

Biochemical and Hematological Alterations in Fish Infected with *Bothriocephalus acheilognathi*

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Annotation: In the current study, the influence of natural infection of *Bothriocephalus acheilognathi* on some biochemical constituents and haematological parameters of the fish suspension and the muscle content of three fish species; *Cyprinus carpio*, *Silurus triostegus* and *Liza abu*, were determined. A total of 108 fish were considered, with 66 infected and 42 uninfected. Infected fish also showed significantly lower protein and fat muscle content, but no significant differences in moisture value were observed when compared to uninfected fish. Serum total protein, cholesterol, and glucose levels of infected fish were shown to be decreased. Hematological analysis revealed reduced RBC and PCV values, while WBC values increased significantly in the infected group. These results were indicative that *B. acheilognathi* infection results in deterioration of both the physiological and nutritional status of fish and perhaps suppressed growth performance in aquaculture.

Keywords: *Bothriocephalus acheilognathi*, fish parasites, biochemical parameters, hematology, muscle composition, aquaculture.

Introduction

Comparison for white fish meat and its protein content (20–92% dry matter). It is regarded as a highly digested feedstuff (GASSEN et al., 1987) and is well accepted (Ali, 1979; Faizi, 1984). Hence, many medical doctors promote fish consumption and often give preference to fish meat compared to poultry meat, especially in men with the digestive system (Al-Taie, 1987).

Fish proteins are high biological value proteins, as they possess all essential amino acids needed by humans (those that cannot be produced in the body itself). These essential amino acids are involved in protein synthesis and other metabolic processes. Fish bodies not only contain valuable proteins, but they also constitute a rich source of important minerals like iron, calcium, phosphorus, iodine, and vitamins A and D (Abdul Hamid, 1994; Bukhari, 1998; Wilson, 2018). It is also a source of additional lipids such as unsaturated fatty acids (contributing to a reduction of blood cholesterol level) (Abu Aqada, 1989; Salman, 1990). Besides, fish contains omega-3 fatty acids, which have many health benefits, such as improving visual function, reducing risk of CVD, and lessening inflammation (Khanji, 1996).

Fish are indispensable for human life, nutritionally and economically. Iraq, which is one of such countries, is said to have varied aquatic environments estimated to reach 1074 thousand hectares of rivers, lakes, streams, reservoirs, and marshes (Muheisen, 1987). Yet, similar to all life forms, fish are susceptible to illnesses and parasitic outbreaks. Although some strains show rather strong resistance under favourable circumstances, parasitic infestations should be seen as one of the major obstacles in practice, interfering with growth, fertility, and potentially reducing survival due to competition for nutrients and tissue damage (Muheisen, 1983; Nikolsky, 1963). The nutritional and environmental aspects exert a marked influence on the health and productivity of sheep as they can induce different disorders, including mineral imbalances, retarded growth, and malfunctioning of the organism. It has been previously reported that the addition of selenium and zinc to the diet of sheep enhances animal meat quality and antioxidant properties (Palani et al., 2020), and their interaction with essential and toxic elements significantly impacts animal health and environment (Palani et al., 2019).

Thus, studying parasites that infect fish is necessary to minimize their negative effect on this important economic resource, increase the level of aquaculture production, and promote the capacity of fish for adaptation to new environments (Hshulman, 1961). Fish diseases can result in decreased productivity and market value with subsequent indirect economic losses for the aquaculture industry. Like general economic stressors, such as crisis and country borrowing (Palani, 2025a; Palani, 2025b), these challenges also emphasize that the management of health and economic sustainability of health are not independent.

Under such circumstances, the purpose of the present study was to assess the influence of infection with the tapeworm *Bothriocephalus acheilognathi* on the blood and meat biochemistry of fish and to examine differences between infected and uninfected fish in this respect.

Materials and Methods

Sample Collection

The fish samples were collected from local markets in Kirkuk and from Greater Zab River near Eski Kalak area - 40 km far from Erbil - from 1st of May to 3rd of August 2013. Three species of fish (N = 108) were sampled, of which 66 were infected with *Bothriocephalus acheilognathi*, and 42 were uninfected.

Table 1. summarizes the distribution of sampled fish:

Fish species	Uninfected	Infected	Total (N)
<i>Cyprinus carpio</i>	15	20	35
<i>Silurus triostegus</i>	17	18	35
<i>Liza abu</i>	10	28	38

Acclimatization and Parasitological Examination

The fish were transferred to the laboratory, each tank filled with river water and accommodated in a large plastic box. Upon arrival, live fish were placed into 50-liter circular containers filled with tap water. They were then left for 2–3 hours in a quiet and dark environment so that they could get used to their surroundings, being as best acclimatized under the conditions mentioned in Pasternack & Rahkonen (1998). After acclimation, fish were wrapped with a towel to reduce stress and may be killed by a blow to the head. We examined the digestive tract in saline under low light conditions. The digestive tract was divided into pieces, stretched out, and inspected under a Kruss light microscope (Germany) with magnification ranging from 16× to 40× to detect *B. acheilognathi*.

Measurement of Blood Parameters

Blood samples were collected by making a vertical incision between the anus and caudal fin. This will allow blood from the duodenum artery to flow out into a butterfly in front of it using a slow motion movie technique. The first few drops were discarded, and the next several drops were taken up as well-preserved material. The following parameters were measured: red blood cell (RBC) count, white blood cell (WBC) count, and hematocrit (PCV).

Biochemical Analyses

Samples for serum were collected in glass tubes and after the caps had been unscrewed centrifuged at 3000 rpm for 15 minutes. We evaluated the following biochemical characteristics:

- Total protein level • Level of glucose • Cholesterol level

Chemical Analyses of Muscle

Fish muscle chemical composition was analyzed according to AOAC (1980) methods:

- Water content: 5 g pure muscle was dried at 105 °C for 24 h in a previously weighed porcelain crucible;
- Protein Content: Based on the use of the semi-micro Kjeldahl method.
- Fat content: Soxhlet extraction (ether, 70 °C, 4 h) Ether extract was calculated (%) as follows:

Ether Extract (%) = $\frac{\text{Weight of beaker after extraction} - \text{Weight of beaker}}{\text{Weight of sample}}$

Statistical Analysis

A baseline for treatment effects evaluation was established through analysis of data using a Completely Randomized Design (CRD). Duncan's Multiple Range Test (Duncan, 1955) determined means and SAS was used for statistical analyses (SAS, 2005). The model used was:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where: Y_{ij} : observation j for treatment i μ : grand mean T_i : treatment effect e_{ij} : random error

Economics, Science, and compilation – Experts on the talk One example, a new home is moved to — the forest floor — because it has been trapped so far beneath one massive blanket of thick leaves that a light was never able to touch it.

Results

Results were revealed significant differences such as between infected and uninfected fish for muscle composition, blood biochemistry indices and hematological indices.

Muscle composition:

Among the three species analyzed, the muscles of uninfected fish contained significantly more protein and fat than the infected fish (*C. carpio*, *Silurus triostegus*, and *Liza abu*). The protein and

fat depositions of infected individuals were significantly lower. On the other hand, the moisture content did not present significant differences between treatments ($P \geq 0.05$) but fish which presented infection had somewhat higher values.

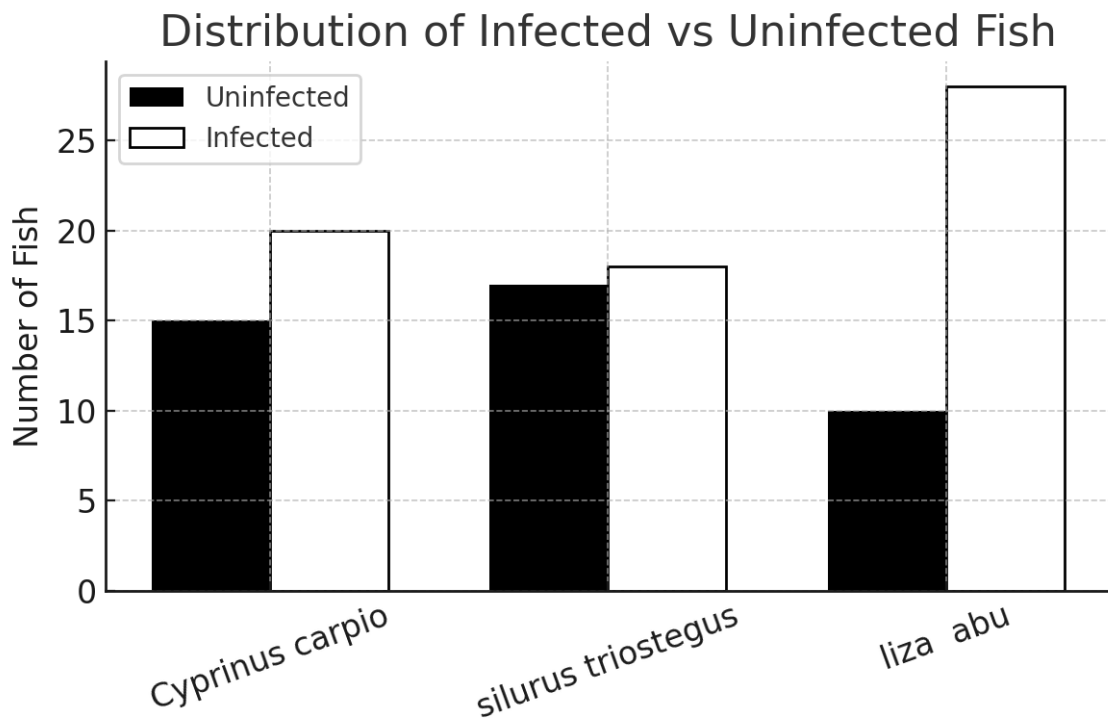


Figure 1: Shows the distribution of infected and uninfected fish by species.

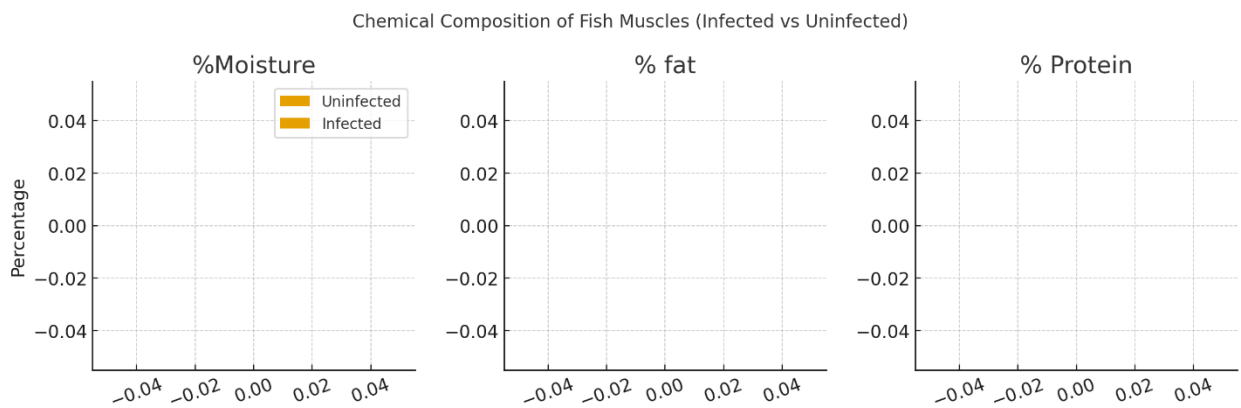


Figure 2: Comparison of the chemical composition of fish muscle (moisture, fat, protein) between healthy and infected fish.

Blood biochemical parameters:

Total protein levels in the serum were determined as reduced in infected fish when compared to healthy fish. For example, uninfected carp and *Liza abu* exhibited markedly higher levels of serum protein relative to infected fish. Similarly, the values of cholesterol and glucose levels decreased in the infected groups, thus suggesting that the parasitic infection adversely affected these biochemical parameters.

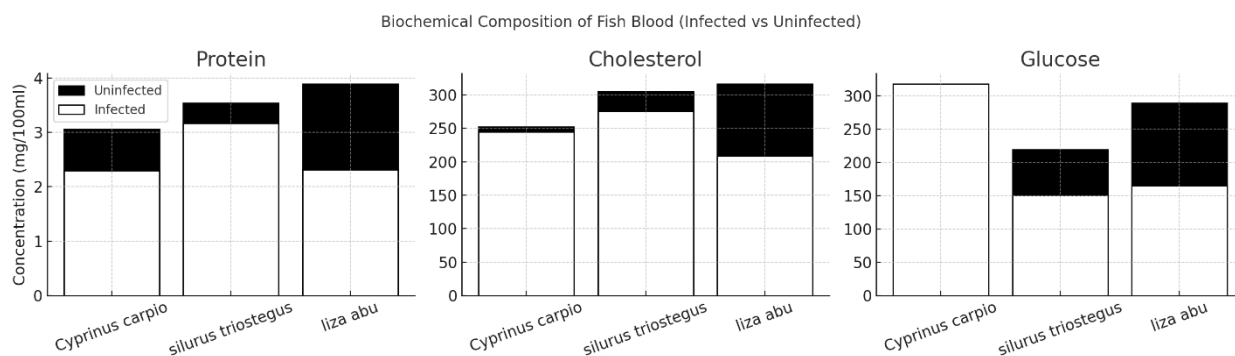


Figure 3: This figure illustrates a comparison of the biochemical components of blood (protein – cholesterol – glucose).

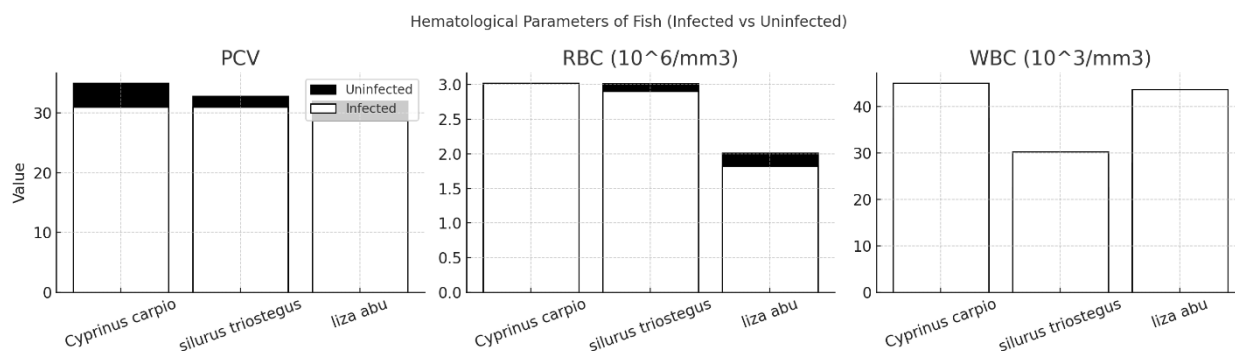


Figure 4: Comparison of blood parameters (PCV, red blood cell count, white blood cell count) between healthy and infected fish.

Hematological parameters:

Infected fish exhibited increased white blood cell (WBC) counts in comparison to those of healthy fish, indicating an immunological response to infection. On the other hand, red blood cell (RBC) number and packed cell volume (PCV) values were significantly higher for uninfected fish and lower for infected fish.

Discussion

Pests and diseases which directly cause economic losses due to death and indirectly decrease the growth of the remaining fish, is one of the major problems in aquaculture (Al-Khafaji, 1998; Daham, 1990).

The tapeworm *Bothriocephalus acheilognathi* is particularly harmful due to adverse effects on the populations of freshwater fish, especially carps (Heckmann et al. 1987; Dove 1998).

Impact on muscle composition:

The concomitant degradation of the proteins and lipids showed that these organisms were associated with the disease through lower abundance of proteins and lipids at both 4 and 24 h of the TBS [6]. This is in agreement with the results of similar studies by other authors (Marcogliese, 2008, a.o.) and could have been due to the uptake of intestinal contents by the parasite [41], which could further decrease nutrient absorption in its host. At the same time the parasite adheres to the intestinal wall, causing lesions (inflammation and necrosis) and decreasing nutrient absorption in muscle (Perez et al., 2017). Fat storage is also reduced. Although movement of energy away from growth and fat accretion is necessary to meet the energy demands of the parasite (Britton et al., 2011; Xi & Wang, 2011), data presented by other authors do support that parasite presence can alter host metabolism.

So, because of the absence of big differences in water content that is consistent with previous work are indicating that the nutrient deficit caused by parasitism can lead to elevated water retention in muscle (Davis et al. 2016). The trends for protein and fat in both the areas are similar in these two areas as well (Abbas et al., 2018; Natarjan & Balakrishnan, 1976).

Impact on blood biochemical traits:

Serum proteins of infected fish are low, indicating a parasitic induced alteration of protein metabolism. Over-training (the insufficient kind) Protein by its protein answer to neuroticism So much cortisol (and overtraining can lead to a body of it) can crush the muscles as well, and lead to the protein breakdown (Chellappa, 1988)—because the body during stress is more inclined to use protein as an energy substrate.

Also, albumin is used by the immune system when producing antibodies and thus albumin was also expected to be lower (Osmani et al., 2009; Almeida et al., 2011). Since the liver manufactures approximately all of the dietary amino acids needed for the maintenance of nitrogen homeostasis (Watts et al., 2001), this decline has an impact on liver function.

Concomitantly, decline of lactate and glucose levels of infected fishes suggest that besides lowering the absorption of nutrients from diet, *B. acheilognathi* negatively modifies metabolic pathways. The parasite apparently recruits glucose for energy directly and deprives the host of the substrates he needed in order to live (Tanveer et al. 2016; Summer et al. 2012).

Impact on hematological traits:

Inflammation levels have been indicated in blood tests. The number of white blood cells (WBC) is reduced in uninfected fish compared to infected ones (Tavares-Dias et al., 2007). Tukey test with 2 groups significantly different. This confirms that immune activation does occur even in trouts that become infected but which remain largely untreated (the offending agent has not had time to mount a response Summer and Behm, 2005).

Parallel reductions of parasitaemic group RBC and evidence of PCV indicated that respiratory exchanges could be impaired or that would be the appearance of anaemia. Such reductions can cause the death of fishes due to lack of nutrients (e.g. Summer et al. 2012; Ernesto et al. 2011).

Looking back, I am now relieved to know that our joint interpretations from those studies provide at least support of the notion that *B. acheilognathi* is probably a fish welfare-strike-at-gold, on the other extreme of the evolutionary enemy-at-sea trade-off- continuum, and clearly very harmful, and, in terms of the fitness and, ultimately, the economic cost to the health and, ultimately, economic value of fish in modern day "aquaculture" culture systems; a reasonable hypothesis, at least.

Conclusion

This case report further identifies *B. acheilognathi* as a putative metabolic derangement related factor in fish. Muscle protein and fat contents were reduced, and serum protein was markedly suppressed. There was a decrease in cholesterol, a little decreased glucose, decreased RBC values and PCV values, but these parameters were still lower than those of healthy fish. On the other hand, fish infected showed an elevated WBC count. These data show that infections by parasites can play a devastating role on health status and/ or nutritional status of fish, and that therefore controlling such infections is needed to avoid high losses in aquaculture production.

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