International Journal of Fisheries and Aquatic Studies 2015; 3(2): 50-54

ISSN: 2347-5129
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.352
IJFAS 2015; 3(2): 50-54

www.fisheriesjournal.com
Received: 25-08-2015
Accepted: 29-09-2015

R Sripriya
P.G. and Research Department of Zoology and Biotechnology, A.V.V.M. Sri Pushpam college (Autonomous), Poondi, 613 503, Thanjavur Dt. Tamil Nadu, India.

K Kumar
P.G. and Research Department of Zoology and Biotechnology, A.V.V.M. Sri Pushpam college (Autonomous), Poondi, 613 503, Thanjavur Dt. Tamil Nadu, India.

K Rajendran
P.G. and Research Department of Zoology and Biotechnology, A.V.V.M. Sri Pushpam college (Autonomous), Poondi, 613 503, Thanjavur Dt. Tamil Nadu, India.

Correspondence
R Sripriya
P.G. and Research Department of Zoology and Biotechnology, A.V.V.M. Sri Pushpam college (Autonomous), Poondi, 613 503, Thanjavur Dt. Tamil Nadu, India.

Seasonal Variation of Serum Enzymes of Indian Freshwater Eel *Anguila bicolor* (Mcclelanand)

R Sripriya, K Kumar, K Rajendran

Abstract
Serum enzymes are important aspects in the management of live species such as *Anguilla bicolor*. The objective of this survey was to discuss the serum enzyme. From this investigation the acid phosphatase of *A. bicolor* showed a slight seasonal fluctuation, the ACP was found maximum value (5.66 ± 0.49 IU/L) was obtained in summer 2011 and minimum value (3.9 ± 0.32 IU/L) in monsoon 2010; ALP, it was found high (150.56 ± 1.58 IU/L) in post monsoon 2011 and low (107.4 ± 1.32 IU/L) in premonsoon 2011; SGOT the minimum values (23.51 IU/L) was obtained in postmonsoon 2010 and maximum (31.51 IU/L) in summer 2011; SGPT showed a slightly the highest value (33.6 ± 1.21 IU/L) was recorded in monsoon 2010 and lowest value (23.9 ± 1.01 IU/L) in summer 2010; LDH was found to be higher value (77.7 ± 1.58 IU/L) was recorded in summer 2010 and lowest value (61.2 ± 1.31 IU/L) in monsoon 2010 was marked seasonal variations during the two years of the study period. Hence, the present study suggested that this fish are important sources and good for human health.

Keywords: *Anguilla bicolor,* ACP, ALP, SGOT, LDH, SGPT

1. Introduction
The eels are considered as a luxury food and consumed as a delicacy in several Asian and European countries. The Japanese eel, *Anguilla japonica* is cultured commercially in Japan, Taiwan, and South Korea and the European eel, *Anguilla anguilla* in Italy, Denmark, West Germany, France and Holland. Like all living species, fish too need nutritious food. There are a number of varieties of fish food available in the stores today. The feeding of fish and their nutrition is one of the most important factors in keeping them healthy. The study on enzyme characteristics with reference to acid and alkaline phosphatase, SGPT, SGOT and LDH, in fishes have been extensively studied by many workers (Begum, 2005; Winkaler *et al.*, 2007; Mandal *et al.*, 2010 and Kumar *et al.*, 2012) [2, 35, 15, 11]. It is invariably observed that the enzyme activities of fishes increased with fish size and diet (Srivastava *et al.*, 1989; Lamaire *et al.*, 1991; Roostacian, 1993; Machala *et al.*, 1997; Sarower *et al.*, 2012) [34, 12, 22, 13, 25]. Enzyme activity was found to be more or less when good quality of water is maintained in aquaculture practice (Sidik *et al.*, 1990; Medda *et al.*, 1995; Sripriya *et al.*, 2012a) [29, 16, 32]. Effect of physico-chemical parameters and seasonal variation on enzyme activities of fishes have also been reported (Singh and Srivastava, 1999; Gabriel *et al.*, 2012) [30, 7]. Acute and chronic effect of toxicans on enzyme activity of various fish species *Channa punctatus* (Sastry and Malik, 1981) [26] *Channa striatus* (Sadhu *et al.*, 1985) [24] *Labeo rohita* (Rajan, 1990) [21] *Sarotherodon mossambicus* (Ruparelia *et al.*, 1992 and Shaikila *et al.*, 1993) [23, 27] *Clarias gariepinus* (Ogueji Okechukwu and Auta, 2007) [17] have been documented.
Activity of LDH in the brain and liver of *Labeo rohita* have been studied (Das and Kukherjee, 2002) [4]. Kapila *et al.* (2002) [9] studied the impact of temperature variation on serum enzyme of *Sehizotherus vicharelsonii*. Activity of acid and alkaline phosphatase in fresh water fish *Cirrhinus mrigala* have been reported (Das *et al.*, 2004) [6] Atef (2005) [1] observed ALP activity in freshwater fish *Oreochromis niloticus* exposed to cadmium. Activity of phosphatase in air breathing catfish *Mystus cavasius* have been studied (Palanisamy *et al.*, 2012) [18]. Magar and Afsar Shaikh (2013) [14] reported effect of Malathion on acid phosphatase activity of fish *Channa punctatus.* Though, information is available on haematology and enzymes of fishes all over the world, the works pertaining to seasonal changes in haematology, haematocrite and enzymes of eel fishes is meagre. Hence the present investigation is aimed to study the enzymes of fish *Anguila bicolor*.

2. Materials and Methods
The freshwater eel fish *Anguilla bicolor* were collected from the freshwater bodies of river Cauvery at Lower Anaicut, Tiruchirappalli, Tamil Nadu, India. They were acclimatized to laboratory condition under the normal temperature for 27±2 ^{0}C in a plastic container containing with sufficient fresh water, so that fishes are submerged. The blood sample were drawn by cardiac puncture using 21 gauge hypodermic needle without EDTA to allowing the clot and serum was separate for studying some enzymatic study. The Acid phosphatase (ACP), Alkaline phosphate (ALP), lactate dehydrogenase (LDH), Serum glutamate acetate transaminase (SGOT), Serum glutamate pyruvate transaminase (SGPT) were estimated by the method of King (1965). The data were analysed statistically and presented in standard manner.

3. Results
3.1 Acid Phosphatase
In the present study, the acid phosphatase in the blood of *A. bicolor* showed a slight seasonal fluctuation. It ranged from 3.7 ± 0.28 to 6.0 ± 0.54 IU/L in 2010 and 3.8 ± 0.34 to 6.1 ± 6.58 IU/L in the year 2011. If was found to be maximum (6.0 ± 0.54 IU/L) in June 2010 and minimum (3.7 ± 0.28 IU/L) in November 2010. The higher value (6.01 ± 0.58 IU/L) was recorded in May 2011 and lower value (3.8 ± 0.34 IU/L) in November 2011(Table 1). The maximum value (5.66 ± 0.49 IU/L) was obtained in summer 2011 and minimum value (3.9 ± 0.32 IU/L) in monsoon 2010 (Table 2).

3.2 Alkaline phosphatase
The alkaline phosphate in the blood of freshwater eel *Anguilla bicolor* showed significant fluctuation. It varied from 98.6 ± 1.24 to 152.1 ± 1.63 IU/L in the year 2010 and 101.8 ± 1.25 to 154.7 ± 1.68 IU/L in 2011. It was found to be low (98.6 ± 1.24 IU/L) in August 2010 and high (152.1 ± 1.68 IU/L) in January 2010. The maximum value (134.7 ± 1.68 IU/L) was recorded in February 2011 and minimum value (101.8 ± 1.25 IU/L) in July 2011 (Table 1). It was found to be high (150.56 ± 1.58 IU/L) in post monsoon 2011 and low (107.4 ± 1.32 IU/L) in premonsoon 2011 (Table 2)

3.3 Serum glutamate oxaloacetate transaminase (SGOT)
In the present study in serum glutamate oxaloacetate transaminase in the blood of *A. bicolor* showed a slight variation. It ranged from 20.7 ± 0.78 to 33.8 ± 1.02 IU/L in the year 2010 and 21.2 ± 0.68 to 32.8 ± 1.28 IU/L in 2011. The maximum value (33.8 ± 1.02 IU/L) was recorded in June 2010 and minimum value (20.7 ± 0.78 IU/L) in December 2010. It was found to be low (21.2 ± 0.68 IU/L) in November 2011 and high (32.8 ± 1.28 IU/L) in April 2011 (Table 1). The minimum (23.51 IU/L) was obtained in postmonsoon 2010 and maximum (31.51 IU/L) in summer 2011 (Table 2).

3.4 Serum glutamate pyruvate transaminase (SGPT)
In the present study serum glutamating pyruvate transaminase in *A. bicolor* showed a slight seasonal variation. It varied from 23.3 ± 0.85 to 34.6 ± 1.23 IU/L in the year 2010 and 23.9 ± 0.96 to 33.9 ± 1.41 IU/L in 2011. It was found to be low (23.3 ± 0.85 IU/L) in April 2010 and high (3.46 ± 1.23 IU/L) in November 2010. The maximum value (33.9 ± 1.41 IU/L) was recorded in December 2011 and minimum value (23.8 ± 0.96 IU/L) in May 2011 (Table 1). The highest value (33.6 ± 1.21 IU/L) was recorded in monsoon 2010 and lowest value (23.9 ± 1.01 IU/L) in summer 2010 (Table 2).

3.5 Lactate dehydrogenase (LDH)
In the present study enzyme lactate dehydrogenase showed a slight seasonal variation. It ranged from 59.8 ± 1.43 to 75.1 ± 1.56 IU/L in the year 2010 and 60.5 ± 1.44 to 74.3 ± 1.59 IU/L in 2011. The maximum value (75.1 ± 1.56 IU/L) was recorded in July 2010 and minimum value (59.8 ± 1.43 IU/L) in January 2010. It was found to the low (60.5 ± 1.44 IU/L) in January 2011 and high (74.3 ± 1.59 IU/L) in June 2011 (Table 1). The higher value (77.7 ± 1.58 IU/L) was recorded in summer 2010 and lowest value (61.2 ± 1.31 IU/L) in monsoon 2010 (Table 2).

Table 1: Serum enzymatic values of freshwater eel *A. bicolor* from January 2010 to December 2011

Month and Year	Acid phosphatase (IU/L)	Alkaline phosphatase (IU/L)	SGOT (IU/L)	SGPT (IU/L)	LDH (IU/L)
Jan. 2010	3.8 ± 0.47	152.1 ± 1.63	21.9 ± 0.78	27.2 ± 1.04	59.8 ± 1.43
Feb. 2010	3.9 ± 0.61	135.6 ± 1.42	23.6 ± 0.84	25.1 ± 0.92	63.4 ± 1.68
March 2010	5.4 ± 0.43	127.3 ± 1.38	25.2 ± 0.93	26.4 ± 0.96	67.9 ± 1.62
April 2010	5.5 ± 0.48	121.8 ± 1.19	27.4 ± 0.95	23.3 ± 0.85	71.5 ± 1.59
May 2010	5.7 ± 0.54	120.2 ± 1.26	30.6 ± 0.88	24.5 ± 1.21	70.3 ± 1.47
June 2010	5.0 ± 0.52	108.9 ± 1.14	33.8 ± 1.02	24.1 ± 0.98	73.4 ± 1.66
July 2010	5.5 ± 0.39	105.3 ± 1.35	32.5 ± 1.05	27.7 ± 1.18	75.1 ± 1.56
August 2010	4.9 ± 0.49	98.6 ± 1.24	31.1 ± 1.14	31.4 ± 1.27	69.6 ± 1.48
Sep. 2010	4.3 ± 0.45	118.3 ± 1.39	29.6 ± 0.99	31.8 ± 1.45	65.1 ± 1.53
Oct. 2010	4.2 ± 0.37	127.6 ± 1.48	24.8 ± 0.91	32.9 ± 1.08	60.7 ± 1.36
Nov. 2010	3.7 ± 0.28	135.4 ± 1.47	21.3 ± 0.87	34.6 ± 1.23	61.8 ± 1.25
Dec. 2010	3.8 ± 0.31	149.1 ± 1.42	20.7 ± 0.78	33.5 ± 1.34	61.2 ± 1.32
Jan. 2011	4.0 ± 0.45	151.8 ± 1.65	22.4 ± 0.79	28.9 ± 1.13	60.5 ± 1.44
Feb. 2011	4.1 ± 0.45	154.7 ± 1.68	24.6 ± 0.93	28.3 ± 1.25	64.2 ± 1.48
March 2011	5.6 ± 0.49	145.2 ± 1.46	24.9 ± 0.99	25.6 ± 1.37	64.8 ± 1.51
April 2011	5.5 ± 0.52	119.5 ± 1.29	32.8 ± 1.28	25.8 ± 1.28	69.1 ± 1.66
May 2011	6.1 ± 0.58	109.7 ± 1.17	31.5 ± 1.15	23.8 ± 0.96	70.5 ± 1.62
June 2011	5.4 ± 0.37	108.6 ± 1.34	30.4 ± 1.02	24.7 ± 0.87	74.3 ± 1.59
July 2011	4.9 ± 0.35	101.8 ± 1.25	31.3 ± 0.97	26.1 ± 0.99	73.8 ± 1.57
August 2011	5.2 ± 0.49	113.4 ± 1.47	32.4 ± 1.19	29.4 ± 1.18	72.4 ± 1.45
Sep. 2011	4.6 ± 0.51	129.3 ± 1.36	27.8 ± 1.18	30.6 ± 1.09	68.3 ± 1.54
Oct. 2011	4.3 ± 0.44	141 ± 1.53	22.9 ± 0.99	29.8 ± 1.26	63.6 ± 1.36
Nov. 2011	3.9 ± 0.36	150.6 ± 1.61	21.2 ± 0.68	32.3 ± 1.34	62.9 ± 1.48
Dec. 2011	3.8 ± 0.34	151.7 ± 1.48	21.7 ± 0.74	33.9 ± 1.41	62.5 ± 1.37

Table 2: Seasonal variation of serum enzymes in freshwater eel *A. bicolor* from Lower Anaicut during 2010-2011

Season and year	Acid phosphatase (IU/L)	Alkaline phosphatase (IU/L)	SGOT (IU/L)	SGPT (IU/L)	LDH (IU/L)
Post monsoon (Jan., Feb., March 2010)	4.36 ± 0.50	138.3 ± 1.47	23.5 ± 0.85	26.2 ± 0.97	63.6 ± 1.57
Summer (April, May, June 2010)	5.4 ± 0.51	116.9 ± 1.19	30.6 ± 0.95	23.9 ± 1.01	77.7 ± 1.58
Pre monsoon (July, Aug., Sept. 2010)	4.9 ± 0.44	107.4 ± 1.32	31.0 ± 1.06	30.3 ± 1.3	69.9 ± 1.52
Monsoon (Oct., Nov., December 2010)	3.9 ± 0.32	137.3 ± 1.45	22.2 ± 0.53	33.6 ± 1.21	61.2 ± 1.31
Post monsoon (Jan., Feb., March 2011)	4.56 ± 0.46	150.56 ± 1.58	23.9 ± 0.90	27.7 ± 1.25	61.8 ± 1.47
Summer (April, May, June 2011)	5.66 ± 0.49	112.6 ± 1.27	31.5 ± 1.15	24.7 ± 1.03	71.3 ± 1.62
Pre monsoon (July, Aug., Sept. 2011)	4.9 ± 0.45	114.8 ± 1.36	30.5 ± 1.05	28.7 ± 1.08	71.5 ± 1.52
Monsoon (Oct., Nov., December 2011)	4 ± 0.38	147.7 ± 1.54	21.9 ± 7.3	32.0 ± 1.33	68 ± 1.40

4. Discussion

Enzyme acid phosphatase is non-specific which hydrolysis phospharic acid ester. It is secreted by prostate cells, erythrocytes, platelets and leucocytes. If blood contains excess quality of acid phosphatase there is a possibility of haemolysis. In the present study acid phosphatase in the blood of eel *A. bicolor* showed a slight seasonal fluctuation. It was found to be high during summer season and low during monsoon seasons may be due to high quantity of water in monsoon seasons and low quantity of water in summer months. Similar observations were reported by earlier workers (Srivastava *et al.*, 1989; Rajan, 1990; Roostacian, 1993; Paul *et al.*, 1995; Kapila *et al.*, 2002; Das *et al.*, 2004; Mandal *et al.*, 2010; Gabriel *et al.*, 2012) [34, 21, 22, 19, 9, 6, 15, 7].

According to Shrivastava and Shrivastava (1998) [28] acid phosphatase activity of *Channa marnclinus*, *C. grachua*, *C. punctatus* and *C. striatus* were found to be more or less similar in pattern when the fishes collected from same habitate of stagnated muddy water. The activity of acid phosphatase and alkaline phosphatase in different tissues of fish *Labeo rohita* showed significant fluctuations when the fish exposed to sublethal concentration of domestic sewage (Rajan, 1990) [21]. There was a significant change noticed in the acid phosphatase activity of *Sarotherodon mossambicus* exposed to sublethal concentration of synthetic detergent (Paul *et al.*, 1995) [19].

Kapila *et al.* (2002) [9] observed a significant decline in the values of acid phosphatase in *Schizothorax richardsonii*, exposed to lower limit of temperature 5-10 °C. In Indian major carps *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* there was an elevated level of acid phosphatase activity, exposed to nitrite toxicity (Das *et al.*, 2004) [6]. In *Labeo rohita* acid phosphatase activity showed marked enhancement after exposure to pollutant (Mandal *et al.*, 2010) [15]. Further, this result correlated with Palanisamy *et al.* (2012) [18] reported that the activity of acid phosphatase and alkaline phosphates decreased significantly in catfish *Mystus cavasius* when exposed to industrial effluent. In *Anguilla bicolor* acid phosphatase decreased when the fish exposed to copper sulphate (Sripriya *et al.*, 2012b) [33]. The acid phosphatase activity significantly decreased in *Channa punctatus*, exposed to malathian (Magar and Afsar-Shaikh, 2013) [14].

Alkaline phosphatase is also a non-specific enzyme which hydrolysis aliphatic, aromatic and heterocyclic components. Alkaline phosphatase is secreted by osteoblast cells under the effect of hormones such as parathyroid and carcitrol. In the present study in *Anguilla bicolor* the amount of alkaline phosphatase showed a slight seasonal variation. The higher value was found in monsoon and post monsoon seasons and lower value in summer and pre monsoon seasons. The fluctuation in alkaline phosphatase activity in various fish species reported by earlier workers (Sastry and Malik, 1981; Gelman *et al.*, 1989; Lamaire *et al.*, 1991; Roostacian, 1993; Mandal *et al.*, 2010; Gabriel *et al.*, 2012) [26, 8, 12, 22, 15, 7].

The presence of acid and alkaline phosphatase in various organs of *Cirrhinus mirgala* varied significantly. According to Gelman *et al.* (1989) [8] the maximum activity of intestinal alkaline phosphatase was found in the fresher of tropical water origin than in cold water. In sea-bass *Dicentrarchus labrax* alkaline phosphatase level significantly increased when the fish fed with artificial feed (Lamaire *et al.*, 1991) [12]. An increase in alkaline phosphatase activity was noticed in *Sarotherondon mossambica* exposed to cadmium (Ruparelia *et al.*, 1992) [23]. Roostacian (1993) [22] stated that alkaline phosphatase activity increased in logistic manner in common carp *Cyprinus carpio* when the culture pond fertilized with phosphate. In *Sarotheron mossombica* severe acidosis may be the cause for inhibition of alkaline phosphatase activity in intoxicated fish (Shaikila *et al.*, 1993) [27].

The *Cirrhinus mrigala* there was a reduction in alkaline phosphatase activity due to toxic ammonia (Das *et al.*, 2004) [6]. Atef (2005) [1] observed significant elevation of ALP in freshwater fish *Oreochromis niloticus* after exposure to cadmium. In *Labeo rohita* increase the level of ALP indicates a stressful condition of the fish (Mandal *et al.*, 2010) [15].

Serum glutamate oxaloacetate transaminase (SGOT) and serum glutamate pyruvate transaminase (SGPT) and lactate dehydrogenase (LDH) are naturally distributed in organisms. These are exist in isoenzyme forms. These enzymes are involved in transamination reactions in living things. In the present study in eel fish *Anguilla bicolor*, SGOT, SGPT and LDH showed a slight seasonal fluctuation. Similar observations were reported by earlier workers (Sadhu *et al.*, 1985; Radaiah and Rao, 1990; Machala *et al.*, 1997; Singh and Srivastava, 1999; Sarower *et al.*, 2012) [24, 20, 13, 30, 25].

According to Childress and Somero (1979) [3] the enzyme activity increased with the increasing fish size. The inhibition of SGOT and SGPT activities observed in the serum of *Channa striatus*, exposed to malathion (Sadhu *et al.*, 1985) [24]. In sea bass changes observed in plasma enzymes GOT, GPT, LDH, ALP and plasma lipids when fed with different diet (Lamaire *et al.*, 1991) [12]. The enzymes GOT, GPT and LDH activity showed marginal changes in *Cyprinus carpio* (Sivakumari *et al.*, 1997) [31]; *Labeo rohita* (Das and Kukherjee, 2002) [4]; *Channa punctatus* (Begum, 2005) [2]; *Clarias gariepinus* (Ogueji Okechukwu and Auta, 2007) [17]. Winkaler *et al.* (2007) [35] observed that the increase in SGOT and SGPT level in fish *Prochlodus lineatus* exposed to pollutants. In *Casassius auratus* enzyme activity increased when the fish infected with parasite *Argulus* (Kumar *et al.*, 2012) [11]. The drop in the LDH activity noticed in *Claries gariepinus* exposed to cypermethin (Gabriel *et al.*, 2012) [7]. The SGOT was found to be low and SGPT high in *Anguilla bicolor* exposed to copper sulphate (Sripriya *et al.*, 2012b) [33].

5. Conclusion

The data clearly indicates the amount of ACP, ALP, SGOT, SGPT and LDH in the serum enzyme showed seasonal variations during the two years of the study period. It indicates that the eels are the main sources of animal protein. Therefore, the present study concludes that the eels *A. bicolor* are highly nutritive and proteinous species good for human consumption.

6. References

1. Atef MM, Biochemical effects of short-term cadmium exposure on the fresh water fish Oreochromis niloticus. J Biol Sci. 2005; 5:260-265.
2. Begum G. *In vivo* biochemical changes in liver and gill of *Clarias batrachus* cypermethrin exposure and following cessation of exposure. Res. Biochem. Physiol., 2005; 82:185-196.
3. Childress JJ, Somero GM. Depth-related enzymic activities in muscle, brain and heart of deep living pelagic marine teleosts. Mar. Biol. 1979; 52:273-283.
4. Das BK, Kukherjee SC. Toxicity of cypermethrin in *Labeo rohita* fingerlings: biochemical, enzymatic and haematological consequences. Comp. Biochem. Physiol., 2002; 134:109-121.
5. Das MK, Das RK, Mondal SK. Some stress sensitive parameters of young major carp, Labeo rohita. Indian J Fish. 2002; 49(1):73-78.
6. Das PC, Ayyappan S, Jena JK, Das BK. Acute toxicity of ammonia its sublethal effects on selected haematological and enzymatic parameters of mrigal, Cirrhinus mrigala (Hamilton). Aquacult. Res., 2004; 35(2):134-143.
7. Gabriel UU, Akinrotimi OA, Ariwerikuma VS. Changes in metabolic enzymes activities in selected organs a tissue of *Clarias gariepinus* exposed to cypermethrin. J Environ Eng Technol. 2012; 1(2):12-18.
8. Gelman A, Mokady S, Cogan U. The thermal properties of intestinal alkaline phosphatase of three kinds of deep-water fishes. J Comp Biochem Physiol. 1989; 94B(1):113-116.
9. Kapila R, Kapila S, Basade Y. Impact of temperature variation on haematology and serum enzymes of *Schizothorax richardsonii* (Gray). Indian J Fish. 2002; 49(2):187-192.
10. King J. Practical clinical Enzymology. New York, New Jersey: D. Van Nostrand Co. Ltd., 1965, 363.
11. Kumar S, Raman RP, Kumar K, Pandey PK, Kumar N, Mallesh B *et al.* Effect of azadirachtin on haematological and biochemical parameters of Argulus-infested goldfish Carasius auratus (Linn.1758). Fish Physiol. Biochem, 2012. doi:10.1007/s10695-012-9736-8.
12. Lamaire P, Drai P, Mathieu A, Lemaire S, Carriere S, Giudicelli J *et al.* Changes with different diets in plasma enzymes (GOT, GPT, LDH, ALP) and plasma lipids (cholesterol, triglycerides) of sea-bass (Dicentrarchus labrax). Aquacult 1991; 93(1):63-75.
13. Machala M, Petrivalsky M, Nezveda K, Ulrich R, Dusek L, Piacka V *et al.* Responsess of carp he patopancreatic 7-ethroxyresorufin-o-deethyltasease and glutathione dependent enzyme to organic pollutants: a fields study. Environ Toxicol *Chem* 1997; 16:1410-1416.
14. Magar RS, Afsar Shaikh. Effect of Malathion on acid phosphatase activity of fresh water fish Channa punctatus. Int. J Pharmacut Chem Biol Sci. 2013; 3(3):720-722.
15. Mandal R, Mandal D, Mishra N, Bahadur A. Effect of surfactants on phosphatase level of fresh water Labeo rohita. J Environ Biol 2010; 31:395-398.
16. Medda C, Bhattacharyya B, Sarkar SK, Ganguly S, Basu TK. Effect of rotenone on activity of some enzymes and their recovery in freshwater carp fingerlings of Labeo rohita. J Environ Biol. 1995; 16(1):55-60.
17. Ogueji Okechukwu E, Auta J. The effects of sub-lethal doses of Lambda-cyhalothrin on some biochemical characteristics of the African cat fish Clarias gariepinus. J Biol Sci. 2007; **7**(8):1473-1477.
18. Palanisamy P, Sasikal G, Mallikaray D, Bhuvaneshwar N, Natarajan GM. Activity levels of phosphatase of air-breathing catfish *Mystus cavasius* exposed to electroplating industrial effluent chromium. Biol. Med. 2012; 4(2):60-64.
19. Paul PI, Vincent S, Ambrose T, sselvanayagam M. Activity of acid phosphaase in the selected tissues of *Sarotherodon mosambicus* (Trewavas) exposed to synthetic detergent. J Ecobiol. 1995; **7**(1):67-70.
20. Radaiah V, Rao KJ. Toxicity of pyrethroid insecticide fenvelerate to a freshwater fish, *Tilapia mossambica* (Peters) changes in glycogen metabolism of muscle. Exotoxicol. Environ. Saf., 1990; 19:116-121.
21. Rajan MR. Acid and alkaline phosphatase activity in different tissues of *Labeo rohita* (Hamilton) in relation to sublethal concentration of domestic sewage. J Nat Conser. 1990; 2(2):121-131.
22. Roostacian P. Surveying adrenaline influence upon acid phosphatase activity in Gassostrea arcullata gonadal extract. J Iranfish Bull. 1993, 3(5).
23. Ruparelia SG, Verman Y, Mehta NS, Rawal VM. Cadmium accumulation and biochemical alteration in the liver of fish Sarotherodon mossambia (Peters). Bull. Environ. Cont. Toxicol 1992; 2(2):129-136.
24. Sadhu KA Chowdhury, Mukhopadhyay. Relationship between serum enzymes, histological features and enzymes, histological features and enzymes in hepatopancreas after sub lethal exposure to malathion and phophamidon in the murrel Channa striatus (B.L.). Int. Environ. Stud., 1985; 24:35-41.
25. Sarower E. Mahfuj Md, Belal Hossain M, Minar MH, Biochemical composition of an endangered fish, *Labeo bata* (Hamilton, 1822) from Bangladesh waters. American J Food Technol. 2012; 7(10):633-641.
26. Sastry KV, Malik PV. Acute and chronic effects of diarinon on some enzymes in certain tissues of a freshwater teleost fish Channa punctatus. J Environ Biol. 1981; 2(3):19-28.
27. Shaikila BI, Thangavel P, Ramaswamy M. Adaptive trends in tissue acid and alkaline phosphatase of Sarotherondon mossombica (Peters) under sevin toxicity. Indian J Environ Helth. 1993; 35(1):36-39.
28. Shrivastava SM, Shrivastava VK. Toxicological effects of carbyl on testicular morphology, gonadropin alkaline and acid phosphatase, to lipid and testosterone levels in Mus musculus. Poll. Res., 1998; 17(3):215-218.
29. Sidik AS, Sugita H, Paat S, Deguchi Y. Alkaline and acid phosphatases in a tank water rearing carp (*Cyprinus carpio*). J. Bull. Coll. Agric. Vet. Met. Nihon. Univ. Nichidai, Nojuho. 1990; 47:32-37.
30. Singh A, Srivastava VK. Toxic effect of synthetic prethroid permenthrin on the enzyme system of the freshwater fish C. striatatus. Chemosphere, 1999; 39:1951-1956.
31. Sivakumari R, Manavalaramunujam R, Ramesh M,

Lakshmi R. Cyperthrin toxicity: Sublethal effects on enzyme activities in a freshwater fish, Cyprinus carpio (var. Communis). J Environ Biol. 1997; 18(2):121-125.

32. Sripriya R, Kannathasan A, Rajendran K. Seasonal variation in the haematological values of the Indian eel Anguilla bicolor (McClelland). *IJBPAS*, 2012a; 1(8):1188-1193.
33. Sripriya R, Malathi M, Rajendran K, Effect of copper sulphate on blood parameters and enzymes of the Indian eel Anguilla bicolor. J Ecotoxicol Environ Monit. 2012b; 22(2):155-161.
34. Srivastava RS, Singh RP, Sharma K, A report or relative acid phosphatase activity in liver of murrel species. J Environ Biol. 1989; 10(2 Suppl):237-238.
35. Winkaler EU, Santos TRM, Machado-Neto JG, Martinez CBR. Acute lethal and sublethal effects of neem leaf extracts on the neotropical freshwater fish Prochilodus lineatus. Comp. Biochem Physiol 2007; 145:236-244.