

Sex-ratio and size distribution of the sand crab, *Emerita* (Order: Decapoda; Family: Hippidae) from Thrikkunnappuzha beach of Alappuzha District, Kerala, India

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ABSTRACT

The sand crab, *Emerita*, play an important role in the nutrient cycling of marine ecosystems. The present paper describes sex ratio and size distribution of *Emerita* collected from the sandy shores of Thrikkunnappuzha, Alappuzha District of Kerala during December 2020 to March 2021. Among the 2925 specimens collected, females contributed 76% and males were 24%. The variation in the total length among males, non-ovigerous females and ovigerous females during the sampling period was found to be statistically significant ($P < 0.0001$). Sex distribution in relation to size, indicated that females were more pronounced in the larger sizes, supporting their protandric hermaphroditic behaviour.

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1. Introduction

Mole crabs of the genus *Emerita*, also known as sand crabs, with a barrel shaped body and tough endoskeleton, are the burrowing crustaceans in the wave-washed sandy beaches of temperate and tropical regions. They are particularly plentiful on beaches of loose sand, retreating with the outgoing tide and burrowing with extraordinary rapidity by means of their flat legs with sickle-shaped ends (Mahapatro *et al.*, 2017). They play many important roles in marine ecosystems, such as nutrient cycling, dispersion and burial of sediments, and secondary production. Some species of *Emerita* have bioluminescent property and help to track fluctuations linked by both environmental as well as human caused phenomena. Tides and the nature of the sea shore have an important role in the distribution of *Emerita*. Their sensitivity to environmental perturbations and pollution makes them a good indicator species for monitoring anthropogenic impact in the marine intertidal region (Wenner, 1988; Subramoniam and Gunamalai, 2003, Horn *et al.*, 2020) and also of coastal current fluctuations such as those seen during El Niño events (Sorte *et al.*, 2001).

Sand crabs are used by humans in a variety of ways. Occasionally *Emerita* is used as a diet and bait for surf fishermen. They were used in the laboratories for neurological studies due to the largest sensory neurons found in their tails (Paul and Paul, 1979) and were also used to isolate bioactive compounds for producing pharmaceutical drugs (Zin *et al.*, 2019). Another important role is that they can be used for monitoring oil spills (Bejarano and Michel, 2016).

The Genus *Emerita* was represented by eleven species across the world. In India, especially from the Kerala coast, there is no detailed study on their taxonomy and distribution, except some reports on their occurrence (Ansell *et al.*, 1972; Chandrasekhar *et al.* 2016; Mahapatro *et al.*, 2017). *Emerita* species that have been reported from India include *Emerita emeritus*, *Emerita asiatica* and *Emerita holthuisi* (Ansell *et al.*, 1972; Chandrasekhar *et al.* 2016; Samantaray *et al.* 2016; Mahapatro *et al.*, 2017).

This paper provides the sex ratio and size distribution of *Emerita*, collected from Thrikkunnappuzha coast on the south-west coast of Kerala, India.

2. Materials and Methods

2.1. Sample and data collection

The present study focused on the sex influenced size variations of *Emerita* (Fig.1) along the sandy beaches of Thrikkunnappuzha (9°10' - 9°20' N and 76°20' - 76°30' E). A total of 2925 *Emerita* specimens were collected during December 2020 to March 2021. Samplings were conducted by hand digging and also using shovel. For studying the distribution of the species, specimens available within a particular area were collected without focusing on its abundance. The specimens were brought to the laboratory in ice boxes and preserved for further analysis. Females can be distinguished from males by the presence of pleopods (Barnes and Wenner, 1968). Females included both ovigerous and non-ovigerous ones.

The total length (L_T) from the anterior tip of the carapace to the tip of the telson, carapace length (L_C) and total weight (W_T) of *Emerita* were measured. Length of the specimen was taken to the nearest millimeter using a measuring scale and the weight to the nearest milligram using an electronic digital weighing balance. The length-frequency analysis was conducted by categorizing *Emerita* in to different size groups of 10mm range and their percentage of occurrence in each group was assessed.

2.2. Statistical analysis

To understand whether any significant variation existed in the total length of the male, non-ovigerous female and ovigerous female of the sand crabs collected, one-way ANOVA was carried out using Graph pad PRISM software (version 5.01). The analysis was also carried out to assess the variation in the carapace length and weight among these three groups. The Tukey's multiple comparison post-test was carried out along with ANOVA test to understand

Table 1. Morphological measurements of *Emerita* collected from Thrikkunnappuzha beach from December 2020 to March 2021 (W_T : total weight; L_T : total length; L_C : carapace length; SD: Standard Deviation)

Sex	N	L_T (mm)		L_C (mm)		W_T (mg)	
		Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Male	704	10-32	18.53±3.30	4-23	9.085±1.860	30-890	207.571±111.322
Female	2221	7-67	30.61±8.79	2-37	14.534±4.322	50-6930	921.56±885.423
Total	2925	7-67	27.71±9.38	2-37	13.222±4.521	30-6930	749.716±831.506

the variation among each groups of *Emerita*. For better understanding of temporal changes in L_T , L_C and W_T of male, the one-way ANOVA was carried out based on the data of each month. The analysis was repeated for non-ovigerous females and ovigerous females also.

The Pearson's correlation was carried out between the total length and weight to understand the interrelationship. The analysis was carried out separately for males, non-ovigerous female and ovigerous females.

3. Results and Discussion

Emerita was found in colonies on the sandy intertidal region and were spotted when the waves pulled back. Of the 2925 specimens collected from December 2020 to March 2021, 2221 were females and among them 1449 were ovigerous. Morphological measurements of the specimens taken from this area were given in Table 1. Sex ratio (1 : 3.15) was skewed towards females (Fig.2). The ovigerous females possess comparatively larger size (W_T 1.072±0.959; L_T 32.699±8.261; L_C 15.414±4.115) than non-ovigerous females (W_T 0.639±0.638; L_T 26.694±8.406; L_C 12.882±4.218).

The variation in the total length among males, non-ovigerous females and ovigerous females along the total sampling period was found to be statistically significant ($P < 0.0001$) (Table 1). The pairwise comparison also exhibited significant difference among each groups ($P < 0.05$) (Table 2). Likewise, in case of carapace length and weight, the variation among these three groups were found to be statistically significant ($P < 0.0001$). The pairwise comparison for these two parameters also exhibited significant difference among each groups ($P < 0.05$) (Table 2). In case of the temporal changes in L_T , L_C and W_T of males, the result of the one-way ANOVA exhibited a significant

variation in all three parameters (Table 3). In case of non-ovigerous and ovigerous females also, the L_T , L_C and W_T were exhibited significant temporal variation. The relation between the L_T and W_T of males, non-ovigerous females and ovigerous females exhibited a significant positive correlation in all three groups of sand crabs ($P < 0.05$). However, the correlation coefficient was relatively higher in ovigerous females, followed by non-ovigerous females and males (Fig. 3).

Sex distribution in this species in relation to size indicated that females were more pronounced in the larger sizes, whereas, males dominated in the smaller size groups (Fig. 4). Barnes and Wenner (1968) suggested a protandric

**Fig. 1.** *Emerita emeritus* collected from the Thrikkunnappuzha coast**Table 2.** Output of the one-way ANOVA and the Tukey's Multiple Comparison post-test

Statistical test	P value
One way ANOVA (for total length)	$P < 0.0001$
<i>Tukey's Multiple Comparison Test</i>	
non-ovigerous female vs ovigerous female	$P < 0.05$
non- ovigerous female vs male	$P < 0.05$
ovigerous female vs male	$P < 0.05$
One way ANOVA (for carapace length)	$P < 0.0001$
<i>Tukey's Multiple Comparison Test</i>	
non- ovigerous female vs ovigerous female	$P < 0.05$
non- ovigerous female vs male	$P < 0.05$
ovigerous female vs male	$P < 0.05$
One way ANOVA (for weight)	$P < 0.0001$
<i>Tukey's Multiple Comparison Test</i>	
non- ovigerous female vs ovigerous female	$P < 0.05$
non- ovigerous female vs male	$P < 0.05$
ovigerous female vs male	$P < 0.05$

Table 3. Result of ANOVA to understand the temporal changes in total length, carapace length and weight of different groups of sand crabs.

One way ANOVA	P value
Male total length	$P < 0.0001$
Male carapace length	$P = 0.0068$
Male weight	$P < 0.0001$
Non- ovigerous female total length	$P = 0.0005$
Non- ovigerous female carapace length	$P = 0.0376$
Non- ovigerous female weight	$P < 0.0001$
Ovigerous female total length	$P < 0.0001$
Ovigerous female carapace length	$P < 0.0001$
Ovigerous female weight	$P < 0.0001$

hermaphroditic behaviour in these organisms because of the progressive seasonal increase in the percentage of females in the larger size groups, coupled with the relative absence of females in some of the smaller size classes. Subramoniam (1981) reported that in the growing stage neotenous male gradually loss its male functions and reverse their sex around 19 mm L_c . Present study also supports these findings. The beach morphodynamics also has a greater role in the distribution of these organisms (Barnes and Wenner, 1968; Dugan and Hubbard, 1996). Among the three *Emerita* species reported from India (Ansell *et al.*, 1972; Samantaray *et al.* 2016; Mahapatro *et al.*, 2017), two species *Emerita emeritus* and *Emerita holthuisi* were observed in this area.

Emerita could be used as a suitable indicator of coastal degradation and pollution. Changes in the nature of the shore also caused changes in the abundance of *Emerita* spp.

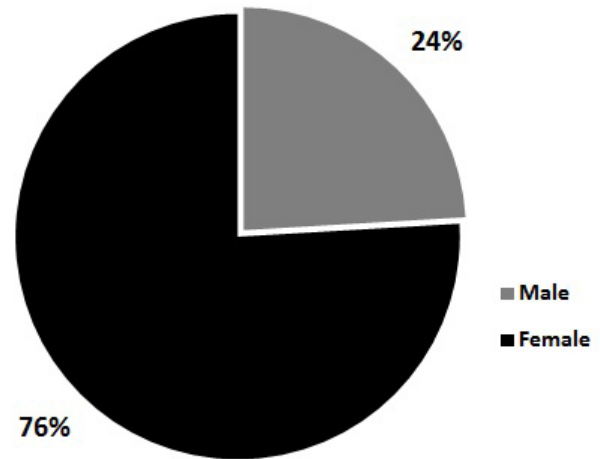


Fig. 2. Sex ratio of *Emerita* in the collections from Thrikkunnappuzha beach during December 2020- March 2021

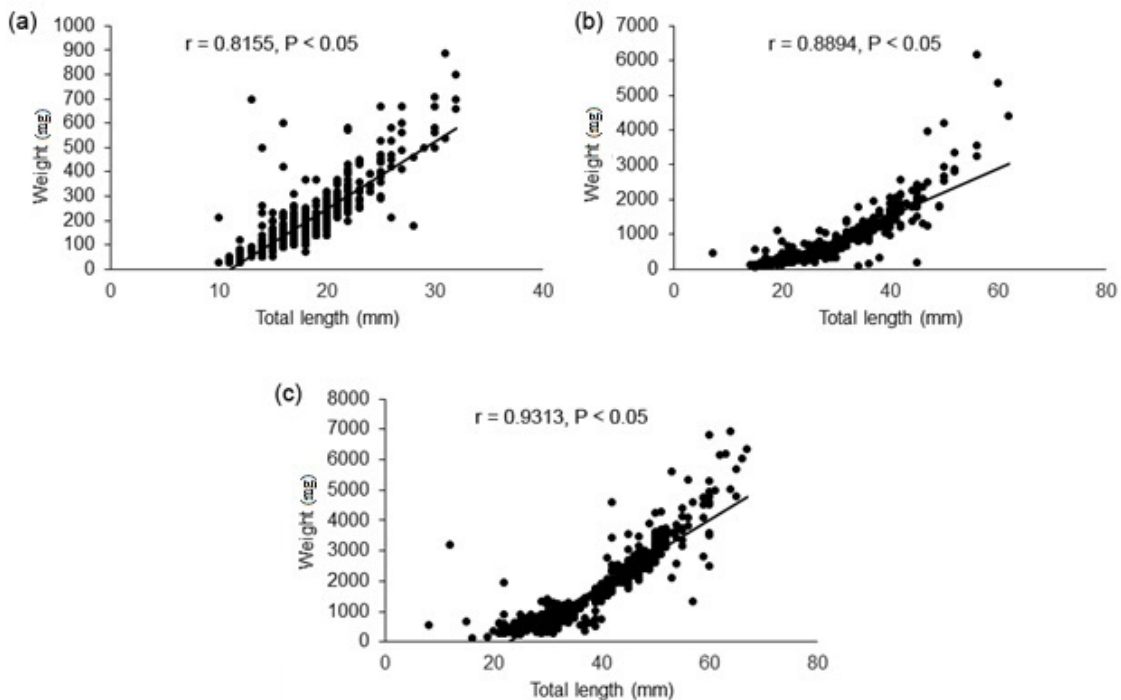


Fig. 3. The relation between total length (mm) and weight (mg) of (a) male, (b) non-berried female and (c) berried female

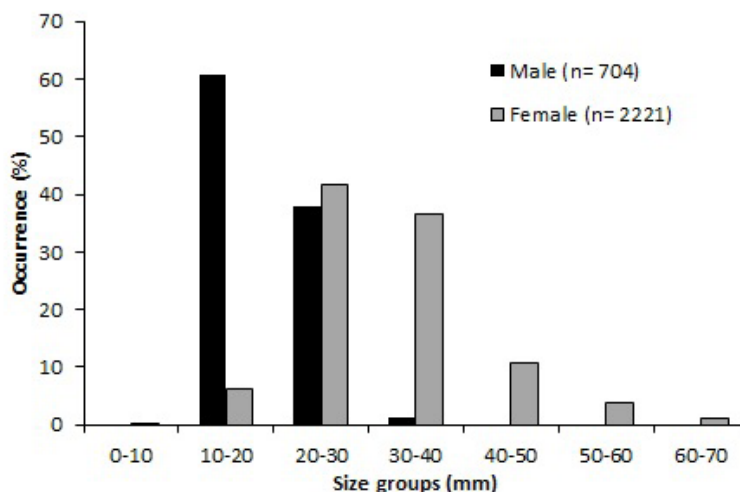


Fig. 4. Occurrence (%) of different size groups of male and female sand crabs in the collection

In the context of the alarming pollution of our beaches, present study conducted on the sex wise distribution of this macro benthic fauna assumes significant. As distributional records and species diversity of *Emerita* are less recorded from Indian beaches, extensive studies on the taxonomy and distribution of this particular group is required.

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