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Morphometric structure of the jumbo tiger prawn, *Penaeus monodon* Fabricius, 1798 from southeast and southwest coasts of India

Vincent Terrence Rebello*, M. K. George[1], M.P. Paulton[1] and T.V. Sathianandan[1]
PG Dept. of Zoology & Aquaculture, St. Albert's College, Ernakulam,
Cochin - 682 018, Kerala, India.
[1]Central Marine Fisheries Research Institute, P.B. No.1603, Cochin - 682018, Kerala, India.

*Correspondence e-mail: drterencerebello2012@gmail.com

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Original Article

Abstract

Morphometric variables were measured to detect variation among the random population samples of *Penaeus monodon* from east and west coast - Kochi, Calicut, Mangalore, Karwar, Kakinada and Chennai of India. Among these variables, PCL showed the highest correlation with the tail weight (TLW) in both males (0.9605) and females (0.9639). Truss network analysis of 26 measurements from the six centres were log transformed and were subjected to Principal Component Analysis and accounted a total of 89.15% variations in truss measurements data and showed no separate cluster formation in the plot of sheared PC scores and hence confirm homogeneous stock structure.

Keywords: *Penaeid prawn, Penaeus monodon, stock, morphometric variables, PCL, truss network, principal component analysis.*

Introduction

Genetic differentiation of marine animal population appears to be directly related to the dispersal ability of the species, because in the marine environment, physical barriers to migration are rare. Taxonomically, the species concept has always remained as the largest unit of any fishery resources. A species is not just a group of morphologically similar individuals, but a group that can breed only among themselves, excluding others (Mayr, 1970). The identification of a taxonomic species based on visible common morphological, anatomical and even biological characteristics is easier throughout its known areas of distribution. Now it is well known that a species may exist as geographically isolated populations or reproductively isolated stocks with their own fishery and biological characteristics. Hence, the ultimate success of any regulatory measures intended for protection against overexploitation and conservation of the basic fishery resources and their protection and conservation to the desired extent and period of time. Nevertheless, defining and identifying distinct units of fisheries management remained as problematic concept (Marr, 1957). The progressive refinement of the morphological, biochemical and molecular concept of the units of fishery management as well as the methods of their identification has further complicated the issue of conservation of the valuable fishery resources throughout the world (Busack *et al*., 1980; Casselman *et al*., 1981; Corti *et al*., 1988; Winans, 1984; Chow and Fujio, 1985; Allendorf *et al*., 1987; Campton and Utter, 1987).

As a result, morphologically defined sub units (stocks) of fisheries management have been identified and reported within many fish and shellfish species of the maritime nations including that of India (Mohamed, 1979; Lester, 1980;

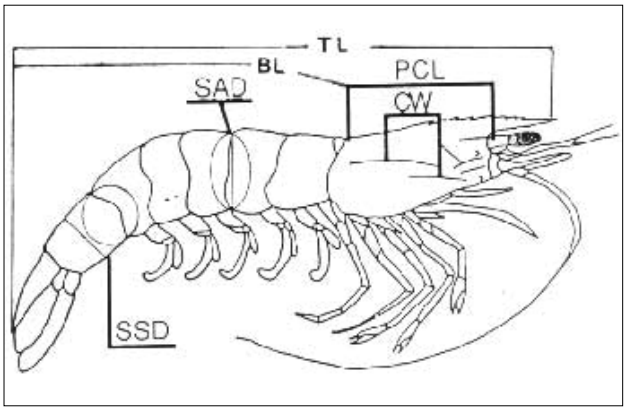
Berglund and Lagercrantz, 1983; Berg and Gall, 1988; Corti *et al.*, 1988; George, 1997; Goswami *et al.*, 1986; Begum, 1995; Paul, 2000; Rao, 1967; Rebello *et al.*, 2013). Such vital discoveries of the hitherto unknown subunits or stocks within a species should help in planning and formulating suitable management strategies for the scientific exploitation and conservation of valuable fishery as well as the genetic resources of any nation.

Material and methods

Population samples of *Penaeus monodon* were randomly collected from selected landing centres of west (Kochi, Calicut, Mangalore, Karwar) and east (Chennai, Kakinada) coast of India. These samples captured by trawl net purchased from landing centres were first frozen and transported to the laboratory in wet ice and then stored at -20°C until used for experiments. Basic information required for genetic studies were collected by the morphometric methods. A total of 627 samples of *P. monodon*, with a size range of 100-300 mm were collected for the analysis. The procedures for collection of basic data were standardized as detailed below (Bookstein, 1982; Strauss and Bookstein, 1982; Lester, 1983; Goswami *et al.*, 1986; Lester, *et al.*, 1990; Lester and Pante, 1992).

Morphometrics

The morphometric data analysed were measurements of the body parts, body shape and counting of meristic character. The thawed samples were weighed individually using the electronic weighing balance (Sartorius). Then a set of seven variables was measured as shown in Fig. 1. Length measurements were taken using a dial caliper having 0.05 mm accuracy (Lester, 1983; Goswami *et al.*, 1986; Lester, *et al.*, 1990; Lester and Pante, 1992). The variables measured were the length of the first abdominal segment along the mid-dorsal line (FSL) the length of the sixth abdominal segment along the mid-dorsal line with shrimp extended (SSL); partial carapace length (PCL) from the posterior margin of the orbit to the posterior edge of the carapace; width of the carapace (CW) at the point of the last dorsal rostral tooth; length of the fifth abdominal (FLF) segment when the shrimp is flexed ventrally; depth of the abdomen (SSD) at the mid-point of the sixth segment; depth of the abdomen (SAD) at the intersection of the second and third segments, circumference of the abdomen (AAC) at the intersection of segments five and six; the weight of the abdomen (TW) severed along the posterior edge of the carapace was also recorded. The rostral teeth number was also counted as a meristic character of the populations. The length variables selected for the present study are shown in Fig. 2. The length measurement on four variables of 627 samples were fed into the computer and the correlation of the variables, viz., SSD, SAD, PCL and CW with the tail weight was deduced by correlation matrix and path-coefficient (direct effect) analysis (Goswami *et al.*, 1986; Lester *et al.*, 1990; Sathianandan, 2003).



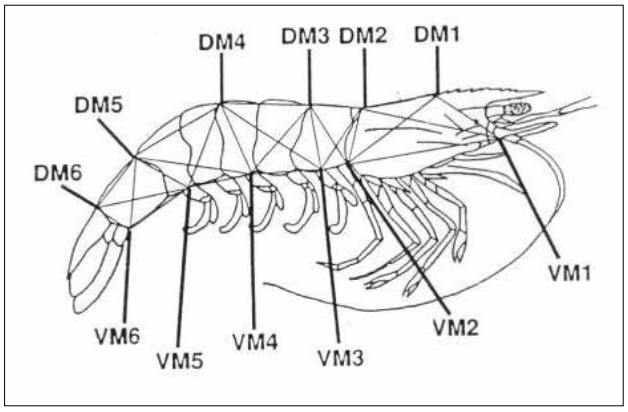
Variables

1.	Total length (TL)	:	Tip of the rostrum-tip of telson.
2.	Body length (BL)	:	Postorbital border of the carapace – tip of telson.
3.	Sixth segment depth (SSD)	:	Depth at the mid-point of the 6th segment.
4.	Second abdominal segment depth (SAD)	:	Depth at the mid-point of the 2nd and 3rd segment.
5.	Partial carapace length (PCL)	:	Posterior margin of orbit-posterior edge of carapace.
6.	Carapace width (CW)	:	At the point of the last dorsal tooth.
7.	Rostral length (RL)	:	Tip of the rostrum-last dorsal tooth.
8.	Total body weight (TW)	:	
9.	Tail weight (TLW)	:	
10.	Rostral teeth number (RTN)	:	

Fig 1. Variables measured in *P. monodon.*

Truss measurements

Truss data of *P. monodon* from Karwar, Mangalore, Calicut, Kochi, Chennai and Kakinada were used for the analysis. The body shape of each sample specimen was measured by truss network method (Lester *et al.*, 1990; Lester and Pante, 1992; Sathianandan, 2003). The thawed specimen was positioned on a water-resistant drawing sheet, head towards the RHS, and body posture and appendages were teased into a natural position. Positioning of specimens in this fashion is a precise process, as evidenced by low measurement error (Winans, 1984). Distinctive and homologous landmarks were selected around the outline of the prawn. Each landmark along the body was indicated and recorded by making a hole with a dissecting needle in the water resistant paper alongside its respective location. Data such as specimen number, body weight, and colour were recorded alongside each specimen. After the landmark information from a set of specimens were recorded (pinned), the paper was placed on an X-Y coordinate



Variables

1.	DM 1	:	Epigastric tooth (anterior)
2.	VM 1	:	Base of the antennal flagellum
3.	DM 2	:	Posterior dorsal median edge of carapace
4.	VM 2	:	Posterior ventral corner of the carapace
5.	DM 3	:	Posterior dorsal edge of tergum of the 1st abdominal segment
6.	VM 3	:	Mid ventral point of the 1st abdominal segment
7.	DM 4	:	Posterior dorsal edge of tergum of the 3rd abdominal segment
8.	VM 4	:	Mid ventral point of the 3rd abdominal segment
9.	DM 5	:	Posterior dorsal edge of tergum of the 5th abdominal segment
10.	VM 5	:	Mid ventral point of the 5th abdominal segment
11.	DM 6	:	Posterior ventral edge of the tergum of the 6th abdominal segment
12.	VM 6	:	Posterior ventral edge of the 6th abdominal segment

(DM – Dorsal measurement; VM – Ventral measurement)

Fig 2. Truss network landmarks made for measuring the body shape of *P. monodon.*

of a graph paper to establish a reference set of X and Y axes to view inter landmark distances (Lester *et al.*, 1990; Lester and Pante, 1992). The Euclidean or morphometric distances between pairs of landmarks were then calculated by computer (using the pythagorean theorem).

Principal component analysis computes a set of uncorrelated composite variables called principal components (PCs) from a variance-covariance (or correlation) matrix (Dunn and Everitt, 1982). The first principal component (referred as PC I) explains the most of the variance in the data set. Geometrically, PC I is thought to lie parallel with the largest axis in the hyperdimensional cloud of data (Green, 1976; Campbell and Atchley, 1981). PC II is independent of PC I, that is, it lies perpendicular to the axis of PC I, and explains the second largest component of variation in the data set. Each PC is a linear combination of the variables and is defined by a vector (an eigen vector) of coefficients and an eigenvalue. The coefficients are essentially a measure of covariance of the character on that PC. The eigenvalue is a measure of variability explained by a particular PC; the sum of the eigen values equals the total variability in a data set. Since on any component only a few characters have large coefficients, the biological interpretation of a component is based on the magnitude and signs of these so-called important characters. The details of the parameters considered for the truss network analysis are given in Fig.2. The data were analysed in computer and a programme was written in dBase III+ to convert these co-ordinates to the distance measurements between the landmarks. The distance measurements were further subjected to sheared PCA and the PC scores got from the analysis were plotted on a graph (Excel or Axum) with PC I and PC II on X and Y axes respectively.

Results and discussion

Morphometrics : Correlation with tail weight

Metric and meristic variables were measured to detect variation among the random samples from different locations. Among these four variables, PCL showed the highest correlation and Path-Coefficient with the tail weight (TLW) in both males (0.9605 & 0.3097) and females (0.9639 & 0.4881) of *P. monodon* from the six locations studied. From the path coefficient analysis, it was found that the partial carapace length (PCL) was the variable having highest correlation with the tail weight irrespective of sex (Table 1 & 2).

Truss network analysis

The 26 truss measurements made on each sample specimen of *P. monodon* from east and west coasts were log transformed and subjected to principal component analysis. The first principal component accounted for 85.80% and the second accounted for 3.35% (Fig.1 & Table 3) of the total variations in the truss data. These two principal components accounted for 89.15% of the variations in truss measurements data and were used to explain the variations. The PC-I and PC-II scores were computed for each of the samples and PC-I scores were

Table.1 Correlation matrix between different morphometric characters of *P. monodon* (male)

Variables	SSD	SAD	PCL	CW	TLW
SSD	1.0000	0.9400	0.9583	0.9473	0.9482
SAD	0.9400	1.0000	0.9595	0.9357	0.9457
PCL	0.9583	0.9595	1.0000	0.9691	0.9605
CW	0.9473	0.9357	0.9691	1.0000	0.9496
TLW	0.9482	0.9457	0.9605	0.9496	1.0000
	PATH-COEFFICIENT (DIRECT EFFECTS) - on TLW				
	Variables	SSD	SAD	PCL	CW
	Effects	0.2337	0.2274	0.3097	0.2153

Table.2 Correlation matrix between different morphometric characters of *P. monodon* (female)

Variables	SSD	SAD	PCL	CW	TLW
SSD	1.0000	0.9609	0.9645	0.9543	0.9390
SAD	0.9609	1.0000	0.9715	0.9616	0.9568
PCL	0.9645	0.9715	1.0000	0.9718	0.9639
CW	0.9543	0.9616	0.9718	1.0000	0.9530
TLW	0.9390	0.9568	0.9639	0.9530	1.0000
	PATH-COEFFICIENT(DIRECT EFFECTS) - on TLW				
	Variables	SSD	SAD	PCL	CW
	Effects	-0.0214	0.3087	0.4881	0.2022

plotted against PC-II scores to see morphometric changes between stations. From the plot it was found that samples from Mangalore formed a separate cluster from samples of other stations though there is mixing up of samples. The plotting of PC I scores against PC II scores of each sample on a graph produced a single clustering which indicated

Table.3 Percentages of principal component analysis in *P. monodon* from South India

PC#	Eigen Value	Percentage	Cum. Percentage
1	342.8323	85.80	85.80
2	13.3903	3.35	89.15
3	6.2296	1.56	90.71
4	5.7940	1.45	92.16
5	4.7872	1.20	93.36
6	4.0971	1.03	94.38
7	3.7836	0.95	95.33
8	3.2311	0.81	96.14
9	2.8502	0.71	96.85
10	2.2864	0.57	97.42
11	1.9486	0.49	97.91
12	1.7772	0.44	98.36
13	1.4752	0.37	98.73
14	1.2093	0.30	99.03
15	0.8541	0.21	99.24
16	0.7057	0.18	99.42
17	0.6435	0.16	99.58
18	0.6064	0.15	99.73
19	0.4010	0.10	99.83
20	0.3214	0.08	99.91
21	0.2418	0.06	99.97
22	0.0402	0.01	99.98
23	0.0377	0.01	99.99
24	0.0158	0.00	100.00
25	0.0129	0.00	100.00
26	0.0032	0.00	100.00

that the morphological profiles of all these six populations are homogeneous. It means that populations of *P. monodon* of South India, irrespective of east and west coasts may belong to a single morphological stock. So the results of morphometric study did not support the hypothesis of stock differences suggested by stock assessment results of Rao *et al*. (1993).

Further analysis was attempted by shearing the principal components of all the size samples. The sheared PC analysis was then carried out. The first two sheared principal components accounted for 89.15% of the total variation in the data. The sheared PC scores were then computed and plotted for the samples from these six stations (Fig.3). There was no separate cluster formation in the plot of sheared PC scores and hence the morphometrics of the samples from the six stations were not significantly different (Strauss and Bookstein, 1982; Lester, 1983).

The reports of stock differentiation of penaeid species are not known except the first attempt of Horton (1982). He detected significantly different morphometric variations in population samples of *P. stylirostris* and *P. vannamei*. However, he could

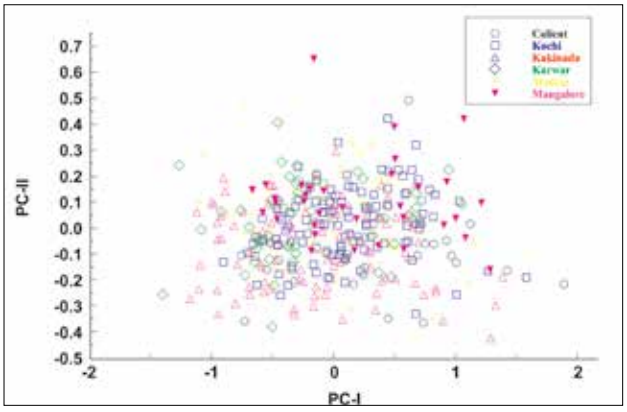


Fig 3. Morphometric profiles (sheared PC scores of truss measurements) of six populations of *P. monodon* of south India

not conclude these differences as basis for genetic stock differences (Lester and Pante, 1992). The reports of stock separations by multivariate analysis of morphometrics of fishes are many (Ihssen *et al*., 1981; Winans, 1984).

However, lack of significant morphological differences even between east and west coast samples of the species does not mean that these coastal populations are interbreeding. The phenomenon of stabilizing selection in different geographical areas may suppress the potential for significant morphological differences which are also expressions of polygenes (Ayala and Keiger, 1980; Lester and Pante, 1992).

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