afrogyrodactylus girgifae Přikrylová et Luus-Powell, 2016 from ***Brycinus nurse*** (Sudan)

Afrogyrodactylus kingi Přikrylová et Luus-Powell, 2014 from ***Micralestes acutidens*** (South Africa) [Fig. 4.4.21B]

Citharodactylus Přikrylová, Shinn et Paladini, 2017

Citharodactylus gagei Přikrylová, Shinn et Paladini, 2017 from ***Citharinus citharus*** (Kenya) [Fig. 4.4.22B]

Diplogyrodactylus Přikrylová, Matějusová, Musilová, Gelnar et Harris, 2009

Diplogyrodactylus martini Přikrylová, Matějusová, Musilová, Gelnar et Harris, 2009 from ***Polypterus senegalus*** (Senegal) [Fig. 4.4.20A]

Gyrodactylus von Nordmann, 1832 [Fig. 4.4.22A]

Gyrodactylus alberti Paperna, 1973 from ***Clarias gariepinus*** (Uganda)

Gyrodactylus alekosi Přikrylová, Blažek et Vanhove, 2012 from ***Clarias gariepinus*** (Mozambique)

Gyrodactylus amphiliusi Paperna, 1973 from ***Amphilius atesuensis*** (Ghana)

Gyrodactylus anabanti Paperna, 1973 from ***Ctenopoma muriei*** (Uganda)

Gyrodactylus camerunensis Nack, Bilong Bilong et Euzet, 2005 from ***Clarias camerunensis*** (Cameroon)

Gyrodactylus chitandiri Zahradníčková, Barson, Luus-Powell et Přikrylová, 2016 from ***Coptodon rendalli*** (Zimbabwe), *Pseudocrenilabrus philander*

Gyrodactylus cichlidarum Paperna, 1968 from *Coptodon guineensis*, *C. zilii*, *Hemichromis bimaculatus*, *H. fasciatus*, ***Sarotherodon galilaeus*** (Ghana), *S. melanotheron*

Gyrodactylus clarii Paperna, 1973 from ***Clarias gariepinus*** (Uganda)

Gyrodactylus ctenopomi Paperna, 1973 from ***Ctenopoma muriei*** (Uganda)

Gyrodactylus cyprinodonti Paperna, 1968 from ***Epiplatys*** sp. (Ghana)

Gyrodactylus cytophagus Paperna, 1968 from ***Poropanchax normani*** (Ghana)

Gyrodactylus ergensi Přikrylová, Matějusová, Musilová et Gelnar, 2012 from ***Sarotherodon galilaeus*** (Senegal), *Oreochromis niloticus*

Gyrodactylus gelnari Přikrylová, Blažek et Vanhove, 2012 from ***Clarias anguillaris*** (Senegal), *C. gariepinus*

Gyrodactylus groschafti Ergens, 1973 from ***Clarias gariepinus*** (Egypt)

Gyrodactylus haplochromi Paperna, 1973 from ***Haplochromis elegans*** (Uganda)

Gyrodactylus hildae García-Vásquez, Hansen, Christison, Bronn et Shinn, 2011 from ***Oreochromis niloticus*** (Ethiopia)

Gyrodactylus ivindoensis Price et Géry, 1968 from ***Enteromius holotaenia*** (Gabon)

Gyrodactylus kyogae Paperna, 1973 from ***Enteromius perince*** (Uganda)

Gyrodactylus malalai Přikrylová, Blažek et Gelnar, 2012 from *Coptodon zillii*, ***Oreochromis niloticus*** (Kenya)

Gyrodactylus micralestes Paperna, 1968 from ***Micralestes*** sp. (Ghana)

Gyrodactylus nigritae Přikrylová, Blažek et Vanhove, 2012 from ***Synodontis nigrita*** (Senegal)

Gyrodactylus nyanzae Paperna, 1973 from *Coptodon rendalli*, *Oreochromis mweruensis*, *O. niloticus*, *O. niloticus* x *mweruensis*, ***O. variabilis*** (Uganda)

Gyrodactylus nyongensis Nack, Bilong Bilong et Euzet, 2005 from ***Clarias camerunensis*** (Cameroon)

Gyrodactylus occupatus Zahradníčková, Barson, Luus-Powell et Přikrylová, 2016 from ***Oreochromis niloticus*** (Zimbabwe), *Pharyngochromis acuticeps*, *Pseudocrenilabrus philander*, *Tilapia* sp.

Gyrodactylus parisellei Zahradníčková, Barson, Luus-Powell et Přikrylová, 2016 from *Oreochromis niloticus*, ***Pseudocrenilabrus philander*** (Zimbabwe), *Tilapia* sp.

Gyrodactylus rysavyi Ergens, 1973 from *Clarias anguillaris*, ***C. gariepinus*** (Egypt)

Gyrodactylus sturmbaueri Vanhove, Snoeks, Volckaert et Huyse, 2011 from *Pseudocrenilabrus philander*, ***Simochromis diagramma*** (Zambia)

Gyrodactylus synodonti Přikrylová, Blažek et Vanhove, 2012 from ***Synodontis nigrita*** (Senegal)

Gyrodactylus thlapi Christison, Shinn et Van As, 2005 from ***Pseudocrenilabrus philander*** (Botswana)

Gyrodactylus thysi Vanhove, Snoeks, Volckaert et Huyse, 2011 from ***Simochromis diagramma*** (Zambia)

Gyrodactylus tranvaalensis Prudhoe et Hussey, 1977 from *Clarias anguillaris*, ***C. gariepinus*** (South Africa)

Gyrodactylus turkanaensis Přikrylová, Blažek et Vanhove, 2012 from ***Clarias gariepinus*** (Kenya)

Gyrodactylus ulinganisus García-Vásquez, Hansen, Christison, Bronn et Shinn, 2011 from ***Oreochromis mossambicus*** (South Africa)

Gyrodactylus yacatli García-Vásquez, Hansen, Christison, Bronn et Shinn, 2011 from ***Oreochromis niloticus***, *Pseudocrenilabrus philander*

Gyrodactylus zimbae Vanhove, Snoeks, Volckaert et Huyse, 2011 from *Ctenochromis horei*, ***Simochromis diagramma*** (Zambia)

Macrogyrodactylus Malmberg, 1957

Macrogyrodactylus anabanti Paperna, 1973 from ***Ctenopoma muriei*** (Uganda)

Macrogyrodactylus clarii Gussev, 1961 from *Clarias gariepinus*, ***Clarias*** sp. (Ethiopia)

Macrogyrodactylus congolensis (Prudhoe, 1957) [syn. *Neogyrodactylus congolensis* Prudhoe, 1957] from *Clarias anguillaris*, ***C. gariepinus*** (Democratic Republic of the Congo) [Fig. 4.4.20B]

Macrogyrodactylus ctenopomi Paperna, 1973 from ***Ctenopoma muriei*** (Uganda)

Macrogyrodactylus heterobranchii N'Douba et Lambert, 1999 from *Clarias anguillaris*, ***Heterobranchus longifilis*** (Ivory Cost)

Macrogyrodactylus karibae Douëllou et Chishawa, 1995 from ***Clarias gariepinus*** (Zimbabwe)

Macrogyrodactylus latesi Paperna, 1969 from ***Lates niloticus*** (Ghana)

Macrogyrodactylus polypteri Malmberg, 1957 from ***Polypterus senegalus*** (Gambia)

Macrogyrodactylus simetiensis Přikrylová et Gelnar, 2008 from ***Polypterus senegalus*** (Senegal)

Mormyrogyrodactylus Luus-Powell, Mashego et Khalil, 2003

Mormyrogyrodactylus gemini Luus-Powell, Mashego et Khalil, 2003 from ***Marcusenius macrolepidotus*** (South Africa) [Fig. 4.4.21A]

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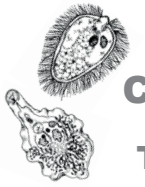

Chapter 4.5.
TREMATODA

Olena KUDLAI, Tomáš SCHOLZ & Nico SMIT

Flukes (Trematoda) – basic characteristics, life cycles, classification and principal diagnostic features

- parasitic flatworms (Platyhelminthes: Neodermata)
- almost 20,000 species classified in 2 subclasses
- subclass Digenea with 2 orders, 25 superfamilies and 148 families
- obligate parasites, almost exclusively endoparasites
- in the digestive system and other organs
- in all groups of vertebrates, with the highest number of species in bony fishes; exceptionally, adults in invertebrates
- body dorsoventrally flattened in most species
- usually with two muscular suckers: the oral sucker at the anterior end of the body and the ventral one (acetabulum) in the mid-region (close to the posterior extremity of the body in Paramphistomatoidea)
- digestive tract well-developed
- body surface covered with tegument (neodermis), sometimes with spines
- all African species in fishes hermaphroditic
- except for some aspidogastreans, life cycles indirect (1-3 intermediate hosts)
- first intermediate hosts molluscs, especially gastropods
- wide spectrum of second intermediate hosts, *e.g.*, molluscs, insects, oligochaetes, fishes
- some species, especially larvae (*e.g.*, metacercariae of the Diplostomidae and Clinostomidae), can be pathogenic for fish hosts
- causative agents of human fish-borne diseases (small liver and intestinal flukes) – not common in Africa

The life cycle of trematodes is complex with both free-living and parasitic stages and involves several hosts (Fig. 4.5.1 A, B). Adults produce eggs that pass in the faeces of the host to the environment where they hatch to release a free-living larva, the miracidium. The miracidium penetrates a molluscan first intermediate host (some marine species infect annelids). After penetration the miracidium develops into a mother sporocyst, the first intramolluscan generation. It multiplies parthenogenetically, producing the second intramolluscan generation – multiple daughter sporocysts or multiple rediae. Daughter sporocysts and rediae reproduce parthenogenetically generating the larvae of the sexual adult – cercariae. There are several ways for cercariae to infect the invertebrate or vertebrate second intermediate host, which host metacercariae. Cercariae may actively penetrate

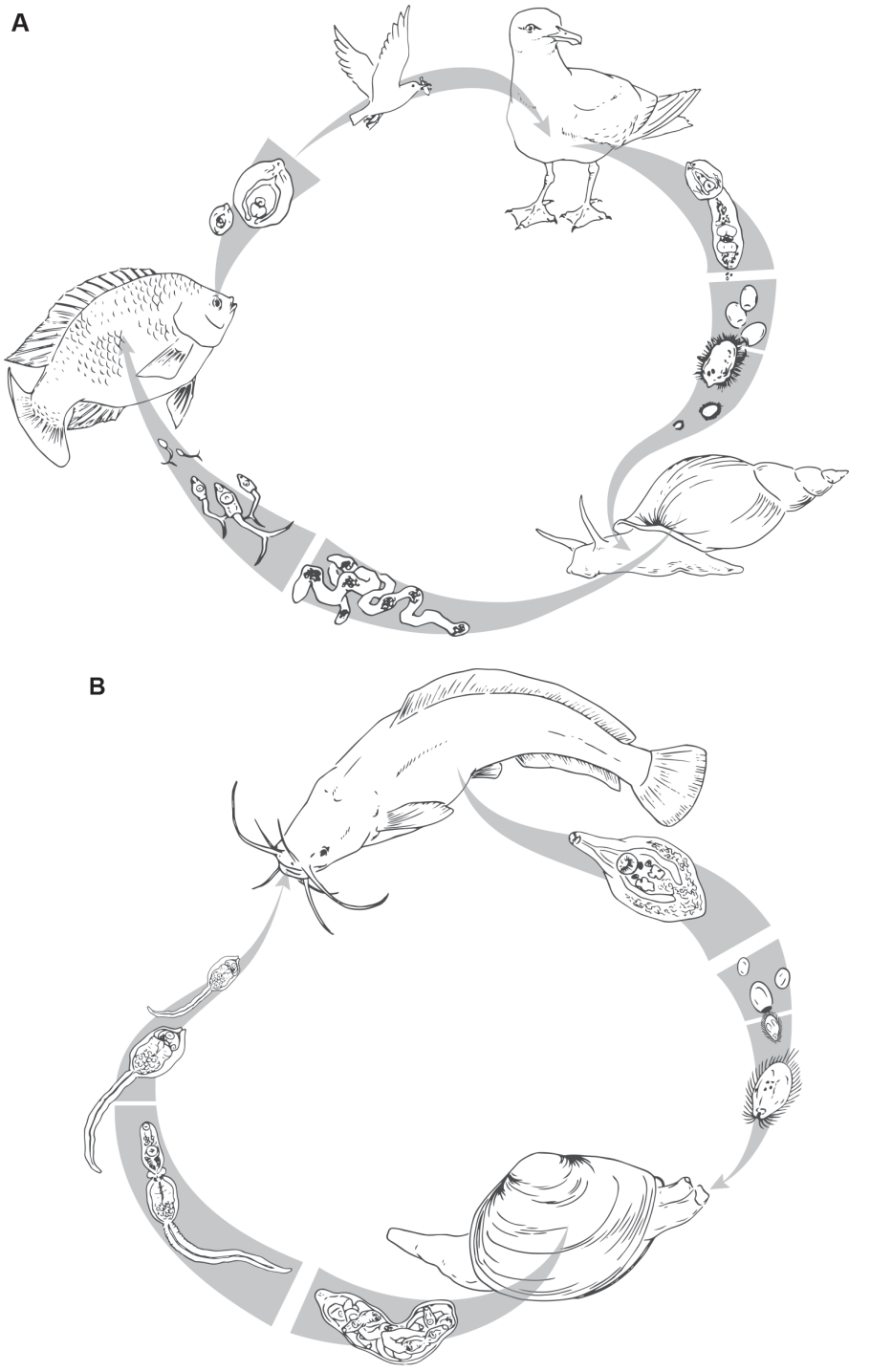

Fig. 4.5.1. Life cycles of trematodes. **A.** *Diplostomum* sp. (fish serves as the second intermediate host); **B.** *Phyllodistomum* sp. (fish serves as the definitive host). (Illustrations by M. Luo.)

through the skin or be eaten by the host. The vertebrate definitive hosts are infected when they consume the second intermediate host.

Trematoda includes two subclasses, Aspidogastrea and Digenea. The former subclass includes only 61 species (Alves *et al.* 2015) compared with almost 20,000 nominal species of digeneans. The fundamental unit of the **classification** of the Digenea is the superfamily. A total of 25 superfamilies with 148 families have been recognised (see Bray *et al.* 2008). As many as 60 families of digeneans include parasites of fishes, and 38 families are exclusively fish parasites. Relatively few of these families possess unique morphological traits that would differentiate them easily from each other. Therefore, individual families are usually characterised by a unique combination of non-unique morphological characteristics. Life cycles and cercarial morphology also play an important role in family definition. As a result, it is very difficult or almost impossible to present simple keys to the families of fish trematodes in Africa.

Seven basic morphotypes of digeneans are recognised based on their general body plan, especially the number and position of suckers, but most trematodes parasitic in African freshwater fishes belong to the distomatous morphological type, which has two suckers, the oral sucker at the anterior end of the body and the ventral one in the mid-region of the body.

Identification to the genus and species level is based on a high number of morphological characteristics, many of them related to the genital organs, such as relative position of the gonads, their shape and extent, the position of the genital pores, structure of the cirrus-sac, the size of the eggs, etc. (see Gibson *et al.* 2002; Jones *et al.* 2005; Bray *et al.* 2008 for keys to trematode genera).

Key to the genera of the Trematoda (adults) of freshwater fishes in Africa

1 (2) Ventral surface of the body with a large muscular, pad-like Baer's disc with numerous alveoli…….***Aspidogaster*** (**subclass Aspidogastrea**) [Fig. 4.5.2A]

2 (1) Ventral surface of the body without the Baer's disc….(**subclass Digenea**)

3 (4) Parasitic in the alimentary canal and associated cavities and organs ……7

4 (3) Not parasitic in the alimentary canal and associated cavities and organs……. 5

5 (6) Adults in the blood system……***Sanguinicola*** (Aporocotylidae) [Fig. 4.5.2D]

6 (5) Adults in tissues of the body…… ……..***Nematobothrium*** (Didymozoidae) [Fig. 4.5.4H]

7 (8) Parasitic in gall or urinary bladders……9

8 (7) Parasitic in other organs……13

9 (10) Parasitic in gall-bladder……11

10 (9) Parasitic in urinary bladder……***Phyllodistomum*** (Gorgoderidae) [Fig. 4.5.4E]

11 (12) Body pyriform; testes symmetrical, extracaecal, *i.e.*, external to the caeca, at level of the ventral sucker; ovary between testes……***Callodistomum*** (Callodistomidae) [Fig. 4.5.2E]

12 (11) Body cylindrical; testes oblique, overlying caeca, posterior to the ventral sucker; ovary pretesticular, lateral, on the same side as the posterior testis……***Cholepotes*** (Callodistomidae) [Fig. 4.5.2F]

13 (14) Circumoral crown of spines present……15

14 (13) Circumoral crown of spines absent……17

15 (16) Intestinal bifurcation just anterior to the ventral sucker; caeca open externally by separate ani; cirrus-sac absent……***Acanthostomum*** (Cryptogonimidae) [Fig. 4.5.3F]

16 (15) Intestinal bifurcation close to pharynx; caeca blind; cirrus-sac present ……...***Masenia*** (Cephalogonimidae) [Fig. 4.5.3A]

17 (18) Forebody expanded laterally……***Deropristis*** (Deropristidae) [Fig. 4.5.4D]

18 (17) Forebody not expanded laterally……19

19 (20) Ventral sucker at the posterior extremity……21

20 (19) Ventral sucker ventral……27

21 (22) Testes caecal or extracaecal……23

22 (21) Testes intercaecal, in middle third of body close to caecal arch, may overlie caeca slightly……***Panamphistomum*** (Cladorchiidae) [Fig. 4.5.3D]

23 (24) Testes diagonal or tandem; anterior testis caecal or extracaecal, posterior testis intercaecal……25

24 (23) Testes symmetrical, overlap caeca at or just behind level of intestinal bifurcation……***Brevicaecum*** (Cladorchiidae) [Fig. 4.5.3C]

25 (26) Body conical; acetabulum massive, wider than the body, with very large, prominent papillae, but without powerful horseshoe-shaped sphincter ……***Basidiodiscus*** (Cladorchiidae) [Fig. 4.5.3B]

26 (25) Body elongate oval; acetabulum not massive, without very large papillae, but with a powerful horseshoe-shaped sphincter……***Sandonia*** (Cladorchiidae) [Fig. 4.5.3E]

27 (28) One testis only……29

28 (27) Two or more testes……33

29 (30) Cirrus-sac absent……***Haplorchoides*** (Heterophyidae) [Fig. 4.5.5B]

30 (29) Cirrus-sac present……31

31 (32) Body elongate; prepharynx indistinct; caeca cylindrical, long, often terminating near the posterior end of the body; testis entirely intracaecal; vitellarium at mid-body; uterus occupying much of hindbody, often extending into forebody……..***Paralecithobotrys*** (Haploporidae) [Fig. 4.5.4F]

32 (31) Body fusiform; prepharynx somewhat longer or shorter than pharynx; caeca sac-like, relatively short; testis entirely postcaecal; vitellarium in hind-body; uterus restricted to the hind-body……***Saccocoelium*** (Haploporidae) [Fig. 4.5.4G]

33 (34) Testes two……..35

34 (33) Testes nine……..***Siphodera*** (Cryptogonimidae) [Fig. 4.5.3H]

35 (36) Caeca terminate blindly……39

36 (35) Caeca unite to form cyclocoel……37

37 (38) Cirrus-sac present; testes symmetrical ……***Trematobrien*** (Apocreadiidae) [Fig. 4.5.2C]

38 (37) Cirrus-sac absent; testes tandem to oblique……***Nicolla*** (Opecoelidae) [Fig. 4.5.5E]

39 (40) Cirrus-sac present……53

40 (39) Cirrus-sac absent……..41

41 (42) Sinus-sac present……..43

42 (41) Sinus-sac absent……...45

43 (44) Pars prostatica long, may be sparsely surrounded by gland cells; seminal vesicle trilocular……***Dinurus*** (Hemiuridae) [Fig. 4.5.6A]

44 (43) Pars prostatica short, connected to the seminal vesicle by the long glandular duct; seminal vesicle variable, tubular, saccular or divided into two or three sections……...***Ectenurus*** (Hemiuridae) [Fig. 4.5.5A]

45 (46) Vitellarium two masses at the posterior extremity of the body ……47

46 (45) Vitellarium follicular, form two lateral bands in hind-body……49

47 (48) Testes anterior to the ovary and vitellarium ……***Halipegus*** (Derogenidae) [Fig. 4.5.4B]

48 (47) Testes posterior to the ovary and vitellarium ……***Gonocerca*** (Gonocercidae) [Fig. 4.5.4C]

49 (50) The vitelline follicles extend posteriorly to level of the ovary or anterior testis……***Thaparotrema*** (Opisthorchiidae) [Fig. 4.5.5G]

50 (49) The vitelline follicles extend posteriorly to level of posterior testis…….51

51 (52) Body oval; oral sucker without enlarged oral spines, opens subterminally……***Neocladocystis*** (Cryptogonimidae) [Fig. 4.5.4A]

52 (51) Body fusiform; oral sucker with enlarged oral spines, opens terminally ……***Brientrema*** (Cryptogonimidae) [Fig. 4.5.3G]

53 (54) Vitellarium reaching posterior extremity…….55

54 (53) Vitellarium not reaching posteriorly extremity……59

55 (56) Uterus extending to, or near to, posterior extremity……***Orientocreadium*** (Orientocreadiidae) [Fig. 4.5.5H]

56 (55) Uterus not extending to, or near to, posterior extremity…… 57

57 (58) Intestinal bifurcation at the posterior margin of the ventral sucker ……***Allocreadium*** (Allocreadiidae) [Fig. 4.5.2B]

58 (57) Intestinal bifurcation anterior to the ventral sucker……***Plagioporus*** (Opecoelidae) [Fig. 4.5.5F]

59 (60) Testes symmetrical……***Malawitrema*** (Macroderoididae) [Fig. 4.5.5D]

60 (59) Testes oblique……61

61 (62) Genital pore extracaecal……..63

62 (61) Genital pore intercaecal……65

63 (64) Genital pore submedian at level of oral sucker……***Emoleptalea*** (Cephalogonimidae) [Fig. 4.5.2G]

64 (63) Genital pore submarginal, sinistral, at the level of pharynx…***Heterorchis*** [*incertae sedis* in the superfamily Plagiorchioidea (*sensu lato*)] [Fig. 4.5.5C]

65 (66) Seminal vesicle bipartite……***Glossidium*** [*incertae sedis* in the superfamily Plagiorchioidea (*sensu lato*)] [Fig. 4.5.5J]

66 (65) Siminal vesicle unipartite……***Astiotrema*** [*incertae sedis* in the superfamily Plagiorchioidea (*sensu lato*)] [Fig. 4.5.5I]

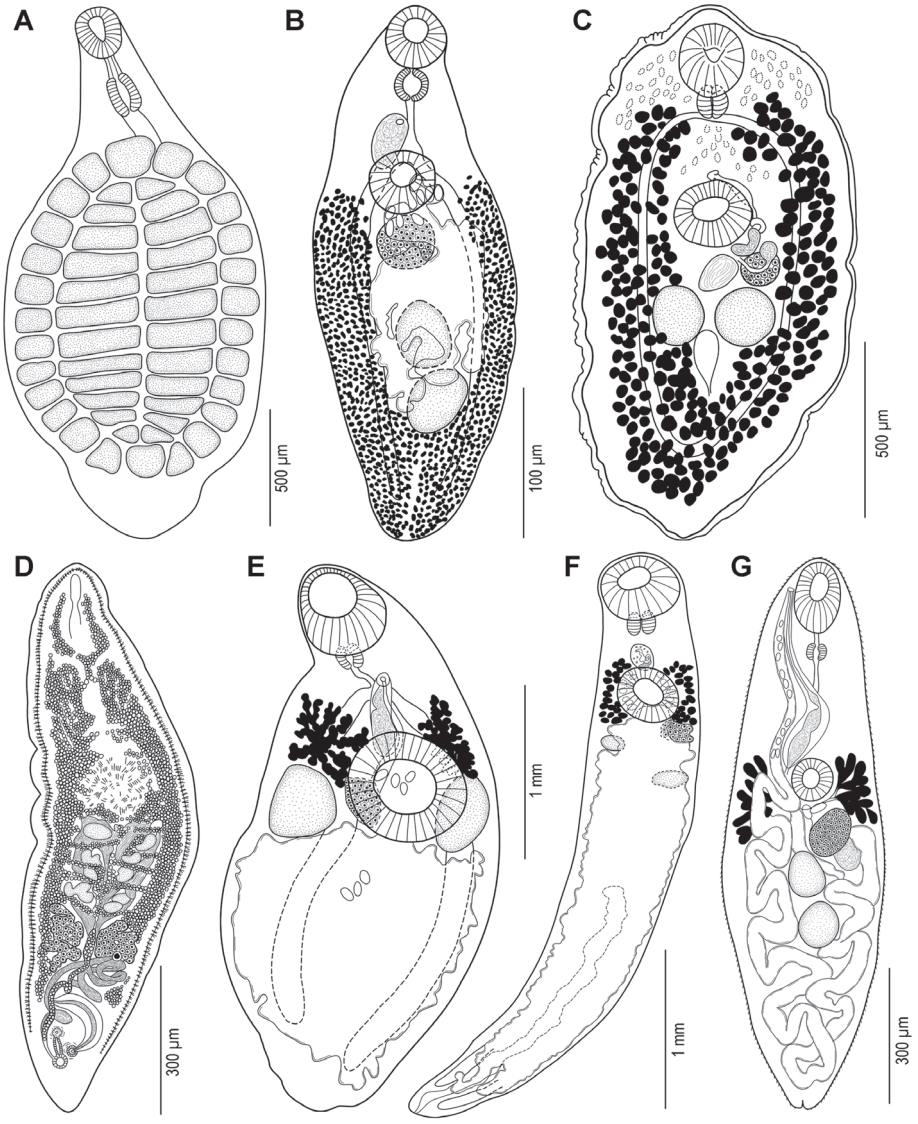

Fig. 4.5.2. Trematoda. **A.** *Aspidogaster africanus* Saoud, Mohamed et Abdel-Hamid, 1974 from *Labeobarbus bynni*; **B.** *Allocreadium mazoensis* Beverly-Burton, 1962 from *Clarias gariepinus*; **C.** *Trematobrien haplochromios* Dollfus, 1950 from *Pseudocrenilabrus philander*; **D.** *Sanguinicola chalmersi* Odhner, 1924 from *Auchenoglanis occidentalis*; **E.** *Callodistomum diaphanum* Odhner, 1902 from *Ctenopoma kingsleyae*; **F.** *Cholepotes ovofarctus* (Odhner, 1902) from *Synodontis schall*; **G.** *Emoleptalea exilis* (Looss, 1899) from *Bagrus bajad*. (Modified from Looss 1899; Odhner 1924; Beverly-Burton 1962; Manter 1962; Saoud *et al.* 1974; Jones 1982; Bray 2002.)

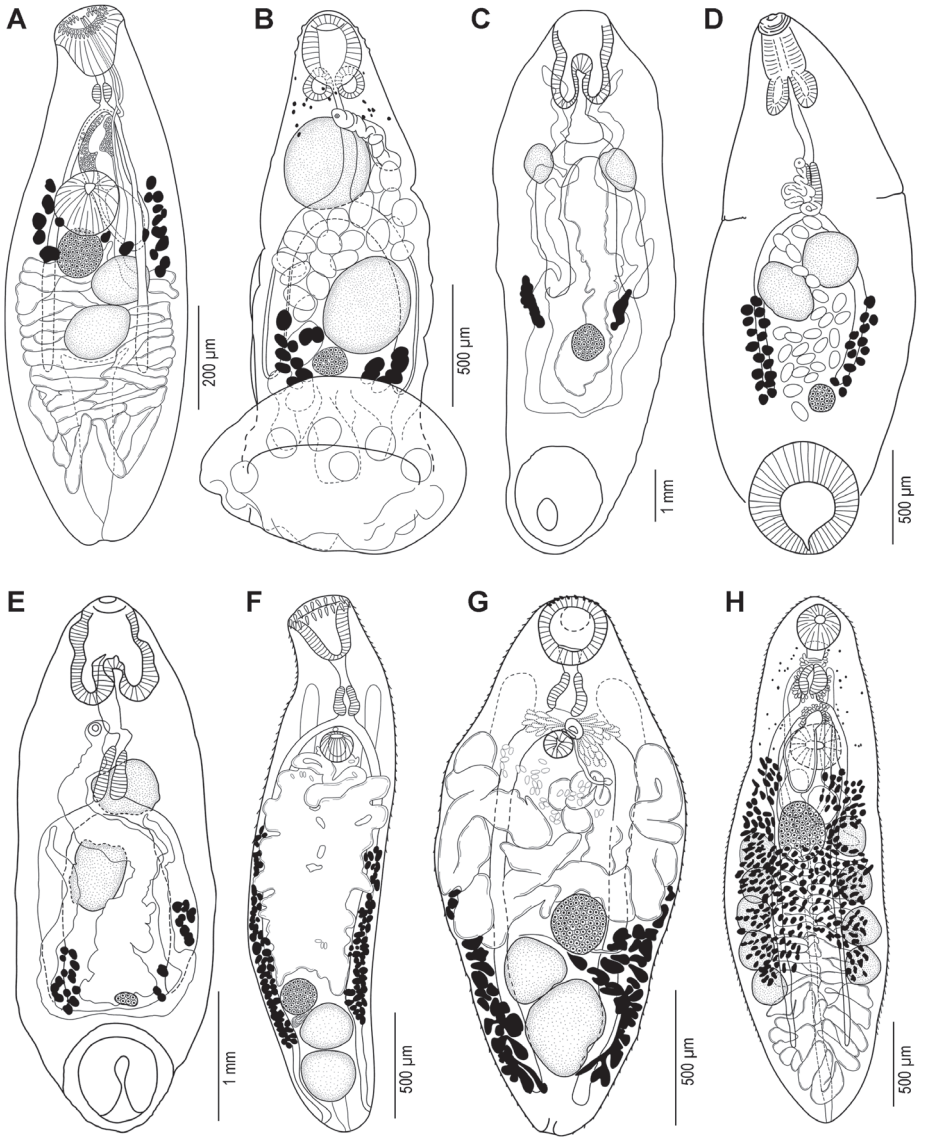

Fig. 4.5.3. Trematoda. **A.** *Masenia ghanensis* (Fischthal et Thomas, 1968) from *Heterobranchus longifilis*; **B.** *Basidiodiscus ectorchis* Fischthal et Kuntz, 1959 from *Synodontis schall*; **C.** *Brevicaecum niloticum* McClelland, 1957 from *Citharinus citharus*; **D.** *Panamphistomum benoiti* Manter et Pritchard, 1964 from *Pseudocrenilabrus philander*; **E.** *Sandonia sudanensis* McClelland, 1957 from *Distichodus nefasch* or *S. schall* (host not specified); **F.** *Acanthostomum absconditum* (Looss, 1901) from *Bagrus bajad*; **G.** *Brientrema malapteruri* Dollfus, 1950 from *Malapterurus electricus*; **H.** *Siphodera ghanensis* Fischthal et Thomas, 1968 from *Chrysichthys nigrodigitatus*. (Modified from McClelland 1957; Manter & Pritchard 1964; Fischthal & Thomas 1968a, b.; Moravec 1976; B and G – holotypes illustrated by T. Scholz).

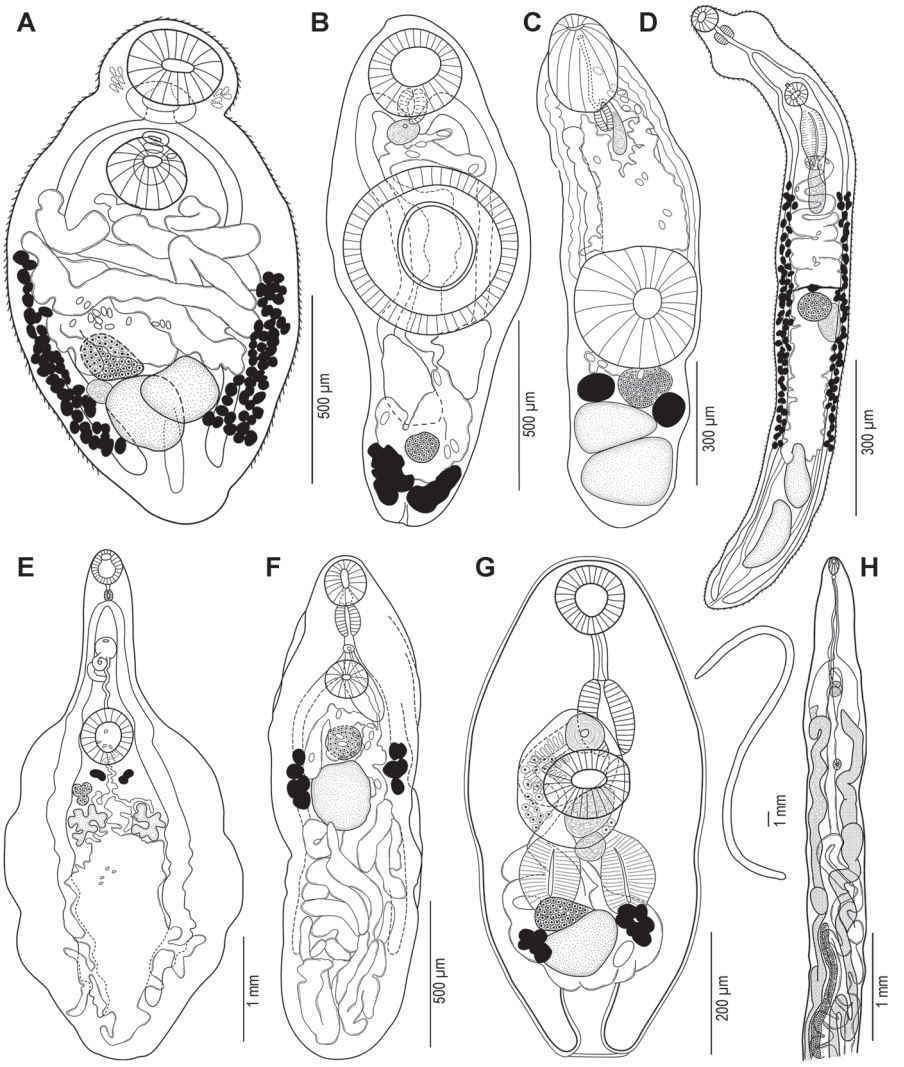

Fig. 4.5.4. Trematoda. **A.** *Neocladocystis congoensis* Manter et Pritchard, 1969 from *Parauchenoglanis monkei*; **B.** *Halipegus ctenopomi* Jones, 1982 from *Ctenopoma kingsleyae*; **C.** *Gonocerca phycidis* Manter, 1925 from *Urophycis chuss*; **D.** *Deropristis inflata* (Molin, 1859) from *Anguilla anguilla*; **E.** *Phyllodistomum bavuri* Boomker, 1984 from *Clarias gariepinus*; **F.** *Paralecithobotrys africanus* Manter et Pritchard, 1964 from *Pseudocrenilabrus philander*; **G.** *Saccocoelium obesum* Looss, 1902 from *Liza aurata*; **H.** *Nematobothrium labeonis* McClelland, 1955 from *Labeo coubie* or *L. horie* (host not specified). (Modified from Odhner 1902; Manter 1925; McClelland 1955; Boomker 1984; Blasco-Costa *et al.* 2009; A, B and F – holotypes illustrated by T. Scholz.)

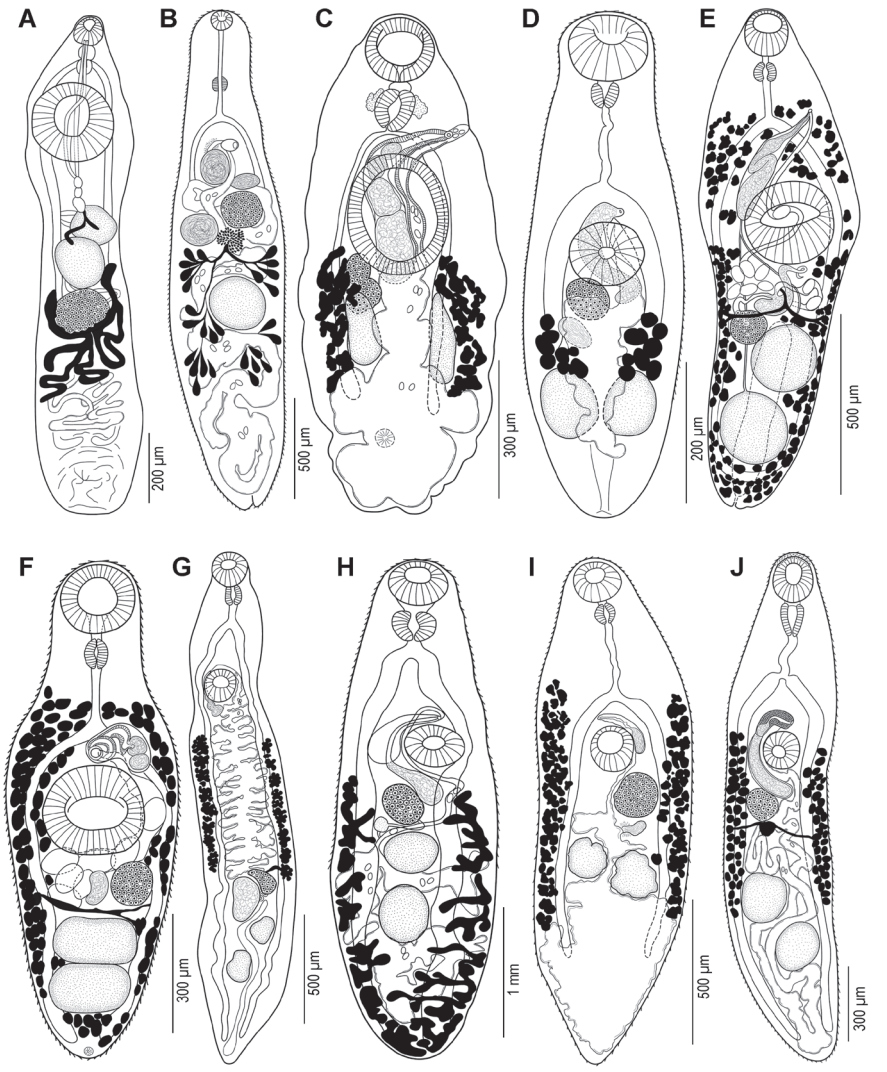

Fig. 4.5.5. Trematoda. **A.** *Ectenurus labeonis* (Fischthal et Kuntz, 1963) from *Labeo forskalii*; **B.** *Haplorchoides cahirinus* (Looss, 1896) from *Bagrus bajad*; **C.** *Heterorchis senegalensis* Vassiliadès et Richard, 1970 from *Protopterus annectens*; **D.** *Malawitrema staufferi* Bray et Hendrix, 2007 from *Clarias gariepinus*; **E.** *Nicolla gallica* (Dollfus, 1941) from *Cottus gobio*; **F.** *Plagioporus niloticus* Vercammen-Grandjean, 1960 from *Oreochromis niloticus*; **G.** *Thaparotrema botswanensis* Van Rensburg, Van As et King, 2013 from *C. gariepinus*; **H.** *Orientocreadium batrachoides* Tubangui, 1931 from *Clarias batrachus* or *Glossogobius giurus* (host not specified); **I.** *Astiotrema turneri* Bray, Van Oosterhout, Blais et Cable, 2006 from *Maylandia zebra*; **J.** *Glossidium lazerae* (Khalil, 1972) from *C. gariepinus*. (Modified from Looss 1899; Dollfus 1959; Vercammen-Grandjean 1960; Fischthal & Kuntz 1963; Vassiliadès & Richard 1970; Khalil 1972; Bray *et al.* 2006; Bray & Hendrix 2007; Jones & Bray 2008; Van Rensburg *et al.* 2013.)

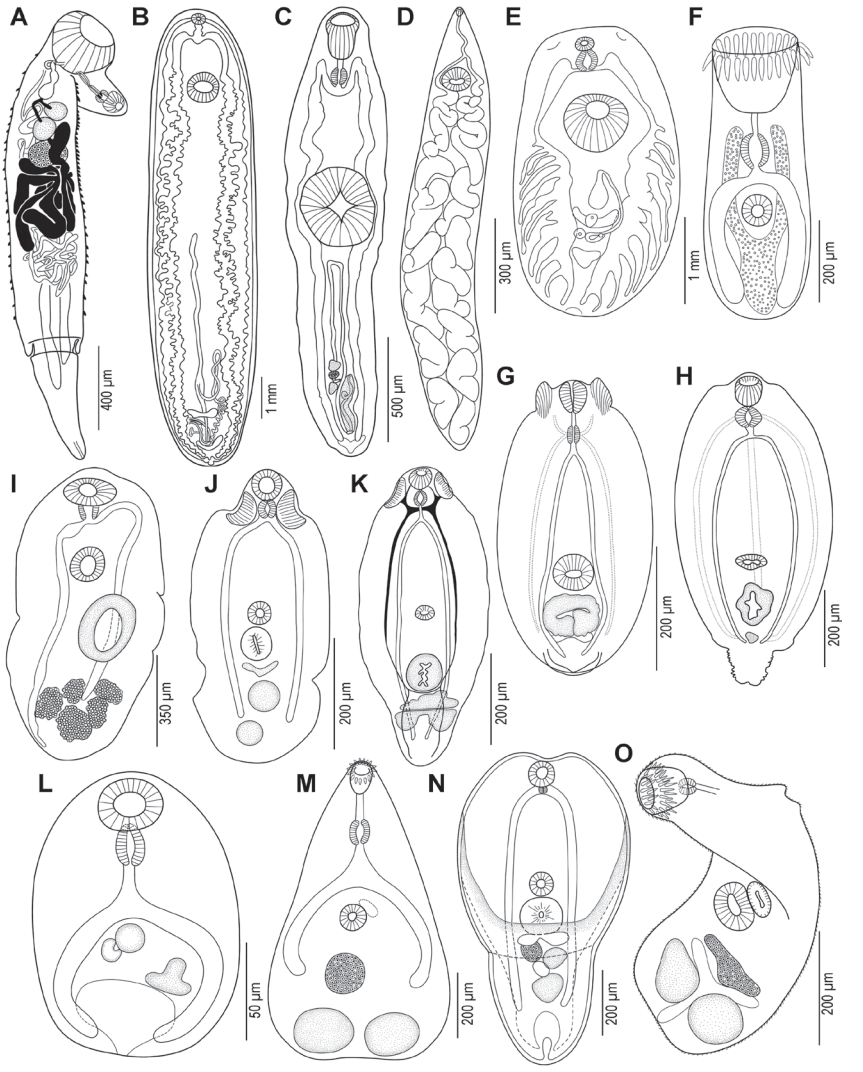

Fig. 4.5.6. Trematoda. **A.** *Dinurus gizae* Fischthal et Kuntz, 1963 from *Hydrocynus forskahlii*; **B.** *Clinostomoides brieni* Dollfus, 1950 from *Clarias gariepinus*; **C.** *Nephrocephalus bagriincapsulatus* (Wedl, 1861) from *Heterotis niloticus*; **D.** *Didymozoidae* gen. sp. from *H. forskahlii*; **E.** *Euclinostomum heterostomum* (Rudolphi, 1809) from *Coptodon zillii*; **F.** Cryptogonimidae gen. sp. (as Metacercariae alestesi Fain, 1953) from *Alestes baremoze* or *C. gariepinus* (host not specified); **G.** *Diplostomum montanum* Zhokhov, 2014 from a cyprinid fish (host not specified); **H.** *Neodiplostomum* sp. from *C. gariepinus*; **I.** *Ornithodiplostomum* sp. from *C. gariepinus*; **J.** *Posthodiplostomoides leonensis* (Williams, 1967) from *Epiplatys* spp.; **K.** *Tylodelphys mashonensis* Beverley-Burton, 1963 from *C. gariepinus*; **L.** *Heterophyes* sp. from *Bagrus bajad*; **M.** *Pygidiopsis genata* Looss, 1907 from non-specified host; **N.** *Posthodiplostomum nanum* Dubois, 1937 from *Epiplatys spilargyreius*; **O.** *Centrocestus cuspidatus* (Looss, 1896) from *Gambusia affinis*. (Modified from Fain 1953; Beverly-Burton 1963; Fischthal & Kuntz 1963; Williams 1967a, b; Fischthal & Thomas 1972; Moravec 1977; Barson & Avenant-Oldewage 2006; Van Rensburg *et al.* 2013; Zhokhov 2014.)

Systematic survey of flukes (Trematoda) in African freshwater fishes

Trematodes identified at least to the genus level are ordered according to their families, which are listed alphabetically, as are their fish hosts. Identification keys for trematode families and genera are provided in the Keys to the Trematoda (Gibson *et al.* 2002; Jones *et al.* 2005; Bray *et al.* 2008). Type species and type hosts are highlighted in bold. The African country where the type locality lies is given if known. Fish names follow FishBase (Froese & Pauly 2017).

List of adult flukes (Trematoda) from African freshwater fishes

Subclass **Aspidogastrea** Faust et Tang, 1936

ASPIDOGASTRIDAE Poche, 1907

Aspidogaster Baer, 1827

Aspidogaster africanus Saoud, Mohamed et Abdel-Hamid, 1974 from *Chrysichthys nigrodigitatus, Labeobarbus bynni* [Fig. 4.5.2A]

Aspidogaster limacoides Diesing, 1834 from *Barbus* sp.

Subclass **Digenea** Carus, 1863

ALLOCREADIIDAE Stossich, 1903

Allocreadium Looss, 1900

Allocreadium aswanensis El-Naffar, Saoud et Hassan, 1984 from ***Labeobarbus bynni*** (Egypt)

Allocreadium engraulicypridis Khalil et Thurston, 1973 from ***Rastrineobola argentea*** (Uganda)

Allocreadium ghanensis Fischthal et Thomas, 1972 from *Synodontis batensoda*, ***Synodontis* sp.** (Ghana)

Allocreadium indistinctum Baer, 1959 from ***Barbus* sp.** (Democratic Republic of the Congo)

Allocreadium mazoensis Beverly-Burton, 1962 from ***Clarias gariepinus*** (Zimbabwe), *Enteromius camptacanthus*, *E. paludinosus*, *E. trimaculatus*, *Haplochromis teegelaari*, *Labeobarbus marequensis* [Fig. 4.5.2B]

Allocreadium sudanensis Saoud, Abdel-Hamid et Ibrahim, 1974 from ***Labeobarbus bynni*** (Sudan)

Allocreadium voltanum Thomas, 1957 from ***Brycinus macrolepidotus*** (Black Volta River)

APOCREADIIDAE Skrjabin, 1942

Trematobrien Dollfus, 1950

Trematobrien haplochromios Dollfus, 1950 from ***Pseudocrenilabrus philander*** (Democratic Republic of the Congo) [Fig. 4.5.2C]

APOROCOTYLIDAE Odhner, 1912

Sanguinicola Plehn, 1905

Sanguinicola chalmersi Odhner, 1924 from ***Auchenoglanis occidentalis*** (Sudan), *Synodontis schall* [Fig. 4.5.2D]

Sanguinicola clarias Imam, Marzouk, Hassan et Itman, 1984 from ***Clarias gariepinus*** (Egypt)

CALLODISTOMIDAE Poche, 1926

Callodistomum Odhner, 1902

Callodistomum diaphanum Odhner, 1902 from *Ctenopoma kingsleyae*, ***Polypterus bichir*** (Sudan), *P. endlicheri* [Fig. 4.5.2E]

Cholepotes Odhner, 1910

Cholepotes ovofarctus (Odhner, 1902) from *Synodontis schall*, ***Synodontis* sp.** (Sudan) [Fig. 4.5.2F]

CEPHALOGONIMIDAE Looss, 1899

Emoleptalea Looss, 1900

Emoleptalea exilis (Looss, 1899) from ***Bagrus bajad*** (Egypt) [Fig. 4.5.2G]

Emoleptalea nwanedi King, Smit, Baker et Luus-Powell, 2018 from *Schilbe intermedius* (South Africa)

Emoleptalea rifaati (Ramadam, Saoud et Taha, 1987) from ***Synodontis schall***, ***S. serratus*** (type host not explicitly mentioned) (Egypt)

Emoleptalea synodontidos Dollfus, 1950 from ***Synodontis notatus*** (Democratic Republic of the Congo)

Emoleptalea sp. from *Nothobranchius furzeri*, *N. kadleci*

Masenia Chatterji, 1933

*Masenia bangweulensi*s (Beverly-Burton, 1962) from *Clarias gariepinus*, ***C. ngamensis*** (Zambia), *Heterobranchus isopterus*

Masenia ghanensis (Fischthal et Thomas, 1968) from *Clarias gariepinus*, *Heterobranchus isopterus*, ***H. longifilis*** (Ghana) [Fig. 4.5.3A]

Masenia proteropora (Thomas, 1958) from ***Clarias anguillaris*** (Ghana)

Masenia synodontis (Khalil et Thurston, 1973) from ***Synodontis victoriae*** (Uganda)

CLADORCHIIDAE Fischoeder, 1901

Basidiodiscus Fischthal et Kuntz, 1959

Basidiodiscus ectorchis Fischthal et Kuntz, 1959 from *Mormyrus kannume*, *Synodontis batensoda*, *S. clarias*, ***S. schall*** (Egypt) [Fig. 4.5.3B]

Brevicaecum McClelland, 1957

Brevicaecum niloticum McClelland, 1957 from ***Citharinus citharus*** (Sudan) [Fig. 4.5.3C]

Panamphistomum Manter et Pritchard, 1964

Panamphistomum benoiti Manter et Pritchard, 1964 from *Clarias gariepinus*, ***Pseudocrenilabrus philander*** (Democratic Republic of the Congo) [Fig. 4.5.3D]

Sandonia McClelland, 1957

Sandonia sudanensis McClelland, 1957 from *Bagrus docmak*, ***Distichodus nefasch***, *D. rostratus*, *Synodontis batensoda*, *S. budgetti*, *S. clarias*, *S. membranaceus*, *S. nigrita*, *S. ocellifer*, ***S. schall*** (type host not explicitly mentioned; Sudan), *S. sorex*, *S. vermiculatus*, *Synodontis* sp. [Fig. 4.5.3E]

CRYPTOGONIMIDAE Ward, 1917

Acanthostomum Looss, 1899

Acanthostomum absconditum (Looss, 1901) from ***Bagrus bajad***, *B. docmak* (Egypt) [Fig. 4.5.3F]

Acanthostomum gymnarchi (Dollfus, 1950) from ***Gymnarchus niloticus*** (Sudan)

Acanthostomum spiniceps (Looss, 1896) from ***Bagrus bajad*** (Egypt), *B. docmak*, *B. filamentosus*, *Chrysichthys nigrodigitatus*

Brientrema Dollfus, 1950

Brientrema malapteruri Dollfus, 1950 from *Distichodus lusosso*, ***Malapterurus electricus*** (Democratic Republic of the Congo) [Fig. 4.5.3G]

Neocladocystis Manter et Pritchard, 1969

Neocladocystis congoensis Manter et Pritchard, 1969 from ***Parauchenoglanis monkei*** (Cameroon) [Fig. 4.5.4A]

Neocladocystis tanganyikae (Prudhoe, 1951) from **unidentified cichlid** (Democratic Republic of the Congo)

Siphodera Linton, 1910

Siphodera ghanensis Fischthal et Thomas, 1968 from ***Chrysichthys nigrodigitatus*** (Ghana), *Hydrocynus brevis*, *Lutjanus goreensis* [Fig. 4.5.3H]

DEROGENIDAE Nicoll, 1910

Halipegus Looss, 1899

Halipegus ctenopomi Jones, 1982 from ***Ctenopoma kingsleyae*** (Senegal) [Fig. 4.5.4B]

DEROPRISTIDAE Cable et Hunninen, 1942

Deropristis Odhner, 1902

Deropristis inflata (Molin, 1859) from *Anguilla anguilla* [Fig. 4.5.4D]

DIDYMOZOIDAE Poche, 1907

Nematobothrium van Beneden, 1858

Nematobothrium labeonis McClelland, 1955 from ***Labeo coubie***, *L. forskalii*, ***L. horie*** [type host not explicitly mentioned], *L. niloticus* (Sudan) [Fig. 4.5.4H]

Nematobothrium sp. from *Labeo coubie*, *L. senegalensis*

GONOCERCIDAE Skrjabin et Guschanskaja, 1955

Gonocerca Manter, 1925

Gonocerca phycidis Manter, 1925 from *Clarias gariepinus* [Fig. 4.5.4C]

GORGODERIDAE Looss, 1899

Phyllodistomum Braun, 1899

Phyllodistomum bavuri Boomker, 1984 from ***Clarias gariepinus*** (South Africa) [Fig. 4.5.4E]

Phyllodistomum ghanense Thomas, 1958 from *Ctenopoma kingsleyae*, ***Mastacembelus nigromarginatus*** (Ghana)

Phyllodistomum linguale Odhner, 1902 from ***Gymnarchus niloticus*** (Egypt)

Phyllodistomum spatula (Odhner, 1902) from ***Bagrus bajad*** (Egypt), *B. docmak*

Phyllodistomum spatulaeforme (Odhner, 1902) from ***Malapterurus electricus*** (Egypt)

Phyllodistomum symmetrorchis Thomas, 1958 from ***Auchenoglanis occidentalis*** (Ghana), *Bagrus bajad*

Phyllodistomum cf. *symmetrorchis sensu* Cutmore, Miller, Curran, Bennett et Cribb, 2013 from *Clarias gariepinus*

Phyllodistomum tana Zhokhov, 2010 from ***Clarias gariepinus*** (Ethiopia)

Phyllodistomum vanderwaali Prudhoe et Hussey, 1977 from ***Clarias gariepinus*** (South Africa)

HAPLOPORIDAE Nicoll, 1914

Paralecithobotrys Freitas, 1948

Paralecithobotrys africanus Manter et Pritchard, 1964 from ***Pseudocrenilabrus philander*** (Democratic Republic of the Congo) [Fig. 4.5.4F]

Saccocoelium Looss, 1902

Saccocoelium obesum Looss, 1902 from *Chelon ramada*, *Mugil cephalus* [Fig. 4.5.4G]

HEMIURIDAE Looss, 1899*

Dinurus Looss, 1907

Dinurus gizae Fischthal et Kuntz, 1963 from ***Hydrocynus forskahlii*** (Egypt) [Fig. 4.5.6A]

Ectenurus Looss, 1907

Ectenurus labeonis (Fischthal et Kuntz, 1963) from ***Labeo forskalii*** (Egypt) [Fig. 4.5.5A]

*The marine genus *Lecithochirium* Lühe, 1901 is not included because reports of *L. magnicaudatum* Fischthal et Kuntz, 1963 from *Labeo forskalii* and *L. musculus* Looss, 1907 from *Heterotis niloticus* are doubtful and apparently represent accidental infections.

HETEROPHYIDAE Leiper, 1909

Haplorchoides Chen, 1949

Haplorchoides cahirinus (Looss, 1896) from ***Bagrus bajad*** (Egypt), *B. docmak*, *B. meridionalis*, *Clarias gariepinus* [Fig. 4.5.5B]

MACRODEROIDIDAE McMullen, 1937

Malawitrema Bray et Hendrix, 2007

Malawitrema staufferi Bray et Hendrix, 2007 from *Bagrus meridionalis*, ***Clarias gariepinus*** (Malawi) [Fig. 4.5.5D]

OPECOELIDAE Ozaki, 1925

Nicolla Wiśniewski, 1933

Nicolla gallica (Dollfus, 1941) from *Anguilla anguilla* [Fig. 4.5.5E]

Plagioporus Stafford, 1904

Plagioporus niloticus Vercammen-Grandjean, 1960 from *Anguilla anguilla*, ***Oreochromis niloticus*** (Democratic Republic of the Congo) [Fig. 4.5.5F]

OPISTHORCHIIDAE Looss, 1899

Thaparotrema Gupta, 1955

Thaparotrema botswanensis Van Rensburg, Van As et King, 2013 from ***Clarias gariepinus*** (Botswana) [Fig. 4.5.5G]

Thaparotrema piscicola (Odhner, 1902) from ***Gymnarchus niloticus*** (Sudan)

ORIENTOCREADIIDAE Yamaguti, 1958

Orientocreadium Tubangui, 1931

Orientocreadium batrachoides Tubangui, 1931 from *Clarias anguillaris*, *C. gariepinus*, *C. ngamensis* [Fig. 4.5.5H]

Orientocreadium indicum Pande, 1934 from *Clarias gariepinus*, *Heterobranchus longifilis*

Genera *incertae sedis* in the superfamily Plagiorchioidea (*sensu lato*)

Astiotrema Looss, 1899

Astiotrema impletum (Looss, 1899) from ***Tetraodon lineatus*** (Egypt)

Astiotrema lazeri El-Naffar, Saoud et Hassan, 1984 from ***Clarias gariepinus*** (Egypt)

Astiotrema reniferum (Looss, 1898) from *Bagrus docmak*, *Clarias gariepinus*

Astiotrema turneri Bray, Van Oosterhout, Blais et Cable, 2006 from *Labeotropheus trewavasae*, *Maylandia emmiltos*, ***M. zebra*** (Malawi), *Melanochromis vermivorus* [Fig. 4.5.5I]

Glossidium Looss, 1899

Glossidium lazerae (Khalil, 1972) from ***Clarias gariepinus*** (Sudan) [Fig. 4.5.5J]

Glossidium pedatum Looss, 1899 from ***Bagrus bajad***, ***B. docmak*** (type host not explicitly mentioned) (Egypt), *Clarias gariepinus*

Heterorchis Baylis, 1915

Heterorchis crumenifer Baylis, 1915 from ***Protopterus aethiopicus*** (Uganda), *P. annectens*, *Protopterus* sp.

Heterorchis protopteri Thomas, 1958 from ***Protopterus annectens*** (Ghana)

Heterorchis senegalensis Vassiliadès et Richard, 1970 from ***Protopterus annectens*** (Senegal) [Fig. 4.5.5C]

List of metacercariae of flukes (Trematoda) from African freshwater fishes

Note: Due to the simple morphology of larval stages, the existence of morphologically similar species and the lack of knowledge on trematode life cycles, reliable identification of larval stages to the species level is usually impossible based only on morphological characteristics. As a result, some morphology-based identification of metacercariae reported from freshwater fishes in Africa may be misidentifications. Molecular techniques have proven to be efficient for identification and elucidation of the life cycles of parasites and should be applied in future studies.

CLINOSTOMIDAE Lühe, 1901

Clinostomoides Dollfus, 1950

Clinostomoides brieni Dollfus, 1950 from *Clarias gariepinus* [Fig. 4.5.6B]

Clinostomum Leidy, 1856

Clinostomum chrysichthys Dubois, 1930 from *Chrysichthys auratus*

Clinostomum complanatum (Rudolphi, 1819) from *Chrysichthys nigrodigitatus*, *Coptodon zillii*, *Enteromius multilineatus*, *Oreochromis niloticus*, *Sarotherodon galilaeus*

Clinostomum macrosomum Jaiswal, 1957 from *Clarias gariepinus*, *Oreochromis niloticus*

Clinostomum tilapiae Ukoli, 1966 from *Chromidotilapia guntheri*, *Coptodon zillii*, *Cyprinus carpio*, *Hemichromis fasciatus*, *Oreochromis mossambicus*, *O. niloticus*, *Pelmatolapia mariae*, *Sarotherodon galilaeus*, *S. melanotheron*

Clinostomum vandehorsti Ortlepp, 1935 from *Marcusenius macrolepidotus*, *Schilbe mystus*

Clinostomum sp. from *Amphilius uranoscopus*, *Chiloglanis pretoriae*, *Citharinus citharus*, *Clarias gariepinus*, *Coptodon zillii*, *Ctenopoma kingsleyae*, *Epiplatys* sp., *Haplochromis obliquidens*, *Hemichromis fasciatus*, *Labeo coubie*, *Labeobarbus beso*, *Oreochromis leucostictus*, *O. mossambicus*, *O. niloticus*, *Oreochromis* sp., *Sarotherodon galilaeus*, *Schilbe intermedius*, *Synodontis eupterus*, *S. nigrita*, *S. schall*, *Tilapia* sp.

Euclinostomum Travassos, 1928

Euclinostomum ardeolae El-Naffar et Khalifa, 1981 from *Oreochromis niloticus*

Euclinostomum clarias (Dubois, 1930) from *Clarias angolensis*

Euclinostomum dollfusi Fischthal et Kuntz, 1963 from *Clarias gariepinus*

Euclinostomum heterostomum (Rudolphi, 1809) from *Chromidotilapia kingsleyae*, *Clarias gariepinus*, *Clarias* sp., *Coptodon zillii*, *Oreochromis mossambicus*, *Sarotherodon melanotheron*, *Tilapia* sp. [Fig. 4.5.6E]

Nephrocephalus Odhner, 1902

Nephrocephalus bagriincapsulatus (Wedl, 1861) from *Auchenoglanis occidentalis*, *Bagrus* sp., *Clarias anguillaris*, *Heterotis niloticus* [Fig. 4.5.6C]

CRYPTOGONIMIDAE Ward, 1917

Cryptogonimidae gen. sp. (as Metacercariae alestesi Fain, 1953) from *Alestes baremoze*, *Clarias gariepinus* [Fig. 4.5.6F]

CYATHOCOTYLIDAE Mühling, 1898

Prohemistomum Odhner, 1913

Prohemistomum vivax (Sonsino, 1892) from *Oreochromis niloticus*, *Schilbe mystus*

DIDYMOZOIDAE Poche, 1907

Didymozoidae gen. sp. from *Hydrocynus forskahlii* [Fig. 4.5.6D]

DIPLOSTOMIDAE Poirier, 1886

Diplostomum von Nordmann, 1832

Diplostomum garrae Zhokhov, 2014 from ***Garra dembecha*** (Ethiopia)

Diplostomum heterobranchi (Wedl, 1861) from *Clarias gariepinus*

Diplostomum longicollis Zhokhov, 2014 from ***Enteromius humilis***, ***Garra dembecha*** (type host not specified) (Ethiopia)

Diplostomum magnicaudum El-Naffar, 1979 from *Oreochromis niloticus*

Diplostomum montanum Zhokhov, 2014 from ***Enteromius humilis***, ***Garra dembecha***, ***Labeobarbus beso***, ***L. gorgorensis*** (type host not specified) (Ethiopia) [Fig. 4.5.6G]

Diplostomum tilapiae Zhokhov, 2014 from ***Oreochromis niloticus*** (Ethiopia)

Diplostomum sp. from *Clarias gariepinus*, *Enteromius humilis*, *Garra dembecha, Oreochromis mossambicus*, *Synodontis nigrita*

Dolichorchis Dubois, 1961

Dolichorchis tregenna (Nazmi Gohar, 1932) from *Clarias gariepinus*

Neodiplostomum Railliet, 1919

Neodiplostomum sp. from *Clarias gariepinus* [Fig. 4.5.6H]

Ornithodiplostomum Dubois, 1936

Ornithodiplostomum sp. from *Clarias gariepinus* [Fig. 4.5.6I]

Posthodiplostomoides Williams, 1969

Posthodiplostomoides leonensis (Williams, 1967) from *Epiplatys sexfasciatus*, *E. spilargyreius* [Fig. 4.5.6J]

Posthodiplostomum Dubois, 1936

Posthodiplostomum nanum Dubois, 1937 from *Coptodon zillii*, *Enteromius humilis*, *Epiplatys sexfasciatus*, *E. spilargyreius*, *Garra dembecha*, *Hemichromis fasciatus*, *Heterobranchus longifilis* [Fig. 4.5.6N]

Tylodelphys Diesing, 1850

Tylodelphys grandis Zhokhov, Morozova et Tessema, 2010 from ***Clarias gariepinus*** (Ethiopia)

Tylodelphys mashonensis Beverley-Burton (1963) from *Clarias gariepinus*, *C. ngamensis* [Fig. 4.5.6K]

Tylodelphys sp. from *Clarias gariepinus*, *Coptodon zillii*, *Cyprinus carpio*, *Micropterus salmoides*, *Oreochromis leucostictus*

Diplostomidae gen. sp. from *Clarias gariepinus*, *Pseudocrenilabrus philander*, *Tilapia sparrmanii*

ECHINOCHASMIDAE Odhner, 1910

Echinochasmus Dietz, 1909

Echinochasmus liliputans (Looss, 1896) from *Oreochromis niloticus*

HETEROPHYIDAE Leiper, 1909

Centrocestus Looss, 1899

Centrocestus cuspidatus (Looss, 1896) from *Gambusia affinis* [Fig. 4.5.6O]

Haplorchis Looss, 1899

Haplorchis sp. from *Oreochromis niloticus*

Heterophyes Cobbold, 1866

Heterophyes aequalis Looss, 1902 from *Oreochromis niloticus*

Heterophyes heterophyes (von Siebold, 1852) from *Oreochromis niloticus*

Heterophyes sp. from *Bagrus bajad* [Fig. 4.5.6L]

Pygidiopsis Looss, 1907

Pygidiopsis genata Looss, 1907 from *Oreochromis niloticus*, *Synodontis batensoda* [Fig. 4.5.6M]

Stellantchasmus Onji et Nishio, 1915

Stellantchasmus pseudocirratus (Witenberg, 1929) from *Oreochromis niloticus*

Stictodora Looss, 1899

Stictodora sawakinensis Looss, 1899 from *Oreochromis niloticus*

PROTERODIPLOSTOMIDAE Dubois, 1936

Pseudoneodiplostomum Dubois, 1936

Pseudoneodiplostomum thomasi (Dollfus, 1935) from *Clarias anguillaris*

STRIGEIDAE Railliet, 1919

Apatemon Szidat, 1928

Apatemon barbusi Zhokhov, Miretskaya, Pugacheva et Tessema, 2008 from *Enteromius humilis*, *E. pleurogramma*, ***E. tanapelagius*** (Ethiopia), *Labeobarbus acutirostris*, *L. dainellii*, *L. gorguari*, *L. intermedius*, *L. nedgia*, *L. beso*

Apatemon tilapiae Zhokhov, Miretskaya, Pugacheva et Tessema, 2008 from ***Oreochromis niloticus*** (Ethiopia)

Apatemon sp. from *Nothobranchius furzeri*

Ichthyocotylurus Odening, 1969

Ichthyocotylurus sp. from *Garra dembecha*

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Chapter 4.6.
CESTODA

Tomáš SCHOLZ & Roman KUCHTA

Tapeworms (Cestoda) – basic characteristics, life cycles, classification and principal diagnostic features

- parasitic flatworms (Platyhelminthes: Neodermata)
- about 5,000 species classified in 19 orders
- obligate endoparasites usually of the digestive system of all groups of vertebrates
- body (strobila) dorsoventrally flattened, usually composed of proglottids ("segments")
- attachment organs (bothria, bothridia, suckers) on the anterior end called scolex (may be absent)
- digestive tract (intestine) absent
- body surface with hair-like structures called microtriches (absorption of nutrients and attachment)
- all African species hermaphroditic, with well-developed vitellarium (vitelline follicles)
- indirect life cycles (1-2 intermediate hosts: copepods, amphipods, oligochaetes, fishes) [Fig. 4.6.1]
- causative agents of human fish-borne diseases (*e.g.*, broad fish tapeworm) – not in Africa

The classification of cestodes is based on well-defined orders (19 in total at present – Caira & Jensen 2017). They are characterised mainly by the morphology of the scolex (the number and type of attachment organs such as paired bothria and bothridia or four muscular suckers – see Figs 4.6.2B, 4.6.5A) and the morphology of the reproductive organs such as the structure of vitelline follicles (diffuse in the cortex, in lateral bands or compact), position of gonads (in the cortex or medulla), egg morphology, structure of the uterus, etc. (*e.g.*, Fig. 4.6.5B; see Khalil *et al.* 1994 for keys to the orders, families and genera of cestodes, and Caira & Jensen 2017 for updated information on all cestodes).

Generic classification and species identification is based on the size and shape of the scolex and its attachment organs such as suckers and apical organs (it may be muscular, *i.e.*, resembling suckers, or glandular, *i.e.*, comprising gland cells), on proglottid morphology, especially the size, position and shape of gonads (*e.g.*, shape, relative position and size of the terminal genitalia, number of testes, extent of vitelline follicles, shape of the uterus and the number of its lateral diverticula, etc.), size and shape of the eggs, morphology of excretory canals, and many other characteristics.

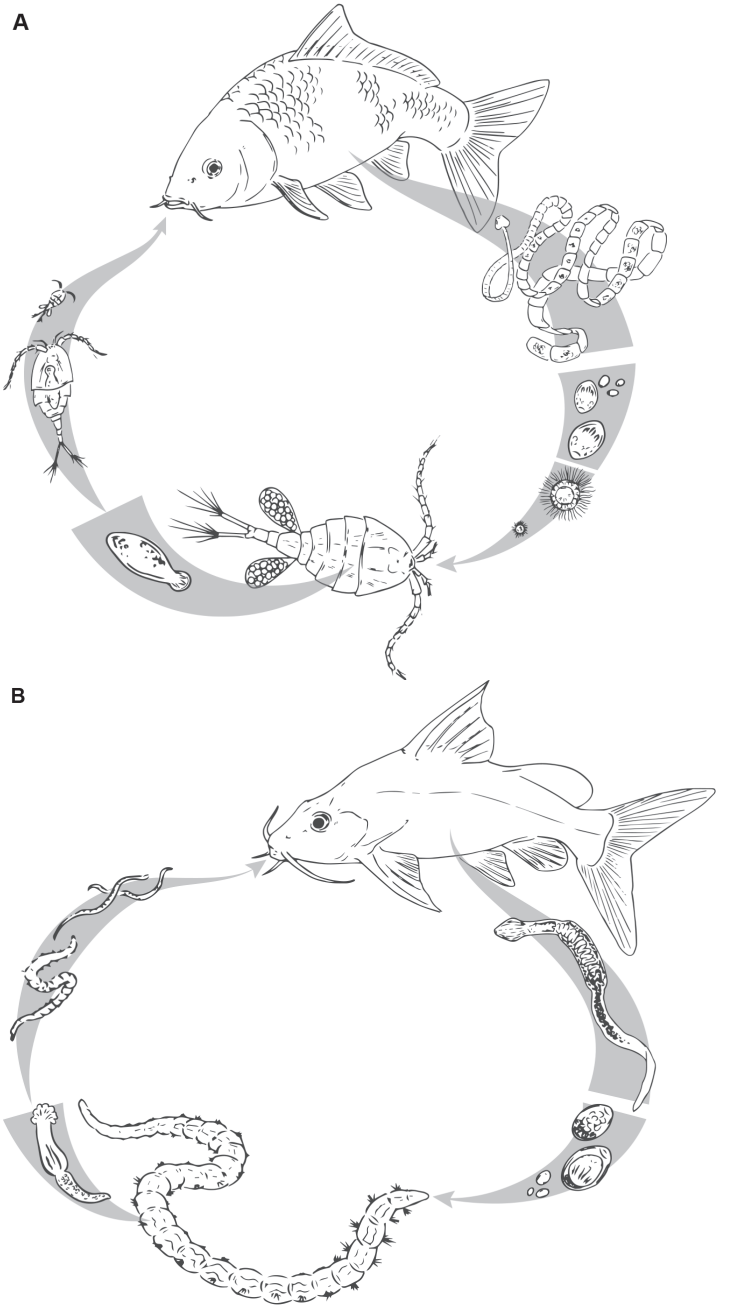

Fig. 4.6.1. Life cycles of cestodes. **A.** *Schyzocotyle acheilognathi* (Yamaguti, 1934); copepods serve as intermediate hosts; **B.** *Wenyonia virilis* Woodland, 1923; naidids serve as intermediate hosts. (Illustrations by M. Luo.)

Key to the orders of tapeworms (Cestoda)

Adults which contain fully developed genital organs and eggs if gravid occur almost exclusively in the intestinal lumen, only *Tetracampos ciliotheca* is also reported to occur in the gall bladder. Larvae called metacestodes, which include plerocercoids and plerocerci, are parenteral, *i.e.*, outside the intestinal lumen except for some tiny larvae of the Gryporhynchidae. Metacestodes do not have fully developed genital organs including eggs and they occur in the mesenteries, intestinal wall, gall bladder and liver.

1 (2) Strobila monozoic (with one genital complex per strobila) [Fig. 4.6.2A]……3

2 (1) Strobila polyzoic (proglottised with several genital complexes per strobila) [Fig. 4.6.2B] ……7

3 (4) Strobila without scolex or attachment organ; adults in body cavity [Fig. 4.6.2A]……...**Amphilinidea**

4 (3) Strobila with scolex [Fig. 4.6.3A]…….. 5

5 (6) Scolex unarmed, without suckers [Fig. 4.6.3E]; adults in intestine …….**Caryophyllidea**

6 (5) Scolex armed with hooks [Fig. 4.6.6A]; larvae in internal organs ……..**Cyclophyllidea** (Gryporhynchidae)

7 (8) Scolex with two bothria or attachment grooves [Fig. 4.6.2E]……9

8 (7) Scolex with four suckers [Fig. 4.6.4A]; adults in intestine……**Onchoproteocephalidea** (formerly Proteocephalidea)

9 (10) Large worms with weakly developed scolex [Fig. 4.6.5D]; larvae free in body cavity……..**Diphyllobothriidea**

10 (9) Scolex with two bothria, armed with hooks or not [Fig. 4.6.2D]; adults in intestine……**Bothriocephalidea**

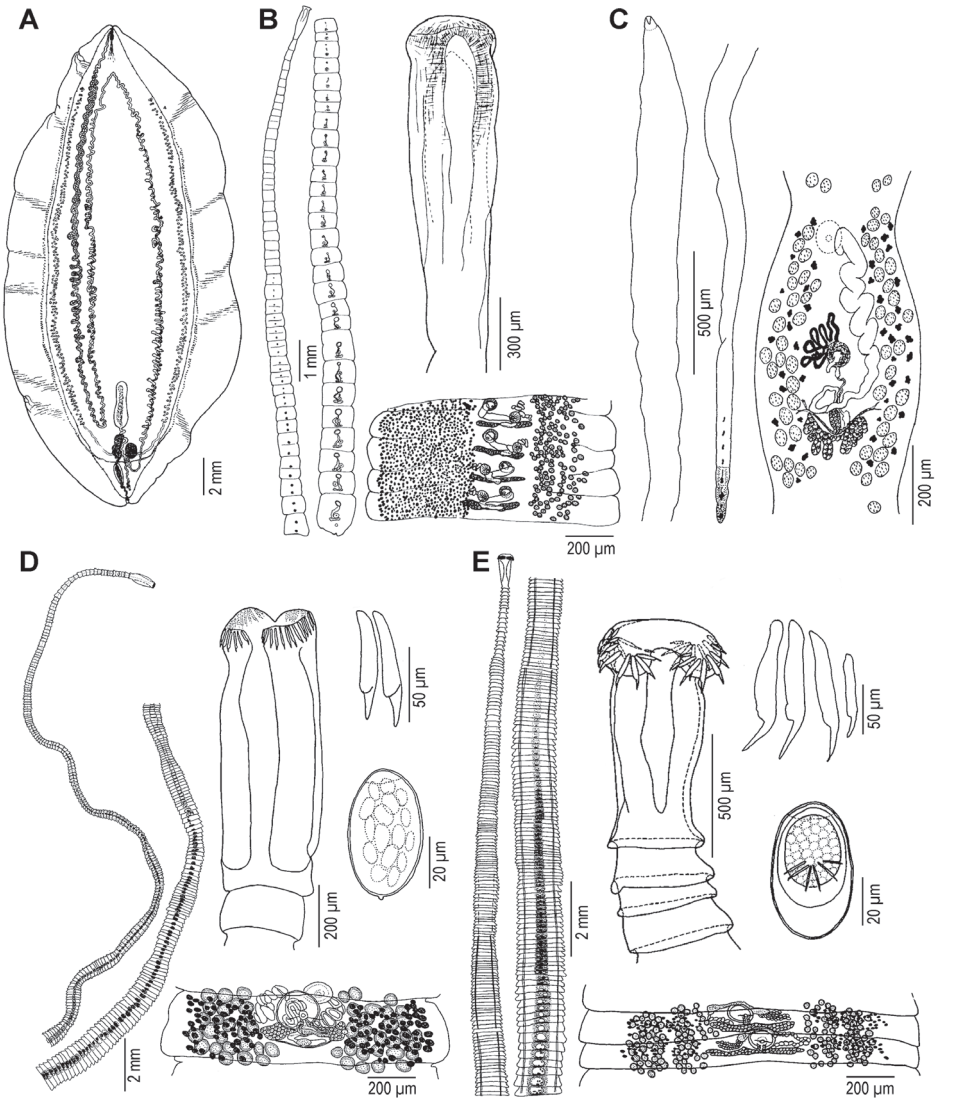

Fig. 4.6.2. Cestoda (Amphilinidea and Bothriocephalidea). **A.** *Nesolecithus africanus* Dönges et Harder, 1966 from *Gymnarchus niloticus*; **B.** *Bothriocephalus claviceps* (Goeze, 1782) from *Anguilla anguilla*; **C.** *Ichthybothrium ichthybori* Khalil, 1971 from *Ichthyborus besse*; **D.** *Kirstenella gordoni* (Woodland, 1937) from *Heterobranchus bidorsalis*; **E.** *Polyonchobothrium polypteri* (Leydig, 1853) from *Polypterus bichir*. (Modified from Dubinina 1982 and Kuchta *et al.* 2012.)

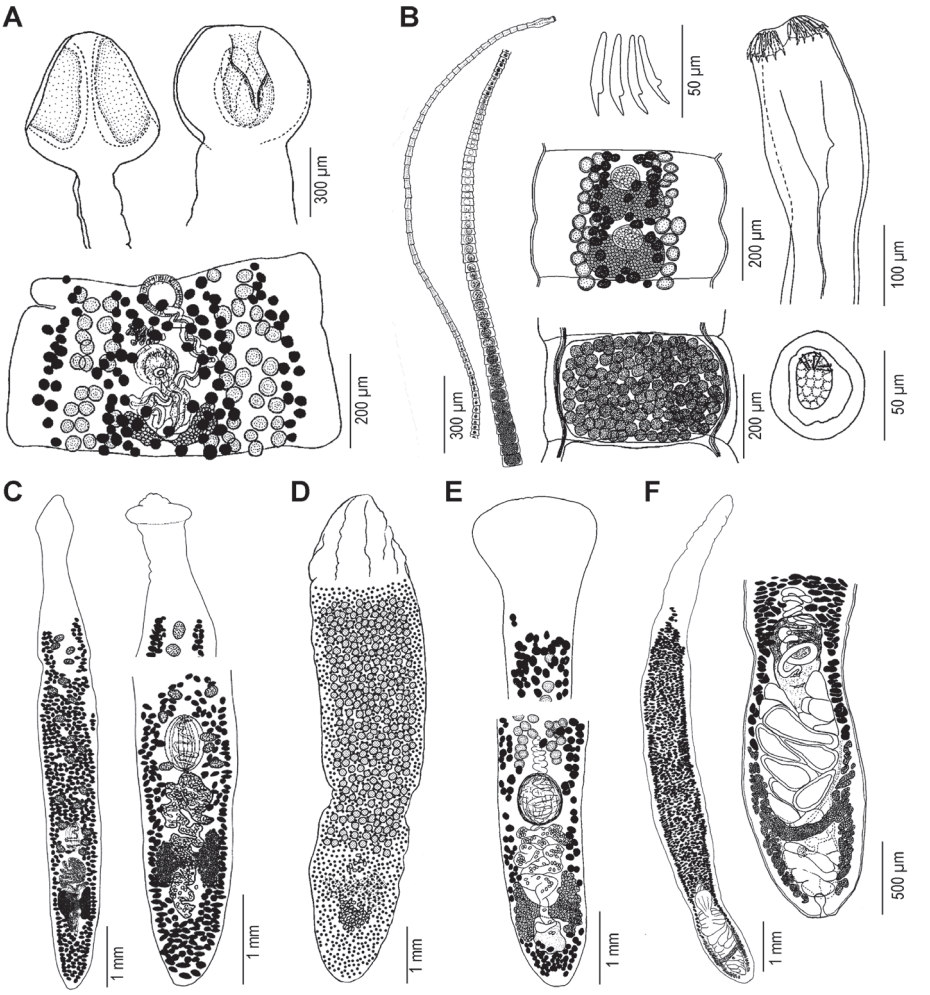

Fig. 4.6.3. Cestoda (Bothriocephalidea and Caryophyllidea). **A.** *Schyzocotyle acheilognathi* (Yamaguti, 1934) from *Cyprinus carpio*; **B.** *Tetracampos ciliotheca* Wedl, 1861 from *Clarias anguillaris*; **C.** *Atractolytocestus huronensis* Anthony, 1958 from *C. carpio*; **D.** *Lytocestoides tanganyikae* Baylis, 1928 from a cichlid; **E.** *Khawia armeniaca* (Cholodkovsky, 1915) from *Arabibarbus grypus*; **F.** *Lytocestus marcuseni* Troncy, 1978 from *Hippopotamyrus harringtoni*. (Modified from Woodland 1937; Troncy 1978; Scholz *et al.* 2011a; Kuchta *et al.* 2012.)

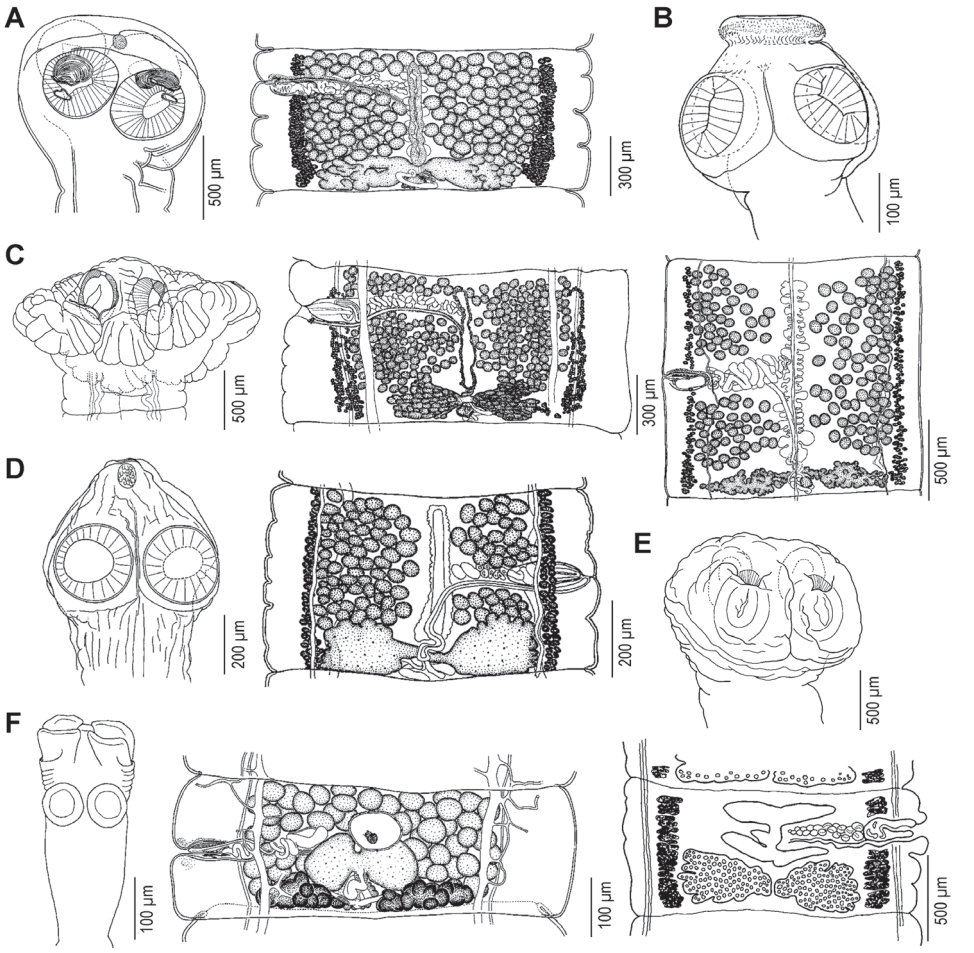

Fig. 4.6.4. Cestoda (Onchoproteocephalidea). **A.** *Barsonella lafoni* de Chambrier, Scholz, Beletew et Mariaux, 2009 from *Clarias gariepinus*; **B.** *Electrotaenia malopteruri* (Fritsch, 1886) from *Malapterurus electricus*; **C.** *Corallobothrium solidum* Fritsch, 1886 from *M. electricus*; **D.** *Proteocephalus synodontis* Woodland, 1925 from *Synodontis schall*; **E.** *Marsypocephalus tanganyikae* (Fuhrmann et Baer, 1925) from *C. gariepinus*; **F.** *Sandonella sandoni* (Lynsdale, 1960) from *Heterotus niloticus*. (Modified from Fuhrmann and Baer 1925; de Chambrier *et al.* 2004, 2008, 2009, 2011; Scholz *et al.* 2011b.)

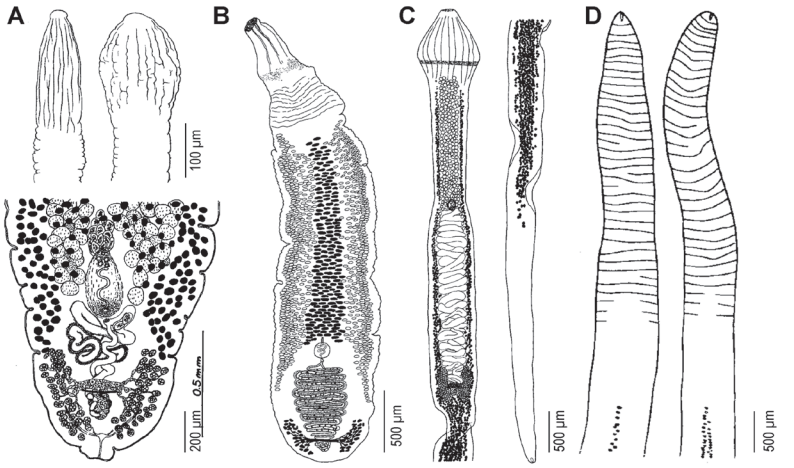

Fig. 4.6.5. Cestoda (Caryophyllidea and Diphyllobothriidea). **A.** *Monobothrioides cunningtoni* Fuhrmann et Baer, 1925 from *Auchenoglanis occidentalis* (scoleces) and *M. woodlandi* Mackiewicz et Beverley-Burton, 1967 from *Clarias ngamensis*; **B.** *Stocksia pujehuni* Woodland, 1937 from *Clarias gariepinus*; **C.** *Wenyonia virilis* Woodland, 1923 from *Synodontis schall*; **D.** *Ligula intestinalis* (Linnaeus, 1758) (plerocercoids) from *Cyprinus carpio*. (Modified from Woodland 1937; Mackiewicz & Beverley-Burton 1967; Dubinina 1980; Schaeffner *et al.* 2011.)

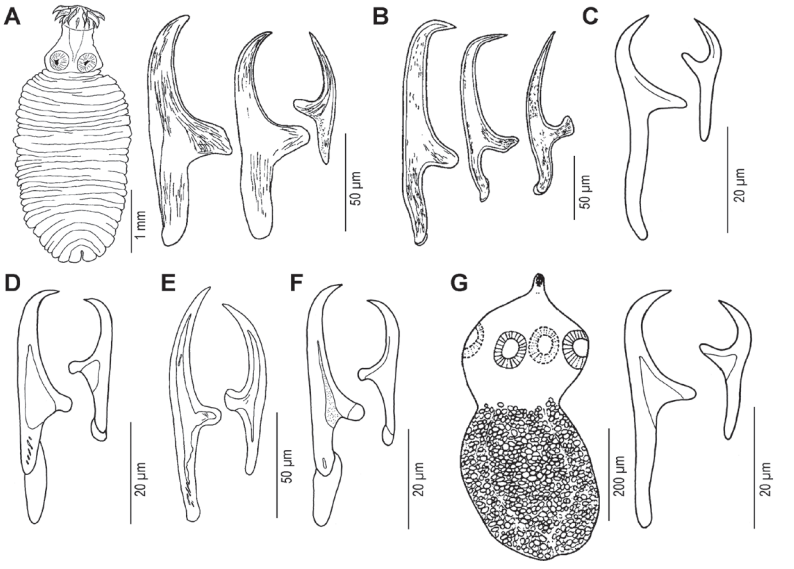

Fig. 4.6.6. Cestoda (Gryporhynchidae – larvae). **A.** *Amirthalingamia macracantha* (Joyeux et Baer, 1935) from *Coptodon zillii*; **B.** *Cyclustera magna* (Baer, 1959) from *C. zillii*; **C.** *Dendrouterina herodiae* Fuhrmann, 1912 from *Schilbe intermedius*; **D.** *Neogryporhynchus lasiopeius* Baer et Bona, 1960 from *Pseudocrenilabrus philander*; **E.** *Paradilepis scolecina* Hsü, 1935 from *P. philander*; **F.** *Parvitaenia samfyia* Mettrick, 1967 from *Tilapia sp.* **G.** *Valipora campylancristrota* (Wedl, 1855) from *Tinca tinca* (total view) and *V. minuta* (Coil, 1950) from *P. philander.* (Modified from Bray 1974; Scholz 1989; Scholz *et al.* 2004, 2018.)

Species are listed alphabetically according to individual cestode orders. Keys to individual cestode orders, their families and genera were provided by Khalil *et al.* (1994). Kuchta *et al.* (2008) split the order Pseudophyllidea Van Beneden in Carus, 1863 into the Bothriocephalidea and Diphyllobothriidea; members of both orders parasitise teleost fishes, but those of the latter order only as larvae (plerocercoids). The type species of each genus and the type host of each species are highlighted in bold. The country where the type locality occurs is given if known. Host names are according to Froese & Pauly (2017).

AMPHILINIDEA Poche, 1922

List of the Amphilinidea (adults) from African freshwater fishes

Nesolecithus Poche, 1922

Nesolecithus africanus Dönges et Harder, 1966 from ***Gymnarchus niloticus*** (Nigeria) [Fig. 4.6.2A]

BOTHRIOCEPHALIDEA Kuchta, Scholz, Brabec et Bray, 2008

Key to the genera of the Bothriocephalidea (adults) from African freshwater fishes (for keys to the species – see Kuchta *et al.* 2012)

1 (2) Apical part of scolex unarmed (without hooks) [Figs 4.6.2B, C; 4.6.3A]……3

2 (1) Apical part of scolex armed (with hooks) [Figs 4.6.2D, E; 4.6.3B]……7

3 (4) Proglottids well demarcated from each other; scolex with well-developed bothria……4

4 (3) Proglottids without obvious demarcation; scolex with weakly developed bothria [Fig. 4.6.2C]……..***Ichthybothrium***

5 (6) Scolex heart-shaped, with deep, sucker-like bothria [Fig. 4.6.3A]…… ……***Schyzocotyle***

6 (5) Scolex elongate to lanceolate, with shallow bothria [Fig. 4.6.2B]…… ……..***Bothriocephalus***

7 (8) Scolex small (< 650 µm); vitelline follicles medullary; testes few (5-20); eggs with transparent, hyaline outer envelope [Fig. 4.6.3B]…… ……***Tetracampos***

8 (7) Scolex large (> 700 µm); vitelline follicles cortical, numerous; testes numerous (> 30, usually more than 100); eggs with hard shell capsule……9

9 (10) Apical disc prominent, wider than scolex, armed with < 36 large, massive hooks, up to 190 µm long; cirrus-sac small, its width representing 5-10% of proglottid width [Fig. 4.6.2E]……..***Polyonchobothrium***

10 (9) Apical disc weakly developed, as wide as scolex or narrower, armed with > 40 hooks shorter than 90 µm; cirrus-sac large, its width representing 16-39% of proglottid width [Fig. 4.6.2D]……..***Kirstenella***

List of the Bothriocephalidea (adults) from African freshwater fishes

Bothriocephalus Rudolphi, 1808

Bothriocephalus claviceps (Goeze, 1782) from ***Anguilla anguilla*** [Fig. 4.6.2B]

Bothriocephalus sp. from *Tilapia* sp.

Ichthybothrium Khalil, 1971

Ichthybothrium ichthybori Khalil, 1971 from ***Ichthyborus besse*** (Sudan), *I. quadrilineatus* [Fig. 4.6.2C]

Ichthybothrium sp. from *Mesoborus crocodilus* [Fig. 4.1F]

Kirstenella Kuchta in Kuchta *et al.* 2012

Kirstenella gordoni (Woodland, 1937) [syn. *Bothriocephalus prudhoei* Tadros, 1966] from ***Heterobranchus bidorsalis*** (Sierra Leone); accidental hosts: *Clarias anguillaris*, *Schilbe mystus* [Fig. 4.6.2D]

Polyonchobothrium Diesing, 1854

Polyonchobothrium polypteri (Leydig, 1853) [syns *Tetrabothrium polypteri* Leydig, 1853; *Onchobothrium septicolle* Diesing, 1854; *Polyonchobothrium septicolle* Diesing 1863; *Anchistrocephalus polypteri* Monticelli, 1900; *Rhynchobothrium polypteri* Klaptocz, 1906; *Polyonchobothrium pseudopolypteri* Meggitt, 1930] from ***Polypterus bichir*** (Egypt), *P. endlicheri*, *P. senegalus* [Fig. 4.6.2E]

Schyzocotyle Akhmerov, 1960

Schyzocotyle acheilognathi (Yamaguti, 1934) [syns *Bothriocephalus acheilognathi* Yamaguti, 1934; *Bothriocephalus* (*Clestobothrium*) *kivuensis* Baer et Fain, 1958; *Bothriocephalus aegyptiacus* Ryšavý et Moravec, 1975; *Bothriocephalus barbus* Fahmy, Mandour et El-Naffar, 1978] from *Carasobarbus fritchii*, *Cyprinus carpio*, *Enteromius annectens*, *E. argenteus*, *E. bifrenatus*, *E. brevipinnis*, *E. mattozi*, *E. paludinosus*, *E. trimaculatus*, *Hydrocynus vittatus*, *Labeobarbus aeneus*, *L. altianalis*, *Labeobarbus bynni*, *L. kimberleyensis*, *L. marequensis*, *L. nedgia*, *Luciobarbus callensis*, *Ptychochromis* cf. *inornatus* [Fig. 4.6.3A]. Records from *Clarias gariepinus*, *Clarotes laticeps*, *Oreochromis mossambicus* and *O. niloticus* need verification.

Tetracampos Wedl, 1861

Tetracampos ciliotheca Wedl, 1861 [syns *Clestobothrium clarias* Woodland, 1925; *Polyonchobothrium cylindraceum* forma *major* Janicki, 1926; *P. cylindraceum* forma *minor* Janicki, 1926; *Polyonchobothrium fulgidum* Meggitt, 1930; *Polyonchobothrium clarias* (Woodland, 1925) Meggitt, 1930; *Polyonchobothrium ciliotheca* (Wedl, 1861) Dollfus, 1934; *Polyoncobothrium ciliotheca* (Wedl, 1861) Yamaguti, 1959; *Polyoncobothrium clarias* (Woodland, 1925) Yamaguti, 1959] from ***Clarias anguillaris*** (Egypt), *C. gariepinus*, *C. liocephalus*, *C. werneri* [Fig. 4.6.3B]

CARYOPHYLLIDEA van Beneden in Carus, 1863

Key to the genera of the Caryophyllidea (adults) from African freshwater fishes

1 (2) Postovarian vitelline follicles present [Figs 4.6.3C-F, 4.6.5C]……3

2 (1) Postovarian vitelline follicles absent [Fig. 4.6.5A, B]……7

3 (4) Body with tail-like posterior part; genital pores in anterior half of the body; in mochokid catfishes (*Synodontis*) [Fig. 4.6.5C]……..***Wenyonia***

4 (3) Body without tail-like posterior part; genital pores near the posterior end of the body……5

5 (6) Vitelline follicles present alongside lateral ovarian lobes; in carp (introduced) [Fig. 4.6.3C]……***Atractolytocestus***

6 (5) Vitelline follicles absent alongside lateral ovarian lobes; in barbels [Fig. 4.6.3E]……..***Khawia***

7 (8) Vitelline follicles absent medially; in *Clarias* [Fig. 4.6.5B]……***Stocksia***

8 (7) Vitelline follicles present also medially (on ventral and dorsal side of cortex) ……9

9 (10) Body small (maximum length 11 mm), tapering slightly from conical scolex with longitudinal wrinkles; vitelline follicles extensive, filling most of cortex throughout body; in cichlids [Fig. 4.6.3D]……***Lytocestoides***

10 (9) Body larger, of different shapes; vitelline follicles less extensive……11

11 (12) Scolex with longitudinal wrinkles; in *Auchenoglanis* and *Clarias* [Fig. 4.6.5A]……***Monobothrioides***

12 (12) Scolex elongate, simple, without longitudinal wrinkles; in Alestidae, Mormyridae and *Clarias* [Fig. 4.6.3F]……...***Lytocestus***

List of the Caryophyllidea (adults) from African freshwater fishes

Atractolytocestus Anthony, 1958

Atractolytocestus huronensis Anthony, 1958 from ***Cyprinus carpio*** [introduced with common carp] [Fig. 4.6.3C]

Khawia Hsü, 1935

Khawia armeniaca (Cholodkovsky, 1915) from *Labeobarbus bynni*, *L. callensis*, *L. tropidolepis*, *L. setivimensis* [reported as *Caryophyllaeus laticeps* (Pallas, 1781)] [Fig. 4.6.3E]

Khawia sp. from *Labeobarbus bynni*

Lytocestus Cohn, 1908

Lytocestus filiformis (Woodland, 1923) from ***Mormyrus caschive*** (Sudan), *Mormyrus* sp.

Lytocestus marcuseni Troncy, 1978 [syn. *L. alestesi* Lynsdale, 1956] from *Brycinus nurse*, ***Hippopotamyrus harringtoni*** (Chad) [Fig. 4.6.3F]

Lytocestus puylaerti Khalil, 1973 from ***Clarias buettikoferi*** (Sierra Leone)

Lytocestus sp. from *Auchenoglanis occidentalis*

Lytocestoides Baylis, 1928

Lytocestoides tanganyikae Baylis, 1928 from a **cichlid** (Tanzania) [Fig. 4.6.3D]

Lytocestoides sp. from *Parectodus* sp.

Monobothrioides Fuhrmann et Baer, 1925

Monobothrioides chalmersius (Woodland, 1924) from ***Clarias anguillaris*** (Sudan)

Monobothrioides cunningtoni Fuhrmann et Baer, 1925 from ***Auchenoglanis occidentalis*** (Zambia) [Fig. 4.6.5A]

Monobothrioides tchadensis Troncy, 1978 from ***Auchenoglanis biscutatus*** (Chad)

Monobothrioides woodlandi Mackiewicz et Beverley-Burton, 1967 from ***Clarias ngamensis*** (Zambia) [Fig. 4.6.5A]

Monobothrioides sp. from *Parauchenoglanis ballayi*, *Synodontis schall*

Stocksia Woodland, 1937

Stocksia pujehuni Woodland, 1937 from ***Clarias gariepinus*** (Sierra Leone) [Fig. 4.6.5B]

Wenyonia Woodland, 1923 (see Schaeffner *et al.* 2011 for a key to species)

Wenyonia acuminata Woodland, 1923 from *Synodontis acanthomias*, ***S. membranaceus*** (Sudan)

Wenyonia longicauda Woodland, 1937 from **Synodontis gambiensis** (now considered to be a synonym of *S. schall*) (Sierra Leone)

Wenyonia minuta Woodland, 1923 [syn. *Wenyonia mcconnelli* Ukoli, 1972] from *Synodontis caudovittatus*, *S. frontosus*, *S. nigrita*, *S. schall*, *S. serratus*; ***Chrysichthys auratus*** (Sudan) is incidental host

Wenyonia synodontis Ukoli, 1972 from *Synodontis schall*, ***S. sorex*** (Nigeria), *S. vermiculatus*

Wenyonia virilis Woodland, 1923 [syns *Caryophyllaeus niloticus* Kulmatycki, 1928; *Wenyonia kainjii* Ukoli, 1972] from *Synodontis batensoda*, *S. budgetti*, *S. caudovittatus*, *S. clarias*, *S. eupterus*, *S. frontosus*, *S.* cf. *geledensis*, *S. nigrita*, *S. ocellifer*, ***S. schall*** (Sudan), *S. serratus*, *S. sorex* [Fig. 4.6.5C]

Wenyonia youdeoweii Ukoli, 1972 from *Synodontis caudovittatus*, ***S. gobroni*** (Nigeria), *S. schall*, *S. serratus*

Wenyonia sp. from *Synodontis batensoda*

Key to the genera of the Onchoproteocephalidea (only family Proteocephalidae; adults) from African freshwater fishes

1 (2) Vitellarium formed by numerous follicles arranged in paired lateral bands; scolex without a highly modified apical structure with retractile lappets……3

2 (1) Vitellarium formed by two compact, but deeply lobulated, postovarian masses near the posterior margin of proglottids; scolex with a highly modified apical structure formed by four muscular retractile lappets [Fig. 4.6.4F] ……***Sandonella***

3 (4) Scolex umbrella-shaped, with widely pyramidal apex and well-developed metascolex, which forms folded collar surrounding suckers; external margins of suckers with semispherical sphincter; body surface with deep longitudinal and transverse grooves (wrinkles) forming rectangular network; in electric catfish (*Malapterurus*) [Fig. 4.6.4C]……***Corallobothrium***

4 (3) Scolex of different shapes, metascolex absent; sphincter on suckers and longitudinal and transverse grooves on the strobila usually absent……5

5 (6) Scolex with apical rostellum armed with tiny hooks; in electric catfish (*Malapterurus*) [Fig. 4.6.4B]……...***Electrotaenia***

6 (5) Scolex without rostellum, without any hooks; in other fishes……7

7 (8) Tapeworms very large, robust (total length up to 173 mm; maximum width 1.8 mm); scolex round, suckers with muscular sphincter; in clariid catfishes ……..9

8 (7) Tapeworms smaller; scolex often conical; suckers without sphincters [Fig. 4.6.4D]……..***Proteocephalus***

9 (10) Scolex with additional posterior orifices and muscular sphincters; testes medullary [Fig. 4.6.4A]…….***Barsonella***

10 (9) Suckers without additional posterior orifices and muscular sphincters; testes in dorsal cortex [Fig. 4.6.4E]……..***Marsypocephalus***

List of the Onchoproteocephalidea (Proteocephalidae; adults) from African freshwater fishes

Barsonella de Chambrier, Scholz, Beletew et Mariaux, 2009

Barsonella lafoni de Chambrier, Scholz, Beletew et Mariaux, 2009 from ***Clarias gariepinus*** (Ethiopia) [Fig. 4.6.4A]

Corallobothrium Fritsch, 1886

Corallobothrium solidum Fritsch, 1886 from ***Malapterurus electricus*** (Egypt) [Fig. 4.6.4C]

Electrotaenia Nybelin, 1942

Electrotaenia malopteruri (Fritsch, 1886) from ***Malapterurus electricus*** (Egypt) [Fig. 4.6.4B]

Marsypocephalus Wedl, 1861

Marsypocephalus aegyptiacus El-Naffar, Saoud et Hassan, 1984 from ***Clarias gariepinus*** (Egypt)

Marsypocephalus daveyi Woodland, 1937 from ***Heterobranchus bidorsalis*** (Sierra Leone)

Marsypocephalus heterobranchus Woodland, 1925 from ***Heterobranchus bidorsalis*** (Sudan)

Marsypocephalus rectangulus Wedl, 1861 from *Clarias anguillaris*, ***C. gariepinus*** (Egypt), *Heterobranchus bidorsalis*

Marsypocephalus tanganyikae (Fuhrmann et Baer, 1925) from ***Clarias gariepinus*** (Zambia) [Fig. 4.6.4E]

Marsypocephalus sp. from *Heterobranchus bidorsalis*

Proteocephalus Weinland, 1858

Proteocephalus beauchampi Fuhrmann et Baer, 1925 from *Chrysichthys brachynema*, ***Chrysichthys* sp.** (Democratic Republic of the Congo); a record from *Synodontis schall* is doubtful

Proteocephalus bivitellatus Woodland, 1923 from a **carnivorous cichlid** (Sierra Leone)

Proteocephalus cunningtoni Fuhrmann et Baer, 1925 from ***Dinotopterus cunningtoni*** (Zambia)

Proteocephalus dinotopteri Fuhrmann et Baer, 1925 from ***Dinotopterus cunningtoni*** (Zambia)

Proteocephalus glanduligerus Janicki, 1928 from ***Clarias anguillaris*** (Egypt), *C. gariepinus*

Proteocephalus membranacei Troncy, 1978 [syn. *Proteocephalus largoproglottis* Troncy, 1978] from ***Synodontis membranaceus*** (Chad)

Proteocephalus pentastomus (Klaptocz, 1906) from ***Polypterus bichir*** (Sudan), *P. endlicheri*, *P. senegalus*

Proteocephalus sulcatus (Klaptocz, 1906) from ***Clarotes laticeps*** (Sudan); accidental hosts: *Chrysichthys* sp., *Clarias anguillaris*, *C. gariepinus*, *Clarotes laticeps*, *Polypterus endlicheri*

Proteocephalus synodontis Woodland, 1925 from *Auchenoglanis* cf. *occidentalis*, *Synodontis batensoda*, *S. caudovittatus*, *S. eupterus*, *S. frontosus*, *S. nigrita*, ***S. schall*** (Sudan), *S. serratus* [Fig. 4.6.4D]

Proteocephalus sp. from *Ichthyborus besse*

Sandonella Khalil, 1960

Sandonella sandoni (Lynsdale, 1960) from ***Heterotis niloticus*** (Sudan) [Fig. 5.6.4F]

CYCLOPHYLLIDEA van Beneden in Braun, 1900 – family Gryporhynchidae Spassky et Spasskaya, 1973

Key to the larvae (metacestodes) of the family Gryporhynchidae (Cyclophyllidea) from African freshwater fishes

1 (2) Hooks of three shapes (4 + 6 + 10 in number), massive, very large (> 200 µm long)……3

2 (1) Hooks of two different shapes (10 + 10 in number), more delicate, smaller ……...5

3 (4) Hooks > 390 µm (larger) and > 240 µm (smaller) long [Fig. 4.6.6A]…… ……..***Amirthalingamia***

4 (3) Hooks < 200 µm (larger) and < 150 µm (smaller) long [Fig. 4.6.6B] ……***Cyclustera***

5 (6) Large hooks > 90 µm long, massive, with slightly curved blade [Fig. 4.6.6E] ……***Paradilepis***

6 (5) Large hooks < 50 µm long, delicate, with abruptly curved blade……7

7 (8) Hooks tiny, large hooks < 31 µm long; in gall bladder [Fig. 4.6.6G]…… ……..***Valipora***

8 (7) Hooks larger, large hooks > 45 µm long; larvae in other sites of infection……9

9 (10) Blade of larger hooks slightly longer, straighter [Fig. 4.6.6F]…… ……***Parvitaenia***

10 (9) Blade of larger hooks slightly shorter, more curved; hooks 48-50 µm long ……11

11 (12) Hooks more robust, with blade tip of larger hooks directed more anteriorly [Fig. 4.6.6D]……...***Neogryporhynchus***

12 (11) Hooks more slender, with blade tip of larger hooks more curved [Fig. 4.6.5C] ……..***Dendrouterina***

List of the larvae (metacestodes) of the family Gryporhynchidae (Cyclophyllidea) from African freshwater fishes (see Scholz et al. 2018 for a review of African gryporhynchid larvae)

Amirthalingamia Bray, 1974

Amirthalingamia macracantha (Joyeux et Baer, 1935) from *Coptodon zillii*, *Oreochromis niloticus*, *Pharyngochromis acuticeps*, *Pseudocrenilabrus philander*, *Tilapia sparrmanii* [Fig. 4.6.6A]

Anomotaenia Cohn, 1900

Anomotaenia sp. from *Hemichromis fasciatus*, *Oreochromis niloticus*; identification needs verification because the genus belongs to the family Dilepididae and no vouchers were deposited by Aderounmu & Adeniyi (1972).

Cyclustera Fuhrmann, 1901

Cyclustera magna (Baer, 1959) from *Coptodon zillii*, *Labeo horie*, *Oreochromis niloticus*, *Sarotherodon galilaeus* [Fig. 4.6.6B]

Cyclustera sp. from *Cyprinus carpio* – see Scholz *et al.* (2008)

Dendrouterina Fuhrmann, 1912

Dendrouterina herodiae Fuhrmann, 1912 from *Schilbe intermedius* [Fig. 4.6.6C]

Neogryporhynchus Baer et Bona, 1960

Neogryporhynchus lasiopeius Baer et Bona, 1960 from *Bathybathes graueri*, *Chetia flaviventris*, *Coptodon rendalli*, *Cyprinus carpio*, *Heterotis niloticus*, *Oreochromis mossambicus*, *O. niloticus*, *Pseudocrenilabrus philander*, *Tilapia sparrmannii* [Fig. 4.6.6D]

Paradilepis Hsü, 1935

Paradilepis delachauxi (Fuhrmann, 1909) from *Chetia flaviventris*, *Coptodon rendalli*, *Labeobarbus marequensis*, *Oreochromis macrochir*, *Pharyngochromis acuticeps*, *Pseudocrenilabrus philander*

Paradilepis maleki Khalil, 1961 from *Benthochromis horii*, *Pseudocrenilabrus philander*

Paradilepis scolecina Hsü, 1935 from *Coptodon rendalli*, *Enteromius paludinosus*, *E. trimaculatus*, *E. unitaeniatus*, *Labeobarbus kimberleyensis*, *Oreochromis mossambicus*, *Pseudocrenilabrus philander* [Fig. 4.6.6E]

Paradilepis sp. from *Chetia flaviventris*, *Coptodon rendalli*, *Oreochromis mossambicus*, *Pharyngochromis acuticeps*, *Pseudocrenilabrus philander*

Parvitaenia Burt, 1940

Parvitaenia macropeos (Wedl, 1855) from *Coptodon rendalli*, *Hemichromis letourneuxi*, *Oreochromis mossambicus*, *O. niloticus*

Parvitaenia samfyia Metrick, 1967 from *Pseudocrenilabrus philander*, *Tilapia* sp. [Fig. 4.6.6F]

Parvitaenia sp. 1 from *Enteromius treurensis*, *E. trimaculatus*

Parvitaenia sp. 2 from '*Barbus*' sp., *Enteromius macrops*, *E. trimaculatus*

Parvitaenia sp. 3 from *Pseudocrenilabrus philander*

Valipora Linton, 1927

Valipora campylancristrota (Wedl, 1855) from *Enteromius paludinosus*, *Pseudocrenilabrus philander* [Fig. 4.6.5G]

Valipora minuta (Coil, 1950) from *Chetia flaviventris*, *Ophthalmotilapia nasuta*, *Pseudocrenilabrus philander*, *Ptychochromis grandidieri* [Fig. 4.6.5G]

DIPHYLLOBOTHRIIDEA Kuchta, Scholz, Brabec et Bray, 2008

List of the Diphyllobothriidea (larvae) from African freshwater fishes

Ligula Bloch, 1782

Ligula intestinalis (Linnaeus, 1758) (plerocercoids) from *Chagunius nicholsi*, *Enteromius kamolondoensis*, *E. lineomaculatus*, *E. lukusiensis*, *E. paludinosus*, *E. radiatus*, *E. unitaeniatus*, *Haplochromis* sp., *Labeobarbus marequensis*, *L. microbarbis*, *Labeo lukulae*, *Rastrineobola argentea* [Fig. 4.6.5D]

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Chapter 4.7.
ACANTHOCEPHALA

Bernd SURES, Yuriy KVACH & Roman KUCHTA

Thorny-headed worms (Acanthocephala) – basic characteristics, life cycles, classification and principal diagnostic features

- parasitic 'worms' (Syndermata: Rotifera)
- about 1,300 species classified in 4 classes (Archiacanthocephala, Eoacanthocephala, Palaeacanthocephala and Polyacanthocephala) and 10 orders (Amin 2013; Warner 2014), from which 19 species occur in Africa
- heteroxenous parasites, with adults in the intestine of vertebrates (definitive hosts) and larvae (cystacanths) in haemocoel of arthropods (intermediate hosts); paratenic hosts (vertebrates) occur occasionally
- behavioural changes of intermediate hosts induced by acanthocephalan larvae (cystacanths) increase their vulnerability to predation and thus foster transmission rates to the definitive host (Sures 2014)
- body divided into a trunk (metasoma) and anterior tip with proboscis armed with hooks (prosoma)

Most of the inner organs of acanthocephalans are located within the trunk. Acanthocephalans are dioecious. The ovaries (ovarian balls) of female worms float in the body cavity. Following fertilisation of mature eggs the ovary degenerates and the body cavity is filled with developing eggs. As soon as eggs contain fully developed first stage larvae (acanthors) they are released by the female through an apparatus called the uterine bell.

In addition to the testes, male worms have one to eight cement glands whose secretions enable a male to plug the vagina of a female after fertilisation. Acanthocephalans lack an intestinal tract and take up all nutrients through their body wall. In addition to nutrients, acanthocephalans take up and accumulate toxic substances such as metals, which makes them excellent indicators of environmental pollution (Sures *et al.* 2017).

Higher-level classification (families, orders and classes – see Amin 2013) is based on the amount of cement glands, the shape of the eggs, presence/absence of subtegumental giant nuclei and spines on the trunk, size and number of proboscis hooks, structure of the excretory system, etc.

At the genus and species-level, the key morphological structure for identification is the proboscis (shape and size of the proboscis, the number of files of proboscis hooks, the number of hooks in individual files, size, shape and type of proboscis hooks, etc.). Other morphological characteristics used for identification include

the size and structure of the egg containing the fully developed acanthor, the position of the cephalic ganglion, the morphology of the reproductive system, *e.g.*, the shape and supination of the penis (male copulatory organ) and the vulva (in females), the number of giant hypodermal nuclei, the length of lemnisci, the size of males and females, etc.

Fig. 4.7.1. Life cycle of acanthocephalans. *Acanthocephalus lucii* (Müller, 1776); isopods serve as intermediate hosts. (Illustration by M. Luo.)

Key to the classes and orders of acanthocephalans in African fishes

1 (2) Lemnisci, cement gland and hypodermal nuclei fragmented; ligament sacs in females single, not persistent; proboscis receptacle double walled. Parasites of fishes, amphibians, reptiles, birds, and mammals (class **Palaeacanthocephala**)……..5

2 (1) Lemnisci, cement gland and/or hypodermal nuclei not fragmented, usually giant; ligament sacs in females double, persistent; proboscis receptacle single-walled, complex or absent……3

3 (4) Trunk spined; proboscis claviform with numerous longitudinal rows of hooks; cement glands separate, elongate pyriform to tubular; eggs with acanthor oval with radial sculpturings at right angles to surface. Parasites of fishes and Crocodilia (class **Polyacanthocephala**) [Fig. 4.7.2D] ……order **Polyacanthorhynchida**

4 (3) Trunk may be spined; proboscis usually small with few radially arranged hooks; cement gland single, syncytial, additional distinct cement reservoir; eggs with acanthor variably shaped but not like above. Parasites of fishes and occasionally amphibians and reptiles (class **Eoacanthocephala**)…..7

5 (6) Parasites of fishes and amphibians [Figs 4.7.2A–C]…… ……..order **Echinorhynchida**

6 (5) Trunk spinose. Parasites of reptiles (rare), birds and mammals; larvae in fish……order **Polymorphida** [Fig. 4.7.2E]

7 (8) Trunk entirely or only anteriorly spined. Parasites of freshwater and marine fishes [Fig. 4.7.3A,C]…….order **Gyracanthocephala**

8 (9) Trunk unarmed [Fig. 4.7.3B,D,E]……..order **Neoechinorhynchida**

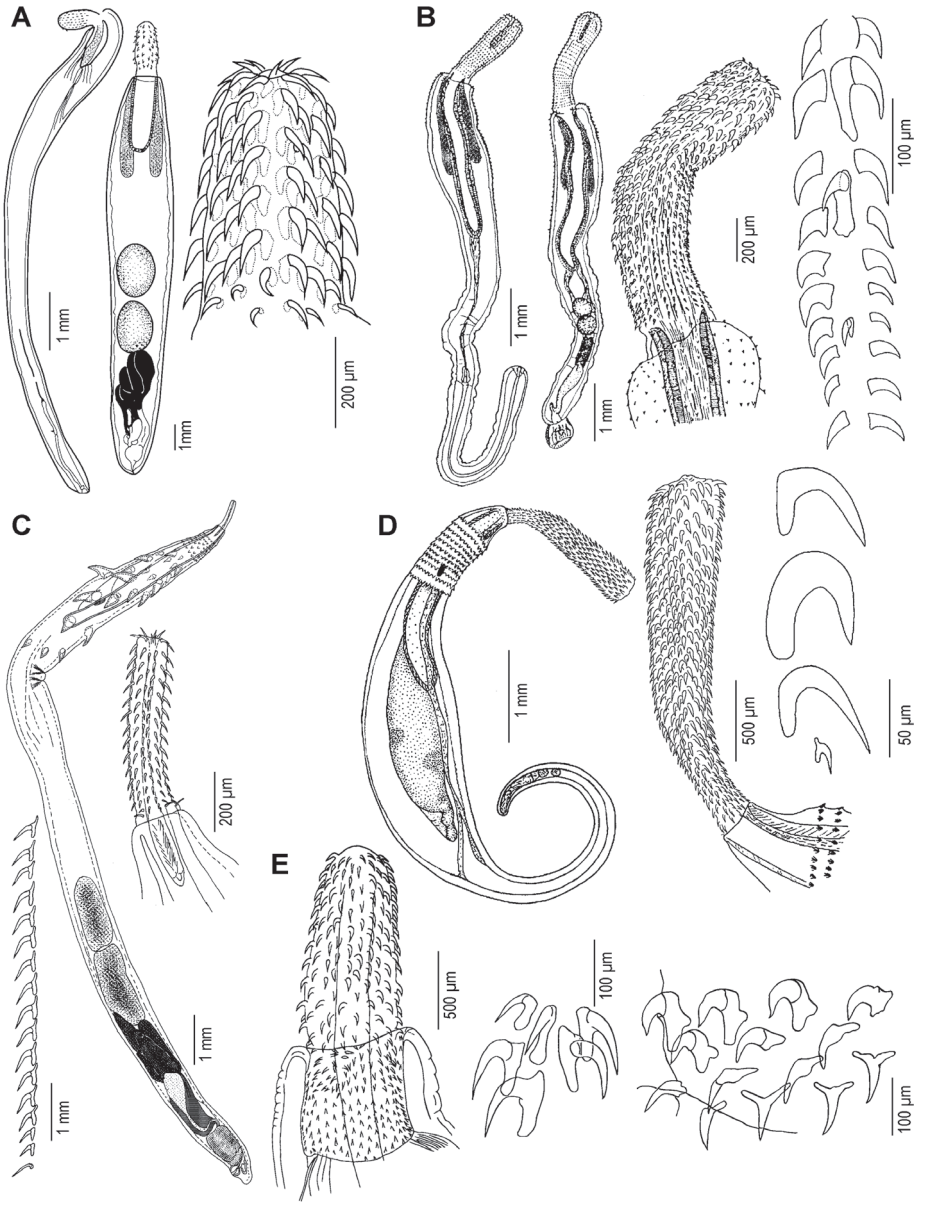

Fig. 4.7.2. Acanthocephala. **A.** *Acanthocephalus lucii* (Müller, 1776) from *Barbus* sp; **B.** *Paragorgorhynchus albertianus* Golvan, 1957 from *Alestes dentex*; **C.** *Megistacantha horridum* (Lühe, 1912) from *Hyperopisus bebe*; **D.** *Polyacanthorhynchus kenyensis* Schmidt et Canaris, 1967 from *Tilapia* sp.; **E.** *Arhythmorhynchus siluricola* Dollfus, 1929 from *Gephyroglanis* sp. (Modified from Dollfus 1929; Petrochenko 1956; Yamaguti 1963; Schmidt & Canaris 1967; Kvach *et al.* 2016.)

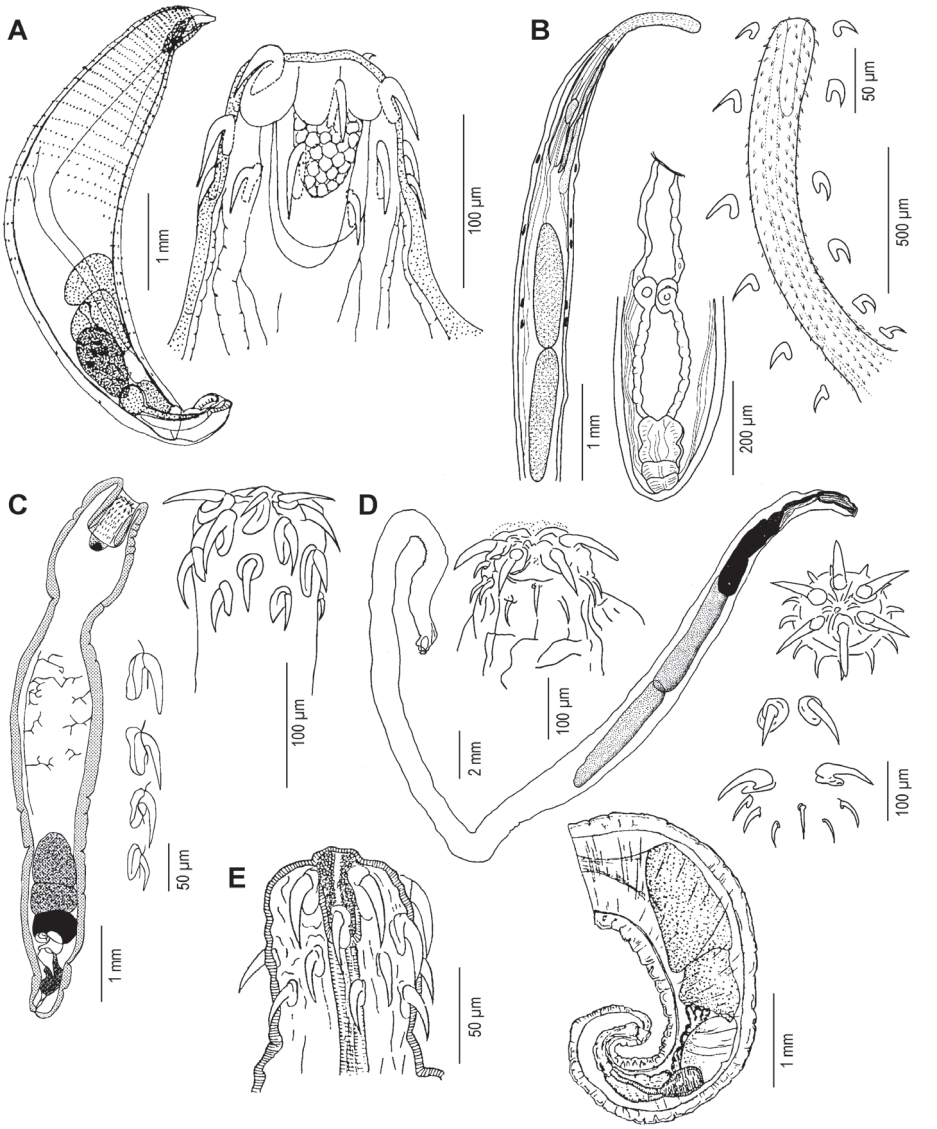

Fig. 4.7.3. Acanthocephala. **A.** *Acanthogyrus malawiensis* Amin et Hendrix, 1999 from *Labeo cylindricus*; **B.** *Tenuisentis niloticus* (Meyer, 1932) from *Heterotis niloticus*; **C.** *Pararaosentis golvani* (Troncy et Vassiliadès, 1973) from *Synodontis batensoda*; **D.** *Neoechinorhynchus africanus* Troncy, 1970 from *Citharinops distichodoides*; **E.** *Hexaspiron nigericum* Dollfus and Golvan, 1956 from *Synodontis membranaceus*. (Modified from Meyer 1932; Dollfus & Golvan 1956; Yamaguti 1963; Troncy 1970; Troncy & Vassiliadès 1973; Amin & Hendrix 1999.)

List of adult spiny-headed worms (Acanthocephala) from African freshwater fishes

Species are listed alphabetically according to individual families; the system of Amin (2013) is followed. No monograph on the Acanthocephala with keys to the families and genera has been published since Petrochenko (1956). Type species and type host species are highlighted in bold. Country of the type locality is given.

Echinorhynchida Petrochenko, 1956

Key to the genera of the Echinorhynchida from African freshwater fishes

1 (2) Trunk unarmed, cylindrical to fusiform; proboscis cylindrical, claviform or spherical, terminal; transition between true proboscis hooks and basal spiniform hooks gradual; neck and proboscis receptacle short; cement glands 6 or 8, usually pyriform to spherical and compact; eggs fusiform or elliptical (family Echinorhynchidae) [Fig. 4.7.2A]…… ***Acanthocephalus***

2 (1) Trunk armed with tegument spines; proboscis subcylindrical; proboscis receptacle long; brain ganglion anterior; cement glands 4-6, elongate and tubular or short and pyriform (family Rhadinorhynchidae)……3

3 (4) Middle-sized worms; trunk armed with tegument spines anteriorly; spines more numerous on the ventral side [Fig. 4.7.2B]……..***Paragorgorhynchus***

4 (3) Body large, 1.5-2 cm in length; trunk covered with giant spines in anterior part. Parasites of mormyrid fish [Fig. 4.7.2C]……***Megistacantha***

List of the Echinorhynchida from African freshwater fishes

Echinorhynchidae Cobbold, 1876

Acanthocephalus Koelreuther, 1771

Acanthocephalus lucii (Müller, 1776) from *Oreochromis niloticus* [Fig. 4.7.2A]

Rhadinorhynchidae Travassos, 1923

Megistacantha Golvan, 1960

Megistacantha horridum (Lühe, 1912) from *Gnathonemus petersii*, *Hyperopisus bebe*, *Hippopotamyrus pictus*, ***Marcusenius cyprinoides*** (Egypt) [Fig. 4.7.2C]

Megistacantha sanghaensis Kvach, Jirků et Scholz, 2016 from ***Mormyrops anguilloides*** (Central African Republic)

Paragorgorhynchus Golvan 1957

Paragorgorhynchus albertianus Golvan, 1957 from *Alestes dentex*, *Bagrus bajad*, *Hydrocynus forskahlii*, ***Lates niloticus*** (Congo), *Schilbe mystus* [Fig. 4.7.2B]

Paragorgorhynchus aswanensis Saoud et Wanas, 1990 from *Bagrus bajad*, *B. docmak*, *Clarias gariepinus*, ***Lates niloticus*** (Egypt), *Tetraodon lineatus*

Paragorgorhynchus chariensis Troncy, 1970 from ***Lates niloticus*** (Chad)

Paragorgorhynchus sp. from *Clarias gariepinus*

Polyacanthorhynchida Amin, 1987

List of the Polyacanthorhynchida from African freshwater fishes

Polyacanthorhynchidae Golvan, 1926

Polyacanthorhynchus Travassos, 1920

Polyacanthorhynchus kenyensis Schmidt et Canaris, 1967 (juvenile) from *Coptodon zillii*, *Enteromius paludinosus*, *Micropterus salmoides*, *Oreochromis leucostictus*, *O. niloticus*, ***Tilapia*** **sp.** (Kenya) [Fig. 4.7.2D]

Polymorphida Petrochenko, 1956

List of the Polymorphida from African freshwater fishes

Polymorphidae Meyer, 1931

Arhythmorhynchus Lühe, 1911

Arhythmorhynchus siluricola Dollfus, 1929 (juvenile) from *Chrysichtys* sp., ***Gephyroglanis*** **sp.** (Cameroon) [Fig. 4.7.2E]

Gyracanthocephala Van Cleave, 1936

Key to the genera of the Gyracanthocephala from African freshwater fishes

1 (2) Trunk armed only anteriorly with circles of spines; circles usually incomplete dorsally (subfamily Quadrigyrinae) [Fig. 4.7.3A]…… ……..***Acanthogyrus***

2 (1) Trunk armed anteriorly with complete circles of spines in one or two regions separated by an unarmed zone; spines in the second region may extend over the rest of the trunk in circles or in longitudinal rows (subfamily Pallisentinae) [Fig. 4.7.3C]…… ***Pararaosentis***

List of the Gyracanthocephala from African freshwater fishes

Quadrigyridae Van Cleave, 1920

Acanthogyrus Thapar, 1927

Acanthogyrus malawiensis Amin et Hendrix, 1999 from ***Labeo cylindricus*** (Malawi) [Fig. 4.7.3A]

Acanthogyrus maroccanus (Dollfus, 1951) from ***Luciobarbus setivimensis*** (Morocco)

Acanthogyrus nigeriensis (Dollfus et Golvan, 1956) from ***Labeo coubie*** (Mali)

Acanthogyrus phillipi (Mashego, 1988) from ***Enteromius neefi*** (South Africa)

Acanthogyrus tilapiae (Baylis, 1948) from *Aristochromis christyi*, *Bagrus meridionalis*, *Coptodon guineensis*, *C. rendalli*, *C. zillii*, *Ctenopharynx pictus*, *Genyochromis mento*, *Haplochromis squamipinnis*, *Haplochromis* sp., *Hemichromis bimaculatus*, *H. fasciatus*, *Labeotropheus fuelleborni*, *Lichnochromis acuticeps*, *Maylandia emmiltos*, *M. zebra*, *Mchenga thinos*, *Melanochromis auratus*, *M. heterochromis*, *M. vermivorus*, *Nimbochromis polystigma*, *Oreochromis andersonii*, *O. esculentus*, *O. leucostictus*, ***O. lidole*** (Tanzania), *O. macrochir*, *O. niloticus*, *O. tanganicae*, *Oreochromis* sp., *Petrotilapia genalutea*, *Placidochromis johnstoni*, *Protomelas annectens*, *P. taeniolatus*, *Pseudotropheus elongatus*, *Sarotherodon galilaeus*, *S. melanotheron*, *Stigmatochromis woodi*, *Tetraodon lineatus*, *Trematocranus placodon*, *Tropheops microstoma*, *T. tropheops*, *Tyrannochromis macrostoma*

Pararaosentis Amin, Heckmann, Ha, Luc et Doanh, 2000

Pararaosentis golvani (Troncy et Vassiliadès, 1973) from *Schilbe mystus*, ***Synodontis batensoda*** (Senegal), *S. frontosus*, *S. membranaceus*, *Tetraodon lineatus* [Fig. 4.7.3C]

Neoechinorhynchida Ward, 1917

Keys to the genera of the Neoechinorhynchida from African freshwater fishes

1 (2) Trunk without dendritic nuclei; proboscis short and subglobular or subcylindrical, armed with a small number of hooks arranged in spiral, circular, or diagonal rows (family Neoechinorhynchidae)……3

2 (1) Proboscis relatively long and cylindrical, armed with many hooks arranged quincuncially, in longitudinal rows. Parasites of fishes (family Tenuisentidae) [Fig. 4.7.3B]…….***Tenuisentis***

3 (4) Six hooks in each of three circles of hooks on the proboscis [Fig. 4.7.3D] ……...***Neoechinorhynchus***

4 (3) Proboscis armed with 6 hooks per circle; anterior trunk with 7 circles of tiny spines [Fig. 4.7.3E]……..***Hexaspiron***

List of the Neoechinorhynchida from African freshwater fishes

Tenuisentidae Van Cleave, 1936

Tenuisentis Van Cleave, 1936

Tenuisentis niloticus (Meyer, 1932) from ***Heterotis niloticus*** (Egypt), *Hydrocynus brevis*, *Lates niloticus* [Fig. 4.7.3B]

Neoechinorhynchidae Van Cleave, 1919

Hexaspiron Dollfus et Golvan, 1956

Hexaspiron nigericum Dollfus et Golvan, 1956 from ***Synodontis membranaceus*** (Nigeria) [Fig. 4.7.3E]

Neoechinorhynchus Stiles et Hassall, 1905

Neoechinorhynchus africanus Troncy, 1970 from ***Citharinops distichodoides*** (Chad), *Citharinus citharus*, *Hydrocynus forskahlii*, *Synodontis membranaceus* [Fig. 4.7.3D]

Neoechinorhynchus ichthyobori Saoud, El-Naffar et Abu-Sinna, 1974 from *Chelon ramada*, ***Ichthyborus besse*** (Sudan)

Neoechinorhynchus rutili (Müller, 1780) from *Clarias gariepinus*

Neoechinorhynchus sp. from *Citharinus citharus*, *Clarias gariepinus*

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Chapter 4.8.
NEMATODA

Šárka MAŠOVÁ & Roman KUCHTA

Nematodes or roundworms (Nematoda) – basic characteristics, life cycles, classification and principal diagnostic features

- roundworms (Ecdysozoa: Nematoda)
- nearly 25,000 species described
- only some groups parasitic in vertebrates
- endoparasites of different organs and tissues
- mostly long narrow cylindrical body, round in cross section, tapered towards both ends
- pseudocoelom
- body surface covered with cuticle
- well-developed digestive tract
- gonochoristic (separate sexes)
- direct or indirect life cycles (Fig. 4.8.1) (monoxeny or heteroxeny)
- four changes of cuticle (moulting)
- causative agents of human fish-borne diseases (*e.g.*, anisakiasis, gnathostomiasis)

Generally, life cycles differ depending upon the species of nematode (Yanong 2002). Development of almost all species of fish nematodes requires an intermediate host with presumable exceptions in some groups such as Capillariidae (see Moravec 2013). A complete nematode life cycle consists of four larval stages (L), separated from one another by a moult (or ecdysis) followed by an immature adult (or subadult): egg → L1 → L2 → L3 → L4 → adult. Larval stages of monoxenous species (with direct life cycle) undergo two transformations after hatching (*e.g.*, Pharyngodonidae). Infective juveniles (L3) may be ingested and mature in the intestine or infect via penetrating the skin and migrate through tissues.

Heteroxenous nematodes (with indirect life cycle) involve one or more intermediate hosts (*e.g.*, *Camallanus* sp. – see Fig. 4.8.1). The first two moults usually occur in the intermediate host. Infection of the definitive host by the L3 is either via ingestion of the intermediate host or inoculation by the intermediate host (Gaugler & Bilgrami 2004).

The classification of nematodes presented here is based on a combination of Moravec (2013), Hodda (2011) and the traditional consensus of nematode relationships according to Blaxter et al. (1998). This presentation includes only parasitic nematode families reported from Africa. Higher-level classification (classes, orders and families) of nematodes is based mainly on the type and morphology of the oesophagus, the anterior part of the digestive tract, the

structure of the anterior end (type of oral opening, lips, interlabia, teeth, buccal cavity, cuticular structures), presence/absence of phasmids, presence and number of caudal papillae, presence/absence of stichosome or trophosome, presence/absence of lateral canals in the excretory system and structure of its terminal duct, type of eggs, morphology of the reproductive system (type of uterus, presence/absence of caudal bursa in males), presence/absence of the precloacal sucker, position of the vulva, etc. (Fig. 4.8.2; see Anderson et al. 2009; Gibbons 2010 for keys up to the genus level).

Generic classification and species identification are based on the details of the anterior end (*e.g.*, deirids, structure of the buccal capsule), the morphology of the male copulatory organs (*e.g.*, spicules, gubernaculum, copulatory bursa), detailed structure of the digestive system (*e.g.*, ventriculus, intestinal caecum, oesophagus, pharynx). Other morphological characteristics used for identification include body size and the proportional size of individual parts (*e.g.*, oesophagus, caeca, tail, position of the vulva) to body length; the position of the excretory pore and the nerve ring, structure of the cuticle; the structures or projections of the eggs and the number and position of caudal papillae. For identification, the infection site and host taxon are also very often important.

Fig. 4.8.1. Heteroxenous (indirect) life cycle of *Camallanus* sp.; copepods serve as intermediate hosts. (Illustration by M. Luo.)

Glossary of taxonomically important morphological characteristics of nematodes

ala (plural alae): thin (flat) cuticular protrusion or fin, running longitudinally, usually lateral or sublateral, frequently paired; cervical alae (see below) on the anterior end; caudal alae on the posterior end of males

amphid: complex sensilla at the anterior body end with chemoreceptory function; its primitive position is lateral and postlabial; opening to the exterior usually as a simple pore [Fig. 4.8.2A-C]

bacillary bands: modification of hypodermis, consisting of longitudinal rows of columnar cells that have pore-like openings to the surface of cuticle (in Trichuroidea) (Anderson *et al.* 2009)

boss (plural bosses): any protruberant part, prominence or swelling of cuticle (*e.g.*, *Galeiceps*, *Philometroides*, *Nilonema*)

bulb or bulbus: bulbous inflation usually in the posterior part of the oesophagus in certain nematodes (*e.g.*, Pharyngodonidae), forces the food into the intestine [Fig. 4.8.2E]

cervical alae: in some parasitic nematodes, wide lateral anterior alae (single, bifid or trifid, often with internal supporting struts)

cheilostome: anterior region of the mouth (stoma), which is lined by external cuticle formation and is not surrounded by oesophageal tissues

collar: any of various structures comparable with a collar (*e.g.*, *Galeiceps*)

collarette: usually anterior cuticular extensions forming an annular ring in the neck region (*e.g.*, Physalopteroidea or *Pseudoproleptus*)

copulatory bursa: copulatory accessorial organ, formed by greatly expanded caudal alae in male tail end of certain parasitic nematodes

corpus: anterior part of oesophagus, acts as a suction pump

deirids (cervical papillae): peripheral somatic sense organs in the anterior part of the body, very often near nerve ring, considered to act as a mechanoreceptor [Fig. 4.8.2N-P]

didelphic: having two uteri

gubernaculum: sclerotised dorsal and lateral walls of the distal cloaca form the gubernaculum that guides the spicules when protracting or retracting and protects the underlying tissue [Fig. 4.8.2R-T]

interlabium: small lobe situated between the lips in certain nematodes [Fig. 4.8.2C]

intestinal caecum: appendage of the intestine extending anteriorly to the oesophagus [Fig. 4.8.2G-J]

isthmus: constriction of the oesophagus, region between corpus and bulb [Fig. 4.8.2E]

labium: lip on the cephalic region [Fig. 4.8.2C]

monodelphic: having one uterus

mucron: a small pointed projection, or spine-like ending on a terminus (*e.g.*, on tail tip of *Galeiceps*)

oesophagus (pharynx): part of the digestive tract that starts behind the buccal cavity or oral opening [Fig. 4.8.2D-J]

oesophastome: bulbous pseudobuccal capsule formed by an expansion of the oesophagus at its anterior end [Fig. 4.8.2D]

phasmids: peripheral somatic sense organs usually on the tail, probably with a chemoreceptory function [Fig. 4.8.2Q,U]

platymyarian: having fibres of the muscle cells adjacent and perpendicular to the hypodermis

spicule: sclerotised male copulatory organ of various shapes, usually paired, located immediately dorsal to the cloaca

stichocyte: glandular unicellular cell forming the stichosome [Fig. 4.8.2M]

stichosome: series of protein synthesising gland cells arranged in a row along the posterior portion of the oesophagus [Fig. 4.8.2L]

trophosome: structure which probably represents a modified intestine serving as a nutrient storage area of certain parasitic nematodes arranged along the posterior portion of the oesophagus

ventricular appendix: appendage of the ventriculus extending posteriorly to the intestine [Fig. 4.8.2H-K]

ventriculus: short region at the anterior end of the intestine [Fig. 4.8.2G-K]

Classification of nematodes infecting African fishes

A single asterisk (*) before a nematode's scientific name denotes that the taxon has been recorded only in its larval stage in the given fish host(s). A double asterisk (**) denotes records of both larvae and adults in the given host(s), whilst an unmarked taxon denotes records of only adults in the given host(s).

Class Adenophorea von Linstow, 1905
Subclass Enoplia Pearse, 1942
Order Enoplida Filipjev, 1929
Suborder Enoplina Chitwood et Chitwood, 1937
Order Trichocephalida Spasski, 1954
Suborder Trichinellina Hodda, 2007
Superfamily Trichinelloidea Ward, 1907
Family Capillariidae Railliet, 1915
Family Cystoopsidae Skrjabin, 1923
Suborder Dioctophymatina Skrjabin, 1927
Superfamily *Dioctophymatoidea Castellani et Chalmers, 1910
Family *Dioctophymatidae Castellani et Chalmers, 1910
Class Secernentea von Linstow, 1905
Order Oxyurida Skrjabin, 1923
Suborder Oxyurina Railliet, 1916
Superfamily Oxyuroidea Cobbold, 1864
Family Pharyngodonidae Travassos, 1920
Order Ascaridida Skrjabin et Schulz, 1940
Superfamily Cosmocercoidea Railliet, 1916
Family Cosmocercidae Railliet, 1916
Family Kathlaniidae Lane, 1914
Family Atractidae Railliet, 1917
Superfamily Seuratoidea Hall, 1916
Family Quimperiidae Gendre, 1928
Family Cucullanidae Cobbold, 1864
Superfamily Ascaridoidea Baird, 1853
Family **Anisakidae Railliet et Henry, 1912
Family *Ascarididae Baird, 1853
Family Heterocheilidae Railliet et Henry, 1915
Order Spirurida Chitwood, 1933
Suborder Camallanina Chitwood, 1937
Superfamily Camallanoidea Railliet et Henry, 1915
Family **Camallanidae Railliet et Henry, 1915
Superfamily Dracunculoidea Cameron, 1934
Family Philometridae Baylis et Daubney, 1926
Family Daniconematidae Moravec et Køie, 1987
Suborder Spirurina Chitwood, 1933
Superfamily **Anguillicoloidea Yamaguti, 1935
Family **Anguillicolidae Yamaguti, 1935

Superfamily *Gnathostomatoidea Railliet, 1895
Family *Gnathostomatidae Railliet, 1895
Superfamily Physalopteroidea Railliet, 1893
Family Physalopteridae Railliet, 1893
Superfamily Thelazioidea Skryabin, 1915
Family ** Rhabdochonidae Travassos, Artigas et Pereira, 1928
Superfamily Habronematoidea Chitwood et Wehr, 1932
Family Cystidicolidae Skryabin, 1946
Superfamily Acuarioidea Railliet, Henry et Sissoff, 1912
Family **Acuariidae Railliet, Henry et Sissoff, 1912

Identification keys and a systematic survey of nematodes (Nematoda) from African freshwater fish

The keys presented below are designed according to Moravec (2006, 2013), Thatcher (2006), Anderson *et al.* (2009), and Arai & Smith (2016) to allow identification of larval and/or adult nematodes up to the genus level. Species are listed alphabetically within the respective higher-order taxa. The type species of each genus and the type host of each species are highlighted in bold. The country where the type locality lies is given if known. Host names follow Froese & Pauly (2017).

Key to the classes of the Nematoda *sensu* Blaxter *et al.* (1998)

1 (2) Amphids always post-labial. Phasmids absent. Caudal papillae absent or few in number. Oesophagus cylindrical or with oesophageal glands free in pseudocoel and forming stichosome or trophosome. Excretory system with out lateral canals and terminal duct not lined with cuticle. Males with one spicule or spicule absent. Eggs usually unsegmented with plug at either pole or hatching *in utero*. First-larval stage often with stylet and usually infective to final host.....**Adenophorea** (**subclass Enoplia**)

2 (1) Amphid apertures on lips, often difficult to see. Phasmids present. Oesophagus never in form of stichosome. Excretory system with lateral canals and terminal canal lined with cuticle. Caudal papillae almost always numerous in males. Spicules two, exceptionally spicules absent. Eggs without polar plugs, rarely operculate at one or both poles, or hatching *in utero*. Early third larval stage infective to the final host.....**Secernentea**

ENOPLIA Pearse, 1942

Key to the superfamilies of the Enoplia from African freshwater fishes

1 (2) Well-developed oesophagus cylindrical; stichosome or trophosome absent. Male tail modified to form ventral sucker-like muscular bursa. Monodelphic. Vulva near anus. Body thick, massive.....**Dioctophymatoidea**

2 (1) Stichosome present. Male tail without muscular bursa. Vulva anterior or near the end of oesophagus. Body small, thin, mostly filiform. Only in *Cystoopsis* is posterior part of body globular.....**Trichinelloidea**

TRICHINELLOIDEA Ward, 1907

Key to the families of the Trichinelloidea from African freshwater fishes

1 (2) Digestive tract incomplete, intestine dilated into a sac, anus absent. Vulva near nerve ring. Female body with thread-like anterior region and poste-

riorly expanded to form vesicles. Parasites of the skin of sturgeons and gars, in Africa known from Cichlidae……**Cystoopsidae**

2 (1) Digestive tract complete including anus. Vulva near mid-region or end of oesophagus. Posterior region of female somewhat expanded but not cylindrical, not vesicle-like. Adults in the digestive tract or liver .....……**Capillariidae**

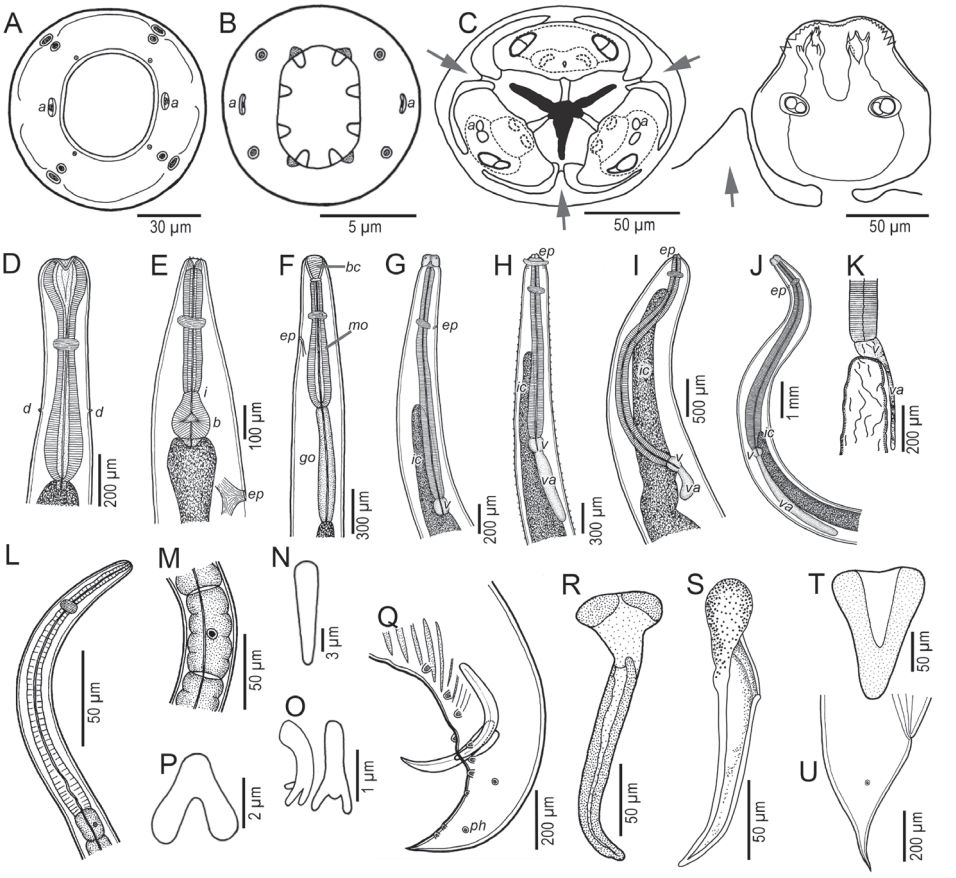

Fig. 4.8.2. Selected morphological characters important for identification. **A-C.** Amphids (*a*) of *Procamallanus daleneae* (Boomker, 1933) (A); *Rhabdochona tricuspidata* Moravec et Jirků, 2014 (B); *Multicaecum heterotis* Petter, Vassiliadès et Marchand, 1979 (C); **D.** Muscular oesophagus with oesophastome and deirids (*d*) of *Cucullanus mormyri* Moravec et Scholz, 2017; **E.** Cylindrical oesophagus of *Chitharinella khalili* Petter, Vassiliadès et Troncy, 1972, ending in a globular bulb (*b*) with valvular apparatus and separated from the corpus by a constriction (isthmus – *i*); **F.** Buccal capsule (*bc*) and oesophagus of *Procamallanus daleneae* (Boomker, 1933) divided into muscular (*mo*) and glandular (*go*) parts; **G-J.** Intestinal caecum (*ic*) of *Dujardinascaris mormyropsis* Moravec et Jirků, 2014 (G); third-stage larva of *Galeiceps* sp. with ventricular appendix (*va*) situated below ventral cephalic tooth (H); third-stage larva of *Contracaecum* sp. (I); *Hysterothylacium anguillae* Moravec, Taraschewski, Appelhoff et Weyl 2012 (J); **K.** Ventriculus with ventricular appendix of *Raphidascaroides bishaii* Khalil, 1961; **L, M.** Capillariidae gen. sp., muscular oesophagus (L); stichocyte in the middle of the stichosome (M); **N-P.** Deirids of *Rhabdochona* spp.; **Q.** Two equal spicules, gubernaculum, eleven pairs of caudal papillae (posterior lateral pair represents phasmids – *ph*) and one additional unpaired median papilla on the anterior cloacal lip of *Falcaustra similis* Moravec et Van As, 2004; **R-T.** Gubernaculum of *Dujardinascaris mormyropsis* Moravec et Jirků, 2014 (R); *Multicaecum heterotis* Petter, Vassiliadès et Marchand, 1979 (S); *Falcaustra similis* Moravec et Van As, 2004 (T); **U.** Phasmid of *Falcaustra piscicola* (von Linstow, 1907). (Modified from Moravec *et al*. 1999, 2012; Moravec & Van As 2004, 2015; Mašová *et al.* 2010; Moravec & Jirků 2014a,b, 2015, 2017; Moravec & Scholz 2017.) ex - excretory pore

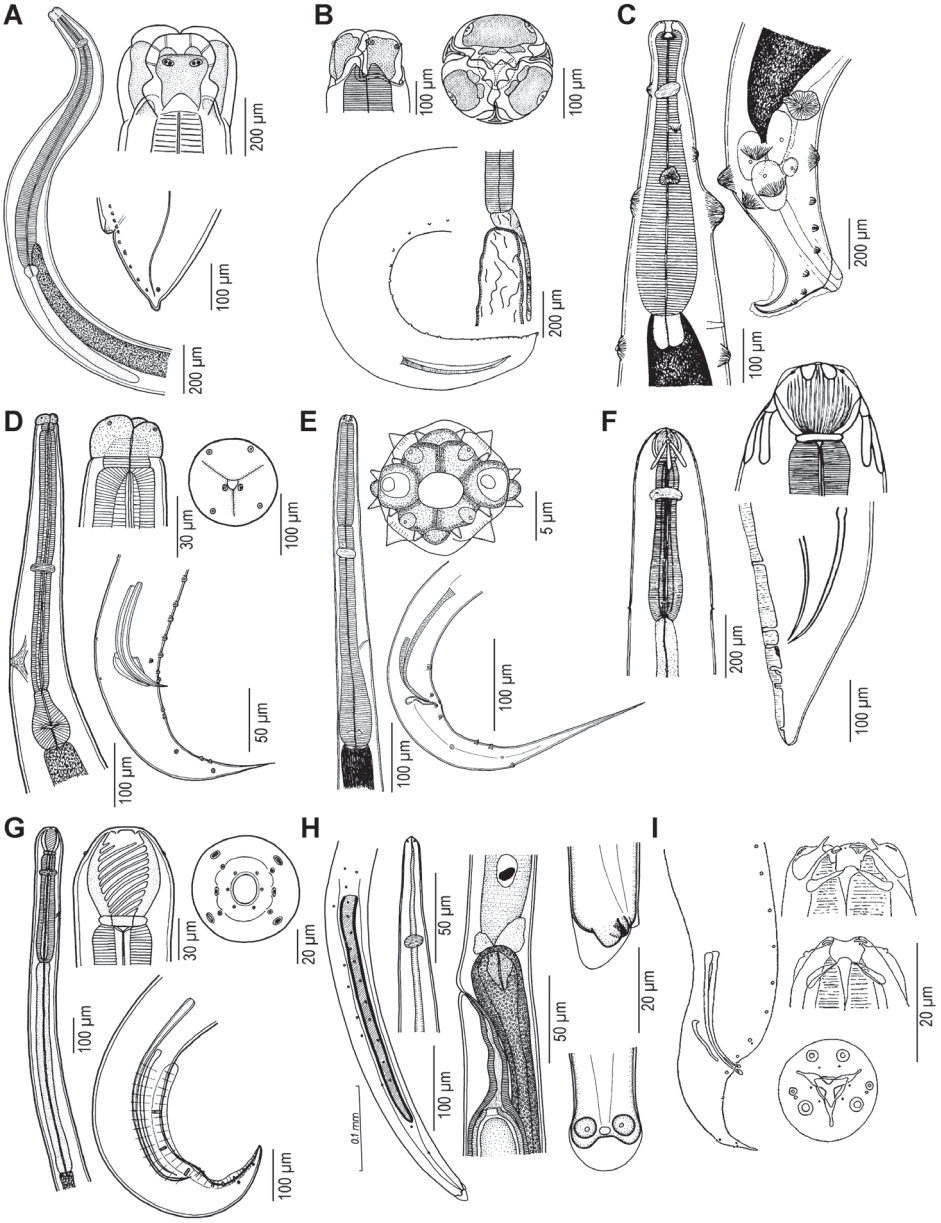

Fig. 4.8.3. Nematoda. **A.** *Hysterothylacium anguillae* Moravec, Taraschewski, Appelhoff et Weyl, 2012 from *Anguilla marmorata*; **B.** *Raphidascaroides bishaii* Khalil, 1961 from *Gymnarchus niloticus*; **C.** *Anguillicoloides papernai* (Moravec et Taraschewski, 1988) from *Anguilla mossambica*; **D.** *Labeonema africanum* Moravec et Van As, 2004 from *Synodontis nigromaculatus*; **E.** *Orientatractis brycini* González-Solís et Mariaux, 2017 from *Brycinus macrolepidotus*; **F.** *Camallanus longicaudatus* Moravec, 1973 from *Labeo horie*; **G.** *Procamallanus* (*Spirocamallanus*) *spiralis* Baylis, 1923 from *Clarias theodorae*; **H.** *Capillostrongyloides fritschi* (Travassos, 1914) from *Bagrus docmak*; **I.** *Aplectana chamaeleonis* (Baylis, 1929) from *Oreochromis niloticus.* (Modified from Khalil 1961; Chen 1966; Moravec 1973, 2001; Moravec & Taraschewski 1988; Moravec & Van As 2004, 2015; Moravec *et al*. 2012; González-Solís & Mariaux 2017.)

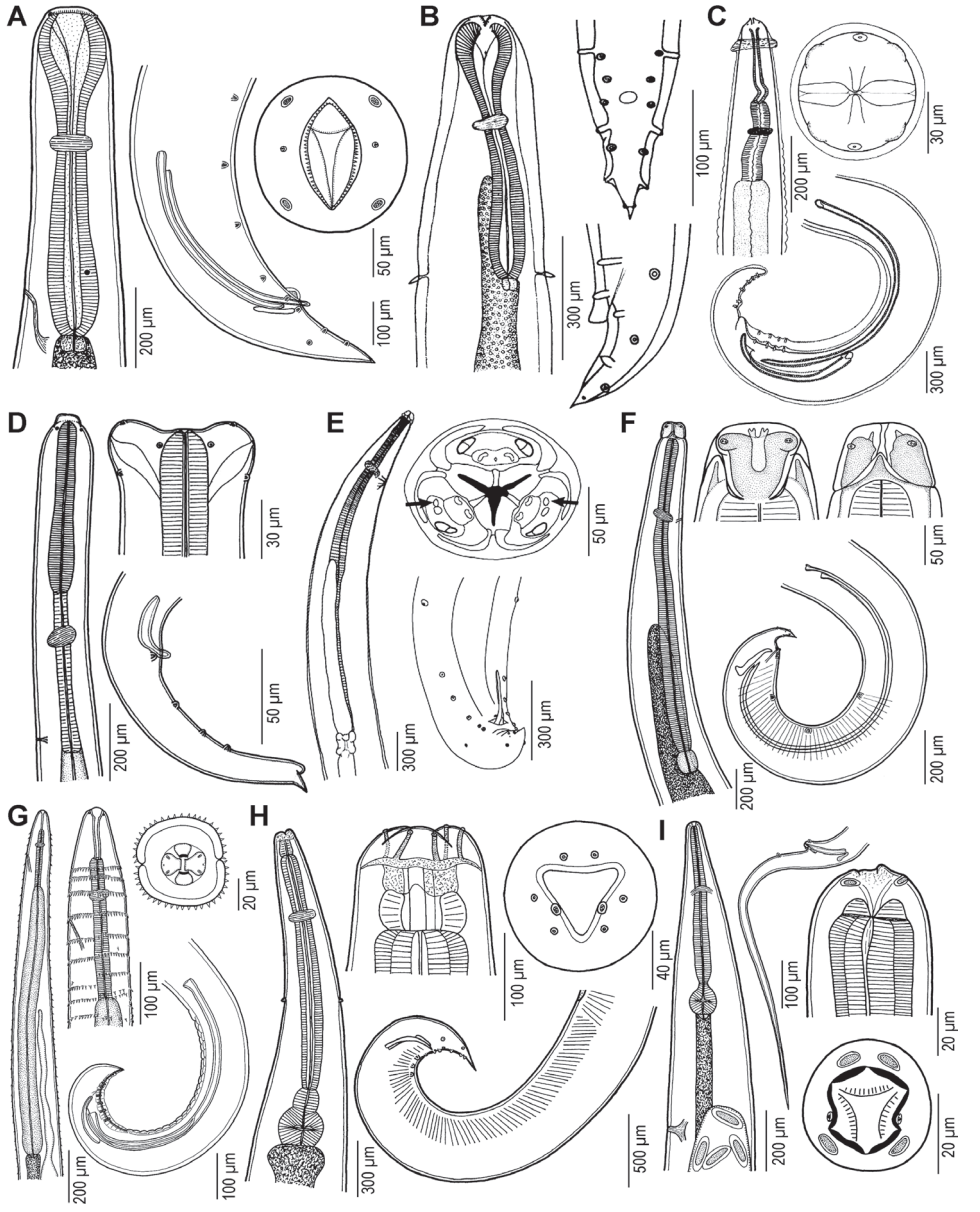

Fig. 4.8.4. Nematoda. **A.** *Cucullanus baylisi* Campana-Rouget, 1961 from *Synodontis schall*; **B.** *Dichelyne fossor* Jägerskiöld, 1902 from *Lates niloticus*; **C.** *Pseudoproleptus africanus* Khalil, 1973 from *Mormyrus* sp.; **D.** *Mexiconema africanum* Moravec, Jirků, Charo-Karisa et Mašová, 2009 from *Auchenoglanis occidentalis*; **E.** *Multicaecum heterotis* Petter, Vassiliadès et Marchand, 1979 from *Heterotis niloticus*; **F.** *Dujardinascaris mormyropsis* Moravec et Jirků, 2014 from *Mormyrops anguilloides*; **G.** *Spinitectus polli* Campana-Rouget, 1961 from *Synodontis decorus*; **H.** *Falcaustra similis* Moravec et Van As, 2004 from *Synodontis nigromaculatus*; **I.** *Cithariniella longicaudata* Moravec et Van As, 2015 from *Schilbe intermedius.* (Modified from Moravec 1974; Moravec & Van As 2004; Moravec *et al.* 2009a; Mašová *et al.* 2010; Moravec & Jirků 2014a, 2017; Moravec & Scholz 2017.)

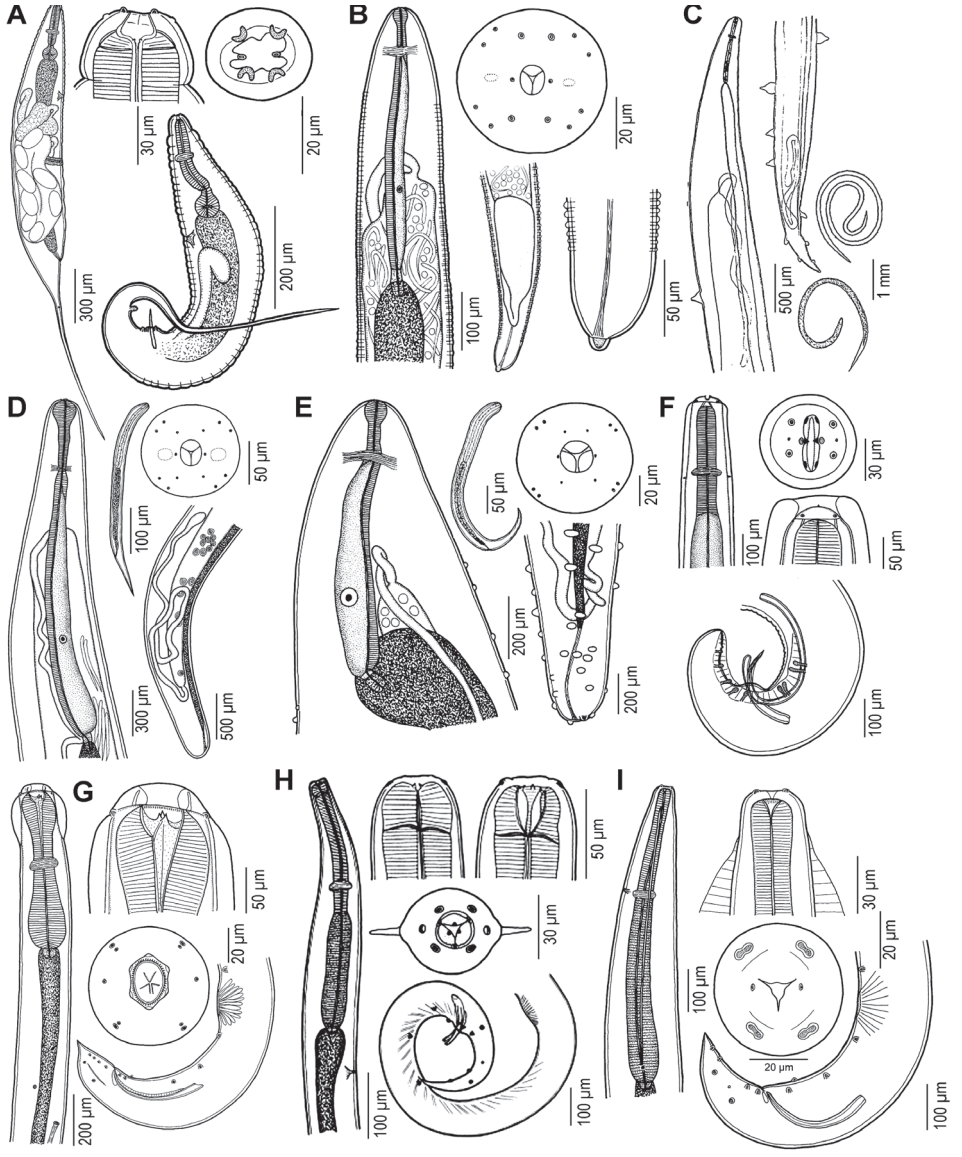

Fig. 4.8.5. Nematoda. **A.** *Synodontisia okavangoensis* Moravec et Van As, 2004 from *Synodontis nigromaculatus*; **B.** *Afrophilometra hydrocyoni* (Fahmy, Mansour et El-Naffar, 1976) from *Hydrocynus forskahlii*; **C.** *Nilonema gymnarchi* Khalil, 1960 from *Gymnarchus niloticus*; **D.** *Philometra lati* Moravec, Charo-Karisa et Jirků, 2009 from *Lates niloticus*; **E.** *Philometroides khalili* Moravec, Halajian, Tavakol, Nyagura et Luus-Powell, 2015 from *Labeo rosae*; **F.** *Heliconema africanum* (von Linstow, 1899) from *Anguilla mossambica*; **G.** *Gendria sanghaensis* Moravec et Jirků, 2017 from *Schilbe marmoratus*; **H.** *Paraquimperia africana* Moravec, Boomker et Taraschewski, 2000 from *Anguilla mossambica*; **I.** *Quimperia lanceolata* Gendre, 1926 from *Ctenopoma kingsleyae.* (Modified from Khalil 1960; Moravec *et al.* 2000; Moravec & Van As 2004; Moravec *et al.* 2009b, 2013, 2015; Moravec & Jirků 2017.)

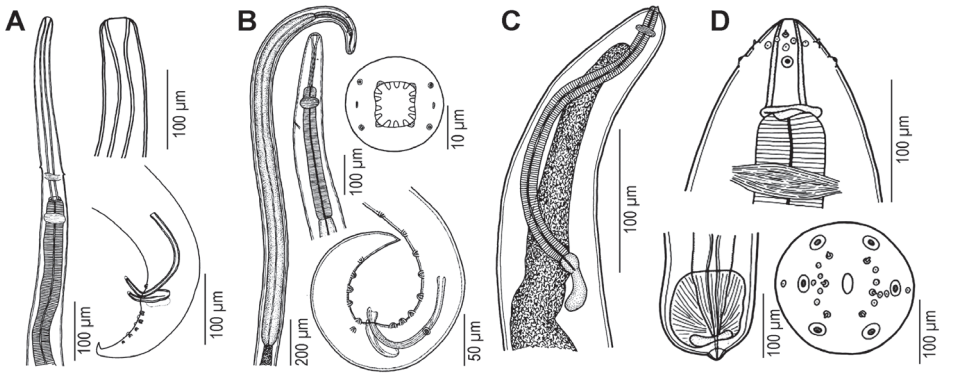

Fig. 4.8.6. Nematoda. **A.** *Prosungulonema africanum* (Moravec et Puylaert, 1970) from *Thoracochromis schwetzi*; **B.** *Rhabdochona* (*Rhabdochona*) *centroafricana* Moravec et Jirků, 2014 from *Enteromius miolepis*; **C.** *Contracaecum* sp. from *Hydrocynus vittatus*; **D.** *Eustrongylides* sp. from *Hydrocynus vittatus*. (Modified from Moravec & Puylaert 1970; Moravec & Jirků 2014b; Moravec & Van As 2015.)

List of the Enoplia from African freshwater fishes

Capillariidae Railliet, 1915

Capillaria Zeder, 1800

Capillaria sp. from *Clarias gariepinus*, *Clarotes laticeps*, *Malapterurus electricus*, *Synodontis zambezensis*

Capillostrongyloides Freitas et Lent, 1935

Capillostrongyloides fritschi (Travassos, 1914) [syns *Capillaria fritschi* Travassos, 1914; *Capillaria yamagutii* Tadros et Mahmoud, 1968] from *Bagrus bajad*, *B. docmak*, *Malapterurus electricus* [Fig. 4.8.3H]

Capillariidae gen. sp. from *Auchenoglanis* sp., *Gnathonemus petersii*

Note: representatives of *Capillaria* are not known from fishes. This very probably concerns a misidentification. For generic key to fish capillariids – see Moravec (2001).

Cystoopsidae Skryabin, 1923

Cystoopsis Wagner, 1867

Cystoopsis sp. from *Tropheus moorii* (see Moravec and Salgado-Maldonado 2003 who reported unpublished data of G.L. Hoffman)

*****Dioctophymatidae Railliet, 1915

Eustrongylides Jägerskiöld, 1909

Eustrongylides africanus (Jägerskiöld, 1909) from *Clarias anguillaris*, *C. gariepinus*

Eustrongylides sp. from *Bagrus docmak*, *Clarias camerunensis*, *C. gariepinus*, *C. theodorae*, *Clarias* sp., *Clarotes laticeps*, *Dinotopterus cunningtoni*, *Enteromius humilis*, *Haplochromis angustifrons*, *H. argenteus*, *H. eduardii*, *H. graueri*, *H. guiarti*, *H. labiatus*, *H. nubilus*, *H. pappenheimi*, *Haplochromis* sp., *Hydrocynus vittatus*, *Labeobarbus altianalis*, *L. tsanensis*, *Lepidiolamprologus cunningtoni*, *Mormyrus caschive*, *Oreochromis niloticus*, *Protopterus aethiopicus* [Fig. 4.8.6D]

Note: *Eustrongylides africanus* was designated as *species inquirenda* by Measures (1988). *Eustrongylides* sp. from *Clarias* sp. was originally misidentified as *Philometra congolensis* Schuurmans-Stekhoven, 1937 – see Moravec (2006).

SECERNENTEA von Linstow, 1905

Key to the orders of the Secernentea from African fishes

1 (2) Male with a reduced number of caudal papillae. Generally only one spicule. Body short and stout. Oesophagus with a bulb. Pre-anal sucker absent. Female with large embryonated eggs often flattened on one side. Monoxenous with two moults in egg. Parasites of colon or rectum……**Oxyurida** (**Pharyngodonidae**)

2 (1) Nematodes lacking most of the above characters…….3

3 (4) Anterior extremity triradiate (except in some members of the Seuratoidea). Head end with three lips (one dorsal and two ventrolateral). Lateral, external labial papillae present. With 2-3 pairs of caudal papillae in dorsolateral position. Oesophagus variable in form but not divided into short muscular and long glandular parts. Pre-anal sucker present or absent in males. Usually found in the intestine of the final host. Larval stages preinfective for final host do not develop entirely in an intermediate host…….**Ascaridida**

4 (3) Anterior extremity bilaterally symmetrical. Lateral, external labial papillae absent. Head end with two lateral lips or lips reduced or absent. Stoma usually well developed, sometimes reduced. Oesophagus divided into shorter anterior muscular part and longer posterior glandular part; division sometimes indistinct. Caudal papillae always ventral or ventrolateral in position. Pre-anal sucker not present. Parasites of anterior part of gut (oesophagus, stomach, rarely duodenum) or tissues and tissue voids. Larval stages preinfective for final host develop entirely in an intermediate host …….. **Spirurida**

Pharyngodonidae Travassos, 1920

Key to the genera of the family Pharyngodonidae from African freshwater fishes

(for keys to the species of *Chitariniella* – see Koubková *et al.* 2010; for keys to pharyngodonid genera from fishes – see Moravec 1994)

1(2) Tail long, slender and sharply pointed. Oral aperture hexagonal. Spicule present……...***Synodontisia***

2 (1) Tail long, slender and sharply pointed. Oral aperture triangular. Buccal cavity present; vulva close to anus; eggs with polar filaments……***Chitariniella***

List of the Pharyngodonidae from African freshwater fishes

Chitariniella Khalil, 1964

Chitariniella citharini Khalil, 1964 from ***Citharinus citharus*** (Sudan), *Distichodus brevipinnis*, *Synodontis schall*, *S. serratus*

Chitariniella khalili Petter, Vassiliadès et Troncy, 1972 [syn. *Chitariniella gonzalesi* van Waerebeke, Chabaud, Bain et Georges, 1988] from *Auchenoglanis biscutatus*, *Paradistichodus dimidiatus*, *Synodontis acanthomias*, *S. batensoda*, *S. frontosus*, *S. greshoffi*, *S. longirostris*, *S. membranaceus*, *S. nigrita*, *S. ocellifer*, ***S. schall*** (Chad), *S. serratus*, *S. sorex*

Chitariniella koubkovae Moravec et Van As, 2015 from ***Paradistichodus dimidiatus*** (Senegal)

Chitariniella longicaudata Moravec et Van As, 2015 from ***Schilbe intermedius*** (Botswana) [Fig. 4.8.4I]

Chitariniella petterae Khalil, 1974 from ***Distichodus schenga*** (Zambia), *Synodontis nigrita*, *S. schall*

Synodontisia Petter, Vassiliadès et Troncy, 1972

Synodontisia annulata Moravec et Van As, 2015 from ***Schilbe intermedius*** (Botswana)

Synodontisia okavangoensis Moravec et Van As, 2004 from ***Synodontis nigromaculatus*** (Botswana), *S. vanderwaali* [Fig. 4.8.5A]

Synodontisia thelastomoides Petter, Vassiliadès et Troncy, 1972 from *Synodontis acanthomias*, *S. decorus*, *S. greshoffi*, *S. nigrita*, *S. nigriventris*, *S. pleurops*, *S. ocellifer*, *S. schall*, ***S. sorex*** (Senegal), *S. zambezensis*, *Xenocharax spilurus*

ASCARIDIDA Skrjabin et Schulz, 1940

Key to the superfamilies of the Ascaridida from African freshwater fishes

1 (2) Lips present or absent, when present variable in number and form. Platymyarian (*i.e.*, having all muscle cells lying next to the hypodermis, their sarcoplasm being uncovered on three sides next to the body cavity). Eggs hatching *in utero* or eggs with delicate shells deposited by females. First moult generally outside eggs. Usually small worms, less than 1 cm long……3

2 (1) With three well-defined lips usually of large size, sometimes separated by interlabia. Coelomyarian (*i.e.*, musculature in which the muscle fibres are next to the hypodermis and perpendicular to it; myofibrils extend varying distances up the side of the muscle cell). Eggs thick-shelled and not embryonated when deposited. First moult inside eggs. Generally large nematodes, more than 1 cm long……5

3 (4) Oesophagus cylindrical, anteriorly differentiated into distinct pharyngeal part, a subspherical or elongate isthmus and a valved bulb possessing uninucleate gland cells. Viviparous nematodes……**Cosmocercoidea**

4 (3) Oesophagus short, simple and cylindrical, or short and divided into two parts of the same or different diameters. Pharyngeal part of oesophagus present or absent. Oviparous nematodes……...**Seuratoidea**

5 (6) Pre-anal sucker present, surrounded by cuticularised ring. Oesophagus with claviform corpus, short isthmus, and valved bulb with binucleated subventral oesophageal glands or oesophagus cylindrical. Caeca absent……**Heterakoidea**

6 (5) Pre-anal sucker absent. Oesophagus simple and cylindrical or terminated by swelling, without valves, containing uninucleate gland cells. Caeca pre-

sent or absent……...**Ascaridoidea**

COSMOCERCOIDEA Railliet, 1916

Key to the families of the Cosmocercoidea from African freshwater fishes

1 (2) Oviparous, or if viviparous, larvae laid in the first stage. Didelphic……3

2 (1) Viviparous with larvae laid in an advanced stage of development and capable of endogenous development. Generally monodelphic……...**Atractidae**

3 (4) Oesophageal isthmus elongate, not spherical. Male without a pre-anal sucker……**Cosmocercidae**

4 (4) Oesophageal isthmus not elongate, generally spherical. Male generally with one or several pre-anal suckers……**Kathlanidae**

Atractidae Railliet, 1917

Key to the genera of the Atractidae from African freshwater fishes

1 (2) Oral opening surrounded by three lips……***Labeonema***

2 (1) Oral opening surrounded by 6 (2 lateral and 4 submedian) poorly developed lips…….. ***Orientatractis***

List of the Atractidae (adults) from African freshwater fishes

Labeonema Puylaert, 1970

Labeonema africanum Moravec et Van As, 2004 from ***Synodontis nigromaculatus*** (Botswana), *S. vanderwaali* [Fig. 4.8.3D]

Labeonema bainae Baker, 1982 from ***Schilbe mandibularis*** (Gabon)

Labeonema bakeri van Waerebeke, Chabaud, Bain et Georges, 1988 from ***Distichodus fasciolatus***, ***D. sexfasciatus*** (type host not explicitly mentioned; Central African Republic)

Labeonema intermedium Puylaert, 1970 from ***Labeo* sp.** (Democratic Republic of the Congo)

Labeonema longispiculatum Moravec et Jirků, 2017 from ***Synodontis acanthomias*** (Democratic Republic of the Congo)

Labeonema synodontisi (Vassiliadès, 1973) [syn. *Raillietnema synodontisi* Vassiliades, 1973] from *Synodontis eupterus*, *S. frontosus*, *S. nigrita*, ***S. ocellifer*** (Senegal), *S. schall*, *S. zambezensis*

Orientatractis Petter, 1966

Orientatractis brycini González-Solís et Mariaux, 2017 from ***Brycinus macrolepidotus*** (Gabon), *Xenocharax spilurus* [Fig. 4.8.3E]

Atractidae gen. sp. from *Schilbe intermedius*

List of the Atractidae (larvae) from African freshwater fishes

Atractidae gen. sp. from *Clarias gariepinus*

Cosmocercidae Railliet, 1916

List of the Cosmocercidae from African freshwater fishes

Aplectana Railliet et Henry, 1916

Aplectana chamaeleonis (Baylis, 1929) [syn. *Oxysomatium chamaeleonis* Baylis, 1929] from *Oreochromis niloticus* [Fig. 4.8.3I]

Note: Chen (1966) found this species common in reptiles also in the frog *Amietia angolensis* (Bocage) and a freshwater fish (*Oreochromis niloticus*).

Kathlaniidae Lane, 1914

List of the Kathlanidae from African freshwater fishes

Falcaustra Lane, 1914

Falcaustra hexapapillata (Khalil, 1962) [syns *Spironoura hexapapillata* Khalil, 1962; *Falcaustra guiersi* Vassiliadès, 1973, *Spironoura guiersi* (Vassiliadès, 1973)] from *Distichodus brevipinnis*, ***D. nefasch*** (Sudan), *D. rostratus*

Falcaustra petrei (Khalil, 1970) from *Distichodus nefasch*, ***D. rostratus*** (Ghana)

Falcaustra piscicola (von Linstow, 1907) [syns *Nematoxys piscicola* von Linstow, 1907; *Spironoura congolense* Taylor, 1925] from *Distichodus lusosso*, ***Distichodus* sp.** (Cameroon)

Falcaustra similis Moravec et Van As, 2004 from *Schilbe intermedius*, *Synodontis acanthomias*, *S. frontosus*, *S. nigrita*, ***S. nigromaculatus*** (Botswana), *S. schall*, *S. serratus*, *S. vanderwaali* [Fig. 4.8.4H]

Falcaustra straeleni Campana-Rouget, 1961 from ***Labeobarbus altianalis***, ***L. intermedius*** (type host not explicitly mentioned; Democratic Republic of the Congo)

Falcaustra sudanensis (Khalil, 1962) from ***Distichodus brevipinnis*** (Sudan), *D. nefasch*

Falcaustra tchadi Vassiliadès et Troncy, 1973 from ***Distichodus brevipinnis*** (Chad), *D. rostratus*

Falcaustra therezieni Petter, 1979 from ***Arius madagascariensis***, ***Ptychochromoides betsileanus*** (type host not explicitly mentioned; Madagascar)

Falcaustra verbekei Campana-Rouget, 1961 from ***Labeobarbus altianalis***, ***L. intermedius*** (type host not explicitly mentioned; Democratic Republic of the Congo)

SEURATOIDEA Hall, 1916

Key to the families of the Seuratoidea from African freshwater fishes

1 (2) Buccal cavity absent, or if present, derived from cheilostome; cuticle of walls of cheilostome has same structure and staining reactions as external body cuticle……...**Quimperiidae**

2 (1) Buccal cavity formed from modifications of the anterior end of oesophagus (oesophastome); walls of oesophastome surrounded by oesophageal tissue……..**Cucullanidae**

Cucullanidae Cobbold, 1864

Key to the genera of the Cucullanidae from African freshwater fishes

1 (2) Intestinal caecum absent……***Cucullanus***

2 (1) Intestinal caecum present……***Dichelyne***

List of the Cucullanidae from African freshwater fishes

Cucullanus Müller, 1777

Cucullanus barbi Baylis, 1923 from *Enteromius perince*, ***Labeobarbus bynni*** (Egypt)

Cucullanus baylisi Campana-Rouget, 1961 from ***Synodontis schall*** (Democratic Republic of the Congo), *Synodontis* sp. [Fig. 4.8.4A]

Cucullanus clarotis Baylis, 1923 from *Clarotes laticeps*, ***Synodontis schall*** (Sudan), *Synodontis* sp.

Cucullanus congolensis Moravec et Jirků, 2017 from ***Auchenoglanis occidentalis*** (Democratic Republic of the Congo)

Cucullanus djilorensis Ndew, Diouf, Bâ et Morand, 2014 from *Labeobarbus bynni*, ***Mugil curema*** (Senegal), *Tilapia sparrmanii*

Cucullanus egyptae Abdel-Ghaffar, Bashtar, Abdel-Gaber, Morsy, Mehlhorn, Al Quraishy et Mohammed, 2014 from ***Anguilla anguilla*** (Egypt)

Cucullanus mormyri Moravec et Scholz, 2017 from *Marcusenius cyprinoides*, ***Mormyrus caschive*** (Sudan), *Mormyrus* sp.

Cucullanus sp. from *Tilapia sparrmanii*

Dichelyne Jägerskiöld, 1902

Dichelyne fossor Jägerskiöld, 1902 from *Bagrus bajad*, ***Lates niloticus*** (Sudan) [Fig. 4.8.4B]

Dichelyne sp. from *Lates niloticus*

Quimperiidae Gendre, 1928

Key to the genera of the Quimperiidae from African freshwater fishes

1 (2) Pre-anal sucker absent in juvenile males, present in fully developed males. Distinct ventral muscle bands in pre-anal region present in males. Parasites of eels……***Paraquimperia***

2 (1) Pre-anal sucker present. Ventral oblique muscle bands in preanal region absent or inconspicuous in males. Parasites of African fishes…….3

3 (4) Cephalic vesicle absent. Cervical alae well developed. Buccal capsule absent. Oral opening triangular……***Quimperia***

4 (3) Cephalic vesicle present. Cervical alae usually absent. Buccal cavity with three teeth, the two-ventrolateral ones sometimes reduced. Oral opening oval to circular……***Gendria***

List of the Quimperiidae from African freshwater fishes

Gendria Baylis, 1930 [syn. *Chabaudus* Inglis et Ogden, 1965]

Gendria chabaudi (Inglis et Ogden, 1965) from ***Heterobranchus bidorsalis*** (Sierra Leone)

Gendria longispiculata Moravec et Jirků, 2017 from ***Schilbe grenfelli*** (Democratic Republic of the Congo)

Gendria polypteri Vassiliadès et Chevalier, 1973 from *Erpetoichthys calabaricus*, ***Polypterus senegalus*** (Senegal)

Gendria thysi (Puylaert, 1970) from ***Parauchenoglanis punctatus*** (Democratic Republic of the Congo)

Gendria tilapiae Baylis, 1930 from ***Sarotherodon galilaeus*** (Mali)

Gendria sanghaensis Moravec et Jirků, 2017 from ***Schilbe marmoratus*** (Central African Rep.) [Fig. 4.8.5G]

Gendria sp. from *Pantodon buchholzi*

Paraquimperia Baylis, 1934

Paraquimperia africana Moravec, Boomker et Taraschewski, 2000 from ***Anguilla mossambica*** (South Africa) [Fig. 4.8.5H]

Quimperia Gendre, 1926

Quimperia lanceolata Gendre, 1926 from ***Ctenopoma kingsleyae*** (Guinea) [Fig. 4.8.5I]

ASCARIDOIDEA Baird, 1853

Key to the families of the Ascaridoidea from African freshwater fishes

1 (2) Oesophagus cylindrical, slightly enlarged posteriorly. Ventriculus absent. Long intestinal caecum present…….**Heterocheilidae**

2 (1) Oesophagus with oblong to cylindrical posterior ventriculus, anterior intestinal caecum and posterior ventricular appendix present or both absent……3

3 (2) If only intestinal caecum present, then excretory pore situated between subventral lips or at base of ventral interlabium……**Anisakidae**

4 (3) Anterior intestinal caecum present, excretory pore approximately at level of nerve ring…….. ***Ascarididae**

**Anisakidae Railliet et Henry, 1912

Key to genera of the Anisakidae from African freshwater fishes

1 (2) Anterior intestinal caecum absent and ventricular appendix present ……...***Raphidascaroides***

2 (1) Both anterior intestinal caecum and ventricular appendix present……3

3 (2) Anterior end with distinct cuticular collar. Body covered by many small cuticular bosses……***Galeiceps***

4 (3) Anterior end without distinct cuticular collar. Body without cuticular projecti ons……5

5 (4) Excretory pore situated at level of nerve ring or somewhat posterior, always distant from head end. Tail of fourth-stage larvae with minute cuticular projections at tip. Adults parasitic in fishes ……***Hysterothylacium***

6 (5) Excretory pore located at base of ventral interlabium. Tail of larvae conical or rounded, without cuticular projections at tip. Adults parasitic in fish-eating birds and marine mammals……...***Contracaecum***

List of the Anisakidae (adults) from African freshwater fishes

Hysterothylacium Ward et Magath, 1917

Hysterothylacium anguillae Moravec, Taraschewski, Appelhoff et Weyl, 2012 from ***Anguilla marmorata*** (South Africa) [Fig. 4.8.3A]

Raphidascaroides Yamaguti, 1941

Raphidascaroides bishaii Khalil, 1961 from *Chrysichthys nigrodigitatus*, ***Gymnarchus niloticus*** (Sudan) [Fig. 4.8.3B]

List of Anisakidae (larvae) from African freshwater fishes

Contracaecum Railliet et Henry, 1912

Contracaecum microcephalum (Rudolphi, 1809) from *Synodontis batensoda*

Contracaecum sp. from *Anguilla mossambica*, *Bagrus bajad*, *B. docmak*, *Boulengerella cuvieri*, *Brycinus imberi*, *B. macrolepidotus*, *B. nurse*, *Campylomormyrus tamandua*, *Chetia flaviventris*, *Clarias gariepinus*, *C. liocephalus*, *C. ngamensis*, *C. platycephalus*, *C. stappersii*, *C. theodorae*, *Clarias* sp., *Clarotes laticeps*, *Coptodon rendalli*, *Cyprinus carpio*, *Decapterus russelli*, *Enteromius humilis*, *E. mattozi*, *E. paludinosus*, *E. trimaculatus*, *E. unitaeniatus*, *Gnathonemus petersii*, *Haplochromis astatodon*, *H. eduardii*, *H. guiarti*, *H. ishmaeli*, *H. mahagiensis*, *H. pappenheimi*, *H. paucidens*, *H. placodus*, *H. serridens*, *Haplochromis* sp., *Hydrocynus brevis*, *H. forskahlii*, *H. vittatus*, *Hydrocynus* sp., *Hyperopisus bebe*, *Labeobarbus altianalis*, *L. marequensis*, *Lates niloticus*, *Lepidiolamprologus cunningtoni*, *Malapterurus electricus*, *Marcusenius stanleyanus*, *Micropterus salmoides*, *Mormyrops anguilloides*, *Oreochromis andersonii*, *O. leucostictus*, *O. macrochir*, *O. mossambicus*, *O. niloticus*, *Pomadasys olivaceus*, *P. commersonnii*, *Pseudocrenilabrus philander*, *Sandelia capensis*, *Sargochromis carlottae*, *S. codringtonii*, *Schilbe intermedius*, *S. mystus*, *Serranochromis angusticeps*, *S. macrocephalus*, *S. robustus*, *Synodontis nigromaculatus*, *Thoracochromis wingatii*, *Tilapia sparrmanii* [Fig. 4.8.6C]

Galeiceps Railliet, 1916

Galeiceps sp. from *Clarias gariepinus*, *Hydrocynus vittatus*, *Thoracochromis wingatii*

Hysterothylacium Ward et Magath, 1917

Hysterothylacium sp. from *Chrysichthys nigrodigitatus*, *Thoracochromis wingatii*

*****Ascarididae Baird, 1853

Key to the genera of the Ascarididae from African freshwater fishes

1 (2) Oesophagus with spherical or elongate ventriculus…….****Porrocaecum***

2 (1) Oesophagus without ventriculus……. ****Amplicaecum***

List of the Ascarididae from African freshwater fishes

Amplicaecum Baylis, 1920

Amplicaecum sp. (type I) from *Alestes baremoze*, *A. dentex*, *Brycinus nurse*, *Bagrus bajad*, *B. docmak*, *Clarias anguillaris*, *C. gariepinus*, *Coptodon zillii*, *Hydrocynus brevis*, *H. forskahlii, H. vittatus*, *Labeo niloticus*, *Malapterurus electricus*, *Oreochromis niloticus*, *Polypterus endlicheri*, *P. senegalus*, *Sarotherodon galilaeus*, *Schilbe mystus*, *S. uranoscopus*, *Synodontis schall*

Amplicaecum sp. (type II) from *Coptodon zillii*, *Oreochromis niloticus*, *Sarotherodon galilaeus*

Porrocaecum Railliet et Henry, 1912

Porrocaecum sp. from *Clarias buthupogon*, *C. dumerilii*, *Micropterus salmoides*, *Periophthalmus barbarus*, *Tilapia* sp.

******Heterocheilidae Railliet et Henry, 1915

Key to the genera of the Heterocheilidae from African freshwater fishes

1 (2) Oesophagus with small posterior ventriculus with two anteriorly and three posteriorly directed appendices of different sizes……***Multicaecum***

2 (1) Ventriculus without appendices……..*****Dujardinascaris***

List of the Heterocheilidae (adults) from African freshwater fishes

Dujardinascaris Baylis, 1947

Dujardinascaris malapteruri (Baylis, 1923) from ***Malapterurus electricus*** (Sudan)

Dujardinascaris mormyropsis Moravec et Jirků, 2014 from ***Mormyrops anguilloides*** (Central African Rep.) [Fig. 4.8.4F]

Dujardinascaris sp. from *Lates microlepis*

Multicaecum Baylis, 1923

Multicaecum heterotis Petter, Vassiliadès et Marchand, 1979 from ***Heterotis niloticus*** (Senegal) [Fig. 4.8.4E]

SPIRURIDA Chitwood, 1933

Key to the suborders and superfamilies of the Spirurida from African freshwater fishes

1 (2) Pseudolabia always absent. Buccal capsule well developed, reduced or absent. Oesophagus divided into muscular and glandular portions or muscular throughout. Oesophageal glands usually uninucleate. Larvae without cephalic hooks, tail generally long and pointed, usually with conspicuous phasmids containing broad cavities and prominent pores. Parasites of gut of cold-blooded vertebrates or other organs of all classes of vertebrates. Intermediate hosts mostly copepods, rarely branchiurids or ostracods (suborder **Camallanina**)……3

2 (1) Head end with pseudolabia, sometimes rudimentary. Buccal capsule (stoma) usually elongate, moderately sclerotised tube. Oesophagus divided into well differentiated muscular and glandular parts. Oesophageal glands

usually multinucleate. Larvae usually with cephalic hooks or spines and inconspicuous pore-like phasmids, containing broad cavities and prominent pores. Parasites of gut or tissues of all classes of vertebrates. Intermediate host invertebrates other than copepods (except Gnathostomatoidea) (suborder **Spirurina**)……7

3 (4) Buccal capsule well developed, orange-brown in colour. Buccal cavity well developed; internal labial papillae tiny; parasitic in the digestive tract……**Camallanoidea**

4 (3) Buccal capsule reduced or absent (except for Anguillicoloidea). If buccal cavity present then simple, rounded, not separated into two valves, tridents absent; internal labial papillae prominent. Not usually parasitic in the digestive tract……5

5 (6) Oviparous. Buccal capsule well developed. Oesophagus short, undivided. Sclerotised copulatory organs absent. Vulva functional. Parasites of swim bladder of eels……**Anguillicoloidea**

6 (5) Viviparous. Buccal capsule usually reduced or absent. Oesophagus divided into muscular and glandular portions or muscular throughout. Spicules, copulatory plate or sclerotised genital cone present. Anus and vulva in gravid worms sometimes atrophied. Parasites of tissues, body cavity or closed cavities and organs of vertebrates……**Dracunculoidea**

7 (8) Buccal capsule well cuticularised, elongate or short. Pseudolabia present or absent……9

8 (7) Buccal capsule weakly cuticularised; two massive lateral trilobed pseudolabia present. Cuticle on the inner face of each pseudolabium thick, generally folded into rounded tooth-like formations that fit into corresponding folds on adjacent pseudolabium. Anterior extremity sometimes swollen into a bulb. Intermediate hosts are copepods or molluscs. Adults in fishes, reptiles and mammals, only larvae in fishes. Note: from Africa unpublished data……..***Gnathostomatoidea**

9 (10) Pseudolabia absent. Buccal capsule variable, sometimes long and cylindrical. Mouth opening hexagonal or oval. Caudal papillae not arranged as in typical spirurid. Adults in the intestine of fishes……**Thelazioidea**

10 (9) Pseudolabia present…… 11

11 (12) Two small pseudolabia present. Cephalic and outer labial papillae not fused. Adults in various organs of fishes……..**Habronematoidea**

12 (11) Two large pseudolabia present. Cephalic and outer labial papillae fused……13

13 (14) Pseudolabia involving entire cephalic surface. Cuticular cephalic ornamentation present, in form of cordons, collarettes or ptilina derived from ante-

rior cuticular structures. Larvae parasitic in arthropods and fishes, adults in birds……..... **Acuarioidea**

14 (13) Pseudolabia with a variable number of teeth on their free borders. Body cuticle immediately behind pseudolabia often expanded to form collarette. Male with ornamented cuticle in posteroventral region (area rugosa). Intermediate hosts insects……..**Physalopteroidea**

**ANGUILLICOLOIDEA Yamaguti, 1935

**Anguillicolidae Yamaguti, 1935

List of the Anguillicolidae from African freshwater fishes

***Anguillicoloides* Moravec et Taraschewski, 1988

Anguillicoloides crassus (Kuwahara, Niimi et Hagaki, 1974) from *Anguilla* spp.

Anguillicoloides papernai (Moravec et Taraschewski, 1988) from ***Anguilla mossambica*** (South Africa) [Fig. 4.8.3C]

CAMALLANOIDEA Railliet et Henry, 1915

Camallanidae Railliet et Henry, 1915

Key to the subfamilies, genera and subgenera of the Camallanidae from African freshwater fishes

1 (2) Buccal capsule round, continuous and not separated into two valves (*i.e.*, single cup-shaped object) (subfamily **Procamallaninae**)……3

2 (1) Buccal capsule divided into two valves united by a posterior hinge (subfamily **Camallaninae**)……5

3 (1) Buccal capsule interior smooth and without markings in both males and females……...***Procamallanus* (*Procamallanus*)**

4 (3) Buccal capsule interior with ridges arranged in a spiral……***Procamallanus* (*Spirocamallanus*)**

5 (2) Buccal capsule composed of two chambers; buccal cavity behind valves large……..***Paracamallanus***

6 (5) Buccal capsule composed of two chambers; buccal cavity behind valves reduced to basal ring……..***Camallanus***

List of the Camallanidae (adults) from African freshwater fishes

Camallanus Railliet et Henry, 1915

Camallanus (*Zeylanema*) *ctenopomae* Vassiliadès et Petter, 1972 [syn. *Camallanus ctenopomae* Vassiliadès et Petter, 1972] from ***Ctenopoma kingsleyae*** (Senegal), *Ctenopoma* sp.

Camallanus kirandensis Baylis, 1928 from ***Barbus* sp.** (Tanzania), *Labeo altivelis*, *L. niloticus*

Camallanus longicaudatus Moravec, 1973 from ***Labeo horie*** (Egypt), *Labeo niloticus* [Fig. 4.8.3F]

Camallanus polypteri Kabré et Petter, 1997 from *Clarias anguillaris*, ***Polypterus bichir*** (Burkina Faso), *Synodontis schall*

Camallanus sp. from *Clarias gariepinus*, *Clarotes laticeps*, *Coptodon zillii*, *Enteromius paludinosus*, *Labeo molybdinus*

Paracamallanus Yorke et Maplestone, 1926

Paracamallanus cyathopharynx Baylis, 1923 [syn. *Paracamallanus senegalensis* Vassiliadès, 1970] from *Clariallabes laticeps*, *Clarias anguillaris*, ***C. gariepinus*** (Egypt), *C. stappersii*, *C. theodorae*, *C. werneri*, *Clarias* sp., *Clarotes laticeps*, *Heterobranchus longifilis*, *Hydrocynus vittatus*, *Schilbe intermedius*, *Synodontis zambezensis*

Paracamallanus sp. from *Clarias gariepinus*

Procamallanus Baylis, 1923

Procamallanus (*Procamallanus*) *armatus* Campana-Rouget et Therezien, 1965 from ***Anguilla* sp.** (Madagascar)

Procamallanus (*Procamallanus*) *laeviconchus* (Wedl, 1861) [syn. *Cucullanus laeviconchus* Wedl, 1861] from *Astatotilapia desfontainii*, *Auchenoglanis biscutatus*, *A. occidentalis*, *Bagrus bajad*, *B. docmak*, *Campylomormyrus tamandua*, *Citharinus citharus*, *C. gibbosus*, *Clarias anguillaris*, *C. gariepinus*, *Distichodus brevipinnis*, *D. nefasch*, *D. rostratus*, *Malapterurus electricus*, *Marcusenius cyprinoides*, *Mormyrops anguilloides*, *Mormyrus caschive*, *M. rume*, *Schilbe intermedius*, *S. mystus*, *Synodontis batensoda*, *S. clarias*, *S. membranaceus*, *S. nigrita*, *S. nigromaculatus*, *S. ocellifer*, ***S. schall*** (Egypt), *S. sorex*, *S. thamalakanensis*, *S. vanderwaali*, *Tetraodon lineatus*

Procamallanus (*Procamallanus*) *pseudolaeviconchus* Moravec et Van As, 2014 from *Clarias alluaudi*, *C. anguillaris*, ***C. gariepinus*** (Egypt), *C. stappersii*, *C. theodorae*

Procamallanus (*Procamallanus*) *siluranae* (Jackson et Tinsley, 1995) from *Erpetoichthys calabaricus* (accidental infection)

Procamallanus (*Spirocamallanus*) *daleneae* (Boomker, 1993) from *Synodontis acanthomias*, *S. afrofischeri*, *S. batensoda*, *S. eupterus*, *S. haugi*, *S. membranaceus*, *S. ocellifer*, *S. schall*, *S. tessmanni*, *S. vanderwaali*, *S. victoriae*, ***S. zambezensis*** (South Africa)

Procamallanus (*Spirocamallanus*) *olseni* (Campana-Rouget et Razarihelissoa, 1965) from ***Rhabdosargus sarba*** (inland brackish-water lake) (South Africa)

Procamallanus (*Spirocamallanus*) *parachannae* Moravec et Jirků, 2015 from ***Parachanna insignis*** (Sudan)

Procamallanus (*Spirocamallanus*) *pseudospiralis* Moravec et Jirků, 2017 from *Synodontis frontosus*, *S. nigrita*, ***S. schall*** (Democratic Republic of the Congo)

Procamallanus (*Spirocamallanus*) *serranochromis* Moravec et Van As, 2015 from *Serranochromis angusticeps*, ***S. macrocephalus*** (Botswana), *S. robustus*

Procamallanus (*Spirocamallanus*) *spiralis* Baylis, 1923 [syn. *Spirocamallanus mazabukae* Yeh, 1957] from *Auchenoglanis occidentalis*, ***Clarias anguillaris*** (Egypt), *C. gariepinus*, *C. stappersii*, *C. theodorae*, *Hepsetus odoe*, *Polypterus endlicheri*, *Synodontis eupterus*, *S. tessmanni* [Fig. 4.8.3G]

Procamallanus (*Spirocamallanus*) sp. from *Synodontis afrofischeri*, *S. membranaceus*, *S. ocellifer*, *S. schall*

Procamallanus sp. from *Clarias gariepinus*, *C. pachynema*, *Clarias* sp., *Mormyrus* sp., *Synodontis schall*

List of the Camallanidae (larvae) from African freshwater fishes

Camalanidae gen. sp. from *Nothobranchius furzeri*, *N. kadleci*, *N. orthonotus*, *N. pienaari*

DRACUNCULOIDEA Cameron, 1934

Key to the families and genera of the Dracunculoidea from African freshwater fishes

1 (2) Spicules absent. Oesophagus distinctly divided into short anterior muscular part and posterior, longer glandular part with two large cell nuclei. Vulva anterior or pre-equatorial, well developed in mature female……family **Daniconematidae** (***Mexiconema***)

2 (1) Spicules present. Oesophagus short, undivided or with markedly large unicellular dorsal oesophageal gland with large cell nucleus; anterior part of oesophagus often bulbously inflated. Vulva posterior or equatorial, more or less completely atrophied in gravid female (family **Philometridae**)……3

3 (4) Cuticle of adult females smooth…….***Philometra***

4 (3) Cuticle of adult females with ornamentation……5

5 (6) Cuticle of adult females covered with numerous narrow transverse bands of raised cuticle, interrupted by narrow smooth lateral fields……...***Afrophilometra***

6 (5) Cuticle of adult females with bosses……7

7 (6) Bosses rounded……***Philometroides***

8 (7) Bosses conical……***Nilonema***

Daniconematidae Moravec et Køie, 1987

List of the Daniconematidae from African freshwater fishes

Mexiconema Moravec, Vidal et Salgado-Maldonado, 1992

Mexiconema africanum Moravec, Jirků, Charo-Karisa et Mašová, 2009 from ***Auchenoglanis occidentalis*** (Kenya) [Fig. 4.8.4D]

PHILOMETRIDAE Baylis et Daubney, 1926

List of the Philometridae from African freshwater fishes

Afrophilometra Moravec, Charo-Karisa et Jirků, 2009

Afrophilometra hydrocyoni (Fahmy, Mansour et El-Naffar, 1976) [syn. *Philometroides hydrocyonae* Fahmy, Mandour et El-Nafar, 1976] from ***Hydrocynus forskahlii*** (Egypt), *H. vittatus* [Fig. 4.8.5B]

Nilonema Khalil, 1960

Nilonema gymnarchi Khalil, 1960 from ***Gymnarchus niloticus*** (Sudan) [Fig. 4.8.5C]

Philometra Costa, 1845

Philometra bagri (Khalil, 1965) [syn. *Thwaitia bagri* Khalil, 1965] from ***Bagrus bajad*** (Sudan)

Philometra lati Moravec, Charo-Karisa et Jirků, 2009 from ***Lates niloticus*** (Kenya) [Fig. 4.8.5D]

Philometra spiriformis Moravec, Charo-Karisa et Jirků, 2009 from ***Lates niloticus*** (Kenya)

Philometroides Yamaguti, 1935

Philometroides africanus Moravec et Van As, 2001 from ***Hepsetus odoe*** (Botswana)

Philometroides khalili Moravec, Halajian, Tavakol, Nyagura et Luus-Powell, 2015 from *Labeo altivelis*, ***L. rosae*** (Zimbabwe) [Fig. 4.8.5E]

Philometridae gen. sp. from *Schilbe intermedius*, *Serranochromis meridianus*, *Synodontis zambezensis*

GNATHOSTOMATOIDEA Railliet, 1895

*Gnathostomatidae Railliet, 1895

List of the Gnathostomatidae (larvae) from African freshwater fishes

Gnathostomatidae gen. sp. from *Nothobranchius furzeri*, *N. kadleci*, *N. orthonotus*, *N. pienaari*

PHYSALOPTEROIDEA Railliet, 1893

Physalopteridae Railliet, 1893

List of the Physalopteridae from African freshwater fishes

Heliconema Travassos, 1919

Heliconema africanum (von Linstow, 1899) [syn. *Spiropterina africana* von Linstow, 1899] from ***Anguilla mossambica*** (South Africa) [Fig. 4.8.5F]

Physalopteridae gen. sp. from *Clarias gariepinus*, *Serranochromis angusticeps*

******THELAZIOIDEA **Skryabin, 1915**

******Rhabdochonidae **Travassos, Artigas et Pereira, 1928**

Key to the genera/subgenera of the Rhabdochonidae from African freshwater fishes

1(2) Two small unarmed pseudolabia, without teeth. Oesophagus long, not clearly divided into muscular and glandular portions ……genus ***Prosungulonema***

2(1) Pseudolabia rudimentary, prostom with teeth. Oesophagus divided into muscular and glandular portions (genus ***Rhabdochona***)……3

3(2) Prostom with 8 or 12 anterior teeth……subgenus ***Globochona***

4(3) Prostom with 14 anterior teeth……subgenus ***Rhabdochona***

List of the Rhabdochonidae (adults) from African freshwater fishes

Prosungulonema Roytman, 1963

Prosungulonema africanum (Moravec et Puylaert, 1970) [syn. *Johnstonmawsonia africana* Moravec et Puylaert, 1970] from ***Thoracochromis schwetzi*** (Angola) [Fig. 4.8.6A]

Prosungulonema campanae (Puylaert, 1973) [syn. *Johnstonmawsonia campanae* Puylaert, 1973] from ***Aphyosemion cameronense*** (Cameroon)*, Thoracochromis schwetzi*

Rhabdochona Railliet, 1916

Rhabdochona (*Rhabdochona*) *centroafricana* Moravec et Jirků, 2014 from ***Enteromius miolepis*** (Central African Republic) [Fig. 4.8.6B]

Rhabdochona (*Rhabdochona*) *esseniae* Mashego, 1990 from *Enteromius lineomaculatus*, *E. paludinosus*, *E. trimaculatus*, *Labeobarbus marequensis* (South Africa)

Rhabdochona (*Rhabdochona*) *gendrei* Campana-Rouget, 1961 from ***Barbus* sp.** (Gambia), *Enteromius camptacanthus*, *E. lineomaculatus*, *E. paludinosus*, *E. trimaculatus*, *Labeobarbus altianalis*, *L. bynni*, *L. intermedius*, *L. marequensis*

Rhabdochona (*Rhabdochona*) *marcusenii* Moravec et Jirků, 2014 from ***Marcusenius greshoffii*** (Central African Republic)

Rhabdochona (*Rhabdochona*) *moraveci* Puylaert, 1973 [syn. *Afrochona camerounensis* Puylaert, 1973] from ***Aphyosemion cameronense*** (Cameroon)

Rhabdochona (*Rhabdochona*) *srivastavai* Chabaud, 1970 from ***Sicyopterus fasciatus*** (Madagascar)

Rhabdochona (*Globochona*) *gambiana* Gendre, 1922 [syn. *Cystidicola minuta* Rodhain et Vuylsteke, 1934] from *Enteromius eutaenia*, *Raiamas moorii*

Rhabdochona (*Globochona*) *paski* Baylis, 1928 [syns *Rhabdochona aegyptica* El-Nafar et Saoud, 1974; *Rhabdochona congolensis* Campana-Rouget, 1961; *Rhabdochona versterae* Boomker et Petter, 1993] from *Alestes baremoze*, *A. dentex*, ***A. macrophthalmus*** (Tanzania), *Anguilla anguilla*, *Bagrus bajad*, *B. docmak*, *Brycinus imberi*, *B. nurse*, *Chrysichthys nigrodigitatus*, *Clarias gariepinus*, *Coptodon zillii*, *Ctenopoma kingsleyae*, *Haplochromis eduardii*, *H. elegans*, *H. graueri*, *H. ishmaeli*, *H. nigripinnis*, *H. nubilus*, *H. serridens*, *H. squamipinnis*, *Haplochromis* sp., *Hydrocynus brevis*, *H. forskahlii*, *Labeobarbus altianalis*, *L. bynni*, *Oreochromis niloticus*, *Phenacogrammus aurantiacus*, *Polypterus senegalus*, *Schilbe mystus*, *Synodontis batensoda*, *S. nigromaculatus*, *S. notatus*, *S. schall*, *Thoracochromis wingatii*

Rhabdochona (*Globochona*) *tricuspidata* Moravec et Jirků, 2014 from ***Raiamas christyi*** (Central African Republic)

Rhabdochona (*Globochona*) sp. from *Epiplatys multifasciatus*

Rhabdochona sp. from *Anguilla anguilla*, *Clarias gariepinus*, *Coptodon rendalli*, *Hydrocynus forskahlii*, *Labeobarbus bynni*, *Schilbe intermedius*, *Serranochromis meridianus*, *Synodontis zambezensis*

List of the Rhabdochonidae (larvae) from African freshwater fishes

Rhabdochona Railliet, 1916

Rhabdochona (*Globochona*) *paski* Baylis, 1928 [syn. *R. congolensis* Campana-Rouget, 1961] from *Auchenoglanis occidentalis*, *Synodontis nigromaculatus*, *Thoracochromis wingatii*

Rhabdochona sp. from *Brycinus macrolepidotus*, *Labeo niloticus*, *Mormyrus caschive*

HABRONEMATOIDEA Chitwood et Wehr, 1932

Cystidicolidae Skryabin, 1946

Key to the genera of the Cystidicolidae from African freshwater fishes

1(2) Cephalic cuticle forming collarette similar to that of physalopterids. Parasitic in the alimentary tract of marine and freshwater fishes……..***Pseudoproleptus***

2 (1) Cuticle with marked ornamentation in form of numerous transverse rings with spines. Parasitic in the alimentary tract of fishes, generally in freshwater……***Spinitectus***

List of the Cystidicolidae from African freshwater fishes

Pseudoproleptus Khera, 1953

Pseudoproleptus africanus Khalil, 1973 from ***Mormyrus* sp.** (Democratic Republic of the Congo) [Fig. 4.8.4C]

Spinitectus Fourment, 1883

Spinitectus allaeri Campana-Rouget, 1961 [syns *Spinitectus macheirus* Boomker et Puylaert, 1994; *Spinitectus macilentus* Boomker et Puylaert, 1994; *Spinitectus minusculus* Boomker et Puylaert, 1994; *Spinitectus moraveci* Boomker et Puylaert, 1994] from ***Alestes dentex***, ***Bagrus bajad***, *B. docmak*, *Clarias gariepinus*, *Clarias* sp., *Heterobranchus isopterus*, ***Lates niloticus***, ***Malapterurus electricus***, *Mormyrus caschive*, *Pantodon buchholzi*, ***Schilbe mystus*** (type host not explicitly mentioned, all from Democratic Republic of the Congo), *Synodontis schall*, *Xenoclarias eupogon*

Spinitectus macilentus Boomker et Puylaert, 1994 from ***Heterobranchus isopterus*** (Ivory Coast)

Spinitectus maleficus Boomker et Puylaert, 1994 from ***Mastacembelus flavidus*** (Democratic Republic of the Congo)

Spinitectus micropectus Boomker et Puylaert, 1994 from ***Mastacembelus micropectus*** (Democratic Republic of the Congo)

Spinitectus monstrosus Boomker et Puylaert, 1994 from ***Mormyrops boulengeri*** (Democratic Republic of the Congo)

Spinitectus mormyri Campana-Rouget, 1961 from ***Mormyrus caschive*** (Democratic Republic of the Congo), *M. rume*

Spinitectus mucronatus Boomker et Puylaert, 1994 from ***Mormyrops anguilloides*** (Democratic Republic of the Congo), *Mormyrops boulengeri*, *M. zanclirostris*

Spinitectus petterae Boomker, 1993 from ***Clarias gariepinus*** (South Africa)

Spinitectus polli Campana-Rouget, 1961 [syn. *Spinitectus zambezensis* Boomker, 1993] from *Synodontis decorus*, *S. nigromaculatus*, ***S. schall*** (Democratic Republic of the Congo), *S. zambezensis* [Fig. 4.8.4G]

Spinitectus thurstonae Ogden, 1967 from ***Mormyrus* sp.** (Uganda)

Spinitectus sp. from *Alestes macrolepidotus*, *Hydrocynus forskahlii*, *H. vittatus*, *Schilbe intermedius*, *Synodontis nigromaculatus*

** ACUARIOIDEA Railliet, Henry et Sisoff, 1912

**Acuariidae Railliet, Henry et Sissoff, 1912

List of the Acuariidae from African freshwater fishes

***Chordocephalus* Alegret, 1941

Chordocephalus sp. [syn. *Skrjabinocara* sp.] from *Clarias gariepinus*

Note: one adult female, three fourth-stage larvae and one unidentifiable nematode found in one catfish; they were very probably ingested by the catfish after regurgitation by a white-breasted cormorant whilst feeding chicks (Boomker 1982).

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Chapter 4.9.
CRUSTACEA

Nico SMIT & Kerry HADFIELD

Crustaceans (Crustacea) – basic characteristics, life cycles, classification and principal diagnostic features

- phylum Arthropoda: subphylum Crustacea
- approximately 67,000 species classified in 65 orders (including free-living and parasitic)
- no internal skeleton – only hard chitinous exoskeleton
- old exoskeleton shed by moulting
- two pairs of antennae
- three pairs of mouthparts
- head with two compound eyes
- biramous appendages (split into two)
- gaseous exchange through gills
- abdominal segments with swimming legs (swimmerets)
- tail segment fan-shaped, ending in a telson and uropods
- sexual reproduction (most have separate sexes but some are hermaphrodites)
- several larval stages (including the nauplius larva)
- circulatory system open (no heart, blood does not circulate in blood vessels)
- two part-nervous system with a ventral nerve cord and system of ganglia

The general classification of free-living and parasitic crustaceans is based on well-defined orders (65 at present). In almost every order of the Crustacea there are species in some kind of association with other species. This ranges from facultative to highly specialised parasitism where the parasite undergoes total morphological adaptation, becoming metabolically completely reliant on the host for its survival. In freshwater, crustaceans are mostly associated with fish, but there are a few examples of lernaeid copepods and branchiurans associated with tadpoles and invertebrates.

Life cycles and strategies differ among the different groups of parasitic Crustacea and range from temporary parasites that move between the hosts and substrate (*e.g.*, *Argulus* spp.) and permanently attached parasites (*e.g.*, *Chonopeltis* spp.) that complete their life cycle on the hosts. The number of life stages also differs between groups where, for example, the larvae of species from the copepod genera *Ergasilus* and *Lamproglena* are free swimming and only females become parasitic after a few moults (as copepodites) [Fig. 4.9.1]. All copepod appendages can exhibit sexual dimorphism, but typically this is most commonly found in the

antennulae, maxillipeds and fifth swimming legs. The precise pattern of sexual dimorphism is highly variable and thus the taxonomy of parasitic copepods is based on the adult female in most cases.

The parasitic Crustacea are characterised mainly by the morphology of the body, mouthparts and appendages. Generic classification and species identification is also based on the size and shape of the various appendages and many other characteristics (see below).

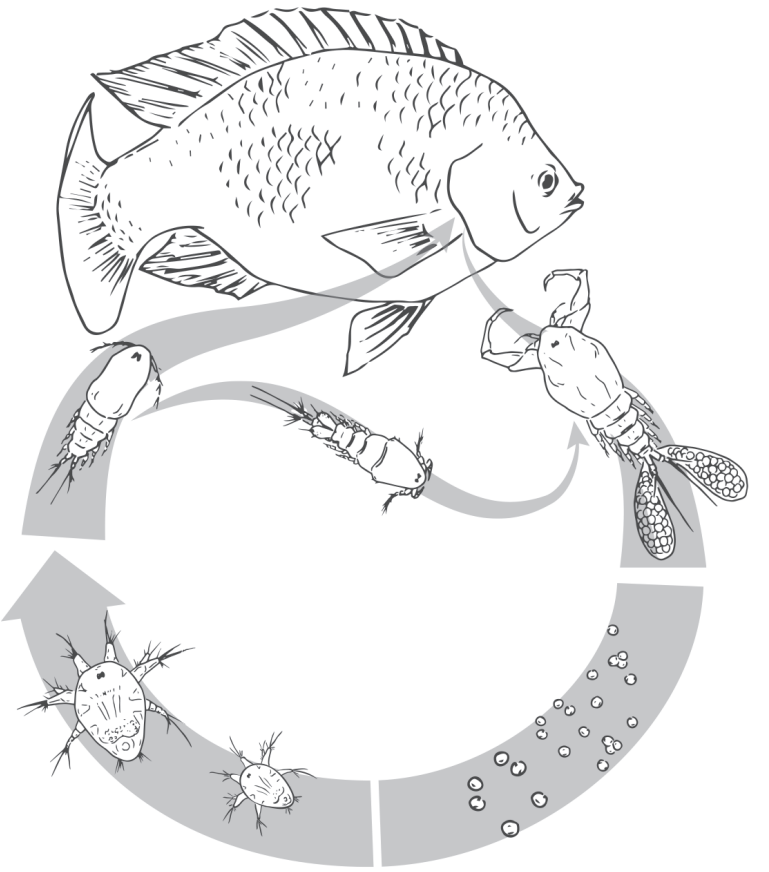

Fig. 4.9.1. Life cycle of *Ergasilus* sp. showing the free-living naupliar and copepodid stages as well as the parasitic adult female. (Illustration by M. Luo.)

Key to the orders of crustaceans (Crustacea) from African freshwater fishes

1 (2) Body dorsoventrally flattened; 4-7 pairs of legs……3

2 (1) Body elongate and not flattened……5

3 (4) Suction discs or hooks present; cephalic shield present; second maxillae terminating with large hooks; egg-sacs present; four pairs of legs on the thorax [Fig. 4.9.2A,B]…… **Arguloida**

4 (3) Suction discs and shield absent; no cephalic shield; mouthparts form a tightly sealed mouth cone; egg sacs absent (young in brood pouch); seven pairs of legs on the thorax [Fig. 4.9.4A]……..**Isopoda**

5 (6) Worm-like body shape, body clearly segmented; anteriorly there is a singular mouth and two pairs of hooks; egg-sacs absent [Fig. 4.9.5F] ……..**Porocephalida**

6 (5) Body cylindrical or irregularly shaped, not always clearly segmented; egg-sacs present (from female abdomen)……7

7 (8) Oral cone present with stylet-like mandibles [Fig. 4.9.6B] ……**Siphonostomatoida**

8 (7) Oral cone absent; often falcate mandibles……..9

9 (10) Long, cylindrical body; antennulae long (but shorter than the length of the body); uniramous antennae [Fig. 4.9.3D]……**Cyclopoida**

10 (9) Body cylindrical or abdomen narrower than the thorax; antennulae reduced in size; antennae modified into hooks [Fig. 4.9.4C]……**Poecilostomatoida**

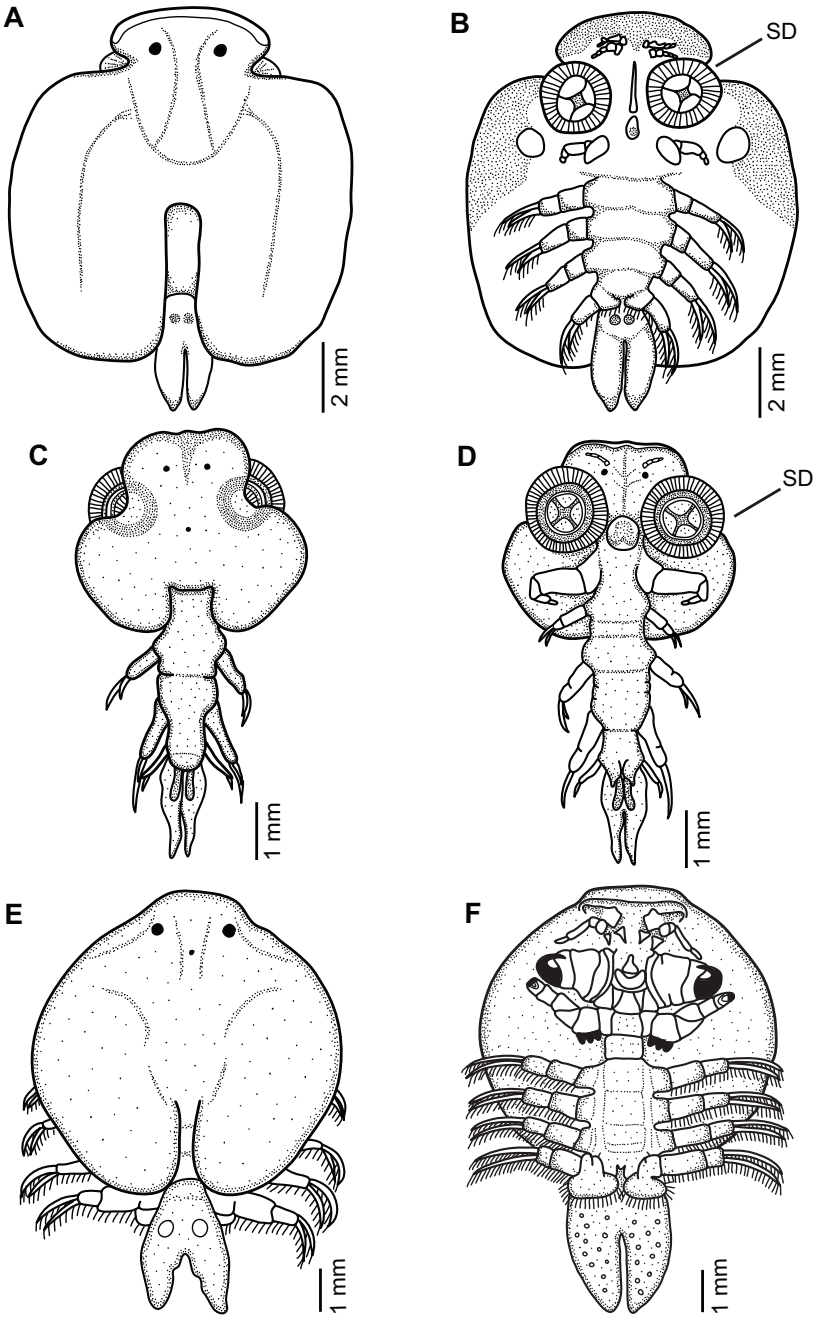

Fig. 4.9.2. Arguloida. **A, B.** *Argulus multipocula* Barnard, 1955, dorsal and ventral views; **C, D.** *Chonopeltis flaccifrons* Fryer, 1960, dorsal and ventral views; **E, F.** *Dolops ranarum* (Stuhlmann, 1892), dorsal and ventral views. (Modified from Fryer 1960; Avenant *et al.* 1989; Smit *et al.* 2005.) SD = suction discs.

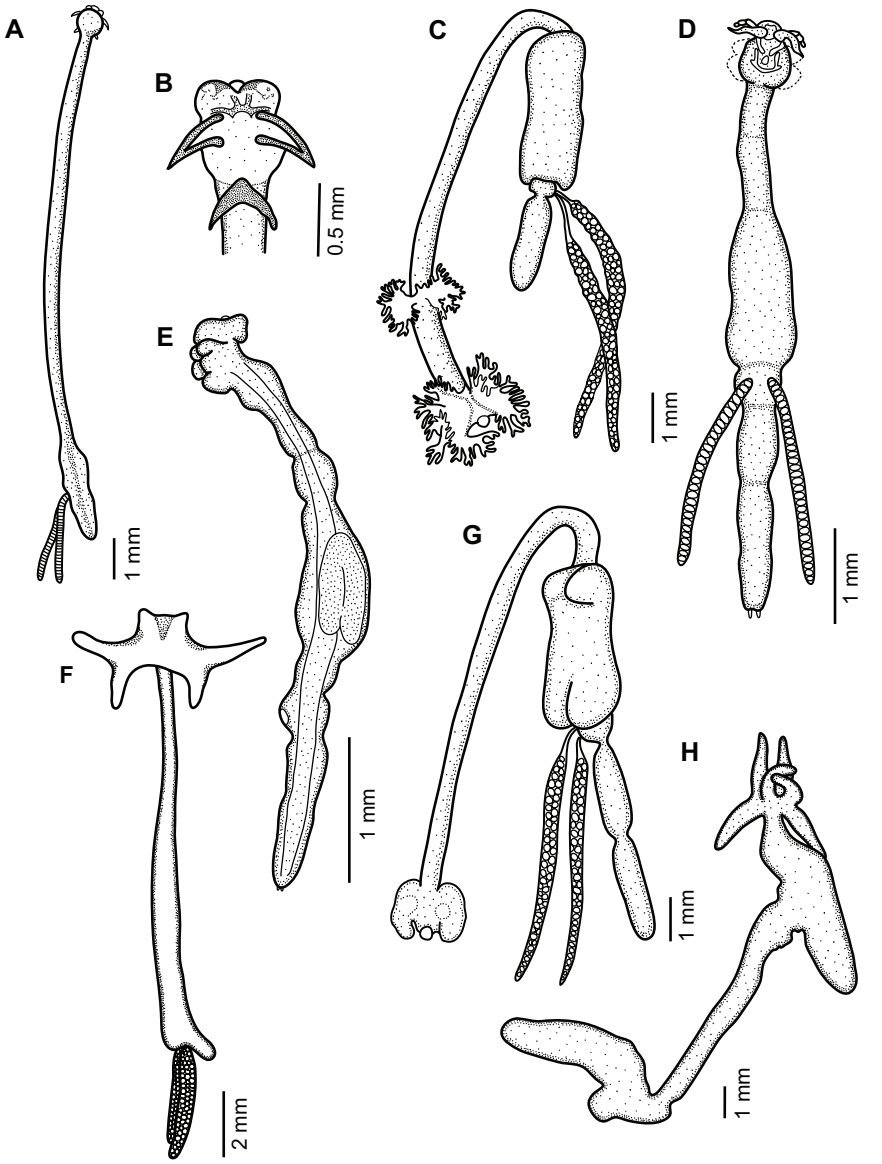

Fig. 4.9.3. Cyclopoida. **A, B.** *Afrolernaea longicollis* Fryer, 1956, entire body and cephalon; **C.** *Dysphorus torquatus* Kurtz, 1924, entire body; **D.** *Lamproglena clariae* Fryer, 1956; **E.** *Lamproglenoides vermiformis* Fryer, 1964; **F.** *Lernaea cyprinacea* Linnaeus, 1758; **G.** *Lernaeogiraffa heterotidicola* Zimmermann, 1922; **H.** *Opistholernaea laterobrachialis* (Fryer, 1959). (Modified from Kurtz 1924; Fryer 1956, 1959, 1964; Marx & Avenant-Oldewage 1996.)

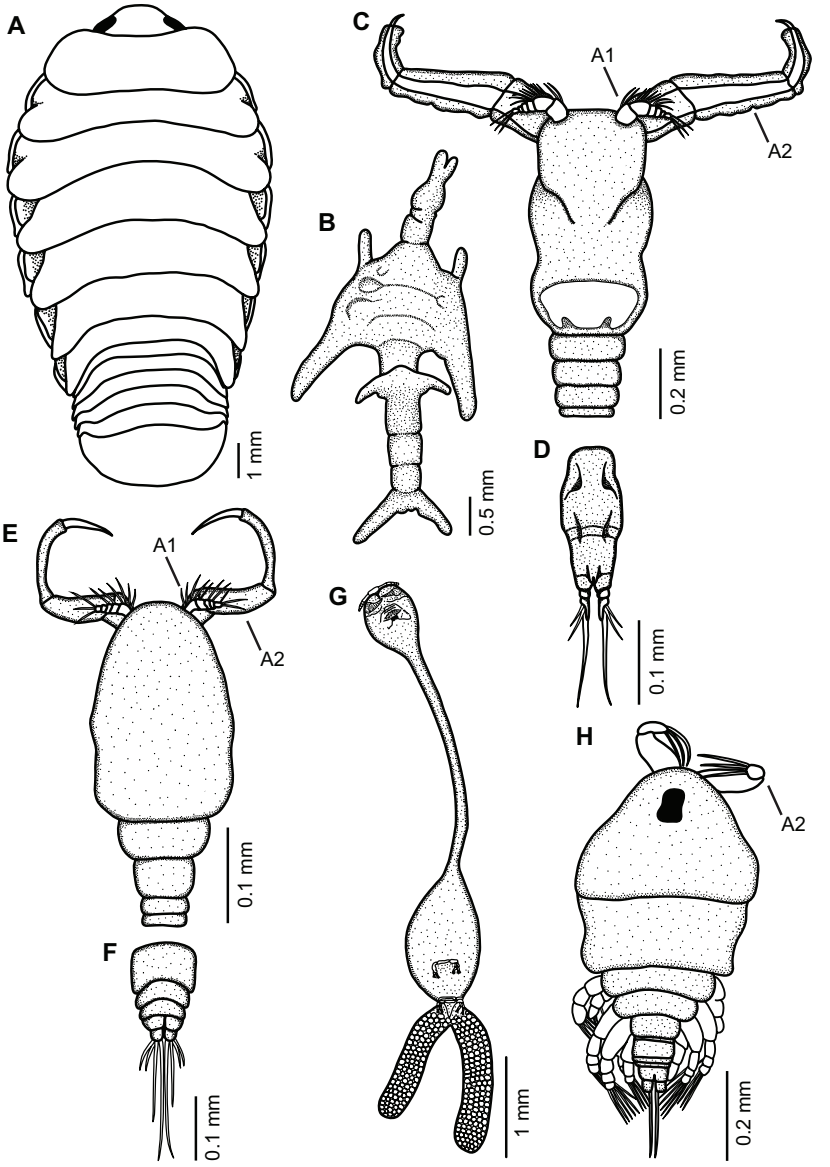

Fig. 4.9.4. Isopoda. **A.** *Ichthyoxenos tanganyikae* (Fryer, 1965); Poecilostomatoida. **B.** *Colobomatus mugilis* Raibaut, Caillet et Ben Hassine, 1978; **C, D.** *Dermoergasilus mugilis* Oldewage et Van As, 1988, dorsal view of antennae, cephalothorax and thorax, and ventral view of genital segment and abdomen; **E, F.** *Ergasilus ilani* Oldewage et Van As, 1988, dorsal view of antennae, cephalothorax and thorax, and ventral view of genital segment and abdomen; **G.** *Mugilicola smithae* Jones et Hine, 1978; **H.** *Paraergasilus minutus* (Fryer, 1956). (Modified from Fryer 1956, 1965; Oldewage & Van As 1988b; Radujković & Raibaut 1990; Kruger *et al.* 1998.) A1 = first antenna; A2 = second antenna.

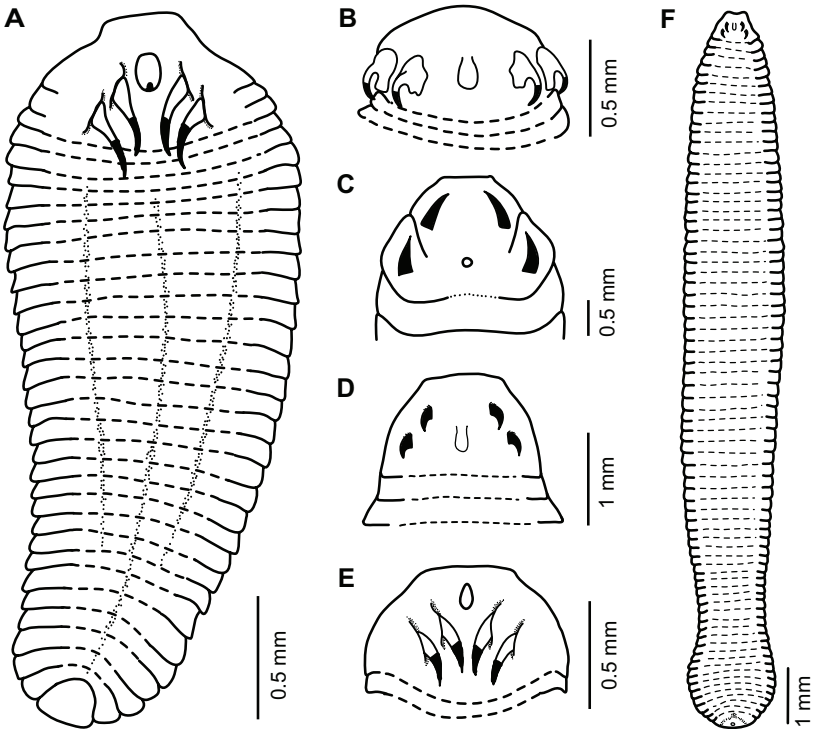

Fig. 4.9.5. Porocephalida. **A.** *Subtriquetra rileyi* Junker, Boomker et Booyse, 1998, entire body of infective larva; **B.** *Alofia* Giglioli in Sambon, 1922, cephalon; **C.** *Leiperia* Sambon, 1922, cephalon; **D.** *Sebekia* Sambon, 1922, cephalon; **E.** *Subtriquetra rileyi* Junker, Boomker et Booyse, 1998, cephalon; **F.** *Alofia merki* Giglioli in Sambon, 1922, entire body of female adult. (Modified from Riley 1994; Junker *et al.* 1998; Christoffersen & De Assis 2013.)

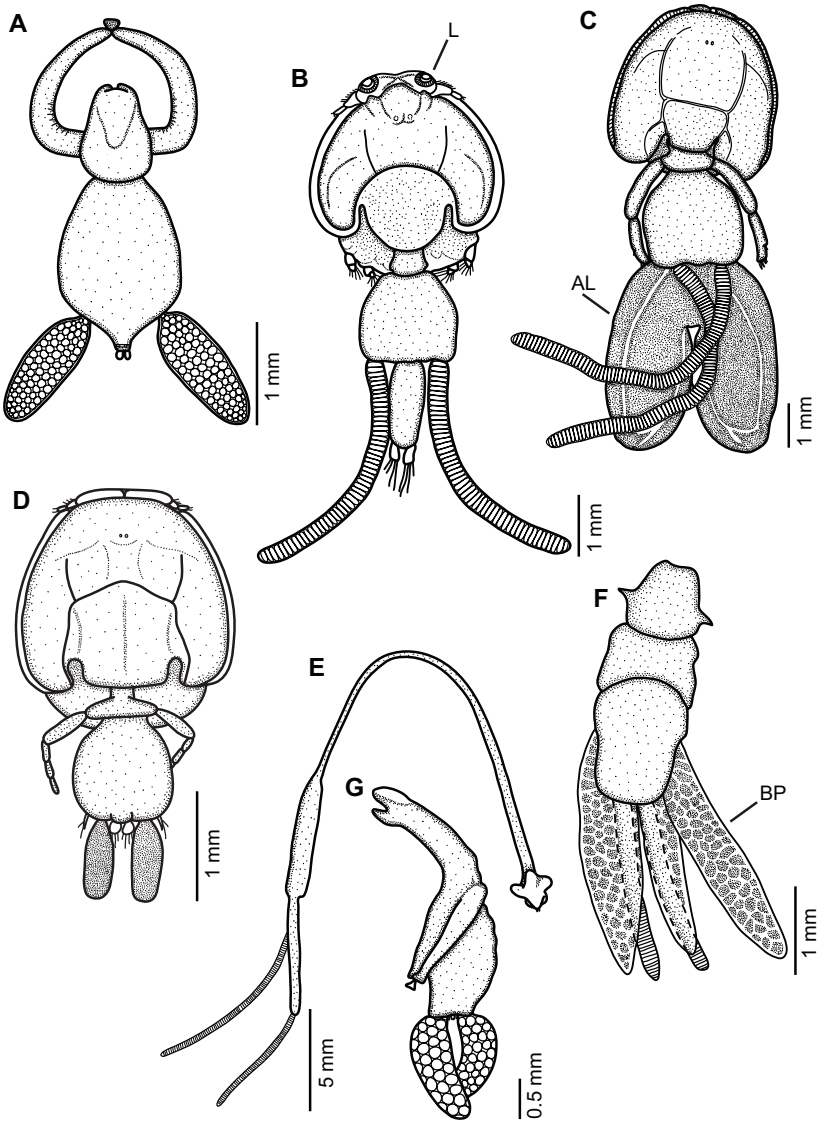

Fig. 4.9.6. Siphonostomatoida. **A.** *Achtheres micropteri* Wright, 1882; **B.** *Caligus apodus* (Brian, 1924); **C.** *Dartevellia bilobata* Brian, 1939; **D.** *Lepeophtheirus plotosi* Barnard, 1948; **E.** *Lernaeenicus neglectus* Richiardi, 1877; **F.** *Lernanthropsis mugilis* (Brian, 1898); **G.** *Parabrachiella mugilis* (Kabata, Raibaut et Ben Hassine, 1971). (Modified from Barnard 1948, 1955; Kabata *et al.* 1971; Raibaut *et al.* 1971; Radujković & Raibaut 1990; Dojiri & Ho 2013.) AL = abdominal alae; BP = bilobate processes; L = lunules.

Keys to genera are provided where applicable. Species are listed alphabetically according to individual crustacean orders. Type species of genera and type host of species are highlighted in bold where available. When no type host is indicated, it means that no type host was originally designated from Africa, and if multiple hosts are indicated it signifies that the original description included more than one host with no specific type host designated. If known, the country where the type locality is situated is also provided. Host names are according to Froese & Pauly (2017) and *Catalog of Fishes* (Eschmeyer *et al.* 2017). Some of the species listed here include those parasitising mullets (Mugilidae) and other fish families that can cross over from marine and brackish regions into the freshwater environment.

ARGULOIDA Yamaguti, 1963 (subclass Branchiura Thorell, 1864)

Key to the genera of the Arguloida (adults) from African freshwater fishes (for a key to the species of *Argulus* see Rushton-Mellor 1994; for a key to the species of *Chonopeltis* see Fryer 1977)

1 (2) Ventral suction discs absent (stout hooks on the first maxilla) [Fig. 4.9.2E,F] ……***Dolops***

2 (1) Ventral suction discs present (modified first maxilla)……3

3 (4) One pair of antennae (antennula absent); carapace anteriorly constricted; thorax elongate (approximately the same length as the carapace); retractable poison stylet absent [Fig. 4.9.2C,D]……...***Chonopeltis***

4 (3) Two pairs of antennae; carapace subcircular; thorax short (approximately half the length of the carapace); retractable poison stylet in front of the mouth tube [Fig. 4.9.2A,B]……***Argulus***

List of the Arguloida (adults) from African freshwater fishes

(* indicates marine or brackish water species that might cross over into freshwater)

Argulus Müller, 1785

Argulus africanus Thiele, 1900 from *Anguilla labiata*, *Bagrus degeni*, *B. docmak*, *B. meridionalis*, *Chrysichthys brachynema*, *Clarias anguillaris*, *C. gariepinus*, ***Clarias* sp.** (Lake Malawi), *Haplochromis guiarti*, *H. obesus*, *H. obliquidens*, *H. retrodens*, *Heterobranchus bidorsalis*, *H. longifilis*, *Heterobranchus* sp., *Hydrocynus vittatus*, *Labeo* sp., *Lates microlepis*, *Mormyrops anguilloides*, *M. longirostris*, *Oreochromis esculentus*, *O. macrochir*, *O. niloticus*, *O. variabilis*, *Polypterus* sp., *Protopterus aethiopicus*, *Schilbe banguelensis*, *Schilbe* sp., *Tilapia* sp.

Argulus alexandrensis* Wilson, 1923 from ***Zeus* sp. (Angola)

Argulus ambloplites Wilson, 1920 from *Clarias gariepinus*, *Hydrocynus vittatus*, ***Parachanna obscura*** (Democratic Republic of the Congo)

Argulus angusticeps Cunnington, 1913 (Lake Tanganyika) – no hosts recorded

**Argulus arcassonensis* Cuénot, 1912 [syns *Argulus otolithi* Brian, 1927; *Argulus zei* Brian, 1924] from *Pseudotolithus typus*, *Zeus faber*

**Argulus belones* van Kampen, 1909 from *Sphyraena barracuda*

Argulus brachypeltis Fryer, 1959 from ***Hydrocynus vittatus*** (Zimbabwe)

Argulus capensis Barnard, 1955 from ***Sandelia capensis*** (South Africa)

Argulus confusus Rushton-Mellor, 1994 [this species is the male originally described as *A. ambloplites* by Wilson in 1920] – no hosts recorded

Argulus cunningtoni Fryer, 1965 from ***Auchenoglanis occidentalis***, ***Bagrus bajad***, ***Clarias gariepinus***, ***Distichodus nefasch***, ***Lates niloticus***, *Lates* sp., *Serranochromis robustus*, ***Synodontis schall*** (all Lake Albert)

**Argulus dactylopteri* Thorell, 1865 from *Dactylopterus volitans*

Argulus dageti Dollfus, 1960 from ***Clarias anguillaris***, ***Heterobranchus bidorsalis***, ***Tetraodon lineatus*** (all Mali)

Argulus dartevellei Brian, 1940 from ***Polydactylus quadrifilis*** (Angola), *Promicrops distalis*

Argulus exiguus Cunnington, 1913 from ***Lamprichthys tanganicanus***, ***Simochromis diagramma*** (both Lake Tanganyika)

Argulus fryeri Rushton-Mellor, 1994 from *Coptodon zillii*

Argulus gracilis Rushton-Mellor, 1994 from ***Auchenoglanis occidentalis*** (Lake Tanganyika)

Argulus incisus Cunnington, 1913 from ***Auchenoglanis occidentalis*** (Lake Tanganyika)

Argulus izintwala Van As et Van As, 2001 from ***Hilsa kelee*** (South Africa)

Argulus japonicus Thiele, 1900 [invasive species] [syns *Argulus matritensis* Arevalo, 1921; *Argulus pelucidus* Wagler, 1935] from *Clarias gariepinus*, *Cyprinus carpio*, *Enteromius mattozi*, *Labeo capensis*, *L. umbratus*, *Labeobarbus aeneus*, *L. kimberleyensis*, *L. marequensis*, *Oncorhynchus mykiss*, *Oreochromis mossambicus*, *Tilapia sparrmanii*

Argulus jollymani Fryer, 1956 from ***Haplochromis* sp.**, ***Protomelas fenestratus*** (both Lake Malawi)

Argulus kosus* Avenant-Oldewage, 1994 [syn. *Argulus smalei* Avenant-Oldewage et Oldewage, 1995] from *Aluterus monoceros*, *Elops machnata*, *Liza luciae*, *Mugil cephalus*, *Oreochromis mossambicus*, *Otolithes ruber*, *Pomadasys commersonnii*, *P. multimaculatus*, *Rhabdosargus holubi*, ***Sarpa salpa* (South Africa)

Argulus melita* van Beneden, 1891 from **shark (Senegal)

Argulus monodi Fryer, 1959 from *Coptodon zillii*, ***Hydrocynus vittatus*** (Zimbabwe)

Argulus multipocula Barnard, 1955 from *Chelon richardsonii* [Fig. 4.9.2A,B]

Argulus personatus Cunnington, 1913 from *Bathybates fasciatus*, ***B. ferox*** (Lake Tanganyika)

Argulus reticulatus Wilson, 1920 from ***Hydrocynus goliath*** (Democratic Republic of the Congo)

Argulus rhipidiophorus Monod, 1931 from *Alestes baremoze*, *Bagrus bajad*, *Barbus* sp., *Clarias gariepinus*, *Clarias* sp., *Haplochromis pappenheimi*, *Haplochromis* sp., *Hydrocynus forskahlii*, *H. vittatus*, ***Hydrocynus* sp.** (Lake Albert), *Labeo* sp., *Lates niloticus*, *Lates* sp., *Oreochromis leucostictus*, *O. niloticus*, *Synodontis schall*, *Tilapia* sp.

Argulus rijckmansii Brian, 1940 – no hosts recorded

Argulus rubescens Cunnington, 1913 from ***Chrysichthys brachynema*** (Lake Tanganyika)

Argulus rubropunctatus Cunnington, 1913 from *Lates angustifrons*, ***Lates microlepis*** (Lake Tanganyika)

Argulus schoutedeni Monod, 1928 from *Citharinus gibbosus*, *Distichodus fasciolatus*

Argulus striatus Cunnington, 1913 from ***Auchenoglanis occidentalis***, ***Chrysichthys brachynema***, ***Clarias gariepinus***, ***Dinotopterus cunningtoni*** (all Lake Tanganyika), *Heterobranchus* sp., *Oreochromis tanganicae*

Argulus trachynoti* Brian, 1927 from ***Trachinotus blochii* (Cameroon)

Argulus vittatus* (Rafinesque-Schmaltz, 1814) [syns *Agenor purpureus* Risso, 1826; *Argulus giganteus* Lucas, 1845; *Argulus purpureus* (Risso, 1826); *Diprosia vittata* Rafinesque, 1814] from *Boops boops*, ***Pagellus erythrinus*, *Pagrus pagrus*, *Sparus aurata*

Argulus wilsoni Brian, 1940 from ***Hydrocynus goliath*** (Democratic Republic of the Congo)

Chonopeltis Thiele, 1900

Chonopeltis australis Boxshall, 1976 from ***Labeo capensis***, ***L. rosae*** (both South Africa), *L. umbratus*, *Labeobarbus aeneus*

Chonopeltis brevis Fryer, 1961 from *Amphilius grandis*, *Amphilius* sp., *Chrysichthys nigrodigitatus*, *Garra* sp., *Labeo cylindricus*, ***L. victorianus*** (Lake Victoria), ***Labeobarbus altianalis*** (Nile River)

Chonopeltis congicus Fryer, 1959 [syn. *Chonopeltis inermis* var. *schoutedeni* Brian, 1940 *partim*] from ***Marcusenius monteiri*** (Zimbabwe)

Chonopeltis elongatus Fryer, 1974 from ***Synodontis longirostris*** (Democratic Republic of the Congo)

Chonopeltis flaccifrons Fryer, 1960 from ***Cyphomyrus discorhynchus*** (Lake Mweru), ***Hippopotamyrus wilverthi*** (Democratic Republic of the Congo), ***Marcusenius* sp.** (Malagarasi River Swamps) [Fig. 4.9.2C,D]

Chonopeltis fryeri Van As, 1986 from ***Clarias gariepinus***, ***C. theodorae*** (both South Africa)

Chonopeltis inermis Thiele, 1900 from *Bathyclarias nyasensis*, ***Chromis* sp.** (East Africa), *Clarias gariepinus*, *C. theodorae*

Chonopeltis lisikili Van As et Van As, 1996 from ***Synodontis leopardinus*** (Botswana), *S. macrostigma*, *S. nigromaculatus*, *S. thamalakanensis*, *S. vanderwaali*

Chonopeltis liversedgi Van As et Van As, 1999 from ***Mormyrus lacerda*** (Botswana)

Chonopeltis meridionalis Fryer, 1964 [syns *Chonopeltis koki* Van As, 1992; *Chonopeltis victori* Avenant-Oldewage, 1991] from *Labeo congoro*, *L. cylindricus*, ***L. rosae*** (Zimbabwe), *L. ruddi*, *Labeobarbus marequensis*

Chonopeltis minutus Fryer, 1977 [syn. *Chonopeltis australissimus* Fryer, 1977] from *Pseudobarbus burgi*, ***P. calidus***, ***P. erubescens*** (both South Africa)

Chonopeltis schoutedeni Brian, 1940 [syn. *Chonopeltis inermis* var. *schoutedeni* Brian, 1940 *partim*] from *Cyphomyrus discorhynchus*, *Marcusenius macrolepidotus*, *M. monteiri*, *Mormyrus longirostris*, *Mormyrus* sp.

Dolops Audouin, 1837

Dolops ranarum (Stuhlmann, 1892) [syn. *Gyropeltis ranarum* Stuhlmann, 1892] from *Astatoreochromis alluaudi*, *Auchenoglanis occidentalis*, *Bagrus bajad*, *B. degeni*, *B. docmak*, *Chetia flaviventris*, *Chrysichthys* sp., *Clarias anguillaris*, *C. gariepinus*, *C. stappersii, Clarias* sp., *Coptodon rendalli*, *C. zillii*, *Enteromius mattozi*, **frog tadpoles** (Lake Malawi), *Hepsetus cuvieri*, *H. odoe*, *Heterobranchus bidorsalis*, *Heterobranchus* sp., *Labeo altivelis*, *L. congoro*, *Labeobarbus marequensis*, *Lates microlepis*, *L. niloticus*, *Micropterus dolomieu*, *M. salmoides*, *Mormyrops anguilloides*, *M. longirostris*, *Oreochromis andersonii*, *O. esculentus*, *O. macrochir*, *O. mortimeri*, *O. mossambicus*, *O. niloticus*, *O. variabilis*, *Parachanna obscura*, *Protopterus aethiopicus*, *Pseudocrenilabrus philander*, *Sargochromis carlottae*, *S. codringtonii*, *S. giardi*, *Serranochromis macrocephalus, S. robustus, Serranochromis* sp., *Schilbe intermedius*, *S. mystus*, *Schilbe* sp., *Synodontis nigromaculatus*, *S. zambezensis*, *Tetraodon lineatus*, *Tilapia* sp. [Fig. 4.9.2E,F]

CYCLOPOIDA Burmeister, 1834

Key to the genera of the Cyclopoida (adults) from African freshwater fishes (for a key to the species of *Lernaea* see Harding 1950; for a key to the species of *Lamproglena* see Fryer 1964)

1 (2) Body clearly segmented; with antennulae and antennae…….3

2 (1) Body not clearly segmented; no antennulae or antennae…….9

3 (4) Body elongate and cylindrical; caudal rami short or produced (extended)……5

4 (3) Body sub-cylindrical, irregularly swollen; caudal rami reduced; maxilla and maxilliped united laterally [Fig. 4.9.3E]…….***Lamproglenoides***

5 (6) Body bent (twisted) up to 180° angle; thorax elongate; posterior part of the body (abdomen) abruptly thickened…….....7

6 (5) Body not bent, with robust maxillipeds terminating in 1-5 claws; thorax with legs, first two segments forming a distinct short neck; abdomen not thickened, with three segments [Fig. 4.9.3D]…….***Lamproglena***

7 (8) Head horns dendritic (head and neck with branched appendages); two abdominal segments [Fig. 4.9.3C]……..***Dysphorus***

8 (7) Head horns rounded, short and soft; no branched neck appendages; three abdominal segments [Fig. 4.9.3G]……..***Lernaeogiraffa***

9 (10) Very long and narrow neck; head with short protuberances anteriorly; pair of robust maxillae terminating in a recurved spine [Fig. 4.9.3A,B]…… ……...***Afrolernaea***

10 (9) Shorter neck; head with noticeable horn-like structures……11

11 (12) Head with 2-3 (rarely 4) large horns (pointed or swollen); body may gradually thicken towards the posterior end [Fig. 4.9.3F]……..***Lernaea***

12 (11) Head with 4 horns, 2 posterior horns directed backwards to form 90° angle; lateral outgrowth extends from the upper neck region [Fig. 4.9.3H] ……***Opistholernaea***

List of the Cyclopoida (adults) from African freshwater fishes

Afrolernaea Fryer, 1956

Afrolernaea annemari Oldewage, 1994 from ***Clarias gariepinus*** (Namibia)

Afrolernaea brevicollis Fryer, 1982 from ***Stomatorhinus corneti*** (Gabon)

Afrolernaea edi Oldewage, 1994 from ***Marcusenius macrolepidotus***, ***Mormyrops anguilloides***, ***Petrocephalus catostoma*** (all Namibia)

Afrolernaea longicollis Fryer, 1956 from *Cyphomyrus discorhynchus*, *Marcusenius macrolepidotus*, ***Mormyrops anguilloides***, ***M. longirostris*** (both Lake Malawi), *Mormyrops* sp. [Fig. 4.9.2A,B]

Afrolernaea mormyroides Van As, 1983 from ***Marcusenius macrolepidotus*** (South Africa)

Afrolernaea nigeriensis (Dollfus, 1960) [syn. *Delamarina nigeriensis* Dollfus, 1960] from ***Mormyrus rume*** (Niger River)

Dysphorus Kurtz, 1924

Dysphorus torquatus Kurtz, 1924 from ***Heterotis niloticus*** (Sudan) [Fig. 4.9.3C]

Lamproglena von Nordmann, 1832

Lamproglena angusta Wilson, 1924 from ***Malapterurus electricus*** (Nile River)

Lamproglena barbicola Fryer, 1961 from ***Labeobarbus altianalis*** (Lake Victoria)

Lamproglena clariae Fryer, 1956 from *Clarias anguillaris*, ***C. gariepinus***, *C. ngamensis*, ***Clarias* sp.** (both Lake Malawi)**,** *Lates niloticus* [Fig. 4.9.3D]

Lamproglena cleopatra Humes, 1957 from ***Labeo forskalii*** (Nile River)

Lamproglena cornuta Fryer, 1965 from *Clarias gariepinus*, ***Heterobranchus bidorsalis*** (Nile River)

Lamproglena elongata Capart, 1956 from ***Citharinus citharus*** (Sudan), *C. latus*, *Hydrocynus vittatus*

Lamproglena hemprichii von Nordmann, 1832 [syn. *Lamproglena aubentoni* Dollfus, 1960] from *Alestes dentex*, *Brycinus nurse*, *Clarotes laticeps*, *Hepsetus odoe*, *Hydrocynus brevis*, *H. forskahlii*, *H. vittatus*, ***Hydrocynus* sp.** (Nile River)

Lamproglena hepseti Van As et Van As, 2007 from ***Hepsetus cuvier*** (previously *H. odoe*) (Botswana)

Lamproglena hoi Dippenaar, Luus-Powell et Roux, 2001 from ***Labeobarbus marequensis*** (South Africa), ***L. polylepis*** (South Africa)

Lamproglena intercedens Fryer, 1964 from *Citharinus* sp.

Lamproglena monodi Capart, 1944 [syn. *Lamproglena nyasae* Fryer, 1956] from *Coptodon rendalli*, *C. zillii*, *Haplochromis bicolor*, *H. degeni*, *H. eduardii*, *H. guiarti*, *H. macrops*, *H. nubilus*, *H. pappenheimi*, *H. retrodens*, *H. schubotzi*, *H. serridens*, *H. squamipinnis*, *Haplochromis* sp., *Hemichromis bimaculatus*, *H. fasciatus*, *Oreochromis esculentus*, *O. macrochir*, *O. niloticus*, *O. variabilis*, *Orthochromis polyacanthus*, *O. stormsi*, *Pseudocrenilabrus philander*, *Pterochromis congicus*, *Sargochromis codringtonii*, *Sarotherodon galilaeus*, *Schwetzochromis neodon*, *Serranochromis macrocephalus*, *S. thumbergi*, *Thoracochromis callichromus*, *T. moeruensis*, *T. schwetzi*, *T. wingatii*, *Tylochromis labrodon*

Lamproglena werneri Zimmermann, 1922 from *Auchenoglanis occidentalis*, ***Bagrus bajad*** (Nile River)

Lamproglena wilsoni Capart, 1955 – no hosts reported

Lamproglenoides Fryer, 1964

Lamproglenoides vermiformis Fryer, 1964 from ***Labeo cylindricus*** ("African Eastern Rivers") [Fig. 4.9.3E]

Lernaea Linnaeus, 1758

Lernaea bagri Harding, 1950 from ***Bagrus meridionalis*** (Lake Malawi)

Lernaea barbicola Leigh-Sharpe, 1930 from ***Barbus* sp.** (South Africa), *Malapterurus electricus*

Lernaea barilius Harding, 1950 from ***Opsaridium microlepis*** (Lake Malawi), *Raiamas steindachneri*

Lernaea barnimiana (Hartmann, 1865) [syns *Lernaea temnocephala* (Cunnington, 1914); *Lernaeocera barnimii* Hartmann, 1870; *Lernaeocera temnocephala* Cunnington, 1914] from *Coptodon zillii*, *Haplochromis nubilus*, *Labeo altivelis*, *L. capensis*, *L. congoro*, *L. cylindricus*, *L. forskalii*, *L. rosae*, *L. umbratus*, *L. victorianus*, *Labeobarbus aeneus*, *L. altianalis*, *L. bynni*, *L. intermedius*, *L. marequensis*, *Lates niloticus*, *Oreochromis esculentus*, *O. leucostictus*, *O. macrochir*, *O. mossambicus*, *O. niloticus*, *O. variabilis*, *Oreochromis* sp., *Tylochromis mylodon*, *Tylochromis* sp.

Lernaea bistricornis Harding, 1950 from *Boulengerochromis microlepis*, *Callochromis pleurospilus*, ***Cardiopharynx schoutedeni*** (Lake Tanganyika), *Cyathopharynx furcifer*

Lernaea composita Wilson, 1924 [syns *Lernaea werneri* (Kurtz, 1922); *Lernaeocera werneri* Kurtz, 1922] from *Clarias gariepinus*, *Distichodus nefasch*, ***Malapterurus electricus*** (Sudan)

Lernaea cyprinacea Linnaeus, 1758 [invasive species] [syns *Lernaea carassii* Tidd, 1933; *Lernaea elegans* Leigh-Sharpe, 1925; *Lernaea esocina* (Burmeister, 1835); *Lernaea ranae* Stunkard et Cable, 1931*; Lernaea tentaculis* Linnaeus, 1746; *Lernaea tentaculis quatuor* Linnaeus, 1746; *Lernaeocera cyprinacea* (Linnaeus, 1746); *Lernaeocera gasterostei* Bruhl, 1860] from *Bagrus docmak*, *Coptodon rendalli*, *Labeo altivelis*, *L. capensis*, *L. congoro*, *L. cylindricus*, *L. rosae*, *L. ruddi*, *Labeobarbus kimberleyensis*, *L. marequensis*, *Oreochromis aureus*, *O. mossambicus*, *O. niloticus*, *O. placidus*, *Pseudocrenilabrus philander*, *Tilapia* sp. [Fig. 4.9.3F]

Lernaea diceracephala (Cunnington, 1914) [syn. *Lernaeocera diceracephala* Cunnington, 1914] from ***Clarias gariepinus*** (Lake Tanganyika), *Heterobranchus longifilis*

Lernaea haplocephala (Cunnington, 1914) [syns *Lernaea bichiri* (Kurtz, 1923); *Lernaeocera bichiri* Kurtz, 1923; *Lernaeocera haplocephala* Cunnington, 1914] from *Labeobarbus aeneus*, ***Polypterus bichir*** (White Nile), ***P. congicus*** (Lake Tanganyika), ***P. senegalus*** (White Nile)

Lernaea hardingi Fryer, 1956 [syn. *Lernaea* sp. cf. *lophiara* Harding, 1950] from *Brycinus nurse*, *Chrysichthys mabusi*, *Coptodon zillii*, ***Nyassachromis serenus***, *Oreochromis niloticus*, ***Rhamphochromis lucius*** (both Lake Malawi), *Sargochromis mellandi*, *Sarotherodon galilaeus*, *Synodontis nigromaculatus*

Lernaea inflata Fryer, 1961 from ***Enteromius argenteus*** (Victoria Nile)

Lernaea lophiara Harding, 1950 from *Copadichromis quadrimaculatus*, ***Coptodon zillii***, ***Diplotaxodon argenteus***, *Labeo cylindricus*, *Labeobarbus johnstonii*, ***Lethrinops lethrinus***, ***L. micrentodon***, *Mylochromis incola*, ***Nyassachromis breviceps***, *N. nigritaeniatus*, ***N. prostoma***, *Otopharynx argyrosoma*, *Placidochromis johnstoni*, ***Rhamphochromis lucius***, ***Taeniolethrinops praeorbitalis***, ***Tropheops tropheops*** (all Lake Malawi)

Lernaea palati Harding, 1950 from ***Copadichromis chrysonotus*** (Lake Malawi)

Lernaea senegali (Zimmermann, 1922) [syn. *Lernaeocera senegali* Zimmermann, 1922] from ***Polypterus senegalus*** (Sudan)

Lernaea tilapiae Harding, 1950 from ***Oreochromis lidole***, ***O. squamipinnis*** (both Lake Malawi)

Lernaea tuberosa Harding, 1950 from ***Engraulicypris sardella*** (Lake Malawi)

Lernaeogiraffa Zimmermann, 1922

Lernaeogiraffa heterotidicola Zimmermann, 1922 from ***Heterotis niloticus*** (Nile River) [Fig. 4.9.3G]

Opistholernaea Yin, 1960

Opistholernaea contorta Fryer, 1965 from ***Distichodus brevipinnis***, ***D. rostratus*** (both Niger River)

Opistholernaea laterobrachialis (Fryer, 1959) [syn. *Lernaea laterobrachialis* Fryer, 1959] from *Oreochromis andersonii*, ***O. macrochir*** (Zambia), *O. niloticus* [Fig. 4.9.3H]

Opistholernaea longa (Harding, 1950) [syn. *Lernaea longa* Harding, 1950] from *Lates angustifrons*, *L. microlepis*, ***L. niloticus*** (Lake Turkana)

ISOPODA Latreille, 1817

List of the Isopoda (adults) from African freshwater fishes

Ichthyoxenos Herklots, 1870

Ichthyoxenos africana (Lincoln, 1972) from ***Lepidiolamprologus attenuatus***, ***L. elongatus*** (both Lake Tanganyika)

Ichthyoxenos expansus Van Name, 1920 from ***Eugnathichthys eetveldii*** (Democratic Republic of the Congo)

Ichthyoxenos tanganyikae (Fryer, 1965) from ***Simochromis diagramma*** (Lake Tanganyika) [Fig. 4.9.4A]

POECILOSTOMATOIDA Thorell, 1859

Key to the genera of the Poecilostomatoida (adults) from African freshwater fishes (for a key to the species of Ergasilidae see Oldewage & Van As 1988a)

1 (2) Body form elongate……3

2 (1) Body generally short and teardrop-shaped……7

3 (4) Thorax 6-segmented, segments 3-4 always fused and enlarged, with two pairs of divergent lateral lobes in form of “X” [Fig. 4.9.4B]…… ……***Colobomatus***

4 (3) Thorax without segmentation; long, slender neck with no appendages; three pairs of biramous legs on abdomen [Fig. 4.9.4G]…….. ***Mugilicola***

5 (6) Thick cuticular covering on second antennae [Fig. 4.9.4C]…… ……...***Dermoergasilus***

6 (5) No cuticular covering on second antennae……7

7 (8) Terminal segment of second antennae smooth and subdivided into three pointed processes [Fig. 4.9.4H]……***Paraergasilus***

8 (7) Terminal segment of second antennae sclerotised and with a single point [Fig. 4.9.4E,F]……***Ergasilus***

List of the Poecilostomatoida (adults) from African freshwater fishes

(* indicates marine or brackish water species that might cross over into freshwater)

Colobomatus Hesse, 1873

**Colobomatus mugilis* Raibaut, Caillet et Ben Hassine, 1978 from *Chelon aurata*, *C. labrosus*, *C. ramada*, *C. saliens* [Fig. 4.9.4B]

Dermoergasilus Ho et Do, 1982

Dermoergasilus mugilis* Oldewage et Van As, 1988 from *Chelon richardsonii*, ***Mugil cephalus* (South Africa), *Pseudomyxus capensis* [Fig. 4.9.4C,D]

Ergasilus von Nordmann, 1832

Ergasilus cunningtoni Capart, 1944 from *Brycinus leuciscus*, *B. nurse*, *Campylomormyrus elephas*, *Distichodus atroventralis*, *D. rostratus*, *Enteromius macrops*, *Hippopotamyrus psittacus*, *Hydrocynus forskahlii*, *Marcusenius greshoffii*, *M. moorii*, *Mormyrops anguilloides*, *M. macrophthalmus*, *M. nigricans*, *Pellonula leonensis*, *Petrocephalus grandoculis*, *Phago loricatus*, *Pollimyrus isidori*, *Pterochromis congicus*, *Raiamas senegalensis*, *Schilbe laticeps*, *Synodontis nigriventris*, *Tylochromis lateralis*, *T. microdon*

Ergasilus flaccidus Fryer, 1965 from ***Oreochromis tanganicae*** (Lake Tanganyika)

Ergasilus ilani* Oldewage et Van As, 1988 from ***Mugil cephalus* (South Africa) [Fig. 4.9.4E,F]

Ergasilus inflatipes Cressey in Cressey et Collette, 1970 from ***Strongylura senegalensis*** (Ghana)

Ergasilus kandti van Douwe, 1912 from *Bagrus bajad*, *Citharinus citharus*, *Lamprologus lemairii*, *Lates niloticus*, *Limnotilapia dardennii*, *Oreochromis tanganicae*, *Plecodus paradoxus*, *Pseudosimochromis curvifrons*, *Pterochromis congicus*, *Synodontis membranaceus*, *Tilapia* sp., *Tylochromis bangwelensis*, *T. mylodon*, *T. polylepis*

Ergasilus lamellifer Fryer, 1961 from *Astatoreochromis alluaudi*, *Haplochromis bicolor*, *H. degeni*, *H. guiarti*, *H. longirostris*, *H. nuchisquamulatus*, *H. obesus*, *H. obliquidens*, *H. retrodens*, ***Haplochromis* sp.** (Uganda), *Parailia pellucida*

Ergasilus latus Fryer, 1960 from *Auchenoglanis occidentalis*, *Chrysichthys nigrodigitatus*, *Coptodon guineensis*, *C. zillii*, ***Oreochromis niloticus***, *Pelmatolapia cabrae*, ***Sarotherodon galilaeus*** (both Lake Turkana), *S. melanotheron*, *S. nigripinnis*, *Schilbe mystus*

**Ergasilus lizae* Krøyer, 1863 [syn. *Ergasilus nanus* van Beneden, 1870] from *Alosa fallax*, *Barbus barbus*, *Chelon ramada*, *C. saliens*, *Mugil cephalus*, *Solea solea*

Ergasilus macrodactylus (Sars, 1909) [syn. *Ergasiloides macrodactylus* Sars, 1909] from *Brycinus imberi, Haplochromis* sp., *Lethrinops* sp., *Pseudotropheus* sp., *Tilapia* sp.

Ergasilus megacheir (Sars, 1909) [syn. *Ergasiloides megacheir* Sars, 1909] from *Bathybates fasciatus*, *B. minor*, *Cyphotilapia frontosa*, *Haplotaxodon microlepis*, *Limnotilapia dardennii*, *Plecodus paradoxus*, *Pterochromis congicus*, *Simochromis* sp., *Synodontis granulosus*, *S. multipunctatus*

Ergasilus mirabilis Oldewage et Van As, 1987 from *Brycinus imberi*, *Clarias gariepinus, C. ngamensis, Cyphomyrus discorhynchus*, *Enteromius afrohamiltoni*, *Glossogobius giuris*, *Hemichromis elongatus*, *Hepsetus odoe*, *Hydrocynus vittatus, Labeo rosae*, *Marcusenius macrolepidotus*, *Petrocephalus catostoma*, *Schilbe intermedius*, *S. mystus*, ***Synodontis leopardinus*** (South Africa), *S. macrostigma*, *S. nigromaculatus*, *S. zambezensis*

Ergasilus nodosus Wilson, 1924 from ***Bagrus bajad*** (Sudan)*, Bagrus* sp., *Brycinus leuciscus*, *B. nurse*, *Campylomormyrus elephas*, *Distichodus atroventralis*, *Hippopotamyrus psittacus*, *Pellonula leonensis*, *Petrocephalus grandoculis*, *Phago loricatus*, *Pterochromis congicus*, *Synodontis nigriventris*, *Tylochromis lateralis*, *T. microdon*

Ergasilus sarsi Capart, 1944 from *Brycinus imberi*, *Clarias anguillaris*, *C. gariepinus*, *C. ngamensis*, *Heterobranchus bidorsalis, Lamprichthys tanganicanus*, *Marcusenius macrolepidotus*, *Pseudotropheus* sp., *Synodontis nigromaculatus*, *Thoracochromis moeruensis*, *Tylochromis bangwelensis*, *T. microdon*, *T. mylodon*

****Ergasilus sieboldi*** von Nordmann, 1832 [syns *Ergasilus baikalensis* Messjatzeff, 1928; *Ergasilus depressus* Sars, 1862; *Ergasilus esocis* Sumpf, 1871; *Ergasilus hoferi* Borodin, 1915; *Ergasilus surbecki* Baumann, 1912; *Ergasilus trisetoceus* von Nordmann, 1832] from *Chelon aurata*, *C. ramada*, *C. saliens*, *Mugil cephalus*

Mugilicola Tripathi, 1960

Mugilicola smithae* Jones et Hine, 1978 from ***Anguilla mossambica* (South Africa), *Crenimugil seheli*, *Planiliza alata*, *P. macrolepis*, *Pseudomyxus capensis* [Fig. 4.9.4G]

Paraergasilus Markevich, 1937

Paraergasilus lagoonaris Paperna, 1969 from ***Aplocheilichthys* sp.**, ***Awaous lateristriga***, ***Coptodon guineensis***, ***Pellonula leonensis***, ***Sarotherodon melanotheron***, ***Sierrathrissa leonensis*** (all Ghana)

Paraergasilus minutus (Fryer, 1956) [syn. *Trigasilus minutus* Fryer, 1956] from ***Petrotilapia tridentiger***, ***Tropheops tropheops*** (both Lake Malawi) [Fig. 4.9.4H]

POROCEPHALIDA Heymons, 1935

List of the Porocephalida from African freshwater fishes

Only larval Porocephalida stages are known to infect fish hosts [Fig. 4.9.5A], however, the morphological information available for the different species on this infective stage is limited. As adults are usually found in the definitive piscivorous vertebrate host (usually a reptile), life-cycle studies or molecular identification may need to be completed for accurate species identification at nymph level.

Alofia Giglioli in Sambon, 1922

Alofia sp. from *Oreochromis mossambicus* [Fig. 4.9.5B]

Leiperia Sambon, 1922

Leiperia cincinnalis (Sambon in Vaney et Sambon, 1910) [syns *Porocephalus nematoides* Beauchamp, 1918; *Reighardia cincinnalis* Sambon in Vaney et Sambon, 1910] from *Alestes macrophthalmus*, *Bathybates ferox*, *Chrysichthys brachynema*, *C. mabusi*, *Coptodon rendalli*, *Lates microlepis*, *L. niloticus*, *Mastacembelus* sp., *Oreochromis mossambicus*, *O. niloticus*, *Sargochromis giardi*, *Serranochromis meridianus* [Fig. 4.9.5C]

Leiperia gracilis (Diesing, 1836) [syns *Leiperia neotropica* Heymons et Vitzthum, 1935; *Pentastoma gracile* Diesing, 1836; *Porocephalus crocodili* Wheeler, 1915] from *Alestes macrophthalmus*, *Chrysichthys mabusi*

Sebekia Sambon, 1922

Sebekia minor (Wedl, 1861) [syns *Pentastoma oxycephalum minor* Wedl, 1861; *Sebekia wedli* Giglioli in Sambon, 1922] from *Coptodon rendalli*, *Marcusenius macrolepidotus*, *Oreochromis mossambicus*, *Poecilia reticulata*

Sebekia okavangoensis Riley et Huchzermeyer, 1995 from *Clarias gariepinus* [Fig. 4.9.5D]

Subtriquetra Sambon, 1922

Subtriquetra rileyi Junker, Boomker et Booyse, 1998 from ***Coptodon rendalli***, ***Oreochromis mossambicus*** (type host not explicitly mentioned; South Africa) [Fig. 4.9.5A,E]

SIPHONOSTOMATOIDA Thorell, 1859

Key to the genera of the Siphonostomatoida (adults) from African freshwater fishes

1 (2) Caudal ramus and posterior processes absent……3

2 (1) Caudal ramus or posterior processes present……5

3 (4) Conical abdomen; lunules present; short and stout egg sacs; genital process absent [Fig. 4.9.6A]……..***Achtheres***

4 (3) Large abdominal alae (wing-like structures); lunules absent; long and slender egg-sacs; 4th somite free and without dorsal plates [Fig. 4.9.6C]……***Dartevellia***

5 (6) Body elongate and cylindrical ……7

6 (5) Body oval, round or irregularly shaped; lacking dorsal plates……..9

7 (8) Body not clearly segmented, with long thoracic neck; legs 1-2 uniramous, legs 3-4 biramous [Fig. 4.9.6E]……..***Lernaeenicus***

8 (7) Body segmented; distinct groove between the cephalothorax and trunk; pits and grooves absent; biramous antennae [Fig. 4.9.6G]…… ……..***Parabrachiella***

9 (10) Lunules present; head and first three thoracic segments fused (4th free) [Fig. 4.9.6B]……....***Caligus***

10 (9) Frontal lunules absent……...11

11 (12) Head and first three thoracic segments fused (4th free); antennula 2-segmented, antenna 3-segmented; 4th leg uniramous [Fig. 4.9.6D]…… ……***Lepeophtheirus***

12 (11) Antennula 9-segmented, antenna 4-segmented; 4th leg with a pair of long, bilobate processes attached to posterolateral corner of trunk [Fig. 4.9.6F] ……***Lernanthropsis***

List of the Siphonostomatoida (adults) from African freshwater fishes

(* indicates marine or brackish water species that might cross over into freshwater)

Achtheres von Nordmann, 1832

Achtheres micropteri Wright, 1882 from *Micropterus salmoides* [Fig. 4.9.6A]

Caligus Müller, 1785

**Caligus apodus* (Brian, 1924) [syns *Pseudocaligus apodus* Brian, 1924; *Pseudolepeophtheirus mediterraneus* Paperna, 1964] from *Chelon aurata*, *C. labrosus*, *C. ramada*, *C. saliens*, *Mugil cephalus* [Fig. 4.9.6B]

Caligus engraulidis* Barnard, 1948 from *Chelon tricuspidens*, *Mugil cephalus*, ***Stolephorus holodon* (South Africa)

**Caligus mugilis* Brian, 1935 [syns *Caligus minimus mugilis* Brian, 1935; *Caligus minimus* var. *mugilis* Brian, 1935] from *Chelon labrosus*

Caligus pageti* Russell, 1925 [syn. *Caligus argilasi* Brian, 1931] from *Chelon aurata,* ***C. ramada* (Egypt), *C. saliens*, *Mugil cephalus*

**Caligus pharaonis* von Nordmann, 1832 [syns *Lepeophtheirus pharaonis* (von Nordmann, 1832); *Sciaenophilus inopinus* Humes, 1957; *Sciaenophilus pharaonis* (von Nordmann, 1832)] – no hosts reported

Dartevellia Brian, 1939

Dartevellia bilobata Brian, 1939 from ***Arius* sp.** (Democratic Republic of the Congo) [Fig. 4.9.6C]

Lepeophtheirus von Nordmann, 1832

Lepeophtheirus monacanthus Heller, 1865 from *Arius latiscutatus, Carlarius heudelotii*

Lepeophtheirus plotosi Barnard, 1948 from ***Plotosus lineatus*** (South Africa) [Fig. 4.9.6D]

Lernaeenicus Le Sueur, 1824

**Lernaeenicus neglectus* Richiardi, 1877 from *Chelon ramada*, *C. saliens* [Fig. 4.9.6E]

Lernanthropsis Ho et Do, 1985

**Lernanthropsis mugilis* (Brian, 1898) [syn. *Lernanthropus mugilis* Brian, 1898] from *Chelon aurata* [Fig. 4.9.6F]

Parabrachiella Wilson, 1915

**Parabrachiella mugilis* (Kabata, Raibaut et Ben Hassine, 1971) [syns *Eubrachiella mugilis* Kabata, Raibaut et Ben Hassine, 1971; *Neobrachiella mugilis* (Kabata, Raibaut et Ben Hassine, 1971)] from *Chelon aurata*, *C. saliens* [Fig. 4.9.6G]

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Chapter 4.10.

HIRUDINEA

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Leeches (Hirudinea) – basic characteristics, life cycles, classification and principal diagnostic features

- phylum Annelida, class Clitellata (segmented worms)
- approximately 680 species globally (480 freshwater)
- cylindrical body
- posterior and anterior disc-shaped suckers
- 34 body segments (constant and do not correspond with the number of rings/annuli observed externally as is seen in other annelids)
- segments divided into rings or annuli (the number of annuli per segment in the middle of the body is taxon-specific)
- number of annuli per segment become progressively reduced towards either end of the body
- each segment with a single, transverse row of sensory structures called sensillae
- no internal skeleton
- often with elaborate colour patterns or brightly coloured
- hermaphrodites
- gaseous exchange through the skin
- eyes and oculiform spots to detect movement
- intermediate hosts for Digenea
- vectors for blood parasites (Haematozoa)

The subclass Hirudinea is divided into two orders based on the morphology of the proboscis and vascular system. Leeches of the order Arhynchobdellida Blanchard, 1894 have a non-protrusible muscular pharynx (with or without jaws) and a haemocoelomic system. Species of the order Rhynchobdellida Blanchard, 1894 have a protrusible proboscis and true vascular system. Sawyer (1986) comprehensively summarised leech biology, behaviour and systematics.

Leeches are hermaphroditic, having separate female and male reproductive systems in one organism. Cross-fertilisation occurs when mating leeches intertwine and spermatozoa are transferred (either by means of a protrusible penis, enclosed in hardened spermatophores, or injected into the body surface of the recipient leech). Internal fertilisation occurs followed by the production of a hardened cocoon (egg case). These cocoons are attached to a solid surface and contain all the eggs as well as a fluid to provide sustenance and energy to the eggs as they grow. Most leeches abandon the cocoons at this stage, but the glossiphoniid leeches show parental care during egg development and after the juveniles have hatched. Once

the juveniles hatch from the cocoons they will seek out a potential host to feed on (Oosthuizen & Siddall 2003).

Leeches are often only temporary ectoparasites and will leave their host shortly after a blood meal. However, some leeches (particularly marine species) may spend most of their lives on a host. In large numbers some leeches can even kill their host (Cruz-Lacierda *et al.* 2000). Leeches can also act as intermediate hosts and vectors for other parasites. Hayes *et al.* (2014) noted a marine fish trypanosome from South Africa, *Trypanosoma nudigobii* Fantham, 1919, inside the marine fish host as well as in the marine leech, *Zeylanicobdella arugamensis* De Silva, 1963. Morphological and molecular techniques were used to confirm the identity of the same trypanosome in both the fish and the leech. The role of a leech as an intermediate host is also known. Recently, *Helobdella adiastola* Ringuelet, 1972, *Helobdella triserialis* (Blanchard, 1849), *Haementeria eichhorniae* Ringuelet, 1978, and *Haementeria* sp. were noted as secondary intermediate hosts for the digenean, *Australapatemon magnacetabulum* Dubois, 1988, in Argentina (see Davies & Ostrowski de Núñez 2012).

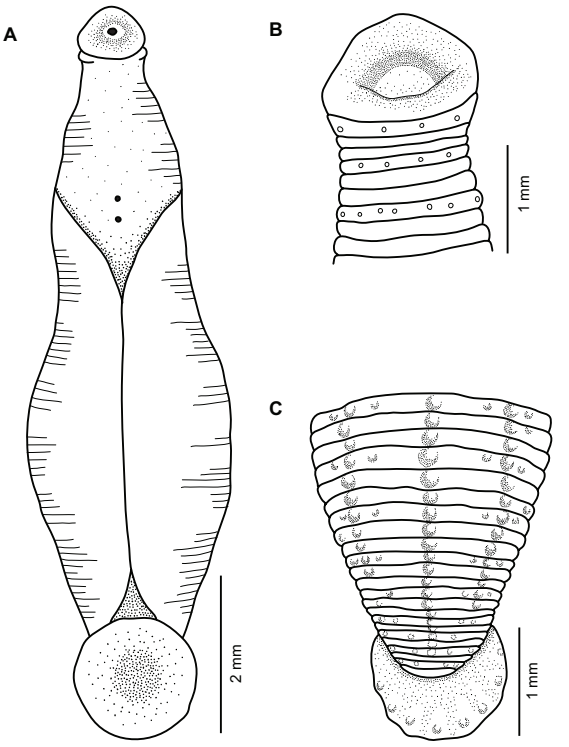

Fig. 4.10.1. Rhynchobdellida. *Batracobdelloides tricarinata* (Blanchard, 1897). **A.** Entire body; **B.** Head region; **C.** Posterior region. (Modified from Oosthuizen 1989.)

A systematic survey of leeches (Hirudinea) in African freshwater fishes

Only a single leech species, *Batracobdelloides tricarinata* (Blanchard, 1897), is currently a confirmed parasite of freshwater fishes from Africa (see Oosthuizen 1989) [Fig. 4.10.1]. However, two other leech species have been mentioned as possible African freshwater fish parasites but without specific hosts or localities recorded. *Hirudo michaelseni* Augener, 1936 (syn. *Aliolimnatis michaelseni* Sawyer, 1986) prefers mammalian hosts but according to Oosthuizen & Curtis (1990) also feeds on fishes, amphibians and snails. *Asiaticobdella buntonensis* (Meyer, 1951) (syn. *Limnatis buntonensis* Meyer, 1951) prefers hippopotami but according to Oosthuizen (1991) could possibly feed on freshwater fishes. These two species are excluded from the list of confirmed ectoparasites of African fishes. Fish names are according to Froese & Pauly (2017) and Eschmeyer *et al.* (2017).

RHYNCHOBDELLIDA Blanchard, 1894

List of the Rhynchobdellida (adults) from African freshwater fishes

Batracobdelloides Oosthuizen in Sawyer, 1986

Batracobdelloides tricarinata (Blanchard, 1897) [syns *Helobdella tricarinata* Blanchard, 1897; *Clepsine nilotica* Johansson, 1909; *Dundjibdella dartevellei* Sciacchitano, 1939; *Dundjibdella plurilineata* Sciacchitano, 1939; *Dundjibdella rubra* Sciacchitano, 1939; *Dundjibdella trilineata* Sciacchitano, 1939; *Dundjibdella triserialis* Sciacchitano, 1939; *Batrachobdella amnicola* Moore, 1958] from *Carassius auratus*, *Clarias gariepinus*, *Labeobarbus kimberleyensis*, *Oreochromis mossambicus*

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