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Variations in Hepatosomatic Index (HSI) and Gonadosomatic Index (GSI) in Fish *Heteropneustes fossilis* Exposed to Higher Sub-Lethal Concentration to Arsenic and Copper

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Abstract: *The effect of sub lethal concentration 1.31 ppm and 1.84 ppm for Arsenic and Copper on the Hepatosomatic and Gonadosomatic indices of the fish Heteropneustes fossilis was studied. In mature female catfish Heteropneustes fossilis on exposure to both test metals at both higher sub lethal concentration registered marked toxicological alterations and reduction in Hepatosomatic index (HSI) and Gonadosomatic index (GSI) throughout the year in exposed fish group. However in the control group fish the values of HSI and GSI in the increasing order in relation to seasonal variation to their maximum range during pre-spawning phase. The reduced values of above parameter found directly proportional to the metal concentration and duration of the exposure. The results of the present study will be useful for selective breeding programme, conservation and sustainable fishery management of H. fossilis in its natural habitat.*

Keywords: *Heteropneustes fossilis,* Sub-Lethal Concentration, Copper, Arsenic HSI and GSI.

Introduction

Fish play a significant role in our economy, food chain and serve as an excellent ecological indicator. During the past few decades our knowledge concerning the incidence along their mass mortality due to aquatic pollution has increased as these fish play important role of mediator or carrier of toxicant and pathogen leading to gradually an inhibition of their population. The effect of heavy metal pollution on aqua fauna is recently attracting widespread attention, particularly in studies related with industrial pollution and is still increasing day by day. Thus metal pollution today is the highest cause of concern in developing countries. Among the various heavy metals copper is an important pollutant discharged into the aquatic environment by industries and through agricultural runoff (Pragatheeswaran *et al.*, 1992; Ramesh *et al.*, 1992). Arsenic is strongly poisonous to metal sensitive enzymes resulting in growth inhibition and death of organisms, pose a number of hazards to humans. Arsenic cause poisoning due to drinking water contamination. The arsenic contamination of aquatic ecosystem is through the use of pesticides, non-ferrous, smelters, coal-fired and geothermal power plant. Moore and Ramamurthy (1984) reported that fresh water normally contains 11-98 mg/l of arsenic. Heavy metals in ecological food chain accumulates and persists due to having long biological half –lives, thus causing a major threat to aqua fauna, particularly, fish constitute the important component of food chain and even a slight alternations in physico-chemical properties due to toxicants in aquatic media exerts its adverse effect on fish physiology and directly or indirectly affecting human health via food. Release of heavy metals pesticides, Fertilizers, radioactive and industrial waste into atmosphere has resulted in gradual contamination of aquatic habitat,. Heavy metal pollution has been reported to affect the fish ovary and an increase incidence of follicular atresia (Jhingran, 1982, Patil and Saidpur, 1989) In present study the sub –lethal affect of Arsenic and copper was assessed

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by exposure to fish *H. fossilis* at sub-lethal concentration for fifteen days every month for a period of complete one year. Since gonadosomatic index (GSI) is an important tool in establishing the breeding period in animals and in fish (Saxena,1986). The liver has a role in the ovarian development, therefore, the hepatosomatic index was correlated with gonadosomatic index.

Materials and Methods

The test fish *Heteropneustes fossilis* of almost same size were purchased in healthy condition from local fish market, procured nearby water ponds of city Kanpur. The live specimen of adult fresh fish were acclimatized under natural photoperiod and standard laboratory conduction for 15 days in fiberglass aquaria containing non-chlorinated tab water of 20 liter volume to recover from stress. Fish of both control and experimental groups were fed every day twice with wheat flour pellets, boiled egg protein and ground dried shrimps. Three groups of 14-fish were exposed to sodium arsenate and copper sulphate ($CuSO_4.5H_20$) both of AR grade to test sub lethal concentration and a control group to studying LC_{50} during this period, the fish were maintained without food and the medium was changed every 24 hours. LC_{50} value for different intervals 24, 48, 72 and 96 hours were calculated by graphical and statistical methods. Group I served as control and other two groups exposed to higher sub-lethal concentration (1.31 ppm and 1.84 ppm for Arsenic and Copper) of both the test metal. Periodically they were sacrificed to take their individual weight and weight of their liver and ovaries to compute their hepatosomatic and gonadosomatic indices by applying formula.

Gonadosomatic index-(GSI)

$$GSI = \frac{\text{Weight of the Gonad}}{\text{Weight of the fish}} x100$$

Hepatosomatic index- (HSI)

$$HSI = \frac{\text{Weight of the liver}}{\text{Weight of the fish}} x\ 100$$

Results and Discussion

Gonadosomatic Index-(GSI)

The Gonadosomatic index (GSI) of the fish *H. fossilis* recorded for each month for a period of 12 months is presented in the Table 1. The Gonadosomatic index (GSI) increased gradually from January (resting-phase) to onwards reaching maximum during May – June (pre-spawning phase). There after it reduced reaching minimum during September –November (post spawning phase). The increase in gonadosomatic index (GSI) during July–August (spawning phase) indicates maximum gonadial growth, where large number of vitellogenic oocyte were observed in a histological section.

The decreased values of gonadosomatic index (GSI) in the month of September - November indicates the end of spawning and reaching spent conditions during December.

At higher sub lethal concentration of both the test metal in all months the gonadosomatic Index (GSI) is reduced with maximum reduction in arsenic exposer comperatively.

Hepatosomatic Index (HSI)

The lowest values of Hepatosomatic index (HSI) was recorded for female *H. fossilis* during September-November and the highest hepatosomatic index (HSI) for female test fish was observed in the developing phase May-June (Pre spawning phase) Hepatosomatic index (HSI) decreased significantly during post spawning phase (September –November) and increased again in the resting phase (December –January) in all the groups. The Hepatosomatic

Table 1 Variations in Hepatosomatic (HSI) and Gonadosomatic index (GSI) in fish *H. fossilis* exposed to higher sub-lethal concentration 1.31 ppm and 1.84 ppm for arsenic and copper.

Reproductive Phase	Control		Arsenic 1.31ppm Exposed		Copper1.84ppm Exposed	
	HSI	GSI	HSI	GSI	HSI	GSI
1. Resting Phase (Dec.-Jan.)	1.21±0.06	1.10±0.02	1.10±0.06	1.16±0.08	1.16±0.03	1.06±0.04
2. Preparatory Phase (Feb.-April)	1.36±0.05	1.40±0.12	1.18±0.05	1.10±0.06	1.21±0.02	1.12±0.03
3. Prespawning Phase (May-June)	1.70±0.16	4.87±0.41	1.34±0.04	3.48±0.48	1.48±0.14	3.88±0.44
4. Spawning Phase (July-Aug.)	1.42±0.03	4.28±0.16	1.28±0.08	3.34±0.14	1.34±0.01	3.63±0.5
5. Post spawning phase (Sept.-Nov.)	1.01±0.05	0.98±0.18	0.92±0.06	.84±0.17	0.98±0.8	0.88±0.28

Values are ± SE against their resting phase P< 0.05, P< 0.01

index values to metal exposure are in the decreasing order. In both exposed group. Arsenic exposure exhibited the lowest values compared to copper exposure, indicating more toxic than copper for fish physiology. Change in HSI is a simple and reliable indicator of gross changes as various metabolic activities of the body are centered in liver (Saxena, 2000). The gradual decrease in both HSI and GSI as compared to control may be attributed to both metals toxicity on fish. Change in HSI thus GSI value are good indication of impaired reproductive physiology in fishes. The oocyte development in fish is intimately associated with hepatic synthesis of egg-yolk precursor protein Vitellogenin which is secreted into blood and ultimately transported to developing Oocyte and deposited as yolk. In present study values of HSI and GSI were more markedly reduced during arsenic exposure comparatively indicating that arsenic is more potentially toxic to liver and ovaries than copper.

In the present study significant decrease in liver protein due to copper and arsenic toxicity might have caused the low values of HSI and GSI, similar decreasing results were also discussed by Patil and Saidpur (1989) who observed the ovarian damage as a single most important indication of exposure to toxic pollutants. Wani and Latey (1983) recorded reduced gonadosomatic index (GSI) in fish *Garra mullya* exposed to cadmium chloride and in *C. batrachus* exposed to mercuric chloride, methyl mercuric chloride and Emisan-6. Lower value of GSI in *Channa punctatus* exposed to mercuric chloride Kirubugaran and Joy, (1989), Ram and Sathyanesan (1984) Reduction in both HSI and GSI values to heavy metal exposure in *Notopterus notopterus* by Sindhe and Kulkarni (2004). Devi *et al.* (1991) also estimated reduced values of HSI in *Ophiocephalus striatus* exposed to Copper, Cadmium and DDT etc. Similar findings were also observed by Kaur and Kaur (2006) in *Channa punctatus* under the stress of Nickle-Chrome electroplating effluent and advocated that fish was most sensitive to stress during spawning phase followed by preparatory phase of the reproductive cycle. An increase in the concentration of biomolecules in blood plasma corresponding to a decline in GSI clearly indicates that the metabolism of fish is affected the biomolecules that are not taken up by the body under the stress of the effluent. Various heavy metals are found be localized in membrane bound vesicles in the gill-epithelial cells, digestive cells, blood cells and kidney cells of fish *Mytilus edulis* (George *et al.*, 1975). Degenerative changes in kidney (Akram *et al.*, 1999) have been reported from Cadmium exposed fish. Toxic effects of heavy metal on biochemical activity and histopathology of liver of fish have been reported by Kasthuri and Chanaran, (1997); Srivastava *et al.* (2002). Singh and Singh, (2007) predicted that endosulphan interfere with phospholipids metabolism in the freshwater fish *H. fossilis* during annual reproductive cycle.

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Units - Control

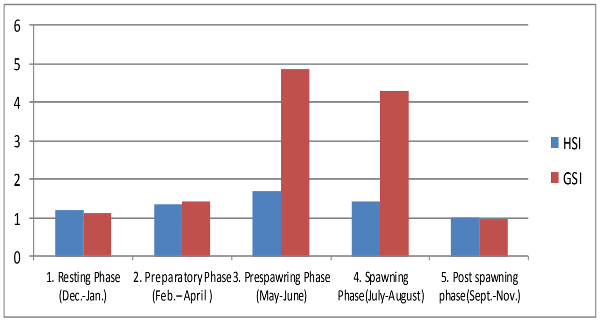

Fig. 1 Histograms indicating values of (N=3) + S.E. against their resting phase, $P<0.05, P<0.01$

Units - Copper 1.84ppm

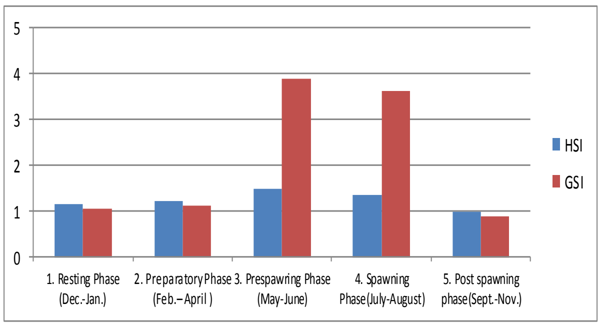

Fig. 2 Histograms indicating values of (N=3) + S.E. against their resting phase, $P<0.05, P<0.01$

Units - Arsenic 1.31ppm

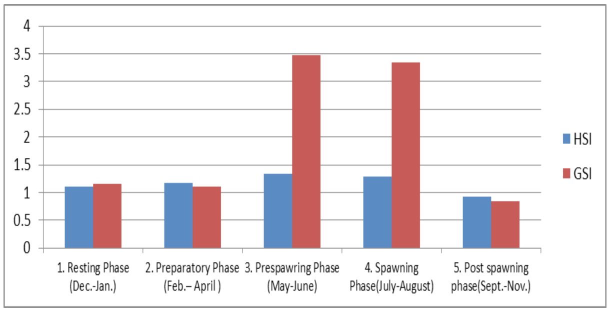

Fig. 3 Histograms indicating values of (N=3) + S.E. against their resting phase, $P<0.05, P<0.01$

However some environmental factor like low level of Calcium, DO in aquatic niches and the enhanced level of BOD, COD and So_4^{--} are also directly related with low values of GSI during reproductive phase of fish (Nath *et al.*, 2003). A similar view was also discussed by Gobell *et al.* (2002) that aquatic contaminates may interfere with fish egg production by interfering with normal estrogen receptor-response in the liver essential to trigger the synthesis of essential egg-components like egg-yolk and protein precursor vitellogenin. In male fish *H. fossilis* exposed to Linear alkyl benzene sulphonate (LAS) lead to cytotoxic damage in testis, resulting into reproductive impairment and thus delayed gonadial maturity (Kumar *et al.*, 2007). It is now quite evident that reduced HSI and GSI are potential indicator, which directly reflect the toxic nature of aquatic medium and thus study is suggestive to take necessary step to monitor the aquatic medium to protect the fish reproductive physiology thus fish population as a whole.

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