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Stock structure analysis of *Priacanthus hamrur* (Forsskal, 1775) along the Indian coast based on truss morphometry

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Short communication

Abstract

The Moontail bullseye, *Priacanthus hamrur* is commonly found in the outer reef slopes and deep-sea waters. In small aggregations, sometimes it is found as schools in oceanic locations. Also found under ledges or hovering next to coral heads during the day. In the present study, 279 specimens were collected from Kakinada, Kolkata, Cochin and Mumbai to investigate the stock differentiation among the populations. A total of 14 morphometric traits and 11 landmark points with 14 truss variables were studied. Factor analysis of different truss variables showed that shapes belonging to a middle portion of the body, anal fin, caudal fin, dorsal fin region and head portion play an important role in differentiating the stocks. All four stocks are separated in the present study. Correct classification of 82.16% is shown by discriminant function analysis of truss measurements within the stocks. The present study can provide in formation for formulating different management strategies leading to sustainable management of this resource along the Indian coast.

Keywords*: Morphometric landmark, Priacanthus hamrur, classification matrix*

Introduction

India has a vast area of Exclusive Economic Zone (2.02 million sq. km) and continental shelf (530000 sq. km) and a coastline of 8118 km. The fishery comprises of over 200 commercially important finfish and shellfish species in commercial landings. The marine resource potential of the Indian EEZ is estimated to be 4.41 million metric tonnes (Anon, 2011). To increase the marine fish production, diversification of fishing activities has been done in the last decades. In India shrimp oriented fisheries export are given priority but to enhance the marine fish catch, exploitation of deep-water fishes and non-conventional demersal resources are needed (Devaraj and Vivekanandan, 1999). Stock identification of *Rastrelliger kanagurta* (Cuvier, 1817), *Megalaspis cordyla* (Linnaeus, 1758)) and *Decapterus russelli* (Ruppell, 1830) has been done from Indian waters (Remya *et al*., 2014; Sajina *et al*., 2011). Bull's eye has emerged as an important fishery resource in the trawl landings along both the west and east coasts of India. Bull's eye was recorded from 50-400 m depth along the north Kerala and Karnataka coast with peak occurrence in 100-150 m. depth (Joseph, 1984; Sivakami *et al*., 2001). There is habitat characterised by high salinity, low temperature and low dissolved oxygen (Pillai *et al.,* 1996). A significant change was observed in the landing pattern of bull's eyes (*Priacanthus* spp.) in 2016.

Landings of bull's eye have been escalated to six times high of 1.30 lakh t in 2016 as compared to 2015 (Anon, 2017). Demersal finfishes formed 29% in which threadfin breams, croakers and *Priacanthus* spp. were found as the major groups. This particular fish species were landed more along the northwest coast during July- September (Biradar, 1988). The estimated total landings of *Priacanthus* spp. during the year 2016 was 29068 t which contributed 2.6% of the total marine landings of Kerala. The species contributed considerably in the commercial fishery were *Priacanthus hamrur* (86%), *Cookeolus japonicus* (12%), *Priacanthus sagittarius* (1%) and *Heteropriacanthus cruentatus* (1%). *Priacanthus hamrur* is one of the most important emerging species among the commercial catches of the Indian coast, but there is a lack of information on its population structure, biology and population dynamics. Stock identification is a central theme in fisheries science that involves the recognition of self-sustaining components within natural populations (Crandall *et al.,* 2000; Thorpe *et al.,* 1996). Patterns of morphometric variation in fishes may indicate differences in growth and maturation rates because body form is a product of ontogeny (Stransky, 2014). Therefore, the present study has been made to identify stocks of *P. hamrur* using truss morphometry which gives a good insight into the stock relationships of this species.

Material and methods

During October 2017 to January 2018, 279 samples of *P. hamrur* were collected from landing centres of Versova (Maharashtra) and Cochin (Kerala) on the west coast and Kakinada (Andhra Pradesh) and Digha (West Bengal) on the east coast (Table 1). *P. hamrur* was identified by following the description given by FAO species identification sheets (Russell, 1990). It is advantageous to sample fish during the spawning season for phenotypic stock study because spawning stocks are geographically separated at that time (Cadrin, 2000).

Digital images of the left side of each of the 279 fishes were made using a canon 5X 50 digital camera. Clean and dry fish after thawing, was placed on a flat plane with a grid of known distances (laminated graph sheet) (Fig. 1) for standard view. Correct identification of the sex based on the

Table 1. Details of sampling

Coast	East Coast		West coast	
Stock	Andhra Pradesh	West Bengal	Maharashtra	Kerala
Landing Centre	Kakinada	Digha	Versova	Cochin
Location	16.57°N	21° 41 N	19.12° N	9.97° N
	82.15°E	87° 33 E	72.82 ° E	76.28° E
Sample sizes (n)	88	64	63	64
Total	279			

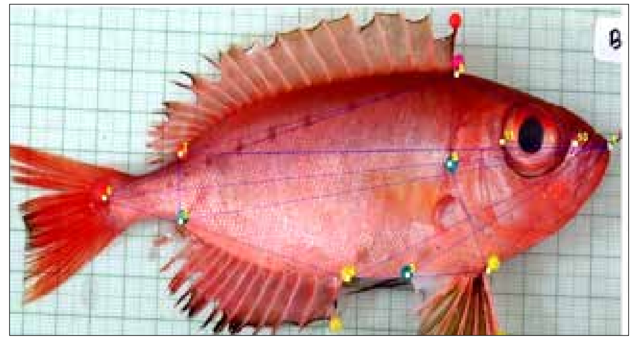

Fig. 1. Truss matrix of different landmarks

external morphometry is not possible in this species. Therefore the sex was observed by direct observation of the gonads after dissecting the specimen. A linear combination of two softwares, tps Dig 2 V2.1 (Rohlf, 2006) and Paleontological Statistics (PAST) (Hammer *et al.,* 2001) was used to extract morphometric data from the images of each. The truss protocol of body in the present study, based on eleven homologous landmarks (Table 4) and truss network of the digitized fish image, was constructed by interconnecting the landmarks of 14 truss measurements (Fig. 1).

Factor analysis was performed for 14 morphometric characters. Among them, 7 showed differentiation at the threshold value (0.6), so, morphometric characters loaded above the threshold value (0.6) were selected for forward stepwise discriminant analysis. Statistica forward (Stastica 12) procedure was used to perform a Stepwise Discriminant Analysis to select a subset of the quantitative variables for use in discriminating among the species. Statistica forward (stastica12) procedure was used for stepwise selection (Klecka, 1980). Statistica forward (Statistica 12) procedure was used to determine the combination (discriminant function) of the responses which best described each species. Each observation was assigned a probability of belonging to a given species based on the distance of its discriminant function from that of each class mean. A total of 14 morphometric characters, sorted after factor analysis, were used for forward stepwise discriminant analysis, and classification matrix and scatter plots were generated.

Results and discussion

Eleven morphometric traits after log transformation and allometric correction were subjected to factor analysis to generate two factors. The factor loadings after varimax rotation for the morphometric variables were analyzed. The characters having factor loading of above 0.60 on any of the first two factors were selected for subsequent Stepwise Discriminant Analysis. The selected variables were pre-pectoral fin length, post-anal fin length, post-dorsal fin length, pre-dorsal fin length, head length, eye diameter, the distance between pre-dorsal & pre-anal fin, depth between insertion of the anal & dorsal fin and dorsal fin base length. Squared mahalanobis distances revealed significant differences among the stocks with maximum distance in between Mumbai and Kakinada (30.97721) followed by Kolkata and Cochin (27.58596), while the minimum distance was observed in between Kolkata and Kakinada (2.6422) followed by Mumbai and Cochin (7.44004) (Table 2). Traditional multivariate test statistics implicitly rely on the Mahalanobis distances among observations (Faith *et al.*, 1987).

Table 2. Squared Mahalanobis Distance between different stocks

Site	Squared Mahalanobis Distances			
	Kakinada	Cochin	Kolkata	Mumbai
Kakinada	0.00000	8.34937	2.64222	30.97721
Cochin	8.34937	0.00000	27.58596	7.44004
Kolkata	2.64222	27.58596	0.00000	16.87737
Mumbai	30.97721	7.44004	16.87737	0.00000

Stepwise (forward) discriminant function analysis

Selected variables (9), after factor analysis, were subjected to Stepwise Discriminant Function Analysis (SDFA). The classification matrix shows 82.16% of correct classification (Table 3). The means of canonical variables shows that Root 1 successfully discriminates between Kakinada, Cochin and Kolkata stocks. Scatter plot (Fig. 2) between Root 1 and Root 2 shows that the stocks can be separated based on characters like pre-anal length, head length, pre-dorsal length, first dorsal fin base length and pre-pelvic length.

In the present study, the minimum and maximum standard lengths observed were 11.91 cm and 27.54 cm respectively. These values are higher than those reported by Saker (2009). Change in the morphological characters of the fish population occurs by the ecological and evolutionary process.

Table 3. Classification matrix of different stocks in stepwise (forward) discriminant analysis

Group	Classification Matrix				
	Percent Correct	Kakinada	Cochin	Kolkata	Mumbai
Kakinada	77.27273	68	0	10	10
Cochin	94.64286	0	53	3	0
Kolkata	62.90322	16	3	39	4
Mumbai	96.82539	2	0	0	61
Total	82.15614	86	56	52	75

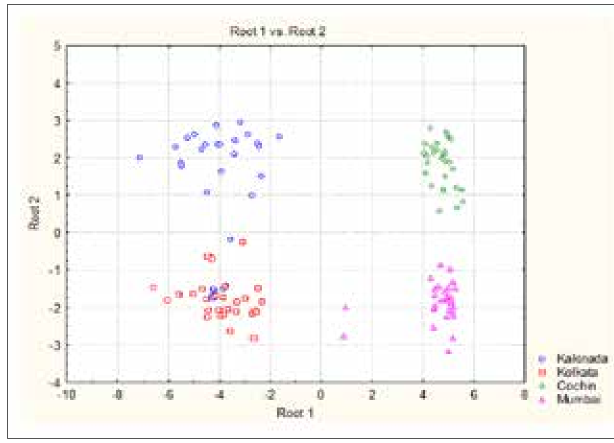

Fig. 2. Scatter plot of discriminant function for Root 1 and root 2 of morphometric variables

Polymorphism involves diversification in behavior, morphology or life history traits in populations and is most commonly seen in vertebrate populations (Robinson and Wilson, 1994; Wimberger, 1994; Smith and Skulason, 1996). Morphometric traits of fish are susceptible to different environmental changes thus exhibit high plasticity of phenotypic characters in overall body shape (Thompson, 1991). The truss morphometric analysis indicated significant phenotypic heterogeneity among populations of *P. hamrur* in India. Root 1 of the analysis was related to major vertical dimensions of the anterior half of the body. The traits loading on the Root 2 were related to the caudal area of the fish. The variation in the caudal region of specimens from the Arabian Sea and the Bay of Bengal could be a consequence of phenotypic plasticity in response to different hydrological conditions between the sea areas. Haas *et al.* (2010) also found that the physical characteristics of habitats drive changes in the morphological attributes of native fish populations. Traits (pre-pelvic length, pre-dorsal length, head length, eye diameter) loaded on factor 1, belonged to the anterior portion of the body and traits such as post-anal length, post-dorsal length, body depth, caudal peduncle depth and dorsal fin base length loaded on factor 2 and they mainly belong to the posterior portion of the fish body. In the present study, most well defined samples are from Mumbai (96.8% correctly classified) followed by samples of Cochin (94.6% correctly classified). The highest misclassification was observed in the samples collected from Kolkata followed by Kakinada samples. This indicates that discriminate function analysis is an effective and convenient method for separating the stocks of *P. hamrur* from Indian waters. Squared Mahalanobis distance analysis was revealed the maximum distance between Kakinada and Mumbai and minimum distances were found between Mumbai and Cochin (Fig. 3). There may be certain reasons behind this such as the pattern of the continental shelf, the inflow of organic matters, an abundance of the

Table 4. Landmarks used for extracting truss measurements from the body of *P. hamrur*

Landmark number	Landmark position
01	Anterior tip of snout on the upper jaw
02	Origin of the pelvic fin
03	Insertion of the pelvic fin
04	Origin of the anal fin
05	Break point of caudal peduncle
06	Insertion of the anal fin
07	Insertion of the dorsal fin
08	Origin of the dorsal fin
09	End of operculum
10	Origin of eye
11	Insertion of eye

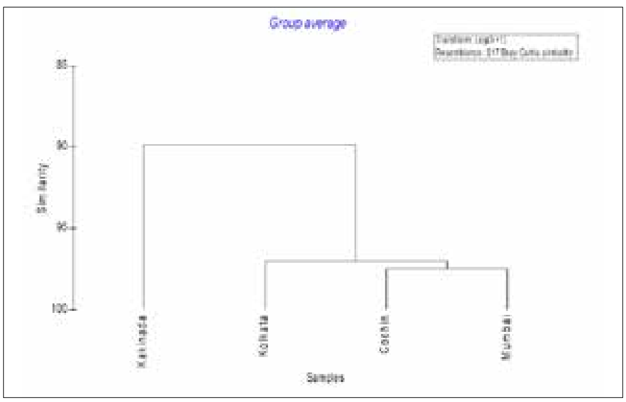

Fig. 3. Dendogram showing the cluster relationship among the four stocks

food item and environmental situations. Distinguishable variation in morphology among fish populations suggests the presence of a stock structure and the movement of the stock is restricted (Elliott *et al.*, 1995). The Morphological variability of fish due to segregation is considered to be an important adaptive strategy for populations experiencing inconsistent environments (Stearns, 1983; Wimberger, 1991). The Arabian Sea and Bay of Bengal are distinct ecosystems in terms of both physical and chemical parameters as reported by various authors (Sherman and Duda, 1999). Morphometric differentiation between the samples in the head characters might be due to differential habitat use and variation in relative head length could be related to the prey size of the fish (Gatz, 1979). So this study is indicating separate stock of *P. hamrur* in Indian waters which will help the fisheries managers to take separate management measures.

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