

# Morphometric and meristic characterisation of *Chrysochir aurea* (Richardson, 1846) from West Bengal coast, India

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## Abstract

The morphometric and meristic characteristics of Reeve's croaker *Chrysochir aurea* (Richardson, 1846) from the West Bengal coast of India were analysed by examining 618 specimens (286 males and 332 females) ranging from 124 to 417 mm in length collected monthly between September 2021 and September 2022. The present investigation, which is the first of its kind, revealed comprehensive morphological variation and sex-based morphological differentiation of *C. aurea*. Compared to the total length of the fish, the standard length ( $b=0.879$ ) had the fastest growth rate, while the second anal spine length ( $b=0.039$ ) had the slowest. Compared to head length, post-orbital length ( $b=0.635$ ) and eye diameter ( $b=0.114$ ) had the fastest and slowest growth rates, respectively. A high degree of significant ( $p<0.01$ ) positive correlation was observed among different morphometric characters of *C. aurea* in relation to total length or head length. Among 13 meristic counts, the coefficient of variation was found to be highest in arborescent appendages (3.78%) and lowest in the dorsal fin spine (0.40%). The fin formula of *C. aurea* based on the meristic counts from the present study can be described as D. X-XI/I/25-28, P. i 16-18, V. I/5, A. 2/7, C. 16-18. The current study also revealed the presence of 24 to 29 pairs of arborescent appendages along the edges of the gas bladder and 7 to 9 gill rakers in the first gill arch on the left side. The results indicated a high degree of homogeneity within the population of *C. aurea* occurring on the coast of West Bengal.



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## Introduction

Sciaenids, commonly known as croakers, grunters and jewfishes under the family Sciaenidae, generally, inhabit muddy bottoms of coastal waters. With a high alpha-diversity, they form an important commercial fishery along the Indian and the West Bengal coasts contributing to about 3 and 7% of the total catch, respectively (CMFRI, 2022). Among the Indian demersal fish landings, maximum contribution of about 22-25% is generally from sciaenids (CMFRI, 2022). The sciaenid resources are predominantly exploited by mechanised multiday trawlers.

The family Sciaenidae is represented by 299 valid species (Fricke *et al.*, 2023) that

are distributed in the Indian, Pacific and Atlantic Oceans. In the Indian Ocean, there are 49 species of sciaenids belonging to 22 genera (Talwar, 1995) of which 37 species belonging to 20 genera, inhabit the Indian seas (Froese and Pauly, 2023). The number of sciaenid species reported from the West Bengal coast varied between 7 and 20 (Chatterjee *et al.*, 2000; Kar *et al.*, 2017; Jana, 2019; Bhakta and Das, 2021).

Morphological and meristic characteristics play a crucial role not only in taxonomic identification of species but also in studying population parameters, growth variability and delineation of fish stocks (Lourie *et al.*, 1999; Murta, 2000; Silva, 2003; Jayasankar *et al.*, 2004; Turan, 2004; Bhakta *et al.*, 2022). They also help to measure the discreteness and relationships among

various taxa, describing their spatial distributions (Ihssen *et al.*, 1981). Morphometric traits are continuous characters that measure different body parts, whereas meristic traits are the number of discrete variables that are enumerable and are fixed during embryonic and larval development (Kumar *et al.*, 2012; Bhakta *et al.*, 2020). Statistical analysis of morphometric traits provides a better understanding of species relationships, as well as the ability to compare the same species across different geographic regions (Bhakta *et al.*, 2020). Therefore, the individuals of a species having sufficiently uniform morphological characters are under the same stock. There is a need for single-stock management since each stock that contributes to a mixed fishery may react differently to exploitation or environmental disturbances and may display asynchronous year-class production (Waldman *et al.*, 1988).

The findings on morphometric and meristic analyses of different species of croakers from Indian waters are reported by Basu (1975) on *Otolithes argenteus* from Mumbai; Gandhi (1982) on *Pennahia anea* (= *aneus*) from Porto Novo; Pillai (1983) on *Otolithes ruber* from Porto Novo; Gulati (1987) on *Otolithes cuvieri* from Bombay; Jayasankar (1989) on *Nibea maculata* from Mandapam; Manojkumar and Acharya (1990) on *Otolithoides biauritus* from Bombay; Chakraborty (1992) on *O. cuvieri*, *Johnius macrorhynchus* and *Johnius vogleri* (= *borneensis*) from Bombay; Bhuyan (2003) on *Johnius carutta*, *Pennahia macrophthalmus* and *O. ruber* from Odisha coast; Kumar (2012) on *Johnieops sina* from Ratnagiri; Sandhya *et al.* (2015) on *O. cuvieri* from Maharashtra; Sanphui *et al.* (2018) on *Panna heterolepis* from the Hooghly River, West Bengal; Bhakta (2020) on *Otolithoides pama* from Hooghly Matlah Estuary, West Bengal; Kumari *et al.* (2020) on *O. cuveiri* and *O. ruber* from Maharashtra coast.

*Chrysochir aurea* (Richardson, 1846), commonly known as Reeve's croaker and locally known as 'lal bhola' in West Bengal, is one of the commercially important and widespread species in the

Indo-West Pacific that mainly inhabits the coastal marine and brackishwaters. The species is primarily found from Sri Lanka, through the Bay of Bengal, to southern China (including Taiwan) and the southern part of Indonesia and Malaysia. However, no detailed and comprehensive studies on the morphometrics, meristics, population parameters and fish biology of *C. aurea* have ever been reported in Indian waters where this resource significantly contributes to the trawl landings. The current study, the first of its kind, is aimed to ascertain its morphometric and meristic characteristics along the West Bengal coast, India.

## Materials and methods

During the present study, a total of 618 specimens of *C. aurea* ranging from 124 to 417 mm in total length and 15.06 to 958.37 g in total weight were collected from the Digha landing centre (21°35'N, 69°36'E) of the West Bengal coast, India from September 2021 to September 2022. A total of 286 specimens were males and 332 specimens were females ranging from 124 to 376 and 131 to 417 mm in total length, respectively (Table 1). Sex was determined in fresh condition by the appearance of the gonads and colour pattern.

The species was mainly caught by trawl net with mesh sizes varying between 18 and 22 mm. The total length of all individuals was measured from the tip of the snout to the tail to the nearest 0.1 mm and weight was taken with an electronic balance to an accuracy of 0.01 g. A total of nineteen morphometric (Fig. 1) and thirteen meristic traits were studied following the standard methods described by Laevastu (1965), Lowe-McConnel (1971), Dwivedi and Menezes (1974) and Grant and Spain (1977). Scatter diagrams were plotted and then the linear regression equation ( $Y=a+bX$ ;  $Y$ =dependent variable,  $X$ =independent variable,  $a$ =intercept,  $b$ =regression coefficient or slope) was fitted using the least square

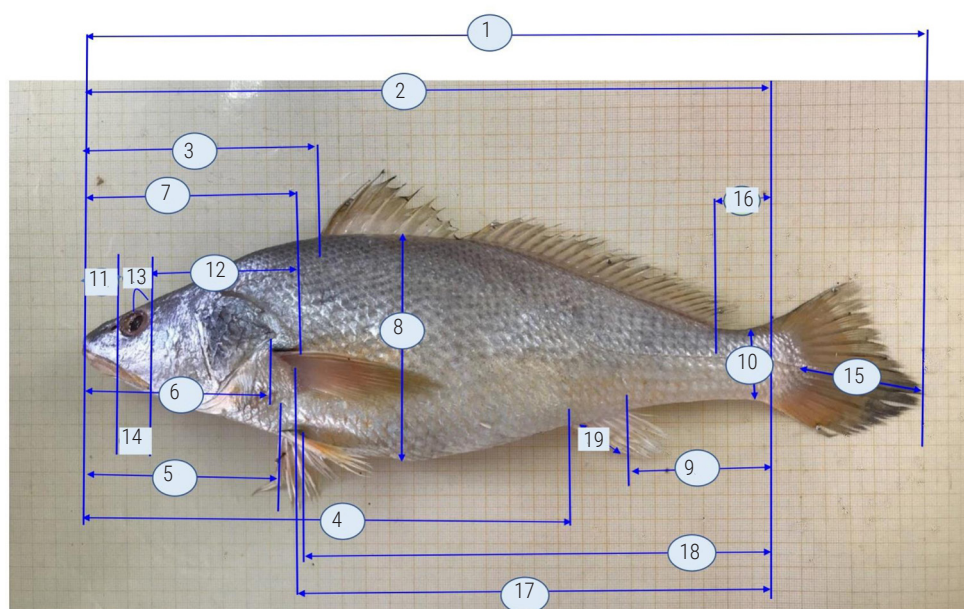


Fig. 1. Morphometric characters of *C. aurea*. 1. Total length (TL), 2. Standard length (SL), 3. Pre-dorsal length (PDL), 4. Pre-anal length (PAL), 5. PPvL = Pre-pelvic length (PPvL), 6. Pre-pectoral length (PPeL), 7. Head length (HL), 8. Body depth (BD), 9. Caudal length (CL), 10. Caudal depth (CD), 11. Snout length (SNL), 12. Post-orbital length (POL), 13. Inter-orbital length (IOL), 14. Eye diameter (ED), 15. Caudal fin length (CFL), 16. Post-dorsal fin base length (PoDFBL), 17. Post-pectoral fin length (PoPeL), 18. Post-pelvic length (PoPvL), 19. Second anal spine length (IINDASL)

Table 1. Statistical estimates of various morphometric characters of *C. aurea* off the coast of West Bengal

| Morphometric characters | Male (n=286) |              |                |        | Female (n=332) |              |                |        | t' value | Pooled (n=618) |              |                |        |
|-------------------------|--------------|--------------|----------------|--------|----------------|--------------|----------------|--------|----------|----------------|--------------|----------------|--------|
|                         | Range (mm)   | Mean±SD (mm) | Standard error | CV (%) | Range (mm)     | Mean±SD (mm) | Standard error | CV (%) |          | Range (mm)     | Mean±SD (mm) | Standard error | CV (%) |
| TL                      | 124-376      | 226.08±47.37 | 2.80           | 20.95  | 131-417        | 216.92±41.37 | 2.27           | 19.07  | 2.541*   | 124-417        | 221.16±44.45 | 1.79           | 20.10  |
| SL                      | 98-323       | 183.23±41.79 | 2.47           | 22.81  | 102-354        | 175.30±36.31 | 1.99           | 20.72  | 2.498*   | 98-354         | 178.97±39.11 | 1.57           | 21.85  |
| PDL                     | 33-108       | 64.12±14.86  | 0.88           | 23.18  | 32-152         | 61.67±14.03  | 0.77           | 22.75  | 2.094*   | 32-152         | 62.80±14.46  | 0.58           | 23.03  |
| PAL                     | 50-221       | 123.69±28.63 | 1.69           | 23.15  | 50-245         | 118.20±25.06 | 1.38           | 21.20  | 2.624**  | 50-245         | 120.74±26.89 | 1.08           | 22.27  |
| PPvL                    | 31-197       | 57.52±14.49  | 0.86           | 25.18  | 32-122         | 56.09±12.73  | 0.70           | 22.69  | 1.289    | 31-197         | 56.75±13.58  | 0.55           | 23.92  |
| PPeL                    | 29-195       | 54.83±14.27  | 0.84           | 26.03  | 21-121         | 53.54±12.45  | 0.68           | 23.26  | 1.188    | 21-195         | 54.14±13.33  | 0.54           | 24.62  |
| HL                      | 30-90        | 55.69±12.06  | 0.71           | 21.65  | 31-111         | 53.85±10.96  | 0.60           | 20.36  | 1.968*   | 30-111         | 54.70±11.51  | 0.46           | 21.04  |
| BD                      | 23-97        | 51.51±12.97  | 0.77           | 25.17  | 28-111         | 49.53±11.96  | 0.66           | 24.16  | 1.965*   | 23-111         | 50.45±12.47  | 0.50           | 24.71  |
| CL                      | 24-74        | 44.55±9.80   | 0.58           | 21.99  | 25-78          | 42.32±8.91   | 0.49           | 21.05  | 2.938**  | 24-78          | 43.35±9.39   | 0.38           | 21.65  |
| CD                      | 9-34         | 18.49±4.54   | 0.27           | 24.54  | 8-38           | 17.79±4.13   | 0.23           | 23.23  | 1.975    | 8-38           | 18.11±4.33   | 0.17           | 23.93  |
| SNL                     | 7-41         | 19.55±9.44   | 0.56           | 48.28  | 8-50           | 19.12±8.83   | 0.48           | 46.18  | 0.580    | 7-50           | 19.32±9.11   | 0.37           | 47.16  |
| POL                     | 7-57         | 26.78±11.69  | 0.69           | 43.67  | 6-73           | 25.32±11.36  | 0.62           | 44.86  | 1.568    | 6-73           | 25.99±11.53  | 0.46           | 44.35  |
| IOL                     | 5-21         | 11.32±2.80   | 0.17           | 24.75  | 6-24           | 10.80±2.49   | 0.14           | 23.01  | 2.425*   | 5-24           | 11.04±2.65   | 0.11           | 23.98  |
| ED                      | 5-16         | 9.39±2.03    | 0.12           | 21.63  | 4-31           | 9.38±2.57    | 0.14           | 27.37  | 0.084    | 5-18           | 9.34±1.97    | 0.08           | 21.07  |
| CFL                     | 10-91        | 42.80±9.33   | 0.55           | 21.80  | 8-90           | 41.49±8.70   | 0.48           | 20.97  | 1.790    | 8-91           | 42.10±9.01   | 0.36           | 21.41  |
| PoDFBL                  | 9-35         | 20.10±4.72   | 0.28           | 23.46  | 2-36           | 19.07±4.32   | 0.24           | 22.67  | 2.814**  | 8-36           | 19.58±4.48   | 0.18           | 22.88  |
| PoPeL                   | 70-238       | 133.24±31.04 | 1.84           | 23.30  | 73-252         | 126.70±26.91 | 1.48           | 21.24  | 2.776**  | 70-252         | 129.73±29.06 | 1.17           | 22.40  |
| PoPvL                   | 69-235       | 129.90±30.64 | 1.81           | 23.59  | 71-250         | 123.14±26.60 | 1.46           | 21.60  | 2.905**  | 69-250         | 126.27±28.72 | 1.16           | 22.74  |
| IINDASL                 | 8-21         | 13.14±2.13   | 0.13           | 16.18  | 8-22           | 12.67±1.94   | 0.11           | 15.35  | 2.896**  | 8-22           | 12.89±2.04   | 0.08           | 15.86  |

\* significant at  $p < 0.05$ , \*\* significant at  $p < 0.05$  and  $p < 0.01$

TL= Total length, SL= Standard length, PDL= Pre-dorsal length, PAL= Pre-anal length, PPvL= Pre-pelvic length, PPeL= Pre-pectoral length, HL= Head length, BD= Body depth, CL= Caudal length, CD= Caudal depth, SNL= Snout length, POL= Post-orbital length, IOL= Inter-orbital length, ED= Eye diameter, CFL= Caudal fin length, PoDFBL= Post-dorsal fin base length, PoPeL= Post-pectoral fin length, PoPvL= Post-pelvic length, IINDASL=Second anal spine length

method (Laevestu, 1965; Snedecor and Cochran, 1967) for the analysis of morphometric characters.

Meristic characters included the number of spines on dorsal, pelvic and anal fins; the number of fin rays on dorsal, pectoral, pelvic, anal and caudal fins; number of rostral, marginal and mental pores, number of arborescent appendages along the side of gas bladder and gill rakers from the first gill arch. The first-gill arch was taken from the left operculum for the count of gill rakers. The characters were counted using a magnifying lens and needle to separate the rays.

Mean, range, standard deviation, standard error and coefficient of variation were calculated for both morphometric and meristic characters. Student's t-test was performed to see if there are any significant differences in mean morphometric characters between the sexes. Analysis of covariance (Snedecor and Cochran, 1967) was done to determine the variation in the 'b' values between the sexes ( $p < 0.05$ ). All the statistical estimates were done by using Microsoft Excel 2021 and SPSS version 21.0 (Statistical Package for the Social Sciences).

## Results and discussion

The descriptive statistics like mean, range, standard deviation, standard error and coefficient of variation of various morphometric characters of *C. aurea* is presented in Table 1. The correlation

coefficient (r) value ranged between 0.679 and 0.994 indicating all morphometric characteristics of *C. aurea* have high degree of positive ( $r > 0.5$ ) and significant correlation ( $p < 0.01$ ) when compared with total length and head length (Table 2 and Fig. 2a-r). The correlation of different morphometric values of *C. aurea* is presented in Table 3.

Among the various morphometric characters studied, standard length ( $r = 0.994$ ), pre-anal length ( $r = 0.991$ ) and post-pectoral fin length ( $r = 0.990$ ) showed a very high degree of positive correlation with total length, while caudal fin length ( $r = 0.845$ ) showed the minimum (Table 2). Correlation coefficient was found to be maximum with post-orbital length ( $r = 0.984$ ) and minimum with eye diameter ( $r = 0.679$ ) in relation to head length of *C. aurea* (Table 2.). According to Manojkumar and Acharya (1990), anal length had the highest and pectoral length had the lowest correlations when compared to total length, while orbital width and snout length had the highest and lowest correlations with head length in *O. biauritus* from the waters of Bombay. Chakraborty (1992) reported high degree of correlation between standard length and total length in *O. cuvieri* and *J. vogleri* from Bombay waters, which is in accordance with the current study. Many researchers are of the opinion that all body parts grow proportionately with total length (Basu, 1975; Rawat and Agarwal, 2003; Dobariyal et al., 2006; Bhakta et al., 2020). Correlation coefficient of head length was minimum with eye diameter and maximum with post-orbital length (Sandhya

Table 2. Linear regression of various morphometric measurements of *C. aurea* against total length and head length (pooled; n=618)

| Sl. No. | Morphometric characters                      | Linear regression equation (Y= a+bX) | 'r'   | 'p' value resulted from ANCOVA |
|---------|----------------------------------------------|--------------------------------------|-------|--------------------------------|
| 1.      | Standard length and total length             | Y= -14.891+0.879X                    | 0.994 | 0.983                          |
| 2.      | Pre-dorsal length and total length           | Y= -5.941+0.310X                     | 0.987 | 0.449                          |
| 3.      | Pre-anal length and total length             | Y= -10.477+0.594X                    | 0.991 | 0.999                          |
| 4.      | Pre-pelvic length and total length           | Y= -0.072+0.255X                     | 0.980 | 0.999                          |
| 5.      | Pre-pectoral length and total length         | Y= -0.998+0.247X                     | 0.982 | 0.152                          |
| 6.      | Head length and total length                 | Y= -1.692+0.255X                     | 0.985 | 0.999                          |
| 7.      | Body depth and total length                  | Y= -10.051+0.274X                    | 0.975 | 0.999                          |
| 8.      | Caudal length and total length               | Y= -0.747+0.199X                     | 0.948 | 0.999                          |
| 9.      | Caudal depth and total length                | Y= -2.501+0.093X                     | 0.962 | 0.999                          |
| 10.     | Caudal fin length and total length           | Y= 15.557+0.117X                     | 0.845 | 0.999                          |
| 11.     | Post-dorsal fin base length and total length | Y= 0.868+0.085X                      | 0.877 | 0.999                          |
| 12.     | Post-pectoral fin length and total length    | Y= -13.457+0.647X                    | 0.990 | 0.999                          |
| 13.     | Post-pelvic fin length and total length      | Y= -15.002+0.639X                    | 0.988 | 0.999                          |
| 14.     | Second anal spine length and total length    | Y= 4.17+0.039X                       | 0.857 | 0.999                          |
| 15.     | Inter-orbital length and head length         | Y= -0.749+0.215X                     | 0.943 | 0.999                          |
| 16.     | Eye diameter and head length                 | Y= 3.101+0.114X                      | 0.679 | 0.999                          |
| 17.     | Snout length and head length                 | Y= -0.443+0.261X                     | 0.937 | 0.999                          |
| 18.     | Post-orbital length and head length          | Y= -3.443+0.635X                     | 0.984 | 0.700                          |

Table 3. Correlation matrix of different morphometric values of *C. aurea* (n=618)

|         | TL    | SL     | PDL    | PAL    | PPvL   | PPeL   | HL     | BD     | CL     | CD     | SNL     | POL    | IOL    | ED     | CFL    | PoDFBL | PoPeL  | PoPvL  | IINDASL |
|---------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|--------|--------|--------|--------|--------|--------|--------|---------|
| TL      | 1.000 | .994** | .987** | .991** | .980** | .982** | .985** | .975** | .948** | .962** | .937**  | .984** | .943** | .679** | .845** | .877** | .990** | .988** | .857**  |
| SL      | -     | 1.000  | .927** | .982** | .853** | .843** | .981** | .974** | .934** | .947** | .260**  | .672** | .941** | .579** | .528** | .859** | .985** | .980** | .851**  |
| PDL     | -     | -      | 1.000  | .909** | .805** | .798** | .934** | .911** | .881** | .896** | .270**  | .607** | .882** | .586** | .572** | .811** | .921** | .917** | .818**  |
| PAL     | -     | -      | -      | 1.000  | .856** | .848** | .978** | .972** | .940** | .939** | .284**  | .647** | .938** | .605** | .609** | .861** | .984** | .984** | .846**  |
| PPvL    | -     | -      | -      | -      | 1.000  | .992** | .855** | .851** | .796** | .811** | .259**  | .555** | .821** | .529** | .545** | .760** | .855** | .855** | .738**  |
| PPeL    | -     | -      | -      | -      | -      | 1.000  | .847** | .845** | .786** | .803** | .244**  | .559** | .815** | .534** | .546** | .737** | .846** | .848** | .731**  |
| HL      | -     | -      | -      | -      | -      | 1.000  | .969** | .932** | .945** | .301** | .645**  | .939** | .639** | .639** | .607** | .848** | .975** | .973** | .848**  |
| MBD     | -     | -      | -      | -      | -      | -      | 1.000  | .928** | .952** | .283** | .636**  | .928** | .608** | .608** | .583** | .846** | .972** | .972** | .848**  |
| CL      | -     | -      | -      | -      | -      | -      | -      | 1.000  | .929** | .241** | .639**  | .908** | .581** | .616** | .867** | .950** | .950** | .814** |         |
| CD      | -     | -      | -      | -      | -      | -      | -      | -      | 1.000  | .281** | .624**  | .917** | .594** | .571** | .839** | .948** | .950** | .826** |         |
| SNL     | -     | -      | -      | -      | -      | -      | -      | -      | -      | 1.000  | -.514** | .209** | .242** | .446** | .099*  | .301** | .316** | .278** |         |
| POL     | -     | -      | -      | -      | -      | -      | -      | -      | -      | -      | 1.000   | .677** | .289** | .169** | .685** | .631** | .617** | .532** |         |
| IOL     | -     | -      | -      | -      | -      | -      | -      | -      | -      | -      | -       | 1.000  | .548** | .558** | .830** | .937** | .933** | .806** |         |
| ED      | -     | -      | -      | -      | -      | -      | -      | -      | -      | -      | -       | -      | 1.000  | .474** | .512** | .605** | .617** | .557** |         |
| CFL     | -     | -      | -      | -      | -      | -      | -      | -      | -      | -      | -       | -      | -      | 1.000  | .510** | .603** | .609** | .544** |         |
| PoDFBL  | -     | -      | -      | -      | -      | -      | -      | -      | -      | -      | -       | -      | -      | -      | 1.000  | .864** | .859** | .721** |         |
| PoPeL   | -     | -      | -      | -      | -      | -      | -      | -      | -      | -      | -       | -      | -      | -      | -      | 1.000  | .994** | .850** |         |
| PoPvL   | -     | -      | -      | -      | -      | -      | -      | -      | -      | -      | -       | -      | -      | -      | -      | -      | 1.000  | .850** |         |
| IINDASL | -     | -      | -      | -      | -      | -      | -      | -      | -      | -      | -       | -      | -      | -      | -      | -      | -      | 1.000  |         |

\*\*Significant at p&lt;0.01

*et al.*, 2015; Bhakta *et al.*, 2020). Sanphui *et al.* (2018) also observed that standard length had the highest degree of correlation followed by pre-anal length with total length for *P. heterolepis* from the Hooghly River, which agreed well with the present study on *C. aurea* from West Bengal. Bhakta *et al.* (2020) found that standard length of *O. pama* had the highest degree of correlation with total length while caudal length had the lowest, which was in line with the present study.

The regression coefficient ('b') between the sexes indicated the changes in growth rate of male and female, however, there were no significant differences (p>0.05) between the sexes found

among the different morphometric characters (Table 2). Therefore, data were pooled for further analysis and interpretation. The regression coefficient ('b') indicated the highest growth rate for standard length (0.879) followed by post-pectoral fin length (0.647), post-pelvic fin length (0.639) and the lowest for the second anal spine length (0.039) against total length. Likewise, when morphometric characters were compared against their head length, highest growth rate (b) was observed for post-orbital length (0.635) and the lowest for eye diameter (0.114). Pillai (1983) and Bhuyan (2003) observed the fastest growth rate in pre-anal length in comparison to total length in *O. ruber* and Telvekar (2006) in *O. cuvieri*. Furthermore, Pillai (1983) observed a faster growth rate

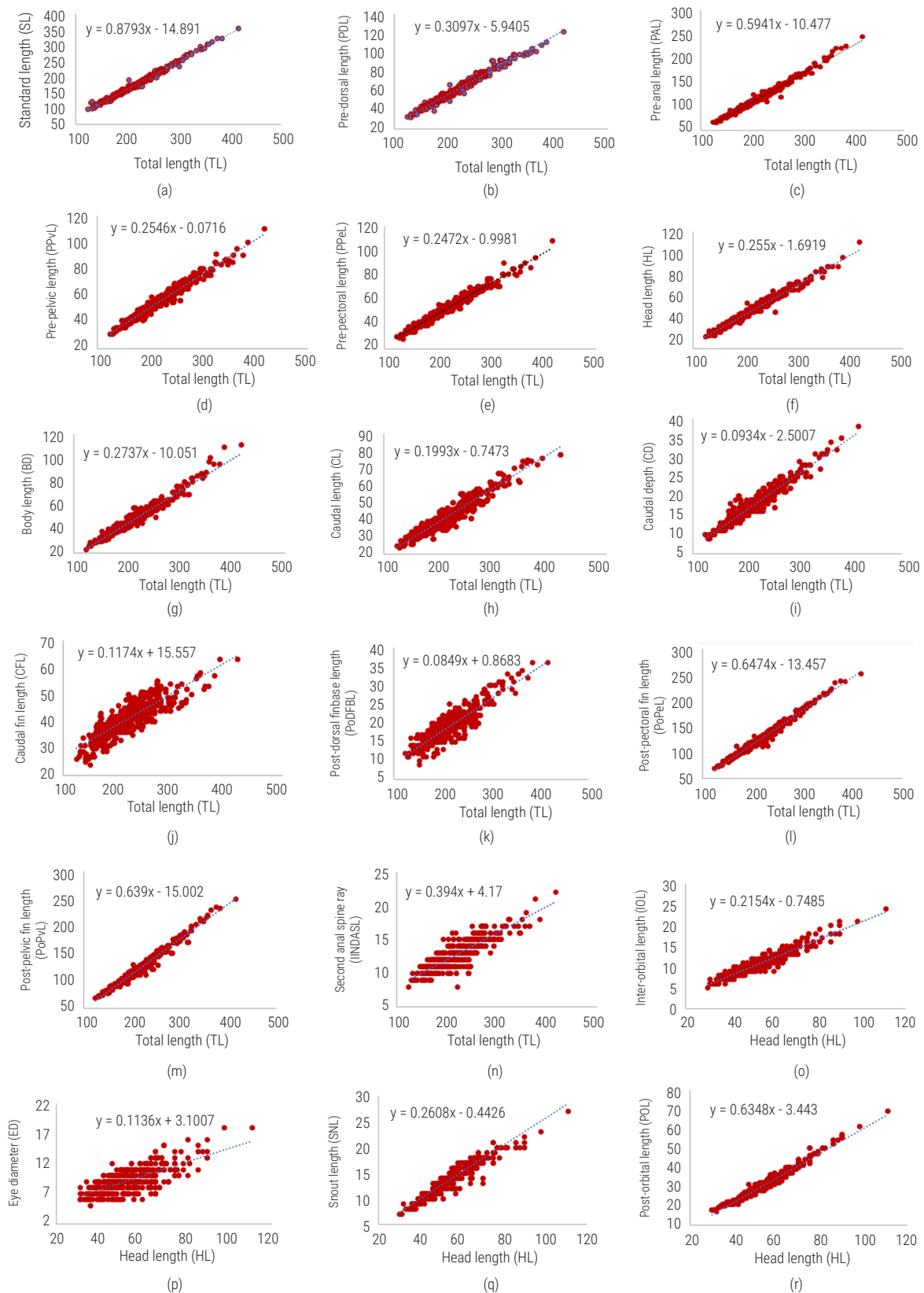


Fig. 2. Scatter diagrams showing relation between different morphometric characters against the total length and head length of *C. aurea*



of the caudal peduncle in *O. ruber* and Telvekar (2006) observed a faster growth rate in standard length of *O. cuvieri* in relation to total length of the species. In consistent with the present study all the above authors also reported the lowest growth rate of eye diameter with the head length of respective species.

The present study recorded a maximum coefficient of variation in snout length (47.16%) followed by post-orbital length (44.35%), body depth (24.71%) and pre-pectoral length (24.62%). Likewise, Kumar et al. (2012) also reported a maximum coefficient of variation in snout length while eye diameter showed the minimum for *J. sina* from the Ratnagiri coast of Maharashtra. According to Sandhya et al. (2015), maximum coefficient of variation was found in caudal depth followed by caudal peduncle length for *O. cuvieri* from Ratnagiri waters, Maharashtra. Caudal length showed a maximum coefficient of variation for *P. heterolepis* from Hooghly River, West Bengal (Sanphui et al., 2018). Similar findings were reported by Bhakta et al. (2020) for *O. pama* from the Hooghly-Matlah Estuary. Fish can adapt to environmental changes by changing their behaviour and physiology due to their phenotypic plasticity. Their morphological alterations as a result reflect the impact of the environment (Sanphui et al., 2018).

Among the nineteen morphometric characters, the results of the t-test showed significant variation ( $p < 0.05$ ) in total length, standard length, pre-dorsal length, head length, body depth and inter-orbital length between male and female; while pre-anal length, caudal length, post-dorsal fin base length, post-pectoral length, post-pelvic length and second anal spine length exhibited significant difference at both 1% ( $p < 0.01$ ) and 5% ( $p < 0.05$ ) level (Table 1). Other morphometric traits did not exhibit significant variation ( $p > 0.05$ ) between sexes. As a result, it was revealed that these morphometric traits were useful for observing the phenotypic variance between the male and female populations of this species along the coast. The males and females often differ in their length and shape (Nikolsky and Birkett, 1963) and can be used to distinguish male and female fishes (Panicker, 2020). The morphometric relationships showed significant differences between male and female red porgy *Pagrus pagrus* (Minos et al., 2008) and goby fish *Oxyurichthys tentacularis* from Astamudi Lake, Kerala (Mohan, 2016).

The present study revealed that the first dorsal fin of *C. aurea* had 10 to 11 spines followed by a notch and the second dorsal fin had 1 spine and 25 to 28 soft rays. The pectoral fin had 16 to 18 fin rays, pelvic fin had 1 spine and 5 soft rays, anal fin had 2 spines and 7 soft rays and caudal fin had 16 to 18 fin rays. The number of arborescent appendages ranged from 24 to 29 pairs along the sides of gas bladder, number of gill rakers of the first-gill arch of left side varied between 7 and 9. The number of rostral pores was recorded at 3, marginal pores were 5 and mental pores were 6. Based on the present study, fin formula of *C. aurea* from the West Bengal coast can be written as: D. X-XI/I/25-28, P.i 16-18, V. I/5, A. 2/7, C. 16-18.

Statistical estimates for various meristic characters are presented in Table 3. The coefficient of variation was found to be highest in arborescent appendages (3.78%) and lowest in dorsal fin spines (0.40%). Mode values for dorsal fin rays (27), arborescent appendages (26) and gill rakers (8) of *C. aurea* indicated that these meristic counts occur frequently in this population because of the same geographical distribution, habitat and influence of other environmental parameters (Chondar, 1974).

Meristic characters recorded in the present study were compared with a few previous literature (FAO, 1974; Mohan, 1981; Talwar, 1995; Sasaki, 2001) and it is well agreed with the previous works (Table 4). In the present study, the number of spines and fin rays in the first part of dorsal fin of *C. aurea* were in the range of X-XI+I and 25-28, respectively with mode values of 10 and 27. FAO (1974) reported X spine in first dorsal part, second part of fin with I spine and 25 to 28 soft rays, while Mohan (1981) observed 25-27 fin rays, Talwar (1995) noticed X+I spine and 25-28 fin rays and Sasaki (2001) reported XI spines and 25-28 fin rays. The meristic counts recorded in the present study agreed well with the range given by various authors for *C. aurea*, the only difference was the presence of 11 dorsal spines, which was, however, recorded only in one specimen.

Sciaenids generally possess 3-5 rostral pores, 5 marginal pores on the snout, 2-6 mental pores on chin and 5-16 gill rakers. Dorsal fin is usually long and continuous with a deep notch between anterior spinous (8-10 spines usually) and posterior portion generally with a single spine and 21-34 soft rays. Pectoral fin with 16-18 rays, pelvic

Table 4. Statistical estimates of various meristic characters of *C. aurea* off the coast of West Bengal

| Meristic character     | Range |     | Mean | Median | Mode | Standard deviation | Standard error | Coefficient of variation (%) |
|------------------------|-------|-----|------|--------|------|--------------------|----------------|------------------------------|
|                        | Max   | Min |      |        |      |                    |                |                              |
| Dorsal fin spines      | 11    | 10  | 10   | 10     | 10   | 0.040              | 0.002          | 0.402                        |
| Dorsal fin rays        | 28    | 25  | 27   | 27     | 27   | 0.774              | 0.031          | 2.901                        |
| Pectoral fin rays      | 18    | 16  | 18   | 18     | 18   | 0.490              | 0.020          | 2.761                        |
| Pelvic fin spine       | 1     | 1   | 1    | 1      | 1    | -                  | -              | -                            |
| Pelvic fin rays        | 5     | 5   | 5    | 5      | 5    | -                  | -              | -                            |
| Anal fin spines        | 2     | 2   | 2    | 2      | 2    | -                  | -              | -                            |
| Anal fin rays          | 7     | 7   | 7    | 7      | 7    | -                  | -              | -                            |
| Caudal fin rays        | 18    | 16  | 17   | 17     | 17   | 0.202              | 0.008          | 1.183                        |
| Arborescent appendages | 29    | 24  | 26   | 26     | 26   | 0.990              | 0.040          | 3.783                        |
| Rostral pores          | 3     | 3   | 3    | 3      | 3    | -                  | -              | -                            |
| Marginal pores         | 5     | 5   | 5    | 5      | 5    | -                  | -              | -                            |
| Mental pores           | 6     | 6   | 6    | 6      | 6    | -                  | -              | -                            |
| Gill rakers            | 9     | 7   | 8    | 8      | 8    | 0.281              | 0.011          | 3.511                        |

Table 5. Comparison of meristic characters of *C. aurea* with other studies

| Author(s)     | Dorsal fin     | Pectoral fin | Pelvic fin | Anal fin | Caudal fin | Gill rakers | Arborescent appendages (pairs) |
|---------------|----------------|--------------|------------|----------|------------|-------------|--------------------------------|
| FAO (1974)    | X+I 26-27      | P i 16-18    | V I 5      | A II 6-7 | -          | 8-9         | 27-30                          |
| Mohan (1981)  | X+I 25-27      | -            | -          | -        | -          | -           | 24-26                          |
| Talwar (1995) | D X+I 25-28    | P i 16-18    | V I 5      | A II 6-7 | -          | 7-10        | 24-28                          |
| Sasaki (2001) | X+I 25-28      | -            | -          | -        | -          | -           | -                              |
| Present study | D X-XI+I 25-28 | P i 16-18    | V I 5      | A II 7   | 16-18      | 7-9         | 24-29                          |

fin with 1 spine and 5 soft rays and anal fin possesses 2 spines (FAO, 1974). The numbers of pelvic and anal fin rays with spine and pectoral fin rays observed in the present study were found to be consistent with the previous works reported by FAO (1974), Talwar (1995) and Sasaki (2001). The number of arborescent appendages along the sides of the gas bladder was reported in the present study as 24 to 29 pairs, while Talwar (1995) reported 24 to 28 pairs, FAO (1974) reported 27 to 30 pairs, while Mohan (1981) observed 24 to 26 pairs of arborescent appendages. The number of gill rakers of the *C. aurea* of the first-gill arch of left side varied between 7 and 9, while Talwar (1995) reported 7-10 and FAO (1974) recorded 8 to 9 gill rakers on lower limb. The maximum number of meristic characters of the present study was found similar to the earlier studies (FAO, 1974; Mohan, 1981; Talwar, 1995; Sasaki, 2001) with little difference in the number of spines in first part of dorsal fin and the number of gill rakers.

Arborescent appendages present on the swim bladder of sciaenids are unique features due to their different shapes which vary from species to species, therefore, considered to be very useful in the identification of different species of croakers. Variation in meristic characters largely depends on the adaptation of the species to their specific geographical location. Several studies on meristic characters on closely related species have been carried out in Indian waters. According to Chakraborty (1992) and Sandhya *et al.* (2015) number of dorsal fin rays ranged from 28 and 32, pectoral fin rays varied from 16 to 18, pelvic fin rays from 7 to 9 and caudal fin rays from 16 to 20 for *O. cuvieri* from Mumbai waters. He also observed anal fin spine with rays constant for the species throughout the study. Kumari *et al.* (2020) described some morphometric and meristic variations between two congeneric sciaenid fishes from Maharashtra. Dorsal spiny rays were found to be the same for both *O. cuvieri* and *O. ruber*. But the number of dorsal soft rays varied from 29-31 in *O. cuvieri* while 29-30 in *O. ruber*; number of gill rakers present on lower limb of first arch was 12-15 in *O. cuvieri* but only 10 in *O. ruber*; number of arborescent appendages on the swim bladder ranged between 32 and 35 for *O. cuvieri* while 28 to 29 for *O. ruber* (Kumari *et al.*, 2020).

Intraspecific variations may be due to environmental factors including temperature, salinity, dissolved oxygen, pH, food availability and growth rate (Lindsey, 1954; Barlow, 1961; Lindsey, 1988) and different ecological conditions (Chondar, 1974). The findings of the present study indicated a high degree of homogeneity within the population of *C. aurea* occurring on the coast of West Bengal, India and will be useful in comparing the same species in different locations and to measure the discreteness between different fish stocks.

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