Research Journal of Agricultural Sciences
An International Journal

Res. Jr. of Agril. Sci. **12**(2): 405–410

P- ISSN: 0976-1675 | **E**- ISSN: 2249-4538

www.rjas.org

Research Paper

Hematological Effects of Ectoparasites in some Catfishes of Indore, Madhya Pradesh

Baba Tabasum*[1] and Rajesh Dixit[2]

Received: 05 Jan 2021 | Revised accepted: 18 Feb 2021 | Published online: 04 Mar 2021

A B S T R A C T

The aim of the present study was to investigate the effect of monogenean helminth ectoparasitic infections on hematological parameters of catfishes (*C. batrachus* and *C. gariepinus*) in Indore, Madhya Pradesh. A total number of 453 fish samples of *Clarias batrachus* and *Clarias gariepinus* were collected consisting of 236 *Clarias batrachus* (143 males and 93 females) and 217 *Clarias gariepinus* (117 males and 100 females) a total of 217 specimens were examined for the period of two years. Results indicated presence of three species of parasites, *Gyrodactylus* sp., *Dactylogyrus* sp. and *Lernea* caused alterations in various hematological indices of both the fishes. Hemoglobin (Hb), Total Erythrocyte Count (TEC), Packed Cell Volume (PCV), Mean Corpuscular Volume (MCV) and Mean Corpuscular Hemoglobin (MCH) were found decreased in the fishes infested with parasites as compared to those which were devoid of any parasitic infestations. Similarly, Total Leucocyte Count (TLC), Erythrocyte Sedimentation Rate (ESR) and Differential Leucocyte Count (DLC) were found increased in parasitized fishes than non-parasitized ones. The results indicated that fishes suffer anemia, loss of appetite and reduced growth when affected with parasites.

***Key words*:** Catfishes, Ectoparasites, Blood indices, Anemia infestations

Fishes fall prey to a large number of parasites, both endoparasites as well as ectoparasites. A variety of endoparasites including nematodes, trematodes, microsporids, copepods, monogeneans are reported from fishes. Endoparasites result in the destruction of host tissues, caused either due to migration of parasites inside the host (mechanical action) or due to the attachment organs of parasites (hooks, suckers) into host tissues as anchors. Ectoparasites are the organisms that inhabit the skin or outgrowths of skin of the host. Some ectoparasites are host specific (e.g., lice), while few can parasitize a wider range of hosts [1]. These usually induce anaemia, hypersensitivity immune reactions, irritability, necrosis, secondary infections, focal haemorrhages, dermatitis. Flukes, leeches, crustaceans, insects are the common fish ectoparasites. Among ectoparasites, monogeneans of the genera D*actylogyrus* and *Gyrodactylus* commonly infest freshwater fishes. *Gyrodactylus* is commonly found on the fish skin, whereas *Dactylogyrus* predominantly affects the gills. *Lernea*, commonly known as anchor worm, are crustacean, copepod parasites that infects the fish commonly found in stagnant or slow-moving water bodies. Infestations are more pronounced during summer months.

Blood is an efficient bio-indicator of the health of an organism [2]. Hemato-biochemical indices are commonly employed for effective monitoring of the organism's response to stressors and thus its health status under adverse conditions. Being a good pathological reflector of the whole body, Hematological parameters are important in diagnosing the functional status of the fish (host) infested by parasites [2] and also to raise the physiological condition and nutritional state of fish [3]. Hematological tests are commonly used to establish normal health status and to diagnose diseases caused by several factors including heavy metals, environmental stress, parasitic infections, genotoxic effect of pollutants, nutrition, and pollution in human and veterinary science [4]. Hematological parameters act as physiological indicators for changing external environments [5] as a result of their association with energetic (metabolic levels), respiration (hemoglobin) and defense mechanisms (leukocyte levels) [6]. Besides this, they also provide an integrated measure of the health status of an organism, which with the passage of time manifests in changes in weight. Therefore, the changes related with hemato-biochemical parameters due to various parasites forms a database for disease diagnosis and for implementing treatment or preventive measures [7]. In this study, the effects of ecto-parasites viz. *Dactylogyrus*, *Gyrodactylus* and *Lernea* on the hematological indices of *Clarias batrachus* and *Clarias gariepinus* were carried out. This study will give an idea not only the pathological conditions induced by parasites in fishes but also it will provide an idea to chalk out plans to get fishes rid of the diseases.

*Baba Tabasum
drtabasum550@gmail.com

[1-2]P.M.B Gujarati Science College, Department of Zoology, Faculty of Life Sciences, Devi Ahilya University, Indore - 452 017, Madhya Pradesh, India

MATERIALS AND METHODS

Study area and sampling of fish specimens

The present study was conducted in P.M.B Gujarati Science College Department of Zoology, Faculty of Life Sciences Devi Ahilya University, Indore, Madhya Pradesh. The experiment was carried out on *Clarias batrachus* and *Clarias gariepinus* fishes and subjected to the parasitological examination. The study was carried for a period of two years (four seasons per year) from December 2017 to November 2019. Collection of experimental fishes was carried on seasonally basis and during each sampling live specimens of *C. batrachus* and *C. gariepinus* were collected and transported to the laboratory in plastic bags. A total number of 453 fish samples of *Clarias batrachus* and *Clarias gariepinus* were collected from the river Narmada falling in the vicinity of Indore city to investigate the pathological changes induced by ectoparasitic forms of helminth parasites. Among *Clarias batrachus*, 236 specimens consisting of 143 males and 93 females were collected for the entire period of two years. In case of *Clarias gariepinus*, a total of 217 specimens were examined for the period of two years among which 117 were males and 100 were females. All the collected fish specimens were subjected for the examination of for the presence of ectoparasites.

Hematological assay

Blood was collected from healthy as well as infected *Clarias batrachus* and *Clarias gariepinus* fishes in live conditions from the caudal peduncle by using 2ml plastic syringe and a needle treated with anticoagulant [8]. Blood samples for hematological studies were preserved in EDTA embedded bottles. Various hematological indices including Hemoglobin (Hb), Total Erythrocyte Count (TEC), Packed Cell Volume (PCV), Erythrocyte Sedimentation Rate (ESR), Total Leukocyte Count (TLC), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), and Differential Leukocyte count (DLC) were analyzed using standard methodology. Baseline data was made by collecting the blood samples from 20 healthy specimens each of *C. batrachus* and *C. gariepinus* which was compared with the blood of the fishes infested with parasites.

Estimation of hemoglobin content

The hemoglobin of the experimental fishes was estimated with the help of hemometer (Sahli's method), consisting of two sealed lateral comparison tubes containing a suspension of acid hematin, and a centrally placed graduated test tube of same diameter. The anticoagulated blood was drawn up to the mark of 20 and immediately added to the N/10 HCl solution in the graduated tube. The Acid hematin solution thus formed was thoroughly stirred with the help of a stirrer and then allowed to stand at least for ten minutes. Then the acid hematin solution was diluted by adding distilled water in a drop wise manner to compare the colour with the references. The colour comparison with references gave gm% of hemoglobin in the blood of fish.

Total erythrocyte count

The TEC in the blood of experimental fishes was determined with the help of hemocytometer. Anticoagulated, non-hemolyzed blood was drawn up to 0.5 graduated mark and then RBC dilution solution (Hayem's solution) up to 101 mark. The pipette was shaken for one minute and immediately after shaking the Neubaurs counting chamber was charged with mixture free from bubbles. The liquid contained in the capillary portion was rejected and counting of RBC's was done under 40X objective (HPF).

$$TEC/\ mm^3 = N \times 1000$$

Where 'N' denotes the total number of Red Blood Cells counted in the 5 squares of the hemocytometer and 1000 is the factor obtained after taking into consideration the initial dilution factor.

Packed cell volume (PCV)

Packed cell volume was also determined with the help of Wintrobe's method. The anticoagulated blood was drawn into the Wintrobe's tube up to 0 mark. The blood-filled tubes were safely placed in the tubes of a centrifuge opposite each other and centrifuged for 30 minutes at the rate of 3000 rpm. The centrifuge was turned off and tubes removed, the reading was taken from the bottom of the tube.

Total leukocyte count (TLC)

The Leucocyte Count (TLC) was determined by the Hemocytometer [9]. Anticoagulated, non-hemolyzed blood was drawn into the erythrocyte pipette up to 0.5 mark and WBC dilution fluid up to 101 mark. The Neubaurs counting chamber was then charged with the mixture after discarding the liquid into the capillary portion of pipette. The counting of the WBC was taken under 40X objectives.

$$\text{Calculation: } WBC/mm^3 = N \times 500,$$

Where, N denotes the total number of WBC counted in the four squares of counting chamber and 500 is the dilution factor.

Mean corpuscular hemoglobin (MCH)

MCH was calculated by the following formula:

$$MCH = Hb\ \% \times 10/TEC/mm^3 = x/g$$

Mean corpuscular volume (MCV)

MCV was calculated with the help of following formula:

$$MCV = \text{Hematocrit value} \times 10/TEC/mm^3 = \times \mu^3$$

Differential leukocyte count (DLC)

DLC was performed in which a small drop of fresh, anticoagulated, non- hemolysed blood was poured on the grease free slide and using a spreader slide, a thin tongue shaped smear was made. The blood smear was air dried and stained with Leishman's stain for 5 minutes. The stain was diluted with distilled water and again kept undisturbed for 10 minutes. Then the slides were washed, dried and observed under oil immersion objective (100X). The percentage of lymphocytes and heterophils were determined using the blood cell counter.

Statistical analysis

The values of all hematological parameters under study were properly recorded and subjected to statistical analysis using Mann-Whitney U test of significance while as descriptive statistics for calculating means and standard deviations, excel was used.

RESULTS AND DISCUSSION

During this study the results revealed that ectoparasites induced severe hematological alterations in both, *Clarias batrachus* and *Clarias gariepinus* fishes. The detailed presentation of hematological deviations is given in the (Table 1-2).

Effect of parasites on hemoglobin content (Hb) (g/L)

In this study, the Hemoglobin Content was measured in parasite infested fishes and compared with the non-parasitized fishes. In *Clarias batrachus*, the mean hemoglobin was recorded 7.16±2.2 g/L in non-parasitized fishes while as in parasite infested samples, the mean hemoglobin was found reduced 6.3±2.2 g/L and was found statistically significant (p≤0.01) (Table 1). In *Clarias gariepinus* the hemoglobin content was also reduced in parasitized fishes as compared to the non-parasitized fishes. The hemoglobin content was found reduced from 6.44±1.77 g/L to 6.02±1.78 which was found statistically insignificant (P≥0.01) (Table 2).

Effect of parasites on total erythrocyte count (TEC)

The Total Erythrocyte Count (TEC) in parasitized *Clarias batrachus* fishes was found reduced to 5.1× 10^6/mm^3 from 5.72× 10^6/mm^3 which were found statistically significant (p≤0.01) (Table 1). In *Clarias gariepinus*, a significant (p≤0.01) difference was recorded in fishes infested with parasites as compared to non-infested fishes. The non-parasitized fishes were recorded to have mean TEC values of 5.46±0.4× 10^6/mm^3 which were found decreased to 4.8±0.1× 10^6/mm^3 and was found statistically significant (p≤0.01) (Table 2).

Table 1 Effects of ecto-parasites on hematological indices of *Clarias batrachus*

Hematological indices	Non-parasitized fishes	Parasitized fishes	P value
Hb (g/L)	7.16±2.2	6.3±2.2	<0.01
TEC (× 10^6/mm^3)	5.72 ±1.8	5.1±1.6	<0.01
TLC (× 10^6/mm^3)	6.08±0.91	7.18±0.87	<0.01
PCV (%)	55.46±2.25	49.08±1.25	<0.01
MCV (%)	1.29-1.89	1.99-4.05	>0.01
MCH (%)	1.12-1.78	1.85-2.47	<0.01
ESR (1st Hour)	47.14±6.7	54.7±5.2	<0.01

Table 2 Effects of ecto-parasites on hematological indices of *Clarias gariepinus*

Hematological indices	Non-parasitized fishes	Parasitized fishes	P value
Hb (g/L)	6.44±1.77	6.02±1.78	>0.01
TEC (× 10^6/mm^3)	5.46±0.4	4.8±0.1	<0.01
TLC (× 10^6/mm^3)	6.62±0.6	7.18±0.8	<0.01
PCV (%)	54.7±5.2	47.14±6.7	<0.01
MCV (%)	1.12-1.178	1.85-4.27	<0.01
MCH (%)	7.6-9.6	6.6-9.5	<0.01
ESR (1st Hour)	47.48±1.9	57.22±3.4	<0.01

Effect of parasites on total leukocyte count (TLC)

While studying the total leukocyte count (TLC) of catfishes, it was noticed that the TLC of parasite infested fishes was found higher than non-parasitized ones in both catfishes. The increase was found more or less similar indicating that parasites have a uniform pattern of inducing stress in catfishes (Table 1). In *Clarias batrachus*, the mean values of TLC in non-infested fishes was 6.08× 10^6/mm^3 which got higher in the infested fishes up to 7.18±0.87×10^6/mm^3 with a statistically significant difference (p≤0.01). In *Clarias gariepinus*, the mean values of TLC in non-infested fishes was 6.62±0.6×10^6/mm^3 which got higher in the infested fishes up to 7.18±0.8×10^6/mm^3 with a statistically significant difference (p≤0.01) (Table 2).

Effect of parasites on packed cell volume (PCV)

During this study, effect of the parasites on hematocrit values of catfishes was also studied. In *Clarias batrachus* the mean hematocrit or PCV of fishes not having any parasite infections was recorded 55.46±2.25% while as in parasite infected fishes; it was recorded 49.08±1.25 with a significant difference (p≤0.01) statistically (Table 1). In case of *Clarias gariepinus*, the mean PCV levels of non-parasitized specimens were 54.7±5.2% which got reduced to 47.48±1.9% and was found statistically significant (p≤0.01) (Table 2).

Effect of parasites on mean corpuscular volume (MCV) (%)

In this study, the mean corpuscular volume of fish samples affected with parasites was assessed and compared with non-parasitized ones. The MCV of control specimens showed an insignificant difference when compared to the parasite affected fishes. In *Clarias batrachus* MCV of non-parasitized fishes ranged from 1.29-1.89% while as in parasite affected ones; it ranged from 1.99-4.05 %. The mean value of MCV in non-parasitized fishes was 1.61± 0.232 and that of diseased fishes was 3.2±0.799 (Table 1). The RBC's depicted normochromic normocytic type of anemia in all the fishes infected with parasites.

In case of *Clarias gariepinus*, mean corpuscular volume of non-parasitized fishes ranged in between 1.12-1.178% whereas in parasite infected ones, it ranged between 1.85-4.27%. The mean values of MCV in parasite infected fishes (2.85±1.249) were found significant (p≤0.05) as compared to non-parasitized fishes (1.46±0.246) (Table 2). The fishes exhibited normochromic normochromic/ microcytic anemia with unusual occurrence of few hypochromic types of RBC's also. But the incidence of hypochromic types of anemia was very less as compared to normochromy.

Effect of parasites on mean corpuscular hemoglobin (MCH) (%)

In this study, the mean corpuscular hemoglobin (MCH) of fish samples affected with parasites was assessed and compared with non-parasitized ones. The MCH of control specimens showed a significant difference when compared to the parasite affected fishes. In *Clarias batrachus* MCH of non-parasitized fishes ranged from 1.12-1.78% while as in parasite affected ones; it ranged from 1.85-2.47%. The mean value of MCH in non-parasitized fishes was 1.46±0.25 and that of

diseased fishes was 2.85±1.25 (Table 1).

In case of *Clarias gariepinus*, mean corpuscular volume of non-parasitized fishes ranged in between 7.6-9.6% whereas in parasite infected ones, it ranged between 6.6-9.5%. The mean values of MCV in parasite infected fishes (8.47±0.48) were found significant ($p \leq 0.05$) as compared to non-parasitized fishes (8.67±0.915) (Table 2).

Effect of parasites on erythrocyte sedimentation rate (ESR)

During this study, effect of the parasites on ESR values of *Clarias batrachus* and *Clarias gariepinus* was studied by first hour reading method. The mean ESR of the non-infected fishes of *Clarias batrachus* specimens was found 47.14±6.7 which rose in the fishes having parasitic infection up to 54.7±5.2 (Table 1). SIMILARLY, in *Clarias gariepinus*, the mean ESR in parasite infected fishes was found 57.22±3.4 as compared to the non-infected ones whose mean values were recorded 47.48±1.9 after 1st hour reading (Table 2). The values of ESR in both the fishes were found statistically significant ($p \leq 0.01$).

Differential leukocyte counts in parasite infested fishes

In this study, differential leukocyte counts were carried out in *Clarias batrachus* and *Clarias gariepinus* fishes having infestation of ectoparasites which was compared with the DLC values of non-parasitized fishes. Various DLC parameters are given as under:

Effect of parasites on monocytes

Monocyte count was found increased in parasitized fishes as compared to the non-infected ones. The normal range of monocytes was 1-3 while as in parasite infested *Clarias batrachus* it was 4-7. Mean values of monocyte count was recorded 2.33±1.154 and that of infected specimens, it was 5.00 ±1.73 (Table 3). In *Clarias gariepinus*, the mean value of monocyte count was higher (5.00±1.73) than the non-infected group (2.33±1.154) with a range of 2-3 and 2-4 respectively for non-infected and parasite infected fish (Table 4).

Effect of parasites on lymphocytes

Lymphocyte count was also found increased in parasitized *Clarias batrachus* as compared to the healthy fishes. The normal range of lymphocyte was 72-80 in healthy specimens while as in parasite infested fishes, it was found 80-82. Mean values of lymphocyte count was recorded 76.00±4.00 and that of infected specimens, it was 83.33±4.16 (Table 3). In *Clarias gariepinus*, the mean value of lymphocyte count was higher (76.00±4.00) than the healthy group (83.33±4.16) with a range of 74-81& 80-87 respectively for non-infected and infected fish species (Table 4).

Effect of parasites on neutrophils

Neutrophil count was also found increased in *Clarias batrachus* infected with parasites as compared to the healthy ones. The normal range of neutrophil was 6-13 while as in infected fishes it was 5-8. Mean values of neutrophil count was recorded 10.00±3.605 and that of infected specimens, it was 7.00±1.73(Table 3). In *Clarias gariepinus* parasitized fishes, the mean value of neutrophil count was higher (10.00±3.605) than the healthy group (7.00±1.73) with a range of 5-11 and 2-3 respectively for healthy and parasitized fishes (Table 4).

Table 3 DLC parameters of *Clarias batrachus* with range and Mean±S.D.

DLC parameter	Range of non-parasitized fishes	Mean±S.D.	Range of parasitized fishes	Mean±S.D.
Monocyte (%)	1-3	2.33±1.154	4-7	5.00 ±1.73
Lymphocyte (%)	72-80	76.00±4.00	80-82	83.33±4.16
Neutrophil (%)	6-13	10.00±3.605	5-8	7.00±1.73
Eosinophil (%)	0-1	0.667±0.577	0-1	0.667±0.577
Basophil (%)	0-1	0.33±0.577	0-2	1.00±1.00

Table 4 DLC parameters of *Clarias gariepinus* with range and Mean±S.D.

DLC parameter	Range of non-parasitized fishes	Mean±S.D.	Range of parasitized fishes	Mean±S.D.
Monocyte (%)	2-3	2.33±1.154	2-4	5.00 ±1.73
Lymphocyte (%)	74-81	76.00±4.00	80-87	83.33±4.16
Neutrophil (%)	5-11	10.00±3.605	2-3	7.00±1.73
Eosinophil (%)	0-1	0.667±0.577	1-2	0.667±0.577
Basophil (%)	0-1	0.33±0.577	1-2	1.00±1.00

Effect of parasites on eosinophils

Eosinophil count was found unaffected in parasitized *Clarias batrachus* when compared to the healthy specimens. The range of eosinophil was 0-1 in both the parasitized group as well as non-parasitized group of fishes. The mean value of eosinophil count in both the groups was 0.667±0.577 (Table 3). In *Clarias gariepinus*, the parasitized fishes had mean value of eosinophil count same as that of non-parasitized ones (0.667±0.577) while as the range of 0-1 and 1-2 respectively was recorded for healthy and parasite infected fishes (Table 4).

Effect of parasites on Basophils

Basophil count was also found slightly increased in parasite infected *Clarias batrachus* as compared to the healthy fishes. The normal range of basophil was 0-1 while as in parasitized fishes, it was 0-2. Mean values of basophil count were recorded 0.33±0.577 for healthy ones and that of parasitized specimens, it was 1.00±1.00 (Table 3). In *Clarias gariepinus*, the mean value of basophil count in parasite infected fishes was comparatively higher (1.00±1.00) than the healthy specimens (0.33±0.577) with a range of 0-1 and 1-2 respectively for healthy and parasite infected fish (Table 4).

In an organism, blood acts as an important bio-index of the health. The Hematological parameters are important in diagnosing the efficient status of the fish infested by parasites health and behave as efficient pathological reflectors. Health condition in fish is quickly reflected in Hematological changes in blood [10]. In the present study, all the Hematological parameters studied, namely Packed cell volume (PCV),

Hemoglobin concentration (Hb) and Red blood cell count (RBC) and White blood cell count (WBC) varied significantly (at P - value 0.0001) between the uninfected and the infected fishes in both *C. batrachus* and *C. gariepinus* species. The study revealed that the PVC, Hb and RBC were lower in the infected specimens than in the healthy ones. The decrease in RBC count, hemoglobin (Hb) value and packed cell volume (PCV) in infected fishes may have occurred because the parasitic infestation often leads to anaemia [11]. Additionally, the parasites simply act as stressors and through the primary stages of stress, the PCV are altered due to the release of catecholamine, an enzyme which activates the RBCs to swell as a consequence of fluid entry into the intracellular compartment. The severe anemia leads to the reduction of RBC, PCV and Hb of the infected fishes [12]. They further stated that anemia in infested ones maybe as a result of chronic liver inflammation which causes depression of erythrogenesis. Similarly observed low hemoglobin concentration in *Trachinotus marginatus* naturally parasitized by the monogenean *Bicotylophora trachinoti* Contrarily to that observed in the present study, they did not observe alterations in the hematocrit and RBC values. This might be because of low parasite numbers [13]. Similarly, did not locate blood alterations in *Lutjanus guttatus* parasitized by dactylogyrids in low, moderate and high [14]. The decrease in RBC, Hb and PCV in fishes infected with hemoparasites. Similar results were documented by in *Clarias gariepinus* that are naturally infected with *T. mukasai* [15-16].

The overall value of WBCs was found elevated in the infected fish than in uninfected fish. The results were in accordance with [17] WBCs play an important role during infestation by stimulating the hemopoietic tissues and immune system to produce antibodies and chemical substances which enhance the defense mechanism in the host against parasitic infections [18]. This occurs as a pathological response. Blood is the first line of defense against diseases due to phagocytes [19]. Similar findings were put forward by [20] also forwarded similar conclusions [21].

The DLC findings reported an elevation in monocytes and lymphocytes while as decrease in other parameters (neutrophils and thrombocytes) [22]. In collaboration with this, [23] also reported an increase in the lymphocyte count in *Heteropneustes fossilis* infected with *Lucknowia indica*. An abnormal reduction of thrombocytes (Thrombocytopenia), has already been noted for *Hoplias malabaricus* parasitized by the nematode *Contracaecum* sp. for *Piaractus mesopotamicus* infected by *Argulus* sp. (Branchiura) and for Nile tilapia *Oreochromis niloticus* parasitized by *Argulus* sp. (Branchiura), *Lamproglena* sp. (Copepoda) and *Epistylis* sp. (Ciliophora) [24]. Thrombocytes play a major role in defending against pathogens, showing inflammatory responses, helping in blood coagulation, and enhancing phagocytosis [25]. The present findings were also in accordance with [26] who described neutropenia in *Channa striata* infected with *Alitropus typus*. Similar findings were reported in *Schizodon intermedius* infested with *Lernaea cyprinace* and in *Channa punctata* infected by *Isoparorchis hypselobagri* (Digenea) and in Atlantic salmon *Salmo salar* infected by the ectoparasites *Gyrodactylus* sp. (Monogenea) and *Saprolegnia* species [27]. Actually, the severe parasitism triggers the migration of neutrophils to the center of inflammation, which may result in their low in the bloodstream. The increase in the number of lymphocytes in infected specimens was in accordance with Pickering, who reported increase in Pikeperch *Sander lucioperca* (Percidae) associated with parasitism. The parameter monocyte was also found to increase in infected fish [28].

CONCLUSIONS

Present study was undertaken to evaluate the effects of various Ectoparasites on hematological indices of catfishes, *Clarias batrachus* and *Clarias gariepinus* in Indore, Madhya Pradesh. The study indicated that various hematological parameters in both the fish species were found altered in the parasitized fishes as compared to those non-infested ones. Hb, TEC, PCV, MCV and MCH were found decreased in the fishes with parasite infections while as TLC and ESR showed a significantly increasing trend in infected fishes than normal. Similarly, DLC studies depicted increase in various WBC counts in parasitized fishes than normal. The study is indicative of induced distress and health degradation in fishes due to parasite infestation.

Acknowledgements

The author is thankful to Department of Zoology, Faculty Life Sciences P.M.B Gujarati Science College DAVV University and Nanaji Deshmukh Veterinary Science University Mhow are humbly acknowledged for providing me necessary laboratory facilities.

LITERATURE CITED

1. Farooq T, Khan I, Tak IU, Dar SA, Yousuf AR. 2016. Endoparasites of some economically important food fishes of River Jhelum, Kashmir (India). *Journal of Parasitic Diseases* 40(3): 860-871.
2. Joshi PK, Bose M, Harish D. 2002. Changes in certain haematological parameters in siluriod catfish, *Clarias batrachus* (L.) exposed to cadmium chloride. *Pollution Resources* 21(2): 119-122.
3. Chagas EC, Val AL. 2003. Effect of vitamin C on weight and hematology of Tambaqui. *Brazilian Agricultural Research Corporation* 38(3): 397-402.
4. Fedato RP, Simonato JD, Martinez CBR, Sofiaa SH. 2010. Genetic damage in the bivalve mollusk *Corbicula fluminea* induced by the water-soluble fraction of gasoline. *Mutation Resources* 700: 80-85.
5. Caruso G, Genovese L, Maricchiolo G, Modica A. 2005. Haematological, biochemical and immunological parameters as stress indicators in *Dicentrarchus labrax* and *Sparus aurata* farmed in off-shore cages. *Aquaculture International* 13: 67-73.
6. Oriakpono O, Hart A, Ekanem W. 2012. Acute haematological response of a cichlid fish *Sarotherodon melanother* on exposed to crude oil. *Journal of Toxicology and Environmental Health Sciences* 4(9): 151-155.
7. Yaji AJ, Auta J. 2007. Sub-lethal effects of monocrotophos on some haematological indices of African catfish *Clarias gariepinus* (Teugels). *Journal of Fisheries International* 2(1): 115-117.
8. Nmor *et al.,* 2004. Observations on the intestinal helminth parasites of cichlids in the upper reaches of River Orogodo, a freshwater body in Delta State, Southern Nigeria. *Tropical Freshwater Biology* 12(13): 131-136.
9. Stevens ML. 1997. Fundamentals of clinical hematology. Saunders, Philadelphia, (Eds) Hudson I. and Hay C.F. 1991. *Antibody Interaction with Antigen. Practical Immunology*. 3rd Edition. Oxford: Blackwell Scientific Publication. pp 208-260.

10. Katz M. 1950. Some interesting cells in the blood of a diseased silver salmon fingerling. *Copea* 4: 295-298.
11. Martins ML, Tavares-Dias M, Fujimoto RY, Onaka EM, Nomura DT. 2004. Haematological alterations of *Lepomis macrocephalus* (Osteichthyes: Aniskidae) in fish pond. *Arq. Brasileiro Medical and Veterinary Zootenecnia* 56: 640-646.
12. Lofty HS, Mahmoud SM, Abdel-Gawad MA. 2003. Some studies on Fascioliasis in Mid-Egypt. *Agricultural Research* 81(2): 209-227.
13. Del Rio-Zaragoza OB, Fajer-Avila EJ, AlmazÁn-Rueda P. 2010. Haematological and Gill responses to an experimental infection of dactylogyrid monogeneans on the spotted rose snapper *Lutjanus guttatus* (Steindachner, 1869).
14. Shahi N, Yousuf AR, Rather MI, Ahmad F, Yaseen T. 2013. First report of blood parasites in fishes from Kashmir and their effect on the haematological profile. *Open Veterinary Journal* 3(2): 89-95.
15. Hassen FEZM. 2002. Studies on diseases caused by Henneguya infection. *Ph. D. Thesis*, Faculty of Veterinary Medicine Suez Canal University, Egypt 2002.
16. Ismail GAE. 2003. Histopatological and physiological studies on naturally infected catfish, *Clarias gariepinus* with trypanosomes. *M. Sc. Thesis*, Faculty of Science Cairo University, Egypt 2003.
17.Omran HH, El-Kholony KH. 2003. 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* 81(2): 739-751.
18. Lebola SL, Saunders DK, Crawford TG. 2001. Observation on blood viscosity in striped bass, *Morone saxatilis* (Walbaum) associated with fish hatchery condition. *Kansas Academy of Science* 104: 183-184.
19. Selvakumar RA. 1981. Effect of copper, zinc and cadmium on *Therapon jarbua* (Forskal). *Ph. D. Thesis*, Annamalai University, India.
20. Pinky K, Qureshi TA, Rekha S, Susan M, Bilal A. 2012. Histopathological and haematological investigations on *Nandus nandus* (Ham.) parasitized by metacercariae of *Clinostomum complanatum* (Rudolphi, 1819). *International Journal of Environmental Sciences* 2(3): 1324-1330.
21. Silva-Souza AT, Almeida SC, Machado PM. 2000. Effect of the infestation by *Lernaea cyprinacea* Linnaeus, 1758 (Copepoda, Lernaeidae) on the leukocytes of *Schizodon intermedius* Garavello & Britski, 1990 (Osteichthyes, Anostomidae). *Rev. Bras Biol*. 60: 217-220.
22. Tufail H, Qureshi NA, Khan N, Iqbal KJ, Khan MR, Maqbool A. 2017. Prevalence and effects of *Lernaea cyprinaceae* (anchor worm) on the growth, skin histopathology and hematology of *Catla catla. Iran Jr Fish Sci*. 16: 341-351.
23. Sexena KK, Chauhan RRS. 1993. Effect of parasitic infection on the blood of *Heteropneustes fossilis* (Bloch). *Bioved.* 4: 41-43.
24. Correa LL, Karling LC, Takemoto RM, Ceccarelli PS, Ueta MT. 2013. Hematological alterations caused by high intensity of L3 larvae of *Contracaecum* sp Railliet & Henry, 1912 (Nematoda, Anisakidae) in the stomach of *Hoplias malabaricus* in lakes in Pirassununga, São Paulo. *Parasitol Res*. 112: 2783-2789.
25. Tavares-Dias M, Martins ML, do Nascimento Kronka S. 1999. Evaluation of the haematological parameters in *Piaractus mesopotamicus* Holmberg (Osteichthyes, Characidae) with *Argulus* sp. (Crustacea, Branchiura) infestation and treatment with organophosphate. *Rev. Bras. Zoology* 16: 553-555.
26. Nagasawa T, Nakayasu C, Rieger AM, Barreda DR, Somamoto T, Nakao M. 2014. Phagocytosis by thrombocytes is a conserved innate immune mechanism in lower vertebrates. *Front Immunology* 5: 445.
27. Mahajan CL, Agrawal NK, John MJ, Katta VP. 1979. Effect of the digenean *Isoparorchis hypselobagri* (Billet, 1898) on an air breathing fish *Channa punctatus* (Bloch) with particular reference to biochemical and haematological changes. *Jr. Fish Dis.* 2: 519-528.
28. Pickering AD. 1986. Changes in blood cell composition of the brown trout, *Salmo trutta* L., during the spawning season. *Jr. Fish Biology* 29: 335-347.