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Analysis of Adaptive Ecological Factors for Quantification of Environmental Thresholds in Fresh Water Crab *Barytelphusaguerini* in the Tributaries of Godavari River in Maharashtra, India

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Abstract

Freshwater crabs constitute one of the largest groups of invertebrates. They areecologically as well as economically important owing to their role in nutrient recycling, water quality monitoring and small-scale fisheries. The organisms colonize the habitat according to the physical space required for survival and being that in heterogeneous environments, the organism is susceptible to many biotic and abiotic stresses. The present investigation deals with the study of analysis of adaptive ecological factors like dissolved oxygen, turbidity, salinity of water samples and also study about desiccation salinity gradients caused by mainly variation in precipitation and human activity in the Godavari river basin which leads to depriving the shelter of the crab species. In order to study the population of the *Barytelphusaguerini* factors such as reproductive cycle, adaption to environmental stress, population structure, sex ratio, abundance etc.

Keywords:*Barytelphusaguerini,* Ecology, Dissolved Oxygen, Turbidity, Shelter, Salinity, Desiccation.

Introduction

Freshwater crabs constitute one of the largest groups of invertebrates occupying the Indian peninsula waters. They have recorded their presence in nearly all freshwater habitats ranging from streams emerging from mountains or highland to large rivers along with all water bodies in the land. They areecologically as well as economically important owing to their role in nutrient recycling, water quality monitoring and small-scale fisheries. Nearly 1280 species belonging to 4 super families occurs throughout the world which accounts 20% of identified brachyuran diversity.

In the Godavari river and its tributaries, it is possible to observe desiccation and gradients of dissolved solids including the salts caused by pouring of rains. The climatic condition prevalent in this region rainfall varies between 1100 mm to 1500 mm and here three climatic seasons are

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well defined. Gangotri *et al.*, (1978) found that the composition and abundance of river fauna is observed to have variation between river and tributaries. Barde et al. (2021)suggested that the preference of crab species for river habitat is related to only with benefits of abiotic factors.

The highest abundance of *Barytelphusaguerini* in the river was accompanied by larger body size, broad carapace length etc. which may be associated with aggregation and consequent competition for resources. So far, no investigations have been carried out on *Barytelphusaguerini* which is abundant in Nanded and Parbhani districts of Marathwada, Maharashtra.

The organisms colonize the habitat according to the physical space required for survival and being that in heterogeneous environments, the organism is susceptible to many biotic and abiotic stresses. It is possible to observe desiccation and salinity gradients caused by mainly variation in precipitation and human activity. For understanding the river and bank system it is important to understand the dynamics of populations of which the distribution is regulated by various factors. This highly heterogeneous environment supports a high diversity of species, mostly invertebrates adapted to withstand local environmental conditions. In order to study the population of the *Barytelphusaguerini* factors such as reproductive cycle, adaption to environmental stress, population structure, sex ratio, abundance etc.

Freshwater crabs inhabit freshwater bodies like rives, ponds, swamps and paddy fields. Some of the freshwater crabs are favorite delicacies among consumers. A study was conducted in districts of Maharashtra namely Thane, Ratnagiri, Sindhudurga, and Kolhapur with a view to gathering information on availability, marketing strategy adopted and preference in the consumption of edible freshwater crabs in the said districts. As part of this endeavor, a study was mainly carried out on the freshwater crabs *Barytelphusacunicularis*, the result of which is reported in this contribution. The studyrevealed in the five freshwater crabs are available in the consumption of edible freshwater in the five districts of Maharashtra and are preferred by people of these districts for consumption. Among all the districts these crabs are abundantly available in Kolhapur district in which there is a well-established market, for them, in contrast to the position in the districts of Konkan region. However, a detailed taxonomic study is required to be carried out for the different edible freshwater crab's species available in Maharashtra so as to gather the information on all such crabs in the state (Barde *et al.*, 2020).

Crabs are adapted to freshwater, semi-terrestrial and terrestrial mode of life with an ability to complete their life cycle independent of marine environment. They are mainly found in streams,

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rivers, pools, ponds, swamps, paddy fields, rock holes or pits, tree trunk holes and leaf axils etc. They are generally active during night time and prefer hidden places for shelter. Freshwater crabs prefer live or dead animals as food. They are the chief source of food for fishes, turtles, birds and mammals. Freshwater crabs also serve as a cheap and important source of protein to human beings particularly tribal and poor peoples. Some crabs are commercially viable as aquarium or aquaculture species besides having some medical importance (Cumberlidge*et al.*, 2009). Many of the freshwater crabs are excellent indicators of good water quality (Yeo *et al.*, 2008). Freshwater crabs are highly endemic due to their limited dispersal ability, low fecundity and selected habitat preference (Pati& Sharma, 2012).Hence the present study was undertaken to investigate some aspects of ecological factors to determine the environmental thresholds for survival offresh water crab *Barytelphusaguerini*.

MATERIAL AND METHODS

The study area: The study was conducted across the Godavari river basin and its tributaries in Marathwada, Maharashtra State, India.Survey was carried out along the sides of river basin and its tributary.

Sampling the data: At each site, location sampled from both river and tributary, the soil temperature, air temperature and temperature nearest water source, salinity were recorded. In each site, location stratum of both river and tributary, the sediment samples were also collected. The substrate was collected monthly kept in refrigerator till analysis of organic matter content in the laboratory. The samples of sediment from each site were analyzed separately. The sample of 10 grams separated for analysis of the percentage of organic matter and the remainder used for particle size analysis.

For the organic matter content, the samples were dried for 1 hour at room temperature and then were placed in a porcelain crucible and transferred to muffle furnace for 1 hour. Each sample was again weighed and the difference in the earlier and later weight (ash free weight) was determined. The organic matter content of the substrate in grams, which was subsequently converted to a percentage (Mantelatto and Fransozo, 1999).

Determination of turbidity: The turbidity of the water with the samples of substrate was measured by Turbidity meter / NephlometerElico model CL 52 D. The turbidity was recordedas NTU, where the units of turbidity from a calibrated Nephelometer are called Nephelometric Turbidity Units (NTU) with 0.1 as clear water and 1.0 as most turbid

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Analysis of dissolved oxygen in water: Dissolved oxygen (DO) is expressed as milligrams of oxygen gas (O2) dissolved in one litre of water (i.e. mg/L). The amount of DO in a waterbody at a specified temperature and salinity (% saturation) gives the maximum values of DO. The DO was determined by DO sensors with temperature and salinity compensation for DO saturation value calculations (DES, 2018).

Factors Affecting Distribution: Oxygen: The experiments were set up to study the response of the crab to the range of oxygen. Ten crabs were kept into a container of clean water approximately 20 cm. deep. A lid of plastic screen was, cover was provide at the bottom of the container, while another plastic screen was balanced so that it extended from the base of the container to above the water surface. The crabs were able to ascend the slanting screen and were then left uninterrupted for four hours. The crabs during this time with chiefly depleted the dissolved oxygen in the water moved for oxygen. The crabs during this time remained at the base of the container under the cover. After this time, the crabs began to ascend and counts were made of crabs appearing the water surface at small gaps (Willason, 1981).

Factors Affecting Distribution: Settlement: Crabs were examined from all the locations form the area of counting of population. The crabs were segregated into two size groups -less than 7 mm wide (juveniles), and greater than 7 mm. The collection of the smallest sizes was incomplete due to the little variation among the adults and juveniles. The young crabs when exposed at one were motionless whereas the adults usually moved. Since these small crabs are similar in size, shape, and colour to the larger particles of the substrate, this behavior makes them very difficult to locate (Willason, 1981).

Factors Affecting Distribution: Competition For Cover: The experiment for competition for cover was deigned similar to the experiments on oxygen, with the provision of cover. It appeared that crabswere strongly attracted to cover. A plastic screen of small size with dimensions of nearly 15cm X 15 cm was placed in a tank. The screen was elevated with support up to 3 cm. This was only provision of cover made available to the crabs in the tank. The level of water was maintained to a depth of 5 cm and crabs released in the tank. The observations of the number of crabs not under cover were recorded in morning for continuously 10 days (Willason, 1981).

Factors Affecting Distribution: Salinity: The gradients of salinity possibly could affect the distribution of the crab across the river and tributaries. In a tank, 50 crabs were placed and water

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of different salinity similar to the level in the river was maintained for six days and maintained till approximately 50% mortality occurred (Willason, 1981).

Factors Affecting Distribution: Desiccation : The effect of desiccation was tested by keeping crabs with similar size in dry plastic laboratory tray and the time to death was recorded. The crabs were accepted as lifeless as there was no movement or response to any stimulus (Willason, 1981).

Factors Affecting Abundance: The study to determine the factors affecting the survival of crabs in a given location, observations were recorded and analyzed. The crabs were measured to be ecologically comparable where the total numbers of the crabs present is regarded as the abundance. It was understood that the number of crabs in the given location is quantity of the bearing capacity of the area that was sufficient for juveniles for settlement in a year to saturate the area.

A multiple regression analysis was performed with crab number present in each area/ location along the rivers against all variables studied during the study. The variables taken were dissolved oxygen (DO), the turbidity (T),the shelter (S), salinity (N) and desiccation (D) (Willason, 1981).

Data analysis: The data was subjected to statistical tests and based on the data analysis the conclusions were drawn (Zar, 2010).

RESULT AND DISCUSSION

A series of experiments were conducted to investigate the ability of organism to survive in situ with the prevalent condition.Experiments were carried out to examine the capability of the crab to sense and respond to grades of oxygen tension. Experiments were also carried out to assess the ability of the crab to survive in low oxygen tensions. The suspension of silt/mud affected the viability of the crabs in the existence of low oxygen tensions. The low oxygen tensions could build up usually in the habitat of the crabs to affect viability of the crab sharing the habitat. Experiments were also carried out to identify the ability to get cover. Experiments were performed to the preferences for types of substrate by the crabs.

A number of locations were inspected to identify the variations between river and tributaries that were inhabited and dominated by crab. Attempts were made to establish whether the crabs dominated the banks of rivers could be due to differential settlement. The effects of salinity and desiccation on the crabs were observed in a experiments on mortality tests. The consequences of

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different environmental factors on the abundance of the crabs were tested by multiple regression analysis on factors measured or estimated during censuses of the crabs.

Effect of Dissolved Oxygen and Turbidity of Water Samples on Crab Survival:

Twenty-two locations were identified as being dominated by the crab distributed over the river of Godavari and it tributaries in Parbhani and Nanded district. The crabs occupying the area along the banks of the rivers and tributaries were marked.The laboratory experiments conducted to assess the reducing power of the sample of substrate generally the day after collecting it. This was carried out by keeping the samples of substrate into one-liter flasks and filling the flasks with clean, aerated river water and corking the flasks to exclude all bubbles. One flask was kept as the control. Analysis of the dissolved oxygen present in the water after addition and another on each flask after one hour was carried out. The difference in the initial and final value was considered as the reducing power.

Table 1: The amount of DO and turbidity of the water samples collected from differentlocation of Godavari river and its tributary

Location	River		Tributary	
	Turbidity	DO	Turbidity	DO
1	0.4	17.5	0.4	16
2	0.6	23.5	0.6	24
3	0.9	35.5	0.9	37
4	1.0	51	1.0	48
5	1.0	45.5	1.0	48.5
6	1.0	47	1.0	48.5
7	1.0	52.5	1.0	50.5
8	1.0	52	1.0	52.5
9	0.8	30.5	0.7	29.5
10	0.9	34	0.9	35
11	0.8	31.5	0.8	31

It was recorded that turbid water possesses elevated reducing power whereas clear water was liable to have small quantity of oxygen eliminated by the sample rapidly (Table 1). The crabs dominating the surveys sample were categorized by the reducing power of substrate samples. The measurement of reducing power is expressed as depletion of oxygen tension (in ppm) from one liter of water in the flask in one hour. Turbidity was recorded by a Turbidity meter / NephlometerElico model CL 52 D.

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Effect of Dissolved Oxygen on crab distribution and survival:

Experiments were conducted to examine the response of the crab towards oxygen gradients and determining the ability to sense and counteract to these gradients.

Ten crabs were transferred into a bucket of containing clean river water with a depth of 21 cm. A rough glass sheet was kept in the bottom of the bucket in a slanting position up to the surface of water. The crabs climbed this slanting sheet and were kept undisturbed for four hours. With increase in time there was depletion of dissolved oxygen in the water. The crabs initially remained at the base of the bucket, after four hours the crabs started climbing. The attempts of crabs reaching the surface at short intervals were counted (Table 2).

The numbers of the counts of crabs reaching the surface of the water per hour were recorded. The depletion of oxygen by the respiration of the crabs leads to oxygen deficit. Ten crabs were kept in a bucket containing 21 cm depth of water and cover in the form of a piece of glass sheet at the bucket base.

Table 2: The effect of DO gradient of the water samples on the crab

Time in Hours	Number of Counts Made	Total	Average
0	0	0	0
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	10	30	3.0
6	12	72	6.0
7	11	89	8.0
8	10	78	7.8
Total	43	269	

It is clear from the table that the crab displays a more inclination to climb and expose to option of climbing to escape from low oxygen or were confined under cover in the region of low oxygen.

Effect of Low Dissolved Oxygen Gradient on Crab Distribution and Survival:

Experiments were also conducted to counts the number of crabs reaching the surface of the water per hour. The oxygen was removed by passing nitrogen gas by bubbling in water. The crabs were kept in the bucket with glass sheet at the bottom, and 21 cm depth of water and 20 crabs were kept in the bucket.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 3160 - 3173
Received 25 April 2021; Accepted 08 May 2021.

Table 3: The effect of DO removal from the water samples on the crab

Hour	Number of Counts made	Total	Average
1	4	2	0.5
2	4	18	4.5
3	4	40	10
4	4	54	13.5
5	4	72	18
6	4	84	21
7	4	90	22.5
8	4	78	19.5
Total	32	438	

Number of dead crabs after 8 hours = 2

The crab shows a better affinity to bare itself when confronted with the option of responding to oxygen gradient by climbing or confining under sheets to counteract to low oxygen. In least cases, it is obvious that crab may remained confined under sheets in spite of oxygen level reaching fatally low (Table 3).

Effect of Settlement on Distribution and Survival of Crabs:

Some locations were dominated by crab and such locations were chosen for the study. This situation could occur if the juvenile crab would have settled on location to which they were adapted. Samples of crabs were examined from all the location of survey carried out. The separation of the crabs into size categories was based on their carapace size. When the young crabs are swiftly exposed initially, they remained motionless for some time, whereas the larger crabs generally moved. As the juvenile crabs were alike in size, shape, and color to the surroundings, it made them difficult to locate.In general, it was found that the rarer species had a much higher ratio of young to old crabs than the dominant species (Table 4).

Table 4: Proportion of all crabs on river and tributaries with a carapace width less than25 mm.

River			**Tributaries**		
Number of small crabs	**Number of large crabs**	**Ratio**	**Number of small crabs**	**Number of large crabs**	**Ratio**
4	38	0.11	4	21	0.19
2	28	0.07	9	33	0.27
41	83	0.49	53	69	0.77
16	82	0.20	25	88	0.28
91	30	3.03	98	41	2.39
2	30	0.07	4	31	0.13

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 3160 - 3173
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10	56	0.18	21	58	0.36
11	27	0.41	4	15	0.27
7	16	0.44	5	14	0.36
34	88	0.39	25	87	0.29
8	6	1.33	9	7	1.29

The ratio of young to old is similar in the river habitat as well as tributaries habitat. This indicated that there was no difference in mortality in the young crabs. This may assumed that settlement is nearly identical among the two locations.

Effect of Salinity on Distribution and Survival of crabs:

The hypothesis that gradients of salinity might affect the distribution of the crab was tested. It is known that fresh water is lighter that saline water where the organisms less tolerant of low salinity have their center of distribution higher than other organisms.Experiments were conducted to assess the effect of salinity distribution on the crab. The river water was taken in the tank and nearly 18 to 21 crabs were kept in the tank. The maximum salinity of the river water determined during the annual survey was recorded and found to be 500 mg/l similarly the river water with rainwater diluted water has the salinity 100 mg/l. The observation was made for six days till approximately 50% mortality had occurred (Table 5).

Table 5: Effect of salinity on crab and Tolerance of the crab for salinity.

Salinity	Live	Dead	Total
1.0	19	1	20
2.0	18	3	21
3.0	12	7	19
4.0	6	12	18
5.0	4	16	20
	59	39	98

The tolerance of the crab for fresh water was equal but over a gradient of increasing salinity it varies. The increase in salinity leads to increase in the mortality of the crab.

The chi square test indicates that $X^2 = 0.00005$, with the increase in salinity there is increase in the difference and hence the difference between the species is significant.

Effect of Desiccation on Distribution and Survival of crabs:

The effect of desiccation on survival of the crab was assessed and it was done by keeping 20 individuals collected from river basin as well as from tributaries. The crabs were matched for

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size and kept in different dry dishpans for observing the time of death. The crabs were assumed to be lifeless after they did not respond to any stimulus.

Table 6: The effect of desiccation on survival of the crab

Sr. No.	River basin crab (Time in minutes)	Tributaries crab (Time in minutes)
1	420	435
2	420	435
3	420	435
4	420	435
5	480	495
6	525	540
7	525	540
8	525	540
9	525	540
10	540	555
11	540	555
12	555	570
13	555	570
14	555	570
15	555	570
16	570	585
17	570	585
18	585	600
19	585	600
20	585	600
Total	10455	10755
Average	522.75	537.75

The average survival time, for crabs from river was 8 hours 42 minutes whereas the tributary crab has average survival time of 8 hours 57 minutes (Table 6). The variation among the two locations was significant. This ability of tributary crab to survive desiccation is higher may be owing to recession of water in much earlier than as compared to river.

factors controlling abundance

The effect of factors affecting the survival of crab in river basin as well as in the tributaries was studied. The factors that affect the survival of crabs were dissolved oxygen, turbidity, shelter, salinity and desiccation. The goal of study was to determine which factors set a limit to the number of crabs that can survive in a location. This was studied with simplicity that the species

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Received 25 April 2021; Accepted 08 May 2021.

from river basin and tributaries were considered to be ecologically equivalent where the simple sum of the crabs present is the given locality was observed as the abundance.

A multiple regression was carried out on the number of crabs occurring in every part of location against all the other variables studied or calculated for that section during the survey. These variables were dissolved oxygen, turbidity, shelter salinity and desiccation.

It was observed that the shelter was most directly connected with the number of crabs present, with less close association with the desiccation on the bank.

Table 7: Regression on crab survey data, with the number of crabs as the dependentvariable, and as independent variables; the dissolved oxygen (DO), the turbidity (T), the shelter (S), the salinity (N) and desiccation (D)

Sr. No.	Variable	Proportion of sum of squares
1	Dissolved Oxygen (DO)	18.124
2	Turbidity (T)	25.243
3	Shelter (S)	61.471
4	Salinity (N)	00.127
5	Desiccation (D)	01.102

The amount of cover was the most important variable associated with the number of crabs per sample (Table 7).The crab displays a more inclination to climb and expose with a choice of ascending to escape from low oxygen, or being confined below cover in the area of low oxygen. The crab shows a better affinity to bare itself when confronted with the option of responding to oxygen gradient by climbing or remaining under sheets to counteract to low oxygen. In least cases, it is obvious that crab may be confined below the sheets even when oxygen attains fatally low levels.

Tolerance limits to low dissolved oxygen tension were assessed for *Cancerirroratus.* More inter stage disparity was exhibited low dissolved oxygen tensioninfluencing the continued existence of the crab. Tolerance may be linked to dimension, developmental stage and interaction level (Vargo & Sastry, 1977).

The ratio of young to old is similar in the river habitat as well as tributaries habitat. This indicates that there is no difference in mortality among the young crabs. It may be presumed that settlement is roughly identical between the two places.The distribution and abundance patterns of aquatic invertebrates are recognized by dynamic habitat selection or inactive adaptation of

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individual on the instance of settlement, or by juvenile or adult mortality following settlement (Keough & Downes, 1982).

Most investigations on the significance of settlement and recruitment patterns in ascertaining spatial patterns of adult invertebrates from marine habitats has centered on species linked with the habitat or mostly immobile adults rather than motile, adults (Barde et al. 2020).

The maximum salinity of the river water determined during the annual survey was recorded and found to be 500 mg/l. Similarly, the river water with rainwater diluted water has the salinity 100 mg/l. The tolerance of the crab for fresh water is identical but over a gradient of increasing salinity varies. The increase in the salinity Lower salinity regions of the small, river-dominated estuaries of southeastern United States may be utilized as important nursery areas, may be associated with increased growth and reduced predation, and may represent a vital habitat for maintenance of local blue crab populations. However, the increase in salinity increases the mortality of the crabs (Posey et al., 2005).

The average survival time, for crabs from river was nearly 9 hours. This ability of tributary crab to survive desiccation is higher may be owing to recession of water in much earlier than as compared to river.

Loss of Water and endurance time was concluded for individual crabs subjected to desiccation. Water content of species in the study was around 66–68% of initial wet weight. Some *C. vittatus* species were resistant to desiccation were the most exposed to air, whereas Pagurus species rarely encounters water loss and cannot withstand water loss and desiccation. However land crabs are more resistant to desiccation (Young, 1978).

The ecology and distribution of the freshwater crabs are turn out to be well known for facing the impending hazards for their enduring continued existence. The protection of many species of freshwater crabs depends mainly on conservation of regions of natural habitat sufficient huge to sustain quality of water. Even though it is still unknown precisely the sensitivity of the freshwater crabs to polluted waters. A large number of studies results showed that crabs did not stay alive when rendered to these factors (Yeo et al., 2007). Urbanization, industrialization, agricultural operation and utilization of natural resources are essential certainty in developing countries, but negotiations may have to be made if it is ascertained that freshwater crab species should not wiped out in the future. Thoughtful and cautious utilization of available natural resources may prevent species extinctions as long as water quality is maintained and is not

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Received 25 April 2021; Accepted 08 May 2021.

heavily polluted. Beside, the forest and vegetation covering on the land is properly maintained and protected (Cumberlidge*et al.* 2009).

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