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Morphotaxonomic studies of *Bangana* (Hamilton, 1822) species from north-east India

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Abstract

The two Cyprinid fish species under genus *Bangana* namely *B. dero* (Hamilton, 1822) and *B. devdevi* (Hora, 1936) were collected from different rivers of the Northeast states and their tributaries. The 108 fish samples were analysed and monitored to establish their comparatively morphology, and relative growth pattern of different body parameters. The study proves that these two species of genus *Bangana* can be differentiated from related *Labeo* sps. based on the snout with depression, crescentric mouth, lips continuous and interrupted post labial fold. The morphological difference at species level was found as lateral line scale, lateral transverse scales (dorsal fin to lateral line and lateral line to pelvic fin), circumpendicular scale and shape of epichordal lobe. The statistical data with respect to 23 morphometric characters exhibited a linear relationship among all the morphometric characters and found highly significant in *B. dero* with some exception in *B. devdevi*. The relative growth pattern of body parameters inferred that in *B. dero* the growth of these parameters are faster as compared to *B. devdevi*. The variations in each morphometric character were also assessed by Analysis of Variance (ANOVA) at 5% significance level which clearly indicated that these species were phenotypically different from each other.

Keywords: Phenotypically, Morphology, Morphometric, Growth pattern

1. Introduction

North East India is a global biodiversity hotspot and has attracted many scientists to work on ichthyodiversity of this region (Kar and Sen, 2007, Vishwanath *et al.*, 2007; 2010, ^[20] Goswami *et al.* 2012; ^[2] Sarma *et al.* 2022) as boasting over 512 fish species (approx. 33% of India's total), heavily dominated by the Cyprinidae family (carp family). The freshwater cyprinids of genus *Bangana* inhabit mostly tropical and subtropical waters and are distributed across much of Southern and Eastern Asia. *Bangana* as sub-genus of *Cyprinus* Linnaeus based on specimens collected from the river Brahmaputra. However, *Bangana* was later regarded as an invalid taxonomic unit, and its species were assigned to either *Labeo* Cuvier (Jayaram, 1981) ^[7] or *Sinilabeo* Rendahl (Wu *et al.*, 1977) ^[22]. Kottelat (1985) ^[10] resurrected *Bangana* and considered it to be a senior synonym of *Tylognathus* Heckel. Jayaram and Dhas (2000) ^[6] have also referred *Bangana* as a synonym of *Labeo* and placed both the species of this genus under *Dero* group based on the snout with depression, crescentric mouth, lips continuous and interrupted post labial fold. Further, Rainboth (1996), ^[15] Kullander *et al.* (1999) ^[11] and Zhang ^[24] and Chen (2006) revised the genus *Bangana* and listed twenty-three species under this genus. However, Zhang ^[24] and Chen (*op cit.*) opined that the total number of species of *Bangana* is somewhat problematical as the other species of this genus outside the China is not studied so far. Twenty-five species of genus *Bangana* have been reported so far but only five species are found in India viz. *B. devdevi*, *B. dero*, *B. diplostoma*, *B. ariza* and *B. almorhae*. Two species of this genus i.e., *Bangana dero* (Hamilton) and *Bangana devdevi* (Hora) have their distribution in North-East, India (Vishwanath *et al.*, 2007). ^[20] The presently known *B. devdevi* was first described by Hora (1936) from Burma as *Labeo devdevi* and later re-described by Jayaram and Das (1980). ^[8]

The conventional tools such as morphological traits, morphometric and meristic studies are widely employed to identify and describe the species. Apart from the availability of the physiological, ecological and anatomical data the ichthyologist is primarily dependent on the morphological characters which differentiate the fishes based on shape, size, placement of fins, body coloration and pigmentation etc. An important taxonomic and nomenclatural work on genus *Bangana* and its 13 species from China has been documented by Zhang and Chen (2006).^[24] There is considerable taxonomic ambiguity regarding both the above-mentioned species; therefore, the present study has been undertaken to address the issue.

2. Material and Methods

During study, samples were collected from there known distributional ranges and taxonomic data and information on morphological, morphometric and meristic characters were

taken and analysed following standard protocols. The specimens of *B. dero* (Hamilton, 1822) were collected from the river Brahmaputra and its tributaries from the North-Eastern states namely Arunachal Pradesh, Assam, Tripura, Manipur and Nagaland and *B. devdevi* (Hora, 1936) from Imphal River and Thoubal river from Manipur during May 2017 to April 2018. The samples were collected by employing different gears (with varying mesh sizes) such as cast net, gill net, drag net and other traditional gears (such as Bamboo traps, Hook and Lines) (Table 1). After collection, initial data such as Length, Weight has been taken and morphological characters were noted. Following initial observation, samples were preserved in 10% formalin and brought to laboratory. Specimens collected as part of the ongoing COE-FAB Project in College of Fisheries (CAU), Tripura were also studied in this respect. Further, the specimens of *B. dero* from NZC of ZSI, Kolkata (Table 2) were also studied for comparison

Table 1: River, locations with geographical coordinates in different state sampled for specimens

Sl. No.	State	River	Location	Geographical Coordinates
1.	Arunachal Pradesh	Thatching, Yamne, Buridwing, Nao-Dihing, Maodining	Borguli, Jenu, Balinag bridge, Miao	28°00.523'N & 095°27.857'E, 28°15.934'N & 095°92.397'E, 27°09.400'N & 96°12.430'E, 27°26.581' N & 95°51.485'E, 27°29.406'N & 98°12.430'E, 28°05.534'N & 095°83.915'E, 23°59.16'N & 94°40.569'E
2.	Tripura	Deo	Kumarghat	24°09'809' N & 092°02'206' E
3.	Manipur	Kugai (Imphal River)	Mongyang	25°519.500'N & 94°23.519'E
4.	Assam	Brahmaputra	Haora, Bhumaraguni	26°31.928'N & 092°20.081'E, 26°36.713'N & 92°51.054'E
5.	Nagaland	Doyang	Depong	26°78.334'N & 094°17.952'E

Table 2: Enlist of studied *B. dero* samples from repository of ZSI, Kolkata

Sl. No.	Registration/ No. of Sample
1	F4598/1
2	F4606/2
3	F4597/2

A total of 31 morphometric characters were taken using digital Vernier calliper to the nearest 0.01mm scale and 13 meristic measurements were recorded by counting with naked eye and microscope. The various morphometric parameters were recorded by following Jayaram (2010)^[5] some of which are diagrammatically represented in Fig. 1. All the morphometric measurements were converted in to ratios in relation to standard length, head length and body depth and expressed as percentage. The taxonomic redescription of these species is prepared by analyzing the differences in morphology, morphometric and meristic characteristics. The statistical analysis was performed using MS Excel 2007 and SPSS version 16.0.

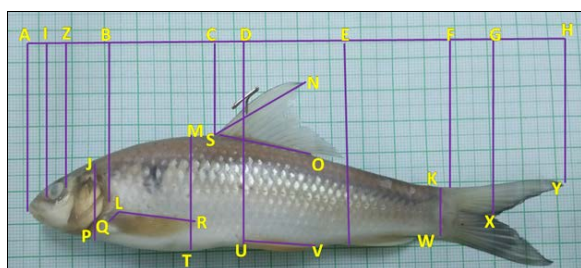


Fig 1: Diagrammatic representation of various body measurements used for Morphometric analysis in the present study

AH: Total length	KW: Least depth of caudal peduncle
AG: Forked length	IZ: Eye diameter
AF: Standard length	UV: Height of pelvic fin
AC: Pre pectoral length	AI: Pre orbital length
AE: Pre anal length	ZB: Post orbital length
AB: Head length	MT: Body depth
AD: Pre pelvic length	JP: Head depth
QL: Pectoral fin base length	SO: Dorsal fin base length
LR: Height of pectoral fin	SN: Height of dorsal fin

3. Result and discussion

Morphological trait of species under the genus *Bangana*

Morphological trait of *Bangana dero* (SL 74.27-213.13) (Fig. 2 A)

Body elongated and compressed on the sides, dorsal profile more elongated from snout to dorsal fin origin. Dorsal fin inserted midway between snout tip and origin of anal fin, and close to snout tip when compared with standard length. Head length 25.58 (21.12-28.50), body depth 25.09 (14.51-29.83) percent of standard length and pre-orbital length 36.29 (28.21-44.19), eye diameter 22.67 (15.41-28.74) percentage of head length. Height of dorsal fin more than body depth. Prominent snout with distinct groove covered with tubercles. Inferior mouth with thick lips, lower lip papillated; post labial fold interrupted at middle. Mouth lunar shaped; tip of mouth reaching the anterior part of eye. A pair of maxillary barbel present at corner of mouth. A distinct black spot is usually present on the 4th or 5th lateral line scale, clearly developed in formalin preserved specimen. Scales and eye of moderate size. Caudal fin deeply forked, tip of epichordal lobe pointed; tip of hypochordal lobe blunt. No distinct spot at the caudal

peduncle in fresh specimen but developed slowly in formalin preserved specimens.

Coloration: Body colour dark greenish on the back, and silvery below. Fins blackish with faint reddish hue, opercule region with golden tinge.

Morphological trait of *Bangana devdevi* (SL 106.1-248.57) (Fig. 2 B)

Body elongated and compressed on the sides, dorsal profile more convex than the ventral. Dorsal fin inserted midway between snout tip and origin of anal fin, close to snout tip when compared with standard length. Head length 23.91 (21.25-31.45), body depth 27.15 (25.29-33.50) percent of standard length and pre-orbital length 34.55 (30.39-39.39), eye diameter 17.29 (15.46-18.86) percentage of head length. Height of dorsal fin less than body depth. Prominent snout with distinct grooves covered with inconspicuous tubercles. Inferior mouth with thick lips, lower lip is papillated; post labial fold interrupted at middle. Horseshoe shaped; tip of mouth not reaching the anterior part of eye. A pair of

maxillary barbels present, concealed in the lateral groove. Black spot on the 4th or 5th lateral line scale usually absent in fresh specimen while developed in formalin preserved specimen. Scales and eye of moderate size. Caudal fin deeply forked with tip of epichordal and hypochordal lobe blunt.

Coloration: Body brownish black with silvery ventral profile. Outer margin of dorsal, pectoral and ventral fin pinkish in color. The outer margin of caudal fin has blackish tinge. Opercule region with golden tinge; a black spot at the base of caudal fin developed in long preserved specimens.

Morphometric and meristic characters of *Bangana dero* and *Bangana devdevi*

Meristic counts: The meristic counts of *Bangana dero* and *Bangana devdevi* showed variations in pectoral fin ray count, lateral line scale, counts of anal fin rays, pre-pelvic scale, dorsal fin origin to lateral line scale and circumpendicular scale (Table 3). Among all these, counts of lateral line scales showed highest variation. Both the species possess single pair of maxillary barbels. The first dorsal spine is very small and covered with muscles.

Table 3: Meristic counts of the selected studied species

Sl. No.	Meristic characters	<i>Bangana dero</i>	<i>Bangana devdevi</i>
1.	Dorsal fin ray count	iii 9	iii/10-12
2.	Pectoral fin ray count	i/16-18	i/16-17
3.	Pelvic fin ray count	i 8	i 8
4.	Anal fin ray count	ii 5	ii 5
5.	Caudal fin ray count	19	19
6.	Lateral line scale (LLS)	43-44	40
7.	Pre dorsal scale	20-22	20-21
8.	Pre pelvic scale	12-13	11-13
9.	Pre anal scale	25-26	24-25
10.	Dorsal fin origin to LL scale	9 ½	7 ½
11.	LL to Pelvic fin scale	7 ½	6 ½
12.	LL to Anal fin scale	6 ½ - 7 ½	6 ½
13.	Circumpendicular scale	22-23	21

Morphometric measurements

The relative growth pattern of various body parts in relation to Total length (TL), Standard Length (SL) and Head Length (HL) for *Bangana dero* and *Bangana devdevi* were analysed. SL, HL, FL, BD, CFL, CFBL and LHCP in relation to total length, HL, BD, DFBL, VFBL, AFBL, PDL, PVL, PAL, PF - VF, VF - AF in relation to Standard length and HW, POL, ED, IOW, INL, HD and PFL in relation to Head length were assessed to find out the significant difference amongst various body parameters (Table 4). The various body parameters were statistically analysed and t-test was performed to arrive at the statistical significance amongst various body parameters and assessed at $p < 0.05$ and $p < 0.001$ significant level wherever necessary (Table 5, 6). The Analysis of Variance (ANOVA) of the different morphometric characters is performed between two species to know the significant phenotypic difference between both the species.

Relative growth pattern of different body parts in *B. dero* (Hamilton, 1822)

The various body parameters were analysed and represented in graphic forms (Fig. 3) which indicated that all the parameters exhibit linear relationship in relation with TL, SL and HL. Maximum number of parameters was found to be highly correlated. The maximum value of correlation coefficient 'r' was of FL with respect to TL (0.997) and minimum was for CFBL with respect to TL (0.256). The 'b'

value showed per unit increment in total length, standard length and head length with respect to various body parameters. Per unit increment with respect to total length was maximum for HL and minimum for CFBL. Similarly, the SL has higher per unit increment with HL and lower with VFBL, the HL has maximum increment with respect to POL and ED while minimum with HW. The p-value of t- test indicated that all the body parameters are highly significant ($p < 0.001$).

Relative growth pattern of different body parts in *B. devdevi* (Hora, 1936)

The various body parameters were analysed and graphically represented (Fig. 4) which showed that all the parameters exhibit linear relationship in relation with TL, SL and HL. Further, all the parameters were found to be highly correlated with respect to TL, SL and HL. The maximum value of correlation coefficient 'r' was of FL with respect to TL (0.999) and minimum was of PF - VF with respect to SL (0.938). The 'b' value inferred per unit increment in TL, SL and HL with respect to various body parameters. Per unit increment with respect to total length was maximum for FL and minimum for LHCP. Similarly, the SL has higher per unit increment with PAL and lower with VFBL, the HL has maximum increment with respect to PFL while minimum with ED. The p-value for t- test indicated that all the body parameters are highly significant ($p < 0.001$), except SL, PAL and HD with respect to TL, SL and HL are significant

($p < 0.05$). The various body parameters such as FL with respect to TL and PFL with respect to HL are found to be non-significant ($p > 0.05$).

Further, the p-value obtained from ANOVA after analysing

mean of the different morphometric characters of both the species were found to be significant ($p < 0.05$), except, POL and ED ($p > 0.05$) which revealed that both the species i.e. *B. dero* and *B. devdevi* are phenotypically different (Table5).

Table 4: Morphometric character of different body parameters in relation to TL, SL and HL

Body parameters	<i>B. dero</i>			<i>B. devdevi</i>		
	Range	Mean	SD	Range	Mean	SD
In % TL						
Standard Length	74.66-85.53	77.83	1.60	77.12-79.19	78.28	0.72
Forked Length	78.23-91.73	86.07	1.57	83.82-87.91	85.60	1.16
Head Length	16.54-22.04	19.90	1.08	16.41-19.42	18.23	0.96
Body Depth	12.41-22.78	19.51	1.63	19.63-21.51	20.73	0.54
Caudal Fin Base Length	7.80-10.00	8.80	0.45	8.98-9.73	9.38	0.26
Caudal Fin Length	14.29-25.71	22.54	1.41	22.15-24.58	23.36	0.72
Least Height of Caudal Peduncle	7.37-16.36	8.82	1.08	8.72-10.09	9.48	0.33
In % SL						
Head Length	21.12-28.50	25.58	1.43	21.25-31.45	23.91	2.68
Body Depth	14.51-29.83	25.09	2.25	25.29-33.50	27.15	2.19
Dorsal Fin Base Length	13.69-21.57	18.57	1.20	20.13-28.28	22.34	2.40
Ventral Fin Base Length	3.69-5.61	4.48	0.40	4.10-5.50	4.81	0.41
Anal Fin Base Length	6.31-9.85	8.01	0.62	8.17-10.57	8.99	0.68
Pre Dorsal Length	40.39-48.41	44.41	1.69	41.45-54.79	44.63	3.58
Pre Ventral Length	47.12-55.38	51.54	1.57	45.99-51.90	48.93	1.54
Pre Anal Length	66.39-79.71	74.84	1.89	70.87-76.04	74.79	1.30
Distance between Pectoral fin to Ventral fin	16.83-28.51	23.60	2.82	22.87-33.06	25.08	2.90
Distance between Ventral fin to Anal fin	17.97-25.89	21.09	1.53	20.16-29.98	23.02	2.72
In % HL						
Head Width	46.23-60.26	52.49	2.91	55.27-65.96	57.86	3.15
Pre Orbital Length	28.21-44.19	36.29	2.78	30.39-39.39	34.55	3.00
Eye Diameter	15.41-28.74	22.67	2.26	15.46-18.86	17.14	1.27
Inter Orbital Width	30.16-39.49	34.29	2.03	34.97-43.30	38.30	2.61
Inter Nostril Length	17.48-28.36	21.14	1.77	20.32-26.17	22.65	1.61
Head Depth	62.24-78.57	71.61	3.59	75.36-84.54	80.36	2.99
Pectoral Fin Length	64.19-84.21	72.58	4.48	76.83-85.46	81.27	3.25

Table 5: Morphometric characters of *Bangana* species

X	<i>Bangana dero</i>					<i>Bangana devdevi</i>				
	a	b	r	p-value	CT	a	b	r	p-value	CT
TL	0.6386	1.2792	0.9963	0.0001 ^{HS}	*	-0.3307	0.7684	0.9748	0.0389 ^S	*
TL	-1.0593	1.1714	0.9973	0.0001 ^{HS}	*	4.3562	0.8302	0.9991	0.1936 ^{NS}	*
TL	-16.9978	5.6883	0.9723	0.0001 ^{HS}	*	6.3246	0.1450	0.9844	0.0001 ^{HS}	*
TL	21.4109	4.2937	0.9571	0.0001 ^{HS}	*	6.3246	0.1450	0.9844	0.0001 ^{HS}	*
TL	7.9616	0.0678	0.2560	0.0001 ^{HS}	□	-1.2153	0.1010	0.9967	0.0001 ^{HS}	*
TL	-10.5972	0.2658	0.7080	0.0001 ^{HS}	*	1.8484	0.2228	0.9943	0.0001 ^{HS}	*
TL	-1.674	0.1027	0.7707	0.0001 ^{HS}	*	0.1769	0.0938	0.9938	0.0001 ^{HS}	*
SL	-13.1073	4.4211	0.9702	0.0001 ^{HS}	*	8.1355	0.1758	0.9407	0.0001 ^{HS}	*
SL	17.5383	3.3071	0.9465	0.0001 ^{HS}	*	2.7006	0.2502	0.9726	0.0001 ^{HS}	*
SL	19.7002	4.3861	0.9534	0.0001 ^{HS}	*	3.9573	0.1925	0.9427	0.0001 ^{HS}	*
SL	101.6811	0.4049	0.0957	0.0001 ^{HS}	□	-1.2757	0.0579	0.9788	0.0001 ^{HS}	*
SL	85.3316	1.6277	0.3237	0.0001 ^{HS}	□	0.5409	0.0856	0.9717	0.0001 ^{HS}	*
SL	-2.9881	2.3193	0.9867	0.0001 ^{HS}	*	4.0578	0.4142	0.9727	0.0001 ^{HS}	*
SL	2.5832	1.9030	0.9725	0.0001 ^{HS}	*	-1.2757	0.0579	0.9788	0.0001 ^{HS}	*
SL	0.9711	1.235	0.9948	0.0001 ^{HS}	*	8.2063	0.6830	0.9689	0.023 ^S	*
SL	25.1709	3.2133	0.9124	0.0001 ^{HS}	*	6.8032	0.1976	0.9380	0.0001 ^{HS}	*
SL	69.7379	1.2204	0.4838	0.0001 ^{HS}	□	-4.7806	0.2665	0.9554	0.0001 ^{HS}	*
HL	16.5076	0.6947	0.7294	0.0001 ^{HS}	*	-5.4084	0.7527	0.9905	0.0001 ^{HS}	*
HL	-1.3534	4.6823	0.9736	0.0001 ^{HS}	*	-3.0344	0.4432	0.9682	0.0001 ^{HS}	*
HL	-1.3534	4.6823	0.7943	0.0001 ^{HS}	*	0.0074	0.1725	0.9527	0.0001 ^{HS}	*
HL	7.0172	2.0137	0.9686	0.0001 ^{HS}	*	-3.0344	0.4432	0.9736	0.0001 ^{HS}	*
HL	6.5925	3.5477	0.9466	0.0001 ^{HS}	*	-2.3993	0.3037	0.9842	0.0001 ^{HS}	*
HL	-2.4925	0.8143	0.9746	0.0001 ^{HS}	*	-8.9580	1.0867	0.9885	0.068 ^{NS}	*
HL	7.2187	1.0036	0.9406	0.0001 ^{HS}	*	-0.3192	0.8571	0.9698	0.110 ^{NS}	*

Here CT = correlation type, * show the strong correlation ($r > 0.7$), Δ show moderate correlation ($r = 0.51-0.69$),

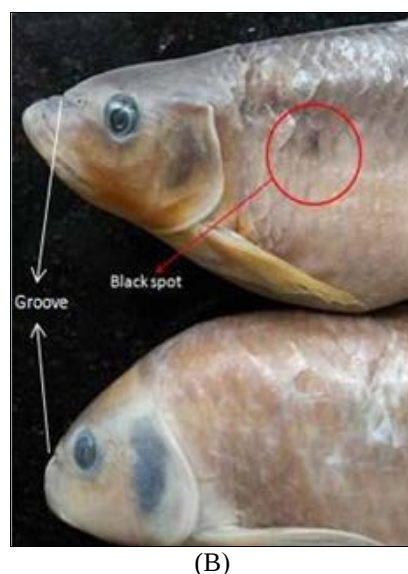
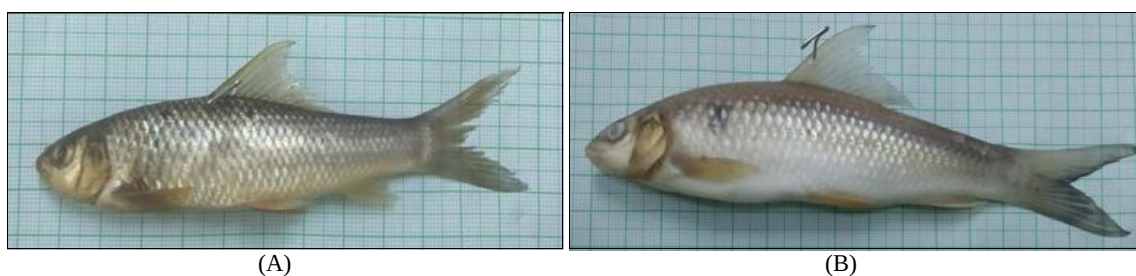
□ represent weak correlation ($r < 50$), - show negative correlation.

t-test: Significant at 5% level ($p < 0.05$), HS: Highly significant correlation (when $p < 0.01$), NS: Not Significant correlation (when $p > 0.05$),

S: Significant correlation (when $p < 0.05$)

Table 6: Descriptive statistics of morphometric characters of *Bangana* species

Morphometric characters	<i>Bangana dero</i>		<i>Bangana devdevi</i>		ANOVA	
	Range	Mean $\pm$ SD	Range	Mean $\pm$ SD	F	P
TL	97.32-270.54	135.1262 $\pm$ 31.4227	144.37-321.75	176.7145 $\pm$ 48.6293	14.89604	0.0002 ^S
SL	74.27-213.13	105.1264 $\pm$ 24.4739	106.1-248.57	135.47 $\pm$ 38.3346	13.00229	0.0004 ^S
FL	81.9-232.47	116.2529 $\pm$ 26.7511	126.92-271.81	151.07 $\pm$ 40.4067	14.5567	0.0002 ^S
HL	18.44-51.04	26.7429 $\pm$ 5.3711	27.32-52.83	31.9572 $\pm$ 17.1564	10.51415	0.0016 ^S
BD	13-54.02	26.4841 $\pm$ 7.0049	30.75-65.89	36.6014 $\pm$ 9.8633	18.4372	0.0001 ^S
DFBL	6.61-42.87	19.4765 $\pm$ 5.3203	25.12-52.65	30.0381 $\pm$ 7.8282	34.23498	0.0001 ^S
VFBL	3-23.97	8.5088 $\pm$ 5.7889	4.67-13.24	6.5727 $\pm$ 2.2688	10.51415	0.0016 ^S
AFBL	5.73-25.06	12.1610 $\pm$ 4.8683	10.03-22.06	12.1427 $\pm$ 3.3784	0.000146	0.9903 ^{NS}
PDL	32.17-93.01	46.6141 $\pm$ 10.4127	50.85-108.78	60.1763 $\pm$ 16.3253	14.34294	0.0002 ^S
PVL	28.8-108.04	53.8822 $\pm$ 12.5067	59.03-114.32	67.2718 $\pm$ 15.8191	10.51415	0.0016 ^S
PAL	54.83-159.51	78.6919 $\pm$ 18.3953	86.49-181.43	100.7355 $\pm$ 27.0225	12.4829	0.0006 ^S
PF-VF	15.45-52.96	24.8824 $\pm$ 6.9498	30.18-57.57	8.0752 $\pm$ 33.5727	10.51415	0.0016 ^S
VF-AF	9.68-52.11	28.9963 $\pm$ 9.7019	24.61-62.87	31.3272 $\pm$ 10.6944	10.51415	0.0016 ^S
HW	9.37-30.5	14.1041 $\pm$ 3.4803	15.93-34.85	18.6463 $\pm$ 5.4453	10.51415	0.0016 ^S
POL	5.27-21.5	9.7953 $\pm$ 2.5969	8.49-20.61	11.13 $\pm$ 3.2082	10.51415	0.0016 ^S
ED	3.89-8.77	6.004 $\pm$ 0.9112	4.77-9.34	5.5218 $\pm$ 1.2976	10.51415	0.0016 ^S
IOW	6.33-20.79	9.2829 $\pm$ 2.4101	10.56-22.59	12.3054 $\pm$ 3.4360	13.8345	0.0003 ^S
INL	3.78-12.63	5.6797 $\pm$ 1.4331	5.69-13.83	7.3090 $\pm$ 2.2116	11.00526	0.0012 ^S
HD	12.86-38.51	19.2848 $\pm$ 4.4875	27.32-52.83	31.9572 $\pm$ 7.1654	16.70727	0.0001 ^S
PFL	5.4-40.93	19.4536 $\pm$ 5.0340	21.45-45.15	27.0727 $\pm$ 6.3327	21.05019	0.0001 ^S
CFBL	7.8-39.08	17.1363 $\pm$ 8.3317	13.67-31.31	16.64 $\pm$ 4.9294	0.037161	0.8475 ^S
CFL	9.63-59.11	25.3222 $\pm$ 11.7972	31.98-73.23	41.2245 $\pm$ 10.8970	17.99864	0.0001 ^S
LHCP	7.89-35.44	12.2129 $\pm$ 4.1902	13.78-30.43	4.5911 $\pm$ 16.7581	11.23816	0.0011 ^S

**Fig 2:** Showing morphological characters of (A) *B. dero* and *B. devdevi*

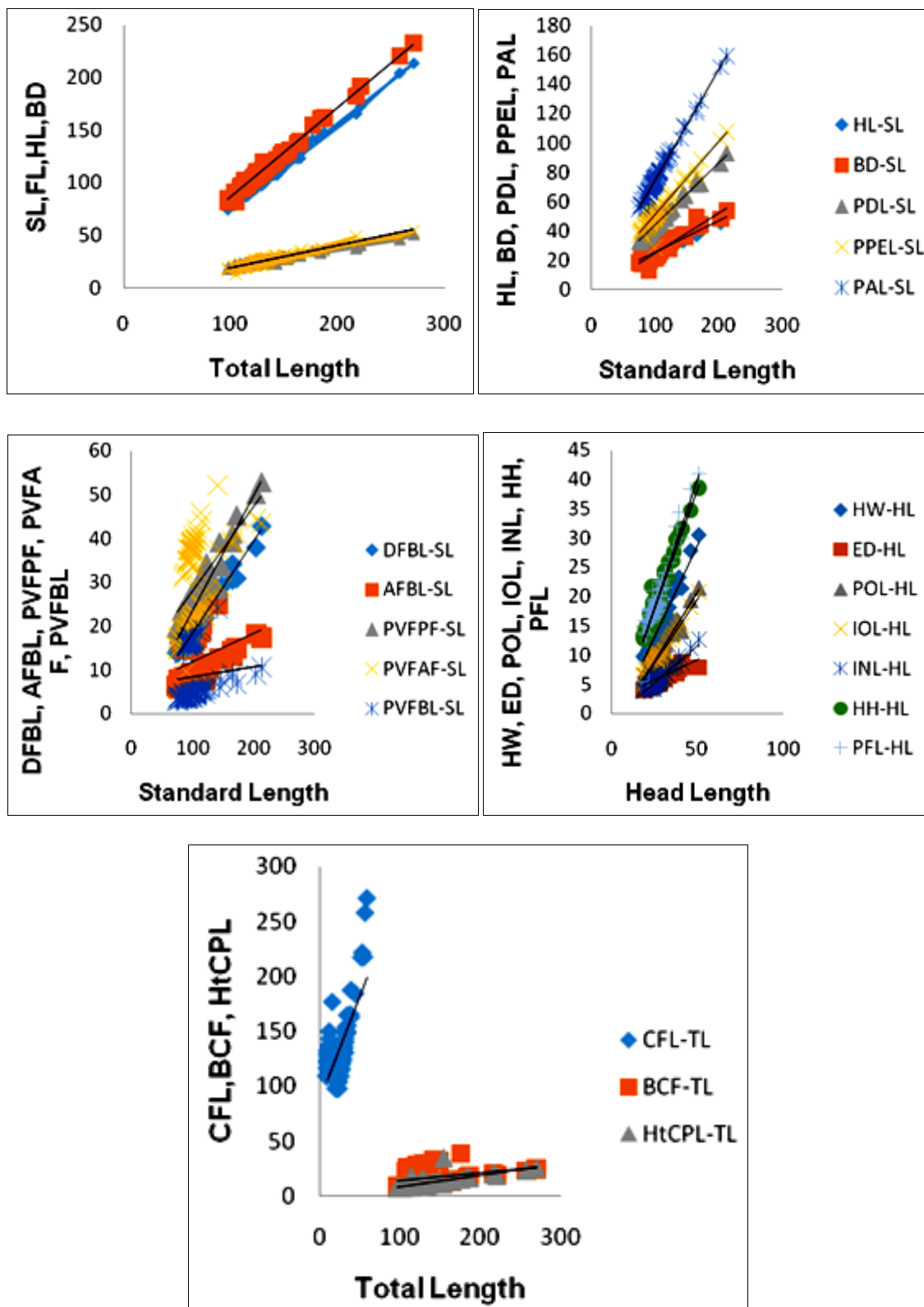


Fig 3: Graphical representation of various body parameters of *B. dero* in relation to Total length, Standard length and Head length

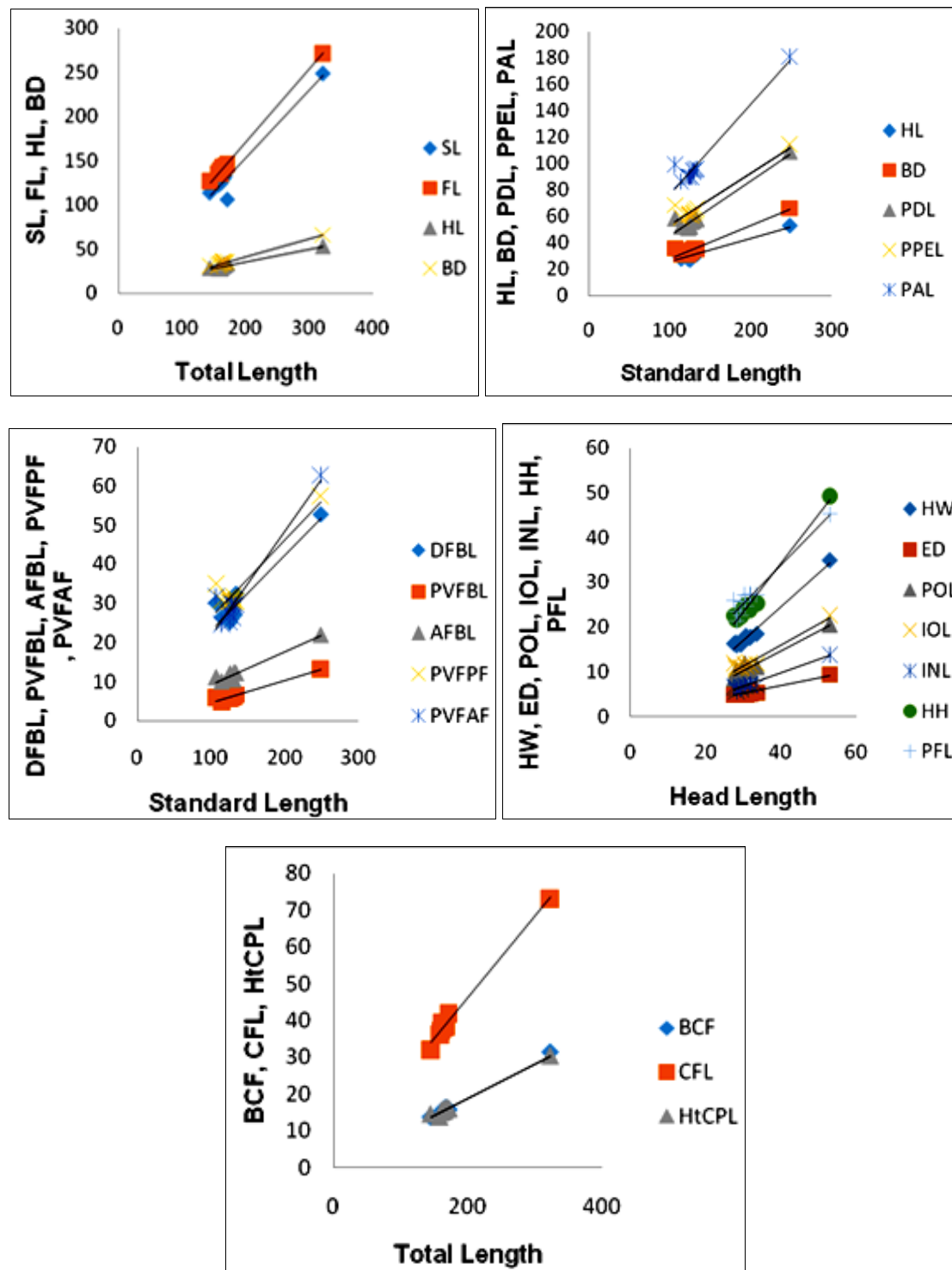


Fig 4: Graphical representation of various body parameters of *B. devdevi* in relation to Total length, Standard length and Head length

Here: SF-Statistics is significant at 5% level ($p < 0.05$), NSF-Statistics is not significant at 5% level (when $p > 0.05$)

The present observations regarding morphological characters coincide with the view of Zhang^[24] and Chen (2006)^[24] and Rainboth (1996).^[15] The results revealed that there are mainly four characters which can distinguish *B. dero* from *B. devdevi* viz. height of dorsal fin in relation to body depth, gape of mouth reaching the anterior margin of eye, black spot on lateral line scale and anterior tip of hypochordal lobe. Some common characters in both the species are found in accordance with work of earlier authors (Jayaram and Das, 1980;^[8] Talwar and Jhingran, 1991;^[19] Rainboth, 1996;^[15] Jayaram and Dhas, 2000^[6] and Zhang and Chen, 2006).^[24] However, Jayaram and Das (1980)^[8] reported the presence of faint black blotch above 6th and 7th lateral line scales in

juvenile of *B. devdevi* whereas in present study no such black spot was observed that may develop in preserved specimen later on. Jayaram and Dhas (2000)^[6] reported insertion of dorsal fin mid-way between tip of snout and caudal peduncle in *B. dero*, which does not comply with the present findings. The height of dorsal fin is found to be more than body depth in *B. dero* and as such follows the view of Talwar and Jhingran (1991).^[19] However, in *B. devdevi* it is less than body depth. The taxonomic description of *B. devdevi* by Jayaram and Das (1980)^[8] reported that eyes are visible from the ventral surface, however this feature was not observed in the present study, which agree with the observations of Talwar and Jhingran (1991).^[19]

The variations in the morphometric and meristic characters have been enormously used by many authors for separating

closely related species. Presently, the variations in morphometric and meristic characters are used to detect the amount of phenotypic differences among the two species of genus *Bangana*. The meristic counts of the two species were almost overlapping except number of branched dorsal fin ray, lateral line scale, dorsal fin to lateral line scale, pelvic fin to lateral line scale and circumpendicular scale. However, all the meristic counts are found to be similar in accordance with Talwar and Jhingran (1991) ^[19] (except for lateral line to pelvic fin scale) and Jayaram and Dhas (2000). ^[6] Talwar and Jhingran (1991) ^[19] quoted 7-8 scales between lateral line to pelvic fin scale in *B. dero* and $6\frac{1}{2}$ - 7 in *B. devdevi* which does not comply with the present findings. Statistical data in respect of 23 morphometric characters in the form of scatter diagram revealed a linear relationship among all this morphometric character in both the species. However, it was observed that per unit increment was very low in *B. devdevi* as compared to *B. dero* and as such the growth rate was found to be varying among different body parameters in both the species. All the morphometric parameters are highly significant ($p < 0.001$) in *B. dero* but in *B. devdevi* some characters (HD and PFL in HL and PAL in SL) are not significant. In *B. dero*, the eye diameter in percentage of head length, head length in percentage of standard length, eye diameter in percentage of head length are found to be varying from those reported by Jayaram and Dhas (2000). ^[6] It was universally accepted that growth of fish increases with the increase in its body length and growth of various body parts are interconnected with each other (Zubia *et al.*, 2015) ^[25]. However, the 'b' value for all the parameters depicted that per unit increment was very low in *B. devdevi* as compared to *B. dero* and as such the growth rate was found to be varying among different body parameters in both the species and coincides with the view of Shabanum *et al.* (2013) ^[17]. Amongst the other statistical parameter, the correlation coefficient was found to be strongly correlated ($r > 0.7$) in *B. devdevi* and *B. dero* (except some parameters). The growth of all the body parameters was found to be linear in relation to TL, SL and HL and as such followed the findings of Zafar *et al.* (2002), ^[23] Negi and Nautiyal (2002), ^[13] Krishnan and Tarana (2010) ^[12] and Negi and Negi (2010). ^[14] Hence, based on the significant differences (ANOVA, $p < 0.05$) in the mean values for each morphometric character clearly revealed that these species were phenotypically different from each other and confirmed the findings of Zubia *et al.* (2015) ^[25] and El-Zaeem (2008). ^[1]

Based on the above finding it is concluded that morphology, morphometric and meristic trait of *B. dero* and *B. devdevi* would provide important taxonomic tools in hands of taxonomist to identify and resolve the existing ambiguity amongst the species of genus *Labeo* and *Bangana*. Conclusively based on the present findings, re-description of the two species has been drawn as here under which would help the researchers in identification of these two closely related species.

Re-description of *Bangana* spp.

1. *Bangana dero* (Hamilton, 1822)

Cyprinus (Bangana) dero Hamilton-Buchanan, 1822, Fishes of Ganges: 277: 385, pl. 22, fig. 78. (Type-locality: Brahmaputra River).

Bangana dero (Hamilton, 1822): Zhang and Chen, 2006, ^[24] Zootaxa, 1281: 41-54

Diagnosis

Diii 9; Pi 16-i 18; Vi 8; Ali 5; C 10+9; LI 43-44; Ltr $9\frac{1}{2}$ / $7\frac{1}{2}$

Body elongated and compressed laterally, dorsal profile more convex from snout to dorsal fin origin. Snout with pointed tip, distinct groove covered with tubercles. Mouth inferior, Lunar shaped, gape of mouth reaching the anterior margin of eye; lips thick, lower lip papillated; post labial fold interrupted at middle. Eye moderate in size, not visible from ventral. A pair of maxillary barbel present at corner of mouth. Dorsal fin inserted nearer to snout tip than to base of caudal fin. Height of dorsal fin more than body depth. Caudal fin deeply forked, tip of epichordal lobe pointed; tip of hypochordal lobe blunt. A distinct black spot usually present on the 4th or 5th lateral line scale. The most consistent and reliable body proportions to differentiate this species from its congeners is body depth 25.09 (14.51-29.83) dorsal fin base length 18.57 (13.69-21.57), pre ventral length 51.54 (47.12-55.38), distance between pectoral and ventral fin 23.60 (16.83-28.51) %SL; head width 52.49 (46.23-60.26), pre orbital length 36.29 (28.21-44.19), eye diameter 22.67 (15.41-28.74), inter orbital width 34.29 (30.16-39.49), head depth 71.61 (62.24-78.57) in %HL.

Colouration: Body dark greenish on the back, and silvery below. Fins blackish with faint reddish hue, opercular region with golden tinge. No distinct spot at the caudal peduncle in fresh specimen but developed slowly in formalin preserved specimens.

Remarks: Snout with distinct groove and tubercles. Gape of mouth reaching the anterior margin of eye. Height of dorsal fin more than body depth. A distinct black spot usually present on the 4th or 5th lateral line scale in fresh specimen. Caudal fin: tip of epichordal lobe pointed; tip of hypochordal lobe blunt.

2. *Bangana devdevi* (Hora, 1936)

Labeo devdevi Hora, 1936, Rec. Indian Mus.; 38(3): 323 (type-locality: Mali Hka river system, Upper Burma).

Bangana devdevi (Hora, 1936): Zhang and Chen, 2006, ^[24] Zootaxa, 1281: 41-54.

Diagnosis

D iii 10- iii 12; Pi 16- i 17; Vi 8; A ii 5; C 10+9; LI 40; Ltr $7\frac{1}{2}$ / $6\frac{1}{2}$

Body elongated and compressed laterally, dorsal profile more convex than the ventral. Snout with blunt tip and distinct groove covered with inconspicuous tubercles. Mouth inferior, horseshoe shaped; gape of mouth not reaching the anterior margin of eye; lips thick, papillated lower lip; post labial fold interrupted at middle. A pair of maxillary barbels present, concealed in the lateral groove. Dorsal fin is inserted nearer to snout tip than to base of caudal fin. Height of dorsal fin is less than body depth. Black spot on the 4th or 5th lateral line scale usually absent. Caudal fin deeply forked with tip of epichordal and hypochordal lobe pointed. The most consistent and reliable body proportions to differentiate this species from its congeners is body depth 27.15 (25.29-33.50) dorsal fin base length 22.34 (20.13-28.28), pre ventral length 48.93 (45.99-51.90) distance between pectoral and ventral fin 25.08 (22.87-33.06) %SL; head width 57.86 (55.27-65.96), pre orbital length 34.55 (30.39-39.39), eye diameter 17.14 (15.46-18.86), inter orbital width 38.30 (34.97-43.30), head depth 80.36 (75.36-84.54) in %HL.

Coloration: Body brownish black with silvery tinge on ventral profile. Outer margin of dorsal, pectoral and ventral fin pinkish in color. The outer margin of caudal fin has blackish tinge. Opercular region with golden tinge; a black spot at the

base of caudal fin more prominent in long preserved specimens.

Remarks: Snout with distinct groove and tubercles. Height of dorsal fin less than body depth. Gape of mouth not reaching the anterior margin of eye. Black spot on the 4th or 5th lateral line scale usually absent in fresh specimen. Caudal fin: tip of epichordal and hypochordal lobe pointed.

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