INT. J. BIOL. BIOTECH., 2 (3): 659-666, 2005.

IMPACTS OF WATER QUALITY ON GROWTH, CONDITION FACTOR AND HAEMATOLOGICAL PARAMETERS OF *OREOCHROMIS MOSSAMBICUS*

Farida Bano, S. Nazneen, M. A. Hussain and Karim Gabol*

Department of Zoology, University of Karachi, Karachi-75270, Pakistan

ABSTRACT

The present study indicates the quality of water impacts both on the growth as well as on the haematological parameters of *Oreochromis mossambicus* as the maximum number of RBC, WBC and Hb concentration were recorded in the fishes which are captured from spot 3, comparatively has less dissolved oxygen, minimum numbers of RBC, WBC and Hb in spot 1. Those water bodies, which have higher oxygen contents, show better growth of fishes.

Keywords: *Oreochromis mossambicus*, condition factor; water quality, water bodies, haematology.

INTRODUCTION

Oreochromis mossambicus (Peters, 1852) is the second most commonly cultured fish in the world (US Dept. Agriculture, APHIS, 1995). However it is originally indigenous to African countries (Farooq *et al.*, 1976), but now it wedged its way in most of the tropical countries due to its high reproductive potential. This fish shows great diversity in feeding habits (Neil, 1966; Bruton and Bolt, 1975; Bowen, 1979; Treweas, 1983; Desilva *et al.*, 1984) and high tolerance for environmental conditions ranging from in fresh waters to highly saline waters (Brock, 1954; Courtney *et al.*, 1974; Dail and Wainright, 1983). Many scientists of different parts of the world have studied various aspects of this species including haematological parameters (Blaxhall,, 1972; Blaxhall and Daisley, 1973; Schalm, 1975; Wedemyer and Yasutake, 1977; Koundinya and Ratnalnurthi, 1979; Doggett *et al.*, 1987; Baniffa and Vijayarani, 1989; Cyriac *et al.*, 1989; Doggett and Harris, 1989; Sampath *et al.*, 1993).

In Pakistan, this species has been introduced in 1951 (Ali, 1999). Now it is found in all warm water of Pakistan and its extensive growth in the fresh water bodies of Sindh and affecting the distribution of other commercially exploitable fishes. Its feeding habits, biology and salinity tolerance have also been observed in Pakistan by various researchers (Beg, 1901; Doha and Haque, 1966; Niak, 1971; Bari and Nazneen, 1984; Aziz *et al.*, 1993).

However nothing has been reported regarding hematology of this fish. In the present study the biological parameters of growth (i.e. length, weight and condition factors) were studied along with hematological parameters to study the impact of water quality on the growth and health of this fish.

Monitoring of fish blood is now considered as the very important diagnostic tool in establishing the health status of fish, (Ithaca, 2000). Blood act as a mediull1 to deliver essential nutrients throughout the body of animal and removes metabolic wastes and pathogens fron1 the body. The chemical composition of fish blood is similar to higher vertebrates, (Thorson, 1958; Satchell, 1971; Tort *et al.*, 1991; Olson, 1992; McCarthy and Conte, 1996).

MATERIALS AND METHODS

For this study specimens of *Oreochromis mossambicus* were collected from four different aquatic water bodies including a fish pond of Gharo, District Thatta (spot 1), Haleji lake, District Thatta (spot 2), Safari park lake, Karachi (spot 3) and Dr. Saleem-uz-Zamman park pond, Karachi (spot 4).

Some physico-chemical parameters of water i.e., water temperature, pH, dissolved oxygen were measured in the field. Samples of blood for haematological analyses were also obtained just after the collection of specimens. Temperature and pH of water was recorded, dissolved oxygen contents were analyzed by Wrinkler's method (Welch, 1952). Blood samples were collected from cardiac puncture techniques as described by Dacies (1963). Dacies fluid was used as a diluting solution and enumeration of erythrocytes and leucocytes was done with the help of Neubauer haemocytometer. The number of erythrocytes and leucocytes were calculated by the given formula proposed by Dacies (1963).

Formula for RBC counts

Number of erythrocytes cells occurring in 0.02 mm3 x 50 (area counted) x 100 (Dilution).

*Corresponding author

Formula for WBC counts

Number of leucocytes cells occurring in 0.1 mm3 x 10 (area counted) x 100 (Dilution). Haemoglobin concentrations were measured of Cynornethoglobin method (Siglna Chemicals Co.). The condition factor was determined by the given formula as referred by Bagenal (1978).

Formula for condition factor

$$K = \frac{100 \times W}{L^3}$$

Where,
K= Condition Factor of fish
W= Weight of fish
L= Length of fish

Statistical analysis

The statistical analysis, including standard deviation, coefficient of variation, standard error, and 95% confidence limit were measured by ANOVA one-way, Coefficient of correlation between the physico-chemical parameters of water, haematological parameters and growth variables (length, weight and condition factor) of *O. mossambicus* were determined by MS Excel, 2000.

RESULTS

A. Variations in biological parameters of growth

Condition factor (K)

Condition factor ranged between 1.543-1.816 .The higher condition factor value (1.816) was observed at spot 1 and the lowest condition factor value (1.543) was observed at spot 3. (Table 13).

B. Variations in physico-chemical parameters of water

1. Water Temperature (Celsius)

Water temperature ranged between 27 to 28 (Celsius). The maximum temperature 28 (Celsius) was observed at spot 3, and the minimum temperature was observed at spot 1 (Table 9).

2. Hydrogen ion concentration (pH)

The pH of water samples ranged between 7.4 to 7.8. The highest value of pH was recorded only in the samples of spot 3, and the minimum pH value was observed at spot 1. Data indicates slight variation in pH at spot 1 to 4 (Table 9).

3. Dissolved oxygen (mg/I)

The dissolved oxygen samples ranged between 7.08-9.06 mg/l. The highest dissolved oxygen value 9.25 mg/l was observed at spot 1 while the lowest value of dissolved oxygen 7.08 mg/l was found at spot 3. Data show remarkable changes in dissolved oxygen level among the selected water bodies (Table 9).

Table 1. Variations in length, weight and condition factor of *Oreochromis mossambicus* at spot 1.

Fish code	Length of fish (cm)	Weight of fish (g)	Condition factor (K)
F-1	22.8	204.53	1.72
F-2	22.3	196.33	1.77
F-3	22.7	221.54	1.89
F-4	22.5	212.35	1.86
F-5	22.3	197.21	1.77
F-6	22.4	201.92	1.79
F-7	22.9	229.14	1.90
F-8	23.4	235.17	1.83
F-9	22.9	213.14	1.77
F-10	23.2	233.17	1.86

Table 2. Variations in length, weight and condition factor of *Oreochromis mossambicus* at spot 2.

Fish code	Length of fish (cm)	Weight of fish (g)	Condition factor (K)
F-1	22.9	231.10	1.92
F-2	22.2	190.30	1.73
F-3	22.3	191.35	1.72
F-4	22.1	185.47	1.71
F-5	22.9	230.78	1.92
F-6	22.7	192.38	1.64
F-7	22.7	199.30	1.70
F-8	23.4	235.17	1.83
F-9	22.6	200.45	1.73
F-10	22.3	196.33	1.77

Table 3. Variations in length, weight and condition factor of *Oreochromis mossambicus* at spot 3.

Fish code	Length of fish (cm)	Weight of fish (g)	Condition factor (K)
F-1	22.1	190.30	1.73
F-2	22.3	191.33	1.72
F-3	23.8	198.31	1.47
F-4	23.5	177.50	1.36
F-5	23.0	188.67	1.55
F-6	22.5	169.97	1.49
F-7	22.7	192.38	1.64
F-8	24.0	211.86	1.53
F-9	22.8	170.32	1.43
F-10	22.3	168.41	1.51

VARIATIONS IN HAEMATOLOGICAL PARAMETERS

1. Erythrocytes cells (RBC)

Erythrocyte ranged between 1.560 to 2.255 million/μl. The higher number of erythrocytes counts were found as 2.255 million/μl at spots 3 and 4 (Table 7,8), while the minimum erythrocyte counts were noticed 1.560 million/μl in the samples of spot 1 (Table 5).

Table 4. Variations in length, weight and condition factor of *Oreochromis mossambicus* at spot 4.

Fish code	Length of fish (cm)	Weight of fish (g)	Condition factor (K)
F-1	22.3	167.37	1.50
F-2	23.5	185.63	1.43
F-3	23.8	198.31	1.47
F-4	22.7	195.32	1.66
F-5	21.6	162.98	1.61
F-6	22.5	169.97	1.49
F-7	23.7	196.50	1.47
F-8	23.0	119.30	1.63
F-9	22.8	201.35	1.69
F-10	24.0	211.86	1.53

Table 5. Variations in haematological parameters of *Oreochromis mossambicus* at spot 1.

Fish code	Red blood cell (million/μl)	Total leukocyte count (thousand/μl)	Haemoglobin (gm/dl)
F-1	1.580	201.0	4.4
F-2	1.675	209.0	4.6
F-3	1.675	207.0	4.1
F-4	1.945	211.0	4.7
F-5	1.560	217.0	4.5
F-6	1.835	204.0	3.8
F-7	1.715	213.0	3.7
F-8	1.605	232.0	4.3
F-9	1.595	221.0	4.6
F-10	1.685	208.0	4.2

Table 6. Variations in haematological parameters of *Oreochromis mossambicus* at spot 2.

Fish code	Red blood cell (million/μl)	Total leukocyte count (thousand/μl)	Haemoglobin (gm/dl)
F-1	1.675	209.0	4.8
F-2	1.945	235.0	4.9
F-3	1.835	216.0	4.2
F-4	1.710	251.0	4.6
F-5	1.615	242.0	4.9
F-6	1.870	247.0	5.3
F-7	1.990	223.0	5.1
F-8	1.755	228.0	4.7
F-9	1.640	219.0	4.4
F-10	1.930	232.0	4.6

Table 7. Variations in haematological parameters of *Oreochromis mossambicus* at spot 3.

Fish code	Red blood cell (million/μl)	Total leukocyte count (thousand/μl)	Haemoglobin (gm/dl)
F-1	1.920	267.0	6.7
F-2	2.060	265.0	6.2
F-3	1.970	257.0	6.5
F-4	1.185	270.0	6.7
F-5	2.040	249.0	6.6
F-6	2.130	252.0	6.2
F-7	1.985	248.0	5.9
F-8	2.155	263.0	6.3
F-9	2.255	241.0	6.1
F-10	2.015	264.0	6.4

2. Leucocytes cells (WBC)

The leucocytes ranged between 201.0 to 270.0 Thousand/μl. The highest value of leucocytes were recorded as 270.0 Thousand/μl in the samples of spots 3 and 4, (Table 7, 8) while the minimum leucocytes was recorded as 201.0 Thousand/μl in the samples of spot 1 (Table 5).

Table 8. Variations in haematological parameters of *Oreochromis mossambicus* at spot 4.

Fish code	Red blood cell (million/μl)	Total leukocyte count (thousand/μl)	Haemoglobin (gm/dl)
F-1	1.920	267.0	6.2
F-2	1.970	248.0	6.5
F-3	2.255	241.0	6.1
F-4	2.155	270.0	6.4
F-5	1.945	211.0	5.7
F-6	1.985	223.0	5.9
F-7	1.870	265.0	5.3
F-8	1.930	232.0	6.4
F-9	1.835	204.0	6.5
F-10	2.185	257.0	6.6

Table 9. Variations in water temperature, pH and dissolved oxygen of water at spot 1-4.

Name of parameters	Spot 1	Spot 2	Spot 3	Spot 4
PH	7.4	7.6	7.8	7.8
Temperature	27.0	27.0	28.0	28.0
Dissolved oxygen	9.06	8.21	7.08	7.93

3. Haemoglobin (Hb)

The haemoglobin concentrations were found between 3.7 to 6.7 g/dl. The maximum value of haemoglobin was recorded as 6.7 g/dl in the samples of spot 3 (Table 7). The minimum haemoglobin was recorded as 3.7 g/dl in the samples of spot 1 (Table 5).

DISCUSSION

All fish tissues require a delivery of nutrients (including oxygen) to function properly. The circulatory system, with blood as its medium, delivers these essential nutrients throughout the body and removes metabolic wastes and pathogens before they reached at harmful concentrations. Due to this water quality is one of the major factor responsible for individual variations in fish haematology.

It is now evident from the data of several studies that values of haematological parameters "number of blood cells and haemoglobin levels" are very important to evaluate the physiological state and health problems of fishes with in a water body due to their close association with slight environmental changes (Cassilas and Smith, 1977).

Table 10. Statistical analysis of erythrocytes (million/μl) of *Oreochromis mossambicus* at spot 1-4.

Name of parameters	Spot 1	Spot 2	Spot 3	Spot 4
Average	1.688	1.7965	2.0715	2.005
Standard deviation	0.121	0.135	0.106	0.142
Coefficient of variance	7.184	7.550	5.139	7.104
Standard error	0.038	0.042	0.033	0.045
95% Confidence upper limit and lower limit	1.774 – 1.601	1.893 – 1.699	2.147 – 1.995	2.106 – 1.903

Table 11. Statistical analysis of leucocytes (thousand/μl) of *Oreochromis mossambicus* at spot 1-4.

Name of parameters	Spot 1	Spot 2	Spot 3	Spot 4
Average	212.3	230.2	257.6	241.8
Standard deviation	9.080	13.798	9.663	23.724
Coefficient of variance	4.277	5.994	3.751	9.811
Standard error	2.871	4.363	3.055	7.502
95% Confidence upper limit and lower limit	218.795 – 205.804	240.070 – 220.329	264.512 – 250.687	258.770 – 224.829

Table 12. Statistical analysis of haemoglobin levels (gm/dl) of *Oreochromis mossambicus* at spot 1-4.

Name of parameters	Spot 1	Spot 2	Spot 3	Spot 4
Average	4.311	4.75	6.36	6.16
Standard deviation	0.355	0.324	0.267	0.416
Coefficient of variance	8.237	6.821	4.20[illegible]	6.767
Standard error	0.112	0.102	0.084	0.131
95% Confidence upper limit and lower limit	4.565 – 4.057	4.981 – 4.518	6.551 – 6.168	6.458 – 5.861

Table 13. Statistical analysis of condition factor (K) of *Oreochromis mossambicus* at spot 1-4.

Name of parameters	Spot 1	Spot 2	Spot 3	Spot 4
Average	1.816	1.767	1.543	1.548
Standard deviation	0.060	0.094	0.120	0.091
Coefficient of variance	3.326	5.322	7.831	5.911
Standard error	0.019	0.029	0.038	0.028
95% Confidence upper limit and lower limit	1.859 – 1.772	1.834 – 1.699	1.629 – 1.456	1.613 – 1.482

Data of the present study also shows that numbers of blood cells (both erythrocytes and leucocytes) and haemoglobin vary in the specimens of fishes captured from different water bodies. Higher number of RBCs were recorded in the specimens which were caught from the Safari park lake (Karachi, spot 3) containing comparatively less oxygen contents while numbers of these cells were comparatively lowest in the specimens which were obtained from a fish pond of Gharo (District Thatta, spot 1) containing higher concentrations of dissolved oxygen. However the number of blood cells and haemoglobin levels were almost similar in the blood of fishes, which were captured, from Haleji lake (District Thatta, spot, 2) and Dr. Saleem-uz-Zamman park pond (Karachi, spot 4). Both these water bodies contain similar oxygen levels ranges from 7.6 to 8.3 mg/l.

According to Moyle arid Cesh (2000) in fishes demands of oxygen vary with the environmental conditions and the number of blood cells per milliliter varies due to balancing the energy costs of erythrocytes production with those of pumping blood to the tissues. Blood with low erythrocytic concentration obviously has to be pumped through the body at a greater rate than blood with higher erythrocytic concentration, if the oxygen demand is high.

Cameran (1975) has reported that a teleost heart requires 4.4% of the total energy of fish so the erythrocytic concentration can have a significant effect on the over all energy balance, including growth (Cameran and Davis, 1970).

Present study also supports this observation as the lowest condition indices and growth rates were observed in specimens, which had higher number of RBCs.

Besides, oxygen contents, water temperature and pH also affect on the concentration of blood cells (Ram and Srinivasa, 1989; Hrubec *et al.*, 1997). It has been observed that when water temperature is low and the fish is not

very active, large numbers of erythrocytes are not required to fulfill the oxygen demands of tissues. Like temperature, pH of the water also influence on the oxygen demands of tissues, which ultimately affects on the erythrocytic concentration. However, in the present study no direct effect of variations of temperature and pH was noticed due to their low magnitude of fluctuations. Statistical analyses of data also support these observations.

REFERENCES

Ahmed, M.F., S.A. Khan and M.R. Mirza (1976). A checklist of the fresh water fishes of Indus plain, Pakistan. *Biologia*, 22: 229-259

Ali, E., Amin M. and A.R. Shakoori (1993). Toxic effects of cadmium chloride on the haematology of fish *Tilapia mossambica. Proc. Pakistan Congr. Zool.*, 13: 141-154.

Ali, S. S. (1999). *Fresh Water Fishery Riology*. 41.

Bari, G.A. and S. Nazneen (1984). Biological studies on the fresh waters 6f Pakistan. Correlation of the alimentary canal structure of some fishes of Haleji Lake with their herbivorous, nature of feeding. *Pak. J. Sci. Ind. Res.*, 27: 29-32.

Beg, A. (1961). Investigations on the food and feeding habits of *Tilapia mossambica. Proc. Conf. Fish of West Pakistan*, 139-141.

Bagenal, T.B. (1978). *Aspects of fish fecundity. In ecology of fresh water fish production*. 75-101, Shelby D. Gerking. Blackwell Scientific Publication. Oxford. 519.

Blaxhall, P.C. (1972). The haematological assessment of the health of freshwater fish. *J. Fish Biology*, 4: 593-605.

Blaxhall, P.C. and K.W. Daisley (1973). Routine haematological methods for use with fish blood. *J. Fish Biology*, 5: 771-781.

Bowen, S.H. (1979). A nutritional constraint in detritivory by fishes: The stunted population of *Sarotherodon mossambicus* in Lake Sibaya, South Africa. Ecological Monographs, 17-31.

Brock, V.E. (1954). A note on the spawning of *Tilapia mossambica* in sea water. *Copeia*, 1: 72.

Bruton, M.N. and R.E. Boltt (1975). Aspects of the biology of *Tilapia mossambica* Peters (Pisces: Cichlidae) in a natural freshwater lake (Lake Sibaya, South Africa). *J. Fish Biology*, 7: 701-715.

Cameron, J.N. and J.C. Davis (1970). Gas exchange in rainbow trout (*Salmo gairdnen*) with varying blood oxygen capacity. *T. Fish Res. Bd. Canada*, 27: 1069-1085.

Cameron, J.N. (1975). Morphometric and flow indicator studies of the teleost heart. *Can. J. Zool.*, 53: 691-698.

Casillas, E. and L.S. Smith (1977). Effect of stress on blood coagulation and haematology in rainbow trout *(Salmo gairdnen). J. Fish Biology*, 10: 481-491.

Centers for Epidemiology and Animal Health. (1995) *Orerriew of Aquaculture in the United State*. Fort Collins, Colo: US Dept. Agriculture, APHIS.

Courtney, W.R., Jr., H.F. Sahlman and W.W. Miley (1974). Exotic fishes in fresh and brackish waters of Florida. *Biological Conservation*, 6: 292-302.

Cyriac, P.J., A. Antony and P.N.K. Nambisan (1989). Heamoglobin and haematocrit values in the fish *Oreochromis mossambicus* (Peters) after short-term exposure to copper and mercury. *Bull. Environ. Contamination and Toxieol.*, 43: 315- 320.

Dacie, J.V. and S.M. Lewis (1963). *Practical Haematology*: 435. J. & A. Churchill, London.

De Silva, S.S., M.K. Perera and P. Maitipe (1984). The composition of nutritional status and digestibility of the diets of *Sarotherodon mossambicus* (Trewevas, 1983) from nine man-made lakes in Sri Lanka. *Environmental Biology of Fishes*, 11: 205-219.

Dial, R.S. and S.C. Wainright (1983). New distributional records for non-native fishes in Florida. *Florida Scientist*, 46: 8-15.

Doggett, T.A., A.B. Wrathmell and J.E.A. Harris (1987). Cytochemical and light microscopical study of the peripheral blood leucocytes of *Oreochromis mossambicus Cichlidae. J. Fish Biol.*, 31: 147-153.

Doggett, T.A. and J.E. Harris (1989). Ultrastructure of the peripheral blood leucocytes of *Oreochromis mossambicus. J. Fish Biol.*, 33: 747-756.

Doha, S. and A. Haque (1966). Studies on the biology of *Tilapia mossambica* (Peters-1). The food and feeding habits. *Pakistan J. Sci. Ind. Res.*, 18 : 205-215.

Haniffa M.A. and S.M. Vijayarani (1989). Haematological effects of textile mill effluent on freshwater fish *Oreochromis mossambicus* (Trewayes). *Ind. J Exp. Biol.*, 27: 476-478.

Hrubec, T.C., J.L. Robertson and S.A. Smith (1997). Effects of temperature on haematologic and serum biochemical profiles of hybrid striped bass (*Morone chrysops* X *Morone saxatilis*). *Am. J. Vet. Res.*, 58: 126-130.

Koundinya, P.R. and R. Ramamurthi (1979). Haematological studies in *Tilapia massambica*(Peters, 1852) exposed

to lethal concentration of sumithion and Sevin. *Curro Sci.*, 48: 877-879.
Moyle, P.B. and J.J. Cech, Jr. (2000). *Fishes, An introduction to ichthyology*, 4th ed. USA, 30.
Nazneen, S. and F. Begum (1981). Salinity tolerance in some fresh water fishes. *Biologia* (Pakistan), 27: 33-38.
Nazneen, S. and F. Begum (1985). Effect of various diet on the growth of Tilapia fish Pakistan. *J. Agric. Res.*, 6: 131-133.
Nazneen, S. and F. Begum (1993b). A study of the food habits of fishes of the Hub River, Baluchistan. *Philippine J. Sci.*, 122: 179-191.
Neil, E.H. (1966). Observations on the behavior of *Tilapia mossambica* (Pisces, Cichilidae) in Hawaiian ponds. *Copeia*, 1 : 50-56.
Niak, 1.U. (1971). Tilapia and its culture in saline area. *Agric. Pakistan*, 22: 81-91.
Ram-Bhaskar, B. and K. Srinivasa-Rao (1989). Influence of environmental variables on haematology, and campendium of normal haematological ranges of milk fish, *Chanos chanos* (Forskal) in brackish culture. *Aquaculture*, 83: 123-136.
Sampath, K., S. Velammal, I. J. Kennedy, R. and James (1993). Haematological changes and their recovery in *Oreochromis mossambicus* (Peters, 1852) as a function of exposure period and sublethal levels of Ekalux. *Acta Hydrobiol.*, 35: 73-83 .
Schalm, O.W., N.C. Jain and E.J. Carrol (1975). *Veterinary Haematology*. 3rd ed. Philadelphia, Lea and Febinger, 45-47.
Trewevas, E. (1983). *Tilapiine fishes of the Genera Sarotherodon, Oreochromis and Danakilia.* British Museum of Natural History, Publ. Num. 878. Comstock Publishing Associates. Ithaca, New York. 583.
Wedemeyer, C.A. and W.T. Yasutake (1977). Clinical methods for the assessment of the effects of environn1ental stress on fish health. *United States Technical Papers and United Sates Fish Wildlife Services.* 89: 1-18.

(*Accepted for publication June 2005*)