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Parasitic Infection with Emphasis on *Tylodelphys* spp. as New Host and Locality Records in Nile Perch; *Lates niloticus* from Lake Nasser, Egypt

Awatef Hamed Hamouda[1]*, Shimaa Sobhy Sorour[2], Nagwan Mahmoud El-Habashi[3] and El-Hussein Amar Adam[4]

[1] *Department of Fish Diseases, Faculty of Fisheries and Fish Technology, Aswan University, postal code: 81528, Egypt*
[2] *Department of Veterinary Parasitology, Faculty of Veterinary Medicine, Kafrelsheikh University, postal code: 33516, Egypt*
[3] *Department of Veterinary Pathology, Faculty of Veterinary Medicine, Kafrelsheikh University, postal code: 33516, Egypt*
[4] *Department of Aquatic Ecology, Faculty of Fisheries and Fish Technology, Aswan University, postal code: 81528, Egypt*
*Corresponding author's Email: awatefhamouda@yahoo.com

ABSTRACT

A total number of 200 *Lates niloticus* were collected alive from several and various localities at Lake Nasser in Aswan governorate, to investigate the prevailing parasites that infect this fish species. All the examined fish were positive for one or more parasites, three trematodes of two families were identified: *Diplectanum simil*e, *Diplectanum lacustri*s and *Tylodelphys* spp. (recorded for the first time in *Lates niloticus* representing new host and locality records), two nematodes of two families: *Philometra ovata* and L_3 larvae of *Contracaecum* spp.(has zoonotic importance), one acanthocephalan parasite: *Rhadinorhynchus niloticus*, two crustaceans parasites of one family: *Ergasilus kandti* and *Ergasilus latus*, while no cestodal infections were recorded at all. The prevalence of trematodes was at 95% meanwhile the nematodes were at 100% in addition to the acanthocephalan parasite was at 24.5% as well, crustaceans parasites were at 69.5%. This study evaluated clinical signs, postmortem examinations, parasitological examinations, seasonal prevalence and histopathological investigations of infected fish in addition to the relation between fish age and parasitism was also described. This study builds on our current understanding of different parasites infecting the wild *Lates niloticus* and provides novel information on the patterns of the isolated parasites and also serves to reassure the consumers that the musculature (the edible part) of the fish was free from any parasitic infections and safe for human consumption provided that the fish must be eviscerated as soon as possible after being caught and adequately cooked.

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INTRODUCTION

Fish is one of the most valuable sources of protein across the world as people obtain about 25% of their animal protein requirements from fish and shellfish (Matter et al., 2013). The rapid increase in the population in Egypt motivates the government to pay attention to the development of fisheries, especially in Lake Nasser. The production from such lake comprises a significant proportion of the Egyptian inland fisheries and is an important alternative source of protein in the face of increasing meat prices.

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In Lake Nasser, the predominant species for sale as fresh fish are the tilapias, followed by *Lates niloticus*, which constitute 25.07% of the fish in the lake (GAFRD, 2016). The annual production of this fish in 2010 was 12,311 tons, representing 0.9% of the total annual production of the fish wealth sector in Egypt (GAFRD, 2010). In Egypt, the Nile perch (*Lates niloticus*), commercially known as Samoos or Ishr-bayad, is a freshwater tropical, carnivorous fish of high commercial and recreational value in Africa, it inhabits a wide variety of habitats, including rivers, lakes, and irrigation channels (Aloo et al., 2017). *Lates niloticus* has been introduced to many lakes in Africa, including Lake Nasser where it is fished commercially. *Lates niloticus* has high edible white meat without bone rich in protein and vitamins especially omega-3 which is vital for human and considered a good fish for aquaculture development (Asnake, 2018).

In the last few years, the increase in parasitic infections among the fish of Lake Nasser has led to a drastic decrease in fish yields, low marketability, as well as rejection of the fish by consumers who fear the macroscopic parasites. Moreover, some parasitic infections in the fish have zoonotic importance, delayed sexual maturity of the fish and increased fish mortality causing great economic losses (Noga, 2010 and Younis et al., 2017).

Trematodes, cestodes, acanthocephalans and nematodes had contributed the most among the major parasitic groups found in freshwater fish (Schmidt, 1990). Migrating larvae of *Contracaecum and Philometra* may cause tissue damage (Noga, 2010). Copepods are extremely important in aquatic ecosystems, where they constitute a food source for small fish, an intermediate host for fish parasites or fish parasites themselves, and serve as vectors of disease (Piasecki, 2004).

Due to the scarcity of scientific information on the incidence, characteristics and effects of parasitic infection on *Lates niloticus* in Lake Nasser, the present work aims to make an- up- to- date study that identifies the present status of some parasitic diseases afflicting *Lates niloticus* at the lake, the seasonal incidence, the histopathological alterations in the infected fish and analyze the relationship between fish age and each detected parasite.

MATERIAL AND METHODS

Ethical approval

Animal ethics committee, Faculty of Fish and Fisheries Technology, Aswan University, Egypt, approved the protocol and conducting of the study.

Study area

The High Dam Lake was created as a result of the construction of the Aswan High Dam in the 1960's. The High Dam Lake extends for 480 kms, from the High Dam in Egypt to the Dal Cataract in Sudan, it lies300 km within the Egyptian borders (as Lake Nasser) and 180 km of it lies within the Sudanese borders (as Lake Nubia). Lake Nasser, together with Lake Nubia, is the second largest man-made lake in the world, after Lake Volta, in Ghana. Lake Nasser is now one of the most important sources of freshwater fish in Egypt.

Fish samples

A total number of 200 *Lates niloticus* of different weights and sizes (50 fish/ season) were collected, randomly and alive, from different localities of Lake Nasser at Aswan governorate during the period of February 2016 to January 2017. The collected fish were transferred alive and kept in prepared glass aquaria in the laboratory of fish diseases, Faculty of Fisheries and Fish Technology, Aswan University. Identification of the host and the length frequency measurements were taken by measuring the standard length (the measurement from the most anterior tip of the body to the posterior end of the vertebral column), the total weight was taken in grams, and scale samples relevant to age determination were collected for subsequent examination.

Age determination

Scales of each fish were extruded from the area below the lateral line at a level behind the pectoral fin on the left side, and used to determine age according to Adam (2004). As the age distribution was determined, an age-length key was constructed. From this key, the length distribution, the number of fish belonging to each age group was determined. All fish under study were belonging to age groups 1, 2, 3, 4, 5, 6, 7 and 8 years.

Clinical and postmortem examination

The fish were subjected to full clinical examination after that, they were euthanized rapidly by percussion stunning followed by destruction of the brain the procedures complied with local and national animal welfare laws, guidelines and policies, the external and internal gross lesions were recorded immediately according to the method described by Noga (2010).

Parasitological examinations

Parasitological examinations were performed and then the collected parasites were washed, fixed, stained and permanently mounted according to the methods described by Lucky (1977) and Woodland (2006).

Identification of collected helminthes

The collected helminthes were identified according to the identification keys of Yamaguti (1958, 1961 and 1963); Thurston and Paperna (1969); Schaperclauus (1992) and Anderson (2000).

Histopathological examination

After necropsy, sections of gills, stomach, intestine, liver, and gas bladder were fixed immediately in 10% formalin and processed for histopathological evaluation, using the routine paraffin embedding method as described by Bancroft and Gamble (2007). Sections of 3µm thick were cut and stained using hematoxylin and eosin for light microscopic examination.

RESULTS

Population structure (age composition)

The frequency and age composition of *Lates niloticus* collected from the study area during the study period is presented in table 1. From the table, it is clear that age group 2 years old (55 %) of *Lates niloticus* was the most dominant group in the catch, followed by age group 1 (18.3 %), then age group 3 (17.8 %); the rest of the groups each comprise less than 8.9 %.

Table 1. Age–length key of *Lates niloticus* collected from lake Nasser, Aswan, Egypt showing frequency of fish specimens in different length groups and their distribution in each age group during the period of February 2016 to January 2017

Length groups (mm)	Freq.	Age groups							
		1	2	3	4	5	6	7	8
200	3	3	0	0	0	0	0	0	0
230	7	7	0	0	0	0	0	0	0
260	23	17	6	0	0	0	0	0	0
290	28	4	24	0	0	0	0	0	0
320	39	0	38	1	0	0	0	0	0
350	22	0	14	8	0	0	0	0	0
380	18	0	5	12	1	0	0	0	0
410	5	0	3	2	0	0	0	0	0
440	6	0	2	3	1	0	0	0	0
470	4	0	1	2	1	0	0	0	0
500	5	0	0	2	3	0	0	0	0
530	1	0	0	0	0	1	0	0	0
560	1	0	0	0	0	1	0	0	0
590	0	0	0	0	0	0	0	0	0
620	0	0	0	0	0	0	0	0	0
650	3	0	0	0	0	0	3	0	0
680	1	0	0	0	0	0	0	1	0
710	1	0	0	0	0	0	0	1	0
740	2	0	0	0	0	0	0	1	1
Sum	169	31	93	30	6	2	3	3	1

Freq. = frequency

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Clinical, postmortem and histopathological examinations induced by parasites

Most of the examined fish showed no pathognomonic abnormalities except heavy parasitic infestation. Moreover, the examined fish exhibited restlessness, poor appetite, emaciation, slight abdominal distension as well as respiratory difficulties manifested by surface swimming and gasping.

Emaciation, dark or pale body coloration, detachment of scales and fin erosions were noticed, especially in the pelvic and caudal areas, together with hemorrhagic spots on different parts of the fish's body and excessive mucus. Alternatively, paleness and congestion were observed in some parts of gills (Figure 1a and Figure 3a). Excessive mucous secretion and erosions of gills tips as well as white spots were observed (Figure 1a). Microscopically, gills revealed varying degrees of pathological changes including congestion of primary lamellae, interlamellar hyperplasia and adhesion of secondary lamellae, loss of the secondary lamellae in some sections (Figure 1b) and pillar cells hyperplasia at the tips of the primary lamellae (Figure 3d). Longitudinal sections of parasites including such crustaceans as *Ergasilus* spp., such as *Ergasilus latus* and *Ergasilus kandti* (Figures 1e and 1f), and monogenea spp. (Figure 3d) such as *Diplectanum simile* and *Diplectanum lacustris* were also observed.

The internal organs of naturally infected fish were pale and anemic, with enlargement and congestion of the spleen and liver (Figure 2a), together with congested and hemorrhagic gas bladder (Figure 4a), hemorrhage of the stomach as well as the enteritis was observed, especially in high parasitic load. Visible parasites could be seen by the naked eye (Figures 2a and 2b). The stomach and intestine revealed marked necrosis, sloughing of the covering epithelium and infiltrations of inflammatory cells, including mononuclear cells and heterophils in the mucosa and submucosa (Figures 6c, 6d, 6e and 6f). Moreover, encysted third stage larva of *Contracaecum* spp. was observed microscopically attached to the serosa of the stomach, together with the significant inflammation of its wall (Figure 2f). The gas bladder revealed hemorrhage and inflammation but the identified parasites, either nematode, or trematode, were not detected microscopically. The livers of the infected fish revealed marked congestion, fatty change and multifocal necrosis of the hepatocytes, which in some areas had infiltrated with mononuclear cells and heterophils (Figures 6a and 6b). Marked heterophils infiltrations were also observed. Proboscis of acanthocephalan was observed and surrounded with inflammatory cells including mononuclear cells and heterophils (Figure 5f).

Parasitological examinations

On the bases of the morphological examinations, the following parasites were identified from *Lates niloticus*: *Diplectanum simile* and *Diplectanum lacustris* (Figures 3b and 3c) as monogeneans trematodes microscopically exhibit a wide range of shapes and sizes as well as *Ergasilus kandti* and *Ergasilus latus* (Figures 1c and 1d) as crustacean parasites from the gills.

Tylodelphys spp., un-encysted metacercariae digenetic trematodes, used fish as intermediate host was recovered from the wall of the gas bladder and reported as new host and locality records. The live specimens were white in color and the stained one had linguiform body, measuring few millimeters with rounded anterior end and conical pointed posterior end (Figures 4b, 4c, 4d, 4e and 4f).

Philometra ovata as nematodes isolated from the gas bladder measuring few millimeters and the live specimens were white in color and transparent (Figures 4g and 4h).

Third stage larva of *Contracaecum* spp. nematodes encapsulated in fibrin sheath and attached to the alimentary canal and encysted in the wall of the stomach in heavy infestation. The liberated live larvae of *Contracaecum* spp. were reddish-yellow in color with long, cylindrical body measuring 25-55 milimeters with rounded anterior and tapered posterior ends (Figures 2b, 2c, 2d and 2e).

Rhadinorhynchus niloticus, acanthocephalan isolated from the stomach, intestine especially rectum and attached to any organ in the abdominal cavity when liberated from the stomach and intestine. It was white in color with long, cylindrical body, measuring 2-3 centimeters and had a slender, hollow construction proboscis that forms the anterior end (Figures 5a, 5b, 5c, 5d and 5e).

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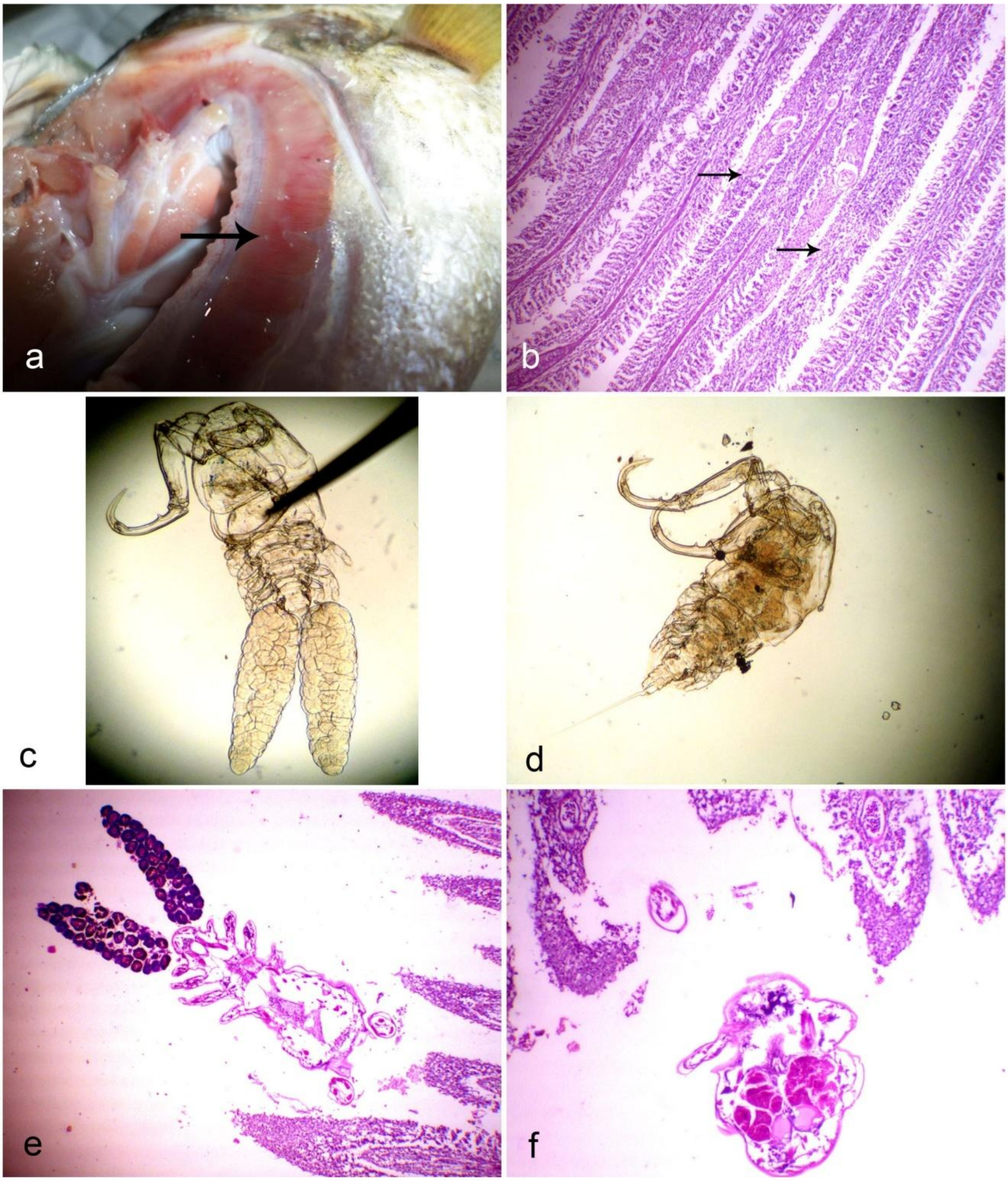

Figure 1. Gills of *Lates niloticus* from lake Nasser infected with *Ergasilus* spp. during the period of February 2016 to January 2017:

a. Pale gills of *Lates niloticus* showing excessive mucus and white dots (*Ergasilus* spp. -arrow).

b. Gills of *Lates niloticus* showing interlamellar hyperplasia and adhesion of secondary lamellae, loss of the secondary lamellae (arrow), H&E,× 100.

c. *Ergasilus latus* infecting the gills of *Lates niloticus*, × 240.

d. *Ergasilus kandti* infecting the gills of *Lates niloticus*, ×200.

e, f. Gills of *Lates niloticus* showing longitudinal sections of *Ergasilus latus* and *Ergasilus kandti* as well as pillar cells hyperplasia at the tips of the primary lamellae**,** H&E, × 200

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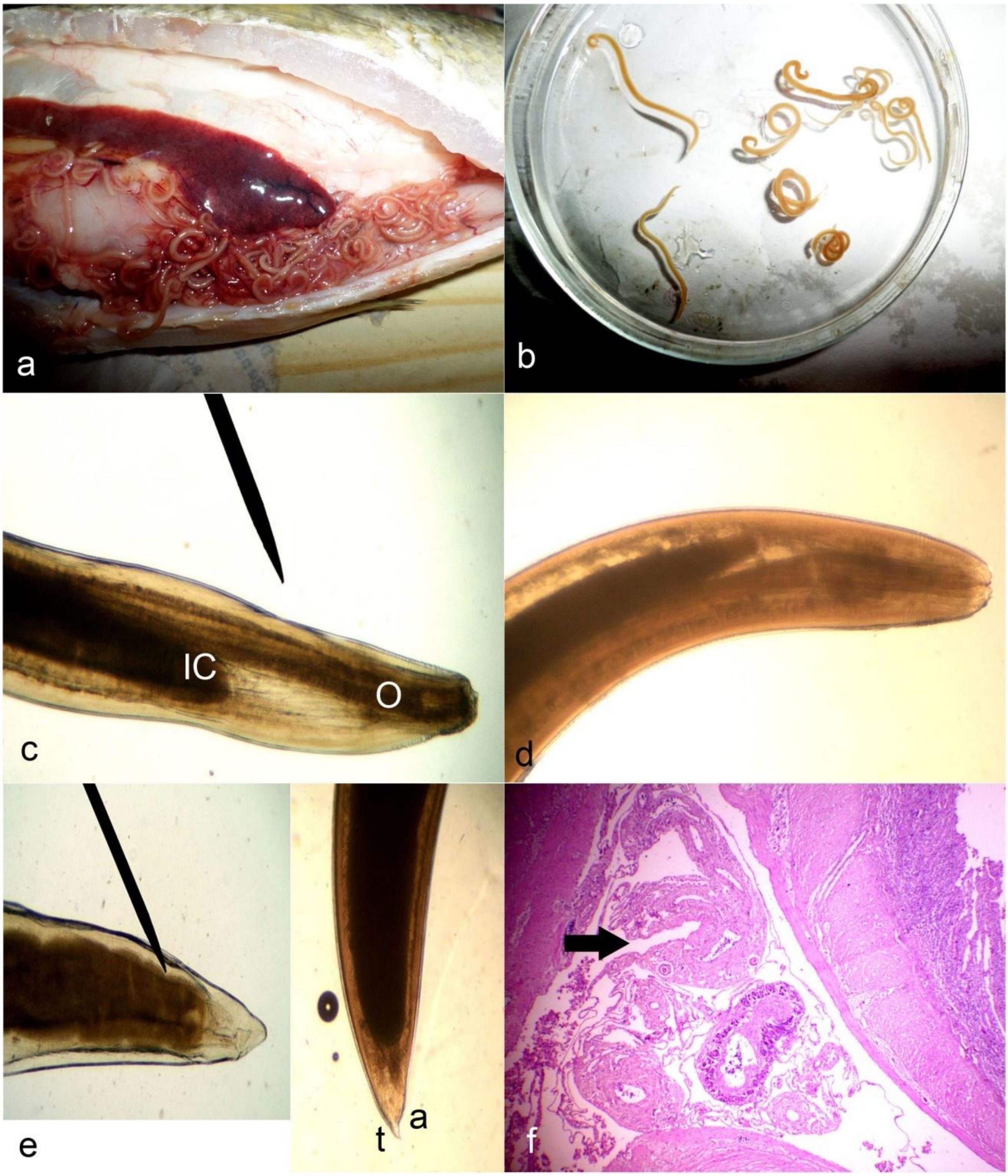

Figure 2. *Lates niloticus* from lake Nasser infected with *Contracaecum* spp. during the period of February 2016 to January 2017:

a. *Lates niloticus* showing congested liver, gas bladder and stomach as well as visible third stage larvae of *Contracaecum* spp. attached to the alimentary canal.

b. Liberated third stage larvae of *Contracaecum* spp. recovered from their fibrinous sheaths.

c. Anterior end of third stage larvae of *Contracaecum* spp. (O, oesphagous- IC, intestinal caecum),× 200.

d. Anterior end of third stage larvae of *Contracaecum* spp.,× 280.

e. Posterior end of third stage larvae of *Contracaecum* spp. (a, anal opening- t, tail end),× 200.

f. Stomach showing encysted third stage larva of *Contracaecum* spp. (arrow) as well as severe necrosis and infiltration of inflammatory cells in the lamina propria and submucosa, H&E,× 100

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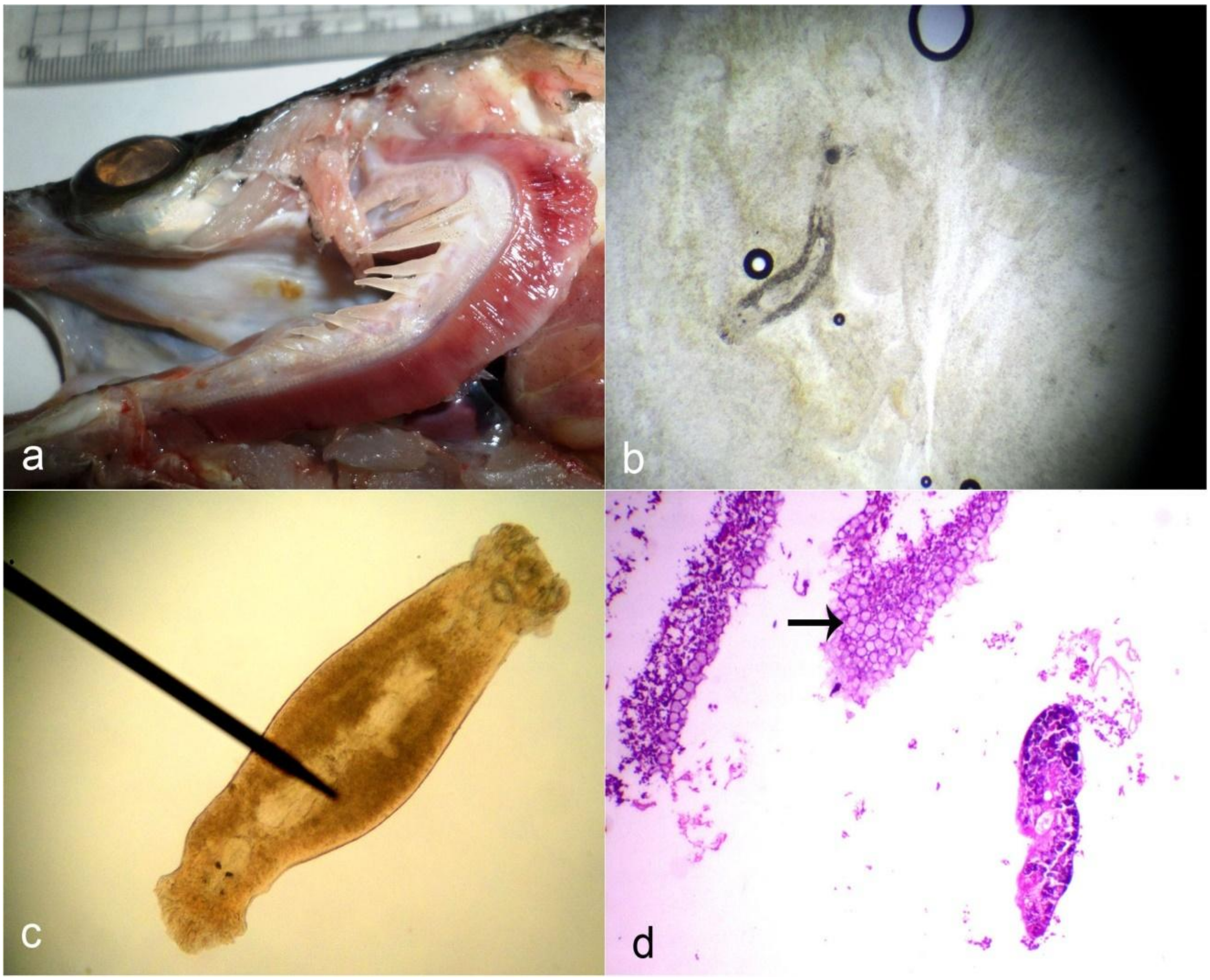

Figure 3. Gills of *Lates niloticus* from lake Nasser infected with monogenetic trematodes during the period of February 2016 to January 2017:

a. Gills of *Lates niloticus* infected with *Diplectanum* spp. showing excessive mucus, pale altered with congested areas as well as erosions of the gills tips.
b. Wet mount of *Diplectanum simile* infecting the gills of *Lates niloticus*,× 200.
c. *Diplectanum lacustris* infecting the gills of *Lates niloticus* stained with acetic acid alum carmine, ×500.
d. Gills of *Lates niloticus* showing pillar cells hyperplasia(arrow)at the tips of the primary lamellae as well as *monogenea* spp**.,** H&E,×200

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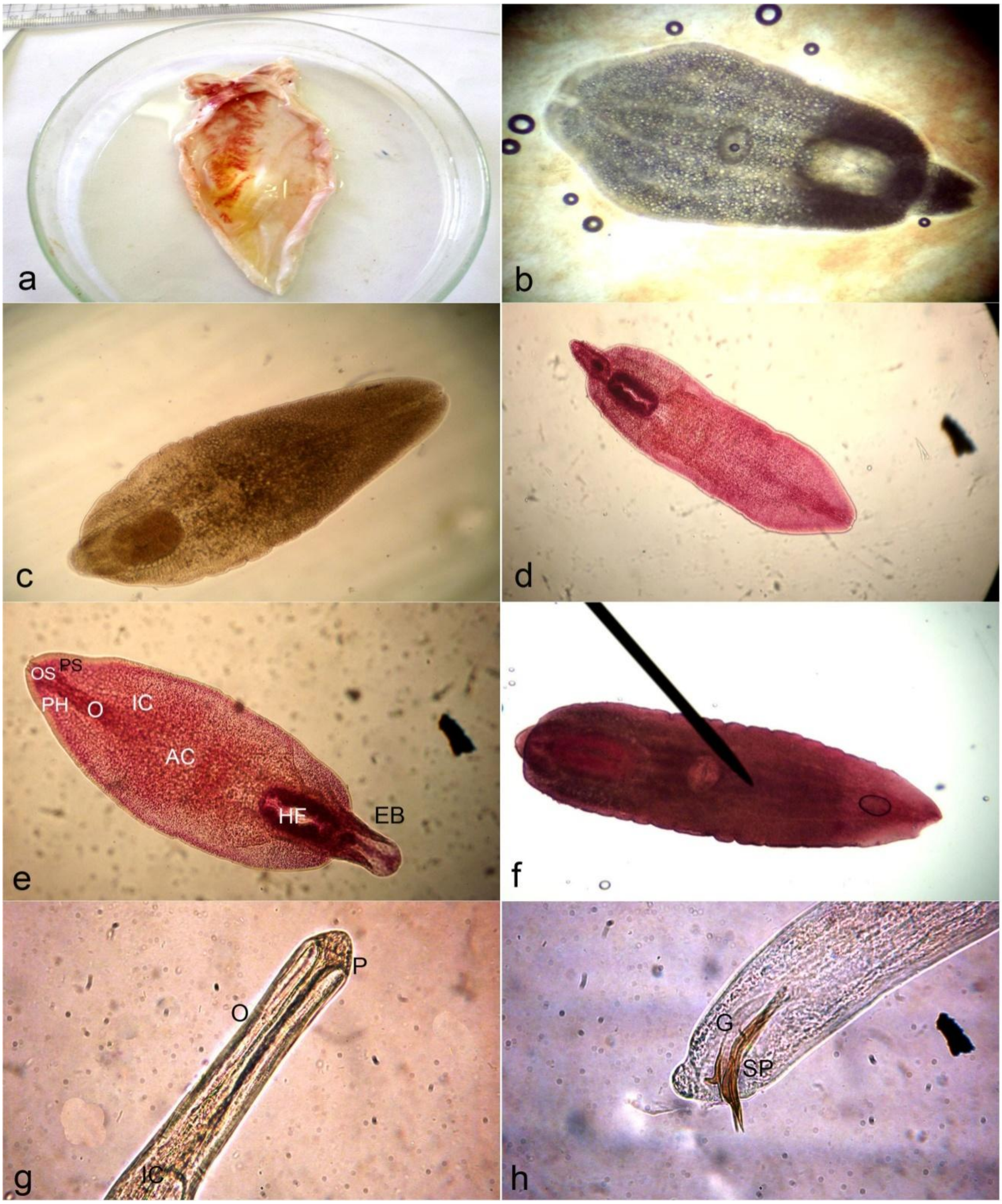

Figure 4. Gas bladder of *Lates niloticus* from lake Nasser infected with *Tylodelphys* spp. and *Philometra ovata* during the period of February 2016 to January 2017:

a. Gas bladder of *Lates niloticus* infected with *Tylodelphys* spp. and *Philometra ovata* showing slightly congested and hemorrhagic areas.

b. Wet mount of *Tylodelphys* spp. recovered from the gas bladder of *Lates niloticus*,× 200.

c,d,e,**f.** *Tylodelphys* spp. recovered from the gas bladder of *Lates niloticus* stained with acetic acid alum carmine,×200. (OS, oral sucker - PS, pseudosucker - PH, pharynx- O, oesophagus - IC, intestinal caeca - AC, acetabulum -EB, excretory bladder - HF, holdfast).

g. Anterior end of *Philometra ovata* recovered from the gas bladder of *Lates niloticus* (P, papillae - O, oesophagus - IC, intestine),× 4000.

h. Posterior end of male *Philometra ovata* (SP, spicules - G, gubernaculum) recovered from the gas bladder of *Lates niloticus*,× 4000

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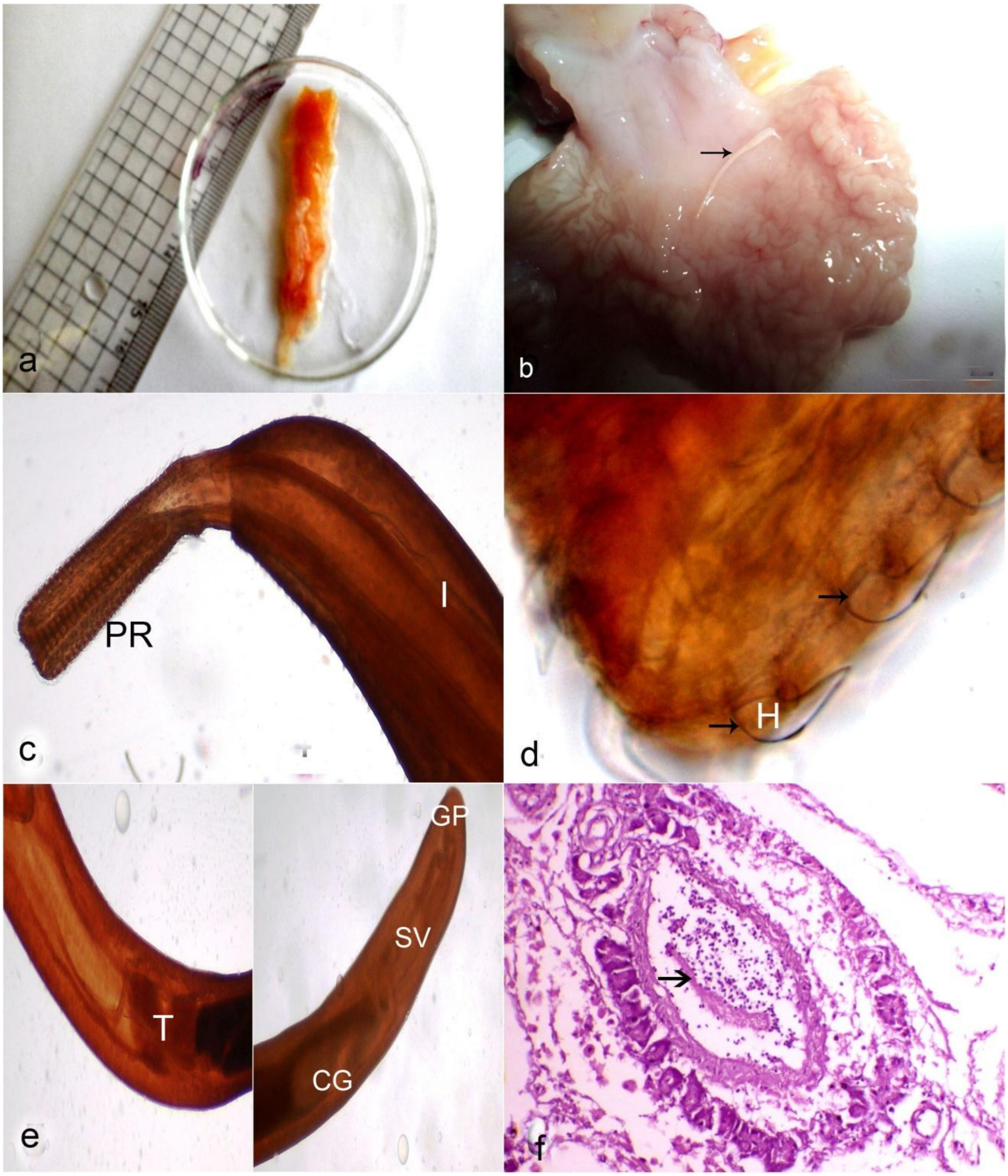

Figure 5. Rectum, stomach and liver of *Lates niloticus* from lake Nasser infected with *Rhadinorhynchus niloticus* during the period of February 2016 to January 2017:

a. *Rhadinorhynchus niloticus* inserted their proboscises in the congested rectum of *Lates niloticus*.
b. *Rhadinorhynchus niloticus* inserted its proboscis in the stomach of *Lates niloticus* (arrow).
c. Anterior end of *Rhadinorhynchus niloticus* infecting *Lates niloticus* (Pr, Proboscis - I, intestine),× 40.
d. Proboscis of *Rhadinorhynchus niloticus* infecting *Lates niloticus* showing the arranged hooks (H) (arrows),× 400.
e. Middle and posterior parts of *Rhadinorhynchus niloticus* infecting *Lates niloticus* (T, tests - CG, cement gland - SV, seminal vesicle - GP, genital pore),× 40.
f. Liver of *Lates niloticus* showing proboscis (arrow) of acanthocephalan surrounded with inflammatory cells including mononuclear cells and heterophils, H&E,× 200

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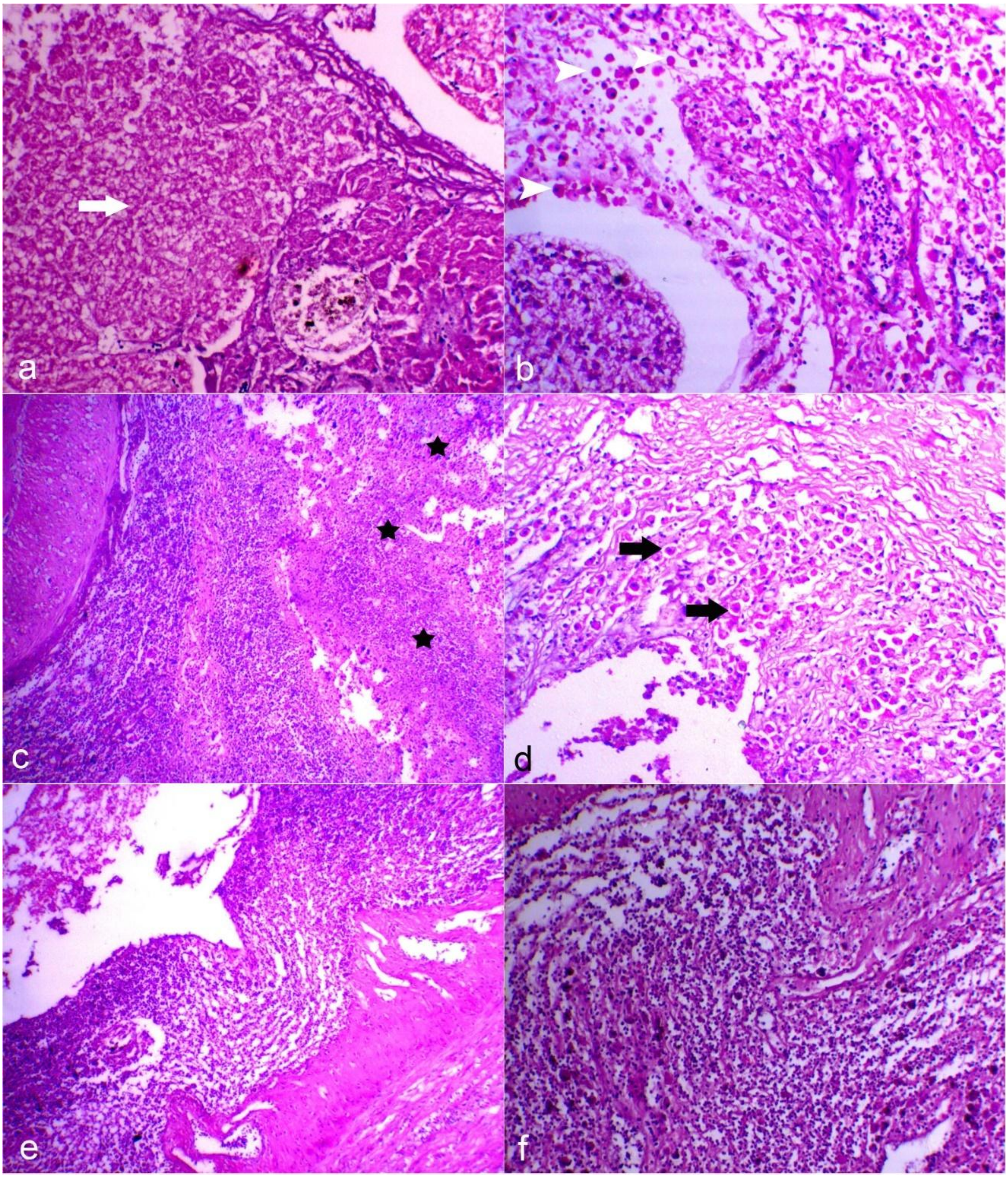

Figure 6. Liver, stomach and intestine of *Lates niloticus* from lake Nasser infected with *Contracaecum* spp. during the period of February 2016 to January 2017:

a. Liver showing marked necrosis of hepatocytes (arrow), H&E,× 100.

b. Liver showing fatty change and marked heterophils infiltrations (head arrow), H&E,× 200.

c. Stomach showing severe necrosis of the mucosa (asterisk) and infiltration of inflammatory cells in lamina propria and submucosa, H&E,× 100.

d. Higher magnification of Figure **6c**.
Stomach showing marked heterophils infiltrations (arrow) in the lamina propria, H&E,× 200.

e. Intestine showing severe necrosis of the mucosa and infiltration of inflammatory cells in the lamina propria and submucosa, H&E,× 100.

f. Higher magnification of Figure **6e**, intestine showing marked heterophils and mononuclear cells infiltrations in the lamina propria, H&E,× 200

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The total and the seasonal prevalence of detected parasites

The examined fish; *Lates niloticus* revealed a trematodal, nematodal, acanthocephalan and crustaceans infection rates of 95%, 100%, 24.5% and 69.5% respectively. However, there were no cestodal infections along the period of study, as presented in (Tables 2 and 3).

Concerning the seasonal dynamics of external *Diplectanum simile* and *Diplectanum lacustris* isolated from the gills of *Lates niloticus* with an overall prevalence of (30%), a higher infection rate was observed during autumn (50,58%), followed by summer (40,45%), spring (20,33%) and then winter (10, 18%) respectively, as presented in (Table 4). The incidence and intensity of infection with *Diplectanum* spp. in *Lates niloticus* was highest in the class 1 age group. *Tylodelphys* spp., un-encysted metacercaria isolated from the gas bladder, used *Lates niloticus* as an intermediate host with a total prevalence of (89%). A higher infection rate was observed during summer (96%), followed by autumn (90%), spring (86%) and then winter (84%), as described in (Table 4). The incidence and intensity of infection with *Tylodelphys* spp. in *Lates niloticus* increased with the class 2 age group.

Regarding the prevalence of different species of nematodal infections in *Lates niloticus*, *Philometra ovata* in the gas bladder was recorded with a total prevalence of 12.5 % and was higher in summer (20%) then spring (12%), winter (10%) and autumn (8%) (Table 4). It was observed much more in individuals belonging to the class 3 age group.

The third stage larvae of *Contracaecum* spp. in the abdominal cavity of the fish investigated were recorded with a prevalence rate of 100% throughout the period of study (Table 4). The recorded presence of *Rhadinorhynchus niloticus* isolated from the stomach and intestine of *Lates niloticus* was highest in winter (40%), then spring (30%), summer (20%) and autumn (8%) with a total prevalence of 24.5 % (Table 4).

The presence of nematodes (*Contracaecum* spp. and *Philometra ovata*) and the acanthocephalan (*Rhadinorhynchus niloticus*) in *Lates niloticus* had increased in incidence and intensity with the age of fish. *Ergasilus kandti* and *Ergasilus latus* were found in the gills of investigated fish at a higher infection rate in summer (90%, 92%), then spring (86%, 90%), autumn (82%, 87%) and winter (20%, 30%) respectively (Table 4). The incidence and intensity of infection with *Ergasilus* spp. in *Lates niloticus* was highest in the class 1 age.

In the present study, we noticed that while the gills are heavily infested with *Ergasilus* spp., the number of *Diplectanum* spp. drastically decreases or are even entirely absent. Interestingly, the musculature of *Lates niloticus* was completely free from any larvae, encysted meatacercariae and adult worms.

The parasites detected in *Lates niloticus* were found throughout the period of study. Some of them showed clear seasonal variation while the others were of nearly uniform frequency during the different seasons, varying only in the intensity of infections. The detected parasites were identified in their larval stages and adult worms were also reported.

DISCUSSION

Signs found on *Lates niloticus* infected with different parasites may be explained as sequences of parasites presenting different parts of the fish. Similar results have been reported on other fish hosts and other parasitic diseases (Hamouda, 2014). Few studies have reported on the occurrence of third stage larvae of *Contracaecum* spp. in *Lates niloticus* of Lake Nasser without any behavior abnormalities (Abd Alkareem, 2004).

Paleness and congestion in some parts of gills might be attributed to the mechanical injuries caused by *Diplectanum* spp. and *Ergasilus* spp. at the onset of infection leading to congestion. Indeed, when flukes increased in number and attacked the gills aggressively, they increase their feeding activities on the blood of the highly vascularized gills, causing anemia and pallor of the gills in the chronic phase. Excessive mucous secretion (as a defensive mechanism to diminish the irritant effect of the pathogen) and the white structures in the gills were *Ergasilus* spp. These results were nearly similar to those recorded by Noga (2010); Rashed (2013) and Hamouda (2014).

Internal gross lesions induced by parasites may be attributed to the presence of macroscopic parasites of third stage larvae of *Contracaecum* spp., *Philometra ovata*, *Tylodelphys* spp. and *Rhadinorhynchus niloticus* (which embed themselves in the lining mucosa of the stomach and intestine, causing local damage and possibly peritonitis). Moreover, proteolytic enzymes discharged from adult worms may be degrading the gastric and intestinal tissues (Woo, 1995). Helminthes produce toxic metabolic by-products which harm the infected host by causing occlusion of blood vessels, intestine and other ducts and resulting in the inflammation and congestion described in the internal organs. The above-mentioned reports suggesting the mechanism of tissue damage induced by parasites were confirmed histopathologically. However, no study has described in detail signs, lesions, evidences and histological damages induced by parasites in *Lates niloticus* as the present paper.

Latus niloticus is a carnivorous fish that assists in the greater transmission of parasites through feeding on young infested fish or aquatic animals that harbor it in the infective stages. This could be the reason for the maximum parasitic infestation rate (100%).

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There is scarcity of information on the isolated parasites of *Lates niloticus* from lake Nasser except 3rd stage larvae of *Contracaecum* spp. (Younis et al., 2017) and *Rhadinorhynchus niloticus*.

The metacercariae of *Tylodelphys* spp., are highly active and never encyst (Schaperclaus, 1992). Many authors around the world have detected *Tylodelphys* spp. in the vitreous humor of fish other than *Lates niloticus* (Otachi, 2009; Blasco-Costa et al., 2017 and Chaudhary et al., 2017) and from cranial cavity of *Clarias gariepinus* (Chibwana et al. 2015). But to our knowledge there is no record of isolation of such parasites from the swim bladder and from *Lates niloticus* so it is new host and locality records.

Philometra ovata was recorded with a total prevalence of 12.5 % and was highest in summer (20%) then spring (12%), winter (10%) and autumn (8%). It was observed much more in individuals belonging to the class 3 age group. These results were nearly identical with those recorded by Innal and Keskin (2005) on *Leucis cephalus* L. fish and lower than recorded by $\mathrm{Y_I}$-$\mathrm{T_E}$ L (2014) on European minnows. Unidentified species of Philometroides were recorded from *Lates niloticus* in Egypt by El-Nafar et al. (1983) with a prevalence of 1.3%. *Philometra lati* isolated from the abdominal cavity of *Lates niloticus* and *Philometra spiriformis* sp. n. from capsules on the inner surface of the gill covers of *L. niloticus* were recorded by Moravec et al. (2009) in Kenya. Members of the family Philometridae has been recorded in different fish species other than *Lates niloticus* in Africa (Khalil, 1960, 1965, 1969 and 1973; Fahmy et al., 1976; El-Nafar et al., 1983 and Moravec and Van As, 2001).

The third stage larvae of *Contracaecum* spp. were recorded with a prevalence of 100% throughout the period of study. This result was identical with that recorded by Rabei (2009) and Younis et al. (2017) and this may be explained as the definitive hosts of *Contracaecum* spp. are pelicans, cormorants and herons and these are ubiquitous throughout the year around lake Nasser, so the infection was equally throughout the year. *Contracaecum* spp. larvae belonging to Anisakid nematodes which are considered to be responsible for anisakidosis disease, a serious zoonotic disease, and there has been a dramatic increase in its reported prevalence throughout the world in the last two decades (Lymbery and Cheah, 2007) so if the fish are not frozen or filleted soon after capture, larval nematode may migrate into the flesh. Accordingly, humans may be infected if viable larvae are consumed in uncooked or undercooked fishes (Younis et al., 2017).

Rhadinorhynchus niloticus was highest in winter (40%), then spring (30%), summer (20%) and autumn (8%) with a total prevalence of 24.5%. This was higher than that recorded by Ebraheem (1992) and Abd Elmageed (2015). The presence of nematodes (*Contracaecum* spp. and *Philometra ovata*) and the acanthocephalan (*Rhadinorhynchus niloticus*) in *Lates niloticus* increased in incidence and intensity with the age of fish and this may be owing to the accumulation of the worms over a longer period giving them available spaces for colonization and accumulation in addition to the larger size of fish, tend to be too big for the piscivorous bird to feed upon (Gichohi et al., 2008 and Zekarias and Yimer, 2008).

Ergasilus kandti and *Ergasilus latus* were found in the gills of investigated fish at a higher infection rate in summer (90, 92%), then spring (86, 90%), autumn (82, 87%) and winter (20, 30%), respectively. This was nearly similar to that recorded by Paperna (1968) but, Aladetohun et al. (2013) recorded the highest infestation rate of *Ergasilus* spp. in *Mugil cephalus* in the rainy seasons.

In the present study, we noticed that while the gills are heavily infested with *Ergasilus* spp., the number of *Diplectanum* spp. is drastically decreased or are even entirely absent. This may be because the heavy infestations with *Ergasilus* make the gills less suitable for monogeneans to establish themselves (Tiiurston and Paperna, 1969). *Ergasilus* feeding activity induces severe focal damage and very heavy infestations can be lethal (Noga, 2010).

The parasites detected in *Lates niloticus* were found throughout the period of study. Some of them showed clear seasonal variation while the others were of nearly uniform frequency during the different seasons, varying only in the intensity of infections. The snail is restricted to waters that remain warm (probably >17 ° C) year – round (Noga, 2010) and in Aswan, the high temperature in all seasons is maintained nearly throughout the year. This favors the development of snails, invertebrate hosts and the final hosts (fish, crocodiles, frogs, snakes and aquatic birds) as well as, an increase in plankton production, which is the source of nutrition of intermediate hosts.

The detected parasites were identified in both larval stages and adult worms, indicating that *Lates niloticus* act as intermediate, definitive or paratenic host contributing the expansion of infestations on intra or inter specific hosts. This could be due to the nature of the life cycle in these parasites, which involves the presence of snails or invertebrate (a crustacean; sometimes an annelid, coelenterate and mollusk) as first intermediate hosts, followed by fish as second intermediate host and finally aquatic birds, fish and reptiles as definitive final hosts (Syobodova and Kolarova, 2004).

Our results may differ partially or completely with many authors and this may be attributed to the different localities of the examined fish, type, age and sex of fish examined as well as, water hydrochemistry in each locality (Hamouda, 2014).

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Table 2. Prevalence of trematodes and nematodes among the examined *Lates niloticus* in lake Nasser, Egypt during the period of February 2016 to January 2017

Fish species	No. Exam. Fish	Trematodal infections										Nematodal infections					
		Diplectanum simile		*Diplectanum lacustris*		Total *Diplectanum* infections		*Tylodelphys* spp.		Total of trematodal infections		*Contracaecum* spp.		*Philometra ovata*		Total of nematodal infections	
		Infected No.	% of infections	Infected No.	% of infections	Infected No.	% of infections	Infected No.	% of infections	Infected No.	% of infections	Infected No.	% of infections	Infected No.	% of infections	Infected No.	% of infections
Lates niloticus	200	33	16.5	45	22.5	60	30	178	89	190	95	200	100	25	12.5	200	100

No. exam. = Number of examined

Table 3. Prevalence of acanthocephalans, crustaceans and cestodes among the examined *Lates niloticus* in lake Nasser, Egypt during the period of February 2016 to January 2017

Fish species	No. exam. Fish	*Rhadinorhynchus niloticus*		*Ergasilus* spp.						Cestodes	
				Ergasilus kandti		*Ergasilus latus*		Total Ergasilus infections			
		Infected No.	% of infections	Infected No.	% of infections	Infected No.	% of infections	Infected No.	% of infections	Infected No.	% of infections
Lates niloticus	200	49	24.5	60	30	90	45	139	69.5	0	0

No. exam. = Number of examined

Table 4. The seasonal prevalence, infection, intensity and mean/fish of helminth parasites in different organs of *Lates niloticus* from lake Nasser, Egypt during the period of February 2016 to January 2017

Type of parasite	% of infected fish	Seasonal prevalence				Susceptible organs	No. of Parasites per inf. fish	Mean /fish
		Spring	Summer	Autumn	Winter			
Diplectanum simile	16.5	20	40	50	10	Gills	4-10	4
Diplectanum lacustris	22.5	33	45	58	18	Gills	6-20	7
Tylodelphys spp.	89	86	96	90	84	Gas bladder	3-33	20
Philometra ovata	12.5	12	20	8	10	Gas bladder	6-60	28
Contracaecum L_3 larvae	100	100	100	100	100	Associated with the alimentary canal	1-99	33
Rhadinorhynchus niloticus	24.5	30	20	8	40	Stomach and intestine	1-7	4
Ergasilus kandti	30	86	90	82	20	Gills	10- 40	15
Ergasilus latus	45	90	92	87	23	Gill	10-60	22
Cestodes	0	0	0	0	0	——	0	0

No. = Number; inf. = infected

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CONCLUSION

Parasitic infestation of *Lates niloticus* is an important factor affecting wild populations of *Lates niloticus* and another aquatic species in Lake Nasser. Therefore, extended investigations about the effects of parasitic infection on fecundity, survival of this fish species are recommended to ensure successful fishery management plans.

Lates niloticus must be gutted soon after capture to avoid the attack of the detected parasites to its musculature which is completely free from any parasitic infection. The disposal of viscera or infected fish parts in water should be strenuously prohibited. Regular monitoring of the fish in Lake Nasser is a must. Further studies on *Tylodelphys* spp. in *Lates niloticus* (new host and locality records) are needed and urged.

DECLARATIONS

Author's contribution

All authors contributed equally to this work whereas they designed, conducted the research and wrote the manuscript.

Competing interests

The authors have declared that no competing interest exists.

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