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Morphometric characterisation of two species of horseshoe crabs viz. *C. rotundicauda* Latreille and *T. gigas* Muller from Bhitarkanika National Park, Odisha, India

S. D. MOHAPATRA[1], N. C. PALEI[2*] AND S. MISHRA[3]

[1]*P.G. Department of Biotechnology and Bioinformatics, Sambalpur University, Odisha, India.*
[2]*Office of the Principal Chief Conservator of Forests (Wildlife) and Chief Wildlife Warden, Odisha, India*
[3]*Indira Gandhi Park Zoo and Deer Park, Rourkela*
**wildpalei@gmail.com*

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ABSTRACT

The morphometric characterisation of two species of horseshoe crabs viz. *Carcinoscorpius rotundicauda* (Latreille) and *Tachypleus gigas* (Muller) was studied from Bhitarkanika National Park, Odisha. Different age groups and sexes from both the species were investigated for morphometric and allometric studies. Various parameters, such as total body length, prosoma length, prosoma width, prosoma-opisthosoma hinge length, opisthosoma length, opisthosoma width, telson length were recorded. The values were found higher in female compared to the male for both the species. Allometry analysis showed significant positive correlation indicating that the different body parts increase proportionately with the gradual increase of body dimension with the advancement of growth.

Key words: Allometry, Bhitarkanika, *C. rotundicauda*, *T. gigas*, morphometric

INTRODUCTION

The horseshoe crabs are the oldest living animals on earth (Khan, 2003). These animals are called living fossils, as they remain unaltered morphologically and genetically through the long evolutionary course of more than 350 million years (Price, 1971). The fossilised records from different parts of the world from different geological time scale (Mikkelsen, 1988) reveals that little structural changes occurred in extant species over the time since the mid-Paleozoic Era (Sekiguchi and Shuster, 2009). There are only four species of horseshoe crabs exist in the present world. These are *Limulus polyphemus* (Linnaeus), *Tachypleus gigas* (Muller), *Tachypleus tridentatus* (Leach) and *Carcinoscorpius rotundicauda* (Latreille). Except for *L. polyphemus* (Linnaeus), the other three species viz. *T. tridentatus, T. gigas* and *C. rotundicauda* are Asian species (Sekigachi and Nakamura, 1979). *L. polyphemus* occurs in the coastal waters of U.S.A. Among the Asian horseshoe crab species, two species, i.e. the Indian horseshoe crab, *T. gigas* and the mangrove horseshoe crab *C. rotundicauda* occur in the Indian subcontinent.

In Asia, *T. gigas* are distributed from the Bay of Bengal particularly from the coast of Odisha in India to China, North Vietnam, Borneo and South-West of Japan (Chatterji and Abidi, 1993; Pati et al., 2015). *C. rotundicauda* is native to India, Indonesia, Malaysia, Philippines, Singapore and Thailand (Chatterji and Abidi, 1993; IUCN, 1996). Both the two species are confined to north-western coasts of the Bay of Bengal along Orissa and West Bengal. In Odisha, both the horseshoe crabs species are reported by (Chatterji, 1999; Dutta, 2007). Coexistence of both *C. rotundicauda* and *T. gigas* is reported in Odisha, particularly from Bhitarkanika region (Chatterji, 1999). Horseshoe

crabs distribution pattern is patchy (Shuster and Botton, 1985) and exhibits site-specificity, especially in areas where eggs and juveniles have thrived (Robert et al., 2014). *T. gigas* prefer relatively clean and sandy beaches in contrast to *C. rotundicauda*, which prefer muddy substratum. *T. gigas* are found on the sandy beach at the mouth of the estuary whereas *C. rotundicauda* are found in the mangroves of the estuary. Both the species occur sympatrically in the mangroves of Odisha. Mature pairs of horseshoe crabs (both the species) in amplexus migrate towards the shore throughout the year for breeding on the mud and sand mixed beaches of Bhitarkanika. These species are also seen to migrate upward, the estuarine river system in Bhitarkanika and Mahanadi delta in mangroves. Both the animals are classified as data deficient in the red list of threatened species.

MATERIALS AND METHODS

Bhitarkanika estuary lies between the latitude 20°29' and 20°47' N and longitude 86°45' and 87°5' in the north-western part of the Bay of Bengal on the Odisha coast. The entire area is situated in the mouth region of the Brahmani and the Baitarani river. This area supports diverse mangrove flora in the Indian subcontinent. The whole estuarine ecosystem gets inundated by semi-diurnal tides. Due to its unique and vast flora and faunal diversity with an area of 672 sq. kms, was designated as Bhitarkanika Wildlife Sanctuary, whereas its core region with an area of 145 sq. kms is designated as Bhitarkanika National Park (Fig. 1).

The area comes under the tropical climate. Monsoon chiefly influences the climate and therefore, biological seasons are classified as pre-monsoon (March-June), monsoon (July-Oct.) and post-monsoon (Nov.-Feb.). Average annual rainfall is around 1600 mm. Temperature varies from a minimum of 10°-15°C in December-January to maximum 40°-45°C in May-June. Tropical cyclones also influence the region in monsoon and post-monsoon period. Due to the high productivity

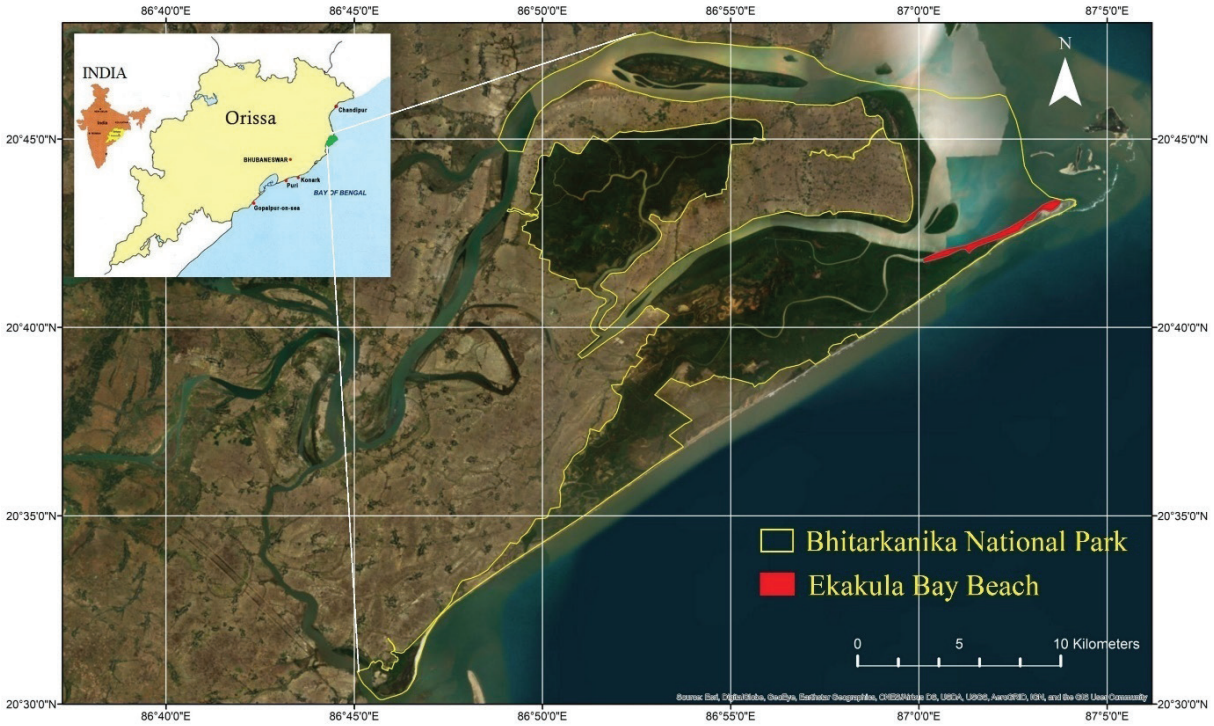

Fig. 1. The Google Earth map of Bhitarkanika National Park showing the sampling site of horseshoe crab Ekakula shelter bay beach

of mangroves, Bhitarkanika sustains a diverse group of animals, including horseshoe crabs. Two species of horseshoe crabs, *T. gigas* (Fig. 2) and *C. routandicauda* (Fig. 3) were studied from Maipura river mouth region on Ekakula shelter bay beach of Bhitarkanika National Park.

The beach comprises of sandy, and muddy substratum, flooded with brackish water that makes the site a suitable habitat for horseshoe crabs. Mangrove species such as *A. alba, A. marina, S. alba, A. rotundifolia, R. mucronata* and *R. apiculata* are present on the beach. The horseshoe crabs usually found to be spawning on the beach throughout the year. Specimens of both the species were collected manually during March 2017. After taking morphometric measurements, the animals were released into their habitat without harming.

The morphometric analysis of horseshoe crabs was carried out following Chatterji et al., 1988. A total of 62 individuals of *C. rotundicauda* horseshoe crabs (31 male and 31 female) and 61 individuals of *T. gigas* horseshoe crabs (30 male and 31 female) were examined for the morphometric study. Specimens were measured with the help of

(a) Dorsal view

b) Ventral view

Fig. 2. Morphometric (a) dorsal view and (b) ventral view of species *T. gigas.* It has distinguished feature of circular frontal margin, triangular telson cross section with irregular sized opisthosoma marginal spine compared to *C. rotundicauda.*

(a) Dorsal view b) Ventral view

Fig. 3. Morphometric (a) dorsal view and (b) ventral view of species *C. rotundicauda*. It has distinguished feature of circular telson cross section with regular sized opisthosoma marginal spine compared to other three species of horseshoe crabs viz. *L. Polyphemus*, *T. gigas* and *T. tridentatu*s.

Vernier Calliper at a precision level of 0.002 cm for different morphometric parameters such as total body length, prosoma length, prosoma width, prosoma–opisthosoma hinge length, opisthosoma length, opisthosoma width and telson length without harming the animal.

Data obtained for all measurements were pooled according to the species and sex of specimens. The mean and standard deviation of various morphometric parameters were calculated and categorised. Independent samples T-test was applied to test differences between male and female specimen of both the species. The regression analysis was performed by R statistical software in order to discover the dissimilarity of the association degrees within different body parts, prosoma length vs. total body length, prosoma width vs. total body length, prosoma–opisthosoma hinge length vs. total body length, opisthosoma length vs. total body length, opisthosoma width vs. total body length, and telson length vs. total body length.

RESULTS AND DISCUSSION

The comparative morphometric analysis assesses the variation in overall morphology between different species. In this study, the morphometric parameters between two species of horseshoe crabs have been investigated. Both the species *C. rotundicauda* and *T. gigas* were found together during the survey at Ekakula beach. This corroborates the findings of Chatterji, 1999 of overlapping habitat and coexistence of these two species in Bhitarkanika. Both the horseshoe

crab species show notable differences in external morphology, based on morphological characteristics following Yamasaki et al. (1988). Most horseshoe crabs of both the species came ashore in ampleux mated pairs. The mating horseshoe crabs are found in tandem where the female was in front of the male.

Sexual dimorphism characteristics of horseshoe crabs are the size differences (Tan et al., 2012). On collation of collected morphometric data, males of both *C. rotundicauda* and *T. gigas* were found to be smaller than females significantly (Table 1 and 2). Independent samples t-test of different body parts between male and female of each species confirms that the females are larger compare to males. Among the *C. rotundicauda* population of Bhitarkanika, the total body length of females had 12.20% higher value than the males. Similarly, the prosoma length, prosoma width, prosoma-ophiostoma hinge length, ophiostoma length, ophiostoma width and telson length showed 14.23, 8.57, 11.79, 14.56, 8.70 and 8.59 % higher values respectively in females than the males (Table 1). In the *T. gigas* population of Bhitarkanika the prosoma length, prosoma width, prosoma ophiostoma hinge length, ophiostoma length, ophiostoma width, telson length and total

Table 1. Measurement of different morphometric parameters of *C. rotundicauda*

	Prosoma length (cm)	Prosoma width (cm)	Prosoma – opisthosoma hinge (cm)	Opisthosoma length (cm)	Opisthosoma width (cm)	Telson length (cm)	Total body length (cm)
(a) Male							
Mean	7.231	13.08	6.294	5.754	9.545	14.58	27.53
SD	0.243	0.494	0.362	0.426	0.425	0.864	1.183
Max	7.615	13.83	7.113	6.452	10.19	16.82	29.97
Min	6.635	11.87	5.618	4.732	8.627	13.27	25.51
(b) Female							
Mean	8.260	14.21	7.035	6.591	10.37	15.84	30.89
SD	0.457	0.857	0.400	1.023	0.396	1.321	1.971
Max	9.006	15.67	7.602	9.952	11.07	17.83	34.97
Min	7.636	12.98	6.344	5.338	9.812	12.41	27.68

Table 2. Measurement of different morphometric parameters of *T. gigas*

	Prosoma length (cm)	Prosoma width (cm)	Prosoma – opisthosoma hinge (cm)	Opisthosoma length (cm)	Opisthosoma width (cm)	Telson length (cm)	Total body length (cm)
(a) Male							
Mean	8.383	14.81	6.745	6.088	9.113	15.47	29.71
SD	0.415	1.215	0.315	0.389	0.539	1.369	1.849
Max	9.446	19.99	7.422	7.288	9.980	18.89	34.02
Min	7.654	13.12	6.090	5.408	7.182	13.30	26.42
(b) Female							
Mean	10.82	18.10	8.517	7.766	11.23	17.92	36.06
SD	0.455	0.652	0.384	0.345	0.391	1.798	2.053
Max	11.78	19.78	9.374	8.550	12.52	20.26	39.07
Min	10.11	16.91	7.308	7.102	10.51	12.51	30.11

body length showed 29.15, 22.20, 26.28, 27.56, 23.26, 15.81 and 21.37% higher values respectively in females than the males (Table 2). The females are prominently bigger than the males in horseshoe crabs (Yamasaki et al., 1988; Key et al., 1996; Brockman and Smith 2009; Srijaya et al., 2012).

The allometry study (the relationship between differences in one body parameters to the other) of body parts of the horseshoe crab is utmost important to monitor its growth characteristic in studying the biology of the organism and serve as a functionally predictive tool for the study of animal's ecology (Vijayakumar et al., 2000). The morphometric characters and their allometric relationship are dependent upon age, local environmental conditions and population density of the species. The regression analysis of different morphometric measurements such as prosoma length, prosoma width, prosoma-ophiostoma hinge length, ophiostoma length, ophiostoma width, and telson length with the total body length of male and female individuals of both the species are presented in Table 3 and 4. The positive correlation between different morphometric parameters and total body length relationship also showed a proportionate increment in these parameters. The increase in the soft body parts could probably be due to increased feeding efficiency and food availability to horseshoe crab (Vijayakumar et al., 2000). The changes in body dimensions of the species, *T. gigas* and *C. rotundicauda* indicate that the relationship could indirectly be influenced by population density, feeding efficiency, food availability and local environmental conditions.

CONCLUSION

Bhitarkanika National Park is unique of its mangrove ecosystem having a healthy population of two horseshoe crab species on its adobe. The well-protected coast and water body on its bay is an ideal refuge for these two horseshoe crab species. Consequently, this morphometric study aims to provide crucial data that related these two horseshoe crab species in Bhitarkanika waters to support further research.

Table 3. Regression relationship between various body parts of *T. gigas* of Bhitarkanika

	Male	Female
Prosoma length vs total body length	$y = 0.158x + 3.695$, $R^2 = 0.494$	$y = 0.018x + 10.181$, $R^2 = 0.006$
Prosoma width vs total body length	$y = 0.328x + 5.063$, $R^2 = 0.249$	$y = 0.051x + 16.282$, $R^2 = 0.025$
Prosoma – opisthosoma hinge length vs total body length	$y = 0.103x + 3.692$, $R^2 = 0.362$	$y = 0.010x + 8.165$, $R^2 = 0.003$
Opisthosoma length vs total body length	$y = 0.115x + 2.677$, $R^2 = 0.297$	$y = 0.031x + 6.659$, $R^2 = 0.033$
Opisthosoma width vs total body length	$y = 0.174x + 3.943$, $R^2 = 0.356$	$y = 0.048x + 9.510$, $R^2 = 0.063$
Telson length vs total body length	$y = 0.698x – 5.281$, $R^2 = 0.890$	$y = 0.795x - 10.767$, $R^2 = 0.825$

Table 4. Regression relationship between various body parts of *C. routandicauda* of Bhitarakanika

	Male	Female
Prosoma length vs total body length	$y = 0.133x + 3.571$, $R^2 = 0.419$	$y = 0.118x + 4.628$, $R^2 = 0.257$
Prosoma width vs total body length	$y = 0.251x + 6.164$, $R^2 = 0.363$	$y = 0.299x + 4.966$, $R^2 = 0.473$
Prosoma – opisthosoma hinge length vs total body length	$y = 0.218x + 0.293$, $R^2 = 0.508$	$y = 0.134x + 2.905$, $R^2 = 0.434$
Opisthosoma length vs total body length	$y = 0.238x - 0.786$, $R^2 = 0.435$	$y = 0.370x - 4.841$, $R^2 = 0.508$
Opisthosoma width vs total body length	$y = 0.217x + 3.576$, $R^2 = 0.364$	$y = 0.144x + 5.933$, $R^2 = 0.512$
Telson length vs total body length	$y = 0.652x - 3.363$, $R^2 = 0.797$	$y = 0.512x + 0.012$, $R^2 = 0.584$

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