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SYSTEMATIC DIVERSITY OF BONY FISH (OSTEICHTHYES)

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Abstract

Classification is an integral part of all sciences. The basis for classifications differs between disciplines but the basic principles are the same— in all cases we seek to understand something fundamental about the things classified. For astronomers, it is understanding the ass-luminosity relationships that lead to unraveling stellar evolution. For chemists, it is understanding how the atomic structure of elements leads to knowing how reactions occur. For systematists, it is understanding the relationships of organisms in the Tree of Life. The meaning of "relationship" in systematics has changed over time, but today it unquestionably means the genealogical affinities produced by the history of evolutionary descent.

keywords: Diversity, Bony Fish

INTRODUCTION

Classification is an integral part of all sciences. The basis for classifications differs between disciplines but the basic principles are the same— in all cases we seek to understand something fundamental about the things classified. For astronomers, it is understanding the mass-luminosity relationships that lead to unraveling stellar evolution. For chemists, it is understanding how the atomic structure of elements leads to knowing how reactions occur. For systematists, it is understanding the relationships of organisms in the Tree of Life. The meaning of “relationship” in systematics has changed over time, but today it unquestionably means the genealogical affinities produced by the history of evolutionary descent. Notions of grades or levels of organization (shades of Lamarck or the Scala Naturae) are displaced by understanding that if a classification is organized strictly according to our best estimate of the Tree of Life, the organization of organisms becomes more predictive and straightforward, just as knowing the mass-luminosity relationships of a star will predict its future evolution or knowing that since the orbitals of a helium atom are full it is likely to not react with an atom of oxygen. Beyond doubt, the principles of phylogenetic systematics are now accepted as a rule; the most useful classification of organisms is that advocated, though never achieved, by Darwin. The “modern era” classification of fishes is considered by many to begin in 1966 with the publication of a provisional classification of teleosts based on “phyletic thinking”.

Prior to this work, the most general classification in use had been proposed by LS Berg from which the endings of modern orders (“-formes”) were retained. PH Greenwood, DE Rosen, SH Weitzman and GS Myers turned the attention of systematic ichthyologists of the day toward classifications that reflected the perceived evolutionary histories of fishes. Many modern clades were not only recognized, they were coupled with explicit characterizations. Many of these characterizations turned out to be synapomorphies supporting many of the clades still recognized today. The work stands as the last pre-cladistic general classification of fishes, revolutionary in that there was explicit phyletic thinking, and yet arranged more along the lines of Simpson’s classification of mammals with its reliance on grades of organization and ancestral groups than on the concepts of strict monophyly and sister-group relationships we recognize today. But, importantly to subsequent developments, PH Greenwood, DE Rosen, SH Weitzman and GS Myers rejected two things, phenetics (group taxa based solely on apparent similarity) and the central role of fossils to classification of recent fishes. Today, fossils are important, of course, not only because they allow estimating divergence times via molecular clock calibrations, but also because it is becoming increasingly clear that integrating paleontological and neontological data improves our understanding of the Tree of Life of fishes and their macroevolutionary history. The first explicitly phylogenetic classification of fishes was published by G Nelson together with a clear discussion of the principles of phylogenetic systematics. Although at the time “phyletic interrelationships” among the included species and higher taxa were quite controversial, G Nelson presented simple cladograms based on earlier views of vertebrate evolution to justify his classification.

His proposal discarded the use of grades and ancestral groups and rejected the idea that "gaps," rates of change, or any other criterion previously accepted by evolutionary systematists could be used to justify elevating the rank of a particular group higher than that of its closest relative. Thus, birds are classified with crocodiles in Archosauria and the entire clade of tetrapods is found within Sarcopterygii. The revolution had begun, spurred on by publication of the multiauthored Interrelationship of Fishes. It is not our place to detail this revolution, it happened slowly as investigators learned how to infer phylogenies and translate their findings into explicit phylogenetic classifications. Many of these changes to fish classifications in general and phylogenetic classification in particular are summarized in DE Rosen, GV Lauder and KF Liem, and M Stiassny, L Parenti and G Johnson.

REVIEW LITERATURE

Ricardo Betancur-R (2017) Fish classifications, as those of most other taxonomic groups, are being transformed drastically as new molecular phylogenies provide support for natural groups that were unanticipated by previous studies. A brief review of the main criteria used by ichthyologists to define their classifications during the last 50 years, however, reveals slow progress towards using an explicit phylogenetic framework. Instead, the trend has been to rely, in varying degrees, on deep-rooted anatomical concepts and authority, often mixing taxa with explicit phylogenetic support with arbitrary groupings. Two leading sources in ichthyology frequently used for fish classifications (JS Nelson's volumes of Fishes of the World and W. Eschmeyer's Catalog of Fishes) fail to adopt a global phylogenetic framework despite much recent progress made towards the resolution of the fish Tree of Life. The first explicit phylogenetic classification of bony fishes was published in 2013, based on a comprehensive molecular phylogeny (www.deepfin.org). We here update the first version of that classification by incorporating the most recent phylogenetic results

Eric J. Hilton (2018) The bony-tongue fishes, Osteoglossomorpha, have been the focus of a great deal of morphological, systematic, and evolutionary study, due in part to their basal position among extant teleostean fishes. This group includes the mooneyes (Hiodontidae), knifefishes (Notopteridae), the abu (Gymnarchidae), elephantfishes (Mormyridae), arawanas and pirarucu (Osteoglossidae), and the African butterfly fish (Pantodontidae). This morphologically heterogeneous group also has a long and diverse fossil record, including taxa from all continents and both freshwater and marine deposits. The phylogenetic relationships among most extant osteoglossomorph families are widely agreed upon. However, there is still

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much to discover about the systematic biology of these fishes, particularly with regard to the phylogenetic affinities of several fossil taxa, within Mormyridae, and the position of Pantodon. In this paper we review the state of knowledge for osteoglossomorph fishes. We first provide an overview of the diversity of Osteoglossomorpha, and then discuss studies of the phylogeny of Osteoglossomorpha from both morphological and molecular perspectives, as well as biogeographic analyses of the group. Finally, we offer our perspectives on future needs for research on the systematic biology of Osteoglossomorpha.

RESEARCH METHODOLOGY

Morphometric study is a powerful tool for characterizing strains/stocks of the same species, which involes detection of subtle variation of shape, independent of size. The complete set of measurements used to describe a form is a morphometriccharacter set (Strauss and Bond, 1990). The studies of morphological and meristic characters of a fish give substantial information with regard to exact identification key of the species (Dhanya et al., 2004) and such identification is prerequisite for cytogenetic and molecular investigations.

Morphometric characters are measurements that describe the absolute size of body parts. Morphometrics can be broadly defined as the body of technique for describing body form (Reist, 1986). Geometric morphometric methods are recent with greater power than traditional (linear - distance) methods to shape differences by retaining information about spatial covariation between landmarks (Rohlf and Marcus, 1993). Bookstein et al., (1982) defined morphometry as the empirical fusion of geometry and biology. Morphometrics can also be defined as the statistical analysis of biological homology treated as geometrical deformation. To overcome inherent weaknesses of traditional character sets, Strauss and Bookstein (1982) proposed the truss network (a geometrical protocol for character selection) and it is a systematic pattern of measurement intermediate between simple triangulation and a globally redundant data set. Geometric morphometrics allows

consideration of shape independent of scale (Bookstein, 1991) and size standardization allows consideration of shape independent of both scale and allometry. Instead of analyzing restricted and often somewhat arbitrary sets of distance measures, geometric morphometrics analysis covariances in landmarkconfiguration (Bookstein, 1991; 1996b) can be used.

Truss analysis has also been successfully used to discriminate and describea wide variety of morphologically distinct species across a range of habitats and such studies have involved in

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commercially important species (Bronte et al., 1999), ecologically specialized species, endangered species, (McElory and Douglas, 1995) and description of new species (Rauchenberger, 1998). Characterization of differing body shapes by truss analysis can be used to identify not only how these groups or individuals differ morphologically but also when changes in condition overtime become statistically relevant. This represents an improvement over traditional measures of condition that only identify gross differences in body forms. Truss analysis has the potential to provide a cheap, accurate and precise alternative method for quantification of fish condition in the lab or field. The triangulation network has advantages over the traditional character data in representation of diagonal measure and more even coverage of shape.

The principal advantage of the truss network includes, the ability to reconstruct from the original data and recognition and compensation for random measurement error. Strauss and Bookstein (1982) suggest that measurement error can be removed by “flattening the truss”. Meristic traits are often considered to be the most reliable taxonomic characteristics, because most are easy to determine.

Results

Studies on the taxonomic identification of the wild rosy barb Pethia conchonius have not so for been attempted either on the Southern and Northern Indian freshwater Riverine, despite its importance to Indian Fisheries. Based on thepresent mophometric comparison on the samples of rosy barb obtained from Uttar Pradesh, Mizoram, Odisha, Andhra Pradesh, Lower Anicut, Mananjeri Sluice,Vaigai Dam, Kerala and Karnataka along the Southern and Northern India, statistically significant differences were observed in mophomertric characters and this the taxonomic characters of rosy barb along the Southern and Northern India constitute morphometrically heterogenus stock.

Day (1958) recorded four morphometric characters in Puntius conchonius such as Total Length - 5 inch, Orbit width 1/3inch, Body depth – 2 inch and Snout length - 1¼ inch. Talwar and Jhingran (1991) measured the characters (TotalLength – 14cm, Head length – 4.1 to 4.5cm and Body Depth – 2.2 to 2.5cm). SajanSajeevan (1991) noticed ten morphometric characters in Pethia conchonius such asTotal Length – 81.2 % TL, Fork Length – 90.6 % TL, Pre-anal Length – 57.8 % TL, Pre-dorsal Length – 42.8 % TL, Pre-pelvic Length – 37.4 % TL, Pre-pectoral Length – 17.9 % TL, Body depth – 34.8 % TL, Head Length – 21.1% TL, Eye diameter

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– 29.8 % SL and Pre-orbital Length – 29.8 % HL. Shafi and Quddus, (2001) reported the Total Length 12.5cm. Rahman (1989, 2005) recorded Total Length – 9.9cm, Standard Length - 4.6 to 4.8cm, Pre-nasal Length -1.0cm, Inter Orbital Width - 1.3 to1.6cm, Head Length - 3.3 to 3.9cm and Body Length - 2.0 to 2.4cm. Choudhury et al. 2011 reported in Mean by parameters such as Total

Length - 7.046cm, Fork Length – 6.384cm, Standard Length – 5.721cm, Pre-anal length – 4.073cm, Pre-dorsal Length – 3.016cm, Pre-pelvic length – 2.635cm, Pre- pectoral length – 1.261cm, Head Length -1.487cm, Body Depth – 2.542cm, Eye Diameter – 0.443cm and Pre-obital length – 0.443cm. Saroniya et al. (2013) noticed thatthe Total Length 5.6 - 10cm, Fork Length – 89.50mm,Standard Length – 77.62mm, Head Width – 17.09mm, Head Length – 20.97mm, Peduncle Depth – 11.94mm, BodyDepth -35.64mm, Eye Diameter – 30.31mm, Snout Length - 27.29mm, Pre-orbital Length – 57.61mm and Post-orbital Length – 49.4mm (Table 18). In Puntius conchonius, the higher values of coefficient of correlation (r) of fork length (0.989), standard length (0.994), body depth (0.975), head length (0.867), head depth (0.689), head width (0.919), pre-pectoral length (0.899), pre- anal length (0.948), pre-dorsal length(0.970), pre-ventral length (0.903), and depth of caudal peduncle (0.916) showed high degree of correlation or interdependence and values of snout length (0.240) and eye diameter (0.458) indicated low degree of correlation in relation to total length. In relation to head length, the highervalues of coefficient of correlation (r) of total length (0.867), body depth (0.880), head depth (0.754), head width (0.864), eye diameter (0.647) and length of pectoral fin (0.702) showed higher degree of correlation and snout length (0.480) showed low degree of correlation.

The linear regression analysis among all the characters compared with total length, fork length (b=0.935), standard length (b=0.827), body depth (b=0.507) showed high growth rate and pre-dorsal length(b=0.475), pre-anal length (b=0.454) showed slow growth rate, while pre-pectoral length (b=0.148), pre-ventral length (b=0.263), head length (b=0.122), head length (b=0.075), head depth (b=0.133), eye diameter (b=0.032), snout length (b=0.018) and depth of caudal peduncle(b=0.120) indicated very slow growth rate. Linear regression analysis of some characters when compared width head length, the total length (b=6.679), body depth (b=3.476) showed very high growth rate and head depth (b=0.596), head width (b=0.963), length of pectoral fin (b=0.732) showed good growth rate while eye diameter (b=0.321) and snout length (b=0.215) showed slow growth rate. Fromthis data, it can be inferred that these characters showed an allometric growth (Saroniya et al., 2013).

The principal Component Analysis has clearly demonstrated an intraspecific morphological variation among the populations of Pethia conchonius from nine different sampling sites of the Northern and Southern India. Measurements of these characters were the most discriminating variable in this study. Accordingly, Mizoram and Karnataka population of P. conchonius was further confirmed by the Principal Component Analysis. The bivariate scatter plots represented that the populations from Mizoram, Karnataka and Andhra Pradesh were in overlapping, while the populations from Mizoram and Karnataka were in separate clusters. This clustering suggests closer morphological similarity between populations from Lower Anicut, Kerala, Vaigai Dam and Odisha whereas: Mizoram and Karnataka populations were morphometric well distinct. As related studies reported earlier Pethia conchonius (Gunawickrama, 2008; De Silva and Liyanage, 2009) genus Pethia (Choudhury and Dutta, 2013). Hence the study of nine site populations of Pethia conchonius were morphologically variation between different their characters. These environmental factors may affect morphological characters. In some studies, environmental conditions, particuraly temperature which prevail during some sensitive developmental stages have been shown to have the greatest influences in morphological characters (Taning, 1952). As noticed in dendrogram, separation of fishes collected from Karnataka and Mizoram were quite clear. The R value of 0.069 showed heterogenisity in the morphometric characters of Pethia conchonius in the Indian waters. Therefore the examined species could be found out the mophometric variation between some characters of same species from different site populations.

Table 1 Description Of Morph metric Characters

Sl.No.	Acronym	Parameters	Description
1	TL	Total Length	Snout tip to the midpoint of caudal fin insert
2	SL	Standard Length	Snout tip to the midpoint of caudalfin origin

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3	Sn to Uc	Snout to Urocentrum	Snout tip to the midpoint of urocentrum
4	PAL	Pre - Anal Length	Snout tip to the origin of anal fin
5	PDL	Pre -Dorsal Length	Snout tip to the origin of dorsal fin
6	PPL or PVL	Pre - Pelvic Length	Snout tip to the origin of ventral fin
7	PPL	Pre - Pectoral Length	Snout tip to the origin of pectoral fin
8	POL	Pre - Occipital Length	Snout tip to the origin of occiput
9	PL	Peduncle Length	Insert of Anal fin to origin of lower caudal fin lobe
10	Do/Pi	Dorsal origin / Pelvic insert	Length from the origin of dorsal fin to that of pelvic fin insert
11	DSH	Dorsal Spinous Height	Dorsal spine base to tip of dorsal spine
12	AFH	Anal Fin Height	Anal spine base to tip of anal spine
13	PD	Peduncle Depth	Anal fin insert to origin of caudal fin
14	CFL	Caudal Fin Length	Origin of caudal fin to end of the caudal fin
15	DFH	Dorsal Fin Height	Dorsal fin base to tip of dorsal fin
16	PFL	Pectoral Fin Length	Origin of pectoral fin to tip of the pectoral fin
17	VFL	Ventral Fin Length	Origin of pelvic fin to tip of the pelvi fin
18	PasL	Pelvic auxiliary	Origin of one side pelvic fin auxiliary scale to another

		scale Length	side tip of the pelvic auxiliary scale.
19	Oc to Do	Occiput to Dorsal origin	Length from the origin of occiput to dorsal origin
20	Oc to Pi	Occiput to Pectoral insert	Length from the origin of occiput to pectoral insert
21	Oc to Pi	Occiput to Ventral insertion	Length from the occiput to that of Ventral fin insert
22	Di to Vi	Dorsal insert to Ventral insert	Length from the insert of dorsal fin to that of Ventral fin insert
23	Do/ Pi	Dorsal origin \ Pectoral insert	Length from the origin of dorsal fin to that of pectoral fin insert.
24	Do to Ao	Dorsal origin to Anal org	Length from the origin of dorsal fin to that of anal fin origin
25	Di/C	Dorsal insertion / Caudal	Length from the insert of dorsal fin to that of caudal fin origin.
26	Di/Ao	Dorsal insertion / Anal org	Length from the insert of dorsal fin to that of anal fin origin
27	Di/Ai	Dorsal insert \ Anal insert	Length from the insert of dorsal fin to that of anal fin insert
28	DFBL	Dorsal Fin Base Length	Length between the visible origins of the first spine and the last ray of the dorsal

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			fin
29	AFBL	Anal Fin Base Length	Length between the visible origins of the first spine and the last ray of the anal fin
30	Pi/Vi	Pectoral insert / Pelvic insert	Length from the insert of pelvic fin to that of pelvic fin insert
31	Pi/Ao	Pectoral insert \ Anal origin	Length from the insert of pectoral fin to that of anal fin origin
32	Pi to Ao	Pelvic insert to Anal origin	Length from the insert of pelvic fin to that of anal fin origin
33	PoDL	Post-Dorsal Length	Length from the last ray of the dorsal fin to origin of caudal fin
34	BD	Body Depth	Distance between points at deepest part of body (measured vertically)
35	DPv	Distance b/w pect fin /vent	Origin of pectoral fin to vent (anal pore)
36	DVv	Distance b/w Vent fin /vent	Origin of pelvic fin to vent (anal pore)
37	HL	Head Length	Snout tip to the posterior edge of operculum
38	Sn to Op	Snout to Opercle	Tip of snout to opercle
39	UJL	Upper Jaw Length	Tip of snout to the posterior end of upper jaw
40	SnL	Snout Length	Snout tip to origin of eye

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41	PNL	Pre - Nasal Length	Snout tip to the origin of nasal
42	OW	Orbit Width	Origin of eye to insert of eye
43	IOW	Inter Orbital Width	Length from one side orbit to next side orbit between gap
44	INW	Inter Nasal Width	Length from one side nasal to next side nasal between gap
45	HW	Head Width	From end of supraoccipital to ventromedial point directly vertical
46	GW	Gape Width	Origin of upper jaw part to tip of snout
47	Lj to Is	Lower jaw to Isthmus	Tip of lower jaw to isthmus
48	Hd at no	Head depth at nostril	Posterior and anterior position of head depth nostril
49	Hd at Pu	Head depth at Pupil	Posterior and anterior position of head depth pupil
50	Hd at Oc	Head depth at Occiput	Posterior and anterior position of head depth occiput

Table 2 - Proportional Values Of The Morphometric Measurements Of Pethia Conchonius From Uttar Pradesh AndMizoram

		UP - Specimen (1 to 4) = 4				**MZ Specimen - (5 to 19) = 15**					
	Morphometric measurements	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	**Standard Length** (mm)	78.18	75.23	79.42	77.34	78.33	75.51	74.99	73.97	73.93	72.63

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2	Snout to Urocentrum	84.45	89.60	86.84	91.99	97.08	97.84	96.16	95.49	91.56	97.24
3	Pre - Anal Length	65.09	72.64	69.69	72.08	74.44	73.65	72.45	71.79	72.64	78.69
4	Pre -Dorsal Length	43.99	49.83	48.03	49.45	49.99	59.10	55.25	57.31	53.50	55.91
5	Pre - Pelvic Length	45.89	50.21	51.62	47.93	52.10	51.14	51.04	50.30	49.85	51.98
6	Pre - Pectoral Length	23.59	28.37	27.12	27.24	25.04	29.04	23.77	26.23	26.82	27.63
7	Pre - Occipital Length	17.60	23.42	19.40	22.24	21.97	22.71	21.94	21.75	22.15	22.00
8	Peduncle Length	10.49	12.08	12.83	13.11	12.50	12.25	11.89	12.14	11.02	11.20
9	Dorsal origin / Pelvic insert	37.22	45.33	41.22	44.83	40.04	45.10	42.99	45.43	41.76	42.15
10	Dorsal Spinous Height	22.94	20.10	17.29	18.36	20.86	20.35	21.53	24.45	24.49	24.90
11	Anal Fin Height	13.54	16.51	13.01	17.15	15.08	16.52	13.87	17.08	15.37	15.31
12	Peduncle Depth	13.82	16.58	14.01	16.31	16.88	16.26	15.69	14.88	14.88	15.03
13	Caudal Fin Length	27.94	34.06	32.03	31.30	31.67	34.70	25.51	31.15	31.47	30.93
14	Dorsal Fin Height	17.10	23.79	17.08	20.37	20.80	24.42	27.49	29.02	28.96	29.50
15	Pectoral Fin Length	18.65	24.80	20.44	24.18	22.72	24.54	21.92	22.47	22.71	22.68
16	Ventral Fin Length	18.83	19.72	21.52	22.07	20.91	18.70	21.57	21.15	20.36	20.64
17	Pelvic auxiliary scale Length	6.15	9.48	8.80	8.80	8.03	8.04	6.11	7.18	6.96	6.38
18	Occiput to Dorsal origin	26.38	30.94	29.51	32.40	31.34	36.77	33.48	36.16	33.34	33.91
19	Occiput to Pectoral insert	24.74	27.42	26.50	28.54	27.12	26.50	25.59	27.24	24.68	24.65
20	Occiput to Ventral insertion	42.60	47.38	47.40	46.27	46.03	48.68	45.30	47.20	45.45	46.03

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21	Dorsal insert to Ventral insert	36.35	44.32	38.39	40.93	41.69	40.80	39.52	40.88	35.92	36.69
22	Dorsal origin \ Pectoral insert	34.70	40.57	38.33	43.36	41.21	41.01	37.77	42.28	37.77	38.25

UP – Uttar Pradesh, **MZ** – Mizoram

23	Dorsal origin to Anal org	35.77	43.42	40.22	42.96	42.62	45.16	43.32	43.33	42.73	43.05
24	Dorsal insertion / Caudal	24.05	28.96	31.27	27.03	27.58	28.92	27.74	28.88	30.08	25.82
25	Dorsal insertion / Anal org	27.94	34.18	32.15	35.99	33.72	34.62	31.33	31.10	30.64	30.06
26	Dorsal insert \ Anal insert	24.14	29.04	29.07	28.10	29.38	28.71	25.88	27.47	27.33	26.64
27	Dorsal Fin Base Length	18.05	20.75	17.79	22.71	16.92	20.78	21.79	19.96	19.72	20.23
28	Anal Fin Base Length	14.19	16.01	11.27	15.13	13.14	16.32	15.69	12.33	11.60	10.82
29	Pectoral insert / Pelvic insert	24.49	25.47	24.15	26.67	29.10	26.25	27.57	26.64	26.46	25.95
30	Pectoral insert \ Anal origin	36.14	41.16	43.96	40.85	41.75	41.01	41.16	40.59	42.34	43.25
31	Pelvic insert to Anal origin	11.44	17.18	19.46	20.28	21.11	17.70	19.85	17.39	19.38	18.32
32	Post-Dorsal Length	43.58	49.95	44.78	48.99	47.86	51.49	49.20	45.70	45.09	46.44
33	Body Depth	33.53	41.60	33.54	38.42	44.09	45.32	41.44	44.19	42.75	42.89
34	Distance b/w Pect fin / vent	40.13	43.36	44.87	43.57	45.88	43.47	45.42	46.20	44.80	44.17

35	Distance b/w Ventral fin / vent	18.39	20.69	24.88	21.28	19.88	20.51	19.85	19.53	20.33	20.34
36	**Head Length**	25.76	29.73	26.61	29.36	27.06	30.44	27.59	29.14	26.78	26.61
37	Snout to Opercle	68.13	67.00	64.14	70.46	77.72	73.60	72.16	77.50	76.57	79.19
38	Upper Jaw Length	17.51	18.53	18.38	14.23	15.81	14.17	14.84	16.61	18.26	18.79
39	Snout Length	25.85	26.29	20.77	29.18	23.21	21.12	22.09	25.45	26.07	22.24
40	Pre - Nasal Length	18.06	20.45	18.21	23.29	19.12	20.12	15.06	17.84	22.25	19.65
41	Orbit Width	35.57	35.19	33.58	34.13	38.63	35.43	35.37	35.76	41.87	40.27
42	Inter Orbital Width	39.81	39.77	42.23	37.76	41.09	34.69	36.72	41.57	44.32	43.53
43	Inter Nasal Width	21.41	18.59	24.42	22.75	23.21	18.72	21.31	20.79	22.80	22.82
44	Head Width	41.93	40.24	45.82	47.35	49.58	46.52	43.54	47.55	48.86	48.80
45	Gape Width	26.13	26.56	25.33	24.48	23.28	26.74	21.24	24.71	27.34	27.71
46	Lower jaw to Isthmus	65.66	67.60	64.31	61.05	70.62	69.39	70.81	74.47	71.30	69.61
47	Head depth at nostril	34.68	37.58	36.31	33.29	34.54	34.49	35.87	33.72	34.97	34.61
48	Head depth at Pupil	58.07	60.09	54.70	51.70	66.92	64.51	59.09	61.13	64.76	67.59
49	Head depth at Occiput	88.37	87.52	86.97	90.23	86.04	84.76	85.09	88.30	87.01	88.21

	Morphometric measurements	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
1	**Standard Length** (mm)	73.57	74.18	76.24	76.69	78.92	75.21	79.60	79.75	79.96
2	Snout to Urocentrum	95.12	90.47	96.71	95.66	95.06	95.54	95.54	95.96	95.50

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3	Pre - Anal Length	73.12	73.81	72.59	70.13	77.08	76.04	74.77	75.48	76.57
4	Pre -Dorsal Length	54.16	54.93	55.06	55.85	70.56	79.48	79.05	76.61	69.76
5	Pre - Pelvic Length	52.05	51.34	51.95	48.97	99.92	86.97	86.56	86.80	101.76
6	Pre - Pectoral Length	28.08	27.26	24.52	26.99	51.40	56.51	55.11	56.84	47.44
7	Pre - Occipital Length	21.97	22.85	21.91	21.88	74.59	82.53	81.06	81.64	89.05
8	Peduncle Length	13.47	11.16	12.95	12.55	59.62	51.60	57.38	58.96	56.85
9	Dorsal origin / Pelvic insert	40.42	46.55	43.44	42.24	354.79	375.16	340.86	355.20	321.15
10	Dorsal Spinous Height	25.65	25.16	23.28	18.61	61.63	44.34	43.50	39.41	52.58
11	Anal Fin Height	15.58	15.53	14.85	16.50	59.03	82.12	88.63	93.43	76.02
12	Peduncle Depth	15.13	15.27	15.67	16.05	102.08	100.48	97.28	95.11	104.60
13	Caudal Fin Length	30.74	31.00	26.55	29.32	202.17	205.36	182.68	191.85	190.23
14	Dorsal Fin Height	28.34	29.02	27.82	20.01	61.20	69.86	68.26	65.08	64.38
15	Pectoral Fin Length	22.50	22.50	22.87	20.41	109.07	104.23	101.97	118.71	109.77
16	Ventral Fin Length	20.96	20.62	22.60	19.38	100.95	79.54	94.99	91.25	94.64
17	Pelvic auxiliary scale Length	7.27	6.75	6.38	7.62	32.68	48.05	44.87	39.86	36.95
18	Occiput to Dorsal origin	36.66	34.24	34.20	36.65	428.65	388.96	421.44	408.15	393.77
19	Occiput to Pectoral insert	27.30	25.51	26.12	27.74	93.78	74.40	75.68	79.49	87.66
20	Occiput to Ventral insertion	48.24	46.58	46.21	46.26	172.20	172.79	166.77	162.13	167.49
21	Dorsal insert to Ventral	40.71	36.52	41.05	43.05	77.07	85.21	93.06	99.81	89.94

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	insert									
22	Dorsal origin \ Pectoral insert	42.29	42.29	38.51	40.88	105.69	100.49	94.96	93.90	100.30
23	Dorsal origin to Anal org	44.64	43.67	43.85	44.67	108.18	111.87	109.25	107.14	103.93
24	Dorsal insertion / Caudal	31.21	28.27	28.88	25.77	64.07	63.81	60.10	58.19	65.79
25	Dorsal insertion / Anal org	31.85	31.25	31.44	31.88	116.20	118.00	118.77	133.12	119.88
26	Dorsal insert \ Anal insert	27.82	27.61	26.55	27.18	86.37	84.98	89.20	78.09	87.85

27	Dorsal Fin Base Length	22.69	20.04	23.36	22.41	74.80	71.45	78.81	80.83	56.43
28	Anal Fin Base Length	12.72	11.01	15.83	13.79	78.61	77.16	61.52	66.59	77.21
29	Pectoral insert / Pelvic insert	28.04	27.69	27.69	26.91	172.55	159.06	195.19	176.30	223.81
30	Pectoral insert \ Anal origin	44.35	45.95	41.36	40.90	147.59	161.63	151.97	153.18	146.31
31	Pelvic insert to Anal origin	19.01	20.04	21.19	19.78	31.66	41.73	48.36	49.66	50.46
32	Post-Dorsal Length	49.89	45.45	49.77	49.04	380.89	290.80	247.96	241.55	220.94
33	Body Depth	43.67	44.80	42.36	44.54	80.18	88.02	90.82	94.11	93.00
34	Distance b/w Pect fin / vent	46.06	44.22	46.72	43.21	114.83	98.61	97.02	94.50	105.66
35	Distance b/w Ventral fin / vent	22.07	20.62	21.39	19.40	45.83	47.72	44.90	48.84	43.76
36	**Head Length**	28.30	25.56	27.43	28.89	139.69	143.42	153.33	137.80	131.45

37	Snout to Opercle	75.31	79.20	71.75	71.94	543.55	501.09	477.37	427.87	553.41
38	Upper Jaw Length	16.99	18.84	14.28	16.51	128.98	113.02	113.57	85.13	127.01
39	Snout Length	24.94	20.90	24.22	29.92	152.67	165.92	126.00	144.42	230.15
40	Pre - Nasal Length	22.51	21.39	19.32	19.55	134.90	149.77	128.95	115.19	150.41
41	Orbit Width	38.74	43.28	36.36	31.66	276.38	257.78	260.87	216.84	243.52
42	Inter Orbital Width	40.67	47.40	40.27	43.76	298.75	270.59	285.71	240.13	336.63
43	Inter Nasal Width	21.34	21.20	21.73	21.85	156.61	141.98	127.77	129.59	168.08
44	Head Width	46.28	49.36	47.80	46.80	334.95	307.89	297.54	285.02	360.02
45	Gape Width	25.52	29.15	22.23	23.65	190.18	169.81	175.69	132.56	181.92
46	Lower jaw to Isthmus	74.23	69.38	70.24	70.02	477.74	493.85	418.21	418.85	538.60
47	Head depth at nostril	39.83	36.80	40.84	33.09	237.55	265.02	221.83	243.52	254.50
48	Head depth at Pupil	62.26	69.68	59.80	63.38	463.92	414.23	419.99	356.60	487.51
49	Head depth at Occiput	83.60	89.11	84.87	86.78	605.40	556.21	537.11	506.10	667.53

MS – Mananjeri Sluice

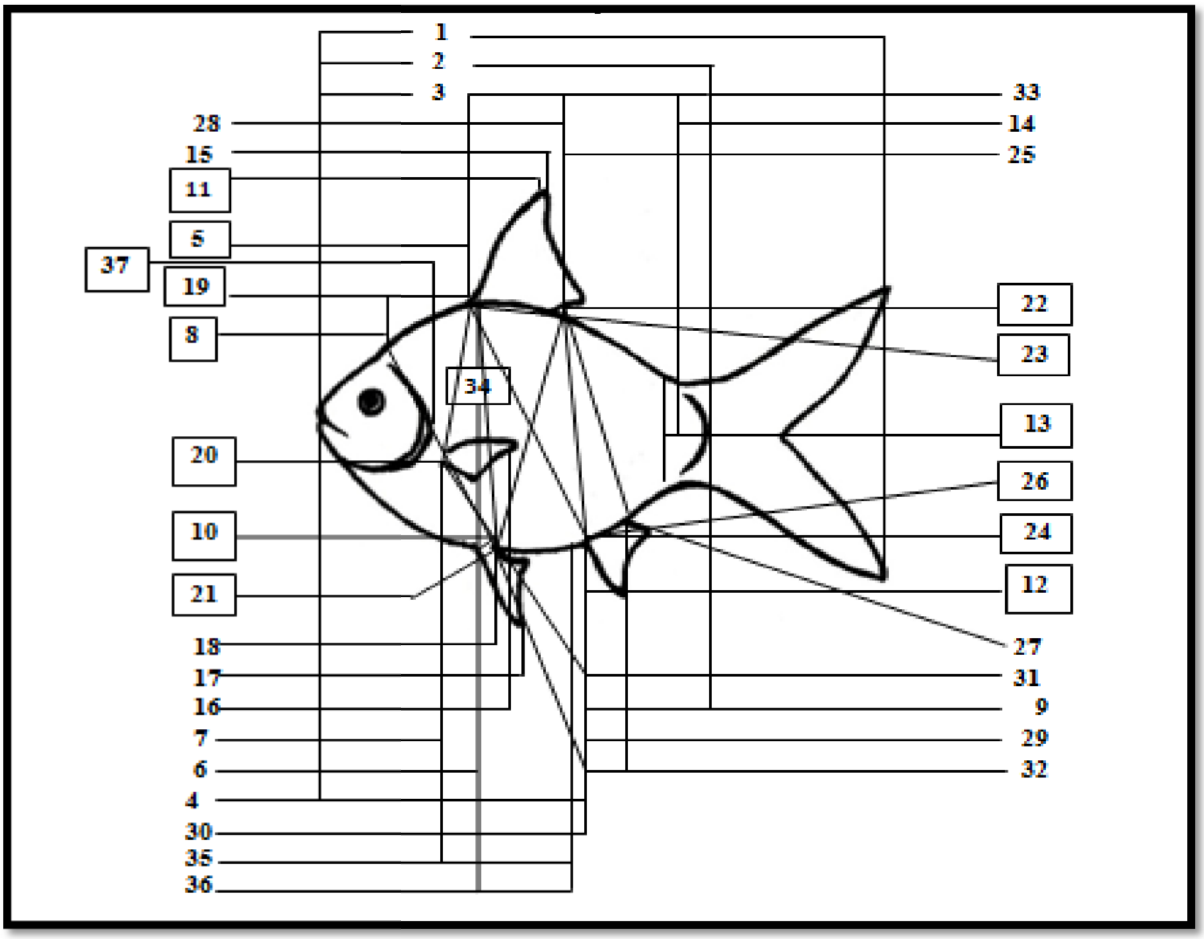

Fig. 3. 1 Schematic Diagram Of Body Characters Of Pethia Con Honius

1.Total Length (TL) 2.Standard Length (SL) 3. Snout to Urocentrum (SU) 4. Pre Anal Length (PAL) 5. Pre Dorsal Length (PDL) 6. Pre Ventral Length (PVL) 7. Pre Pectoral Length (PPL) 8. Pre - Occipital Length (POL) 9. Peduncle Length (PL) 10. Dorsal origin / Ventral insert (Do/Vi) 11. Dorsal Spinous Height (DSH) 12. Anal Fin Height (AFH) 13. Peduncle Depth (PD) 14. Caudal Fin Length (CFH) 15. Dorsal Fin Height (DFH) 16. Pectoral Fin Length (PFL) 17. PelvicFin Length (VFL) 18. Ventral auxiliary scale Length (VasL) 19. Occiput to Dorsal origin (Oc- Do) 20. Occiput to Pectoral insert (Oc-Pi) 21. Occiput to Ventral insertion (Oc-Vi) 22. Dorsal insert to Ventral insert (Di-Vi) 23. Dorsal origin \ Pectoral insert (Do-Pi) 24. Dorsal origin to Anal org (Do-Ao) 25. Dorsal insertion / Caudal (Di-C) 26. Dorsal insertion / Anal org (Di-Ao) 27. Dorsal insert \ Anal insert (Di-Ai) 28. Dorsal Fin Base Length (DFBL) 29. Anal Fin Base Length (AFBL), 30. Pectoral insert / Ventral insert (Pi-Vi), 31. Pectoral insert \ Anal origin (Pi- Ao) 32. Ventral insert to Anal origin (Vi-Ao) 33. Post-Dorsal Length (PoDL) 34. Body Depth (BD) 35. Distance b/w Pectoral fin / vent (DP-A) 36. Distance b/w Ventral fin / vent (DV-A) 37. Head Length (HL).

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CONCLUSION

The tropical Asian cyprinid genus Pethia, which contains some 120 valid species, as long as been suspected to be polyphyletic. Here, thorough examination of external morphology, osteology and molecular level identification was carried out. Morphometric and meristic are helpful in easy and correct identification of fish species in laboratory as well as at natural habitats. Morphometry study is a powerful tool for characterizing strains/stocks of the same species, which involves detection of subtle variation of shape, independent of size. The studies on morphological and meristic characters of fish provide substantial information with regard to exact identification key of the species and such identification are prerequisite for cytogenetic and molecular investigations. This study was carried out to investigate the variability of Pethia conchonius (Hamilton, 1822) collected from nine different locations of wetlands in India during April 2013 to December 2016. The 9 locations include Deoria - Kuvana (Uttar Pradesh), Tuivawl – Tuivawl River (Mizoram), Budha Palang - Budha Palang River (Odisha), Dweleswaram – Godavari (Andhra Pradesh), Lower Anicut (Tamil Nadu), Mananjeri Sluice (Tamil Nadu), Vagai Dam (Tamil Nadu), Malampuzha Dam (Kerala) and Belagola – Pillar Bridge (Karnataka).

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