

A Survey Parasitic of Nile Tilapia (*Oreochromis niloticus*) with Special Reference to their Immune Status, Histopathological Aspects and Nutritional Values

Mahmoud Kh Radwan^{1*}, Sabry M. Shehata¹, Yasser M. Abdelhadi², Ramadan A Mohammed² and Mohamed H Mohamed¹

¹Marine Biology Branch, Zoology Depart, Al-Azhar University, Cairo, Egypt

²Central Laboratory for Aquaculture Research, Abbassa, Egypt

Received: 14.01.2021 / Accepted: 28.01.2021 / Published online: 04.02.2021

Abstract:

Fish farming characterizes a vital and healthy basis of protein for human nutrition. Presently, Nile tilapia (*Oreochromis niloticus*) is the second most elevated fish species worldwide, and its fillet plays an important role in the international occupation of fish meat. This study was performed to investigate the alterations that associated with infected Nile tilapia by parasites. The fish were observed for any clinical abnormalities, postmortem changes, biochemical and histopathological changes. There were significant changes in the evaluated physiological parameters in all infected groups than uninfected fish. The lesions were variable among the infected groups, however; lesions intensity was more pronounced in fish infected with both pathogens.

Keywords: *Oreochromis niloticus*; Biochemical and histopathological changes; Nutritional values

*Correspondence to:

Radwan KHM, Marine Biology Branch, Zoology Department, Faculty of Science, Al-Azhar University, Cairo, Egypt, E-mail: ma_kh_1983@yahoo.coms

Introduction

Fish and other aquatic animals are critical to providing a high-value protein source and important micronutrients for much of the world. As production from capture fisheries remains stable, aquaculture's critical role in meeting increased demand for aquatic food products is driving researchers to assess the sustainability of the industry. In addition, consumers are becoming increasingly concerned with the environmental and ethical impacts of their food choices [1]. In Egypt, aquaculture has become an increasingly important activity as an immediate source of animal protein required for the country's growing population [2].

Fish parasites constitute the main cause of economic losses in aquaculture, including various types of pathogens (protozoa, trematodes, cestodes, nematodes, acanthocephalan and crustacean parasites), those causing deformity, weight loss mortality etc [3]. Parasitic diseases of fish reduce the amount and quality of food available to peoples around the globe. It is imperative, therefore, to investigate the relationship between the environmental factors as it affects the parasites that affect production and quality of fishes [4]. Hematological parameters constitute an important tool that reveals the health state of fish. Parasitism may induce lowered growth and haematological alteration [5].

Fish diseases and histopathology, with a broad range of causes can be used as indicators of environmental stress, since they provide a definite biological end point of histological exposure, it is a mechanism which can provide an indication of fish health by determining early injury to cells and can therefore be considered an important tool to determine the effect of parasites on fish tissue [6]. Moreover, histopathological biomarkers can be sensitive indicators of subcellular stress in organisms exposed over short and long periods to a range of pollutants [7].

Materials and Methods

Abbasa Fish Farm, one of the most productive of the Egyptian fish farms, is located in EL-Sharkia Governorate between latitudes 30° 32 ' North and latitudes 31° 44' East. The fish farm is about 2200 feddans. A total of 846 cultivated fishes *Oreochromis niloticus* were collected seasonally during the period from October, 2015 to September, 2017 formed the material for the present study. Fishes were anaesthetized and blood was collected from the caudal blood vessels by a sterile syringe and kept for

physiological analysis. After dissection, a known weight of muscles was kept under freezing condition at 4°C until the latter examinations. Moreover, the clinical, postmortem, parasitological, physiological, histopathological and nutritional values were conducted.

Parasitological studies

Macroscopic examination: Macroscopic examination was done according to Syme [8] for the detection of any parasites in different parts of the fish body by naked eyes and hand lens.

Identification of isolated parasites: Protozoans were identified according to Ahmed et al. [9]. Monogenetic trematodes were identified according to Eissa [3]. Cestodes and nematodes were identified according to Paperna [10]. Acanthocephala were identified according to Ramadan [11]. While crustacean parasites were identified according to Eissa [3].

Physiological studies: Blood samples were divided into three parts, the first part kept in clean and dry tubes and centrifuged for 15 min for separation of serum (collected serum was stored at -20°C) for aspartate aminotransferase (ASAT), alanine aminotransferase (ALAT) and total protein, The second part was taken on a dry and clean Eppendorf tube with sodium fluoride as anticoagulant factor and centrifuged for 15 min for separation of plasma for glucose analysis. The third part was taken on a dry and clean Eppendorf tube with EDTA solution for measuring hemoglobin (Hb), Red Blood Cell (RBCS), White Blood Cells (WBCs), Packed Cell Volume (PCV) [12].

Nutritional value of the fish muscles: Muscle samples were analyzed for moisture, protein; lipid, carbohydrates and ash were determined by using the standard process of [13].

Histopathological studies: Autopsy samples were taken from the liver, gills, muscles, skin, and eye of fish of different sized groups and fixed in 10% formol saline for twenty four hour. Washing was done in tap water then serial dilutions of alcohol (methyl, ethyl and absolute ethyl) were used for dehydration. Specimens were cleared in xylene and embedded in paraffin at 56 degree in hot air oven for twenty four hours. Paraffin bees wax tissue blocks were prepared for sectioning at 4 microns by slide microtome. The obtained tissue sections were collected on glass slides, deparaffinized and stained with hematoxylin and eosin stain and examined under the electric light microscope [14].

Results

Seasonal dynamics of parasitic infection in different groups of *O. niloticus*

Results (Table 1) showed that, the highest value of protozoans in *O. niloticus*, was recorded during summer (12.77%) and the autumn (12.18%) and the lowest value (7.81%) was obtained during winter. However, prevalence of trematodes was declined gradually from 38.63% during summer to 27.10% during spring. While, the maximum prevalence of cestoda (5.92%) were detected during summer and the minimum value (0.88%) was observed during winter. On the other hand, the highest prevalence of acanthocephalan parasites was observed during spring (8.88%) and the lowest (4.39%) during winter. The highest prevalence of crustacean was recorded during summer and the lowest during autumn; being 14.33 & 4.06%, respectively.

Physiological studies: Data (Table 2) revealed that, Red Blood Cell count (RBCs), hemoglobin content and Packed Cell Volume (PCV) decreased in the infected *Oreochromis niloticus*, compared with the uninfected ones. Also, they were higher in female than in male groups. However, white blood cell counts were increased with the increasing infection. Also, WBCs values in females were higher than in males. Concerning *O. niloticus*, data showed increased activity of aspartate aminotransferase activity (ASAT) and alanine aminotransferase (ALAT) in the infected fish than the uninfected one of both sized groups. On the other hand, glucose increased with the increasing infection. Regarding to *O. niloticus* the highest values of total protein in the serum were recorded in uninfected small males and large females; being 4.13 ± 0.12 g/dl in the former and 4.31 ± 0.09 g/dl in the latter. While, the lowest values were recorded in the infected samples of the same sized groups; being 3.15 ± 0.14 g/dl in male groups and 3.00 ± 0.14 g/dl in female ones.

Table 1: Seasonal dynamics of parasitic infection in *O. niloticus*, collected from Abbasa Fish Farm

Family	Spring (214)	Prevalence (%)	Summer (321)	Prevalence (%)	Autumn (197)	Prevalence (%)	Winter (114)	Prevalence (%)	Totals (846)	Prevalence (%)
Protozoa	21	9.81	41	12.77	24	12.18	9	7.89	95	11.23
Trematoda	58	27.1	124	38.63	69	35.03	37	32.46	288	34.04
Cestoda	9	4.21	19	5.92	5	2.54	1	0.88	34	4.02
Acanthocephala	19	8.88	27	8.41	12	6.09	5	4.39	63	7.45
Crustacea	25	11.68	46	14.33	8	4.06	9	7.89	88	10.4
Total	132	61.68	257	80.06	118	59.9	61	53.51	568	67.14

Table 2: Effect of parasitic infection on haematological and biochemical parameters in *Oreochromis niloticus*, collected from Abbasa Fish Farm, according to sex and sized groups.

Parameters	Sex	Small fish		Large fish	
		Uninfected	Infected	Uninfected	Infected
RBCs ($\times 10^6$ cell /mm ³)	Males	2.27 ± 0.29	1.82 ± 0.11	2.57 ± 0.28	1.97 ± 0.09
	Females	2.72 ± 0.39	1.80 ± 0.10	3.13 ± 0.21	2.28 ± 0.33
WBCs ($\times 10^3$ cell/mm ³)	Males	21.41 ± 0.39	25.63 ± 0.55	22.76 ± 0.57	24.02 ± 1.25
	Females	23.96 ± 0.71	26.03 ± 0.95	25.30 ± 0.92	25.82 ± 0.81
Hb (g/dl)	Males	8.35 ± 0.45	6.66 ± 0.22	9.37 ± 0.23	7.12 ± 0.23
	Females	8.81 ± 0.21	6.91 ± 0.16	9.74 ± 0.37	7.36 ± 0.35
PCV (%)	Males	23.21 ± 0.92	20.61 ± 1.14	25.22 ± 0.72	22.15 ± 0.56
	Females	24.07 ± 0.94	21.47 ± 0.46	25.93 ± 0.45	22.00 ± 0.47
AST (U/ml)	Males	35.72 ± 2.61	41.82 ± 2.55	42.51 ± 1.19	44.92 ± 3.02
	Females	40.26 ± 1.65	56.08 ± 3.11	42.73 ± 1.33	50.82 ± 2.50
ALT (U/ml)	Males	27.13 ± 1.44	35.86 ± 2.87	27.22 ± 0.72	33.59 ± 3.16
	Females	26.79 ± 0.33	30.44 ± 0.74	27.88 ± 1.14	29.54 ± 1.26
Glucose (mg/dl)	Males	63.34 ± 3.51	72.13 ± 2.04	66.83 ± 1.24	69.98 ± 1.36
	Females	64.87 ± 1.99	74.96 ± 4.81	65.46 ± 2.63	68.33 ± 4.31
Total protein (g/dl)	Males	4.13 ± 0.12	3.15 ± 0.14	3.92 ± 0.18	3.37 ± 0.07
	Females	4.03 ± 0.14	3.00 ± 0.14	4.31 ± 0.09	3.44 ± 0.19

Results revealed that, protein contents in *O. niloticus*, decreased with infection and increasing sized group. It was relatively higher in females than in males of this fish. Concerning *O. niloticus*, lipid contents in the fish males was fluctuated between $4.91 \pm 0.28\%$ in the uninfected group of small fishes and $5.65 \pm 0.012\%$ in the infected large sized groups. In females, however, it was varied from $4.76 \pm 0.61\%$ in uninfected small fishes to $5.46 \pm 0.35\%$ in the infected ones. Moreover, carbohydrate contents in the muscles decreased with infection and increasing sized groups. In general it was higher in females than in males, except uninfected large group. Results showed that, moisture in *O. niloticus* was slightly increased with infection and increasing sized groups. Regards to ash contents in male fishes was peaked in the uninfected large fishes ($2.31 \pm 0.41\%$) and declined in the infected small one ($1.75 \pm 0.21\%$). In females, however, it was varied from $1.76 \pm 0.21\%$ in uninfected small fishes to $2.68 \pm 0.35\%$ in the infected ones (Table 3).

Histopathological alterations on the different organs of the infected fishes: Microscopic examination of the gills of infected *O. niloticus*, with trematods revealed desquamation of primary and secondary gill filament epithelium and subepithelium infiltration of lymphocytes (Figure 1). Degenerated parasitic cyst at the tip of the primary gill filament; surrounded with moderately thick fibrous capsule with a prominent round infiltrated cells in the inter filamentous tissue was also observed. Epithelium of primary and secondary gill filament, revealed increased number of primary and secondary mucous secreting cells and subepithelial lymphocytic infiltration (Figures 2 and 3).

Histopathological examination of skin and muscles of the infected *O. niloticus*, showed encysted metacercaria among muscle fibers; it was represented by central degenerated

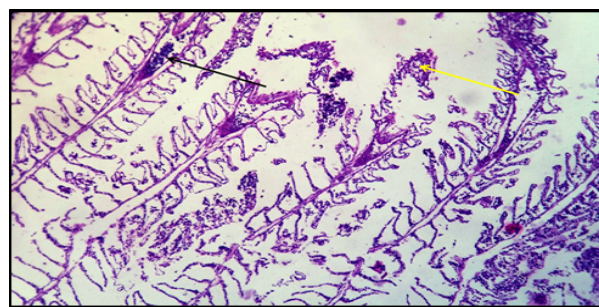


Figure 1: Photomicrograph of gills of *O. niloticus*, showing desquamation gill filament epithelium (yellow arrow) and sub epithelium infiltration of lymphocytes (black arrow) (H. and E. stain- X 40).

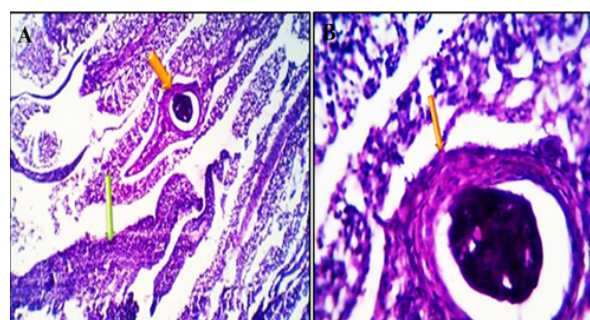


Figure 2: Photomicrograph of gills of *O. niloticus*, showing parasitic cyst embedded between lamellar epithelium with surrounding fibrous connective tissue capsule (H. and E. stain- X 100).

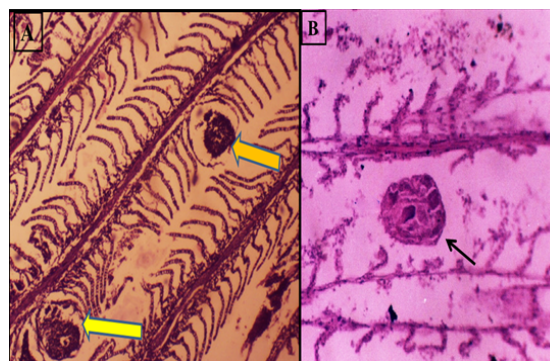


Figure 3: Photomicrographs of gills of *O. niloticus*, showing parasitic cyst embedded between lamellar epithelium with surrounding fibrous connective tissue capsule at the area of parasitic attachment is completely destroyed (A). Gills infested with *Lamproglana* parasite (B) (H. and E. stain- X 40, 100).

Table 3: Effect of parasitic infection on the nutritional value (protein, lipid, carbohydrates, moisture and Ash) in the muscles of *Oreochromis niloticus*, collected from Abbasa Fish Farm, according to sex and sized groups.

Parameters	Sex	Small fish		Large fish	
		Uninfected	Infected	Uninfected	Infected
Protein content (%)	Males	17.51 ± 0.67	16.62 ± 0.27	16.32 ± 0.27	15.92 ± 0.15
	Females	17.97 ± 0.43	15.69 ± 0.66	17.25 ± 0.10	16.25 ± 0.82
Lipid content (%)	Males	4.91 ± 0.28	5.47 ± 0.09	5.54 ± 0.19	5.65 ± 0.12
	Females	4.76 ± 0.61	5.46 ± 0.35	5.25 ± 0.35	5.38 ± 0.20
Carbohydrates (%)	Males	1.65 ± 0.31	1.11 ± 0.22	1.60 ± 0.15	1.09 ± 0.21
	Females	2.15 ± 0.29	1.38 ± 0.38	1.47 ± 0.07	1.31 ± 0.25
Moisture percentage (%)	Males	73.94 ± 0.28	75.06 ± 0.34	74.23 ± 0.30	75.14 ± 0.77
	Females	73.36 ± 0.55	75.18 ± 0.77	73.42 ± 0.50	74.39 ± 0.54
Ash content (%)	Males	1.98 ± 0.46	1.75 ± 0.21	2.31 ± 0.41	2.20 ± 0.20
	Females	1.76 ± 0.21	2.29 ± 0.20	2.60 ± 0.17	2.68 ± 0.35

parasitic element, surrounded by thin fibrous capsule, followed by aggregation of eosinophilic granular cells and lymphocytes. Moreover, the affected muscle fibers showed distortion, degeneration and interstitial edema (**Figure 4**). Moreover, muscle fibers showed interstitial edema, mild lymphocytic infiltration prominent field of cohenheim and longitudinal striations. Hyaline degeneration in some fibers "swelling and eosinophilia" and pyknotic nuclei were also detected (**Figure 5**).

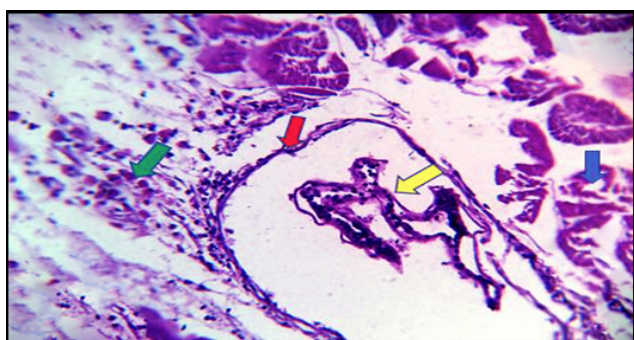


Figure 4: Photomicrograph of skin and muscles of *O. niloticus*, showing encysted metacercaria (yellow arrow), fibrous capsule (red arrow) and aggregation of eosinophilic granular cells (green arrow) (H. and E. stain- X 100).

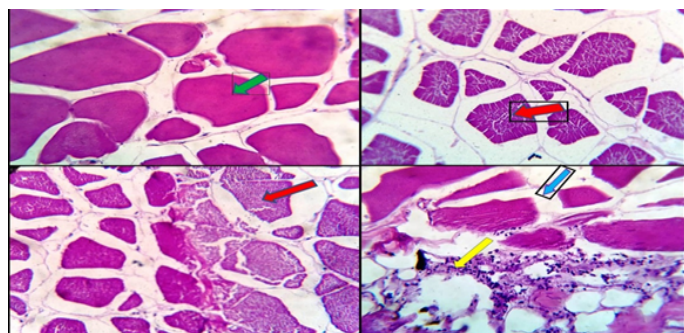


Figure 5: Photomicrograph of muscle of infected *O. niloticus*, showing interstitial edema (blue arrow) mild lymphocytic infiltration (yellow arrow) and pyknotic nuclei (green and red arrow) (H. and E. stain- X 40, 100).

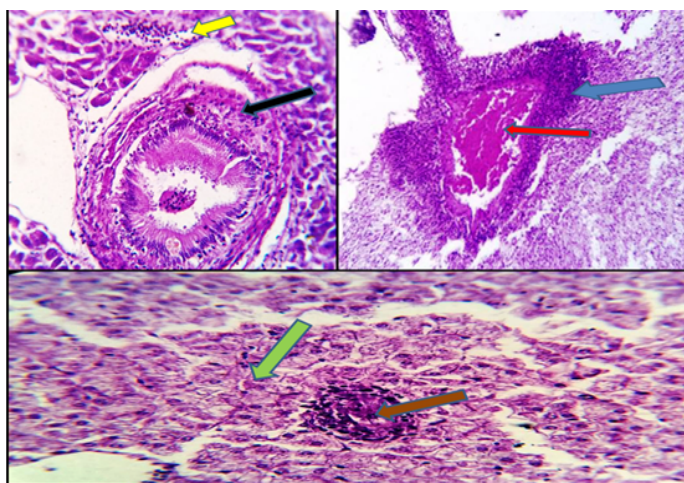


Figure 6: Photomicrographs of the liver of infected *O. niloticus*, showing cystic caseated material (red arrow) aggregation of lymphocytes (blue arrow) degenerated parasitic cyst (brown arrow) hydropic degeneration (green arrow) edema (yellow arrow) bile duct cystically fibrosed (black arrow) (H. and E. stain- X 40, 100).

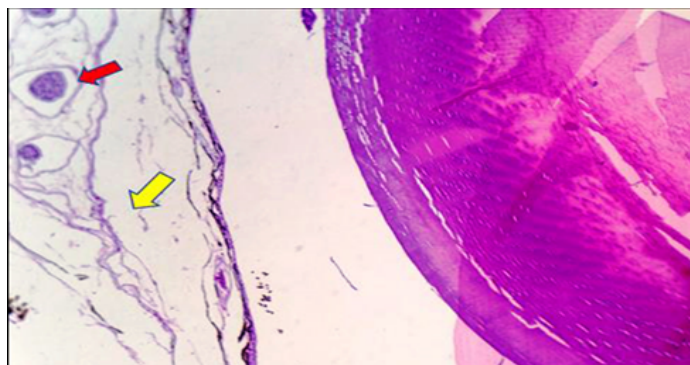


Figure 7: Photomicrograph of the eye of infected *O. niloticus*, showing scleral congestion (red arrow) and edema (yellow arrow) (H. and E. stain- X 40, 100).

Results (**Figure 6**) showed that, the liver of infected *O. niloticus*, have focal replacement of the hepatic parenchyma by cystic caseated material surrounded by aggregation of lymphocytes and melanomacrophages and degenerated parasitic cysts. The hepatic parenchyma showed small degenerated parasitic cyst surrounded by aggregation of lymphocytes. The hepatic cells showed hydropic degeneration. The hepatoportal pancrease revealed interstitial edema and infiltration of lymphocytes and melanomacrophages (yellow arrow). The bile duct is cystically fibroses. Concerning to infected *O. niloticus*, eyes, scleral congestion and edema were the main changes detected in the examined eyes (**Figure 7**).

Discussion

Parasites are attracting increasing interest from parasite ecologists as bio indicators of environmental pollution originating from human activities, due to the variety of ways in which they respond to such anthropogenic pollution [15].

The highest prevalence of protozoan of *O. niloticus*, was observed during summer and the lowest during winter. These findings was agree with that obtained by Abu El-Wafa [16] and Noor El-Deen [17] whom recorded that, the highest prevalence was recorded during summer and autumn and disagree with Soror [18] who revealed that, the highest prevalence was recorded during winter and spring. However, the highest values of prevalence encysted metacercariae in *O. niloticus* were recorded during summer and the lowest values were observed during winter. Similar observations were previously reported by many authors including [19-21]. The warm water during summer may increases the activity of cercarial emergence and penetration. Similar observation was cited previously by Harrod and Griffiths [22]. Results revealed that, the maximum prevalence of cestoda parasitic in *O. niloticus*, was recorded during summer and the minimum during winter; this could be

related to the availability of intermediate hosts of these parasites at these seasons and increase the feeding activity in warm temperature. These results nearly agreement with the findings recorded by Negm El-Din et al. [23,24]. The presence of fewer internal cestode parasites in *O. niloticus* could be attributed to its resistance to parasitic infections. This may be explained by the fact that *O. niloticus* species rarely succumb to disease epidemics and have a remarkable power of recovery from infections [25].

Blood is a good bio-indicator of the health of any organism; it also acts as a pathological reflector of the whole body. Hence, haematological parameters are important in diagnosing the functional status of the fish (host) infested by parasites and also to evaluate the physiological condition and nutritional state of fish [26].

The present study exhibited that, the reduction in RBCs count, Haemoglobin (Hb) value and packed cell volume (PCV) in the infected fishes may be as a result of the parasitic infestation that often leads to anemia. These observations agree with Tavares-Dias et al. [27] whom recorded decreasing in the erythrocyte numbers and hematocrit percentage in *O. niloticus* infected by parasites. Similar observation were recorded by Martins et al. [5] whom found that, the reduction in haemoglobin content in the infected catfish occurred as a result of the parasitic infection that often leads to anemia.

Moreover, the increase in WBCs count occurred as a pathological response since WBCs play a major role during infestation by stimulating the haemopoietic tissues and immune system to produce antibodies and chemical substances which work as defense agent against infection [28]. The obtained result was in agreement with those reported by many authors including Mlay et al. [29-31] whom concluded that, the positive correlation between WBCs and prevalence of parasites infection i.e. WBCs increased according to intensity of infection. Changes in WBCs and differential leucocyte counts have been reported to play an important role in assessing the health status of the fish. On other hand, the activities of ASAT and ALAT were significantly higher in the infected fishes when compared to the uninfected ones. Similar finding was observed by Nnabuchi et al., [26] whom reported that AST, ALT and Urea showed a significant increase in *O. niloticus* infected with external protozoa and monogenetic trematodes. Also, the increases in blood sugar level in the infected fishes may be due to increase in the breakdown of liver glycogen or due to decreased synthesis of glycogen from glucose. Hyperglycemic condition in naturally as well

as experimentally stressed fishes may be due to impairment in the hormone level in blood involved in the carbohydrate metabolism. These findings were in agreement with Ali and Ansari [31]. On the other hand, many fish diseases were found to alter the concentration of total protein, albumin and globulin. It has been shown that total serum protein content in the fish infected with parasites decreased significantly [32]. The depletion in protein and carbohydrate contents in the muscles of infected fishes may be due to the nutritional needs for parasites make them compete with the host's needs. The decrease in protein content may contribute to the effect of gut parasites which feed on gut contents of host fish. Result were in agreement with those recorded by Habiballah et al., [33,34]. The increase of lipid in the muscles observed in the present investigation owing to the attack by various parasites might be the result of host's defensive mechanism to with stand the effect of infestation. In order to compensate the loss, due to intensive attack of parasites, the host tries to produce more of the nutrients. Results declared that, rise in moisture as a result of influence of parasites there was also a concomitant relation of moisture owing to multiple infestation, while the protein content showed an inverse relationship. Result was also similar to that observed by Mozhdeganloo and Heidarpour [35].

Histopathological examinations of fish collected from fish farm revealed, much higher incidence of pathological alterations. The effect of parasites in the present study can be detected using an analysis of pathologies, where the pathological alterations in fish are net result of adverse biochemical and physiological changes within the present finding were in agreement with [15]. The histopathological examination of the gill, liver, skin and muscles of the infected fish indicated that, the organs most affected by infection of parasites. This is similar to the observation of Rahman et al. [36,37].

Conclusion and Recommendation

From this study, we demonstrated that pathological outcomes and adverse health effects on fish could be related to habitat use, preferences and environmental variables associated with these. Fish farmers and sellers should be progressive on the potential risk of parasitic infestation in fishes in order to avoid economic loss and more studies on parasites to be conducted, selection of hosts and parasites as indicators of pollution and other stressors. Since some of these parasites are zoonotic to fish eating birds and mammals, the fish consumer should avoid eating half cooked fish. That is fish should be very well cooked before eating, this request

for raising awareness in fish health management and the application of appropriate control measures.

References

- Andersson K (2000) LCA of food products and production systems. *Int J Life Cyc Assess* 5: 239–248.
- FAO (2014) FAO Director-General meets typhoon-stricken farmers in the Philippines. In: FAO [online].
- Eissa IAM (2002) Parasitic fish diseases in Egypt. Dar ElNahdda El- Arabia Publications 32: 149-160.
- Mondo UB (1999) Protozoan, crustocean and ciliated diseases of fish. *Vet Parasitol pathology* A.B.U, Zaria.
- Martins ML, Tavares-Dias M, Fujimoto RY, Onaka EM, Nomura DT (2004) Haematological alterations of *Leporinus macrocephalus* (Osteichthyes: Anostomidae) naturally infected by *Goezia leporine* (Nematoda: Anisakidae) in fish pond. *J Arq Bras Med Vet Zoo* 56: 640-646.
- Fartade AM, Fartade MM (2016) Histopathological study of fresh water fishes infected with *ptychobothridean* tapeworms parasite from Godavri Basin MS (India). *Int J Res Biosci* 5: 39-42.
- Adams SM, Greeley MS, Ryon MG (2000) Evaluating effects of contaminants on fish health at multiple levels of biological organization: extrapolating from lower to higher levels. *Hum Ecol Risk Assess* 6: 15-22.
- Syme JD (1966) Fish and fish inspection. London 95-115
- Ahmed AK, Tawfif MAA, Abbas WT (2000) Some parasitic protozoa infecting fish from different localities of the River Nile, Egypt. *Egypt J Zool* 34: 59 -79.
- Paperna I (1996) Parasites, infections and diseases of fishes in Africa: An update. CIFA Technical paper FAO 31.
- Ramadan AM (1994) Studies on the intestinal parasites of some freshwater fish. Thesis Fac Vet Med 224.
- Young DS, Friedman RB (2001) Effects of disease on clinical laboratory tests .Washington.
- AOAC (Association of Official Analytical Chemists) (2005) Dietary fiber in foods containing resistant maltodextrin. In: Official methods of analysis of the Association of Official Analytical Chemists. Washington.
- Banchroft JD, Stevens A, Turner DR (1996) Theory and practice of histological techniques Fourth edition, Churchill Living Stone, New York, London, Sanfrancisco, Tokyo. 740.
- Ali SM, Yones EM, Kenawy AM, Ibrahim TB, Abbas WT (2015) Effect of El-Sail Drain wastewater on Nile Tilapia (*Oreochromis niloticus*) from River Nile at Aswan, Egypt. *J Aquac Res Develop* 6: 294-301.
- Abu El Waf, SAO (1988) Protozoan parasites of some freshwater fishes in Behera Province. Thesis Fac of Vet Med Alex 142.
- Noor El- Deen AI (2007) Comparative studies on the prevailing parasitic diseases in monosex tilapia and natural male tilapias in Kafr El- Sheikh Governorate fish farms. Thesis Fac of Vet Med 442.
- Soror EI (2008) Studies on some internal parasitic diseases of Nile Tilapia in Kalubia Governorate. Fac of Vet Med 229.
- Mahdy OA (1991) Morphological studies on the role of some fresh water fishes in transmitting parasitic helminthes of some avian hosts. Fac Vet Med 382.
- Wang GT, Yao WJ, Nie P (2001) Seasonal occurrence of *Dollifustremavaneyi* (Digenea: Bucephalidae) metacercariae in the bullhead catfish *Pseudobagrus fulvidraco* in a reservoir in China. *Dis of Aquat Organisms* 44: 127-131.
- Wagih NG, Aly SM, Abdel-Rahman K, Amer OH (2010) Histopathological, parasitological and molecular biological studies on metacercariae from *Oreochromis niloticus* and *Clarias gariepinus* cultured in Egypt. *Zagazig Vet J* 38(4):92-105.
- Harrod C, Griffiths D (2005) *Ichthyocotylurus erraticus* (Digenea: Strigeidae); factors affecting infection intensity and the effects of infection on pallon (*Coregonus autumnalis*), a glacial relict fish. *J Parasitol* 131: 511-519.
- Negm-El-Din MM (1998) Further studies on *Trypanosoma mukasai* Hoare. *Deutsche Tierarztliche Wochenschrift* 105: 175-181.
- Shager GEA (1999) Enteric helminth parasites of fresh water fish at Abbassa in Sharkia Governorate. Thesis Fac Vet Med 179.
- Ayanda OI (2009) Comparative parasitic helminth infection between cultured and wild species of *Clarias gariepinus* in Ilorin, North Central Nigeria. *Sci Res Essay* 4: 1821.
- Nnabuchi UO, Ejikeme OG, Didiugwu NC, Ncha OS, Onahs SP, et al. (2015) Effect of parasites on the biochemical and haematological indices of some clariid (Siluriformes) catfishes from Anambra River. *Int J of Fisheries and Aqua Studies* 3: 331-336.
- Tavares- Dias M, Moraes FR, Martins ML, Santana AS (2002) Haematological changes in *Oreochromis niloticus* (Osteichthyes: Cichlidae) with gill *Ichthyophthiriasis* and *Saprolegniosis*. *Boletim do Instituto de Pesca*. 28: 1-9.
- Khurshid I, Ahmad F (2012) Impact of helminth parasitism on haematological profile of fishes of Shallabugh Wetland, Kashmir. *Tren Fisheries Res* 1: 10-13.
- Mlay PS, Seth MS, Balthazary RT, Chibunda EC, Phiri JH, et al. (2007) Total plasma proteins and hemoglobin levels as affected by worm burden in freshwater fish in Morogoro, Tanzania. *Livestock Res Rural Develop* 19: 2-9.

- Shah AW, Parveen M, Mir HS, Sarwar SG, Yousuf AR (2009) Impact of helminth parasitism on fish haematology of Anchar Lake. *J of Nutrition* 81: 42-45.
- Ali H, Ansari KK (2012) Comparison of haematological and biochemical indices in healthy and monogenean infected common carp, *Cyprinus carpio*. *Annals of Biol Res* 3: 1843-1846.
- Maqsood S, Samoon MH, Singh P (2009) Immunomodulatory and growth promoting affect of dietary levamisole in *Cyprinus carpio* fingerlings against the challenge of *Aeromonas hydrophila*. *Turkish J Fisheries Aquacult Sci* 9: 111-120.
- Habiballah SYM, Idris OF, Sabahelkhier MK (2011) Morphometric and gross chemical studies of healthy and infected rabbit fish, (*Siganus rivulatus*) by helminthes parasite in Red Sea Coast, Sudan. *Austral J Basic Appl Sci* 5: 450-456.
- Ashokan KV, Mundaganur DS, Mundaganur YD (2013) Ecto and endo parasites in *Labeo rohita*, major carp (Hamilton) in Krishna River segment in Sangli district. *Int J Res Chem Enviro* 3: 16-19.
- Mozhdeganloo Z, Heidarpour M (2014) Oxidative stress in the gill tissues of goldfishes (*Carassius auratus*) parasitized by *Dactylogyrus* species. *J Parasitic Dis* 38: 2692-72.
- Rahman MZ, Hossain Z, Mullah MFR, Ahmed GU (2002) Effect of diazinon 60EC on *Anabus testudineus*, *Channa punctatus* and *Barbades gomonotus*. *The ICLARM Quarterly* 25: 8-11.
- Omitoyin BO, Ajani EK, Fajimi AO (2006) Toxicity gramoxone (paraquat) to juvenile African catfish American Eurasian. *J Agric Environ Sci* 11: 26-30.