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Morphometric alterations in exotic freshwater fish, *Ctenopharyngodon idella* (Cuv. and Val.) upon exposure to endosulfan

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Abstract
Variations in morphometric characters of a fish, *Ctenopharyngodon idella* (Cuv. and Val.) collected from local fish farms have been studied upon exposure to sub lethal doses of endosulfan. Ten characters were studied in percentage of total fish length from which only two characters have been observed to be altered significantly while others showed either non-significant or no specific trend of increase or decrease. In percentage of head length, five characters have been studied and here also two characters have been observed to be altered significantly. The fins were observed to be damaged at the margins. The characters studied have been observed to be genetically controlled though environment has influence on them. Some characters such as maximum body depth and minimum body depth in percentage of total length; eye diameter and inter-orbital distance in percentage of head length can be considered as the morphological pollution indicators.

Keywords: Morphometric characters, *Ctenopharyngodon,* Toxicity, Endosulfan, Morphological pollution indicators.

1. Introduction
Genus *Ctenopharyngodon* comes under the family Cyprinidae, which includes carps and minnows. Popularity of *Ctenopharyngodon idella* (Cuv. and Val.) stems from their ability to be cultured easily; exclusive herbivorous habit hence effective biological control on wide variety of aquatic vegetation without causing chemical pollution; being delicious and source of high quality protein. So, today it is world's one of the most important aquaculture species used for weed control in rivers, fishponds and reservoirs. In India, 382 fingerlings of this fish were brought to the Pond Culture Division of Central Inland Fisheries Research Institute, Cuttack (Orissa) from Hong Kong in December, 1959, basically for two purposes viz. to culture as food fish; and to control undesirable aquatic macro vegetation (Jhingran, 1991) [1]. Farmers have put this fish to their ponds for same purposes as the cost of stocking phytophagous fish is lower than the cost of herbicidal control. It flourishes currently in various parts of the country successfully.

In general, fish demonstrate greater variances in morphological traits both within and between populations than other vertebrates and are more susceptible to environmentally induced morphological variations. The morphometric relationships between various body parts of fish can be used to assess the well being of individuals and to determine possible difference between separate unit stocks of the same species (King, 2007) [2]. The cause of variations in the morphometric and meristic characters may range from variability to the intra-specific which is under the influence of environmental parameters (Hubbs, 1921; Vladykov, 1934; McHugh, 1954; Allendrof *et al*., 1987; Wimberger, 1992) [3-7]. Fish are very sensitive to environmental changes and quickly adapt themselves by changing necessary morphometrics (Hossain *et al.,* 2010) [8]. Information on the morphometric measurements of fishes and the study of statistical relationship among them are essential for taxonomic work (Narejo, 2010) [9], Vladykov (1934) [4]. Tandon *et al*. (1992) [10] are of view that morphometric characters can be successfully employed for ascertaining the genetically controlled and environmentally controlled characters. The various morphometric characters have been categorized on the basis of range difference into genetically (narrow range), intermediate (moderate range) and environmentally (vast range) controlled characters (Johal *et al.,* 1994) [11].

If ecological conditions can alter the morphometric characters of the fishes as stated then the toxic water can certainly alter morphometric characters of fish. With this objective, the morphometric characters of *Ctenopharyngodon idella* (Cuv. and Val.), have been studiedupon exposure to sublethal concentrations of endosulfan. Endosulfan (6,7,8,9,10,10 hexachloro-1-5,5a,6,9,9a hexahydro,6,9, methano-2,4,3-benzodioxathiepine 3-oxide) an organochloride pesticide has no doubt been banned by Supreme Court of India but it is still being used in Punjab for controlling pests of cotton.

2. Materials and Methods

Live healthy fish (12.56 ± 1.52 cm and 25.40 ± 2.53 gm) were procured from local fish farm in Barnala, Dist. Punjab, India and acclimatized to laboratory conditions for a week under natural photoperiod and water temperature ranging from 26 ^{0}C±2.68 ^{0}C. During the period of acclimatization the fish were fed with grass, banana leaf. The physicochemical properties of test water were analysed as per the standard methods (APHA, 2005) [12].

Fig 1: Lateral view of *Ctenopharyngodon idella* (Cuv. and Val.)

Then three groups (10 fish each) were exposed to two sublethal concentrations viz. 0.00075 mg/L and 0.001 mg/L for 15 days, 30 days, and 45 days in plastic tanks. A parallel control set was run simultaneously in toxicant free tap water. The morphometric measurements were recorded following Jayaram (2010) [13]. Statistical calculations such as mean, standard deviation (S.D.), range have been calculated after Snedecor and Cochran (1967) [14]. Then results were tested using student's t-test. After each stipulated exposure period, the deviations in the mean values of exposed fish were compared with those of the control groups for any change.

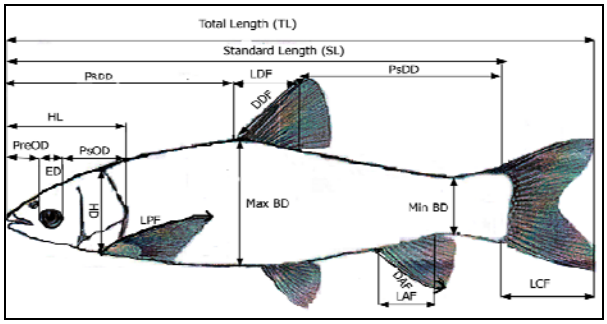

Fig 2: Outline diagram of *Ctenopharyngodon idella* (Cuv. and Val.) indicating various morphometric characters.

3. Results and Discussion

Various characters like head length, pre-dorsal length, post-dorsal length, length of dorsal fin, depth of dorsal fin, length of pectoral fin, length of anal fin, depth of anal fin, maximum body width and minimum body width have been studied in percentage of total body length and results are given in table 1. There was a regular highly significant decrease (p<0.01) in the maximum body width as well as minimum body width after all exposure periods of 15 days, 30 days and 45 days in both the concentrations. When compared to control group, maximum body width decreased by 15.68% and 19.40% after 15 days; by 11.27% and 12.72% after 30 days and by 16.83% and 28.21% at the end of 45 days in 0.00075 mg/L and 0.001 mg/L respectively while minimum body width decreased by 14.67% and 19.56% after 15 days; by 12.07% and 12.48% after 30 days and by 17.38% and 27.02% at the end of 45 days in 0.00075 mg/L and 0.001 mg/L respectively.

Decrease in body width might be due to hyperactivity in order to overcome stress caused by the toxicant. Hyperactivity resulted in fast oxidation of stored food which in turn might have resulted in decrease in body width. This is in agreement with decrease in serum glucose (Bala, 2014) [15].

Table 1: Morphometric alterations in percent of total length in *Ctenopharyngodon idella* (Cuv. and Val.) exposed to different sublethal concentrations of endosulfan for 15 days, 30 days and 45 days.

	15 Days			30 Days			45 Days		
Body proportion/ Character	**Control**	**0.00075 mg/L**	**0.001 mg/L**	**Control**	**0.00075 mg/L**	**0.001 mg/L**	**Control**	**0.00075 mg/L**	**0.001 mg/L**
Total Length (cm)	13.16 ±0.69 (11.02-14.22)	12.85±0.878 (10.08-13.21)	12.96±1.003 (9.20-13.84)	13.14± 1.021 (10.11-14.01)	12.98± 1.045 (10.0-13.97)	11.74 ± 0.953 (9.53-13.32)	13.33 ± 0.998 (10.78-14.68)	12.78 ± 0.745 (10.57-14.20)	12.93 ± 0.837 (10.62-13.58)
Head length	24.12 ± 0.629 (23.91-26.08)	23.11±0.61 (21.9-23.89)	22.87±0.849 (20.98-23.78)	23.07 ± 1.15 (22.70-25.23)	20.74 ± 1.23 (18.80-22.32)	20.39 ± 1.41 (18.70-22.40)	23.07 ± 1.15 (22.70-25.23)	23.05 ± 4.85 (18.97-24.94)	22.90 ± 1.15 (21.56-23.70)
Pre-Dorsal Length	43.29 ± 1.76 (39.17-46.03)	42.27±2.06 (40.08-47.51)	42.31±2.07 (42.04-47.64)	43.25 ±2.17 (41.2-47.27)	42.35±1.68 (41.18-50.21)	42.22±2.17 (38.11-46.29)	43.25 ±2.17 (41.2-47.27)	42.02±1.91 (38.53-46.06)	42.14±2.49 (39.22-47.37)
Post-Dorsal Length	36.57 ± 2.46 (31.02-42.23)	35.70±2.47 (31.08-41.43)	36.24±2.12 (29.98-37.01)	36.53±1.99 (31.56-38.56)	35.45±2.08 (30.34-38.19)	35.30±1.98 (31.32-39.40)	36.53±1.99 (31.56-38.56)	35.12±2.35 (32.21-40.34)	34.49±2.82 (31.11-39.97)
Length of Dorsal Fin	9.59 ± 0.654 (8.78-11.96)	9.47±0.920 (8.64-10.84)	9.26 ±0.531 (8.86-10.77)	9.47±0.455 (8.83-11.43)	9.50±0.686 (8.68-10.93)	9.31±0.29 (8.71-10.47)	9.47±0.455 (8.83-11.43)	9.43±0.652 (8.89-10.26)	9.37±0.724 (8.63-10.40)
Height of Dorsal Fin	21.65 ± 1.65 (18.36-23.67)	20.99 ±1.56 (18.25-23.77)	20.91 ±1.47 (18.25-23.33)	20.68±1.39 (18.09-23.47)	20.15±1.60 (17.79-23.47)	19.99±1.54 (17.73-22.98)	20.68±1.39 (18.09-23.47)	20.59 ±1.42 (18.06-22.78)	19.91±1.11 (18.00-21.17)

Length of Pectoral Fin$^{\oslash}$	17.27 ± 1.10 (15.74-18.70)	17.14 ±1.04 (15.52-18.63)	17.15±1.10 (15.48-18.53)	17.29±1.602 (15.59-18.47)	17.24±0.996 (15.73-18.65)	17.27±0.892 (15.53-18.67)	17.29±1.602 (15.59-18.47)	17.14 ±1.04 (15.52-18.63)	17.15±1.10 (15.48-18.53)
Length of Anal Fin$^{\oslash}$	5.13 ± 1.022 (3.88-6.08)	4.99±1.113 (3.86-6.02)	3.896±1.2 (3.45-5.89)	5.08±1.20 (3.76-6.12)	4.79±1.13 (3.84-5.32)	3.81±1.2 (3.35-4.89)	5.08±1.20 (3.76-6.12)	4.49±1.13 (3.54-5.02)	3.81±1.2 (3.35-4.24)
Height of Anal Fin$^{\oslash}$	16.05 ± 0.563 (13.60-17.95)	14.88 ± 0.789 (12.46-18.04)	14.67 ± 1.023 (12.88-16.75)	16.12±0.563 (13.60-17.95)	14.65±1.074 (11.36-17.82)	13.67 ±1.023 (11.88-15.98)	16.12±0.563 (13.60-17.95)	14.38±1.008 (12.36-17.13)	13.07 ±1.202 (11.18-15.39)
Max. Body Depth$^{\oslash}$	26.27 ± 1.336 (23.12-28.15)	22.15 ± 1.99** (18.56-24.78)	19.44 ± 1.91** (17.36-23.04)	26.41±1.382 (22.71-28.31)	23.97±1.792** (21.7-27.01)	23.01±1.22** (21.10-26.02)	26.41±1.382 (22.71-28.31)	21.70±1.783** (19.60-24.78)	18.73±1.74** (17.47-22.06)
Min. Body Depth$^{\oslash}$	12.38 ± 0.805 (10.98-13.75)	10.03 ± 0.68** (9.02-11.43)	9.06 ± 0.817** (8.68-10.93)	11.30±0.878 (10.28-12.45)	9.51±0.786** (8.19-10.95	8.94±0.915** (7.65-10.05)	11.30±0.878 (10.28-12.45)	9.58 ±0.797** (8.78-10.96)	9.26±0.347** (8.26 -9.84)

Values in parentheses indicate range. $^{\oslash}$**GC –** Genetically controlled character.
Level of significance $^{*}p< 0.05$; $^{**}p< 0.01$. Non significant ($p > 0.05$)

Table 2: Morphometric alterations in percent of head length in *Ctenopharyngodon idella* (Cuv. and Val.) exposed to different sublethal concentrations of endosulfan for 15 days, 30 days and 45 days.

	15 Days			30 Days			45 Days		
Body Proportion (in cms)	**Control**	**0.00075 mg/L**	**0.001 mg/L**	**Control**	**0.00075 mg/L**	**0.001 mg/L**	**Control**	**0.00075 mg/L**	**0.001 mg/L**
Head length	3.18±2.601 (286-3.28)	2.94±1.42 (2.88-3.02)	2.86±1.782 (2.80-2.98)	3.18±2.601 (286-3.28)	2.94±1.42 (2.88-3.02)	2.86±1.782 (2.80-2.98)	3.294±1.88 (2.96-3.34)	3.15±1.69 (3.08-3.22)	2.98±1.248 (2.94-3.10)
Head Depth$^{\oslash}$	36.17±1.78 (32.16-39.92)	35.50±1.345 (31.06-37.33)	36.22±2.378 (29.14-38.14)	38.78±2.23 (31.47-39.02)	37.90±2.08 (30.22-38.43)	37.±2.16 (32.46-40.14)	35.77±1.782 (31.16-38.92)	36.20±1.35 (32.06-39.67)	36.29±1.237 (31.14-38.86)
Inter-orbital Distance	46.60±1.25 (44.25-49.85)	42.022±1.16* (43.02-48.86)	45.41±1.169* (43.06-48.26)	46.39±0.966 (44.28-48.79)	44.19±1.37* (43.04-48.28)	44.34±1.069* (42.04-46.86)	46.30±1.72 (44.14-50.15)	44.92±1.13* (43.0-47.67)	44.34±1.065* (42.04-46.86)
Eye Diameter	22.64±1.15 (20.98-24.45)	24.18 ±1.485* (20.45-25.21)	24.48± 1.61* (11.89-16.31)	22.60±1.21 (21.01-24.98)	24.44±1.282* (26.76-25.79)	24.84±1.347* (26.92-25.16)	22.67±1.42 (20.67-24.90)	24.25±1.03* (21.67-25.79)	24.86±1.584* (21.45-26.2)
Pre-orbital Distance$^{\oslash}$	28.48 ±2.66 (24.32-30.16)	29.82±1.987 (27.86-33.04)	29.19±1.098 (30.97-35.02)	29.78±2.137 (29.12-36.42)	30.54±1.98 (29.10-35.46)	29.07±2.024 (28.92-34.81)	30.62±1.187 (26.50-30.20)	29.97±1.10 (26.61.30.14)	29.63±2.251 (26.87-31.02)
Post-orbital Distance$^{\oslash}$	71.32 ± 2.45 (60.66-71.78)	69.81±2.61 (65.32-72.12)	70.77±2.31 (66.19-70.67)	71.60±2.230 (66.37-73.37)	69.44±2.189 (64.28-73.34)	71.89±0.968 (70.54-73.81)	69.31±1.321 (64.24-72.12)	69.98±2.01 (65.67-72.37	69.07±2.211 (64.43-74.57)

Values in parentheses indicate range. $^{\oslash}$GC – Genetically controlled character.
Level of significance $^{*}p< 0.05$; $^{**}p< 0.01$. Non-significant ($p> 0.05$)

Pre-dorsal length and post-dorsal length revealed no specific trend of increase or decrease on exposure to endosulfan. A decrease though non-significant ($p>0.05$) has been observed in the heights of dorsal, anal, pectoral fins and length of dorsal fin in both the concentrations on all exposure periods. In most of the fishes, however, the fins were damaged at the margins under the impact of endosulfan.

The characters like head depth, inter-orbital distance, eye diameter, pre-orbital distance and post-orbital distance of *Ctenopharyngodon idella* (Cuv. and Val.) exposed to endosulfan as well as in control set have been studied in percent of head length and the results are given in table 2.

The head depth, pre-orbital distance and post-orbital distance in percent of head length showed no specific trend of increase or decrease with respect to control value in 0.00075 mg/L and 0.001 mg/L concentrations after 15, 30 and 45 days. Inter-orbital distance in percent of head length showed significant ($p>0.05$) decrease in all the concentrations.

With increase of concentration of endosulfan the eye diameter in percent of head length increased (exophathalmia) significantly ($p<0.05$) at all exposure periods. It increased by 6.83% and 8.60% after 15 days; by 8.14% and 9.20% with respect to control value after 30 days and by 30.44% and 37.84% in 0.00075 mg/L and 0.001 mg/L of endosulfan after 45 days with respect to control value (Table 2). The maximum value of eye diameter (24.86 cm) was observed after 45 days of exposure in 0.001 mg/L.

These results are in agreement with earlier workers. Exophthalmia has been observed by Sawhney (1997) [16] in *Channa punctatus* and by Bhatia (1999) [17] in *Heteropneustes fossilis* upon exposure to malathion and endosulfan respectively. Various workers (Van Duijin, 1967 and Malhotra *et al.,* 1978) [18, 19] have reported that exophathalmia is hormone dependent. According to them exophathalmic condition on exposure to toxicant in some fishes is due to the disturbance in hormonal equillibrium of hypophysis.

There are some characters such as maximum body depth and minimum body depth in percentage of total length; eye diameter and inter-orbital distance in percentage of head length which showed significant differences when on exposure to sublethal concentrations of endosulfan for 15, 30 and 45 days. These characters of the test fish *Ctenopharyngodon*

idella (Cuv. and Val.) can be considered as the morphological pollution indicators.

Since the exposure at maximum has been for 45 days in present investigations, the results are in accordance to Howard (1954) [20] who opined that differences in morphometric and meristic characters arise as a result of changes in local environment through genetic variations, which result from natural selection during long periods of geographical isolation. Bhatia (1999) [17] has also mentioned that maximum body depth and minimum body depth in percentage of total length; eye diameter and inter-orbital distance in percentage of head length showed significant differences in *Heteropneustes fossilis* on exposure to sub lethal concentrations of endosulfan for different durations.

4. Conclusions

Data in the present investigations showed that most of the studied morphometric characters of *Ctenopharyngodon idella* (Cuv. and Val.) in control had been within the range of genetically controlled characters or non-plastic characters. Ten characters were studied in percentage of total fish length and five characters have been studied in percentage of head length. There were some characters such as maximum body depth and minimum body depth in percentage of total length; eye diameter, interorbital distance in percentage of head length which show significant differences when exposed to sub lethal concentrations of endosulfan for 15 days, 30 days and 45 days. These characters of *Ctenopharyngodon idella* (Cuv. and Val.) can be considered as the morphological pollution indicators.

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