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RESEARCH ARTICLE

Stock discrimination of *Etroplus suratensis* (Bloch) along the South Indian coast by morphometric analysis

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Abstract. The objective of the present study was to analyze the morphometric and meristic variations of an estuarine fish, *Etroplus suratensis*, in five locations along the South Indian coastal region. In total, 651 individuals were collected and 16 morphometric and six meristic counts were taken. The results of univariate (ANOVA) and multivariate (Principal Component Analysis, PCA) analyses showed that the east coast stocks (Machilipatnam, Mudasalodai, Rajakkamangalam) have overlapping morphological characteristics, whereas the west coast stock (Cochin) was distinctly different, but there were no significant differences observed in meristic characters among the five stocks. Therefore, it was presumed that Machilipatnam, Mudasalodai, and Rajakkamangalam were the same stock. The morphometric data discriminated *E. suratensis* into two stocks, i.e., those of the east and west coasts. However, further molecular-based analysis is very much needed to validate these stocks.

Keywords: *Etroplus suratensis,* morphometric, multivariate analysis, stock structure

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Introduction

The pearlspot, *Etroplus suratensis* (Bloch), is an important brackish water fish belonging to the family Cichlidae. Detailed studies about the biology and ecology of this species were conducted especially in South India and Sri Lanka (Pethiyagoda 1991, Bindu and Padmakumar 2014). Recently, the length weight relationship of *E. suratensis* was reported from India (Chandrasekar and Sivakumar 2012). Bindu and Padmakumar (2014) reported on the reproductive biology of *E. suratensis* and concluded that females are moderately fecund and spawn between 1,200 and 4,400 eggs. Morphometric and meristic characters are the fundamental keys in systematic studies in ichthyology. These data are useful for examining and graphically displaying differences in shape (Ibańez et al. 2007, Mojekwu and Anumudu 2015), and they are also very valuable for estimating growth variability in ontogenetic traits and population variations. Therefore, morphometric data are also valuable for discriminating among fish species and stocks or populations. Interspecies morphometric variations among fishes are very

common (Luthy et al. 2005, Sin et al. 2009). But within species morphometric and meristic character variations are rare (Thangaraj et al. 2018). If they do occur, they can be influenced by respective geographical environmental conditions, and variable characters can be used for stock discrimination (Kinsey et al. 1994, Poulet et al. 2004). A detailed morphometric and meristic analyses of *E. suratensis* in different geographical regions has not been reported in India or elsewhere. The objective of the present study was to characterize the morphometric variations in *E. suratensis* and to identify any morphological distinctions that could be used to differentiate among stocks at five sampling sites along South India.

Materials and methods

Sample collection and morphometric measurements

Etroplus suratensis (Fig. 1) were sampled in the 2013–2014 period from five locations in South India as indicated in Figure 2. A total of 651 individuals (Machilipatnam, n=94; Mudasalodai, n=214; Rajakkamangalam, n=146; Cochin, n=96; Mangalore, n=101) were collected using cast nets. Specimens were identified in the field based on external markings (bars and spots) and the number

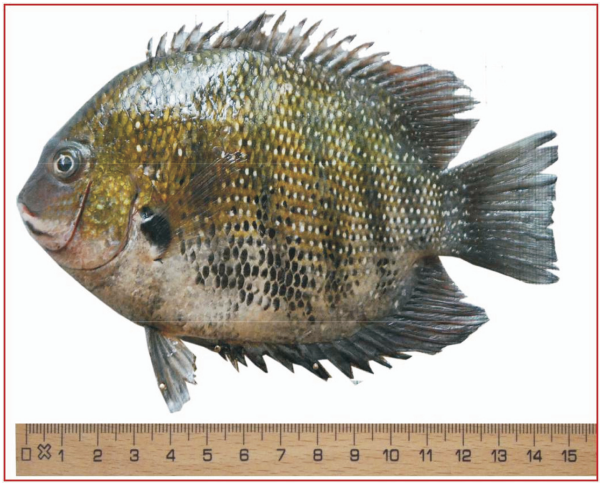


Figure 1. *E. suratensis*.

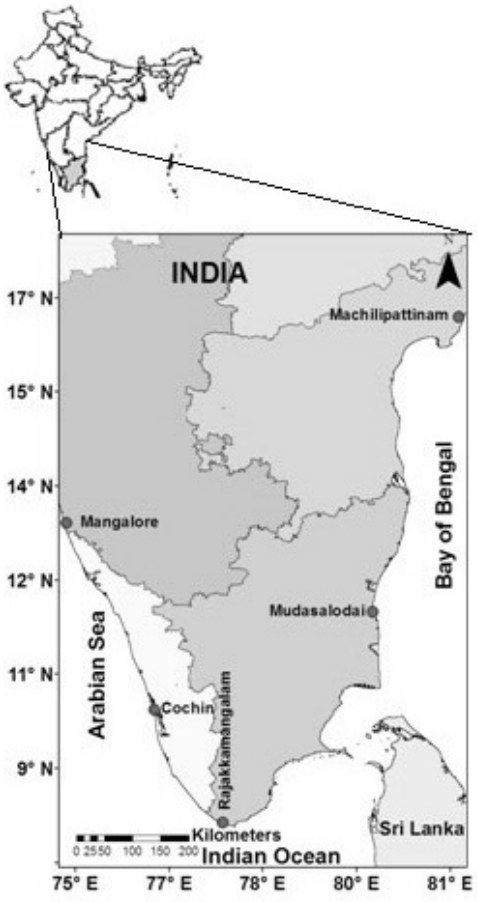
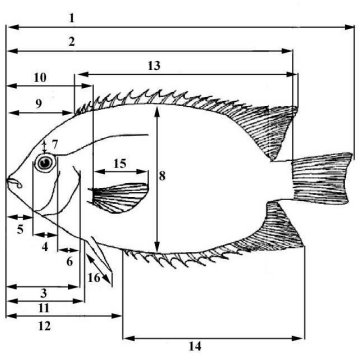


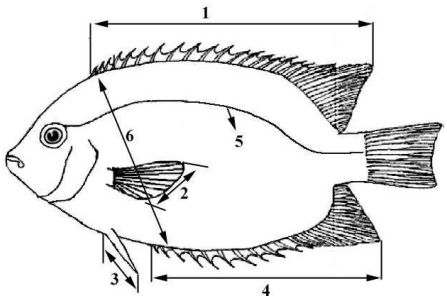
Figure 2. Map showing the collection sites of *E. suratensis*.

of dorsal spines according to standard books (Talwar and Jhingran 1991, Jayaram 1999). Samples were frozen soon after collection and defrosted just before being measured in the laboratory. All morphometric measurements of the samples were taken by the same person. A total of 16 morphometric and six meristic counts were recorded in as per Gunawickrama (2007). The 16 morphometric characters are given in Table 1 and illustrated in Figure 3. Morphometric measurements were taken from the left lateral aspect with a digital caliper (Mitutoyo, Standard error = 0.01 mm). Meristic counts were taken twice on the same specimen using hand-held magnifying lens and a dissection microscope. The meristic characters are illustrated in Figure 4.



1. Total length
2. Standard length
3. Head length
4. Eye diameter
5. Snout length
6. Post - orbital length
7. Inter orbital distance
8. Maximum body deapth
9. Pre - dorsal distance
10. Pre - pectoral distance
11. Pre - ventral distance
12. Pre - anal distance
13. Dorsal fin base length
14. Anal fin base length
15. Pectoral fin length
16. Ventral fin length

Figure 3. Schematic diagram showing the morphometric characters of *E. suratensis*.



1. Dorsal fin rays
2. Pectoral fin rays
3. Ventral fin rays
4. Anal fin rays
5. Lateral line scales
6. Transverse scales

Figure 4. Schematic diagram showing meristic characters in *E. suratensis*.

Table 1
Definitions of morphometric measurements and meristic counts used in this study

Character	Description	Acronym
Total length	Distance from the left foremost tip of the snout to the posterior edge of the forked portion of the caudal fin	TL
Standard length	Tip of the upper jaw to the tail base	SL
Head length	From the front of the upper lip to the posterior end of the opercular membrane	HL
Eye diameter	The greatest bony diameter of the orbit	ED
Snout length	The front of the upper lip to the fleshy anterior edge of the orbit	SNL
Post-orbital length	Distance between the hind margin of the orbit and bony opercular margin	POL
Inter-orbital distance	Distance between the eyes on dorsal side	IOD
Maximum body depth	Maximum body depth	MBD
Pre-dorsal distance	Front of the upper lip to the origin of the dorsal fin	PDD
Pre-pectoral distance	Front of the upper lip to the origin of the pectoral fin	PPD
Pre-ventral distance	Front of the upper lip to the origin of the ventral fin	PVD
Pre-anal distance	Front of the upper lip to the origin of the anal fin	PAD
Dorsal fin base length	From base of first dorsal spine to base of last dorsal ray	DFBL
Anal fin base length	From base to tip of the anal fin	AFBL
Pelvic fin length	From base to tip of the pelvic fin	PFL
Ventral fin length	From base to tip of the ventral fin	VFL

Statistical analysis

All the morphometric data of the five populations were analyzed using univariate analysis of variance (ANOVA), with Tukey HSD (for unequal N) post-hoc comparison tests to investigate significant morphometric differences. Tests were considered significant at $P<0.05$. The multivariate statistical analysis method of principal component analysis (PCA) was performed in the statistical package PAST (version 2.14) and IBM SPSS (version 21) to discriminate among populations based on grouping components significantly using all morphometric measurements.

Results

One-way ANOVA revealed that the morphometric characters of the east coast stock (Machilipatnam, Mudasalodai, Rajakkamangalam) of *E. suratensis*

Table 2
Morphometric data of *E. suratensis* from five collection sites

Characters	Machilipatnam	Mudasalodai	Rajakkamangalam	Cochin	Mangalore
TL (cm)	13.76 ± 2.71[a]	12.20 ± 2.50[b]	14.10 ± 2.90[a]	16.16 ± 2.85[c]	14.27 ± 3.40[a]
SL (%TL)	10.66 ± 0.25[a]	9.43 ± 0.14[b]	10.99 ± 0.17[a]	13.38 ± 0.25[c]	11.19 ± 0.21[a]
HL (%TL)	3.67 ± 0.68[a]	3.24 ± 0.04[b]	3.69 ± 0.05[a]	4.32 ± 0.08[c]	3.76 ± 0.06[a]
ED (%TL)	0.99 ± 0.27	0.88 ± 0.01[a]	1.04 ± 0.02[a]	1.09 ± 0.03[a]	1.01 ± 0.02[a]
SNL (%TL)	1.40 ± 0.27[a]	1.21 ± 0.01[b]	1.34 ± 0.22[a]	1.64 ± 0.03[c]	1.40 ± 0.02[a]
POL (%TL)	1.38 ± 0.27[a]	1.19 ± 0.01[a]	1.32 ± 0.22[b]	1.61 ± 0.25[c]	1.38 ± 0.02[a]
IOD (%TL)	1.44 ± 0.09[a]	1.30 ± 0.06[a]	1.62 ± 0.07[b]	2.09 ± 0.10[c]	1.15 ± 0.09[a]
MBD (%TL)	6.47 ± 0.13[a]	5.73 ± 0.08[b]	6.84 ± 0.10[a]	8.21 ± 0.15[c]	6.59 ± 0.12[a]
PDD (%TL)	4.81 ± 0.09[a]	4.22 ± 0.06[b]	5.02 ± 0.07[a]	5.60 ± 0.11[c]	4.84 ± 0.12[a]
PPD (%TL)	4.79 ± 0.09[a]	4.22 ± 0.07[b]	4.00 ± 0.06[b]	4.34 ± 0.08[c]	3.62 ± 0.07[a]
PVD (%TL)	4.24 ± 0.08[a]	3.73 ± 0.05[b]	4.48 ± 0.64[a]	4.94 ± 0.09[c]	4.27 ± 0.07[a]
PAD (%TL)	5.88 ± 0.10[a]	5.32 ± 0.07[b]	5.65 ± 0.86[a]	6.90 ± 0.12[c]	5.32 ± 0.10[b]
DFBL (%TL)	7.32 ± 0.15[a]	6.61 ± 0.10[b]	7.74 ± 0.12[a]	8.78 ± 0.18[c]	7.83 ± 0.14[a]
AFBL (%TL)	5.27 ± 0.14[a]	4.98 ± 0.07[b]	5.66 ± 0.09[a]	6.35 ± 0.13[c]	5.59 ± 0.11[a]
PFL (%TL)	3.00 ± 0.05[a]	2.52 ± 0.03[b]	3.10 ± 0.04[a]	3.51 ± 0.06[c]	3.02 ± 0.05[a]
VFL (%TL)	2.39 ± 0.04[a]	1.94 ± 0.03[b]	2.42 ± 0.04[a]	2.78 ± 0.03[c]	2.50 ± 0.04[a]

Values in rows with different superscripts are significantly different at P< 0.05

Table 3
Meristic counts in *E. suratensis* collected from five locations

Characters	Machilipatnam	Mudasalodai	Rajakkamangalam	Cochin	Mangalore
Dorsal fin rays and spines	XV-XIX, 12-16	XVIII-XIX, 12-15	XVIII-XIX, 13-15	XVII-XIX, 13-15	XVII-XIX, 12-15
Pectoral fin rays and spines	I, 16	I, 16	I, 16	I, 16	I, 16
Ventral fin rays and spines	I, 5	I, 5	I, 5	I, 5	I, 5
Anal fin rays and spines	XI–XIII, 10–13	X–XI, 10–12	XI–XIII, 10–12	XII–XIII, 10–13	XI–XIII, 10–13
Lateral line scales	35–40	35–40	35–40	35–40	35–40
Transverse scales	16–24	16–18	16–18	24–25	24–28

differed significantly (P<0.05) from west coast counterparts except for the Mangalore stock (Table 2). Whereas no differences were observed in meristic counts in any of the five stocks (Table 3). The Cochin stock was entirely different from the other four stocks as per the morphometric study. The east coast stocks of Machilipatnam, Mudasalodai, and Rajakkamangalam showed high similarity in most characters. Interestingly, all the characters except PAD in the Mangalore stock were similar to those of the Machilipatnam stock.

PCA analysis resulted in two components, where component 1 had an eigenvalue of 2.81 that explained about 85% of total variation, and component 2 had an eigenvalue of 0.186 thaat explained about 5.18% of total variation (Table 4).

Table 4
Variables associated with principal components and sum of squared loadings for the morphometric measurements of *E. Suratensis*

	Component	
Variables	PC1	PC2
SL	0.968	-0.022
HL	0.956	-0.008
ED	0.671	-0.082
SnL	0.938	-0.010
POL	0.940	-0.011
IOD	0.489	0.870
MBD	0.976	-0.024
PDD	0.980	-0.038
PPD	0.961	-0.040
PVD	0.984	-0.035
PAD	0.965	-0.024
DFBL	0.980	-0.040
AFBL	0.953	-0.033
PFL	0.966	-0.041
VFL	0.955	-0.058
% of variance	85.046	05.183
Cumulative %	85.046	90.229
Eigenvalues	2.81	0.186

Discussion

As per the multivariate analysis of 16 morphometric characters in the five *E. suratensis* stocks, higher similarity was found among the east coast stocks and the Cochin stock was completely different from the other stocks. At the same time, the Mangalore stock, which is located geographically on the west coast, was significantly differ from the west coast Cochin stock; however, it was very close to the Machilipatnam stock on the east coast. This study shows the quantitative morphological methods that can differentiate the *E. suratensis* stock into two groups.

Thangaraj et al. (2018) undertook morphometric and meristic analysis of Ladyfish, *Elops machnata* (Forsskål), Din four locations and observed a clear pattern of morphometric differentiation among the stocks. The present study also showed a tentative pattern of differentiation among the stocks and revealed two groups. There were no significant differences observed in the meristic characters in the five stocks in the present investigation. These results suggest that environmental variations have no influence on these meristic characters. Similarly, no variation was found in meristic characters of populations of *Clupea harengus* L. sampled from different environmental conditions in the Baltic Sea (Jorgensen et al. 2008) or in *E. machnata* collected from different estuaries of South India (Thangaraj et al. 2018). These results suggest that variations arising in meristic characters might require long periods of evolution. Beside the morphological aspects, variations are also influenced by geographical or habitat aggregation factors (Elliott et al. 1995) and feeding habits (Cavalcanti et al. 1999). Apart from this, feed niche and water depth are also crucial factors in differentiating variation in fish morphology (Clabaut et al. 2007). Therefore, further study on genetic data analysis is crucial to validate the precise stock variation of *E. suratensis* in Indian waters.

Conclusions

The univariate and multivariate analysis of morphometric characters of *E. suratensis* showed that stocks at Machilipatnam, Mudasalodai, Rajakkamangalam, and Mangalore have higher biometric similarity, and they can be considered to be the same stock, while the Cochin stock was discriminated as separate. Therefore, it is concluded that there are two *E. suratensis* stocks in South Indian waters, i.e., the east and west coast stocks. However, a further study based on genetic analysis is very much needed to validate the stocks further.

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Author contributions. S.C. responsible for data collection, sample maintenance, and data analysis; R.M. responsible for data collection, sample maintenance, and data analysis; M.T. developed study design, provided supervision, data validation, data analysis, review, edited the draft manuscript and corrected it. All authors read and approved the final manuscript.

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