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Biometrics and Sexual dimorphism of *Neolissochilus hexagonolepis* (McClelland)

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ABSTRACT
Understanding the sexual dimorphism in fish is an uphill task and is paradoxical in different species. In general, the studies on the biometrics of fish form the basis of fishery investigations particularly in the management and exploitation of fishery resources. The present study was carried in order to obtain characteristic relationship of various morphological parameters between the sexes of *Neolissochilus hexagonolepis* (McClelland). Considerable differences in the percentage of some morphometric characters on standard length have been observed between males and females. The males were found to have greater head width at operculum, snout length, predorsal length and preanal length than the females. On the other hand, the females had greater body depth at dorsal fin insertion, pectoral fin length, anal fin height and ventral fin height than the males. The males were found to have greater value of biometric index for body depth at dorsal fin insertion, pectoral fin length, anal fin height and height of ventral fin than the females; while the females had greater values for head width at operculum, snout length, predorsal length and preanal length. The variation in the biometric index and percentage of anal fin height on standard length was highly significant between males and females. Together the values of correlation coefficient ‘r’ between the variable characters and the standard length were found positive, with the highest value of regression coefficient ‘b’ in case of total length (b=1.3082) and lowest in case of head height at eye (b=0.0366).

Keywords: Mahseer, Dimorphism, fisheries, conservation.

1. Introduction
Neolissochilus hexagonolepis (McClelland) or Chocolate mahseer is a coldwater fish species belong to the family Cyprinidae and is one of the members of pride indigenous mahseer. In India *N. hexagonolepis* is present in the coldwater of North-Eastern states; where it has been reported from the reservoirs and lakes of Assam [1], Arunachal Pradesh, Meghalaya [2], Mizoram [3], Sikkim and North Bengal [4]. Outside India the species was reported from Bangladesh, Bhutan, China, Yunnan, Indonesia, Malaysia, Myanmar, Pakistan, Thailand & Vietnam [1, 5]. *N. hexagonolepis* is abundant in most of the big rivers, lakes and reservoirs of Nepal from 250m to1500m altitude, having a preference for water temperature 10^0 to 30^0 C [6]. In Arunachal Pradesh (Lat. 27^0 and 29^0 $30^/$ N; Long. 92^0 $8^/$ $57^{//}$ and 97^0 $12^/$ E) the species was previously recorded from Yembung division [7] and Tirap division. It is also found in rivers Kameng, Subansiri, Dikrong, Pachin, Dibang, Ranga, Siang, Lohit, Noadihing, Buridihing and Tirap [8].

A commonly known fact that some species of fishes show well marked sexual dimorphism, which may be of two kinds: i) some species possess structural peculiarities directly related with fertilization of ova. These are in the form of copulatory organ in male for introducing the milt in to the body of the female and ii) some species possess structural peculiarities that are not connected with sexual union or fertilization.

In most fishes excepting the elasmobranches and a few teleosts, fertilization is external in water. In several species of fishes, sexual differences are not related with copulation between male and female, and are generally well marked during spawning season. In most of the teleosts, females are larger in size with enlarged rounded belly during the breeding season. A common secondary sexual character is the brighter colour of the body and fins in the male, as in the Cyprinodontidae, Cichlidae, Labyrinthidae and Labridae. In a number of cyprinids, the male becomes much brighter in colour during the breeding season. The males in many cyprinids developed horny tubercles on the head and body, especially during breeding season.

Knowledge of biometrics is very essential in identification and classification of fish. Slight but significant changes occur in the biometrics of the fish of different stocks, races or populations. In order to manage and exploit the fishery resources we must have good knowledge of species composition of an ecosystem supporting the fishery, and so it becomes important to know whether the catch comes from a single stock or several. The inter-specific variation in the fish over the area of investigation is potentially an important matter from the point of view of future development. Biometrics of a fish indicate some of the important events in the life of fish such as size at first maturity stage, variation in growth of different sexes, gonad development, breeding season and general wellbeing. But, no such comprehensive work on *Neolissochilus hexagonolepis* (McClelland) has been done anywhere. Therefore, an attempt was made to study various morphometric parameters in relation to standard length with the aim to determine whether these parameters differ in different sexes.

2. Materials and Methods

Fish specimens of Chocolate Mahseer were the primary materials for the study of morphometrics and sex dimorphism. The fishes were purchased from different markets in the study area and specimens were preserved in 10% dilution of formalin solution and studied in the laboratory.

In laboratory the fish samples were pooled together irrespective of the sites and the morphometric measurements were noted separately for each specimen and the sex of the specimen was noted against the morphometric measurements by observing the gonads after dissecting the abdomen of the fish. Altogether 139 numbers of adult fishes belonging to the size group of 220 mm to 340 mm length were studied. The selection of size group was done on the basis of minimum length size at which the maturity was observed. Measurements of various morphometric characters were noted as per literature [9, 10, 11]. A total of 30 morphometric and 04 meristic characters have been taken up for study according to the described methods [12, 13, 14]. Divider and measuring board, having graduations in millimeter have been used for various measurements. All the linear measurements were made to the nearest mm. The standard length of each specimen was used as a basis of reference for all the measurements. The number of times each morphometric character went into the reference length of the fish was considered as the Biometric Index [15]. For each character, a mean biometric index has been calculated. The regression of various body characters against Standard length were compared by using the covariance technique [16]. The regression equation was obtained by least square method with the formula: Y= a + b X; where ‘Y’ is the variable character such as total length, head length etc., ‘a’ is the constant value to be determined, ‘b’ is the regression coefficient and ‘X’ the standard length. The correlation coefficient ‘r’ of variable characters on the standard length was computed. For computing the growth of the body parts in relation to total length, the rectilinear regression was used as it is time saving, easier to interpret and less likely to lead to confusing or doubtful conclusions [17]. The computer software MS EXCEL was used for all the statistical analysis of the data.

3. Results and Discussions

3.1 General Morphometrics

Values of correlation coefficient ‘r’ between the variable character and the standard length were found positive which indicate that all the parameters increase gradually with increase in standard length. The regression coefficient ‘b’ and the intercept ‘a’ of different variable characters (Y) on standard length (X) were also computed and the regression equation for each character is presented in (Table 2). The table depicts highest value of ‘b’ in case of total length (b= 1.3082) and lowest in case of head height at eye (b= 0.0366); which indicates that the total length has maximum rate of growth than all the other parameters, while head height at eye has the minimum rate of increase.

3.2 Sex differentiation

The meristic characters were found almost similar in all the studied samples irrespective of size and sex (Table 1). Considerable differences in the percentage of some morphometric characters on standard length have been observed between males and females (Table 3). The males were found to have greater head width at operculum, snout length, predorsal length and preanal length than the females. On the other hand the females had greater body depth at dorsal fin insertion, pectoral fin length, anal fin height and ventral fin height than the males (Fig 1). Among all the dissimilar characters the height of anal fin was found highly significantly lower in males than the females. The snout length is the second most significantly different character which is higher in males than the females. Difference in the biometric index of morphometric characters on standard length has also been observed between males and females (Table 4). The males were found to have greater biometric index for body depth at dorsal fin insertion, pectoral fin length, anal fin height and height of ventral fin than the females. However, the females had greater values for head width at operculum, snout length, predorsal length and preanal length. The difference in the biometric index of anal fin height on standard length was highly significant (t=5.1661) between males and females. The males have shorter anal fin height than females with biometric index of 5.781 and 5.274 for males and females respectively.

Table 1: Meristic characters of N. hexagonolepis

S.no.	Parameters	values
1.	No. of dorsal fin rays	ii+10
2.	No. of pectoral fin rays	ii+14
3.	No. of ventral fin rays	i+8
4.	No. of anal fin rays	ii+6
5.	No. of caudal fin rays	9+8
6.	No. of Lateral line scales	24-25+3

The biometry of copper mahseer *Acrossocheilus hexagonolepis* (McClelland) from the North-Eastern India has been studied earlier [9] and found a high degree of positive correlation between the different morphometric parameters with reference length (standard length) as well as a considerable difference in the morphometric characters between males and females. According to that study, the males have greater height of dorsal, pectoral and ventral fins; and the females have greater height of anal fin, greater girth, mouth gape, length of upper jaw and the length of barbels.

Another study obtained linear relationship in *Rhinomugil corsula* collected from two reservoirs of Tamil Nadu [18]. Some classical studies in *Mugil tade* [19] and in *Mugil cumesius* [20] reported standard length having the maximum rate of growth, and the depth of head through orbit having the minimum growth rate. Some workers have reported straight line linear relationship [21] while some reported a non-linear relationship in certain fishes [17, 22]. They observed that the ratio between various parts with increasing length of different stages of life may not be having constant relative growth. Significant sexual dimorphism in various body parts has been reported in half beaks [23] and in *Labeo calbasu* [24].

Most of the biometric indices of *N. hexagonolepis* were found almost constant in the present study. A constant index in any of the biometric characters in relation to its reference length is isometric [15]. A similar case has been reported in case of *Lates niloticus* [25]. Males and females often differ in the length and shape of the fins [26]. In the males of many Cyprinoids, both the paired and the unpaired fins are slightly larger than the females. Examples of some species where male were found to differ in length and shape of fins have been reported. For example, in the males of certain lake Baikal Sculpins, *Cotio comephorus*, the thoracic fins were found to be significantly larger [26]. It has been reported that in *Xiphophorus* (Family Pocciilidae) there is a long outgrowth on the caudal fin whereas in the males of many pleuronectids of the family Bothidae, the rays of the dorsal fin are elongated, and so on [26]. Therefore, the mentioned differences in the morphometric characters noted for males and females of *N. hexagonolepis* may be considered as sexually dimorphic feature.

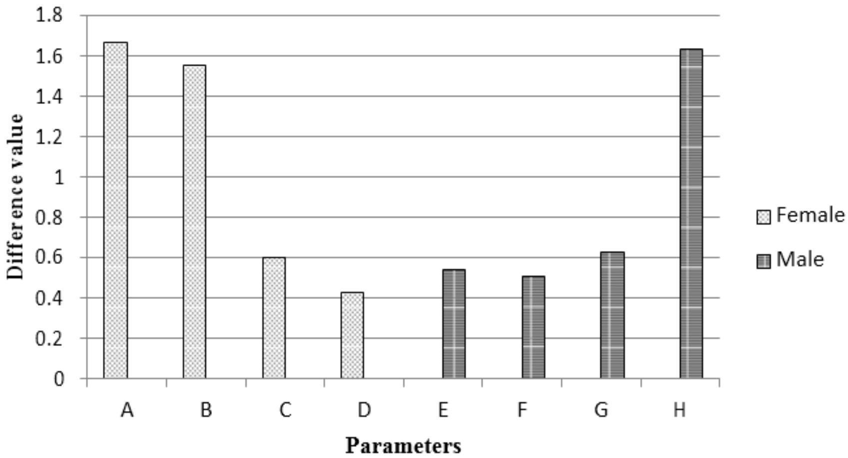

Fig 1: Differences in percentage on standard length of external sexual characters between sexes. A total of eight parameters are shown. In order to clearly visualize the distinction, the difference values for each of the parameters are taken and the particular parameter being greater in each of the sexes are shown. *symbolic expression of the parameters are such as: A= Anal fin height, B= Body depth at dorsal fin insertion, C= Pectoral fin length, D= Height of ventral fin, E= Head wide at operculum, F= Snout length, G= Predorsal length, H= Preanal length

Table 2: Regression and correlation of different morphometric characters on standard length of *N. hexagonolepis*

S. No.	Parameters	Regression equation	Correlation Coefficient 'r'
1	Total length	Y= -1.9209 + 1.3082 X	0.99371
2	Body depth at dorsal fin insertion	Y= -5.5646 + 0.2888 X	0.83654
3	Lateral head length	Y= -0.4047 + 0.2496 X	0.95272
4	Head height at occiput	Y= 13.1948 + 0.0994 X	0.93418
5	Head height at eye	Y= 20.2406 + 0.0366 X	0.69865
6	Head wide at operculum	Y= 11.8939 + 0.0793 X	0.85213
7	Head wide at eye	Y= 13.7708 + 0.0415 X	0.81665
8	Eye diameter	Y= 2.5432 + 0.0387 X	0.75505
9	Interorbital distance	Y= -4.8300 + 0.1163 X	0.92315
10	Snout length	Y= 1.2481 + 0.0748 X	0.78496
11	Mouth gape wide	Y= -2.0122 + 0.0771 X	0.80513
12	Dorsal fin height	Y= 12.7834 + 0.1745 X	0.66768
13	Dorsal fin base length	Y= 5.4345 + 0.1219 X	0.84317
14	Pectoral fin length	Y= -2.1101 + 0.2087 X	0.90818
15	Anal fin height	Y= -5.1026 + 0.2024 X	0.83143
16	Anal fin base length	Y= -1.9193 + 0.0863 X	0.83635
17	Caudal peduncle length	Y= 5.0853 + 0.1379 X	0.83101
18	Caudal peduncle height	Y= 2.4617 + 0.1017 X	0.82184
19	Predorsal length	Y= -1.3485 + 0.4944 X	0.98882
20	Prepectoral length	Y= 27.1317 + 0.0961 X	0.90912
21	Prepelvic length	Y= 55.0321 + 0.2198 X	0.99463
22	Preanal length	Y= 71.2313 + 0.3758 X	0.99425
23	Maxillary barbel length	Y= -3.7806 + 0.0828 X	0.88683
24	Rostral barbel length	Y= -1.6169 + 0.0640 X	0.85753
25	Fork Length	Y= 38.3122 + 1.0032 X	0.99688
26	Distance between PF & VF	Y= 3.5028 + 0.2888 X	0.95783

27	Height of ventral fin	Y= -0.7227 + 0.1820 X	0.93016
28	Post orbital length	Y= 2.9984 + 0.1213 X	0.85037

Table 3: Difference of morphometric characters on standard length between two sexes of *N. hexagonolepis*

S.No.	Morphometric parameters	% on Standard Length				MD	SE	t-Values	Remarks
		Mean		Range					
		Male	Female	Male	Female				
1	Body depth at dorsal fin insertion	25.64	27.19	24.378 – 27.751	25.11 - 30.74	1.549	0.6340	2.443833	S
2	Lateral head length	25.29	24.75	22.768 – 25.946	23.39 - 25.53	0.543	0.2669	2.033235	NS
3	Head height at occiput	16.95	17.12	16.279 – 17.838	16.49 - 17.54	0.165	0.3587	0.458692	NS
4	Head height at eye	13.72	14.53	12.935 – 15.676	14.43 - 14.62	0.806	0.3593	2.242032	NS
5	Head width at operculum	14.19	13.65	13.953 – 15.789	12.87 - 14.43	0.537	0.5204	1.031538	S
6	Head wide at eye	11.54	11.23	10.698 – 12.432	11.11 - 11.34	0.314	0.1922	1.632643	NS
7	Eye diameter	5.04	5.05	4.651 – 5.556	4.26 - 5.67	0.011	0.1174	0.094036	NS
8	Interorbital distance	9.32	9.39	8.837 – 10.048	8.66 - 10.66	0.065	0.1781	0.366984	NS
9	Snout length	8.33	7.82	7.143 – 9.013	7.20 - 8.61	0.515	0.1878	2.742505	S
10	Mouth gape wide	6.96	6.73	5.581 – 8.155	6.19 - 7.38	0.230	0.2053	1.122291	NS
11	Dorsal fin height	23.60	23.31	20.089 – 25.871	19.91 - 27.32	0.292	0.6710	0.435028	NS
12	Dorsal fin base length	14.74	14.64	13.305 – 16.268	13.19 - 15.79	0.105	0.2836	0.371804	NS
13	Pectoral fin length	19.73	20.33	17.857 – 21.030	19.05 - 21.59	0.608	0.2785	2.184174	S
14	Anal fin height	17.33	19.00	14.732 – 18.660	18.18 - 20.62	1.668	0.3905	4.271069	S
15	Anal fin base length	7.59	7.84	6.867 – 8.612	6.93 - 8.61	0.249	0.1947	1.280448	NS
16	Caudal peduncle length	16.36	16.19	14.957 – 18.140	15.15 - 17.53	0.163	0.3092	0.527353	NS
17	Caudal peduncle height	11.85	11.69	9.746 – 12.432	11.28 - 12.29	0.163	0.1534	1.064675	S
18	Predorsal length	49.01	48.38	47.907 – 49.751	47.37 - 49.36	0.999	0.3960	2.522142	S
19	Prepectoral length	24.19	24.62	22.886 – 24.865	23.98 - 25.26	0.431	0.4898	0.88028	NS
20	Prepelvic length	51.63	51.54	51.163 – 52.093	51.03 - 52.05	0.089	0.3993	0.223026	NS
21	Preanal length	76.98	75.35	76.216 – 77.990	75.26 - 75.44	1.629	0.6803	2.393937	S
22	Maxillary barbel length	6.48	6.43	6.047 – 7.071	5.26 - 7.05	0.047	0.1901	0.245818	NS
23	Rostral barbel length	5.55	5.64	5.150 – 6.061	4.68 -6.30	0.087	0.1579	0.55274	NS
24	Fork Length	114.26	114.31	112.5 - 115.38	113.66 - 114.89	0.057	0.3053	0.187958	NS
25	Distance between PF & VF	28.80	29.77	27.78 - 30.80	28.09 - 30.74	0.975	0.3645	2.674563	NS
26	Height of ventral fin	17.18	17.61	15.63 - 18.03	17.23 - 18.22	0.430	0.2835	1.517088	S
27	Post orbital length	13.60	13.05	11.16 - 14.16	12.71 - 13.24	0.542	0.2092	2.593253	NS
28	Length of free margin of DF	19.98	18.70	18.43 - 21.18	16.81 - 20.34	1.286	0.9426	1.364726	NS
29	Length of free margin of PF	16.12	15.72	12.43 - 18.23	13.45 - 17.18	0.399	1.0321	0.386779	NS
30	Length of free margin of AF	12.49	13.22	11.11 - 13.30	11.49 - 13.93	0.723	0.4384	1.64848	NS

*S= Significant, NS= Not Significant, MD- Mean Differences, SE- Standard Error.

Table 4: Difference of biometric indices between two sexes of *N. hexagonolepis*

S.No.	Parameters	Mean BI on Standard length			Standard Error of differences	t-Values	Remarks
		Male	Female	Mean Difference			
1	Body depth at dorsal fin insertion	3.910	3.6977	0.2084	0.08529	2.4439	S
2	Lateral head length	3.955	4.0449	0.0490	0.04412	1.1098	NS
3	Head height at occiput	5.856	5.8458	0.0105	0.12364	0.0847	NS
4	Head height at eye	7.131	6.8843	0.2472	0.18223	1.3563	NS
5	Head wide at operculum	6.703	7.3506	0.6477	0.28070	2.3074	S
6	Head wide at eye	8.690	8.9091	0.2193	0.15912	1.3785	NS
7	Eye diameter	19.898	19.9082	0.0875	0.48314	0.1811	NS
8	Interorbital distance	10.747	10.6970	0.0084	0.19845	0.0421	NS
9	Snout length	12.041	12.8420	0.6555	0.29015	2.2592	S
10	Mouth gape wide	14.729	14.9000	0.2185	0.47739	0.4578	NS
11	Dorsal fin height	4.255	4.3314	0.0556	0.12676	0.4387	NS
12	Dorsal fin base length	6.809	6.8492	0.0745	0.13391	0.5565	NS
13	Pectoral fin length	5.074	4.9275	0.1878	0.06880	2.7302	S
14	Anal fin height	5.781	5.2738	0.6075	0.11759	5.1661	S
15	Anal fin base length	13.240	12.8260	0.2694	0.33316	0.8086	NS
16	Caudal peduncle length	6.136	6.1889	0.0275	0.11406	0.2409	NS
17	Caudal peduncle height	8.451	8.5643	0.1137	0.11043	1.0294	NS
18	Predorsal length	2.041	2.0675	0.0265	0.01153	2.3017	S
19	Prepectoral length	4.186	4.0650	0.1208	0.08175	1.4780	NS
20	Prepelvic length	1.937	1.9405	0.0030	0.01501	0.2015	NS
21	Preanal length	1.296	1.3272	0.0310	0.01172	2.6446	S
22	Maxillary barbel length	15.483	15.6939	0.2114	0.49616	0.4260	NS
23	Rostral barbel length	18.055	17.8932	0.1620	0.52502	0.3086	NS
24	Fork Length	0.878	0.8748	0.0028	0.00235	1.2142	NS
25	Distance between PF & VF	3.427	3.3617	0.0648	0.04266	1.5187	NS
26	Height of ventral fin	5.912	5.6796	0.2320	0.09733	2.3835	S
27	Post orbital length	7.658	7.6631	0.0052	0.11577	0.0447	NS
28	Length of free margin of DF	5.067	5.3819	0.3147	0.26396	1.1921	NS
29	Length of free margin of PF	6.734	6.4364	0.2978	0.42549	0.6999	NS
30	Length of free margin of AF	7.886	7.6031	0.4682	0.28319	1.6534	NS

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