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Relationship between biometric parameters and fecundity of crab *Potamon koolooense* (Rathbun, 1904) from hillstream Khoh of Uttarakhand, India

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Abstract
The present study was carried out to determine the relationship between biometric parameters and fecundity of *Potamon koolooense* (*P. koolooense*), a freshwater crab inhabiting the hillstream Khoh of Uttarakhand. A total of 90 female crab samples were taken from a local fisherman for data analysis during January 2015 to December 2015. Out of them, 42 were ovigerous and 48 were non-ovigerous female. Fecundity ranged from 124 eggs for crab of carapace width 3.3 cm, carapace length 2.5 cm, abdominal width 1.3 cm and total weight 17.7 gm to 375 eggs for crab of carapace width 4.7cm, carapace length 3.5 cm, abdominal width 2.3 cm and total weight 43.8 gm. Highly positive significant relationship was found between fecundity (F) and carapace width (CW): $R^2 = 0.955$, $p<0.01$, n = 42, carapace length (CL): $R^2 = 0.673$, $p<0.01$, n = 42, abdominal width (AW): $R^2 = 0.867$, $p<0.01$, n = 42 and total weight (TW): $R^2 = 0.915$, $p<0.01$, n = 42. Carapace width is best correlated with fecundity among all the biometric parameters. Data of frequency of occurrence of ovigerous and non-ovigerous female suggests that the species spawns from the end of February to mid-July.

Keywords: Crustacea, Morphometry, Egg count, Regression analysis, Khoh

1. Introduction
Crustacean shows a great diversity of embryonic development especially owing to a significant variation in egg size. In freshwater crabs, female incubate their eggs which remain attached to the pleopods that are beneath the abdomen from spawning to hatching (Wehrtmann *et al.,* 2010) [1]. They show direct development and maternal care of a small number of offspring, in contrast to marine crabs which release thousands of planktonic larvae. This reproductive strategy of direct development is common in all families of true freshwater crabs (Cumberlidge and Ng, 2009) [2]. According to Hines (1982, 1991) [3, 4], a lack of relationship between body size and fecundity may have several causes, such as individual variation in egg production, seasonal food availability and multiple spawning, in addition to natural egg loss.
Reproduction is the main mechanism to maintain species proliferation and continuity. In brachyuran crabs, reproduction is extremely diversified leading to maximum egg production and offspring survivorship (Magalhães *et al.,* 2006; Yeo *et al.,* 2008) [5, 6]. Fecundity in crustaceans is generally defined as the number of eggs produced by a female during a particular spawning season. Among the Brachyura, there is considerable variation in fecundity often varying as a function of female body size (Hines, 1988) [7]. Fecundity is an important population parameter for species of commercial value as it allows to estimate the reproductive potential of the species (Mantelatto and Fransozo, 1997; Dumont and D'Incao, 2004) [8, 9].
P. koolooense, a freshwater crab inhabiting the hill streams of Uttarakhand, prefers the slow moving and shallow water habitats occurring under the roots of aquatic plants, submerged rocks and among fissures or occasionally out of the water preferably in night time but always in the close vicinity of the water source. It attains the size ranging from 1.5 cm to 6.2 cm in terms of carapace width for both male and female in their natural habitats. Studies on various aspects such as morphometric analysis, growth pattern, structure and seasonal changes in ovaries of the same species were accomplished by Singh *et al.* (2013) [10]; Rana *et al.* (2014) [11]; Joshi and Khanna (1982) [12] respectively but information on fecundity is still lacking. In this study, we have tried to evaluate the existence of a relationship between fecundity and biometric parameters such as carapace width, carapace length, abdominal width and the total weight of *P. koolooense* from hillstream Khoh of Uttarakhand.

2. Materials and Methods

The study was carried out along the hillstream Khoh, a tributary of Ganga river in district Pauri Garhwal, Uttarakhand, India that lies between 25º 45′ to 30º 15′ Latitude North and 78º 24′ to 79º 23′ Longitude East. Sampling was always taken on a monthly basis during the day time in 50 m stretch along the length of the stream for two hours from the selected sites during January 2015 to December 2015. Samples of *P. koolooense* were collected from local fishermen who have collected them by turning out the roots of marginal plants, under the stones and from the sandy bottom of the stream. Samples were transported to the Fish Biology and Aquaculture Unit, Department of Zoology and Biotechnology, H.N.B. Garhwal University. Biometric parameters such as carapace width (CW), carapace length (CL), abdominal width (AW) were measured by using Vernier calliper to the nearest 0.1 cm and total weight by using electronic weighing balance (Anamed, M × 7000 Series) to the nearest 0.1 gm. To estimate fecundity, egg mass from pleopods of each female were removed with the help of soft hair brush and were placed in petri-dishes filled with water, eggs were separated them from egg mass by gentle stirring on adding a solution of sodium hypochlorite solution gradually and counted manually. Fecundity was estimated as the method is given by Rodriguez *et al.* (1997) [13]. Statistical analysis was performed in MS Excel 2007 to obtain the relationship between biometric parameters and fecundity of *P. koolooense*.

3. Results and Discussion

Biometric parameters and their relationship studies of an animal are important in several respects such as to have a full understanding of its biology and population dynamics. In the present investigation, it was observed that *P. koolooense* spawned once in a year because ovigerous females were collected at a particular time i.e. during March, April, May, June and July. This suggests that the species is an annual breeder and breeds with the onset of the monsoon season. Of the collected 90 females, 42 were ovigerous and 48 were non-ovigerous. Maximum number 14 of ovigerous and 11 of non-ovigerous female was found in the month of April and September respectively (Fig. 1). Brachyuran crabs inhabiting tropical waters usually breed throughout the year, whereas those found in temperate waters breeds only in certain months (Saradha, 1998) [14]. It is generally suggested that near the tropics, reproduction occurs throughout the year because environmental conditions are generally favourable for gonadal development (Emmerson, 1994) [15].

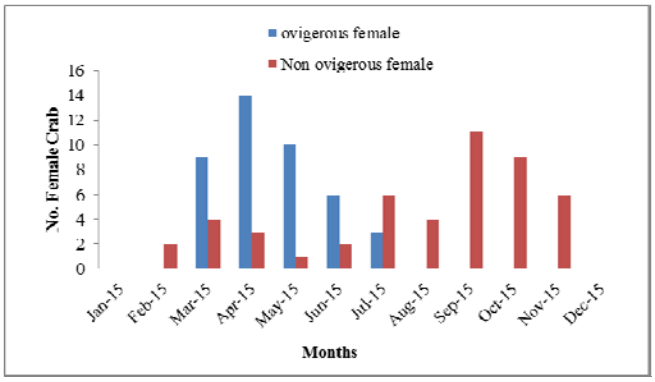

Fig 1: Frequency of occurrence of ovigerous and non-ovigerous female of *P.koolooense*

Fecundity is calculated as the number of eggs carried externally by the female (Kumar *et al.*, 2003) [16]. Fecundity of crabs varies from species to species and also varies within the same species due to different factors such as age, size, nourishment, ecological conditions of the water body (Hines, 1982; Turra and Leite, 2001) [2, 17]. In the present study fecundity ranged from 124 eggs for crab of carapace width 3.3 cm, carapace length 2.5 cm, abdominal width 1.3 cm and total weight 17.7 gm to 375 eggs for crab of carapace width 4.7cm, carapace length 3.5 cm, abdominal with 2.3 cm and total weight 43.8 gm. Relatively low fecundity was observed in *P. koolooense* which is in agreement with the observation of Dobson (2004) [18] as they have reported that the broods of freshwater crabs comprise only a few hundred eggs (compared to hundreds of thousands of marine crabs) each of which is quite large, at a diameter of around 1 mm (0.04 inch). Similar low fecundity was also recorded by Liu and Li (2000) [19] in freshwater crab *Candidopotamon rathbunae* where the number of eggs present in brooding females varied from 9 to 117 and only a few crabs had more than 100 eggs. Micheli *et al.* (1990) [20] have also recorded fecundity in *Potamon fluviatile* which ranged from 55 to 157 eggs. Fecundity increases linearly with increase in the biometric parameters of the animal. Recently, Arshad *et al.* (2006) [21] in blue swimming crab, *P. pelagicus* had stated that number of eggs increases linearly with the increase in carapace length, carapace width, body weight and weight of oviposition.

In crabs, studies on the relationship between the morphological features and fecundity are scanty. In general, the fecundity of decapod crustaceans is evaluated as the number of eggs or weight of eggs produced by a female in a single egg batch (Batch fecundity) and is positively correlated with body size (or) weight of females. It is also significantly related to the female crab's carapace width (Erdman and Blake, 1988) [22]. During the present investigation, a significant (p<0.01) positive linear relationship with high $R^2 = 0.955$ was observed between carapace width and fecundity (Fig. 2). The regression equation for fecundity and carapace width was $F = -479.1CW^{176.6}$. A similar relationship was observed between carapace width and fecundity by Koolkalya *et al.* (2006) [23] in *Scylla olivacea* and Tallack (2007) [24] in *Cancer pagurus.* Tallack (2007) [24] has also reported a non-significant positive correlation between fecundity and carapace width in *Necora puber*. The positive significant linear relationship between carapace length and fecundity was observed as $F = -211.3CL^{128.8}$ ($R^2 = 0.673$, p<0.01) (Fig. 3). A similar relationship between carapace length and fecundity was observed in *Lithodes aequispina* (Jewett *et al.*, 1985) [25] and *Platyxanthus patagonicus* (Carsen *et al.*, 1996) [26].

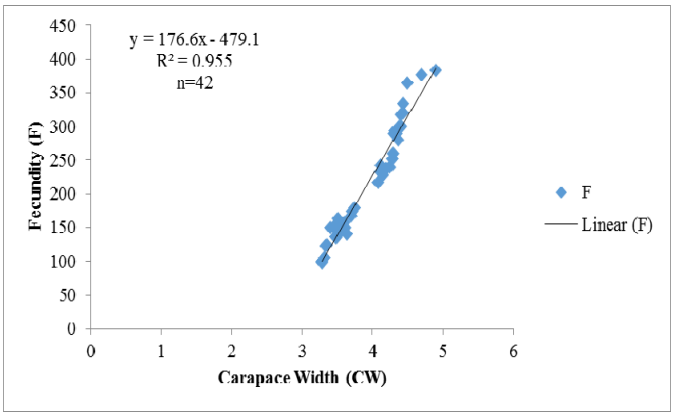

Fig 2: Linear relationship between carapace width and fecundity of *P. koolooense*

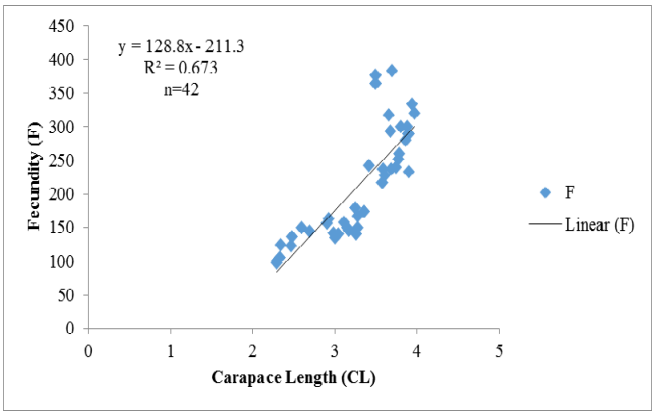

Fig 3: Linear relationship between carapace length and fecundity of *P. Koolooense*

Fecundity showed the significant positive linear relationship with abdominal width and fecundity. This could be expressed as $F = - 134.6\ AW^{194.1}$ ($R^2 = 0.867$, $p<0.01$) (Fig. 4). Our results are in agreement with the findings of Mantelatto and Fransozo (1997) [8] as they have reported that the fecundity of *Callinectes ornatus* increased with an increase in abdomen width and carapace width. Higher fecundity was observed for an animal with a larger abdomen in the present study. This is in agreement with Fransozo *et al.* (2002) [27] as they have suggested that the changes in the abdomen width of female *Ocypode quadrata* are related to the capacity of the female to incubate the egg mass. Estimated relationship between total body weight and fecundity was also found positively significant at ($p<0.01$) and linear with high $R^2 = 0.915$ and was represented as $F = - 37.01\ TW^{8.721}$ (Fig. 5). Similar positive correlation between total body weight and fecundity with high r^2 value (0.908) was reported by Haddon (1994) [28] in *Ovalipes catharus.* Raghunath *et al*. (2008) [29] has also observed a positive correlation between total body weight and fecundity in crab *Portunus pelagicus*. Sharma and Subba (2005) [30] on the freshwater prawn *Macrobrachium lamareii* also showed a positive relationship between body weight and fecundity, but with low r-squared.

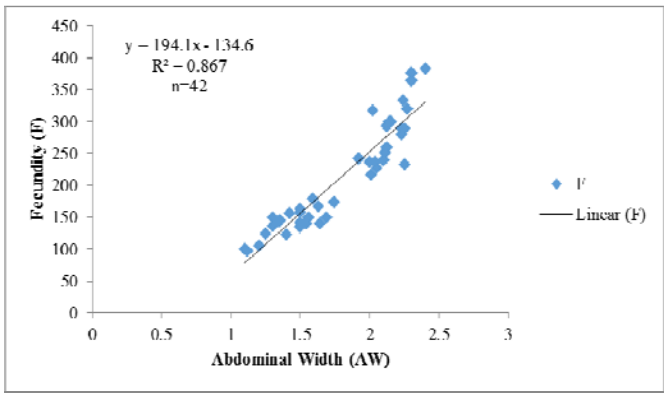

Fig 4: Linear relationship between abdominal width and fecundity of *P. koolooense*

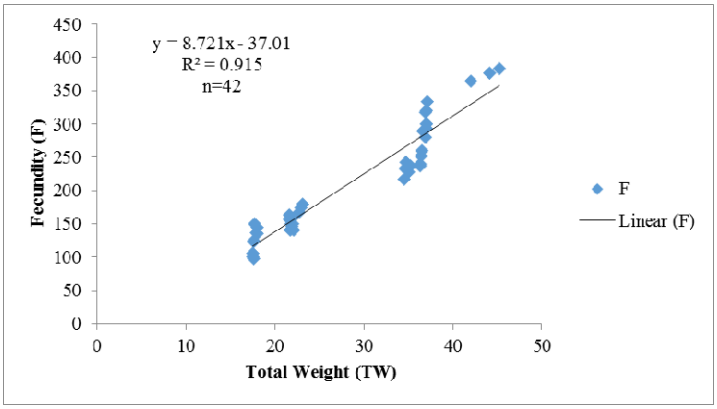

Fig 5: Linear relationship between total weight and fecundity of *P. koolooense*

The results of the present study revealed the positive relationships between biometric parameters and fecundity of *P. Koolooense* which are highly significant at $P<0.01$ and linear but the degree of relationship varied considerably. Among them carapace width with high $R^2 = 0.955$ value was found to be the most suitable characteristic for predicting fecundity. The present study would provide insights in the understanding of the reproductive potential of the studied species and will hopefully stimulate more studies on the ecology and biology of the species.

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