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Morphometric analysis: A tool to identify green puffer fish *Tetraodon fluviatilis* (Hamilton, 1822) from the Digha coastal region, West Bengal, East coast of India

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Abstract
Tetraodontidae is a family of primarily marine and estuarine fish of the order Tetraodontiformes but some of the species are confined to freshwater environments also. 70 specimens of *Tetraodon fluviatilis* (Hamilton, 1822), commonly known as green puffer fish were collected from the Digha coastal region, West Bengal (between 21°32´N to 22°40´N latitude and 88°05´E to 89°00´E longitude). Morphometric measurements and meristic counts of different size groups of the puffer fishes were studied. All the meristic counts remain constant with increasing body length.

Keywords: *Tetraodon fluviatilis,* green puffer fish, morphometric measurements, meristic count

Introduction
The most important step of taxonomic research is proper identification of a species [1]. Morphometric measurements and meristic counts are known as simplest and genuine methods for the identification of a specimen which can be denoted as morphological systematics [2]. Morphometric studies are not only essential to realize the taxonomy but also the physiological condition of a species in an environment [3]. The shape and structures are unique to the species and the variations in its feature are probably related to the habit and habitat among the variants of this species [4]. Morphometric measurement is measurements of different external body parts of an organism and meristic counts mean anything that can be counted [5]. Genus Tetraodon is based on several phenotypic and osteological characters like laterally expanded sphenotic bone beyond frontal to form a broad flattened lobe, orbital roof scarcely arched, the lateral ethmoid not bent down before the eye, mesethmoid broad, upper lateral line not reaching end of tail, presence of 19 vertebrae, dermal ossifications of back bearing simple prickles, evenly scattered spines on either sides, dorsal fin maximally containing 16 fin rays; nasal organ is an elevated tube [6]. Morphological characters are phenotipically plastic and are influenced each year by the physical environment during spawning and early juvenile stages [7]. Morphometric and meristic study will provide a vigorous tool for measuring discreteness of the same species, therefore all such characters had most commonly used by several ichthyologists for the differentiation of fish species or geographically variants or populations [8]. The study of morphometric relationship can be helpful to identify any particular species or to determine that whether there is any similarity of characters or differences among their male and female fishes. In fish, morphometric characters represent one of the major keys for determining their systematic relationships, growth variability, ontogenetic trails and various other population parameters [8, 9, 10, 11]. Studies on morphometric and meristic characters might have also potential value in taxonomy, conservation and fisheries management [12, 13]. It can also be used to evaluate the influence of various environmental factors, availability of food items and spawning condition on fish [14]. So, morphometric characters are considered as suitable tools for the identification of any fish species, genera or stocks of fish, its habitat as well as the ecological conditions of sea, rivers, lakes etc. [15, 16, 17]. Present study describes the record of occurrence of the freshwater puffer fish, *Tetraodon fluviatilis* (Hamilton, 1822) from the Digha coastal region, West Bengal (between 21°32´N to 22°40´N latitude and 88°05´E to 89°00´E longitude).

Materials and Methods
Study Region
Collection of Puffer fishes were made from the Digha coast (between 21°32´N to 21°45´N latitude and 87°32´E to 87°50´E longitude), in Purba Medinipur District, West Bengal, east coast of India. Three different fishing stations (Figure 1) of this coastal region which were Digha mohona, Sankarpur, Soula (Table 1). This sea coast is situated at the northern end of Bay of Bengal with low gradient and a shallow sand beach [18]. Survey has been carried out trawling and local fishing. Local fishing were made from this coastal region like Digha, Sankarpur, Mandarmoni, Soula, Junput, Rasulpur etc. Length of this coast line is almost 30 - 35 Kilometers.

Table 1: Three Fishing stations with GPS Location from where samples were collected periodically from Digha coast during this survey.

S. No.	Station Name	GPS Location
Station 1	Digha mohona	21°37´N latitude and 87°32´E longitude
Station 2	Sankarpur	21°38´N latitude and 87°34´E longitude
Station 3	Soula	21°44´N latitude and 87°50´E longitude

Fig 1: Satellite image of study region and three fish landing centers (**Station 1**- Digha mohona, **Station 2** - Sankarpur, **Station 3** - Soula) along Digha coastal region, West Bengal, east coast of India. (Source – Google Earth)

Sample Collection: Samples had been collected for three years (January, 2013 - January, 2016). Immediately after the collection, the fishes were photographed for their original colour and shape of puffer fish species. For the purpose of photograph "Nikon Coolpix L 24" was used, made by Nikon Corporation, Japan (14.0 Megapixel, 3.6 X optical zoom). After collection the samples were kept in different ice boxes according to their length and weight. Then the samples were brought to the laboratory and immediately washed. After transfer to the laboratory, the fishes were preserved in 10% neutralized formalin for identification up to the species level. For each specimen, total length (TL) was then measured along with all morphometric parameters by digital caliper to the nearest 0.1 mm, and body weight measured with an electronic balance to 0.01 g. Details of morphometric measurements and meristic counts were recorded along with their means and standard deviation, using SPSS (13.0) software [19]. Because of the variation in size of fish, morphometric data was statistically adjusted to permit comparative analysis in terms of shape independent of size. Terminology used in the morphological description of puffer fish shown in figure 2 [20, 21]. Total 70 fishes were divided into two groups according to their size.

Group A: 2.0 - 5.99 cm (35 Specimens)
Group B: 6.0 - 12.0 cm (35 Specimens)

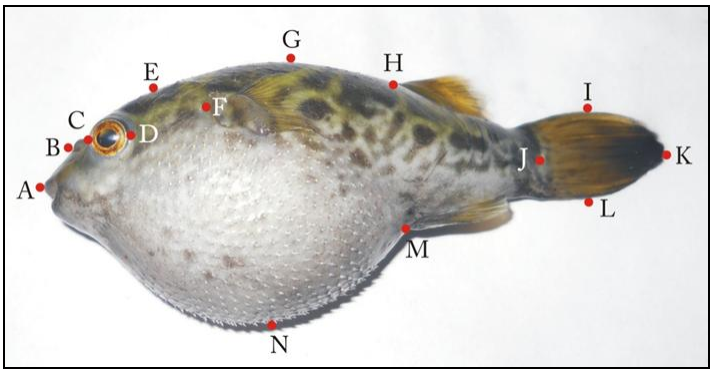

Fig 2: Process of taking morphometric measurements of *Tetraodon fluviatilis* (Hamilton, 1822) in which parameters are AK = Total length (TL) = Fork length (FL), AJ = Standard length (SL), GN = Body depth (BD), AC = Pre Orbital Length (POL), AB = Snout Length, CD = Orbital diameter (OD), AE = Head Length (HL), AH = Pre Dorsal Length (PDL), AF = Pre Pectoral Length (PPL), AM = Pre Anal Length (PAL), JK = Caudal fin length (CL), IL = Caudal fin height (CH).

Results and Discussions

According to morphometric analysis the present specimens have greatest resemblance to the above descriptions based on:

1. Rosette shaped nasal organ is very prominent with spongy tissue.
2. Head length is almost 2.4 – 2.6 times greater than Snout length (Table 2 and Fig 1).
3. Standard length is almost 2.4 times greater than head length (Table 2 and Fig 1).
4. Inter – orbital space is convex, without a groove (Fig 3A).
5. Mouth is terminal, directed forwards (Fig 3A).
6. Three large yellowish dark patches encircled on back, middle patch is situated between pectoral fins, posterior patch in front of dorsal fin (Fig 3B).

3A **3B**

Fig 3: Lateral view (Fig 3A) and Dorsal view (Fig 3B) of *Tetraodon fluviatilis* (Hamilton, 1822)

Meristic counts also show similarities with existing data provided by Dekkers i.e. dorsal fin ray 13 , pectoral fin ray 21, anal fin ray 11 (Table – 3). The meristic counts were independent of body size [5, 21, 22]. The correlation between different morphometric measurements of *Tetraodon fluviatilis* are given in Table 4.

Table 2: Morphometric measurements (cm) of Juvenile (Group A) and Adult (Group B) *Tetraodon fluviatilis* (Hamilton, 1822) along with their mean and Standard Deviations.

Parameters	Group - a	GROUP - B
Total length (TL=FL)	3.45 ± 0.2028	9.57 ± 0.8797
Standard length (SL)	2.66 ± 0.1586	7.68 ± 0.6145
Body depth (BD)	1.03 ± 0.0758	3.16 ± 0.2113
Pre orbital length (POL)	0.31 ± 0.0224	0.81 ± 0.0019
Post orbital length of Head (PHL)	0.37 ± 0.0112	1.13 ± 0.0578
Orbital diameter (OD)	0.43 ± 0.0240	0.69 ± 0.0257
Head length (HL)	1.11 ± 0.0490	2.61 ± 0.1396
Snout length (SnL)	0.46 ± 0.0013	1.06 ± 0.0658
Pre Dorsal Length (PDL)	1.98 ± 0.1128	5.54 ± 0.4789
Pre Pectoral Length (PPL)	1.21 ± 0.1412	2.99 ± 0.1656
Pre Anal Length (PAL)	2.02 ± 0.1134	5.43 ± 0.3212
Caudal fin length (CL)	0.77 ± 0.0039	2.05 ± 0.0112
Caudal fin height (CH)	0.67 ± 0.0241	2.93 ± 0.1112

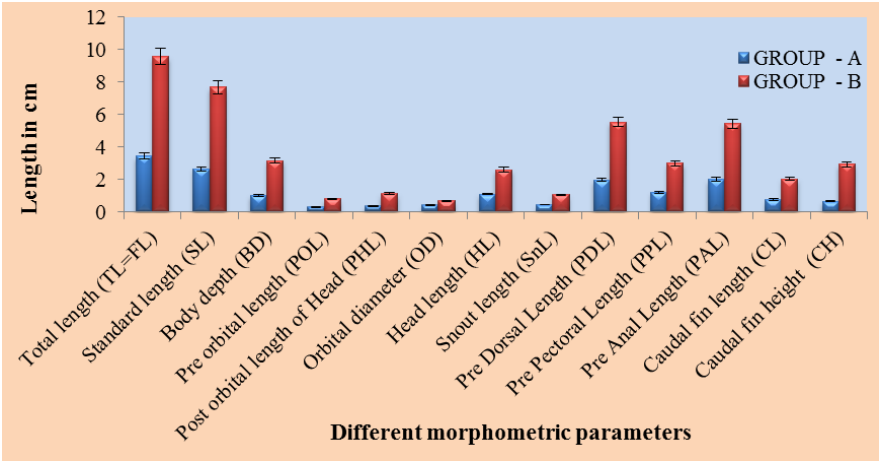

Fig 4: Showing morphometric measurements of Juvenile (Group A) and Adult (Group B) *Tetraodon fluviatilis* (Hamilton, 1822).

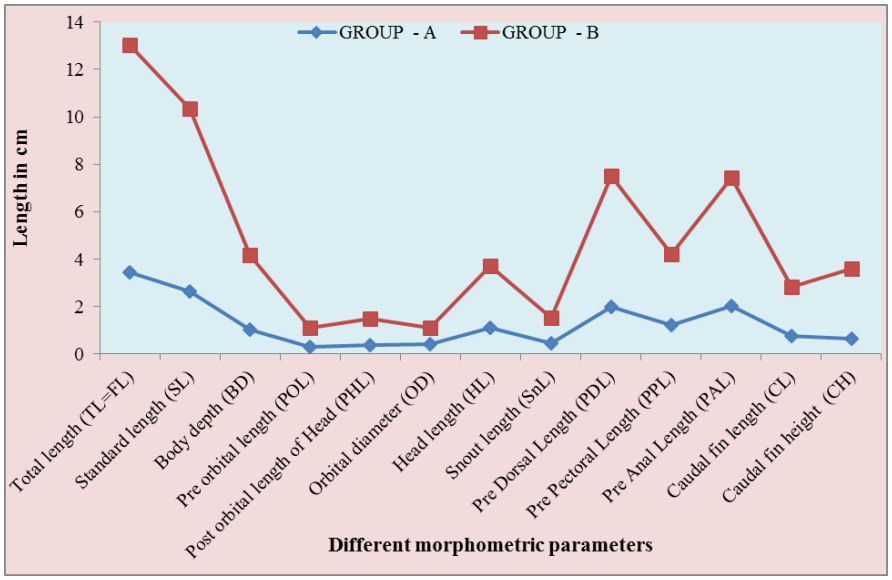

Fig 5: Comparison of Morphometric measurements of Juvenile (Group A) and Adult (Group B) *Tetraodon fluviatilis* (Hamilton, 1822).

Table 3: Meristic counts of adult and juvenile *Tetraodon fluviatilis* (Hamilton, 1822)

Distribution Group	Meristic Counts			
	Dorsal Fin rays	Pectoral Fin rays	Anal Fin rays	Caudal Fin rays
Adults	13	21	11	11
Juveniles	13	21	11	11

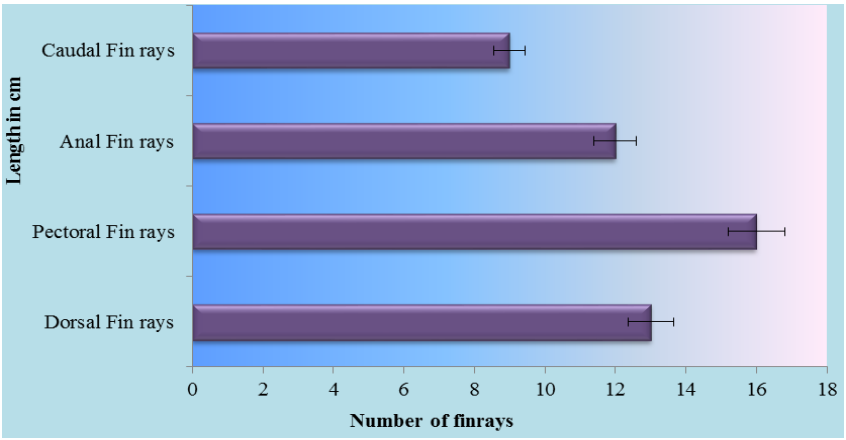

Fig 6: Meristic counts of adult and juvenile *Tetraodon fluviatilis* (Hamilton, 1822)

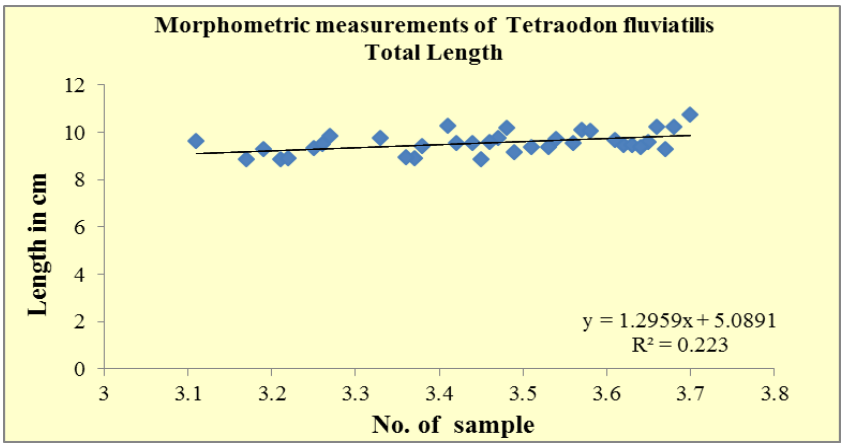

Fig 7: Correlation curve of total length of *Tetraodon fluviatilis* (Hamilton, 1822)

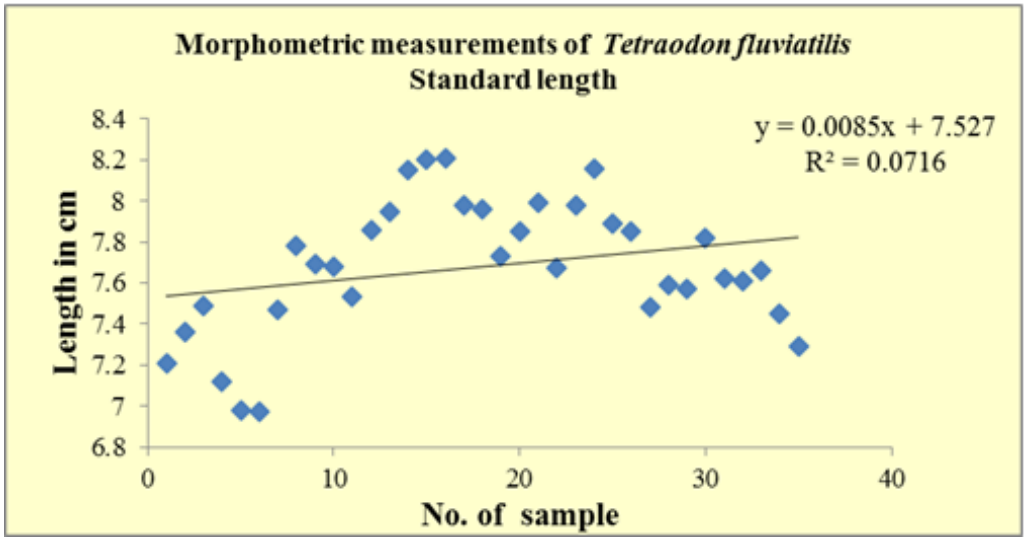

Fig 8: Correlation curve of standard length of *Tetraodon fluviatilis* (Hamilton, 1822)

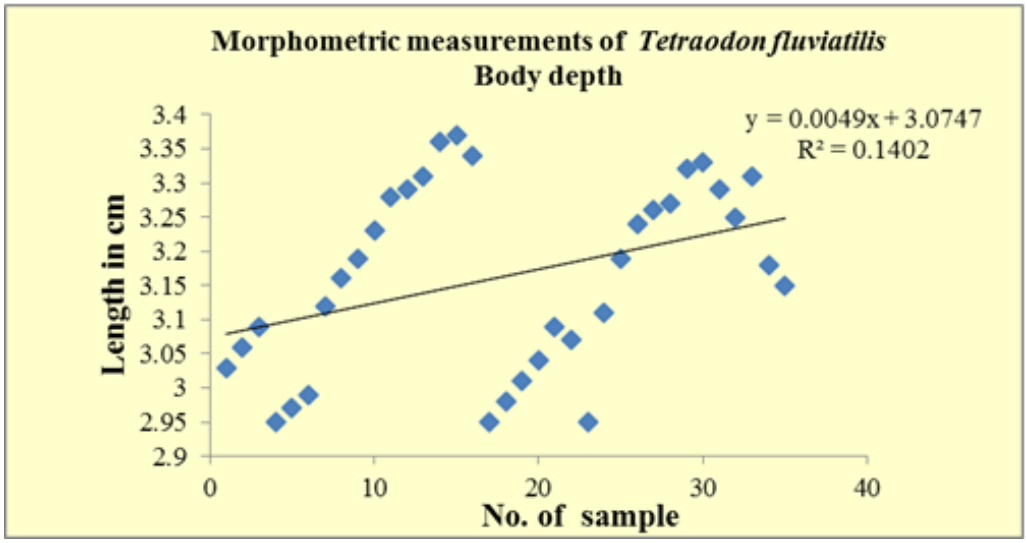

Fig 9: Correlation curve of body depth of *Tetraodon fluviatilis* (Hamilton, 1822)

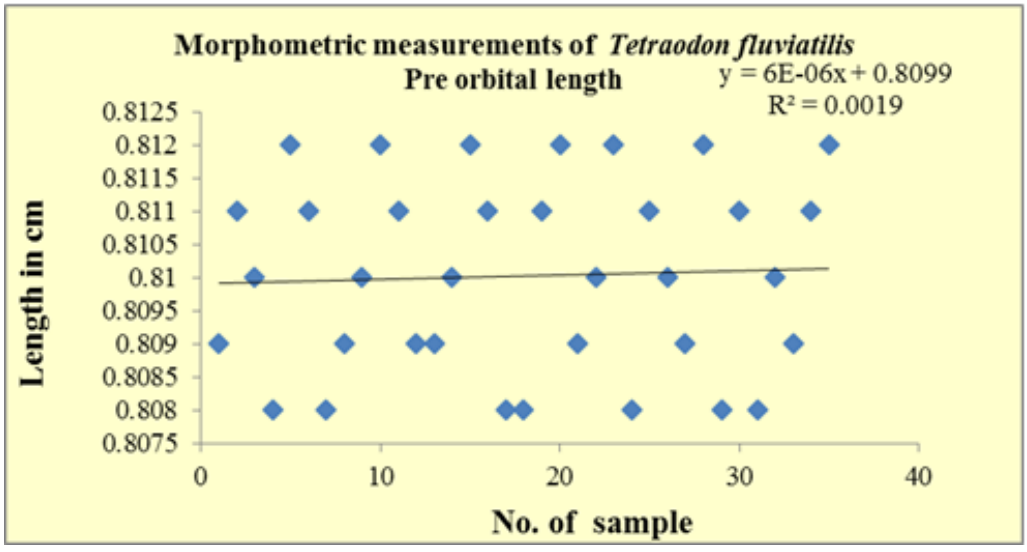

Fig 10: Correlation curve of pre orbital length of *Tetraodon fluviatilis* (Hamilton, 1822)

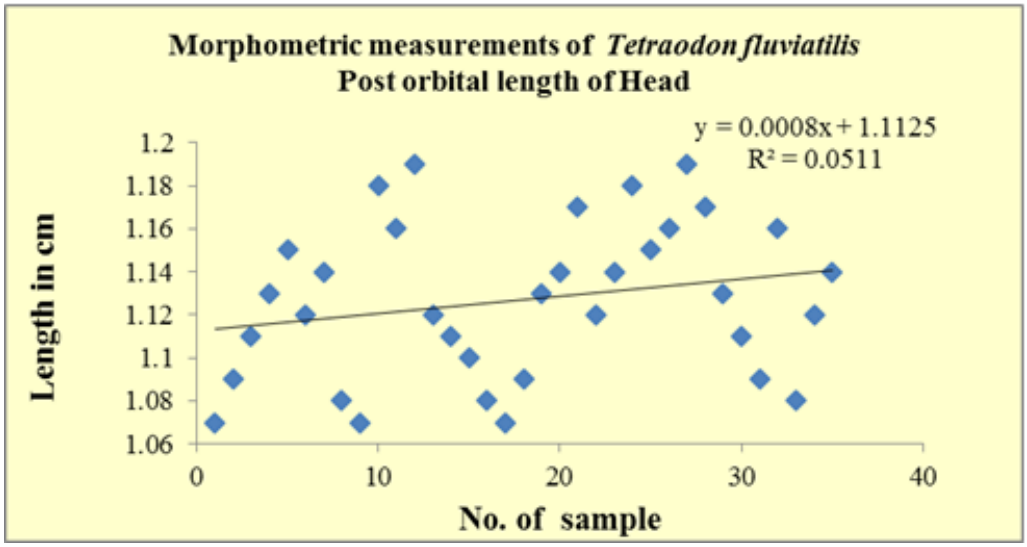

Fig 11: Correlation curve of post orbital length of head of *Tetraodon fluviatilis* (Hamilton, 1822)

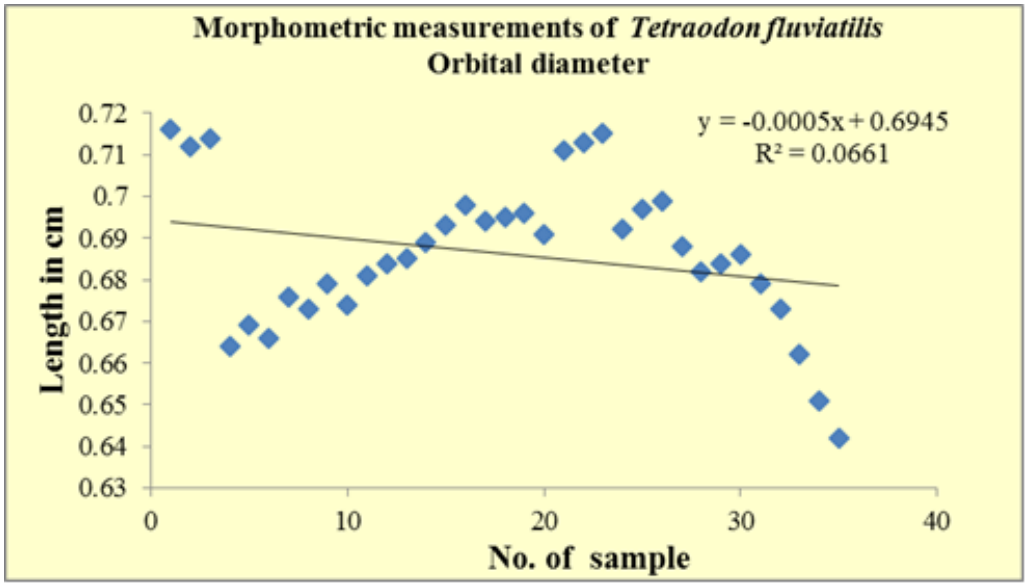

Fig 12: Correlation curve of orbital diameter of *Tetraodon fluviatilis* (Hamilton, 1822)

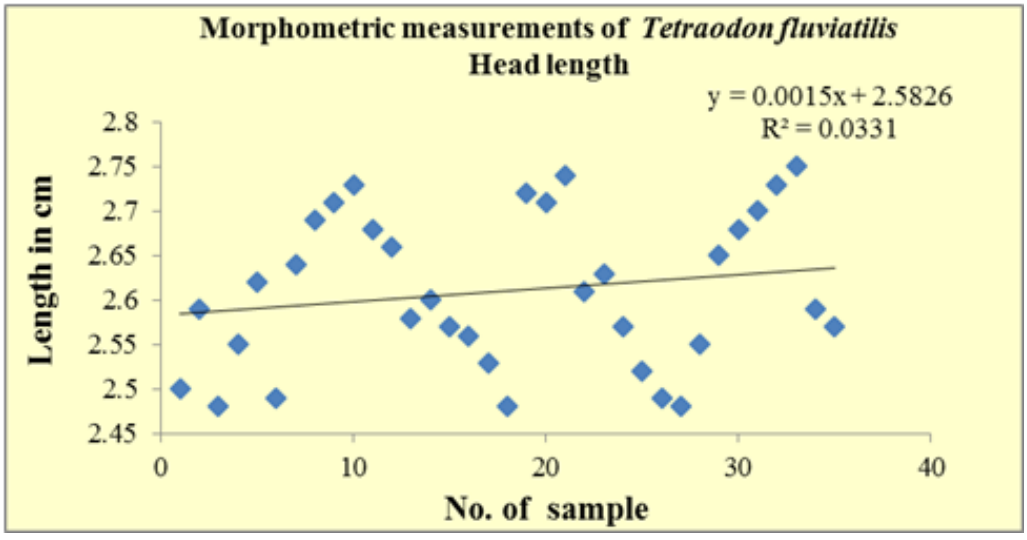

Fig 13: Correlation curve of head length of *Tetraodon fluviatilis* (Hamilton, 1822)

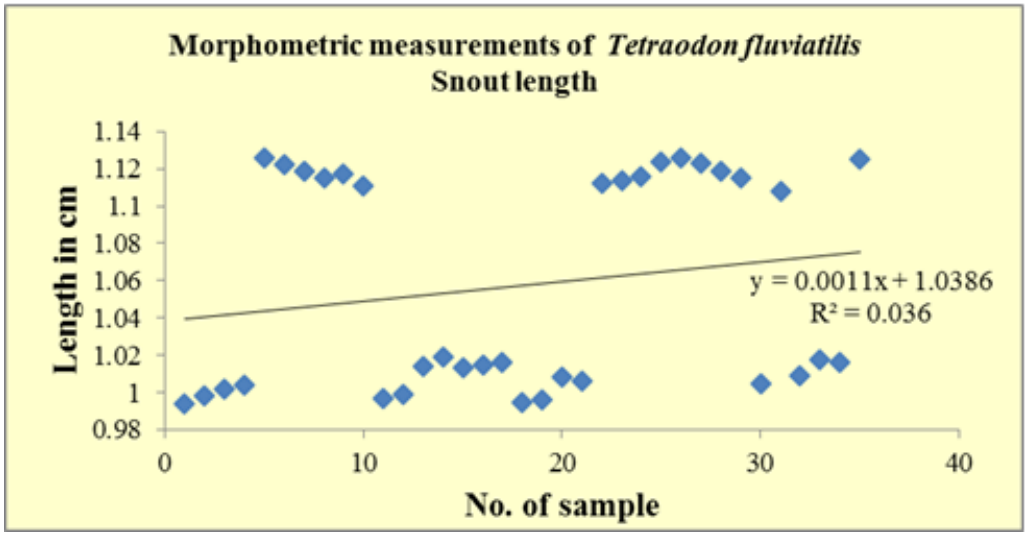

Fig 14: Correlation curve of snout length of *Tetraodon fluviatilis* (Hamilton, 1822)

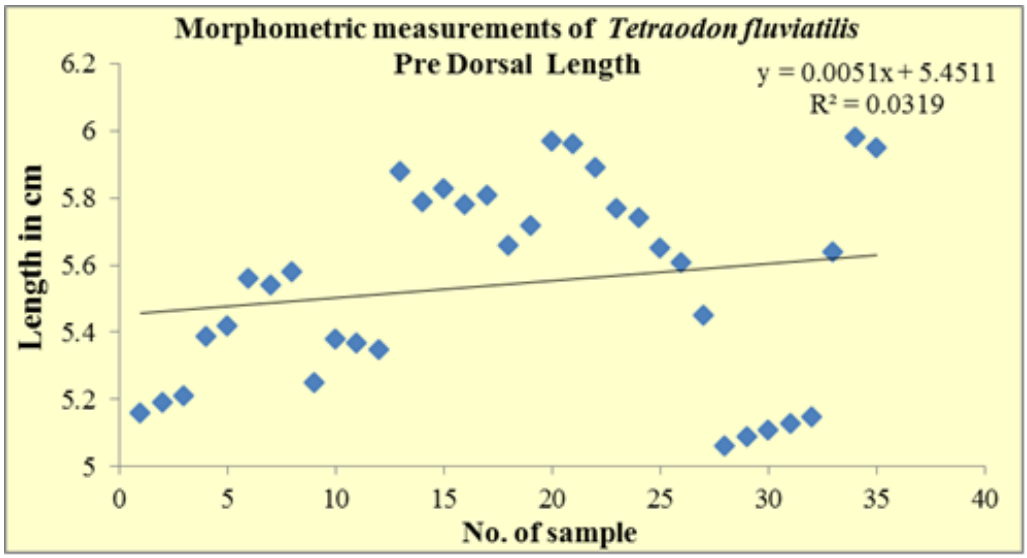

Fig 15: Correlation curve of pre dorsal length of *Tetraodon fluviatilis* (Hamilton, 1822)

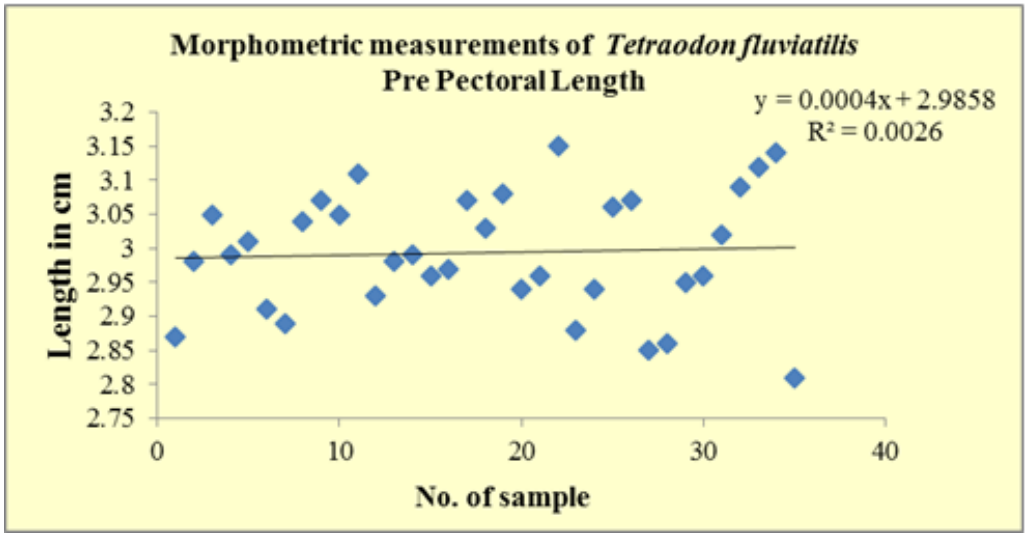

Fig 16: Correlation curve of pre pectoral length of *Tetraodon fluviatilis* (Hamilton, 1822)

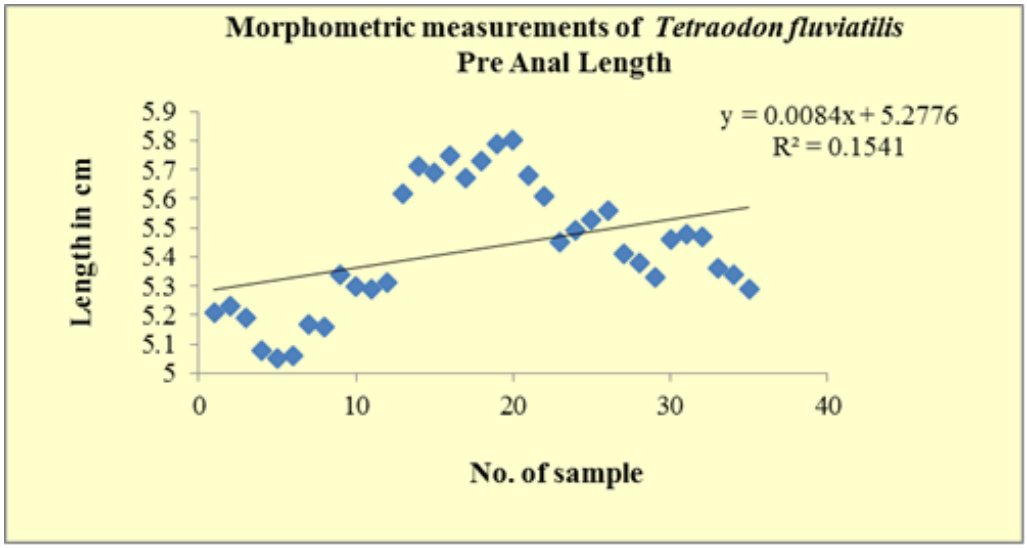

Fig 17: Correlation curve of pre anal length of *Tetraodon fluviatilis* (Hamilton, 1822)

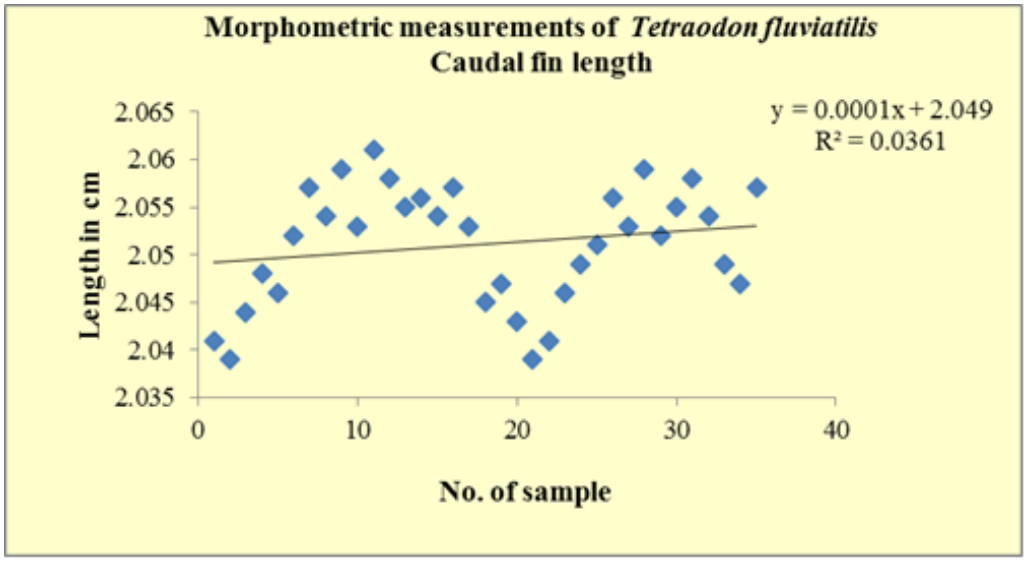

Fig 18: Correlation curve of caudal fin length of *Tetraodon fluviatilis* (Hamilton, 1822)

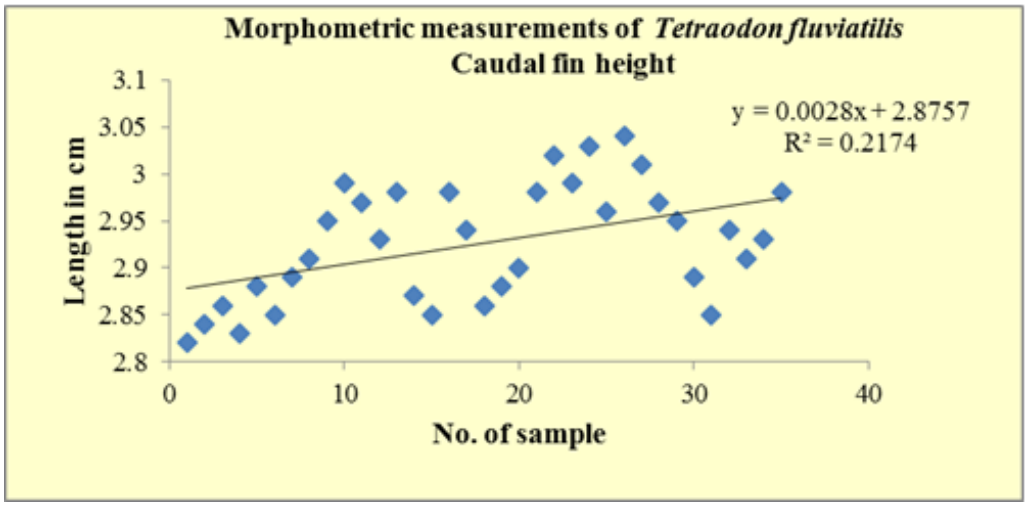

Fig 19: Correlation curve of caudal fin height of *Tetraodon fluviatilis* (Hamilton, 1822)

Table 4: Correlation between different morphometric measurements of *Tetraodon fluviatilis* (Hamilton, 1822) Total length (TL) = Fork length (FL), Standard length (SL), Body depth (BD), Pre Orbital Length (POL), Snout Length (SnL), Orbital diameter (OD), Head Length (HL), Pre Dorsal Length (PDL), Pre Pectoral Length (PPL), Pre Anal Length (PAL), Caudal fin length (CL), Caudal fin height (CH).

SL-BD	SL-POL	SL-PHL	SL-OD	SL-HL	SL-SnL	SL-PDL	SL-PPL	SL-PAL	SL-CL	SL-CH
0.373832	-0.0794	-0.03768	0.401862	0.132841	-0.19538	0.414556	0.119951	0.800419	0.158802	0.365595

Conclusion

The morphometric measurements and meristic counts confirmed that the test organism is *Tetraodon fluviatilis* from the Digha coastal region of West Bengal, east coast of India.

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