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Short Communication

Morphometric differentiation of hermit crabs, superfamily: Paguroidea from Mumbai, North-West coast of India

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The present communication deals with an attempt to differentiate species of hermit crabs, collected from Maharashtra region, using morphometric features. A total of 16 morphometric measurements features were recorded from each specimen. The morphometric features like cheliped dactylus length, cheliped propodus length, carapace length, ocular peduncle length, antennular peduncle length and propodal length have been found to be important traits in the separation of the species. Among these first three, cheliped dactylus length, cheliped propodus length and carapace length, are most important in differentiation. The analysis also indicated 99.55 % correct discrimination of the species based on selected traits.

[Keywords: Cheliped, Discriminant analysis, Hermit crab, Morphometric]

Introduction

Arthropods are the most dominant and diverse among animals but failed to attract the required attention of biologist and ecologists, like vertebrates. Hermit crabs (Crustacea: Anomura: Decapoda) are the most distinctive group of animals extensively spread across the intertidal, subtidal, estuarine, mangrove and coral reef areas of tropical countries[1,2]. The wide variation in the habitats made them evolve with various behavioural adaptations which influenced their distribution and diversity. These animals are known for their soft abdomen which is prone to attack by predators. To escape from the predation and also from desiccation, they are highly dependent on gastropod shells available in the vicinity[3,4]. These anomuran crabs form a very important link in the food web of the oceans, especially as the principal food of economically valuable species of fishes. Group Anomura is comprised of 7 super families, 223 genera and around 2500 species, worldwide[5]. The hermit crabs, belonging to super family Paguroidea, are represented by 1100 species under six families, worldwide[6]. In Indian waters, 112 species of hermit crabs are reported so far[7].

The process of understanding the biodiversity pattern becomes crucial in the fast-changing aquatic environment and it becomes even critical when the group is ecologically important. There are a number of reports on the occurrence of hermit crabs[8-17], with some new addition to the faunal list[18-23]. Despite their ecological significance, very little is known about their systematics and ecology in India, especially from Maharashtra region. Hence, there is a need to understand the occurrence of hermit crabs in concerned habitats, which would form the baseline for further studies, and management of resources dependent on them. In this context, the findings of the present investigation on the identification of the species would facilitate future researchers for assessment of diversity and the ecological objectives.

Materials and methods

Extensive field surveys were carried out to collect hermit crab samples from the intertidal areas of Aksha beach, Bandstand, Alibaug, Srivardhan and also from trawl bycatch landings in Versova, Mumbai, Maharashtra between August 2014 and April 2015 (Fig. 1). Collected crabs with shells were washed and preserved in 70 % alcohol and brought to the laboratory for further studies. Later, the crabs were pulled out of the shells by twisting the animal slowly against the direction of shell spiral. The collected hermit crabs were identified based on the standard keys[10,24,25]. During this period, four species of hermit crabs under three genera *viz*. *Clibanarius padavensis* De Mann, 1888; *Clibanarius longitarsus* (De Haan, 1849); *Diogenes alias* McLaughlin & Holthuis, 2001 and *Pagurus Kulkarnii* Sankolli, 1962, were identified. The identification of most species is primarily dependent on the colour pattern of the body where it becomes very difficult to differentiate them in absence of colour. Hence the

morphometric study of four species was done by selecting 16 morphometric variables (Table1 & Fig. 2), recorded to the nearest of 0.01 mm. All 16 variables were subjected to Factor analysis to extract the variables, responsible for differentiation. Means of eighteen morphometric ratios were compared for discriminating the species using MANOVA. The measurements were subjected to Canonical analysis to identify highly contributing variables in the discrimination. The heavily loaded variables from Canonical analysis were subjected to Discriminant analysis to classify the specimen in their respective groups. The whole statistical analyses were carried out using the software package "Statistica".

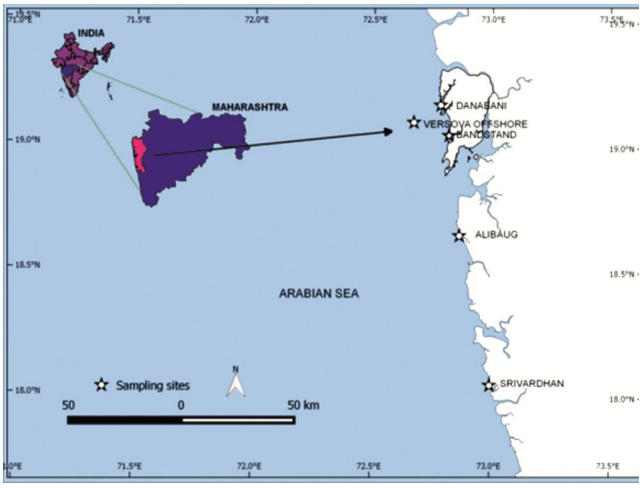

Fig. 1 — Location of sampling sites along the Maharashtra coast

Results

Multivariate analysis of four selected species of hermit crabs shows a significant difference between them (Wilks Lambda = 0.00, F = 71.154, $p < 0.05$). The first factor was loaded with high values of cheliped dactylus length, cheliped propodus length and carapace length (Fig. 3A) and second canonical variables explained high values on ocular peduncle length, antennular peduncle length and propodal length (Fig. 3B). The first and second canonical variables explained 47.93 % and 39.25 %, respectively. The scatter plot of first and second canonical scores explained clear discrimination of all four species of hermit crabs (Fig. 4).

Means of canonical variables also explained the correct separation of four species of hermit crabs. The heavily loaded variables in first and second canonical

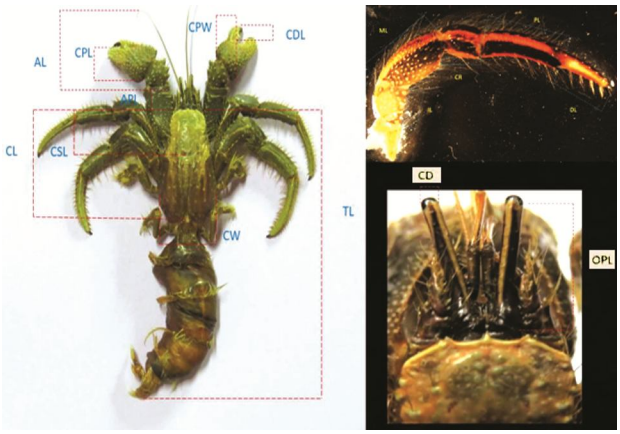

Fig. 2 — Morphometric variable selected during the study

Table 1 — Morphometric characters of hermit crabs used for the present study

Acronym	*Morphometric character*
Cephalic Shield length (CSL)	The distance from the tip of the rostrum to the midpoint of the posterior margin of the shield
Carapace Length (CL)	The distance from the tip of the rostrum, along the midline, to the posterior end of the carapace
Carapace Width (CW)	The maximum width of carapace at any position.
Ocular Peduncle Length (OPL)	The total length of an ultimate peduncular segment including cornea on the lateral face of peduncle.
Corneal Diameter (CD)	The maximum width of the cornea measured on the dorsal surface.
Antennae Length (AL)	The distance from the ultimate segment to the tip of the antennal flagellum
Antennular Peduncle Length (APL)	The distance from the base of antennae to an ultimate peduncular segment.
Total Length (TL)	The distance from the tip or rostrum to the tip of the telson.
Cheliped Propodus Length (CPL)	The distance from the tip of the propodus fixed finger to the base of propodus.
Cheliped Propodus Width (CPW)	The maximum width of propodus at any point.
Cheliped Dactylus Length (CDL)	The distance from the tip of the dactylus movable finger to the case of dactylus.
Dactylus Length (DL)	The distance from the tip of the third left dactylus to the base of dactylus on the mesial surface
Propodal Length (PL)	The distance from the tip of the third left propodus to the base of propodus on the mesial surface.
Carpus Length (CR)	The distance from the tip of the third left carpus to the base on the mesial surface.
Merus Length (ML)	The distance from the tip of the third left merus to the base on the mesial surface.
Ischium Length (IL)	The distance from the tip of the third left ischia to the base on the mesial surface.

analysis have been used for discriminant analysis which showed the overall correct classification rate of 99.55 % with *P. kulkarni*, *C. padavensis* and *D. alias* showed 100 % of the individuals correctly qualified while individuals of *C. longitarsus* where shown 98.33 % correct classification (Table 2).

Discussion

The relationship between the various families and animals within the groups of anomurans has become the subject of interest to many workers both at morphological and molecular level in recent years[26,27]. Even though there is a lot of confusion prevailed among the classification of hermit crab during 1987-2001, McLaughlin[25] presented an illustrated key to support the identification. In the present study, we have extracted a total of 16 morphometric variables (Table 1) following the standard measurements[6]. The multivariate analysis showed a significant difference among the species. Earlier workers have used various morphometric characters in differentiation at family and species level[5,10,25]. Results of the present study revealed the difference, mainly based on measurements of cheliped like cheliped dactylus length, cheliped propodus length, and carapace length, and also on ocular peduncle length, antennular peduncle length, and propodal length.

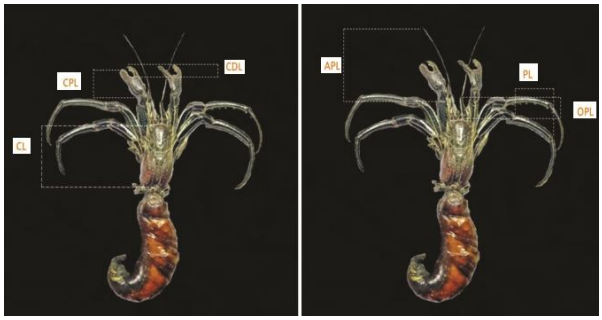

Fig. 3 — A) First factor, B) Second factor with the highest loading in the canonical axis of CDA

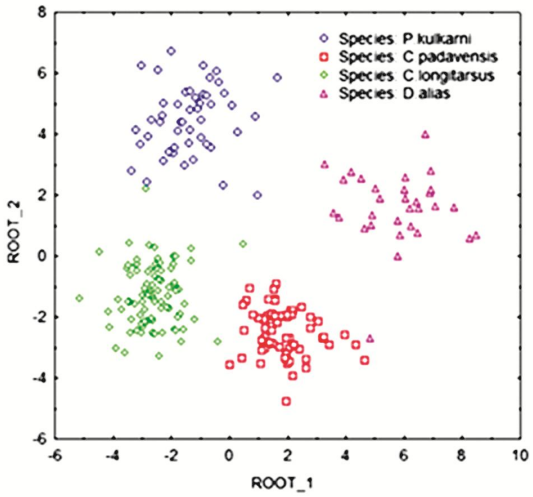

Fig. 4 — Scatter plot of discriminant function for Root 1 and 2 of the morphometric variables

Table 2 — Classification matrix of 4 hermit crabs species: a) *P. kulkarni* b) *C. padavensis* c) *C. longitarsus* d)*D. alias*

	Percent	a	*b*	*c*	*d*
a	100.00	48	0	0	0
b	100.00	0	60	0	0
c	98.33	1	0	86	0
d	100.00	0	0	0	31
Total	99.65	49	60	86	31

The species, under genus *Clibanarius*, can be separated easily from the other two genera *Pagurus* and *Diogenes*, based on chelipeds of more or less equal size and spine like a tooth on both carpus and merus of cheliped[10]. The species under genus *Pagurus* and *Diogenes* have larger right cheliped[6,25]. *Pagurus kulkarni* (family Paguridae) can be discriminated from other hermit crabs by the longer shield, short corneal peduncle, longer antennal flagellum (AL) and larger right cheliped[28]. Among the collected genera, *Diogenes* is highly diverse morphologically leading to the number of species and more often sexual dimorphic which shows size-related differences; thus, increasing difficulties in correct identification. Therefore, identification of the species, based only on the key will lead to misidentification, hence advised to verify all diagnostic characters. *Diogenes alias* can be separated from other three hermit crabs by having a combination of features like longer dactylus, palm and prominent denticles on right cheliped.

The study concludes that hermit crabs can be easily discriminated using a combination of morphometric characters. Though the present investigation includes only four species belonging to three different genera, it is advised to carry out a similar study with the maximum number of species falling under same or different genera with the integration of phylogenetic study, which will provide more authentications in species identification. The present findings would help in correct identification of above-mentioned species in future. Moreover, this piece of information will form the baseline for other researchers, as there exists a huge scope in ecological and ethology study relating to the hermit crab in Indian waters.

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