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Some aspects of reproductive biology in commercially important edible freshwater crab *Barytelphusa cunicularis* (Westwood, 1836)

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Abstract
The freshwater crab *Barytelphusa cunicularis* (Westwood, 1836) is one of the most common freshwater crabs in the state of Maharashtra. The crab inhabits seasonal freshwater bodies such as rivers, canals, streams, lakes, wells, dams, and other irrigation projects. The crab is edible and highly nutritious and a rich source of calcium. The crab is fished by local sellers and sold in large numbers in weekly markets in cities, towns and villages in Maharashtra. This paper provides baseline information regarding the breeding cycle *viz*., the colouration of gonads, gonadosomatic index, and breeding season of *B. cunicularis*. The result obtained shows that *B. cunicularis* breeds throughout the year. However, a high percentage of mature female crabs was seen in the months of June and July. The study of female gonads shows that the colouration of the ovary varies according to the maturation phase of the animal. The female crabs can be grouped into Immature females (ovary colour: white and translucent), Maturing females (ovary colour: yellowish), Matured females (ovary colour: dark yellow/orange), and, Ovigerous females (ovary colour: faint yellowish or brown). The ovarian index is highest during months of June and July indicating peak reproductive activity in this period. The male crab testis shows no colour change according to maturation phase, and they remain creamy white throughout the year. The male crabs breed throughout the year, however, the male crabs have higher gonadal index during June to September. This shows higher reproductive activity during June to September. Basic knowledge on season wise breeding behaviour and reproductive biology of the species could help in formulating strategies on captive reproduction and aquaculture production of edible freshwater crabs in India.

Keywords: freshwater crab, reproduction, breeding cycle, gonadal index

Introduction
Reproductive biology has a critical role in the population dynamics and life history strategies of freshwater crabs. In freshwater crab species of commercial importance, the knowledge of reproductive biology is highly useful for successful fisheries management. The freshwater crab *Barytelphusa cunicularis* (Westwood, 1836) [20] is commonly occurring freshwater crab in the state of Maharashtra. It is commonly found in rivers, ponds, lakes, wells, dams, etc. The *B. cunicularis* is an edible highly nutritious commercially important crab and sold in large numbers in weekly markets in cities, towns and villages in Maharashtra. They live in burrows, located on the embankments of small streams, canals, paddy fields, dams, lakes and rivers. This crab species coexists with other species *B. gueirini* (Westwood, 1836) [20] and *Cylindrotelphusa* sp. (Alcock, 1909).
Perusal of literature shows that numerous published records are available on population and reproductive biology of marine, intertidal and estuarine crabs (Pillay and Nair, 1971; Sukumaran and Neelakantan, 1996; Sallam, 2005; Henmi and Koga, 2009; Omolara, 2010) [16, 23, 18, 8, 14]. However, literature on the population and reproductive biology of freshwater, semiterrestrial or land crabs is scanty and insufficient (Liu and Jeng, 2007; Lara and Wehrtmann, 2009; Wehrtmann *et al*., 2010; Pathre and Patil, 2010; Sudha devi and Smija, 2013). This paper provides a baseline information regarding breeding cycle *viz*., colouration of gonads, gonadosomatic index, breeding season of *B. cunicularis*. Basic knowledge on reproductive biology of the species could help in formulating strategies on captive reproduction and aquaculture production of edible freshwater crabs in India.

Material and Methods
This work was carried out from January 2004 to December 2005 at the Research laboratory, Department of Zoology, Dr Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra, India as part of doctoral work. A brief description of the methodology employed is as follows:

1. ***Animal Maintenance:*** Specimens of *B. cunicularis* were obtained from Kham River near Aurangabad, Maharashtra, India. Crabs were maintained in aerated condition at 20°C. Animals of different carapace lengths were used for the experiment (in between 1 to 9 cm carapace length). They were fed with an earthworm. The water was changed daily. The specimens of *B. cunicularis* were selected without distinction of sex.

2. ***Breeding cycle:*** The *B. cunicularis* were collected twice a month from January 2004 to December 2005. The male and females were counted and recorded every time. The percentage of Immature, Maturing, and Matured males and females were calculated to study the breeding behaviour.
3. ***Gonad index:*** In the laboratory, the body weight of ten males and females was noted and the gonads of crabs were removed and blotted with filter paper. The colour of the ovary and testis were also noted and then transferred to a previously weighed aluminium foil pan. The wet weight of gonads was recorded and the gonadal index in males and females was calculated by the following formula (Anderson and Gutreuter, 1983) [2]: *Gonad index* = [(*Weight of gonad ÷ Weight of animal) × 100*]

Results and discussion

***Breeding cycle*:** The breeding cycle can be observed by observing coloration of the ovaries. The female crabs with dark yellow (Fig 1B) or orange ovaries are mature females as shown earlier (Sherkhane, 2007). On the basis of colouration of the ovary, the maturation stages of the crab, *B. cunicularis* are given in Table 1.

Table 1: Maturation stages of ovary in crab *B. cunicularis.*

Sr. No.	Maturation phase of the ovary	Coloration of the ovary
1.	Immature crab	White and translucent
2.	Maturing crab	Yellowish
3.	Matured crab	Dark yellow or orange
4.	Ovigerous crab	Faint yellowish or brown

The observations revealed that the reproducing males and females were found throughout the year which indicated possibility of breeding all year round. The high percentage of mature female crabs was seen in the months of June and July.

In June 2004, the percentage of matured females was 55% and it was 56% in June 2005. In July 2004, the matured female observed at 67% and 66% in July 2005.

The maximum percentage of immature female crabs was found in the month of January. The females with spent ovary were found in the month of November. In November 2004 and 2005 the percentage of spent females was 55% and 54% respectively.

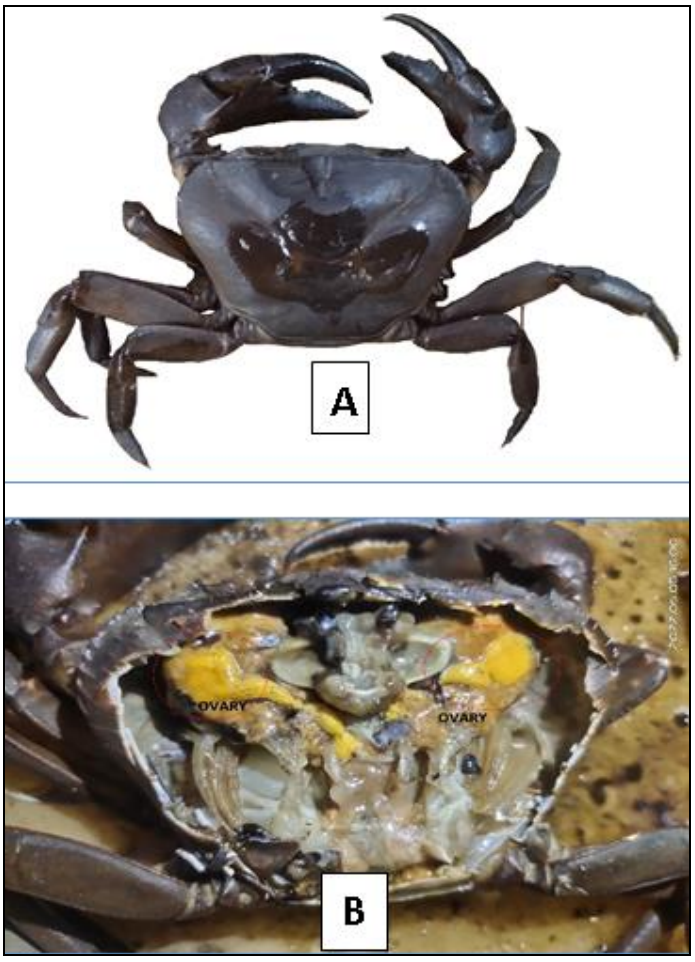


Fig 1: A: *Barytelphusa cunicularis* specimen (top). B: The crab specimen dissected open to showing yellow colored ovaries (bottom)

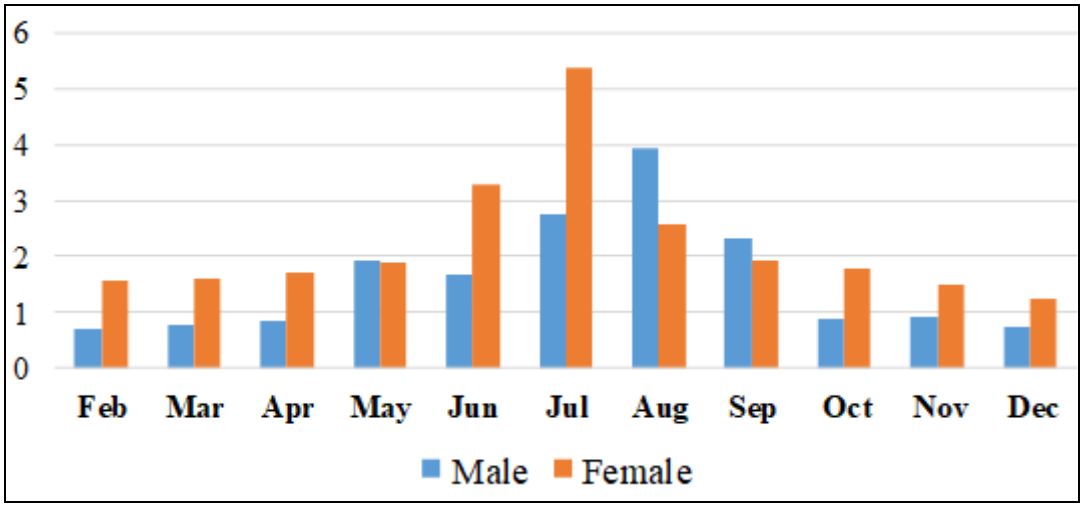
The observation of male gonads showed that the peak percentage of mature males was recorded in the months of July and August, whereas the peak percentage of immature males was found in the month of January. Comparatively higher values of gonadal indices were observed from June to September for both male and female crabs. This indicates peak maturity of gonads and high breeding activity from June to September of the year.

The ovary of *B. cunicularis* like other decapods goes through changes in size and colour during its initial development to maturity and in succeeding cycles of vitellogenesis and oviposition. Developmental changes in ovary have been assigned by different authors on the basis of oocyte size, ovary size and colour (Byard, 1975; Chang, 1993) [3, 5].

On the basis of colouration of the ovary, the maturation phases of crab, *B. cunicularis* are as follows: Immature females (ovary colour: white and translucent), Maturing females (ovary colour: yellowish), Matured females (ovary colour: dark yellow/orange), and, Ovigerous females (ovary colour: faint yellowish or brown) (Table-1; Graph-1).

Table 2: Month wise changes in the colour of gonads and gonadal index in crab *B. cunicularis.*

Sr. No.	Months	Colour of the testis	Colour of the ovary	Testicular index		Ovarian index	
				2004	2005	2004	2005
1.	January	Creamy white	White/pale yellow	0.562±0.075	0.642±0.042	0.759±0.042	0.752±0.029
2.	February	Creamy white	Yellowish white	0.698±0.062	0.624±0.036	1.572±0.570	1.642±0.059
3.	March	Creamy white	Pale yellow	0.782±0.071	0.971±0.040	1.586±0.042	1.476±0.012
4.	April	Creamy white	Yellow	0.846±0.056	1.740±0.016	1.692±0.054	3.507±0.046
5.	May	Creamy white	Dark yellow	1.926±0.019	1.928±0.019	1.876±0.078	4.670±0.078
6.	June	Creamy white	Dark yellow/orange	1.672± 0.079	2.512± 0.029	3.287± 0.059	5.264± 0.054
7.	July	Creamy white	Dark yellow/orange	2.742± 0.056	3.714± 0.032	5.372± 0.082	5.890± 0.025
8.	August	Creamy white	Yellowish red	3.949± 0.072	4.168± 0.048	2.586± 0.072	3.023± 0.050
9.	September	Creamy white	Yellowish brown	2.336± 0.052	2.684± 0.028	1.926± 0.046	2.720± 0.042
10.	October	Creamy white	Pale yellow	0.869±0.073	0.932±0.043	1.789±0.729	1.762±0.054
11.	November	Creamy white	White/pale yellow	0.921±0.096	1.246±0.036	1.486±0.026	1.472±0.032
12.	December	Creamy white	White/pale yellow	0.748±0.042	0.928±0.042	1.242±0.044	1.592±0.054



Graph 1: Seasonal variations in the gonadal indices of male and female crabs during year 2004.

The male crab testis shows no colour change according to maturation phase, and they remain creamy white throughout the year. The histological details of the testis have been dealt with and showed that consists of several testicular lobules, also known as seminiferous tubules or testicular acini (Sherkhane *et al*, 2010) [20]. The male

crabs breed throughout year, however, the male crabs have higher gonadal index during June to September. This shows higher reproductive activity during June to September (Table-2; Graph-1). The breeding process in freshwater as well as marine water crustaceans show definite patterns. The reproductive cycle in crustacean studied by many workers (Chandran, 1968; Mirajkar *et al*., 1982; Liu and Li, 2000; Metin and Aydin, 2017) [4, 13, 11, 12]. Chandran (1968) [4] observed breeding cycle in *Charylodis veriegata* and *Scylla serrata* and found that these crabs are biannual breeder. The crustaceans *Mewtapenaeus affinis (Metin and Aydin, 2017) [12], Macrobrachium kistnensis* (Mirajkar *et al*., 1982) [13] are biannual breeders. The freshwater crab, *Candidiopotoman rathbunal* is annual breeder (Liu and Li, 2000) [11].

***Gonadal index*:** Gonadal index is a function of breeding cycle in marine and estuarian crustaceans. The gonadal index has been widely used as a measure of reproductive phase in many groups of crustaceans. The relation between gonad size and body weight and gonad development during a year has already been established in crustaceans by several investigators (Liu and Jeng, 2007; Lara and Wehrtmann, 2009; Wehrtmann *et al*., 2010; Pathre and Patil, 2010; Sudha and Smija, 2013) [10, 9, 25, 20, 22]. Studies on control of reproduction in crustaceans showed that the reproductive activities are neuroregulated by hormones from CNS. Eyestalk neuropeptide such as gonad-stimulating hormone (GIH) apparently act on female ovaries (Charniaux-Cotton and Payen, 1988; Quackenbush, 1991; Fingerman, 1987) [6, 17, 7]. whereas in males its action on the testes appears to be indirect via a direct effect on the androgenic gland.

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