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# Intraspecific Diversity of Freshwater Murrel, *Channa punctatus*

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**Abstract**
Variation in the morphometric and meristic characters of *Channa punctatus* (Bloch, 1793) across the different environmental gradient was analyzed in order to study the intraspecific divergence in *C. punctatus*. A linear relationship was noted between different body measurements and total length of the fish in each environment. Significant variations in the morphometric and meristic characters were noted between the populations of *C. punctatus.* In one-way analysis of variance (ANOVA), a total of 13 morphometric traits out of 15 and 2 meristic traits out of 5 were found to be significantly different ($p<0.05$) between the populations, in which most of the morphometric traits were highly significant ($p<0.001$). Differences between the slopes of various regression lines of each morphometric measurements between the compared populations were also found to be significant at 0.1%, 1% and 5%. These findings indicate the presence of different phenotypic stocks of *C. punctatus* across the environmental gradient.

**Keywords:** *Channa punctatus*, morphometric, meristic, regression, stock.

## 1. Introduction

The study of intraspecific divergence and its application for the conservation and management of the fish species are well recognized. Quantitative morphological techniques have been used not only for identification of fish but also to discriminate the fish stocks of a species. Phenotypic variation according to the change in the environmental conditions has been used widely by ichthyologist to study the population structure belonging to the same species [1, 2]. Variations in the environmental conditions of different regions are because of the combined effects of the biotic and abiotic factors of the environment. The geographic location characterized by the features like altitude, latitude, climate, and abiotic components like physical and chemical properties of the water bodies etc. directly or indirectly affect the environment of the place where the fish inhabit [3]. The variations in phenotypic traits are the resultant of either environment or genetic or the combination of both. The effects of environmental factors in the variation in morphology of fishes were studied and reported by several workers [4, 5, 6, 7, 8, 9]. Morphometric and mersitic characters are also useful for the sex discrimination to segregate male and female in fishes [10]. Fishes with same morphometric and meristic characters are usually assumed to constitute a stock and variations between the stocks helps in stock structure analysis and also for any short duration environmentally induced variation [11, 12, 13]. Several workers provide morphometric and meristic data on the several fishes and emphasized their utility in separating stocks of the fishes living in the same or different environment [14, 15, 16, 17, 18, 19, 20, 21, 22].

The morphology of fish, *Channa punctatus* was studied in context of species identification by a number of workers [23, 24, 25, 26]. However, the study on intraspecific variations on *C. punctatus* using traditional morphometric and meristic methods is limited, and notable among them are Samad and Jafri [27], Dars *et al.* [28], Saikia [29], Khan *et al.* [30] and Kashyap *et al.* [31]. Therefore the present study was planned and carried out on the intraspecific diversity of freshwater murrel, *C. punctatus* using morphometric and meristic traits collected from different geographical sites.

## 2. Materials and Methods

A total of 220 fish samples were collected from three different regions i.e., River Gomti at Lucknow (26º 56' N 80º 43' E, n=100), ponds situated at Kolkata (22º 34' N 88º 22' E, n=50) and Malihabad (26º 92' N 80º 71' E, n=70). These regions of the country are geographically isolated and characterized by different environmental conditions

**2.1 Morphometric Traits Measurements**

A total of sixteen morphometric traits (Fig. 1) were measured using fine compass, scale, fine forceps, needle and fish measuring board. The following 16 morphometric traits were used in this study:

Total length (TL, 1-7): Measurement from anterior end of snout to posterior end of caudal length.

Standard length (SL, 1-6): Measurement from anterior end of snout to base of caudal fin.

Head length (HL, 1-12): Measurement from anterior end of snout to posterior edge of operculum.

Snout length (SnL, 1-2): Measurement from anterior end of snout to anterior end of eye.

Eye diameter (ED, 2-3): Measurement from anterior to posterior end of the eye orbit.

Inter orbital length (IOL): Measurement of least distance between two eye orbits

Pre dorsal length (PDL, 1-4): Measurement from anterior end of snout to origin of first dorsal spine.

Pre pectoral length (PPL, 1-13): Measurement from anterior end of snout to origin of pectoral fin.

Pre pelvic length (PVL, 1-10): Measurement from anterior end of snout to origin of pelvic fin.

Pre anal length (PAL, 1-9): Measurement from anterior end of snout to origin of the anal fin.

Dorsal fin length (DFL, 4-5): Measurement from proximal to distal end of dorsal fin.

Pectoral fin length (PFL, 13-14): Measurement from Proximal to distal end of pectoral fin.

Pelvic fin length (PeFL, 10-11): Measurement from Proximal to distal end of pelvic fin.

Anal fin length (AFL, 8-9): Measurement from Proximal to distal end of anal fin.

Caudal fin length (CFL, 6-7): Measurement from Proximal to distal end of caudal fin.

Body depth (BD): Measurement between dorsal and ventral surfaces at the point of origin of the origin of dorsal fin

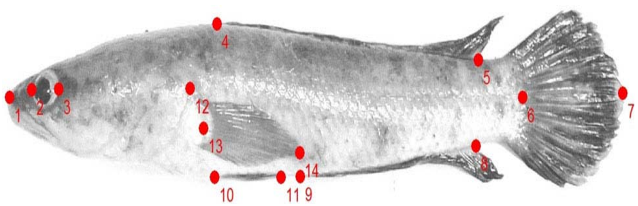


**Fig. 1:** Schematic image of *C. punctatus* depicting the major morphometric parameters measured between the points plotted.

***Measurements:*** *total length (1–7), standard length (1–6), head length (1–12), snout length (1–2), pre dorsal length (1–4), pre pectoral length (1–13), pre pelvic length (1–10), pre anal length (1–9), dorsal fin length (4–5), pectoral fin length (13–14), pelvic fin length (10–11), anal fin length (8–9), caudal fin length (6–7), eye diameter (2–3)*

**2.2 Meristic Traits**

The five countable traits were taken into consideration for this study which is as follows

Dorsal fin rays (DFR): Counting of number of rays in dorsal fin.

Pectoral fin rays (PFR): Counting of number of rays in pectoral fin.

Pelvic fin rays (PeFR): Counting of number of rays in pelvic fin.

Anal fin rays (AFR): Counting of number of rays in anal fin.

Caudal fin rays (CFR): Counting of number of rays in caudal fin.

**2.3 Statistical Analysis**

One way ANOVA was used to find out the significantly different ($p<0.05$) morphometric and meristic traits of the three populations. Linear regression analysis of different morphometric characters (standard length, head length etc.) taking total length (TL) as independent parameter was computed to evaluate the growth of various parameters. The statistical relationships were derived using the following regression equation

$$Y = a + bX$$

Where 'X' is total length (TL) as independent variable and 'Y' is the other dependent morphometric variables, 'a' and 'b' are the intercept and slope of the regression line respectively. The different morphometric characters of each stock were log transformed before subjection to linear regression analysis. To examine the variation between the populations on the basis of the morphometric variables, the regression slopes of each morphometric character versus total length (TL) were tested by means of 't'- test. The 't' value was computed as per the following formula

$$t = (b1-b2) / (Sb1-Sb2)$$

Where 'b' is the slope of regression line, and 'Sb' is the standard error of 'b'.

The coefficient of difference (CD) was calculated using the equation as given by Snedecor [32]

$$CD = Mx-My/ SDx+SDy$$

Where,

CD = Coefficient of difference between two stocks

Mx= Mean of x component of stock one

My= Mean of y component of stock two

SDx= Standard deviation of x component of stock one

**3. Results**

The three populations of *C. punctatus* differed in a number of morphometric and meristic characters. The results of analysis of regression of different body measurements on total length (TL) and coefficient of their correlation (r) are given in Table 1. The linear relationship in the regression analysis between the different morphometric measurements on total length of the three populations of *C. punctatus* indicated that with increase in total length of fish there was corresponding change in other traits and thus was highly correlated. However, the low values of coefficient of correlation (r) were noted in eye diameter (ED) and snout length (SnL) in the populations of River Gomti, Kolkata Pond and Malihabad Pond respectively, but these values were statistically significant ($p<0.05$). In one way ANOVA, total of 13 morphometric traits out of 15 and 2 meristic traits out of 5 were found to be significantly different ($p<0.05$) between the populations (Table 2). Most of the morphometric traits were highly significant ($p<0.001$) among the three populations of *C. punctatus.*

Differences between the slopes of various regression lines of each morphometric measurements in three populations of *C. punctatus* are given in Tables 3, 4 and 6. The comparison of slopes estimated between the populations of River Gomti and Pond of Malihabad showed significant differences in 13 morphometric traits out of 15, in which 10, 1 and 2 traits were found to be significant at 0.1% ($p<0.001$), 1% ($p<0.01$) and 5% ($p<0.05$) levels respectively. Similarly, the values of 9 and 1 slopes out of 10 morphometric traits between Kolkata and Malihabad showed a significant difference at the levels of 0.1% ($p<0.001$) and 5% level ($p<0.05$) respectively. However, only 5 morphometric traits were found statistically significant ($p<0.05$) between the populations of River Gomti and Pond of Kolkata. The details of coefficient of difference (CD) between populations are given in Table 5. The high values of CD were obtained for head length (HL), pre-pectoral length (PPL), pre-dorsal length (PDL), pre-anal length (PAL) and pre-pelvic length (PPeL) between the population of River Gomti and Pond of Malihabad, with head length (HL) having maximum value of CD. Between the River Gomti and Pond of Kolkata population, maximum CD was noted in pelvic fin length (PeFL), whereas maximum CD was observed in body depth (BD) between the Pond of Kolkata and Pond of Malihabad (Table 6).

**Table 1:** Relationships between different body measurements (Y) on total length (X) of *C. punctatus* collected from three different habitats

| Morphometric Traits | Mean ± SE | Regression Equation Y = a + bX | Correlation Coefficient 'r' | p value |
|---|---|---|---|---|
| **River Gomti** | | | | |
| BD | 2.34 ± 0.05 | Y = -0.9134 + 1.100X | 0.8559 | p<0.0001 |
| SL | 12.04 ± 0.18 | Y = -0.0599 + 0.9804X | 0.9928 | p<0.0001 |
| HL | 4.23 ± 0.06 | Y = -0.4485 + 0.9239X | 0.9629 | p<0.0001 |
| ED | 0.74 ± 0.05 | Y = -0.5799 + 0.3661X | 0.2203 | 0.0276 |
| IOL | 1.05 ± 0.02 | Y = -1.059 + 0.9271X | 0.8807 | p<0.0001 |
| SnL | 0.85 ± 0.01 | Y = -0.9358 + 0.7396X | 0.6808 | p<0.0001 |
| PDL | 4.54 ± 0.07 | Y = -0.4239 + 0.9294X | 0.9769 | p<0.0001 |
| PPL | 4.32 ± 0.06 | Y = -0.4582 + 0.9402X | 0.9745 | p<0.0001 |
| PPeL | 4.52 ± 0.07 | Y = -0.3086 + 0.8271X | 0.7533 | p<0.0001 |
| PAL | 6.77 ± 0.10 | Y = -0.2977 + 0.9696X | 0.9835 | p<0.0001 |
| DFL | 6.67 ± 0.11 | Y = -0.3419 + 1.002X | 0.9803 | p<0.0001 |
| PFL | 2.33 ± 0.04 | Y = -0.7910 + 0.9929X | 0.8142 | p<0.0001 |
| PeFL | 1.65 ± 0.03 | Y = -0.5848 + 0.6866X | 0.6231 | p<0.0001 |
| AFL | 4.39 ± 0.08 | Y = -0.5941 + 1.062X | 0.9049 | p<0.0001 |
| CFL | 2.53 ± 0.28 | Y = -0.4454 + 0.7369X | 0.3724 | p<0.0001 |
| **Pond of Malihabad** | | | | |
| BD | 2.04 ± 0.07 | Y = -0.9785 + 1.164 X | 0.9518 | p<0.0001 |
| SL | 10.48 ± 0.29 | Y = -0.1441 + 1.053 X | 0.9888 | p<0.0001 |
| HL | 3.52 ± 0.11 | Y = -0.6473 + 1.079 X | 0.9380 | p<0.0001 |
| ED | 0.55 ± 0.01 | Y = -0.9070 + 0.5819 X | 0.7504 | p<0.0001 |
| IOL | 0.85 ± 0.02 | Y = -1.167 + 0.9897 X | 0.9171 | p<0.0001 |
| SnL | 0.65 ± 0.02 | Y = -0.9028 + 0.6424 X | 0.6261 | 0.0002 |
| PDL | 3.84 ± 0.11 | Y = -0.5778 + 1.051 X | 0.9950 | p<0.0001 |
| PPL | 3.73 ± 0.11 | Y = -0.6078 + 1.066 X | 0.9850 | p<0.0001 |
| PPeL | 3.93 ± 0.11 | Y = -0.6144 + 1.092 X | 0.9801 | p<0.0001 |
| PAL | 5.85 ± 0.16 | Y = -0.4098 + 1.064 X | 0.9911 | p<0.0001 |
| DFL | 5.75 ± 0.16 | Y = -0.4454 + 1.090 X | 0.9886 | p<0.0001 |
| PFL | 1.97 ± 0.05 | Y = -0.7762 + 0.9682 X | 0.9535 | p<0.0001 |
| PeFL | 1.34 ± 0.03 | Y = -0.9247 + 0.9506 X | 0.9339 | p<0.0001 |
| AFL | 3.70 ± 0.11 | Y = -0.6992 + 1.146 X | 0.9742 | p<0.0001 |
| CFL | 2.18 ± 0.06 | Y = -0.7778 + 1.009X | 0.9610 | p<0.0001 |
| **Pond of Kolkata** | | | | |
| BD | 2.20 ± 0.05 | Y = -0.7744 + 1.007X | 0.7824 | p<0.0001 |
| SL | 10.58 ± 0.19 | Y = -0.2836 + 0.8992X | 0.9731 | p<0.0001 |
| HL | 3.65 ± 0.07 | Y = -0.5137 + 0.9714X | 0.9246 | p<0.0001 |
| ED | 0.59 ± 0.01 | Y = -0.4947 + 0.2397X | 0.4504 | 0.0125 |
| IOL | 0.81 ± 0.02 | Y = -1.179 + 0.9790X | 0.7982 | p<0.0001 |
| SnL | 0.64 ± 0.01 | Y = -1.094 + 0.8136X | 0.7507 | p<0.0001 |
| PDL | 4.03 ± 0.08 | Y = -0.4601 + 0.9613X | 0.9375 | p<0.0001 |
| PPL | 3.80 ± 0.07 | Y = -0.4466 + 0.9264X | 0.9308 | p<0.0001 |
| PPeL | 4.00 ± 0.07 | Y = -0.3703 + 0.8780X | 0.9290 | p<0.0001 |
| PAL | 5.89 ± 0.11 | Y = -0.2584 + 0.9278X | 0.8460 | p<0.0001 |
| DFL | 5.79 ± 0.11 | Y = -0.2430 + 0.9078X | 0.9102 | p<0.0001 |
| PFL | 2.06 ± 0.05 | Y = -1.025 + 1.208X | 0.8712 | p<0.0001 |
| PeFL | 1.44 ± 0.05 | Y = -1.092 + 1.125X | 0.6814 | p<0.0001 |
| AFL | 3.99 ± 0.09 | Y = -0.5410 + 1.031X | 0.8831 | p<0.0001 |
| CFL | 2.14 ± 0.05 | Y = -0.9636 + 1.166X | 0.7970 | p<0.0001 |

**Table 2:** Significant (p<0.05) morphometric and meristic parameters in one way ANOVA analysis of three populations of *C. punctatus.*

| Traits | | Sum of Squares | df | Mean Square | F | p value |
|---|---|---|---|---|---|---|
| BD | Between Groups | 2.865 | 1 | 2.865 | 12.799 | .001 |
| | Within Groups | 24.395 | 109 | .224 | | |
| | Total | 27.260 | 110 | | | |
| SL | Between Groups | 76.061 | 1 | 76.061 | 23.930 | .000 |
| | Within Groups | 346.454 | 109 | 3.178 | | |
| | Total | 422.514 | 110 | | | |
| HL | Between Groups | 14.162 | 1 | 14.162 | 36.446 | .000 |
| | Within Groups | 42.356 | 109 | .389 | | |
| | Total | 56.519 | 110 | | | |
| ED | Between Groups | .997 | 1 | .997 | 3.794 | .054 |
| | Within Groups | 28.633 | 109 | .263 | | |
| | Total | 29.629 | 110 | | | |
| IOL | Between Groups | 1.863 | 2 | .931 | 37.103 | .000 |
| | Within Groups | 3.966 | 158 | .025 | | |
| | Total | 5.828 | 160 | | | |
| SnL | Between Groups | 1.527 | 2 | .763 | 49.474 | .000 |
| | Within Groups | 2.438 | 158 | .015 | | |
| | Total | 3.965 | 160 | | | |
| PDL | Between Groups | 14.676 | 2 | 7.338 | 19.566 | .000 |
| | Within Groups | 59.256 | 158 | .375 | | |
| | Total | 73.932 | 160 | | | |
| PPL | Between Groups | 11.834 | 2 | 5.917 | 16.800 | .000 |
| | Within Groups | 55.650 | 158 | .352 | | |
| | Total | 67.484 | 160 | | | |
| PPeL | Between Groups | 11.891 | 2 | 5.946 | 13.579 | .000 |
| | Within Groups | 69.181 | 158 | .438 | | |
| | Total | 81.072 | 160 | | | |
| PAL | Between Groups | 30.582 | 2 | 15.291 | 17.077 | .000 |
| | Within Groups | 141.473 | 158 | .895 | | |
| | Total | 172.055 | 160 | | | |
| DFL | Between Groups | 30.537 | 2 | 15.268 | 16.666 | .000 |
| | Within Groups | 144.751 | 158 | .916 | | |
| | Total | 175.288 | 160 | | | |
| PFL | Between Groups | 3.738 | 2 | 1.869 | 13.584 | .000 |
| | Within Groups | 21.741 | 158 | .138 | | |
| | Total | 25.480 | 160 | | | |
| PeFL | Between Groups | 2.707 | 2 | 1.354 | 17.683 | .000 |
| | Within Groups | 12.095 | 158 | .077 | | |
| | Total | 14.802 | 160 | | | |
| AFL | Between Groups | 12.624 | 2 | 6.312 | 12.558 | .000 |
| | Within Groups | 79.413 | 158 | .503 | | |
| | Total | 92.037 | 160 | | | |
| CFL | Between Groups | 15.930 | 2 | 7.965 | 1.632 | .199 |
| | Within Groups | 771.151 | 158 | 4.881 | | |
| | Total | 787.081 | 160 | | | |
| DFR | Between Groups | 5.907 | 2 | 2.954 | 1.815 | .166 |
| | Within Groups | 257.086 | 158 | 1.627 | | |
| | Total | 262.994 | 160 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| PFR | Between Groups | .288 | 2 | .144 | .417 | .660 |
| | Within Groups | 54.470 | 158 | .345 | | |
| | Total | 54.758 | 160 | | | |
| PeFR | Between Groups | .004 | 2 | .002 | .302 | .740 |
| | Within Groups | .990 | 158 | .006 | | |
| | Total | .994 | 160 | | | |
| AFR | Between Groups | 5.739 | 2 | 2.870 | 6.966 | .001 |
| | Within Groups | 65.081 | 158 | .412 | | |
| | Total | 70.820 | 160 | | | |
| CFR | Between Groups | 4.084 | 2 | 2.042 | 5.263 | .006 |
| | Within Groups | 61.295 | 158 | .388 | | |
| | Total | 65.379 | 160 | | | |

**Table 3:** Comparison between the regression coefficient in River Gomti and Pond of Malihabad of *C. punctatus*

| S. No. | Morphometric Traits | River Gomti | | Pond of Malihabad | | t-value | p value |
|---|---|---|---|---|---|---|---|
| | | b | Sb | b | Sb | | |
| 1 | BD | 1.1000 | 0.0672 | 1.1640 | 0.0696 | 25.70 | *** |
| 2 | SL | 0.9804 | 0.0120 | 1.0530 | 0.0295 | 4.14 | *** |
| 3 | HL | 0.9239 | 0.0262 | 1.0790 | 0.0741 | 3.24 | *** |
| 4 | ED | 0.3661 | 0.1637 | 0.5819 | 0.0952 | 3.15 | ** |
| 5 | IOL | 0.9271 | 0.0504 | 0.9897 | 0.0799 | 2.12 | * |
| 6 | SnL | 0.7396 | 0.0804 | 0.6424 | 0.1486 | 1.42 | NS |
| 7 | PDL | 0.9294 | 0.0205 | 1.0510 | 0.0196 | 128.00 | *** |
| 8 | PPL | 0.9402 | 0.0219 | 1.0660 | 0.0346 | 9.85 | *** |
| 9 | PPeL | 0.8271 | 0.0730 | 1.0920 | 0.0411 | 8.31 | *** |
| 10 | PAL | 0.9696 | 0.0181 | 1.0640 | 0.0266 | 11.07 | *** |
| 11 | DFL | 1.0020 | 0.0204 | 1.0900 | 0.0308 | 8.47 | *** |
| 12 | PFL | 0.9929 | 0.0715 | 0.9682 | 0.0569 | 1.68 | NS |
| 13 | PeFL | 0.6866 | 0.0871 | 0.9506 | 0.0676 | 13.56 | *** |
| 14 | AFL | 1.0620 | 0.0505 | 1.1460 | 0.0492 | 68.85 | *** |
| 15 | CFL | 0.7369 | 0.1855 | 1.0090 | 0.0539 | 2.07 | * |

****p<0.001, **p<0.01, *p<0.05, NS= Non significant, b= slope, Sb = Standard error of b*

**Table 4:** Comparison between the regression coefficient in River Gomti and Pond of Kolkata of *C. punctatus*

| S. No. | Morphometric Traits | River Gomti | | Pond of Kolkata | | t- value | p value |
|---|---|---|---|---|---|---|---|
| | | b | Sb | b | Sb | | |
| 1 | BD | 1.1000 | 0.0672 | 1.0070 | 0.1515 | 1.10 | NS |
| 2 | SL | 0.9804 | 0.0120 | 0.8992 | 0.0402 | 2.87 | ** |
| 3 | HL | 0.9239 | 0.0262 | 0.9714 | 0.0756 | 0.96 | NS |
| 4 | ED | 0.3661 | 0.1637 | 0.2397 | 0.0898 | 1.71 | NS |
| 5 | IOL | 0.9271 | 0.0504 | 0.9790 | 0.1396 | 0.58 | NS |
| 6 | SnL | 0.7396 | 0.0804 | 0.8136 | 0.1353 | 1.35 | NS |
| 7 | PDL | 0.9294 | 0.0205 | 0.9613 | 0.0674 | 0.68 | NS |
| 8 | PPL | 0.9402 | 0.0219 | 0.9264 | 0.0688 | 0.29 | NS |
| 9 | PPeL | 0.8271 | 0.0730 | 0.8780 | 0.0661 | 7.44 | *** |
| 10 | PAL | 0.9696 | 0.0181 | 0.9278 | 0.1105 | 0.45 | NS |
| 11 | DFL | 1.0020 | 0.0204 | 0.9078 | 0.0781 | 1.63 | NS |
| 12 | PFL | 0.9929 | 0.0715 | 1.2080 | 0.1287 | 3.76 | *** |
| 13 | PeFL | 0.6866 | 0.0871 | 1.1250 | 0.2284 | 3.10 | ** |
| 14 | AFL | 1.0620 | 0.0505 | 1.0310 | 0.1035 | 0.58 | NS |
| 15 | CFL | 0.7369 | 0.1855 | 1.1660 | 0.1671 | 23.32 | *** |

****p<0.001, **p<0.01,*p<0.05, NS= Non significant, b= slope, Sb = Standard error of b*

**Table 5:** Comparison between the regression coefficient in Pond of Kolkata and Pond of Malihabad of *C. punctatus*

| S. No. | Morphometric Traits | Pond of Kolkata | | Pond of Malihabad | | t- value | p value |
|---|---|---|---|---|---|---|---|
| | | b | Sb | b | Sb | | |
| 1 | BD | 1.0070 | 0.1515 | 1.1640 | 0.0696 | 1.92 | NS |
| 2 | SL | 0.8992 | 0.0402 | 1.0530 | 0.0295 | 14.32 | *** |
| 3 | HL | 0.9714 | 0.0756 | 1.0790 | 0.0741 | 68.97 | *** |
| 4 | ED | 0.2397 | 0.0898 | 0.5819 | 0.0952 | 63.49 | *** |
| 5 | IOL | 0.9790 | 0.1396 | 0.9897 | 0.0799 | 0.18 | NS |
| 6 | SnL | 0.8136 | 0.1353 | 0.6424 | 0.1486 | 12.87 | *** |
| 7 | PDL | 0.9613 | 0.0674 | 1.0510 | 0.0196 | 1.88 | NS |
| 8 | PPL | 0.9264 | 0.0688 | 1.0660 | 0.0346 | 4.09 | *** |
| 9 | PPeL | 0.8780 | 0.0661 | 1.0920 | 0.0411 | 8.54 | *** |
| 10 | PAL | 0.9278 | 0.1105 | 1.0640 | 0.0266 | 1.62 | NS |
| 11 | DFL | 0.9078 | 0.0781 | 1.0900 | 0.0308 | 3.86 | *** |
| 12 | PFL | 1.2080 | 0.1287 | 0.9682 | 0.0569 | 3.34 | *** |
| 13 | PeFL | 1.1250 | 0.2284 | 0.9506 | 0.0676 | 1.08 | NS |
| 14 | AFL | 1.0310 | 0.1035 | 1.1460 | 0.0492 | 2.12 | * |
| 15 | CFL | 1.1660 | 0.1671 | 1.0090 | 0.0539 | 1.39 | NS |

****p<0.001, **p<0.01,*p<0.05, NS= Non significant, b= slope, Sb = Standard error of b*

**Table 6:** Coefficient of difference (CD) between the populations of *C. punctatus*

| S. No. | Morphometric Traits | River Gomti vs Pond of Malihabad | River Gomti vs Pond of Kolkata | Pond of Kolkata vs Pond of Malihabad |
|---|---|---|---|---|
| 1 | BW | 1.21 | 0.87 | 0.57 |
| 2 | BD | 2.66 | 0.74 | 2.01 |
| 3 | TL | 4.53 | 1.92 | 0.12 |
| 4 | SL | 6.87 | 1.81 | 0.17 |
| 5 | HL | 19.24 | 2.47 | 0.67 |
| 6 | ED | 0.41 | 0.30 | 1.41 |
| 7 | IOL | 4.73 | 3.72 | 1.84 |
| 8 | SnL | 5.23 | 2.96 | 0.06 |
| 9 | PDL | 9.09 | 2.11 | 1.13 |
| 10 | PPL | 12.01 | 2.14 | 0.36 |
| 11 | PPeL | 6.72 | 1.54 | 0.31 |
| 12 | PAL | 7.95 | 2.20 | 0.12 |
| 13 | DFL | 6.30 | 2.04 | 0.13 |
| 14 | PFL | 3.08 | 2.02 | 6.30 |
| 15 | PeFL | 2.87 | 4.74 | 1.59 |
| 16 | AFL | 4.65 | 1.29 | 1.80 |
| 17 | CFL | 0.26 | 0.27 | 0.90 |
| 18 | DFR | 0.03 | 0.24 | 0.41 |
| 19 | PFR | 0.03 | 0.09 | 0.15 |
| 20 | AFR | 0.30 | 0.19 | 0.50 |
| 21 | CFR | 0.25 | 0.31 | 0.06 |

## 4. Discussion

Morphometric analysis is considered to be very important in identification of any stocks of a fish species. The study of morphological traits is used to evaluate the variations in body shape rather than body size [33]. Regression analysis is one of the statistical techniques that are very useful to study growth rate and thus helps in indicating variation due to body shape developed because of different growth rates. The current study on the morphometric characters of *C. punctatus* revealed that all the 15 morphometric measurements of the fish have strong linear association with the total length (TL) as the value of coefficient of correlation (r) was highly significant ($p<0.0001$) in all the relationships of three populations, which showed that with the increase in total length (TL) of fish there was a corresponding increase in length of various body measurements. The similar results were also reported by Khan [34], Chatterji *et al.* [35], Hammed *et al.* [36], Serajuddin [10], Pathak *et al.* [37] and Kashyap *et al.* [31] in the case of *Labeo rohita, Labeo bata, Labeo calbasu, Mastacembelus armatus, Macrognathus pancalus* and *C. punctatus* respectively. However the measurements like eye diameter (ED) in River Gomti and Pond of Kolkata and snout length (SnL) in Malihabad population showed the low values of correlation coefficient (r) indicating week relationship between total length and eye diameter or snout length. Singh and Tandon [38] related the decrease in the eye diameter of fish of River Gomti to the water turbidity of the River. Maximum value of coefficient of difference (CD) between the River Gomti and Pond of Malihabad for head length (HL) was reported in the current study having a value of 19.24. Khan *et al.* [30] also reported the variation between the populations of *C. punctatus* which were mainly due to differences in head length. The variations in the head region are considered to be the result of differences in the feeding regimes [39] or it may be due to the availability of food in the region [40].

Comparison of slopes of the regression analysis for each morphometric parameter between populations also indicated differential growth rates as many parameters were found to significant at 0.1% ($p<0.001$), 1% ($p<0.01$) and 5% level ($p<0.05$) in student 't' test. These significant differences in slopes for morphometric parameter indicated the variable growth rate for a parameter between the compared populations. These variations in the morphometric and meristic characters between the three populations suggested a relationship between the phenotypic heterogeneity and geographical barrier, showing limited intermingling among the three populations of *C. punctatus*. These differences in the phenotypic characters among the three populations may be due to the geographic isolation and change in the environmental conditions or may be due to restricted intermingling between the populations. The phenotypic discreteness in the present study suggested a direct relationship between the extent of phenotypic divergence and geographic separation where geographical barriers are considered to be the limiting factors for inhibiting migration among stocks.

## 5. Conclusion

The significant divergence in morphological and meristic traits revealed that intraspecific variation existed among the specimens of *C. punctatus*.

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