International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
(A Peer Reviewed, Referred, Indexed and Open Access Journal)
DOI: 10.22192/ijarbs Coden: IJARQG (USA) Volume 10, Issue 7 -2023

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2023.10.07.008

Biochemical and hematological responses of *Cyprinus carpio* fish to *Philometra pellucida* parasite infestation

Ashok Kumar
Department of Zoology, M.L.K PG College, Balrampur, U.P, India

Abstract

This study investigates the impact of the nematode parasite *Philometra pellucida* on the biochemical composition and antioxidant levels in various tissues of *Cyprinus carpio*, a common freshwater fish species. The study focuses specifically on how the nematode *parasite Philometra pellucida* affects different tissues (muscle, gut, liver, and gill) of the *Cyprinus carpio* fish. The results reveal significant changes in the infected fish's biochemical composition, with noticeable reductions in carbohydrates, proteins, and lipids. Additionally, the research provides strong evidence of distinct differences in blood-related parameters between fish infected with the parasite and those that are not. The infected fish show decreased counts of red blood cells (RBC), lower hemoglobin (Hb) levels, and reduced packed cell volume (PCV), all indicative of a condition known as anemia, which aligns with consistent findings from previous studies. The presence of parasites acts as a stressor, leading to changes in PCV due to the release of catecholamine, which impacts the RBCs. The observed anemia in infected fish is linked to the suppression of erythrogenesis, the process of red blood cell formation, and is associated with chronic liver inflammation. Conversely, infected fish exhibit a significant increase in the count of white blood cells (WBC), a pathological response crucial for fighting parasitic infestations. The elevated WBC count stimulates hemopoietic tissues and the immune system to produce antibodies and chemical substances, acting as defense agents against infections. The study also finds elevated enzyme activities of aspartate aminotransaminase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP), along with higher creatinine and urea values in the parasite-infected fish.Overall, this study sheds light on how *Philometra pellucida* infestation impacts the biochemical profiles and blood-related parameters of *Cyprinus carpio*. The observed changes in various tissues and blood parameters contribute to a better understanding of how infected fish respond physiologically. This knowledge is crucial for assessing fish health and has implications for managing fisheries and conservation efforts.

Keywords: *Philometra pellucida*, *Cyprinus carpio*, Biochemical, Hematological, Parasite, Infestation

ARTICLE INFO

Article History:

Received 5th June, 2023
Received in revised form 24th June, 2023
Accepted 10th July, 2023
Published online 31st July 2023

Introduction

Parasites can profoundly impact fish health, affecting both wild populations and those reared in aquaculture. The specific consequences vary based on factors such as the parasite type, fish species, and the individual fish's overall well-being. External parasites like ectoparasites latch onto the fish's skin, fins, or gills, causing physical harm, irritation, inflammation, and wounds. These injuries can create openings for infections, jeopardizing the fish's overall health. Additionally, parasites consume the fish's resources like blood, mucus, and tissues, leading to nutritional stress, and hindering the fish's ability to obtain adequate nutrients for optimal health and growth. Moreover, the presence of parasites can weaken the fish's immune system, rendering them more susceptible to secondary infections caused by bacteria, viruses, or other harmful microorganisms. Parasites pose a major threat to both freshwater and marine fishes worldwide, and they are particularly concerning in tropical regions. These parasites have a profound impact on the fish, affecting various aspects of their lives. This includes changes in their biology, behavior, nutrient absorption, immune system functionality, vision impairment, and overall health. Depending on the type and quantity of parasites infesting the fish, they may also suffer from decreased growth, reduced ability to reproduce (fecundity), and even physical injuries caused by the parasites. Several studies (Iyaji, 2008; Bichi *et al.*, 2010; Nmor *et al.*, 2004; Echi *et al.*, 2009) have highlighted the significant consequences of parasitic infections on fish populations. When fish are infected with parasites, they may exhibit changes in their behavior, such as increased lethargy, reduced appetite, or irregular swimming patterns, as they try to cope with the parasite's presence. The parasites can impede the fish's growth and development, resulting in stunted growth and reduced reproductive success. Certain parasites, like some monogenean worms that feed on blood, can cause anemia in fish by depleting their blood supply, leading to weakness and decreased vitality. In more severe cases, parasite infestations can lead to significant mortality among fish populations, especially in individuals that are highly stressed or have compromised immune systems. In the context of aquaculture, outbreaks of parasites can result in economic losses due to decreased growth rates, elevated mortality rates, and the need for expensive treatments and interventions.

Parasites can significantly impact commercially important fish species, leading to disruptions in their physiological and biochemical processes, which can ultimately harm their overall health. These parasites are widespread in water bodies, particularly in areas that receive wastewater containing harmful chemicals and pathogens, which are already known to have detrimental effects on aquatic life (Cazenave *et al.*, 2014). The interactions between parasites, pathogens, and chemicals can result in the accumulation of adverse effects or even create synergistic impacts, compounding the risks to fish populations. Understanding the roles, functions, and lifestyles of parasites is crucial for characterizing the dynamics of an ecosystem (Iwanowicz *et al.*, 2011; Costa *et al.*, 2012).

In challenging environmental conditions, hemato-biochemical indices have emerged as valuable tools for effectively monitoring the impact of stressors on fish health. These indices play a vital role in assessing how organisms respond to various stress factors and offer valuable insights into their overall well-being, especially in adverse situations. In general, hematological tests serve two primary purposes: first, they help establish the normal health status of the organisms, and second, they aid in diagnosing diseases caused by a range of factors, including parasitic infections, nutritional imbalances, pollution, genotoxic effects of pollutants, environmental stress, and heavy metal exposure. These tests are commonly used in human and veterinary sciences (Fedato *et al.,* 2010). By studying the changes in biochemical parameters associated with various parasites recorded in a database, these tests can assist in diagnosing diseases and guide the application of appropriate treatments or preventive measures (Yaji*et al.,* 2007). This valuable information can significantly contribute to the management and conservation of fish populations, safeguarding their health and resilience against the challenges posed by parasites and other stressors.

Cyprinus carpio, commonly known as freshwater garfish, is a needlefish species inhabiting freshwater and brackish environments in South and Southeast Asia. This fish is notably abundant in vitamin-A content, which plays a crucial role in preventing blindness, particularly in children. With its distribution in significant regions of South Asia, it holds global importance due to its appealing taste and high nutritional value (Talwar *et al.,* 1991; Frose *et al.,* 2012).

Philometrid nematodes are commonly found in various aquatic environments, including freshwater, brackish water, and marine habitats, and they are known to infect both wild and cultured fish species of commercial importance. The females of these nematodes are typically larger in size, owing to certain morphological and biological characteristics (Moravec et al., 2006). Most of these nematode species tend to infect the intestinal tract of the fish (Moravec *et al.,* 2002). As a result of the parasitic infection, the fish experience a loss of intestinal contents and essential nutrients, caused by the damage inflicted on their tissues by the parasites. In cases where the number of parasites is substantial, the intestinal mucosa of the fish can be completely destroyed, leading to the death of the host. Fluid-filled spaces may also form on the inner surface of the fish's body due to the infection. Consequently, the parasitic presence triggers biochemical and enzymatic changes within the host fish.

Materials and Methods

Collection of fish samples

In the months of May to June 2023, a group of freshwater fish known as *Cyprinus carpio* was collected from the Rapti River in Balrampur, India, for research purposes. Among the 60 fish that were captured, some were found to be infected with an internal nematode parasite called *Philometra pellucida*. To investigate the impact of this parasitic infection, the researchers examined and evaluated potential biochemical changes in the fish. In the study, the gills, liver, gut, and muscle of each fish were carefully dissected and their individual weights were measured. This allowed the researchers to assess the specific effects of the parasite on different organs and tissues of the fish. By analyzing the biochemical changes and comparing the organ weights between infected and uninfected fish, the researchers can gain valuable insights into the physiological consequences of the parasitic infection.

Parasitological examination

A thorough parasitological examination was conducted to identify and detect the presence of the parasite *Philometra pellucida* within the body cavity and internal organs of the fish.

Biochemical analysis

Biochemical analyses were conducted to assess the carbohydrate, total protein, and lipid levels in various organs of the fish *Cyprinus carpio*. The carbohydrate content was determined using the method described by Carrol *et al.* (1956), while the total protein concentration was estimated using Lowry's method (1951). For measuring the lipid content, the Frings *et al.* (1972) procedure was followed. These tests provided valuable data on the nutritional composition of the fish's different organs.

Haemato-biochemical assay

Blood was drawn from 60 live fish through the caudal peduncle (tail area) and heart using a 2ml plastic syringe and needle treated with an anti-coagulant, following the procedure described by Lucky (1977). The collected blood samples for hematological studies were preserved in bottles containing EDTA, while bottles with heparin were used for analyzing enzymes (Aspartate aminotransaminase - AST, Alanine aminotransferase - ALT, alkaline phosphatase - ALP, Creatinine, and Urea).After the blood collection, each fish was euthanized by a blow to the head, and the liver was removed and weighed for organ indices assessment. The Packed Cell Volume (PCV) was determined by using Hawsley microcapillary tubes, which were then centrifuged for 5 minutes, following the method by Abudu and Sofola (1994).For the analysis of Red Blood Cells (RBC), White Blood Cells (WBC), Hemoglobin (Hb), and Packed Cell Volume (PCV), the methods of Blaxhall and Diasley (1973) were employed. The heparinized blood samples were centrifuged at 300 rpm for 10 minutes to collect the serum for further analysis of AST and ALT (Blaxhall and Diasley, 1973), ALP (Bessey, Lowry & Brock, 1946), urea (Jenkins, 2004), and creatinine (Bessey, Lowry & Brock, 1946).Organ indices were calculated using the methods described by Jenkins (2004). The collected data were subjected to statistical analysis using a one-way analysis of variance at a 95% confidence level, and the means were compared using Fisher's Least Significant Difference test at a 95% confidence level.

Results and Discussion

Biochemical in freshwater fish *Cyprinus carpio*

Assessing the health of wild fish populations requires the identification of biological markers that can indicate their status at various levels of their biological organization. The ability of wildlife to respond to different stressors depends on a multitude of external and internal factors. One crucial aspect determining their sensitivity or resistance to stress is the condition of defense mechanisms within their bodies. These defense mechanisms play a vital role in safeguarding organisms against diseases and environmental pollution resulting from human activities and other anthropogenic impacts. Therefore, understanding and monitoring these biological markers are essential for evaluating the overall health and well-being of wild fish populations.

In the assessment of fish health, a range of biochemical is commonly employed. These parameters serve as indicators of the fish's physiological condition and provide insights into the influence of various biotic factors (such as pathogens, parasites, and disease state) and abiotic factors (including anthropogenic pollution and habitat degradation) on the fish's well-being (Martinez et al., 2005; Van der Oose *et al.*, 2003). Out of these parameters, biochemical characteristics are particularly valuable as they are widely used as early warning indicators of any changes in the health status of the fish. Monitoring these biochemical markers allows researchers to detect potential issues and address them early on, thus aiding in the effective management and conservation of fish populations.

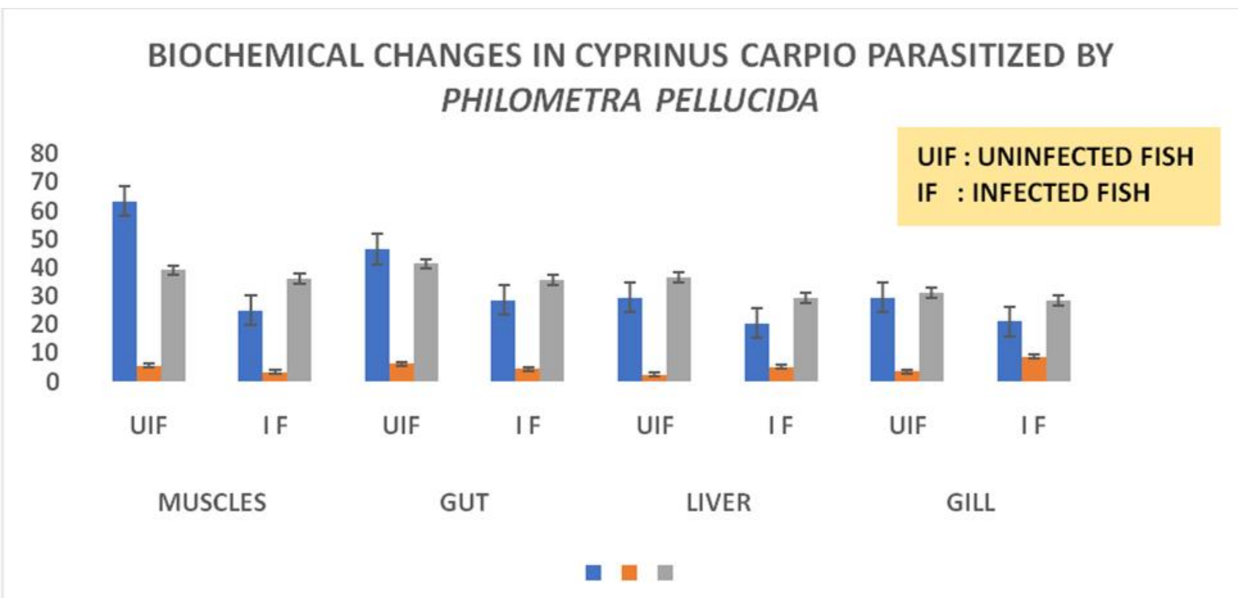
Table: 1 Biochemical parameter of freshwater fish, *Cyprinus carpio*

Organs		Biochemical Tests		
		Protein (mg/g)	**Lipid (mg/g)**	**Carbohydrate (mg/g)**
Muscles	Uninfected fish	63.4±0.48	5.5±0.48	39.2±0.51
	Infected fish	24.9±10.0	3.3±1.15	36.1±0.48
Gut	Uninfected fish	46.5±0.33	6.3± 0.88	41.4±0.73
	Infected fish	28.5±0.14	4.5±0.37*	35.7±1.20
Liver	Uninfected fish	29.5±0.14	2.4±0.64	36.6±1.27
	Infected fish	20.4±0.28	5.1±0.14	29.4±0.37
Gill	Uninfected fish	29.4±0.14	3.6±0.35	31.2±0.36
	Infected fish	21.21±0.36	8.7±0.88*	28.5 ±0.35

Each value is mean ± SD of observations, * Indicates significant

Table 1 and Figure 1 present the quantitative values of biochemical estimation in *Cyprinus carpio*, a freshwater fish species. The study compared the carbohydrate, protein, and lipid content in different organs (gut, liver, gill, and muscle) of infected and uninfected fish.

Figure: 1 Biochemical parameter of freshwater fish, *Cyprinus carpio*



In uninfected fish, both carbohydrate and protein content were higher in all examined organs (muscle, gut, liver, and gill) compared to infected fish. For instance, the carbohydrate content was lower in infected muscle (36.1±0.48), gut (35.7±1.20), liver (29.4±0.37), and gill (28.5±0.35) when compared to uninfected fish organs (39.2±0.51, 41.4±0.73, 36.6±1.27, and 31.2±0.36) respectively. Similarly, protein content was significantly higher in uninfected muscle, gut, liver, and gill (63.4±0.48, 46.5±0.33, 29.5±0.14, and 29.4±0.14) compared to infected fish organs (24.9±10.0, 28.5±0.14, 20.4±0.28, and 21.21±0.36) respectively. However, the lipid content showed an interesting pattern. The infected fish had higher lipid content in their liver (5.1±0.14) and gill (8.7±0.88) compared to the uninfected fish liver (2.4±0.64) and gill (3.6±0.35). This finding indicates a significant difference between the biochemical profiles of infected and uninfected fish, suggesting the potential impact of the parasite on lipid metabolism.

Interestingly, we also noticed a significant increase in lipid levels in the liver and gill of infected fish, which aligns with Tanaka et al. (2002) who observed higher hydroxyl lipid levels in the liver of diseased fish compared to healthy fish.

Overall, the study demonstrates that the presence of the parasite *Philometra pellucida* influences the biochemical composition of the fish organs, particularly affecting carbohydrate, protein, and lipid levels in different tissues.

In our current investigation, we observed a decline in biochemical parameters, specifically carbohydrate, protein, and lipid content, in freshwater fish *Cyprinus carpio* that were infected with the internal nematode parasite *P. pellucida.* These findings are consistent with previous studies. For instance, Hassan *et al.* (2010) reported a reduction in total protein and carbohydrate levels in the liver and muscle of fish species *Epinephelus summana* infected with helminths. Similarly, Rajaram *et al.* (2018) found lower carbohydrate and lipid content in fish infected with the crustacean parasite Cymothoid isopods.Parasites can have significant effects on the health of fish, impacting both wild populations and those raised in aquaculture settings. These effects can vary depending on the type of parasite, the fish species, and the overall health of the individual fish. External parasites, such as ectoparasites, attach themselves to the fish's skin, fins, or gills, leading to physical damage. This can cause irritation, inflammation, and wounds, making the fish more susceptible to infections and compromising their overall health. Parasites feed off the host's resources, including blood, mucus, and tissues. This can lead to nutritional stress, where the fish may struggle to obtain enough nutrients to maintain optimal health and growth. Parasite infestations can weaken the fish's immune system, making them more vulnerable to secondary infections by bacteria, viruses, or other pathogens.

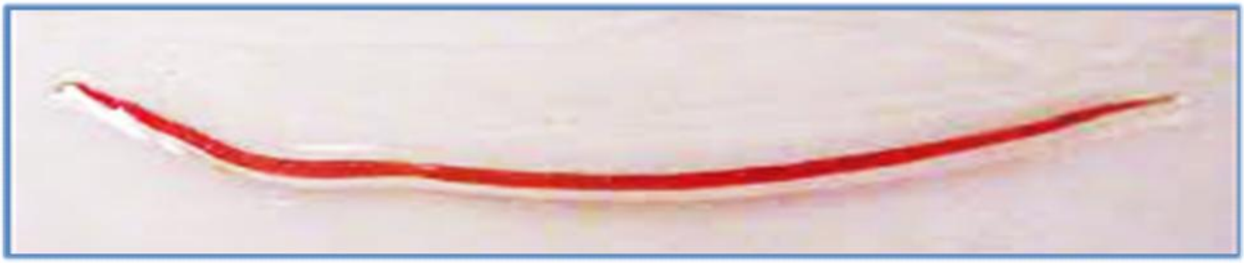
Infected fish may display altered behavior, such as increased lethargy, reduced feeding activity, or abnormal swimming patterns, as they try to cope with the presence of parasites. Parasites can hinder the growth and development of fish, leading to stunted growth and reduced reproductive success. Blood-feeding parasites, like some monogenean worms, can cause anemia in fish by depleting their blood supply, leading to weakness and decreased vitality. In severe cases, parasite infestations can cause significant mortality in fish populations, particularly in highly stressed or immunocompromised individuals. In aquaculture, parasite outbreaks can lead to economic losses due to decreased growth rates, increased mortality, and the need for costly treatments and interventions.

Table: 2 Effect of parasites on the hematological profile of the infected *Cyprinus carpio* parasitized *by Philometra pellucida*

Cyprinus carpio				
S.No.	**Parameters**	**Infected**	**Uninfected**	**P- values**
1.	**RBC(cells/mm^3)**	1.99 ±1.18	3.51 ±0.01	0.0001*
2.	**WBC (cells/mm3)**	6.51 ±0.02	3.31±0.36	0.0001*
3.	**Hb (g/dl)**	6.50 ±0.23	10.01 ±0.02	0.0001*
4.	**PCV (%)**	17. 01 ±0.01	29.69± 0.02	0.0001*
5.	**Creatinine (U/L)**	1.69 ±0.02	1.01 ±0.01	0.001*
6.	**Urea (U/L)**	38.21±0.23	25.20 ±0.28	0.001*
7.	**AST (U/L)**	96.69±0.36	74.09 ±0.38	0.001*
8.	**ALP (U/L)**	78.92±0.15	51.03±0.31	0.001*
9.	**ALT (U/L)**	131.0±1.01	90.69 ±0.11	0.001*

**P<0.01 level of significance

In simpler terms, blood serves as a reliable indicator of an organism's overall health and can provide valuable information about its well-being. For instance, in the case of fish infested with parasites, analyzing their blood's hematological parameters helps in understanding the fish's functional condition. Additionally, by examining the blood, scientists can assess the fish's physiological state and nutritional health.



Philometra pellucida

In this study, all the blood-related parameters analyzed showed significant differences ($p<0.05$) (Table :2)between the fishes that were infected and those that were not infected with parasites. These findings align with the research conducted by several other scientists. For instance, previous studies have indicated that *Heteroponeutus fossils* infected with *Lucknowiaindica* displayed an increased count of lymphocytes (Sexena*et al.*, 1993). In Clarias batrachus carrying helminth infections, a higher level of eosinophils was observed (Sinha et al., 2010), while fishes infected with hemoparasites showed reduced levels of RBC, Hb, and PCV, as reported by Shahi *et al.* (2013).

The reduction in RBC count, hemoglobin (Hb) value, and packed cell volume (PCV) in infected fishes may be a result of the parasitic infestation that often leads to anemia(Martins,*et al.*2004). Furthermore, the parasites simply acted as stressors, and during the primary stages of stress, the PCV is altered due to the release of catecholamine (an enzyme) which mobilizes RBCs to swell as a result of fluid entry into the intracellular compartment (Chocchia, *et al.* 1989). Similar results were recorded by Hassen (2002)and Ismail (2003) in *Clarias gariepinus* that are naturally infected with *T. mukasai*.

Lofty (2003) and Omran *et al.* (2003) conducted studies that also highlighted the severe anemia seen in infected fish. This anemia is characterized by a reduction in the levels of red blood cells (RBC), packed cell volume (PCV), and hemoglobin (Hb). The underlying cause of this condition was identified as chronic liver inflammation, which leads to a suppression of erythrogenesis, the process of red blood cell formation.In contrast, the infected fishes showed a significant increase in white blood cell (WBC) count compared to their uninfected counterparts. On the other hand, the infected fish exhibited a notable elevation in their white blood cell (WBC) count when compared to the fish that were not infected. According to the studies conducted by Lebola *et al.* (2001) and Hassen (2002), this increase in WBCs is considered a pathological response. During parasitic infestations, WBCs play a crucial role by stimulating hemopoietic tissues and the immune system to produce antibodies and chemical substances, functioning as defense mechanisms against infections. Similar findings supporting this process were also reported by Pinky et al. (2012) in their own related research.

Alanine aminotransferase is remarkably specific for liverfunction since aspartate aminotransferase is mostly present in the kidney. The activities of AST and ALT were significantly higher ($P<0.05$) in the infected fishes when compared to the uninfected fishes. AST, ALT, and Urea showed a significant increase in infection with parasites. Blood serum AST,ALT enzyme activities, creatinine, and Urea values were increased in infected *Cyprinus carpio*. The increase in the activity of AST and ALT in theserum of the infected fishes revealed that the parasites hadan effect on the parenchymous tissues and skeletal musculature, which probably may have altered the permeability and integrity of cell organelles. The pattern of ALT and AST activities observed in this study are biochemical symptoms tending towards liver cytolysis, indicating a disturbance in the structure and integrity of cell organelles like the endoplasmic reticulum and membrane transport system. Alterations in their activities may have adverse effects on the amino acid metabolism of the tissues and consequently, the intermediates needed for gluconeogenesis. Serum urea and creatinine levels were observed to be elevatedin the present study due to parasitic infestation of fishes. Creatinine leaves the muscles and enters the blood where it is a waste product largely from the muscle breakdown. It is removed by filtration through the glomeruli of the kidney and excreted as urine. The increase in the level of creatinine in the infected fishes may be a result of the alteration of the muscle structure of the infected fishes by parasites. Elevated levels of creatinine and urea in fishes infected with protozoan parasites. Urea is a principal end product of protein catabolism. It is awaste product metabolized in the liver and excreted by the kidney. The increases in the urea values in the infected fishes may be due to gill dysfunction (caused by *Philometra pellucida* parasite mainly found in the gills) as urea is mainly excreted through the gill. These collective results highlight the consistent impact of parasitic infections on the biochemical composition of fish organs, particularly affecting carbohydrate, protein, and lipid levels. Such studies play a crucial role in understanding the effects of parasitic infections on fish health and metabolism.

Conclusion

In conclusion, this study provides valuable insights into the impact of *Philometra pellucida* parasite infestation on the biochemical composition and blood-related parameters of *Cyprinus carpio*. The infected fish demonstrated significant alterations in their biochemical profiles, including reduced carbohydrates, proteins, and lipids. Moreover, clear distinctions were observed in blood-related parameters, with infected fish showing lower RBC counts, Hb levels, and PCV, indicating anemia, while exhibiting an elevated WBC count as a defense mechanism against the parasitic infestation. The study highlights the physiological responses of infected fish, emphasizing the importance of understanding and managing fish health for fisheries and conservation efforts.

The combined findings underscore the consistent influence of parasitic infections on the biochemical composition of fish organs, with notable effects on carbohydrates, proteins, and lipids. These studies are essential for comprehending the repercussions of parasitic infections on fish health and metabolism. Further research in this area can unveil underlying mechanisms and potential strategies to mitigate the effects of parasitic infections on aquatic ecosystems

References

1. Bichi AH, Dawaki SS. A Survey of the ectoparasites on the gills, skin, and fins of *Oreochromis niloticus* at Bagauda Fish Farm, Kano, Nigeria. Bayero Journal of Pure and Applied Science. 2010; 3(1): 83-86.
2. Carroll NV, Longley RW, Roe JH. Glycogen determination in liver and muscle by use of anthrone reagent. J. Biol. Chem. 1956; 220: 583-593.

3. Cazenave J, Bacchetta C, Rossi A, Ale A, Campana M, Parma MJ. Deleterious effects of wastewater on the health status of fish: a field caging study. Ecological Indicators. 2014; 38:104-112.
4. Chagas EC, Val AL. Effeito da vitmina C no ganho de peso e emparametroshematologicos de tambaqui. Pesquisa Agropecuaria Brasileira. Brasilia 2003; 38(3):397-402.
5. Chocchia G, Motais R. Effect of catecholamines on deformability of red blood cells from trout: relative roles of cyclic AMP and cell volume. Journal of Physiology 1989; 412:321-332.
6. Costa JL, Marques JF, Alves J, Gamito R, Fonseca VF, Gonçalves CI, Cabral HN, Costa MJ. Is parasitism in fish a good metric to assess ecological water quality in transitional waters? What can be learned from two estuarine resident species? Ecological Indicators. 2012;19:154-160.
7. Echi PC, Eyo JE, Okafor FC. Co-parasitism and morphormetrics of three clinostomatids Digenea: Clinostomatidae; in Sarotherodonmelanotheron from a tropical freshwater lake. Animal Research International. 2009;6(2): 982-986.
8. Fedato RP, Simonato JD, Martinez CBR, Sofiaa SH. Genetic damage in the bivalve mollusk *Corbicula fluminea* induced by the water-soluble fraction of gasoline. Mutation Resources. 2010; 700:80-85.
9. Frings CS, Queen CA, Dunn RT, Fendley TW. Improved determination of total serum lipids by sulfo-phospho-vanillin reaction. Clinical Chemistry. 1972;18:673-674.
10. Frose R, Pauly D. Fish base 2012. World Wide Web electronic publication.
11. Hassan AA, Akinsanya B, Adegbaju WA. Impacts of helminth parasites on *Clarias gariepinus* and *Synodontis clarias* from Lekki Lagoon, Lagos, Nigeria. Report and Opinion. 2010;2(11):42-48.
12. Hassen FEZM. Studies on Diseases Caused by Henneguya Infection. Ph.D. Thesis, Faculty of Veterinary Medicine Suez Canal University, Egypt 2002.
13. Ismail GAE. Histopatological and Physiological Studies on Naturally Infected Catfish, Clarias gariepinus with Trypanosomes. M.Sc. Thesis, Faculty of Science Cairo University, Egypt 2003.
14. Iwanowicz DD. Overview on the effects of parasites on fish health. In: Cipriano, R.C., Bruckner, A.W., Shchelkunov, I.S. (Eds) Bridging America and Russia with Shared Perspectives on Aquatic Animal Health. Proceedings of the Third Bilateral Conference between Russia and the United States, 12-20 July, 2009, held in Shepherdstown, West Virginia. Landover, Maryland, USA. Khaled bin Sultan Living Oceans Foundation. 2011;176-184.
15. Iyaji, Eyo JE. Parasites and their freshwater fish host. Bio-Research 2008; 6(1):328-338.
16. Joshi PK, Bose M, Harish D. Changes in certain haematological parameters in siluriod catfish, *Clarias batrachus* (L.) exposed to cadmium chloride. Pollution Resources 2002; 21(2):119-122.
17. Lebola SL, Saunders DK, Crawford TG. Observation on blood viscosity in striped bass, *Morone saxatilis* (Walbaum) associated with fish hatchery condition. Kansas Academy of Science 2001; 104:183-184.
18. Lofty HS, Mahmoud SM, Abdel-Gawad MA. Some studies on Fascioliasis in Mid-Egypt. Agricultural Research 2003; 81(2):209-227.
19. Lowry OH, Rosebrough NJ, Farr AL, Randall RJ. Protein Measurement with the Folin Phenol Reagent. J. Biol. Chem. 1951;193:265-275.
20. Martinez-Alvarez RM, Morales AE, Sanz A. Antioxidant defenses in fish: biotic and abiotic factors. Reviews in Fish Biology and fisheries, 2005;15:75-88.

21. Martins ML, Tavares-Dias M, Fujimoto RY, Onaka EM, Nomura DT. Haematological alterations of *Lepomis macrocephalus* (Osteichthyes: Aniskidae) in fish pond. Arq. Brasileiro Medical and Veterinary Zootenecnia 2004; 56:640-646.
22. Moravec F, Wang GT. *Dentiphilo metramonopteri* n. gen., n. sp. (Nematoda: Philometridae) from the abdominal cavity of the rice field eel *Monopterus albus* in China. J. Parasitol. 2002;88:961-966
23. Moravec F. Dracunculoid and anguillicoloid nematodes parasitic in vertebrates. Prague: Academia, 2006; 634.
24. Nmor JC, Egwunyenga AO, Ake JEG. Observation of the intestinal helminths parasites of cichlids in the upper reaches of River Orogodo, a freshwater body in Delta State, Southern Nigeria. Tropical Freshwater Biology. 2004; 13:131-136.
25. Omran HH, El-Kholony KH. The influence of Nitroxynil on clinical, biochemical and haematological parameters in Egyptian buffaloes affected with liver flukes in Sharkia governorate. Egyptian Journal of Agricultural Research 2003; 81(2):739-751
26. Pinky K, Qureshi TA, Rekha S, Susan M, Bilal A. Histopathological and haematological investigations on *Nandus nandus* (Ham.) parasitized by metacercariae of *Clinostomum complanatum* (Rudolphi, 1819). International Journal of Environmental Sciences 2012; 2(3):1324-1330.
27. Rajaram R, Kumar KR, Vinothkumar S, Metillo EB. Prevalence of cymothoid isopods (Crustacea, Isopoda) and proximate analysis of parasites and their host fishes, Southeastern India. Journal of Parasitic Diseases. 2018; 42(2): 259-268.
28. Sexena KK, Chauchan RRS. Effect of parasitic infection on the blood of *Heteropneustus fossilis* (Bloch). Bioved 1993; 4:41-43.
29. Shahi N, Yousuf AR, Rather MI, Ahmad F, Yaseen T. First report of blood parasites in fishes from Kashmir and their effect on the haematological profile. Open Veterinary Journal 2013; 3(2):89-95.
30. Sinha KP. Haematological manifestation in Clarias batrachus carrying helminth infection. Journal of Parasitic Diseases 2010; 24:167-170.
31. Talwar PK, Jhingran AG. Inland fishes of India and adjacent countries. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi, Bombay and Calcutta, India, 1991; 2:1063.
32. Tanaka R, Higo Y, Shibata T, Suzuki N, Hatate H, Nagayama K, Nakamura T. Accumulation of hydroxy lipids in live fish infected with fish diseases. Aquaculture. 2002; 211(1-4): 341-351.
33. Van der Oose R, Beyer J, Vermeulen NPE. Fish bioaccumulation and biomarkers in environmental risk assessment: a review. Environmental Toxicology and Pharmacology. 2003; 13:57-149.
34. Yaji AJ, Auta J. Sub-lethal effects of monocrotophos on some haematological indices of African catfish *Clarias gariepinus* (Teugels). Journal of Fisheries International. 2007;2(1):115-117.
35. Lucky Z. Methods for the Diagnosis of Fish Diseases. Amerno publishing Co., PVT, LTD, New Delhi, Bombay, Calcutta and New York 1977.
36. Abudu JO, Sofola DA. Relationship between red cell mass and packed cell volume in Nigeria primigraviadae. Nigerian Journal of Physiological Sciences 1994; 10(1/2):13-21.
37. Blaxhall G, Diasley N. Routine haematological methods for use with fish blood. Journal of Fish Biology 1973; 5:771-941.
38. Bessey OA, Lowry OH, Brock MJ. A method for rapid determination of alkaline phosphatase with five cubic millimeters of serum. Journal of Biological Chemistry 1946; 164:321-329.

39. Jenkins JA. Fish Bioindicators of Ecosystem condition at the Caleasieu Estuary, Louisiana. National Wetlands Research Center USGS, Lafayette 2004.

Access this Article in Online	
Quick Response Code	Website: www.ijarbs.com
	Subject: Fish Biology
DOI:10.22192/ijarbs.2023.10.07.008	

How to cite this article:
Ashok Kumar. (2023). Biochemical and hematological responses of *Cyprinus carpio* fish to *Philometra pellucida* parasite infestation. Int. J. Adv. Res. Biol. Sci. 10(7): 71-81.
DOI: http://dx.doi.org/10.22192/ijarbs.2023.10.07.008