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MORPHOMETRIC ANALYSIS OF FIVE SPECIES OF PONYFISHES (FAMILY:LEIOGNATHIDAE) COLLECTED FROM TAMILNADU COAST, INDIA

V. G. ANIL KUMAR [a], A. KARTICK [a] AND M. THANGARAJ [a*]

[a] Centre of Advanced Study in Marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai, Tamil Nadu - 608 502, India.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Leiognathids, commonly known as ponyfishes are characterised by their protrusible mouth and there are a lot of controversies in their nomenclature. In this study, a total of five species of family Leiognathidae were collected from the Parangipettai landing centre, Tamilnadu, India. For morphometric analysis, 24 morphometric data points were collected for each species and their variation was studied. There were significant variations among the species, with minor overlap. Out of 24 characters, 14 were unique to each species. The features on pectoral and pelvic fins, upper and lower jaw lengths and pre-orbital length were highly significant variable characteristics among the ponyfish studied. Among the five species, the within-species variation was more in *Gazza minuta* and *Eubleekeria splendens*. But the within -species variation was less in *Karalla dussumieri* and *Nuchequula gerreoides*.

Keywords: Ponyfish; leiognathidae; morphometric; principal component analysis.

1. INTRODUCTION

Morphometric and meristic characters have long been used to separate species, populations and races. It also helps identify species and find sexual dimorphism [1]. Morphometric studies are often used to support descriptions of new species based on morphological - differences in closely related species [2,3,4]. Some studies emphasise new taxonomic descriptions by integrating new analysis tools into morphometry [5,6]. Morphological analysis can also be used for phylogenetic assessment [7], phenotypic plasticity [8, 9] and to study various fish conditions [10].

Ponyfishes, also called as silverbellies, belong to the family Leiognathidae and are one of the most

**Corresponding author: Email: coralholder@yahoo.com;*

commercially important fish groups in fishing industry due to the high quantity of bone and fatless flesh that provide plenty of calcium and protein [11]. Ponyfishes have bacterial light organs in the throat region from which light is spread through the belly [12]. Leiognathidae was initially composed of only two genera, Leiognathus and Gazza. Starting from the evolution or retrieval of the genus Secutor, the family currently includes at least nine genera [13, 14]. Many of the species are synonyms and this leads to lot of controversy in the nomenclature. Hence, the family Leiognathidae is in need of taxonomic revision [15, 16]. Morphometric data is commonly analysed using univariate statistics (ANOVA) and multivariate statistics, such as principal components analysis (PCA). PCA is always superior to univariate analysis because it considers the covariance or correlation structure of the data and considers relationships among all measured morphometric and shape characters [17].

In India, the morphometric and meristic character analysis in Leiognathidae is very rare and no previous work is available to distinguish the species. To fill the paucity, the study was planned to delineate five species belonging to the Parangipettai region of the Tamilnadu coast, using morphometric analysis.

2. MATERIALS AND METHODS

2.1 Sample Collection

A total of 450 fish were collected from the Parangipettai landing centre (11.4831° N, 79.7729° E) from January to June, 2019. After collection, the samples were preserved in ice and brought to the laboratory for identification and morphometric measurements. The species were identified by the FAO sheet [18].

2.2 Morphometric Measurements and Data Analysis

Twenty four morphometric characters were measured using a digital Vernier caliper with an accuracy of 0.01mm. Here, most of the major measurements were converted as percentage of standard length rather than total length or fork length, as per the previous study by Onsoy et al. [19]. An ANOVA was carried out for all morphometric characters and *P*-values were calculated. PCA was performed using SPSS 15.0 software. Characters that were used in the present study and their abbreviations are listed in Table 1. The diagrammatic representations of the measured characters are displayed in Fig. 1 and Fig. 2.

Table 1. Morphometric characters and their abbreviations used in this study

Sl. No.	Characters	Abbreviation
1.	Standard Length	SL
2.	Head length	HL
3.	Pre-dorsal Fin Length	PDL
4.	Pre-pectoral Fin Length	PPcL
5.	Pre-anal Fin Length	PAL
6.	Pre-ventral Fin Length	PVL
7.	Pectoral Fin Length	PcFL
8.	Pelvic Fin Length	PlFL
9.	Anal Fin base Length	ABL
10.	Dorsal Fin base Length	DBL
11.	Caudal Peduncle Length	CPL
12.	Caudal Peduncle Width	CPW
13.	Head Width	HW
14.	Body Width	BW
15.	1^{st} Dorsal Fin Spine Length	1^{st}DSL
16.	2^{nd} Dorsal Fin Spine Length	2^{nd} DSL
17.	3^{rd} Dorsal Fin Spine Length	3^{rd} DSL
18.	1^{st} Anal Fin Spine Length	1^{st} ASL
19.	2^{nd} Anal Fin Spine Length	2^{nd} ASL
20.	3^{rd} Anal Fin Spine Length	3^{rd} ASL
21.	Eye diameter	ED
22.	Pre-orbital Length	POL
23.	Upper Jaw Length	UJL
24.	Lower Jaw Length	LJL

Table 2. Morphometric characters in five ponyfishes

Characters	*Eubleekeria splendens*	*Karalla dussumieri*	*Nuchequula gerreoides*	*Gazza minuta*	*Equulites leuciscus*
SD (mm)	76.80±8.50	57.67±5.29	59.66±5.37	84.97± 8.43	84.97±13.05
HL (mm)	24.76±2.98	18.98±1.77	19.43±1.35	26.99± 2.40	22.53±3.34
HL (% of SL)	$32.23±1.06^{a}$	$32.93±1.29^{b}$	$32.64±1.62^{a}$	$31.82± 1.34^{a}$	$26.55±0.74^{c}$
PDL (% of SL)	$38.03±2.64^{a}$	$39.21±1.96^{b}$	$42.01±1.53^{c}$	$41.57± 1.62^{c}$	$38.50±1.02^{a}$
PPcL (% of SL)	$36.19±1.31^{a}$	$36.96±1.81^{b}$	$35.61±2.78^{a,c}$	$34.92± 1.46^{c}$	$31.19±1.15^{d}$
PAL (% of SL)	$53.05±2.01^{a}$	$52.99±2.10^{a}$	$53.06±2.22^{a}$	$52.93± 2.18^{a}$	$50.97±2.23^{b}$
PVL (% of SL)	$35.08±1.55^{a}$	$36.42±1.94^{b}$	$36.49±1.49^{b}$	$33.13± 2.07^{c}$	$32.40±1.41^{d}$
PcFL (% of SL)	$25.31±1.31^{a}$	$22.39±1.04^{b}$	$21.48±1.15^{c}$	$19.09± 1.15^{d}$	$17.66±0.75^{e}$
PlFL (% of SL)	$16.47±0.88^{a}$	$17.21±0.94^{b}$	$14.49±0.85^{c}$	$14.01± 1.09^{d}$	$12.02±0.77^{e}$
ABL (% of SL)	$41.82±1.51^{a}$	$40.13±1.83^{b}$	$40.89±2.32^{b}$	$39.96± 1.38^{b}$	$40.47±1.28^{b}$
DBL (% of SL)	$55.48±1.71^{a}$	$51.73±1.93^{b}$	$52.56 ±1.64^{c}$	$48.84± 1.69^{b}$	$51.68±1.37^{d}$
CPL (% of SL)	$5.33±0.47^{a}$	$4.93±0.57^{b}$	$5.76±0.75^{c}$	$5.22± 0.54^{a}$	$4.89±0.42^{b}$
CPW (% of SL)	$8.14±0.45^{a}$	$7.26±0.44^{b}$	$6.52±0.67^{c}$	$6.35± 0.34^{c,d}$	$6.28±0.37^{d}$
HW (% of SL)	$30.01±1.25^{a}$	$27.62±1.02^{b}$	$28.31 ±2.56^{b}$	$30.47±1.34^{c}$	$23.39±0.83^{d}$
BW (% of SL)	$55.15±2.06^{a}$	$49.21 ±1.58^{b}$	$45.39 ±1.13^{c}$	$45.22 ±1.63^{c}$	$41.40±1.67^{d}$
1stDSL (% of SL)	$5.42±0.55^{a}$	$4.58±0.54^{b}$	$3.25±0.35^{c}$	$2.52±3.46^{c,d}$	$2.18±0.26^{d}$
2nd DSL (% of SL)	$22.14±1.70^{a}$	$25.58±2.82^{b}$	$22.09±0.35^{a}$	$18.83±1.33^{c}$	$38.85±2.38^{d}$
3rd DSL (% of SL)	$19.55±1.54^{a}$	$21.59±1.44^{b}$	$18.01 ±1.42^{c}$	$16.75±1.24^{d}$	$20.42±1.66^{e}$
1st ASL (% of SL)	$6.12±0.68^{a}$	$5.89±0.52^{a}$	$4.94±0.49^{b}$	$2.81±0.32^{c}$	$2.17±0.36^{d}$
2nd ASL (% of SL)	$18.92±1.51^{a}$	$18.54±1.17^{a}$	$17.83±1.21^{b}$	$15.41±0.87^{c}$	$16.35±1.75^{d}$
3rd ASL (% of SL)	$14.87±1.19^{a}$	$14.43 ±1.01^{b}$	$13.68±1.25^{c}$	$12.52±0.90^{d}$	$11.59±0.89^{e}$
ED (% of HL)	$37.66±1.71^{a}$	$33.49±2.19^{b}$	$32.97±1.97^{b}$	$36.15±1.54^{c}$	$30.60±1.70^{d}$
POL (% of HL)	$19.56 ±1.81^{a}$	$33.49±1.97^{b}$	$26.52±2.27^{c}$	$25.08±1.83^{d}$	$23.75±1.95^{e}$
UJL (% of HL)	$45.96±2.58^{a}$	$54.97±2.49^{b}$	$60.87±2.10^{c}$	$68.73±2.81^{d}$	$59.34±2.78^{e}$
LJL (% of HL)	$40.50±2.14^{a}$	$45.02±2.41^{b}$	$50.34±2.27^{c}$	$60.34±2.76^{d}$	$46.67±2.19^{e}$

Values on the raw sharing the common superscript are not significantly varied (P < 0.05)

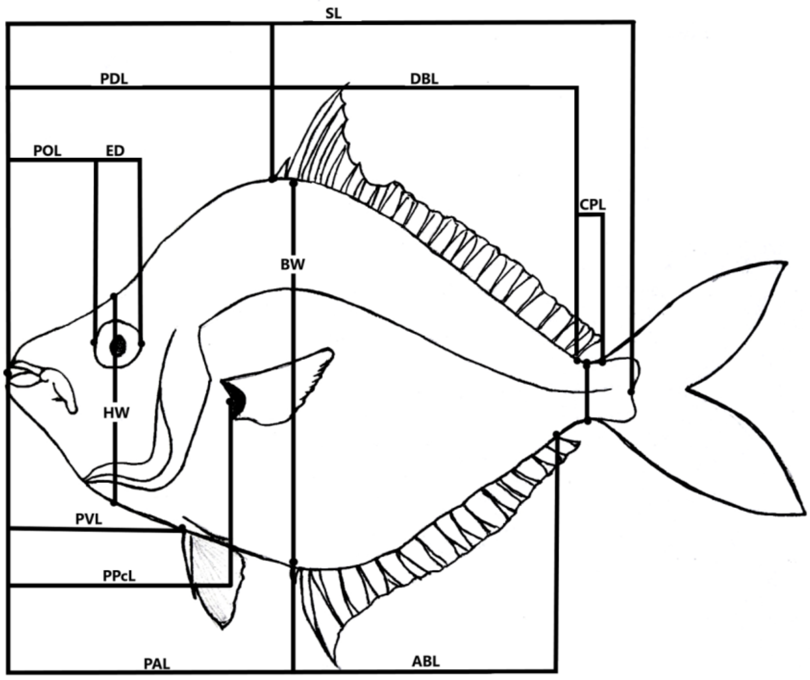

Fig. 1. Diagrammatic representation of morphometric characters used in this study

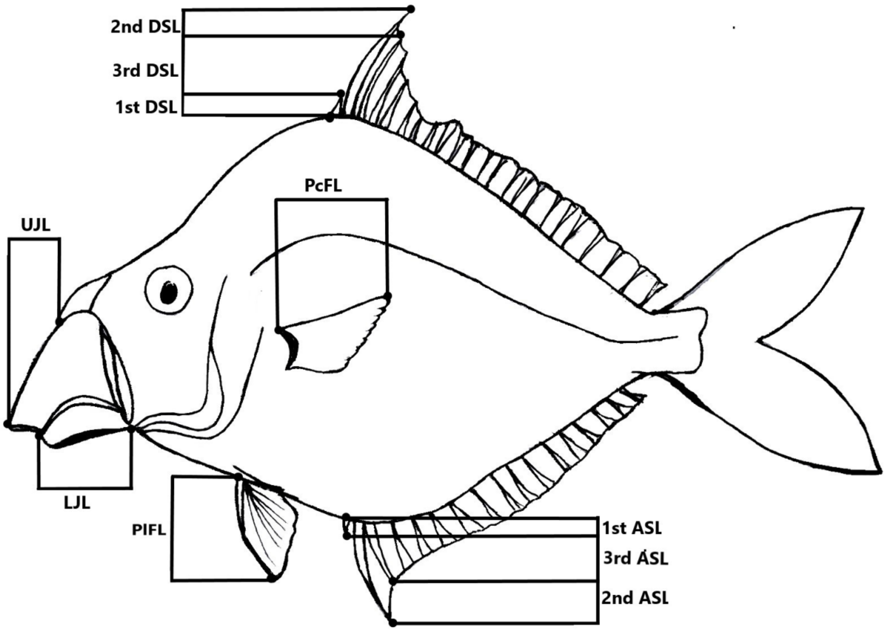

Fig. 2. Diagrammatic representation of morphometric characters used in this study

3. RESULTS AND DISCUSSION

The specimens collected were identified as *Eubleekeria splendens* (Cuvier, 1829), *Karalla dussumieri* (Valenciennes, 1835), *Nuchequula gerreoides* (Bleeker, 1851), *Gazza minuta* (Bloch, 1795) and *Equulites leuciscus* (Gunther, 1860). Average values as percentage of SL or HL for each character are given in Table 2.

Among the 24 morphological values, most of them showed high significant variation at the level of $P < 0.05$, in five species. In the case of HL, a significant variation was observed between all species except *E. splendens* (38.03±2.64), *G. minuta* (31.82±1.34) and *N. gerreoides* (32.64±1.62) and the lowest value of HL was observed in *E. leuciscus* (26.55±0.74). Variation in PDL was significant among all species except *E. splendens* (38.03±2.64) and *E. leuciscus* (38.50±1.02). PPcL also showed a significant variation among the three species, except for *E. splendens* (36.19±1.31) and *N. gerreoides* (35.61±2.78). However, for PAL, only *E. leuciscus* (50.97±2.23) showed a significantly lower value, and it was almost similar in other species. PVL values were similar in *K. dussumieri* (36.42±1.94) and *N. gerreoides* (36.49±1.49) but varied in other species. The ABL showed significant variation only in *E. splendens* (41.82±1.51). DBL was significantly similar in *K. dussumieri* (51.73±1.93) and *G. minuta* (48.84±1.69). CPL was significantly similar in *E. splendens* and *G. minuta* and also in *G. minuta* and *E. leuciscus*. The HW value was highly variable except in *K. dussumieri* (27.62±1.02) and *N. gerreoides* (28.31 ±2.56). Like HW, the BW value also showed a significant variation, except for *G. minuta* (45.22 ±1.63), and *N. gerreoides* (45.39 ±1.13). The 1st DSL value showed significant variation in *E. splendens* and *K. dussumieri*. But the value of *G. minuta* was similar to that of *N. gerreoides* and *E. leuciscus*. The second DSL showed the most significant variation of all the characters among the species. 1st and 2nd ASL values showed significant variation in all species except *E. splendens* and *K. dussumieri*. PVL, DBL, HW, BW, 1st ASL, 2nd ASL, and ED showed a high level of variation, but the variation was insignificant only for *K. dussumieri* (14.43 ±1.01) and *N. gerreoides* (32.97±1.97). Among all the morphometric characters, PcFL, PlFL, 3rd DSL, 3rd ASL, POL, UJL, and LJL showed high significant variation between all the five species.

In Eigen values of PCA, PC1 showed a 48.8% confidence level and PC2 showed a 30.2% one. Variations in PC1 were mainly due to HL, PDL, PPcL, PVL, PcFL, PlFL, ABL, DBL, CPW, BW, 1st DSL, 3rd DSL, 1st, 2nd and 3rd ASL, ED, POL, UJL, and LJL. Among these, the highest variation was shown by UJL and LJL. Variations along PC2 were due to HL, PDL, PPcL, PAL, PVL, PcFL, PlFL, CPL, CPW, HW, BW, 1st, 2nd and 3rd DSL, 1st ASL, 3rd ASL, and LJL. All the characters that were selected for the present study showed considerable weightage that can be used to discriminate at species level, in either PC1 or PC2, as shown in Table 3.

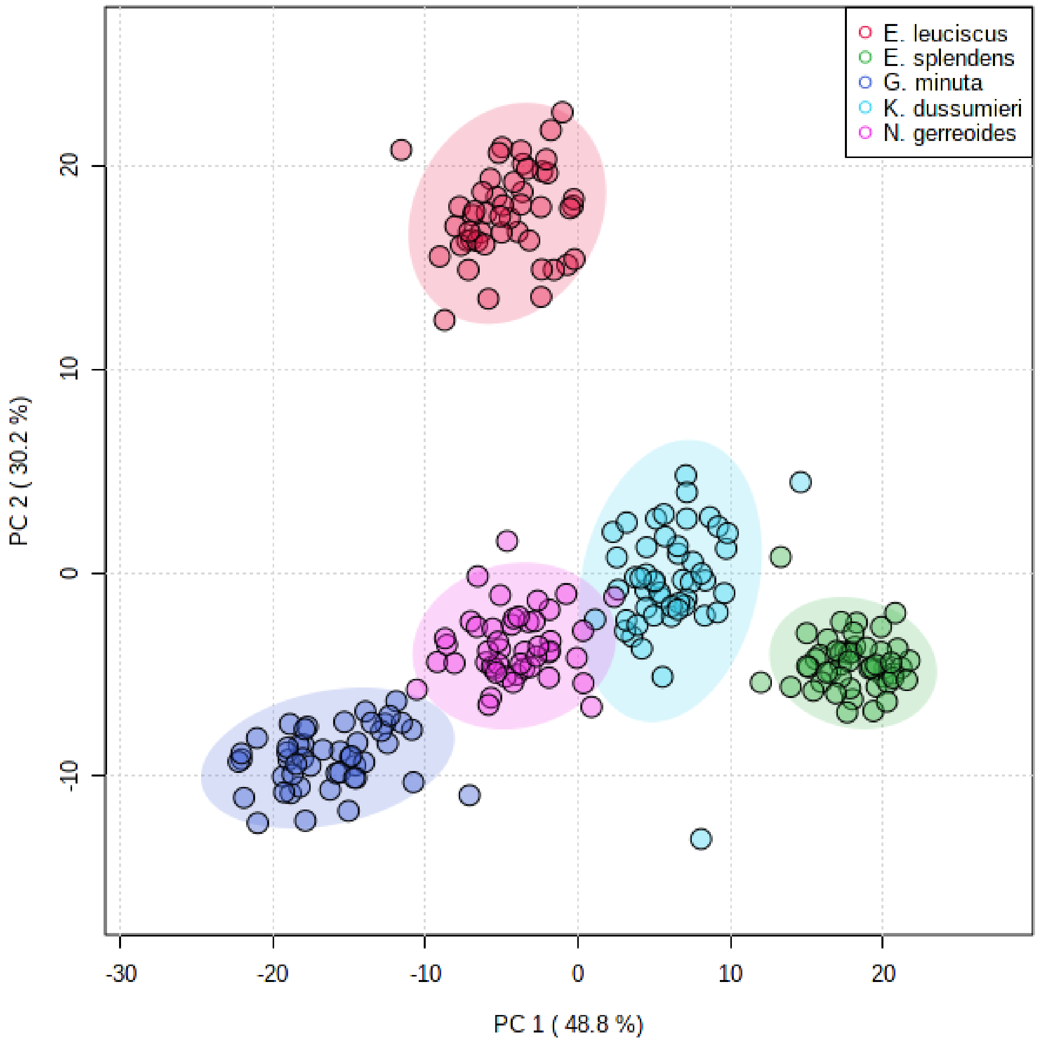

Fig. 3. PCA score plot for five species of ponyfishes

The PCA scatter plot is given in Fig. 3 and it is evident that each group was separately clustered with minor overlap. In this plot, *G. minuta* and *N. gerreoides* showed a negative correlation, while *K. dussumieri* and *E. splendens* showed a positive correlation along PC1. Except for *E. splendens*, all of the species had a negative correlation along PC2, while only *E. leuciscus* had a high positive correlation along PC2 and was clustered far away from the other species. Along with PC1, more correlation was exhibited between *N. gerreoides* and *K. dussumieri*, followed by *N. gerreoides* and *G. minuta*, and then by *K. dussumieri* and *E. splendens*. The least correlation along PC1 was observed between *G. minuta* and *E. splendens.* When considering PC2, *E. leuciscus* showed high variation from all other species.

Morphometric variation among five ponyfish from five genera was analysed in the present study. Morphological variation increases from lower to higher taxa, and it is mainly due to genetic variation [20]. Though species constitute the smallest taxonomic group, morphological variations are evident in populations also [21]. Morphological variation in fish can affect their diet and can modify their feeding behavior and feeding patterns [22,23]. Even though morphological studies have various applications, the present study is mainly focused on discriminating the ponyfish, which are in turn used in fisheries management as in earlier studies [24].

The morphological data of *E. splendens* are consistent with the previous findings [25,26]. In *E. splendens,* the values of PVL, PcFL, PlFL, ABL, DBL, CPW, HW, BW, 1st DSL, 3rd DSL, 3rd ASL, ED, POL, UJL, and LJL showed significant variations from all other species. Among the five species, *E. splendens* showed maximum similarity to *N. gerreoides* and maximum variation to *E. leuciscus*. These findings are consistent with previous findings by Seth et al. [24], who found that *N. gerreoides* had a significant shape difference from the species *E. leuciscus* based on Procrustes distance studies. Morphometric characters of *K. dussumieri* are similar to earlier reports by Abraham et al. [25]. *Karalla dussumieri* showed the least variation compared to *N. gerreoides* with five morphometric characters (PAL, PVL, ABL, HW, and ED). *Karalla dussumieri* can be distinguished from *E. leuciscus* by most of the characters, and this was confirmed by molecular data in the previous report [27].

Table 3. Morphometric variable loadings for the first and second principal components in five ponyfishes

Characters	PC 1 (48.8%)	PC 2 (30.2%)
HL	0.2779	0.7878
PDL	-0.4567	0.3673
PPcL	0.3544	0.6401
PAL	0.1033	0.3877
PVL	0.3473	0.3600
PcFL	0.7545	0.4540
PlFL	0.5889	0.5208
ABL	0.3032	0.0417
DBL	0.7224	-0.0352
CPL	0.0158	0.2635
CPW	0.7621	0.2627
HW	0.0953	0.8507
BW	0.7788	0.5091
1^{st} DSL	0.5457	0.2585
2^{nd} DSL	-0.0009	-0.9786
3^{rd} DSL	0.4692	-0.4542
1^{st} ASL	0.7462	0.4449
2^{nd} ASL	0.6581	0.1022
3^{rd} ASL	0.5969	0.4319
ED	0.2499	0.6495
POL	-0.6875	0.0265
UJL	-0.9746	0.0810
LJL	-0.9116	0.3438

For *N. gerreoides*, the morphometric characters of the present study are similar to those reported for *N. mannusella* by Chakrabarty and Sparks [16], but values of PVL, HW, UJL, and LJL are slightly higher in *N. gerreoides*. Values of PDL, PcFL, PlFL, DBL, CPL, CPW, 3^{rd} DSL, 3^{rd} ASL, POL, UJL, and LJL in *N. gerreoides* showed significant variation from the other four species. The same observations were recorded in a previous study by Seth et al. [24]. A morphological study on *G. minuta* by Yoshitaka *et al*. [28] and Jawad et al. [29] produced similar results as in the present study. *G. minuta*'s PcFL, PlFL, 3rd DSL, 3rd ASL, POL, UJL, and LJL were significantly different from the other four species. Data obtained for *E. leuciscus* showed a similar kind of value to that of Abraham et al. [25]. The values of PcFL, PlFL, 3^{rd} DSL, 3^{rd} ASL, POL, ULJ, and LJL were significantly different from the other four species. *Equulites leuciscus* showed maximum similarity with *G. minuta* based on only three characters (ABL, CPW, and 1st DSL). This result is not in accordance with the previous study by Seth *et al*. [24]. In this study, PcFL, PlFL, 3^{rd} DSL, 3^{rd} ASL, POL, UJL, LJL, PVL, DBL, HW, BW, 1^{st} ASL, 2^{nd} ASL, and ED showed significant variation among the five species. These findings are consistent with Echem's [30] findings in shape variation studies on Leiognathidae.

A PCA should be performed, as the N:P ratio must be greater than three for an effective PCA interpretation [31]. In the present study, the N:P ratio was around 18, which shows a high confidence level. In the PCA scatter plot, each species is clustered into distinct groups with minor overlap. This overlapping may be due to the overall similarity and shape of the animals [32]. Along with PC1, maximum variation was observed between *E. splendens* and *G. minuta*. Interspecific variation was significantly higher than intraspecific, and is reflected in Fig. 3. In the PCA scatter plot, the intra-specific variation was less in *E. splendens* and was higher in *K. dussumieri*, but the intra-specific variation was reported as less by Seth *et al*. [24] in *K. dussumieri.*

4. CONCLUSION

Morphometric analysis of ponyfish in this study revealed that each species was separately scattered and minor overlapping was observed due to the deviation in morphological characteristics within the group. Minor overlap may be due to certain genetic similarities and some common characteristics they share since they belong to the same family. For the effective identification of ponyfishes, molecular level identification is very much needed.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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