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Arun Kumar
Department of Fisheries Resource Management, College of Fisheries, Central Agricultural University (Imphal), Tripura, India

Mrinal Kanti Datta
Department of Fisheries Resource Management, College of Fisheries, Central Agricultural University (Imphal), Tripura, India

Lekiningroy Dann
Department of Fisheries Resource Management, College of Fisheries, Central Agricultural University (Imphal), Tripura, India

Debashis Jena
Department of Fisheries Resource Management, College of Fisheries, Central Agricultural University (Imphal), Tripura, India

Sengbira K Sangma
Department of Fisheries Resource Management, College of Fisheries, Central Agricultural University (Imphal), Tripura, India

Shrish Chandra Yadav
Department of Fish Genetics and Breeding, College of Fisheries, Central Agricultural University (Imphal), Tripura, India

Pramod Kumar Pandey
College of Fisheries, Central Agricultural University (Imphal), Tripura, India

Corresponding Author:
Debashis Jena
Department of Fisheries Resource Management, College of Fisheries, Central Agricultural University (Imphal), Tripura, India

A systematic assessment of some barbs from Tripura based on morpho-meristic tools

Arun Kumar, Mrinal Kanti Datta, Lekiningroy Dann, Debashis Jena, Sengbira K Sangma, Shrish Chandra Yadav and Pramod Kumar Pandey

Abstract
In the present study, four genus of barb fishes comprising of six species i.e., *Puntius chola*, *P. sophore*, *Pethia conchonius*, *P. ticto*, *Barbus gonionotus* and *Systomus sarana* were studied which were collected from Tripura state of India. The similarity in morphological features and colour pattern some time makes taxonomic identification of this genus difficult. Considering these facts, the present study was carried out for the systematic study of this group in Tripura by morphological methods i.e. by morphometric and meristic study. In this study, most of the meristic characters were found to be overlapping. However, some characters like pectoral fin ray, pelvic fin ray and circumpendicular scales could be taken for the separation of *P. conchonius* (i/17-18), *B. gonionotus* (i/6-7) and *S. sarana* (15-17) respectively from rest of the species. The discriminant function analysis (DFA) of the morphometric data showed that body depth (Root value: 0.655), anal fin base length (Root value: 0.4211) and dorsal fin base length (Root value: 0.236) were the characters of Root 1 that separated *P. ticto* and *P. conchonicus* from others while the characters like distance between pectoral-pelvic fin (Root value: 0.406), pelvic fin length (Root value: 0.201) and pre pelvic length (Root value: 0.151) of Root 2separated *S. sarana* from *P. sophore*. Characters like inter-orbital length (Root value: 0.474) and dorsal fin base length (Root value: 0.442) of Root 3 differentiated *B. gonionotus* from the other species. However, DFA could not separate *P. conchonius* and *P. ticto*.

Keywords: Barbs, *Puntius*, morphometry, Tripura

1. Introduction
Tripura, (with a geographical area of 10686 km^2) the North-Eastern hilly State of India (22^{0}56' to 24^{0}22' N and 91^{0}00' to 92^{0}00’ 20'E latitude) is located in the sub-Himalayan region. Tripura is bestowed with 14 rivers, which are mostly annual in nature. Among them, the major rivers are Gumti, Howra, khowai, Dhalai, Manu, Juri, Longai, Fenny and Muhuri rivers that drain into Bangladesh. The state Tripura attributed with a vast diversity of fish fauna as a part of Himalayan and Indo-Burma hot spot [1].

Barbs are tropical freshwater fishes belonging to the family: Cyprinidae and inhabit mostly in tropical South and Southeast Asia [2, 3]. Tropical Asian genus cyprinid *Puntius* is the largest genus under its family, containing 220 nominal species, out of which 120 are distributed in South Asia and 53 in India [2]. Barbs are generalized and exhibit great variations even within the individuals of the same species. This causes great difficulty in identifying these species with common taxonomic characters [4, 5, 6, 7. 8]. From the NorthEast India, four genus of barbs were reported namely; (*Poropuntius*, *Puntius*, *Pethia* and *Systomus*) and out of these, three genera (*Puntius*, *Pethia* and *Systomus*) are known from Tripura and another genus *Barbonymus* has been newly found in the state. Morphology (include both morphometric and meristic study) is the most commonly used taxonomic tools for the differentiation of species and population. A number of workers have used these techniques for taxonomic identification of fishes [9, 10, 11]. The morphometric and meristic characters of many barb species are almost overlapping [12]. Phenotypic plasticity of fish allows them to respond adaptively to environmental change by modification in their physiology and behaviour, which leads to changes in their morphology, reproduction or survival that mitigate the effects of environmental variation [13, 14]. No detail work has been done on the systematics of the species under the genus Puntius and its closely related species, available in the state of Tripura to overcome the difficulty in identifying these species with common taxonomic characters. Hence, in the present research, both morphometric and meristic tools were applied so that its

subsequent conservation strategies can be formed for its future management.

2. Materials and Methods

2.1 Sample collection

The study was carried out in Tripura, one of the smallest North-Eastern state ($22^0$56'- $24^0$22' N and $91^0$0' – $92^0$0' 20' E). A map showing the study area and important drainage system are given in fig.1. Fish specimens were collected from different water bodies of Tripura states of India from May 2018 to April 2019. Specimens collected as part of the ongoing COE-FAB Project of College of Fisheries (CAU), Tripura were also used for comparisons. Various fishing gears such as cast net, gillnet, drag net, scoop net and other local contrivances were employed for the collection of specimens. The samples were then preserved in 10% formalin and brought to the Dept. of Fisheries Resource Management (FRM) laboratory of College of Fisheries for further analyses.

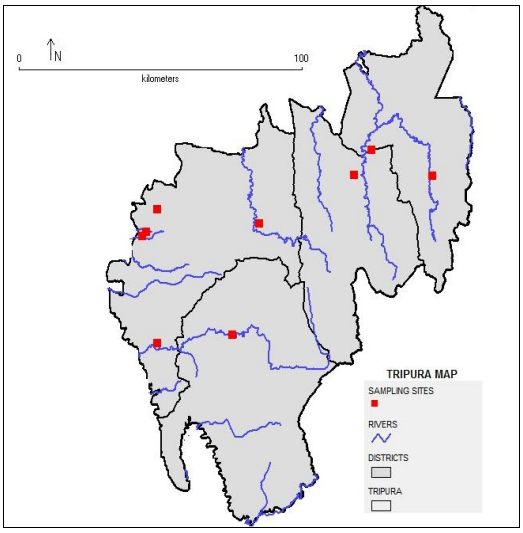

Fig 1: Map showing the locations of Tripura used for sampling

2.2 Morphometric and meristic study

In the present study, 30 morphometric and 14 meristic characters were recorded to analyse the pattern of variation between different species of barbs. The morphometric parameters were measured by a digital vernier calliper to the nearest 0.01mm scale. All the measurements were taken on the left side of the specimen. Among the various measurements, total length, standard length, head length, pre-orbital (Snout length), eye diameter, post-orbital length, pre-dorsal length, pre-pectoral length, post-pelvic length, pre-anal length, distance between pectoral and pelvic, distance between pelvic and anal were taken parallel to the anterior-posterior body axis while body depth and head depths were taken perpendicular to the body axis between dorsal and ventral margins. A diagrammatic representation of various body measurements used for morphometric analyses of the present study is shown in Fig. 2.

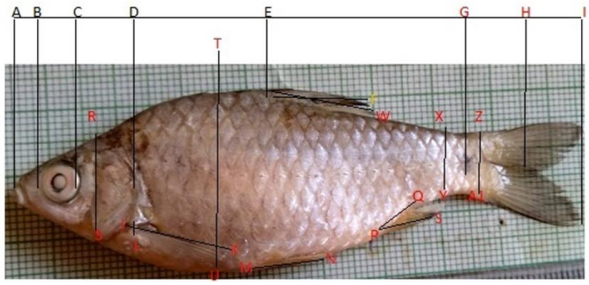

Fig 2: Diagrammatic representation of various body measurements used for Morphometric analysis in the present study

2.3 Statistical analysis of morphometric data

All the morphometric measurements were converted in to ratios in relation to standard length and head length for further analysis. All the ratios were subjected to descriptive analysis (mean, minimum, maximum, standard deviation and coefficient of variation). ANOVA was performed for different variables to test for the significant difference among different species. All the significant morphometric characters were used for forward stepwise DFA. Classification matrix and scatter plot were also generated**.**

3. Results

3.1 Morphometric study

All the morphometric parameters (30) generated were converted to ratios with respect to standard length (23) and head length (7) of the fish to overcome the size dependency. All the thirty transformed variables were subjected to one way ANOVA to test for the significant difference among different species and from these variables 22 variables were found to be significant ($P<0.05$) at 5% level of significance. All the 22 significant morphometric variables were taken for forward stepwise DFA to examine the sufficiency of the morphometric attributes for the discrimination of the species.

Classification matrix (Table 1) showed that out of fifty specimens of *P. chola*, forty eight were grouped properly (96%) by the model, whereas two specimens showed more affinity towards *P. sophore*. For *P. sophore*, out of fifty-six specimens, fifty-five specimens were properly classified (98.21%) with one specimen having relative morphometric proximity to *P. chola*. For *B. gonionotus*, all specimens were classified correctly (100%). For *S. sarana*, out of forty-eight specimens, forty-six specimens were properly classified (95.83%) in which one is showing more affinity to *P. sophore* and another specimen to the *B. gonionotus*. For *P. conchonius*, out of fifty specimens, forty-seven specimens were properly classified (94%) with two specimens having relative morphometric proximity to *P. ticto* and one is similar to *B. gonionotus*. For *P. ticto*, out of fifty-two specimens, forty-seven specimens were properly classified (90.38%) with five specimens showing more closer to *P. conchonius*. Forward stepwise discriminant analysis generated five roots (Table 2) out of which the first three roots are capable of explaining 91.4%.

Table 1: Classification Matrix of different species

Group	Per cent correct	*P. chola* P=.17857	*P. sophore* P=.20000	*B. gonionotus* P=.08571	*S. sarana* P=.17143	*P. conchonius* P=.17857	*P. ticto* P=.18571
P. chola	96.0000	48	2	0	0	0	0
P. sophore	98.2143	1	55	0	0	0	0
B. gonionotus	100.000	0	0	24	0	0	0
S. sarana	95.8333	0	1	1	46	0	0
P. conchonius	94.0000	0	0	1	0	47	2

P. ticto	90.3846	0	0	0	0	5	47
Total	95.3571	49	58	26	46	52	49

Table 2: Standardize coefficients of canonical analysis variables of different species

Variables	Root 1	Root 2	Root 3	Root 4	Root 5
Body depth (BD)/ Standard length (SL)	0.875146	-0.296247	-0.116477	0.108065	0.311359
Distance between pectoral and pelvic (DBPP)/SL	0.241211	0.877798	0.239782	0.185584	-0.420400
Distance between pelvic and anal fins(DBPA)/SL	-0.362545	-0.725763	-0.458410	-0.418253	-0.325378
Dorsal fin base length (DFBL)/SL	-0.104499	-0.415906	0.640282	-0.043200	-0.452337
Dorsal fin length (DFL)/SL	0.027469	0.293771	-0.019696	-0.628762	0.364074
Inter orbital width (IOL)/ Head length (HL)	-0.063718	-0.151477	-0.559625	0.282897	-0.072963
Anal fin base length (AFBL)/SL	0.522482	0.148092	-0.381026	0.122787	-0.117792
Horizontal gape of mouth (HGM)/HL	-0.161900	-0.071580	0.026763	-0.219231	0.264559
Anal fin length (AFL)/SL	-0.049208	0.012779	-0.147985	-0.609421	-0.069745
Eye diameter (ED)/ (HL)	0.217892	0.111654	0.289630	0.212320	-0.046966
Head width (HW)/HL	-0.360121	0.188436	-0.383269	0.076946	-0.019673
Head depth (HD)/HL	0.069571	-0.119255	0.406556	0.211601	0.212459
Pre pelvic length (PPL)/SL	-0.045213	0.629938	-0.075747	-0.456807	0.292250
Pelvic fin length (PvFL)/SL	0.269386	-0.539520	-0.091586	0.564167	-0.212289
Length of caudal peduncle (LCP)/SL	0.325987	-0.049217	0.030365	-0.014103	-0.177606
Post orbital length (PoOL)/SL	-0.014892	-0.144059	0.120461	0.046018	0.511317
Pre anal length (PAL)/SL	-0.126310	-0.159866	-0.198071	0.118356	0.101657
Pre orbital length (POL)/HL	0.072008	-0.038925	0.075483	-0.208014	-0.370480
Least depth of caudal peduncle (LDCP)/SL	-0.066616	-0.044647	0.197108	0.234149	0.301163
Pectoral fin base length (PeFBL)/SL	-0.072721	0.199963	0.021938	-0.038808	-0.001094
Caudal fin base length (CFBL)/SL	-0.098231	0.171058	-0.148515	-0.010524	-0.088858
Pre pectoral length (PPcL)/SL	-0.133514	-0.079508	0.168374	0.118491	-0.082298
Eigenval	9.323996	6.525835	3.271332	1.258310	0.522439
Cum.Prop	0.446083	0.758296	0.914805	0.975005	1.000000

The means of canonical variables (Table 3) showed that Root 1 clearly separated *P. ticto* and *P. conchonius* from rest of the other species. Root 2 separated *S. sarana* from *P. sophore* and Root 3 clearly separated *B. gonionotus* from the rest of the species. However, *P. conchonius* and *P. ticto* DFA could not be separated, suggesting that both the species possesed common type of body shape. Factor structure matrix (Table 4) of the variables were analysed to find the most significant variables, which contributes greatly in discriminating the species under studied. The variables with respect to standard length viz., body depth, dorsal fin base length, anal fin base length were the main characters which contributes to Root 1 for discriminating *P. ticto* and *P. conchonius* from all other species in the present study. Distance between pectoral-pelvic fin, pre pelvic length and pelvic fin length were the characters which are mainly contributed in the discrimination of *S. sarana* and *P. sophore* in the root 2 (Fig. 3). In root 3, inter-orbital length and dorsal fin base length are the main characters for discrimination *B. gonionotus* from rest of the studied species (Fig. 4). Distance matrix among different species based on morphometric data is given in table 5 and a cladogram based on distance matrix is given in fig. 5, which also showed close relationship between *P. conchonicus* and *P. ticto*.

Table 3: Means of Canonical variables of different species

Species	Root 1	Root 2	Root 3	Root 4	Root 5
P. chola	-1.22368	-2.49827	1.41411	-1.51346	-0.705530
P. sophore	-2.89978	-2.60470	-0.04242	1.29881	0.574454
B. gonionotus	-0.52605	0.10399	-5.47341	-1.24361	0.101865
S. sarana	-3.22865	4.71544	0.65436	0.10645	-0.183695
P. conchonius	3.97259	0.07200	-0.38152	1.23252	-0.901710
P. ticto	3.70275	0.73730	0.97497	-0.65287	1.049331

Table 4: Factor structure matrix of different species

Variables	Root 1	Root 2	Root 3	Root 4	Root 5
BD/SL	0.655133	-0.133380	-0.191306	0.028510	0.180605
DBPP/SL	0.094793	0.406123	-0.291844	0.061240	-0.313129
DBPA/SL	-0.135118	-0.287274	-0.444317	-0.118023	-0.313630
DFBL/SL	0.236572	-0.206252	0.442234	-0.202010	-0.204421
DFL/SL	0.292114	0.052994	0.024602	-0.615425	0.225385
IOL/HL	0.007192	0.061739	-0.474015	0.353131	-0.040718
AFBL/SL	0.421192	0.041609	-0.107991	-0.155275	0.003381
HGM/HL	-0.041781	0.114106	-0.024730	-0.071754	0.361304
AFL/SL	0.276504	0.002090	-0.160643	-0.508538	-0.078310
ED/HL	0.165432	0.178463	0.172714	0.214433	-0.134888
HW/HL	-0.133450	0.268917	-0.307415	0.209777	0.061282
HD/HL	-0.109299	0.008014	0.046369	0.244991	0.164640

PPL/SL	0.096256	0.151345	0.039851	-0.075656	0.005181
PvFL/SL	0.262188	-0.201047	-0.031292	-0.062840	-0.069984
LCP/SL	0.166675	0.067854	-0.074739	-0.012364	-0.221150
PoOL/SL	-0.156055	-0.052262	-0.121317	0.026704	0.395857
PAL/SL	-0.028907	0.014487	-0.137488	-0.112302	0.049116
POL/HL	0.041719	0.044866	0.023976	-0.074364	-0.218394
LDCP/SL	0.270690	-0.085219	-0.070418	0.121025	0.178887
PeFBL/SL	-0.017109	0.093849	-0.044120	-0.005193	-0.048498
CFBL/SL	0.211132	0.072748	-0.133535	0.029300	0.081235
PPcL/SL	0.073548	0.039140	0.167072	-0.087769	-0.014062

Table 5: Distance matrix among different species based on morphometric data

Species	*P. chola*	*P. sophore*	*B. gonionotus*	*S. sarana*	*P. conchonius*	*P. ticto*
P. chola	0	14.65536	56.26898	60.30752	44.76919	38.99049
P. sophore	14.65536	0	49.55329	56.84755	57.20878	59.92505
B. gonionotus	56.26898	49.55329	0	68.69284	54.11689	61.38873
S. sarana	60.30752	56.84755	68.69284	0	77.68114	66.86893
P. conchonius	44.76919	57.20878	54.11689	77.68114	0	9.95082
P. ticto	38.99049	59.92505	61.38873	66.86893	9.95082	0

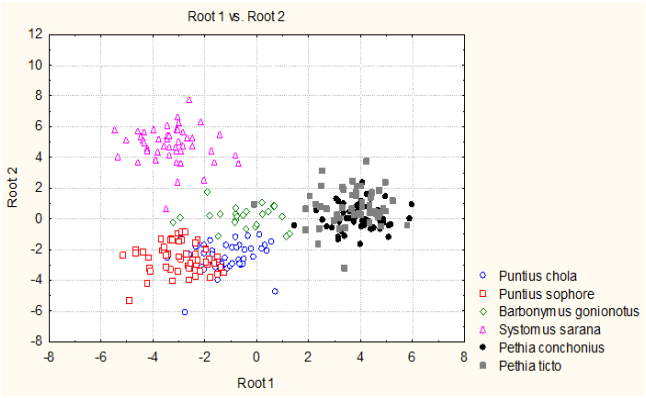

Fig 3: Scatter plot between Root 1 and Root 2

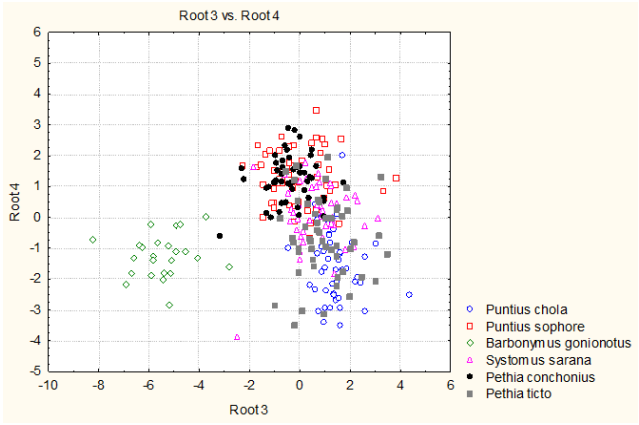

Fig 4: Scatter plot between Root 3 and 4

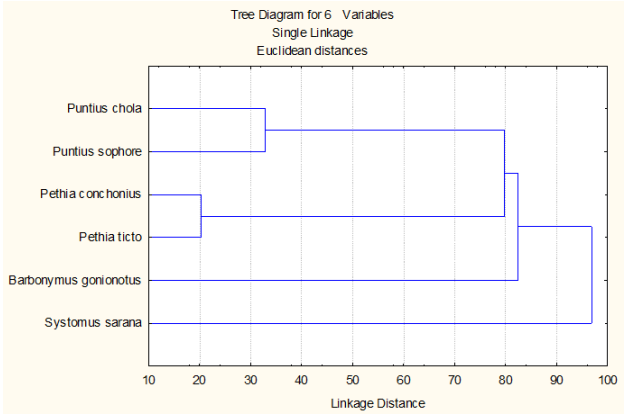

Fig 5: Cladogram based on the morphometric distance between the species of *barbs*

3.2 Meristic counts

A total of 14 meristic characters (Table 6) were taken in the present study. Most of the meristic characters were found to be overlapping. However, some characters like pectoral fin ray, pelvic fin ray and circumpendicular scales could be taken for the separation of *P. conchonius*, *B. gonionotus* and *S. sarana* from rest of the species.

Table 6: Meristic counts of various species of *barbs* for the study

SI. No.	Meristic characters	*P. chola*	*P. sophore*	*B. gonionotus*	*S. sarana*	*P. conchonius*	*P. ticto*
1	Dorsal fin ray	iii-8	iii-iv-8-9	iv-8	iii-iv 8	Iii/ 7-8	iii-iv 8
2	Pectoral fin ray	i-14	i/14-15	i/13-14	i/14-16	**i/17-18**	i/12-14
3	Pelvic/ ventral fin ray	i-8	i-8	**i/6-7**	i-8	i-8	i-8
4	Anal fin ray	ii- 5	ii- 5	ii-iii 5	ii- 5	ii-ii 5	ii-5
5	Caudal fin ray	ii-17	ii-17	ii-ii/17	ii-17	ii-iii/17	ii-17

6	Lateral scales	26-28	22-27	28-30	30-33	24-26	23-25
7	Pre- dorsal scales	10-12	8-10	9-10	10-11	8-11	9-11
8	Pre- pelvic scales	9-11	10	9-10	9-10	10-12	10-11
9	Pre- anal scales	15-18	14-15	19-20	17-19	15-19	15-16
10	Dorsal fin origin to lateral line scales	5 ½	5	5-6½	4½-5½	4-5½	3½-4½
11	Lateral line to pelvic fin scales	3½-4	3½	3-4½	4½	3½-5	4-4½
12	Lateral line to anal fin scales	4½	3½	3-3½	3½-4	3-4	3½
13	Circumpendicular scales	11-13	12	10-12	15-17	12	11
14	No. of barbells	1 pair	Nil	2 pair	2 pair	Nil	Nil

4. Discussion

Genus specific common characters found in this study are in accordance following [3, 15, 16]. 14 meristic characters were analysed in the present study, from which very few characters are distinct enough to differentiate some species. Except pectoral fin rays count, all other fin rays count were found to overlapping between the species. *P. conchonius* showed distinct variation from other species in terms of pectoral fin rays count i.e., i/17-18 while in other species, it was found to be overlapping. Circumpendicular scales could be considered as an important meristic character in identifying *S. sarana* from its congeners, as the number of circumpendicular scales was in the range of 15-17. The dorsal fin rays were found to be 8-9 for most of the species in this study which was also supported by [17] while deviated from earlier studied as 10 [18] or 11 [19, 20, 15, 21]. Number of barbels is also another important character for separating these species at generic level. Single pair maxillary barbels was present in *P. chola*, while a pair of maxillary and a pair of rostral barbels were present in *S. sarana* and *B. gonionotus* while other species lacking barbels.

A total of 30 morphometric characters were studied. The results of the morphometric study revealed that there were significant variations in the morphometric characters for some species. ANOVA showed that 25 variables were significant (at 95% level of significance) Forward stepwise DFA of these 25 variables successfully discriminated four species out of six species. The DFA generated five roots from which Root 1 clearly separated *P. ticto* and *P. conchonius* from the rest of the species based on the variables like BD/SL, DBPA/SL, AFBL/SL and HW/HL. Root 2 clearly separated *S. sarana* from *P. sophore* based on the variables like DBPP/SL, PPL/SL, and PvFL/SL. However, *P. conchonius* and *P. ticto* could not be separated by any of the Roots, suggesting that the two species are having similar type of body shape. Further, a cladogram based on the morphometric distance between the species of *Puntius* also showed a close relationship between b *P. conchonius* and *P. ticto.* [22] Also found close association between *P. conchonicus* and *P. ticto*. In this study, it was found that *S. sarana* is the distant species while [22] found *P. sophore* is the most distant one. It is believed to be the environmental effects as collected samples were from Assam while this study included the samples of Tripura only. Close association between *P. conchonicus* and *P. ticto* based on morphometric traits also found by [17].

5. Conclusion

This study suggests that meristic characters are not enough to differentiate all the barb species available in Tripura though species specific characters are available for some species. While considering morphometric characters, some parameters are quite helpful for the separation of four species out of six species. So, the rest two species demands other approaches to make them separated from each other. Morphometric and meristic traits of the studied barbs in this study would provide important taxonomic informations to taxonomists to identify and resolve the existing ambiguity between these fishes. This study would pave the way for the aquaculturist during breeding, culture as well as for the environmentalists in developing a suitable management plan for their conservation.

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7. References

1. Goswami UC, Basistha SK, Bora D, Shyamkumar K, Saikia B, Changsan K. Fish diversity of North East India, inclusive of the Himalayan and Indo Burma biodiversity hotspots zones: A checklist on their taxonomic status, economic importance, geographical distribution, present status and prevailing threats. International Journal of Biodiversity and Conservation. 2012; 4(15):592-613.
2. Jayaram KC. The freshwater fishes of the Indian region, 1st edn. Narendra Publishing House, Delhi, 1999, p. 551.
3. Pethiyagoda R, Meegaskumbura M, Maduwage K. A synopsis of the South Asian fishes referred to Puntius (Pisces: Cyprinidae). Ichthyological Exploration of Freshwaters. 2012; 23(1):69.
4. Kortmulder K, DE SILVA SS, Schut J. Habitat, Associations and Competition of Eight Barbus (= Puntius) Species (Pisces, Cyrinidae) Indigenous To Sri Lanka. Netherlands Journal of Zoology. 1983; 34(2):159-181.
5. Kottelat M, Pethiyagoda R. *Puntius asoka*, a new species of cyprinid fish from Sri Lanka. Aquarium Terrarium and Zeitschrift, 1989; 8**:**472-475.
6. Jayaram KC. Revision of the Genus Puntius Hamilton from Indian Region: (Pisces: Cypriniformes, Cyprinidae, Cyprininae) Zoological Survey of India, 1991; 135.
7. Kullander SO, Fang F. Two new species of *Puntius* from northern Myanmar (Teleostei: Cyprinidae). Copeia. 2005; 2:290-302.
8. Kullander SO. Five new species of Puntius from Myanmar (Teleostei: Cyprinidae). Ichthyological Exploration of Freshwaters. 2008; 19(1):59.
9. Ihssen PE, Booke HE, Casselman JM, McGlade JM, Payne NR, Utter, FM. Stock identification: materials and methods. Canadian journal of fisheries and aquatic sciences. 1981; 38(12):1838-1855.
10. Melvin GD, Dadswell MJ, McKenzie, JA. Usefulness of meristic and morphometric characters in discriminating populations of American shad (*Alosa sapidissima*) (Ostreichthyes: Clupeidae) inhabiting a marine environment. Canadian Journal of Fisheries and Aquatic Sciences. 1992; 49(2):266-280.

11. Quilang JP, Basiao ZU, Pagulayan RC, Roderos RR, Barrios EB. Meristic and morphometric variation in the silver perch, *Leiopotherapon plumbeus* (Kner, 1864), from three lakes in the Philippines. Journal of applied ichthyology. 2007; 23(5):561-567.
12. Pillay TVR. A morphometric and biometric study of the systematics of certain allied species of the genus *Barbus* Cuv. & Val. In Proceedings of the National Institute of Science, India (Vol. 17), 1951, pp. 331-348.
13. Stearns SC. A natural experiment in life-history evolution: field data on the introduction of mosquitofish (*Gambusia affinis*) to Hawaii. Evolution. 1983; 37(3):601-617.
14. Meyer A. Phenotypic plasticity and heterochrony in *Cichlasoma managuense* (Pisces, Cichlidae) and their implications for speciation in cichlid fishes. Evolution. 1987; 41(6):1357-1369.
15. Jayaram KC. Revision of the genus *Puntius* Hamilton from Indian region. Rec. Sur. India. 1991; 135: 178.
16. Datta Munshi JS, Srivastava MP. Natural history of fishes and systematics of freshwater fishes in India. Narendra Publishing Co. Delhi, India, 1988.
17. Saroniya RK, Saxsena DN, Nagpure NS. The morphometric and meristic analysis of some Puntius species from Central India. Biolife. 2013; 1(3):144-154.
18. Hamilton F. An account of the fishes found in the river Ganges and its branches. Bishen Singh Mahendra Pal Singh, Dehradun. 1981; pp.310-315
19. Day F. The fishes of India being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma, and Ceylon. Vol. 2, Reprinted 1978. Today & Tommarrow's book agengy, New Delhi. 1878.
20. Srivastava G. Fishes of U.P. and Bihar. Vishwavidyalaya Prakashan, Varanasi, 1980.
21. Talwar PK, Jhingran AG. Inland Fishes of India and Adjacent Countries, Vol. 1, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi-Calcutta. 1991; pp.263- 264
22. Choudhary S, Saikia P, Sougrakpam M, Brahma D, Dutta K. Assessment of morphometric variation and establishing taxonomic relationship among six species under Puntius genus. Int. J. Environ. Res. 2011; 1:233-237.