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An overview of cercariae from the Egyptian inland water snails

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ABSTRACT

The study on trematode larvae found in Egyptian molluscs was initiated by the pioneering work of Sonsino in 1892 and Looss in 1896. Since then tens of cercariae and some digenean life cycles have been reported in the country. Unfortunately, only fragmentary publications are available for identification of cercariae present in the country. In addition, some of such publications may not be accessible to some researchers, as they are either theses or published in old volumes of non-international journals. The present work was carried out with the aim of preserving our heritage through reviewing the different types of cercariae known from the Egyptian inland water snails. We provide a survey based on literature. Major types of cercariae known to exist in the country are covered. They are presented as regards description, development, taxa, importance and snail hosts. This review can be used as a field guide for identification of cercariae colonising the Egyptian inland water snails.

1. Introduction

In digenetic trematodes, cercariae represent a juvenile stage of the vertebrate-inhabiting adult worms. In addition, the name cercaria can be used properly in a generic sense for a species in which the adult stage is unknown, as is done with the term cysticercus and microfilaria among some cestodes and nematodes, respectively[1,2]. Generally, the cercaria has an oval or elongated body, flattened in the dorsoventral plane, and a tail. An oral sucker is localized subterminally at the anterior extremity of the body. There may be also a ventral sucker which is located in the middle or posterior part of the body. In addition, there are digestive and protonephridial excretory systems, different types of glands, genital primordium and sensory organs (external sensory papillae and eyespots). Morphology of the tail varies considerably in the different species. It may be considerably shortened or completely lost. The range of variation in cercarial morphology is considerable, and most have specializations that enable them to survive a brief free-living existence and make themselves available to next host[2,3].

A classification system has been created by Lühe in 1909 for grouping of cercariae into several types based on their morphological variations[4]. In this system, salient morphological characteristics are used for grouping cercariae into various major groups, and each major cercarial group may be divided into sub-groups on the basis of minor morphological differences. In this classification, Lühe recognized five major groups: lophocercariae, gasterostome, monostome, amphistome and distome cercariae[4]. The classification of Lühe was modified and supplemented by many subsequent workers. Probably the most complete version of this classification is available in the review by Dawes in 1946[5]. Species identification based on morphology of cercariae is usually difficult and unreliable. However, by using detailed morphological criteria alone, identification of cercariae to the family level, and occasionally to the genus level is possible[1].

In Egypt, since the pioneering work of Sonsino in 1892 and Looss in 1896 on the role of molluscs as intermediate hosts of digenetic trematodes[6,7], only fragmentary publications are available for identification of cercariae present in the country. In addition, some of such publications may not be accessible to some researchers. This is because they are either theses or published in old volumes of non-international journals. The present work was carried out with the aim of preserving our heritage through reviewing the different types of cercariae known from the Egyptian inland water snails.

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We provide a survey based on literature. Major types of cercariae known to exist in the country are covered. They are presented as regards description, development, taxa, importance and snail hosts. Nomenclature of the different snail species was done according to Lotfy and Lotfy in 2015[8].

2. Monostome cercariae

2.1. Description

This type of cercariae is characterized by the absence of both the ventral sucker and pharynx; and by the presence of a simple tail, two or three pigmented eye spots, a pair of adhesive organs at the posterior extremity of the body, two excretory canals in body uniting near the eyes, and dense cystogenous glands (Figure 1). They are divided into two subtypes: ephemera cercariae which generally have three eyespots (triocellate) and urbanensis cercariae which, in most cases, have two eyespots (diocellate). Noteworthy, cercaria urbanensis itself is a species with three eyespots[1,5].

2.2. Development

This type of cercariae develops in a redia, which in turn arises from a miracidium without the intervention of a sporocyst stage. Monostome cercariae are born in an immature stage which completes development and encysts in the open[1,5].

2.3. Taxa

These cercariae are produced by species of the families Notocotylidae Lühe, 1909; Pronocephalidae Looss, 1899; Mesometridae Poche, 1926; and Microscaphidiidae Looss, 1900. The family Notocotylidae colonises the digestive tract, commonly the caeca, of birds and mammals[9]. The family Pronocephalidae occurs primarily in the intestines of marine and aquatic reptiles with a few species occurring in marine fishes[10]. The family Mesometridae is a small family of five genera, currently comprising seven species from the digestive tract of marine teleost fishes[11]. The family Microscaphidiidae inhabits the digestive tracts of marine and freshwater chelonians and teleosts[12].

2.4. Importance

The monostomes have no medical or veterinary importance[1, 5, 13].

2.5. Snail hosts

Only cercariae of the ephemera subtype were reported from the country in eight snail species:

1. *Bellamya unicolor* (*B. unicolor*) snails were reported to be infected with an unidentified species of this subtype[14].

2. *Biomphalaria alexandrina* (*B. alexandrina*) snails were reported to be infected with an unidentified species of this subtype[14,15].

3. *Bithynia goryi* [most probably *Gabbiella senaariensis* (*G. senaariensis*)] snails were reported to be infected with an unidentified species of this subtype[16,17].

4. *Cleopatra bulimoides* (*C. bulimoides*) snails were reported to be infected with unidentified species of this subtype[14,18].

5. *G. senaariensis* snails were reported to be infected with *Catatropis indicus* (Notocotylidae) cercariae[19].

6. *Melanoides tuberculata* (*M. tuberculata*) snails were reported to be infected with *Paramonostomum aegyptiacum* (Notocotylidae) cercariae[20]. In addition, snails of the same species were reported to be infected with unidentified species of ephemera subtype[7,14,21,22].

7. *Planorbis planorbis* (*P. planorbis*) snails were reported to be infected with an unidentified species of this subtype[14].

8. *Potamides conicus* (*P. conicus*) snails were reported to be infected with an unidentified species of this subtype[23].

3. Gymnocephalous cercariae

3.1. Description

This type of cercariae is a form of the leptocercous cercariae which include also echinostome and stylet cercariae. The leptocercous type is characterized by a straight slender tail that is much narrower than the cercarial body (Figure 2). Also, the ventral sucker of leptocercous cercariae is situated on mid-ventral surface of the body[5]. The term “gymnocephalous” literally means “naked headed”; *i.e.* cercariae without ornamentation of body. The gymnocephalous cercariae are featured with having two almost equal suckers. Neither stylet nor spiny collar is present. Numerous cystogenous glands are present in the body[1].

Figure 1. Monostome cercaria.

Figure 2. Gymnocephalous cercaria.

3.2. Development

Known species of this type develop in rediae and encyst on objects in the water or in fishes[1].

3.3. Taxa

The gymnocephalous cercariae are produced by species of the family Fasciolidae (and some other families)[1].

3.4. Importance

Species of the family Fasciolidae have great veterinary importance[1].

3.5. Snail hosts

In Egypt, gymnocephalous cercariae are shed by nine species of freshwater snails:

1. *B. alexandrina* snails were reported to be infected with cercariae belonging to the genera *Fasciola* (Family Fasciolidae)[24,25], and *Ribeiroia* (Family Psilostomatidae)[26].

2. *Bithynia* sp. (most probably *G. senaariensis*) snails were reported to be naturally infected with an unidentified species of gymnocephalous cercariae[27].

3. *C. bulimoides* snails were reported to be naturally infected with cercariae belonging to the genus *Philophthalmus* (Family Philopthalmidae)[7,26,28-32]; *Sphaeridiotrema szidati* (Family Psilostomatidae)[33]; and unidentified gymnocephalous cercariae[31,34].

4. *Galba truncatula* snails were reported to be naturally infected with cercariae belonging to the genus *Fasciola*[25,35], and successful experimental infections with *Fasciola hepatica* (*F. hepatica*) and *Fasciola gigantica* (*F. gigantica*) were described[36-38].

5. *Lanistes carinatus* (*L. carinatus*) snails were reported to be naturally infected with unidentified species of gymnocephalous cercariae[16,39,40].

6. *Lymnaea stagnalis* (*L. stagnalis*) snails were reported to be naturally infected with cercariae belonging to the genus *Fasciola*[35].

7. *M. tuberculata* snails were reported to be naturally infected with unidentified species of gymnocephalous cercariae[18,27,31,34,41-43].

8. *Pseudosuccinea columella* (*P. columella*) snails were reported to be naturally infected with cercariae of *F. gigantica*[44-46].

9. *Radix natalensis* (*R. natalensis*) snails were reported to be naturally infected with cercariae belonging to the genus *Fasciola*[14,18,27,35,42,45,47-51]. Results of experimental infection confirmed the susceptibility of this snail species to be infected with *F. gigantica*[52] and *F. hepatica*[52,53]. It is worth mentioning that in 2008 Hussein and Khalifa reported failure to infect *R. natalensis* with *F. hepatica*[54]. In 2001, Lotfy *et al.* concluded that *F. gigantica* was better adapted to *R. natalensis* snails than *F. hepatica*. They added that although adult *R. natalensis* snails were refractory to experimental infection with *F. hepatica*, immature snails can be infected and the infection may proceed to maturity[52].

4. Echinostome cercariae

4.1. Description

This type belongs to the leptocercous cercariae[5]. The oral sucker without a stylet but is surrounded by a head collar which bears a row or two of collar spines around its margin, as in the adult forms of these parasites (Figure 3). The eyespots are absent. Numerous cystogenous glands are present in the body[1,5,13]. Some echinostome cercariae and especially those of the genus *Echinostoma* possess two types of glands, known as penetration and paraesophageal glands[55].

Figure 3. Echinostome cercaria.

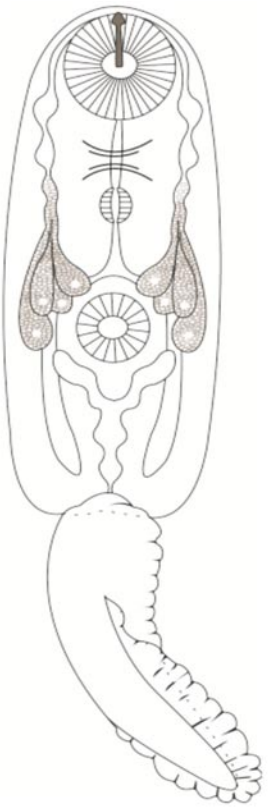

Figure 4. Ornatae cercaria.

4.2. Development

The echinostome cercariae develop in rediae, and encyst in invertebrates (including snails) and/or vertebrates (including fishes and amphibians)[1,5,13].

4.3. Taxa

The echinostome cercariae are produced by species of the family Echinostomatidae which are intestinal parasites of fishes, reptiles, birds and mammals[1,5,13].

4.4. Importance

Some species of the family Echinostomatidae may have veterinary importance[1,5,13]. Echinostomes are antagonistic to the development of other trematodes in the same snail host[56-58]. Thus competing echinostome larvae might be used to control other trematodes[59]. It was suggested to use echinostomes in schistosomiasis endemic foci in Egypt to suppress the development of schistosomes[60]. Field studies confirmed that the prevalence of echinostome cercariae in any locality in Egypt is usually on the expense of *Schistosoma* cercariae[40].

4.5. Snail hosts

In Egypt, echinostome cercariae are shed by seven species of freshwater snails:

1. *B. alexandrina* snails were reported to be naturally infected with cercariae belonging to the genus *Echinoparyphium*[27]; *Echinostoma liei*[26,61]; *Echinostoma revolutum*[27,40,62]; *Echinostomum recurvatum* (Syn. *Echinoparyphium recurvatum*)[40]; *Nephrostomum ramosum*[63,64]; and many unidentified species of echinostome cercariae[34,40,65-70]. Noteworthy, the species *Echinostoma liei* may be synonymous with *Echinostoma revolutum*[62].

2. *Bulinus truncatus* (*B. truncatus*) snails were reported to be naturally infected with cercariae of *Echinoparyphium bioccalerouxi*[27,62]; *Echinoparyphium ralphaudyi*[71,72]; *Echinostoma revolutum*[40]; *Echinostomum recurvatum*[6,21,26,29-31,40,73-76] and many unidentified species of echinostome cercariae[34,42,60,65,66]. It is to be noted here that the species *Echinoparyphium bioccalerouxi* may be synonymous with *Echinostomum recurvatum*[27,62].

3. *C. bulimoides* snails were reported to be naturally infected with unidentified species of echinostome cercariae[32].

4. *Haitia acuta* (*H. acuta*) snails were reported to be naturally infected with unidentified species of echinostome cercariae[42,65].

5. *L. carinatus* snails were reported to be naturally infected with unidentified species of echinostome cercariae[31,77].

6. *P. columella* snails were reported to be naturally infected with *Echinostoma caproni* and an unidentified species of echinostome cercariae[46].

7. *R. natalensis* snails were reported to be naturally infected with unidentified species of echinostome cercariae[48,65].

5. Stylet cercariae (Xiphidiocercariae)

5.1. Description

This type of cercariae is a form of the leptocercous cercariae[5]. They are equipped with a stylet in the anterior margin of the oral sucker which is used in penetration of their next host. This type of cercariae is divided into four subtypes[1,5,13,78]:

1) The ornatae cercariae (Figure 4) in which the tail is provided with a dorso-ventral finfold, the virgula organ is absent, and the ventral sucker is smaller than oral sucker.

2) The virgulate cercariae (Figure 5) in which the tail is without dorso-ventral finfold, a bilobed or pyriform virgula organ (contains mucoid secretions) is present in the region of the oral sucker, and the ventral sucker is smaller than the oral sucker.

3) The ubiquita cercariae (Figure 6) in which the tail is without dorso-ventral finfold, the virgula organ is absent, and the ventral sucker is vestigial or absent.

4) The armatae cercariae (Figure 7) in which the tail is without dorso-ventral finfold, the virgula organ is absent, and the oral and ventral suckers are of equal size or the ventral sucker is larger than the oral sucker.

However, Nasir in 1972 reviewed the classification of stylet cercariae, and commented that none of the different characters used have significant taxonomic value and that of the stylet cercariae should be left without subdivisions[79].

5.2. Development

They develop in sporocysts, and encyst in invertebrates, amphibians and reptiles. Sometimes they may encyst in sporocysts of other trematodes[1,5,13].

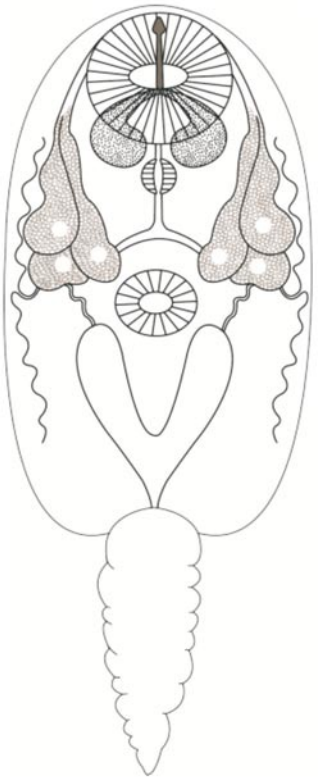

Figure 5. Virgulate cercaria.

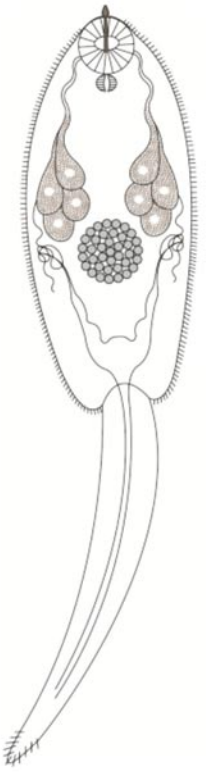

Figure 6. Ubiquita cercaria.

Figure 7. Armatae cercaria.

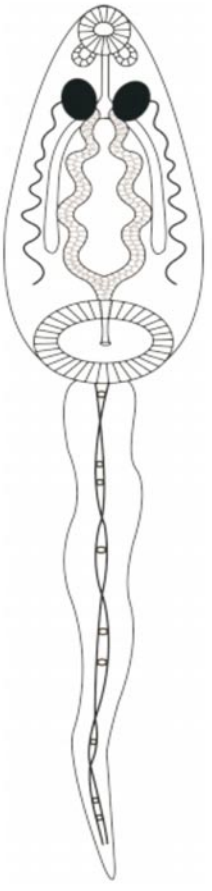

Figure 8. Paramphistomoid cercaria.

5.3. Taxa

The ornatae subtype is produced by the families Haematoloechidae and Macroderoididae. Haematoloechids are lung parasites of amphibians. Macroderoidids are intestinal parasites of fishes and amphibians. The virgulate subtype is produced by species of the families Allassogonoporidae (Gyrabascidae), Lecithodendriidae and Pleurogenidae. Allassogonoporids are parasites of bats and rodents (and experimentally in carnivores). Lecithodendriids are parasites of bats, and occasionally birds. Pleurogenids are parasites of amphibians and mammals. The ubiquita cercariae are produced by trematodes of the families Microphallidae and Eumegacetidae. Microphallids are intestinal parasites of most vertebrate classes, but mainly birds. Eumegacetids are bird parasites. The armatae subtype is produced by species of the families Auridistomidae, Cephalogonimidae, Haplometridae (Plagiorchiidae), Ochetosomatidae (Reniferidae), and Telorchiidae. Auridistomids are intestinal parasites of North American, European and African turtles. Cephalogonimids are parasites in the gastro-intestinal tract of fishes, amphibians and reptiles. Haplometrids are intestinal parasites in all groups of vertebrates. Ochetosomatids are parasitic in Nearctic and Neotropical snakes. Telorchiids are intestinal parasites of reptiles and amphibians[1,5,13,78,80].

5.4. Importance

They have no medical or veterinary importance[1,5,13].

5.5. Snail hosts

In Egypt, different studies revealed the presence of different species of stylet cercariae in 12 species of freshwater snails:

1. *B. unicolor* snails were reported to be naturally infected with cercariae belonging to the genus *Eumegacetes* (Family Eumegacetidae)[81], and unidentified species of stylet cercariae[14,49,50,82].

2. *B. alexandrina* snails were reported to be naturally infected with cercariae of *Lepoderma ramlianum* (Family Plagiorchiidae)[83], and unidentified species of stylet cercariae[14,49,50].

3. *Bithynia* sp. (most probably *G. senaariensis*) snails were reported to be naturally infected with unidentified species of stylet cercariae[27].

4. *B. truncatus* snails were reported to be naturally infected with cercariae of *Lepoderma ramlianum*[15,21,72,76,83,84], and unidentified species of stylet cercariae[7,14,26,27,29-32,34,40,42,49,50,60,83,85-87].

5. *C. bulimoides* snails were reported to be naturally infected with unidentified species of stylet cercariae[14,15,21,26,29-32,34,40,49,50,82,83,86,88].

6. *H. acuta* snails were reported to be naturally infected with unidentified species of stylet cercariae[14,49,50].

7. *L. carinatus* snails were reported to be naturally infected with unidentified species of stylet cercariae[14-16,27,31,32,34,39,40,77,82,83,89].

8. *L. stagnalis* snails were reported to be naturally infected with an unidentified species of stylet cercariae[44].

9. *M. tuberculata* snails were reported to be naturally infected with cercariae that belong to the genus *Eumegacetes*[81], *Lecithodendrium granulosum* (Family Lecithodendriidae)[90,91], *Lecithodendrium pyramidum* (Family Lecithodendriidae)[26,92], and unidentified species of stylet cercariae[14,15,21,22,26,31,32,34,40,41,43,49,50,83,89,90,93,94].

10. *Planorbella duryi* (*Helisoma duryi*) snails were reported to be naturally infected with unidentified species of stylet cercariae[14].

11. *P. planorbis* snails were reported to be naturally infected with unidentified species of stylet cercariae[14,49,50].

12. *R. natalensis* snails were reported to be naturally infected with unidentified species of stylet cercariae[14,15,27,30,31,34,44,48-51,83,86,95-97].

6. Paramphistomoid cercariae

6.1. Description

Paramphistomoid (syn. Paramphistome, and Amphistome) cercariae are amongst the largest known freshwater cercariae. They are featured with having a prominent body, a large ventral sucker that is situated at the posterior end of the body, a small unbranched tail, and globular masses of highly refractive material which fill the main excretory canals (Figure 8). Two pigmented eyespots are present near the anterior end of the body[5]. This type of cercariae can be assigned to three subtypes: (1) Cercaria pigmentata which is pigmented and with anastomosed mediolateral branches of the ascending main excretory tubes, and usually without pharyngeal appendages; (2) Cercaria diplocotylea which is without pigmentation and mediolateral branches, usually with pharyngeal appendages, main excretory tubes either straight or convoluted; and (3) Cercaria intermedia which is with antero- and posterolateral diverticula of the main excretory tubes, with or without pigmentation, and with pharyngeal appendages[98].

6.2. Development

They develop in rediae, and are born in a relatively immature stage which complete development in the snail host tissues. They usually encyst on objects in water or in the skin of tadpoles[5,98].

6.3. Taxa

Paramphistomoid cercariae are relatively a homogenous group and all belong to the adults of the superfamily Paramphistomoidea. The majority of paramphistomoids are intestinal parasites. They are found in fishes, amphibians, reptiles, birds (one genus) and mammals, including man. They are more common in fresh- and brackish-water fishes than in marine fishes[99].

6.4. Importance

Paramphistomes of the pigmentata subtype are intestinal parasites of mammals, especially ruminants. Some species of them have great veterinary importance. Species of the diplocotylea and intermedia subtypes have no medical or veterinary importance[5,98].

6.5. Snail hosts

Several species of paramphistomoid cercariae were reported from four species of freshwater snails in Egypt:

1. *B. alexandrina* snails were reported to be naturally infected

with paramphistomoid cercariae which may be *Paramphistomum microbothrium* (*P. microbothrium*) (syn. *Calicophoron microbothrium*)[67,68,100].

2. *Bulinus forskalii* (*B. forskalii*) snails were reported to be naturally infected with *P. microbothrium*[6,101]. *Gastrodiscus aegyptiacus* (*G. aegyptiacus*) a parasite of equines and pigs, was reported from Egypt[7,102,103]. *B. forskalii* has been reported as a snail host of *G. aegyptiacus* in other countries[104-107].

3. *B. truncatus* snails were reported to be naturally infected with *P. microbothrium*[6,15,72,101]. Infection with *Paramphistomum cervi* cercariae were reported by some authors[76,108,109], but these reports are doubtful because the presence of the species *Paramphistomum cervi* in Egypt is doubtful[95,110-112]. Many authors reported unidentified species of paramphistomoid cercariae from *B. truncatus* snails[21,26,27,29-31,34,40,42,49,50,60,95].

4. *C. bulimoides* snails were reported to be naturally infected with *Gastrodiscus aegyptiacus*[7]. The ability of the parasite to infect the snail was denied by several authors[107,113]. However, it was reported that *G. aegyptiacus* succeeded to infect *Cleopatra* sp. under experimental conditions in Zimbabwe[114]. Cercariae belonging to the genus *Megalodiscus* were isolated from the snail *C. bulimoides*[26,31]. Many authors reported unidentified species of paramphistomoid cercariae from *C. bulimoides* snails[21,26,34,42,88].

7. Furcocercous cercariae

7.1. Description

This type of cercariae is mainly characterised by a forked tail into which the body is not retractable. Some of the furcocercous cercariae may bear a pair of pigmented eyespots or may have a pharynx. The forked-tail may be either brevifurcate or longifurcate. Brevifurcate forked-tail is that in which the length of each of the furcal ramus is less than half the length of the main tail stem. Longifurcate forked-tail is that in which the furcal ramus is more than half the length of the main tail stem. The furcocercous type of cercariae is divided into five main subtypes[1,115]:

1) The lophocercous apharyngeate cercariae (Figure 9): This subtype is featured with the presence of a brevifurcate tail, absence of the pharynx, the oral sucker is absent, the ventral sucker is vestigial or absent, and the eyespots are absent. Some species have a fin extending the full length of the body dorsal side. The penetration gland cells are of one type. The body is in the resting position above the tail.

2) The brevifurcate apharyngeate monostome cercariae (Figure 10): This subtype is featured with the presence of a brevifurcate tail, absence of the pharynx, the oral sucker is present but the ventral sucker is absent. The penetration gland cells are of one type. The eyespots are sometimes present. The body finfold is present. The body is in the resting position below the tail.

3) The brevifurcate apharyngeate distome cercariae (Figure 11): This subtype is featured with the presence of a brevifurcate tail, absence of the pharynx, and the presence of the oral and ventral suckers. Furcal finfolds and eyespots are sometimes present. The penetration gland cells are of two types.

4) The longifurcate pharyngeate monostome (Vivax) cercariae (Figure 12): This subtype is featured with the presence of a longifurcate tail, the presence of the pharynx, the presence of the oral sucker, but ventral sucker vestigial or absent. The penetration gland cells are of one type. The body finfold is absent but the furcal finfolds are sometimes present. The excretory pores are located at tips of furcae. The caudal bodies in tail-stem are absent.

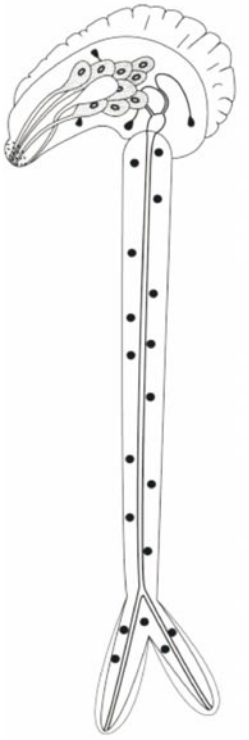

Figure 9. Lophocercous apharyngeate cercaria.

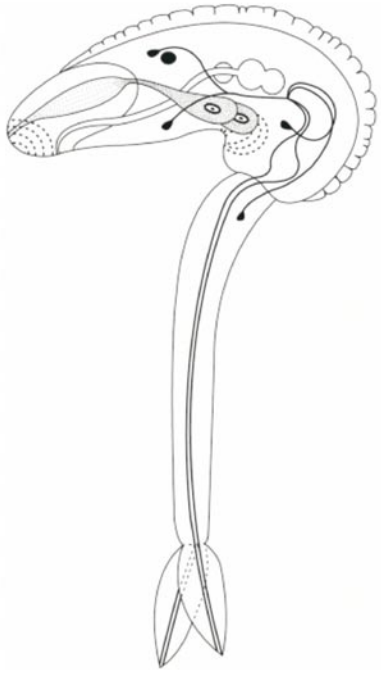

Figure 10. Brevifurcate apharyngeate monostome cercaria.

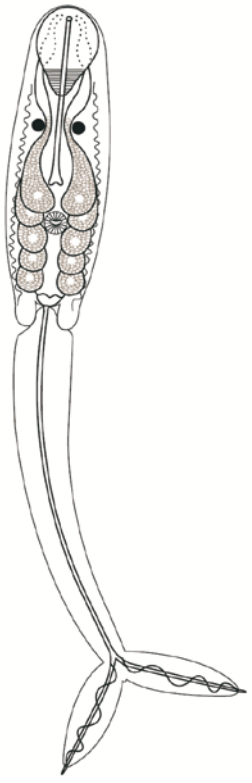

Figure 11. Brevifurcate apharyngeate distome cercaria.

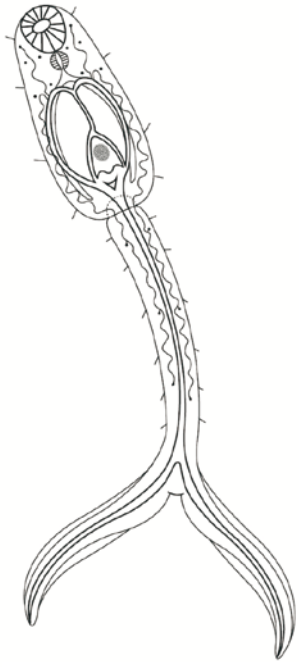

Figure 12. Longifurcate pharyngeate monostome (Vivax) cercaria.

5) The longifurcate pharyngeate distome (Holostome or Strigid) cercariae (Figure 13): This subtype is featured with the presence of a longifurcate tail, the presence of the pharynx, and the oral and ventral suckers. The penetration gland cells are of one type. The body and furcal finfolds are absent. The excretory pores are located on sides of the furcae. Caudal bodies are present in the tail-stem.

Figure 13. Longifurcate pharyngeate distome (Holostome or Strigid) cercaria.

Figure 14. Opisthorchioid cercaria.

7.2. Development

Some genera develop in sporocysts and others in rediae. The cercariae may actively penetrate the definitive host without prior encystment (blood flukes) or they may encyst in vertebrates. The lophocercous apharyngeate type develops in sporocysts, and does not encyst but actively penetrates the definitive host. The brevifurcate apharyngeate monostome type develops in rediae and encysts in fishes. The brevifurcate apharyngeate distome type develops in sporocysts, and penetrates the definitive host directly. The longifurcate pharyngeate monostome type develops in sporocysts, and encysts in fishes. The longifurcate pharyngeate distome type develops in sporocysts and encysts in snails, tadpoles, reptiles and fishes[1,115].

7.3. Taxa

The lophocercous apharyngeate type is produced by species of the family Sanguinicolidae (blood parasites of fishes). The brevifurcate apharyngeate monostome type is produced by species of the family Clinostomatidae which are parasites in the mouth and oesophagus of birds. The brevifurcate apharyngeate distome type is produced by species of the families Spirorchiidae which are blood parasites of reptiles and Schistosomatidae which are blood parasites of birds and mammals. The longifurcate pharyngeate monostome type is produced by species of the family Cyathocotylidae which are intestinal parasites of reptiles, birds and mammals. The longifurcate pharyngeate distome type is produced by species of the families Strigeidae and Diplostomatidae which are intestinal parasites of birds and mammals[1,115].

7.4. Importance

Some species of the family Sanguinicolidae may have some veterinary importance. Species of the family Schistosomatidae have great medical and veterinary importance. The brevifurcate apharyngeate monostome, the longifurcate pharyngeate distome type, and the longifurcate pharyngeate monostome type have no medical or veterinary importance[1,115].

7.5. Snail hosts

Several species of furcocercous cercariae were reported from 10 species of freshwater snails in Egypt:

1. *B. unicolor* snails were reported to be naturally infected with unidentified species of furcocercous cercariae[14].
2. *B. alexandrina* snails were reported to be naturally infected with *Apharyngostrigea ibis*[64,116], (maybe) *Bilharziella polonica* (*B. polonica*)[117], *Schistosoma mansoni*[14,27,31,32,42,64,67,68,70,87,117-119], and unidentified species of furcocercous cercariae[15,21,31,32,34,40,64,67,68,87,117,120].
3. *Bithynia* sp. (most probably *G. senaariensis*) snails were reported to be naturally infected with unidentified species of furcocercous cercariae[27].
4. *B. forskalii* snails were reported to be naturally infected with an unidentified species of (schistosome) furcocercous cercariae[109,121].
5. *B. truncatus* snails were reported to be naturally infected with *Cynodiplostomum azimi*[15,72,122], *Schistosoma haematobium* cercariae[27,32,72,76,85,87,109,118,123], and unidentified species of furcocercous cercariae[21,26,31,34,40,60,76,85,95,109,124].
6. *C. bulimoides* snails were reported to be naturally infected with cercariae of the genus *Cardicola*[26,31,32], and *Prohemistomum vivax*[6,15,16,125,126], and unidentified species of furcocercous cercariae[14,18,26,31,32,34,40,88,89,120,127,128].
7. *Gyraulus ehrenbergi* snails were reported to be naturally infected with cercariae similar to those of *B. polonica*[117].
8. *M. tuberculata* snails were reported to be naturally infected with cercariae similar to those of *B. polonica*[117]. The snail species was found naturally infected with cercariae belonging to the genus *Gigantobilharzia*[22,26,31,93,129], and unidentified species of furcocercous cercariae[14,41,43,90,130].
9. *P. planorbis* snails were reported to be naturally infected with unidentified species of furcocercous cercariae[14].
10. *R. natalensis* snails were reported to be naturally infected with unidentified species of furcocercous cercariae[31,42].

8. Opisthorchioid cercariae

8.1. Description

This type of cercariae has unforked tail with well-developed

dorso-ventral finfolds (Figure 14). The ventral sucker is vestigial or absent, eyespots are present, adhesive organs at posterior end of the body are absent, and cystogenous glands in body are few in number[1,5,13]. The opisthorchioid cercariae are subdivided into two subtypes; parapleurolophocercous and pleurolophocercous cercariae. Some authors do believe that parapleurolophocercous and pleurolophocercous cercariae are synonymous which is not correct[15]. The tail of the pleurolophocercous cercaria is provided with only dorso-ventral finfolds. When the tail shows additional lateral finfolds, the cercaria is called parapleurolophocercous[131,132].

8.2. Development

They develop in rediae mostly in prosobranch snails and encyst in fishes and amphibians. Adult flukes of most species are parasitic in the liver, bile-ducts and gall-bladder of birds and mammals, with some species found in the digestive tracts of reptiles and teleosts[1,5,13,80].

8.3. Taxa

Generally, opisthorchioid cercariae are produced by species in the superfamily Opisthorchioidea. The families Cryptogonimidae and Opisthorchiidae produce pleurolophocercous cercariae. Parapleurolophocercous and pleurolophocercous cercariae have been reported for the family Heterophyidae[1,5,13,80].

8.4. Importance

Some species of the families Heterophyidae and Opisthorchiidae have great medical importance *e.g. Heterophyes heterophyes* (*H. heterophyes*) (Family Heterophyidae), and *Clonorchis sinensis*, *Opisthorchis viverrini* and *Opisthorchis felineus* (Family Opisthorchiidae)[1,5,13,133].

8.5. Snail hosts

In Egypt, known cercariae of this group are shed from four species of inland water snails:

1. *P. conicus* snails were reported to be naturally infected with cercariae of *Heterophyes aequalis*, *Heterophyes dispar* and *H. heterophyes*[134-138]. Also, this snail was reported to act as the intermediate host of *Stictodora sawakinensis*[136-138] and unidentified species of the genus *Stictodora* (Family Heterophyidae)[23,139-141].

2. *C. bulimoides* snails were reported to be infected with cercariae of the genus *Centrocestus* (Family Heterophyidae)[26,31,40], *Haplorchoides cahirinus* (Family Heterophyidae)[26,142], and several unidentified species of this type of cercariae[31,88].

3. *M. tuberculata* snails were reported to be naturally infected with cercariae of *Centrocestus aswanensis* (Family Heterophyidae)[143], *Centrocestus unequiorchalis*[144,145], *Haplorchis pumilio* (*H. pumilio*) (Family Heterophyidae)[16,26,40,89,90,146-151], and *Haplorchis yokogawai*[26,149,152]. It is worth mentioning that in addition to *H. pumilio* and *Haplorchis yokogawai*, other two species *Haplorchis pleurolophocerca* and *Haplorchis taichui* were reported from Egypt. *M. tuberculata* may be the snail host of these species[153]. *M. tuberculata* snails were reported to be naturally infected with cercariae of *Pygidiopsis genata*[6,7,154], *Stellantchasmus falcatus* (Heterophyidae)[155], and cercariae belonging to the genus *Stictodora*[26,29,30,149,156]. Also, this snail was reported to act as the intermediate host of several unidentified species of opisthorchioid cercariae[15,21,22,31,41,157]. Noteworthy, it was mentioned in some literature that *H. heterophyes* is transmitted by this snail[158]. However, this information is doubtful and needs to be confirmed by some studies.

4. *R. natalensis* snails were reported to be infected with opisthorchioid cercariae[16], which were identified as *H. pumilio*[151]. Except for this report opisthorchioid cercariae are known only from prosobranch snails[78].

9. Cystophorous cercariae

9.1. Description

The tail of this type of cercariae is large (Figure 15), and has a chamber (caudal cyst), at the anterior end, into which the cercarial body may withdraw[78,159].

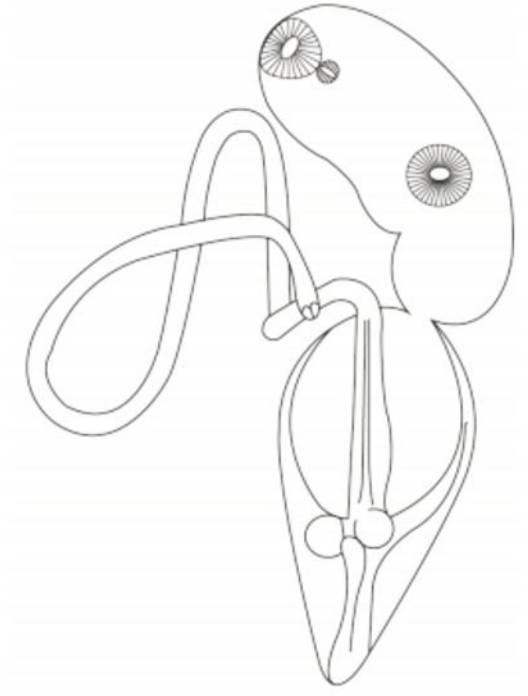

Figure 15. Cystophorous cercaria.

9.2. Development

This type of cercariae develop in rediae (rarely daughter-sporocysts). The metacercariae are found in aquatic organisms. The definitive hosts acquire the infection by feeding[80,160].

9.3. Taxa

They are produced by trematodes in the families Gorgoderidae and Hemiuridae, and possibly other families[27,78,159].

9.4. Importance

Gorgoderids are parasites of amphibians, fishes and reptiles. Many species inhabit the urinary bladder of their hosts but, more rarely, other locations, such as the swim-bladder, coelom (elasmobranchs), gall-bladder or intestine, are utilized[80]. Hemiurids are usually parasitic in gut or associated organs of fishes, occasionally amphibians, rarely reptiles[160].

9.5. Snail hosts

There is only one report describing the presence of an unidentified species of cystophorous cercariae in *B. alexandrina*[27].

10. Unknown rare types

In addition to the above mentioned Egyptian types of cercariae, there are some strange rare forms well documented in the literature[90,161,162]. Such forms could not be assigned to any of the known types.

11. Conclusion

Cercariae were described in the literature from 18 species of inland water snails (eight prosobranchs and 10 pulmonates) from Egypt. *B. unicolor* snails were reported to be infected with monostome, stylet and furcocercous cercariae. *B. alexandrina* snails were reported to be infected with monostome, gymnocephalous, echinostome, stylet, paramphistomoid, furcocercous and cystophorous cercariae. *Bithynia* sp. (most probably *G. senaariensis*) snails were reported to be infected with monostome, gymnocephalous, stylet and furcocercous cercariae. *B. forskalii* snails were reported to be infected with paramphistomoid and furcocercous cercariae. *B. truncatus* snails were reported to be infected with echinostome, stylet, paramphistomoid and furcocercous cercariae. *C. bulimoides* snails were reported to be infected with monostome, gymnocephalous, echinostome, stylet, paramphistomoid, furcocercous, and opisthorchioid cercariae. *G. senaariensis* snails were reported to be infected with monostome cercariae. *Galba truncatula* snails were reported to be infected with gymnocephalous cercariae. *Gyraulus ehrenbergi* snails were reported to be infected with furcocercous cercariae. *H. acuta* snails were reported to be infected with echinostome and stylet cercariae. *L. carinatus* snails were reported to be infected with gymnocephalous, echinostome and stylet cercariae. *L. stagnalis* snails were reported to be infected with gymnocephalous and stylet cercariae. *M. tuberculata* snails were reported to be infected with monostome, gymnocephalous, stylet, furcocercous and opisthorchioid cercariae. *Planorbella duryi* snails were reported to be infected with stylet cercariae. *P. planorbis* snails were reported to be infected with monostome, stylet and furcocercous cercariae. *P. conicus* snails were reported to be infected with monostome and opisthorchioid cercariae. *P. columella* snails were reported to be infected with gymnocephalous and echinostome cercariae. *R. natalensis* snails were reported to be infected with gymnocephalous, echinostome, stylet, furcocercous and opisthorchioid cercariae.

Freshwater pulmonates seem to be better hosts for trematode larvae compared to prosobranchs, because of their explorative behaviour and great tolerance to water and oxygen deficit[163,164].

Conflict of interest statement

We declare that we have no conflict of interest.

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