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Effects of sub-lethal cadmium toxicity on gonadosomatic index of freshwater catfish, *Heteropneustes fossilis*

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1. Abstract : The study aimed to investigate the effects of sub-lethal (SL) concentrations of Cadmium (Cd) on the Gonadosomatic Index (GSI) of freshwater stinging catfish, *Heteropneustes fossilis*. Hence, the adult freshwater stinging catfishes of 18.36 ± 0.25 cm in length and 38.86 ± 1.41 gm in weight were exposed to five different SL concentrations of Cd like 1.11, 2.21, 4.41, 8.82 and 17.64 mg/l Cd for 28 days, following Static Renewal Test (SRT) method. On 14^{th} and 28^{th} day of experiment, fishes of both male and female were taken from each tank and gonads were dissected out and measured to determine the GSI. A control experimental set up was also maintained for comparison. Statistical analysis of the data on GSI revealed significant difference in GSI between control and Cd treated fishes and also between fishes treated with two different SL Cd concentrations.

Key words: Gonadosomatic Index, Sub-lethal Toxicity, Cadmium, *Heteropeneustes fossilis*

2. Introduction

Contamination of inland water bodies with a wide range of pollutants has become a serious issue over the last few decades. In particular, heavy metal pollution poses threats to the aquatic organisms due to their toxicity and ability to accumulate in the body. The natural aquatic systems are being contaminated with heavy metals released from domestic, industrial and other manmade activities. Fish chronically exposed to low levels of environmental pollutants like heavy metals like cadmium, lead and mercury may eventually suffer from reproductive dysfunctions like reduction in spawning frequency, spawning success, gamete production and larval survival. Hence, the present study aimed at investigating the sub-lethal effects of the heavy metal, Cadmium on the testicular and ovarian Gonadosomatic Index of *Heteropneustes fossilis*.

3. Materials and Methods

The freshwater catfish, *H. fossilis* measuring an average length of 18.36 ± 0.25 cm and weight of 38.86 ± 1.41 gm were obtained from a fish market in Tirunelveli, Tamil Nadu. The fishes were kept in 500 L FRP tanks containing 140 L water and acclimatized in laboratory conditions for one month prior to the commencement of experiments. The acclimated fishes were divided into five experimental groups of 10 fishes, consisting of 5 male and 5 female in each tank. Five sub-lethal (SL) test concentrations of Cd (1.11, 2.21, 4.41, 8.82 and 17.64 mg/l) were selected based on 96 hrs LC_{50} for Cd to *H. fossilis* (44.13 mg/l) obtained in our earlier study (Jayakumar *et al.*, 2016). The metal compound (Cadmium chloride monohydrate) was used for the preparation of test medium and the bioassay result was expressed as metal (Cadmium) concentration only, following the formula used by Devi (2010). A control set up was also maintained in a Cd free medium. Test lasted for 28 days. Static renewal bioassay method was followed to carry out the study (APHA, 1995). Experimental test solutions were renewed every 24th hour. A duplicate experimental set up was also maintained. During the study, male and female were taken from control and each treatment tank on 14^{th} and 28^{th} day. Later, the length and weight of each fish was measured and dissected out to remove the gonads. Then, gonads were weighed separately sex-wise to the nearest 0.1 mg in an electronic balance for the estimation of GSI. The GSI, regarded as coefficient of maturity, was determined by the following formula as proposed by Nikolsky (1963).

$$\text{GSI} = \frac{\text{Gonad Weight (g)}}{\text{Total Body Weight (g)}} \text{ x } 100$$

4. Results and Discussion

Effect of SL doses of Cd on GSI of male and female *H. fossilis* after 14 and 28 days of exposure is presented in Table 1. In male control fish, testicular GSI was estimated to be 1.28±0.07 after 14 days and it increased to 2.63±0.10 after 28 days of exposure to control medium. In contrast, in treated fish, the testicular GSI was observed to decrease from 1.28±0.07 to 1.00±0.09 after 14 days of exposure and from 2.63±0.10 to 0.91±0.07 after 28 days of exposure to the highest concentration of Cd (17.64 mg/l) in male *H. fossilis*. Similarly, in female control fish, ovarian GSI was estimated to be 7.59±0.06 after 14 days and it was found to increase to 9.21±0.10 after 28 days of exposure to control medium. The ovarian GSI was found

to decrease from 7.59±0.06 to 6.10±0.07 after 14 days and from 9.21±0.10 to 5.13±0.10 after 28 days of exposure to the highest concentration of Cd (17.64 mg/l) in female *H. fossilis* (Figure 1). The changes in GSI were noted to be dose and time dependent. Further, the change in the testicular and ovarian GSI of treated fish was assessed to be statistically significant for both male and female at 5% level ($P<0.05$). In addition, Post Hoc multiple comparisons made by LSD showed that there was a significant difference between treatments at 5% level ($P<0.05$).

In the present study, SL doses of Cd resulted in significant changes in testicular and ovarian GSI, causing biphasic effects (Figure 1and Table 1). At low concentrations and at short term exposure, Cd stimulated gonadal growth (increased GSI) but at 28 days of exposure, it inhibited the gonadal growth (decreased GSI). This is in conformity to the acceleration of ovarian growth in Atlantic croaker, *Micropogonius undulatus* exposed to 1 ppm of Cd (Thomas, 1989) and increase in testicular GSI in zebrafish exposed to Cd (Wall, 1999). However, reduction in GSI observed at high doses at both short and long term exposures and at low doses at long term exposure is in harmony with the reports of the earlier works done with Cd in various fish species. Ahsan and Ahsan (1974) and Sehgal and Pandey (1984) reported decreased GSI in Cd exposed walking catfish and male guppy respectively. Cadmium was found to significantly decrease ovarian and testicular GSI in the freshwater fish *Bata* (*Labeo bata*) and winter flounder (*Pseudopleuronectes americanus*) (Das, 1988 and Pereira *et al.,* 1993). Thomas (1988) observed reduction in GSI in Atlantic croaker, *Micropogonius undulatus* exposed to lead. However, in contrast, Cd (1 ppm) was found to accelerate the ovarian growth in Atlantic croaker (Thomas, 1989). Cadmium decreased ovarian GSI in freshwater eel, *Monopterus albus* (Singh, 1989) and winter flounder, *Pleuronectes americanus* (Pereira *et al.,* 1993). Exposure to lead resulted in reduction in GSI and oocyte (egg) diameter in sexually maturing female rainbow trout (Ruby *et al.,* 2000). The influence of long-term exposure of Cd to goldfish (*Carassius auratus*) caused a decrease in the gonadosomatic index (GSI), and ovulation did not occur (Szczerbikm *et al.,* 2006). Shalaby *et al.* (2006) reported decrease in fecundity, ovarian GSI and testicular GSI and testosterone level in male blue tilapia (*Oreochromis aureus*) exposed to chromium. Our results are also corroborated by investigations on the effects of bisphenol-A on the GSI of fathead minnow which revealed increased ovarian GSI in all treatments over the 164-d exposure period and increased testicular GSI in selected treatments during the same period (Sohoni *et al.,* 2001). As pointed out by Kime *et al.,* 1999, trace elements which induce the production of metallothioneins in the gonads might have disrupted

gamete production (reduced GSI) by disturbing normal zinc homeostasis, essential for the development of both eggs and sperm.

5. Conclusion

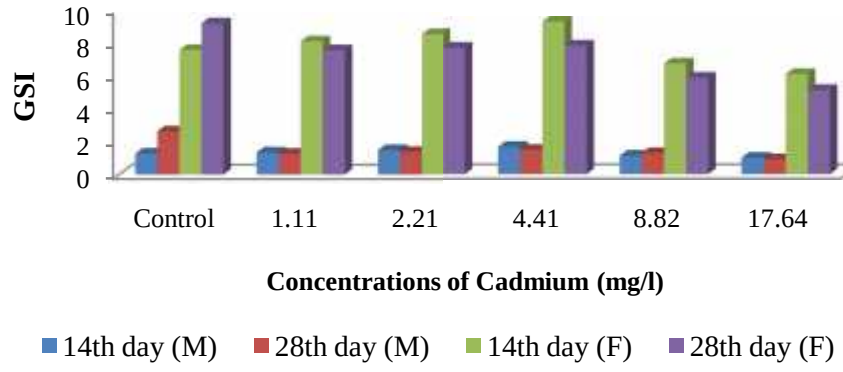
It is evident from the present study that exposure of catfish to different SL concentrations of Cadmium poses great stress on the fish and elicits severe changes in the gonads resulting in reduced GSI. The present result suggested that SL toxic exposure to Cadmium leads to damages in the gonads of stinging catfish, *Heteropneustes fossilis*, confirming the possibility of Cadmium to be a toxicant.

Table 1. Testicular and Ovarian GSI in *H. fossilis* (♂ & ♀) after 14 and 28 days of exposure to SL concentrations of Cd

Conc. (mg/l)	Testicular GSI		Ovarian GSI	
	14 day	28 day	14 day	28 day
Control	1.28 ± 0.07	2.63 ± 0.10	7.59 ± 0.06	9.21 ± 0.10
1.11	1.35 ± 0.08	1.27 ± 0.08	8.12 ± 0.09	7.57 ± 0.03
2.21	1.49 ± 0.08	1.38 ± 0.06	8.55 ± 0.21	7.70 ± 0.12
4.41	1.67 ± 0.05	1.48 ± 0.05	9.28 ± 0.26	7.83 ± 0.14
8.82	1.13 ± 0.11	1.29 ± 0.18	6.74 ± 0.11	5.88 ± 0.18
17.64	1.00 ± 0.09	0.91 ± 0.07	6.10 ± 0.07	5.13 ± 0.10

*Values are given as Mean ± Standard Error of Mean (SEM)

Fig. 1. GSI of male and female catfish, *H. fossilis* after 14 and 28 days of exposure at SL concentrations of Cd



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