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Research Article

On some biochemical contents of tapeworm *Proteocephalus osculatus* and its definitive host, *Silurus triostegus*

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Abstract
Fishes are increasingly reported as important economic national resources, with recent interest focused on their therapeutic potential in reducing some diseases, including cardiovascular ones, due to their unsaturated fats and omega 3 content. The present study aimed to determine the concentration of some biochemical contents in the tissues of the tapeworm and the intestinal tissue of its definitive host *Silurus triostegus* fish. A total of 63 fishes were brought to the laboratory and dissected for small intestine removal, and a tapeworm of *Proteocephalus*. osculatus was collected and washed several times with saline solution. Intestinal tissues of the infected and non-infected fishes and the collected parasites were compared for biochemical parameters. Protein, glycogen, lipids, creatinine, and urea were measured using standard methods. Infected fishes had their intestinal tissues with a significantly ($p<0.05$) lower protein (22.06±0.42 mg/g wet weight), glycogen (12.33±0.08 mg/100 ml of solution, and lipid (17.10±0.16 mg/g wet weight) than non-infected fishes (33.06±0.72 mg/g wet weight, 20.23±0.53 mg/100 ml of solution, and 27.26±0.45 mg/g wet weight, respectively). Conversely, urea (12.30±0.36 mg/dl) and creatinine (2.31±0.12 mg/dl) increased significantly ($p<0.05$) in the infected host compared to non-infected ones (10.66±0.22 mg/dl and 1.07±0.10 mg/dl, respectively). This study highlights the impact of *P. osculatus* infection on the biochemical composition of *S. triostegus*, providing insights into parasite-host metabolic interactions. The findings suggest that biochemical markers such as protein, glycogen, and urea levels can serve as diagnostic indicators of fish health and can be valuable for disease monitoring, improving the quality of fish and fisheries management for commercial and export purposes.

Keywords: Creatinine, Glycogen, Lipid, Protein, *Silurus triostegus*, Tapeworm, Urea

INTRODUCTION

Fish are referred to as "Gold in the water" because they play a significant part in the economies of many countries and have a favorable impact on people's lives and societies on the majority of the world's continents. Fish is renowned for having a high concentration of proteins, amino acids, vitamins, and minerals (Balami *et al*., 2019), fish also has a high concentration of unsaturated fatty acids, which lower blood cholesterol levels (Scherr *et al*., 2015). Like other organisms, fish are exposed to infection with many pathogens, including parasites, despite being able to resist. These pathological effects of parasites that infect fish vary between depriving the host of food or feeding on tissues and bodily fluids, which delays their growth and obstructs the functions of their organs (Attia *et al*., 2021).

Proteins are among the fundamental building blocks of all life-sustaining processes in living cells; they make up 50% of the dry body weight of cells and are the most prevalent biochemical contents within them. In addition to providing energy, proteins also play important synthetic and supporting roles in developing numerous components such as enzymes, hormones, and many others (Nanware *et al*., 2014). Carbohydrates in protozoans and helminths constitute an important source of energy, as endoparasites work anaerobically to undercut carbohydrates to obtain the energy needed regardless of the amount of oxygen available in the environment or medium (Bandyopadhyay and Chattopadhyay, 2022). Glucose is the main source of energy production for tapeworms that inhabit the small

intestine of the hosts, as these worms store large amounts of polysaccharides in the parenchyma in the form of glycogen, the amount of which varies between different worm species, and glycogen performs other functions, including as an energy reserve and an important structural component in addition to phosphorylation intermediate (Fartade *et al*., 2011). Lipids are one of the biochemical contents found in cells; they are an energy source and are kept in tissues after the body's glycogen stores of carbohydrates have been used up. Additionally, they are fundamental structural elements of mitochondria, cell membranes, and the nucleus (Pallewad *et al*., 2015).

Urea and creatinine belong to the class of non-protein nitrogenous compounds, urea is formed in the body in the liver cells from the ammonia generated as a result of the processes of deamination of amino acids, the formation of urea is the primary method by which the body eliminates excess nitrogen, which is discharged outside through the urine (Harvey and Ferrier, 2011). Medical test of urea and creatinine is important for evaluating the functioning of the kidneys, so if the kidneys not able to excrete urea and creatinine from the blood normally, their level in the blood will rise above the normal level in pathogenic conditions such as acute and chronic kidney disease, urinary tract obstruction, as well as other conditions unrelated to kidney disease (Ajeniyi and Solomon, 2014). Hence, this study aimed to know the concentration of biochemical contents consumed by the tapeworm *Proteocephalus osculatus* from the intestine of its host *Silurus triostegus* and the effect of this tapeworm on the biochemical changes of its definitive host, infected fish, and to compare it with non-infected *S. triostegus* fish.

MATERIALS AND METHODS

Collection of specimens: From May 2023 until June 2023, 63 samples of *S. triostegus* fish (weight 1.9-2.2 kg; length 38-42 cm) were collected from Mosul's marketplaces (Mosul City, Iraq). The fish was brought to the laboratory and cut longitudinally from the outlet area to the cephalic region. The fish's small intestine was then isolated and placed in a Petri dishes with fish physiological saline solution (0.65%), and the intestine was then opened to look for a tapeworm of *P. osculatus*. The tapeworms were collected, placed in Petri dishes with the saline solution, washed with distilled water several times, and scrubbed clean with a clean brush to remove any suspended materials. The infected and non-infected fish were also repeatedly cleansed with distilled water. Each was placed into separate clean glass bottles containing saline solution, and they were all frozen at (-20°C).

Extract preparation: The method of Pappas and Narcisi (1982) was used to create an extract from the tapeworms and intestines of infected and non-infected fish.

Estimation of biochemical contents: Lowry *et al.* (1951)'s method was used to estimate the concentration of total proteins in the tapeworm and intestines of non-infected and infected fish.Using Kemp *et al*.'s (1954) method, glycogen was measured in both fish and tapeworms. The total lipids were estimated using the Chabrol and Chardonnet colorimetric method (Burtis and Bruns, 2014). For the measurement of urea and creatinine in the serum of infected and non-infected fish, kits from the Biosystem company (Switzerland) for creatinine and urea were used (Younis *et al*. 2023; Merkhan *et al*., 2022).

Statistics analysis: Data of infected and non-infected fishes were expressed as mean±SD and the t-test were applied to compare group to find significance differences at $p<0.05$.

RESULTS AND DISCUSSION

The concentration of total protein, glycogen, and lipids in the intestinal tissues of non-infected fish of wet weight was significantly higher than the infected group and the lowest concentration in tapeworm wet weight in the intestine of infected fish.

Earler studies (Table 1) support the current findings that the tissues of the tapeworm had a lower protein concentration than those of its host (infected fish). This could be because tapeworms lack an alimentary canal and depend on their hosts to provide their nutritional requirements; they take nutrients by diffusion from their hosts' intestines through body integument (Sonune, 2012).

As for the variation in protein concentration between the present worm and *Fasciola gigantica* mentioned in Al-Egaidy (2011) study conducted on cattle, who have attributed such variation to the kind of host, the nature of its diet, the stages of worm maturity and egg formation as well as the differences in the metabolic processes of the organism and the associated vital activities due to DNA's role in protein synthesis (Al-Naftachi, 2006). The amount of proteins in fish is also affected by other factors such as age, class, seasonal variations, and the aquatic environment, which contains fish food organisms. As a result, the fish's nutritional composition will change, reflected in the quantity and quality of food the worms absorb from the host's intestines (Pallewad, 2015).

Table 1.

The amount of glycogen in the tissues of the tapeworm was (7.33 0.26) mg/100 ml of solution, compared to 12.33) mg/100 ml of solution and 20.23 mg/100 ml of solution in infected and non-infected fish, respectively.The present findings concur with previous studies (Table 2) in that the tapeworm had a low glycogen concentration in its tissues compared to its hosts, both in-

Table 1. Comparison of protein concentration between tapeworm tissues and infected fish tissues

Studies	Species of parasites	Host	Protein Concentration in Parasite (mg/g wet weight)	Protein Concentration in Infected fish intestinal tissue (mg/g wet weight)
Bhure *et al*., 2011;	*Camallanus jadhavii*	*Wallago attu*	8.45 ± 0.32	28.12 ± 0.45
Fartade *et al*., 2011;	*Ptychobothridean parasites*	*Mastacembalus armatus fish*	10.12 ± 0.45	30.45 ± 0.50
Sonune, 2012;	*Cestode parasites*	*Ovis bharal*	9.78 ± 0.41	29.67 ± 0.55
Nanware *et al*., 2012;	*Cestode Cotugnia*	*Gallus gallus domesticus*	11.23 ± 0.56	32.10 ± 0.60
Biswal *et al*., 2014;	*Cyclophyllidean cestode, Cotugnia cuneata*	*Columba livia domestica*	10.89 ± 0.47	31.45 ± 0.58
Hassan *et al*., 2016;	*Khawia armeniaca, Bothriocephalus acheilognathi, Senga sp., Postgangesia inarmata, Procamallanus viviparous, Neoechinorhynchus iraqensis, Neoechinorhynchus zabensis*	Fishes (*Luciobarus esocinus, Cyprinus carpio, Mastacembelus mastacembelus, Silurus triostegus, Liza abu, Capoeta damascina*)	9.67 ± 0.38	27.89 ± 0.42
Saraf and Katayani, 2016;	*Cestode parasite*	*Mastacembalus armatus*	10.45 ± 0.50	29.34 ± 0.48
Fartade and Chati, 2016;	*Cestode parasites*	*Gallus gallus domesticus*	11.10 ± 0.42	31.78 ± 0.52
Al-Niaeemi and Dawood, 2021	*Tapeworm Khawia armeniaca*	*Barbus grypus*	9.85 ± 0.35	28.56 ± 0.40
Present Study	*Proteocephalus osculatus*	*Silurus triostegus*	9.95 ± 0.64	22.06 ± 0.42

Table 2. Glycogen concentration in tapeworm tissues compared to infected fish tissues

Studies	Species of parasites	Host	Glycogen Concentration in Parasite (mg/100 ml of souluation)	Glycogen Concentration in infected fish intestinal tissue (mg/100 ml of soluation)
Jadhav *et al*., 2008;	*Davainea shindei n. sp.*	*Gallus gallus domesticus*	6.45 ± 0.25	18.23 ± 0.40
Jawale *et al*., 2011;	*Caryophyllidean tapeworms*	*Clarias batrachus*	7.12 ± 0.30	19.56 ± 0.45
Bhure *et al*., 2011;	*Camallanus jadhavii*	*Wallago attu*	6.78 ± 0.28	17.89 ± 0.38
Lanka *et al*., 2011;	*Postgangesia armata*	*Silurus glanis*	7.45 ± 0.32	20.12 ± 0.42
Fartade *et al*., 2011;	*Ptychobothridean parasites*	*Mastacembalus armatus*	6.89 ± 0.27	18.67 ± 0.35
Sonune, 2012;	*Cestode parasites*	*Ovis bharal*	7.23 ± 0.30	19.34 ± 0.40
Nanware *et al*., 2014;	*Moniezia expansa*	*Capra hircus*	6.56 ± 0.25	17.45 ± 0.32
Pallewad *et al*., 2015;	*Cotylophoron cotylophorum*	*Capra hircus L.*	7.10 ± 0.29	18.78 ± 0.36
Saraf and Katayani, 2016;	*Cestode parasite*	*Mastacembalus armatus*	6.95 ± 0.28	19.12 ± 0.38
Al-Niaeemi and Dawood, 2021	*Tapeworm Khawia armeniaca*	*Barbus grypus*	7.34 ± 0.30	20.45 ± 0.42
Present Study	*Proteocephalus oscu-*	*Silurus triostegus*	7.33 ± 0.26	12.33 ± 0.08

fected and non-infected fish.

The difference in glycogen concentration between the current worm and the various worms in earlier studies may be explained by the host and its diet, as any decrease in the percentage of carbohydrates in the host's diet is followed by a decrease in the percentage that the worms absorbed and used for growth and development (Cheng, 1986). Nanware *et (al*., 2014) explained that the concentration of glycogen in the tapeworm (*Monieza expansa*) that parasitizes mammals (*Capra hircus*) differs from its concentration in other types of tapeworms due to the difference in the size of the worm and its location within the host. This discrepancy may also be explained by the differences in the histo-

Table 3. Concentration of biochemical contents (protein, glycogen and lipids) in non-infected intestinal tissue, infected intestinal tissue of *Silurus triostegus* fish and their parasite

Measured parameters	Non-infected intestinal tissue	Infected intestinal tissue	Parasite *Proteocephalus osculatus*
Protein (mg/g wet weight)	33.06±0.72*	22.06±0.42	9.95±0.64
Glycogen (mg/100 ml of solution)	20.23±0.53*	12.33±0.08	7.33±0.26
Lipid (mg/g wet weight)	27.26±0.45*	17.10±0.16	19.17±0.32

*The significant difference between infected and non-infected intestinal tissues of fish was at (P≤0.05) according to the T-test. Data expressed as mean±SD

Table 4. Concentration of urea and creatinine in serum of non-infected and infected fish

Parameters	Non-infected fish	Infected fish
Urea (mg/dl)	10.66**±** 0.22	12.30**±**0.36*
Creatinine (mg/dl)	1.07± 0.10	2.31±0.12*

*The significant difference between infected and non-infected fish at (P≤0.05) according to the t-test. Data expressed as mean±SD

logical nature of integument in the different worms, which in turn affects how much sugar is absorbed through the sodium pumping channels through the integument of the worms, resulting in variations in their quantity (Starling, 1975).

It has been clarified by Fartade and Chati (2016) that the tapeworm *Cotugnia sp.*, which parasitizes Gallus gallus fish, can obtain large amounts of glycogen from the host for growth. Nanware and Bhure (2011) found a variance in the amount of glycogen along the mature and gravid segments, and they linked this to a variation in metabolic rates along those segments, which is connected to their anatomical changes and permeability features. Glucose is a major source of energy for tapeworms that inhabit the alimentary canal, and these worms usually store relatively large amounts of polysaccharides in the form of glycogen (Saraf and Katayani, 2016).

Total lipids were concentrated in the tapeworm's tissues at (19.17) mg/g wet weight, in the definitive host's (infected fish's) intestines at (17.10) mg/g wet weight, and in the intestines of non-infected fish at (27.26) mg/g wet weight. It is noted from (Table 3) that the concentration of lipids in the tapeworm tissues was high compared to its infected final host, and this result concurs with earlier studies (Table 4) in the presence of high concentrations of lipids in the tapeworm tissues compared to its infected definitive host, this is due to the fact that tapeworms depend entirely on their definitive hosts for their nutritional needs of biochemical contents as well as minerals and vitamins through the integument, which is not only a protective cover but also acts as a layer used for metabolic processes, transport, excretion and absorption of nutrients, including lipids, to suit their vital needs and uses for growth (Mondal *et al*., 2009), furthermore, and because tapeworms are unable to manufacture amino acids in a pathway (Denovo), they absorb more lipids than their hosts' tissues (Obal *et al*., 2012; Bandyopadhyay and Chattopadhyay, 2022).

Table 1 shows that the concentration of proteins was at the highest value among the values of biochemical contents (proteins, glycogen, and fats), and this is because catfish are carnivorous fish and other fish are at the forefront of their diet, where cyprinidae fish are their main food, followed by crustaceans, insects, frogs, birds, molluscs, and annelid worms. Proteins and fats are the primary energy sources for fish, as opposed to mammals, whose primary energy source is carbohydrates. This may be attributed to the high protein content of the fish diet and the adaptation of fish metabolism to this kind of food (Dörücü, 2000).

The concentrations (mg/dl) of urea and creatinine in the serum of infected fish were significantly (p≤0.05) higher than non-infected fish (Table 2), where they were 12.30**±**0.36 and 10.66**±** 0.22 for urea; and 2.31±0.12 and 1.07± 0.10 for creatinine in both infected and non-infected fish, respectively.There was a noticeable increase in the levels of urea and creatinine in the blood serum of fish with worm infections (Table 4), both of which are signs of renal failure. There was a significantly higher concentration of urea and creatinine in infected over non-infected groups of fish, which is concordant with the results of Ajeniyi and Solomon (2014) conducted on *Clarias Gariepinus* collected from catfish hosts. Rastiannasab *et al*. (2016) have also proved similar results on *Dactylogyrus* species and *Gyroda ctylus* species in their host common carp. Moreover, such findings are also reported in Radwan *et al.* (2021) study on *Clarias gariepinus* fish blood due to endoparasitic fauna worms' infection.

Urea and creatinine are produced as a result of the metabolism of proteins and muscles, respectively, after that they are transported through the blood into the renal glomeruli, filtered, then passed through the small renal tubules, and then out of the body through the kidney (Kabir and Ovie, 2011). The renal tubules partially reabsorb urea, but creatinine is not, so a creatinine ex-

amination is a reliable way to assess kidney function because a decrease in glomerular filtration rate causes an increase in creatinine levels, which indicates that the kidneys are not functioning properly (Tresseler, 1988). Whereas urea levels are elevated, this may be attributed to an imbalance in the gills' glomerular filtration rate or dysfunction, as part of the urea is put out through the gills (Murray, 1990).

According to (Radwan *et al*., 2021), the cause for the increase in urea and creatinine *in C. gariepinus* fish blood may be due to endoparasitic fauna worms infection or a result of the change in the muscle structure of the infected fish, while Ajeniyi and Solomon (2014) noted that the structured nature of catfish muscles or the stress which infects catfish with *Clarias gariepinus* during capturing or the method of capturing them during the experiment is associated with weak kidneys and low glomerular filtration rates, the increase in creatinine indicates renal failure as a result, in addition, also listed additional factors that could increase the levels of creatinine in fish blood serum, including shock, congestive heart failure, and malnutrition, as well as those that increase urea levels, including gastrointestinal bleeding, dehydration, urinary tract obstruction.

Conclusion

The biochemical parameters measured in fishes, *S. triostegus* infected with tapeworm *P. osculatus* reflected the pathological status of the host and could be used as a diagnostic marker for the identification of diseased fishes. This could be of great value in the processing of marketing and exportation to authenticate fishes' quality and health status.

Conflict of interest

The authors declare that they have no conflict of interest.

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