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HABITAT ECOLOGY OF A FRESHWATER CRAB, *SARTORIANA SPINIGERA* (WOOD-MASON, 1871) IN THREE DISTRICTS OF EASTERN ODISHA

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The habitat ecology of freshwater crab *Sartoriana spinigera* was studied for a period of two years (January 2010-December 2011) in two distinct ecosystems *viz*., the canal and the ponds in three districts of eastern Odisha (Cuttack, Kendrapara and Bhadrak). These crabs were available in good numbers in the monsoon season in these districts with two peaks of abundance in each year. During the first and second year of study the total crab availability showed a greater peak in the month of August and lower in the month of April. It was found that the freshwater crab *S. spinigera* required an optimal habitat having a sandy clay soil. The water parameters in the study sites were found varied such as temperature 24.36 to 35.19°C, pH 5.9 to 7.6, conductivity 0.423 to 0.461µS/cm, dissolved oxygen 3.4 to 6.9 mg/l, free CO_2 13.3 to 18.2 mg/l, total alkalinity 115 to 156 mg/l, phosphate 0.012 to 0.036 mg/l, ammonia nitrogen 0.008 to 0.053 mg/l and nitrate nitrogen 0.041 to 0.054 mg/l. Similarly, the sample crabs required different soil parameters in their habitats: pH 6.5-7.3, organic carbon 0.45-0.63 mg/l, nitrogen 8.28-8.84 mg/l, phosphate 1.23-1.86 mg/l and conductivity 0.053-0.072 µS/cm. Further, it was observed that to support the scavenging and omnivorous food habits of such crabs, a rich growth of micro flora and fauna was essential in their habitat. The gut content analysis of such crabs showed the presence of phytoplankton, zooplanktons like copepods, ostracods, amphipods, isopods along with crustacean larvae and their appendages, molluscan larvae, eggs of fishes, certain unidentified species and soil. This study confirmed the food habit of crabs and thus explained the role of these crabs in the food web of their habitats.

INTRODUCTION

Freshwater habitats are now becoming the most threatened ecosystems worldwide (Dudgeon *et al*., 2005; Revenga *et al*., 2005). So the conservation strategy of freshwater ecosystem in particular is affected by a dearth of baseline ecological data (Dudgeon, 2000; 2003; Abell, 2001). Human population growth including the anthropogenic activities is causing widespread degradation of such freshwater habitats. In aquatic biodiversity, freshwater crabs occupy an important position for maintaining

stability of ecosystems. One of the endemic freshwater crab species *Sartoriana spinigera* (Wood-Mason, 1871) found in shallow water bodies such as paddy fields, ponds, canals and low water levels of lakes, rivers etc. play an important role in maintaining the aquatic ecosystem as a scavenger, predator and hunting arthropod. The habitat of these crabs is believed to be unique as they play an important role in nutrient cycle and small-scale fisheries. Crabs are one of the important arthropods in freshwater bodies as they dominate the benthic invertebrate communities in terms of biomass (Hill and O'Keeffe, 1992). They occupy a significant position in freshwater ecosystems in the tropics, which have a diverse endemic fauna. But the rapid loss and deterioration of freshwater habitats put them under imminent threat. These crabs have an active aquatic life stage; the egg laying and hatching occur in water. These crabs live in water but they prefer to live in burrows in the terrestrial as well as paddy fields and at the bottom of water bodies. Therefore, the primary purpose of this research was to study the habitat as well as to establish ecological parameters (including the soil and water) of the edible crab, *S. spinigera* in freshwater ecosystems that affect the lifecycle of this species.

MATERIALS AND METHODS

Identification of sites and crab collection

Preliminary investigation was carried out in eight coastal districts of eastern Odisha to know the crab availability. Out of these districts, three districts were selected for study on the basis of crab abundance. Five sites were selected in these three districts for the study of crab habitats. Out of these five selected sites, three were from lentic water (canal) environment (located in Jagatpur canal of Cuttack district) and two were from lotic water (pond) environment (located in Kendrapara and Bhadrak districts) (Fig.1). Jagatpur canal is one of the largest canals in eastern Odisha (17.49N latitude to 22.34N latitude and from 81.27E longitude to 87.29E

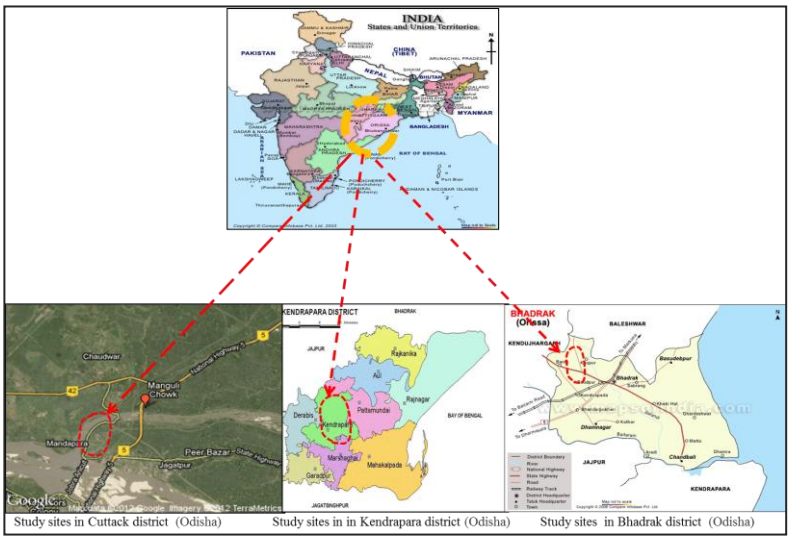

Fig.1. Study sites in 3 coastal districts of Odisha (Cuttack, Kendrapara and Bhardrak) in India

longitude), which starts from the river Mahanadi of Cuttack district (Latitude: 20.4654384°N and Longitude: 85.8780463°E). The selected ponds were located in the districts of Kendrapara (20°20′- 20°37′N Latitude and 86°14′-87°01′E Longitude) and Bhadrak (20°43′-21°13′N Latitude and 86°16′-87°0′E Longitude). The sites located in the lentic water environment were chosen from the upstream (S1), midstream (S2) and downstream (S3) of Jagatpur canal. Similarly the other two sites were from two different ponds *viz.*, pond at Kendrapara (S4) and pond at Bhadrak (S5). The field study was carried out from January 2010 to December 2011. At each site of 100 square meters, various sizes of crabs were collected manually or by using drag net and traps. All the collected samples were packed in polyethylene bags placed in insulated boxes along with ice and brought to the laboratory of Zoology Department, Utkal University, Odisha for further analysis. The crabs were buried in ice throughout the storage period and re-icing was done at every 24 h to maintain a temperature closer to that of ice. The crab identification was carried out following the key of Alcock (1910) on the basis of carapace, appendages and, G1 and G2 morphology. G1 (stouter terminal segment and a stouter sub-terminal segment) and G2 (straight terminal segment and an elongated sub-terminal segment) refer to the first gonopod and second gonopod of the crabs. About 203 specimens were collected monthly from the selected sites during a time span of two calendar years. The total catching of such crabs was counted and listed. The crabs were also differentiated into male and female by observing their abdomen. In case of male crab, it had a long, narrow and inverted T shaped abdomen whereas the females had an inverted U shaped abdomen.

Physico-chemical analysis of water and soil

The water and sediment samples for physico-chemical analyses were collected from all the five sites described earlier. The sampling was done in early morning hours. The surface water samples were collected in pre-cleaned two-liter polyethylene bottles with necessary precautions whereas; the sediments were collected in zip-lock polyethylene bags by using spatula. The water samples collected were analyzed using the standard methods described in APHA (2005). The water samples were analyzed for temperature (°C), pH, conductivity (μS/cm), dissolved oxygen (DO) (mg/l), free-CO_2 (mg/l), total alkalinity (mg/l), phosphate (mg/l), ammonia nitrogen (mg/l) and nitrate nitrogen (mg/l). For the determination of temperature of water where the crabs were collected, graduated thermometer and for pH analysis of water, pH meter (Eutech, Singapore)were used and all these measurements were carried out at the site. The concentration of DO was measured using azide-modification Winkler method. DO was estimated by fixing the sample water with manganous sulphate solution and alkaline iodide solution at the study site itself which was later estimated in the laboratory. The other physico-chemical parameters such as conductivity, free-CO_2, total alkalinity, phosphate, ammonia nitrogen and nitrate nitrogen were analyzed in laboratory following standard methods (APHA, 2005). Similarly, soil pH, organic carbon, nitrogen, phosphorus

and conductivity were also measured following standard methods described elsewhere (APHA, 2005). The texture of the soil (sand, silt and clay %) was studied only in three months of second year study at all the five sites. The water and soil parameters of five sites were tabulated and their average values and standard deviations calculated.

Abundance of flora and fauna in the selected sites

For the study of micro-flora and micro-fauna including planktonic abundance in the water, samples were collected from all the five selected sites. From each site, 10 liter of water sample was collected and filtered using standard plankton net. The collected organisms were preserved in 4% formaldehyde solution. Plankton was also fixed by adding 4% neutralized formalin and identified by light microscopic study on the basis of their gross morphological as well as special structures. Similarly, the micro-flora and micro-fauna were also identified (Prescott, 1984; Goswami, 2004).

Gut content analysis of crabs

Crabs were collected from late June to late October from each of the five sites. A total of 80 crabs were collected, 15 from canal water, 35 from one pond and 30 from another pond. The gut content analysis was carried out by both points method and occurrence method (Hyslop, 1980). The point method was unsuitable for foods, which consist of a high proportion of soft tissue whereas the occurrence method was appropriate for most foods. The crabs were anaesthetized by formaldehyde solution. The fore gut of each crab was dissected out and contents were observed by microscopic study and assigned a visual estimate of gut-fullness based on an index of 1-4, with 1 equal to 0 to 25% gut fullness and 4 equal to 75 to 100% gut fullness. Gut contents were placed on a 24-grid Petri dish containing saline water, and each grid was analysed separately using a dissection microscope. Gut contents were separated into five categories such as phytoplankton, zooplankton, crustacean appendages, insects, molluscs and unidentified organisms using a visual assessment. All phytoplankton, plants and animal matters were identified to the lowest taxonomic (Family and genus of the organism) level (Prescott, 1984; Lal, 2000; Goswami, 2004). Finally, a comparative assessment of available micro flora and fauna in the gut and in the environment was done.

RESULTS

The survey of crab population in canal and pond water revealed the availability of many aquatic flora and fauna. Among the available fauna, *S. spinigera* was found prominently from the site. This crab species was identified based on the classification of Alcock (1910) (Fig. 2A). The carapace of this species was broad, gently convex and smooth with slightly concave free edge. The antero-lateral margin of carapace was entire, sharp and had clear epibranchial spine. The orbits were without large spines and a distinct H-shaped deep gastric groove was present. In *S. spinigera*, the G1 had a stouter terminal

segment and a stouter sub-terminal segment whereas the G2 had a straight terminal segment and an elongated sub-terminal segment. A total of 203 of such crabs were collected, 46 from site-1 (S1), 24 from site-2 (S2) and 33 from site-3 (S3), 59 from site-4 (S4) and 41 from site-5 (S5). *S. spinigera* was found to be harbored at the pond bottom and canals and also found in the water-air-interface zones having shallow water. These crabs were available with two peaks of abundance in each year. During the first year of study, the total crab catch was maximum in August and minimum in April. Similar observation was also recorded in the second year. The population structure of male (Fig. 2B) and female crab catch (Fig. 2C) in different months of both the years showed varied abundance with peak in the monsoon season (Fig. 3).

The physico-chemical parameters of water from all these sites are shown in Figs. 4 & 5. The maximum water temperature was 35.19°C in May and minimum of 24.36°C in January months of the study periods. The pH of water was in the range of 5.9-7.6 during the study period. Conductivity of water varied between 0.423-0.461 µS/cm during the two years. The DO was maximum (6.9 mg/l) in July and minimum (3.4 mg/l) in March.

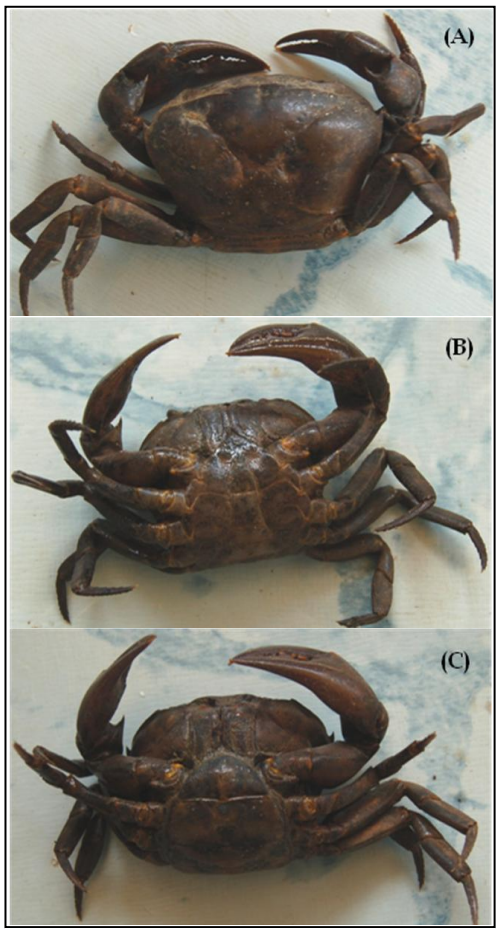

Fig. 2. Morphology of freshwater crab, *S. spinigera*, (a) dorsal view, (b) ventral view of male crab and (c) ventral view of female crab

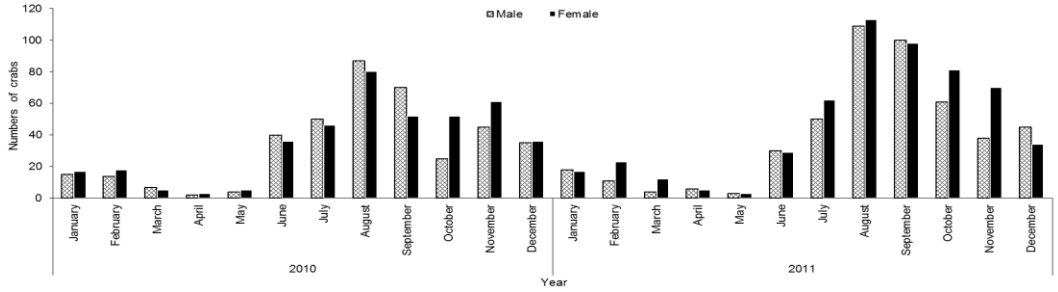

Fig. 3. Graph showing numbers of crabs (*S. spinigera*) collected from 5 study sites of three districts of eastern Odisha.

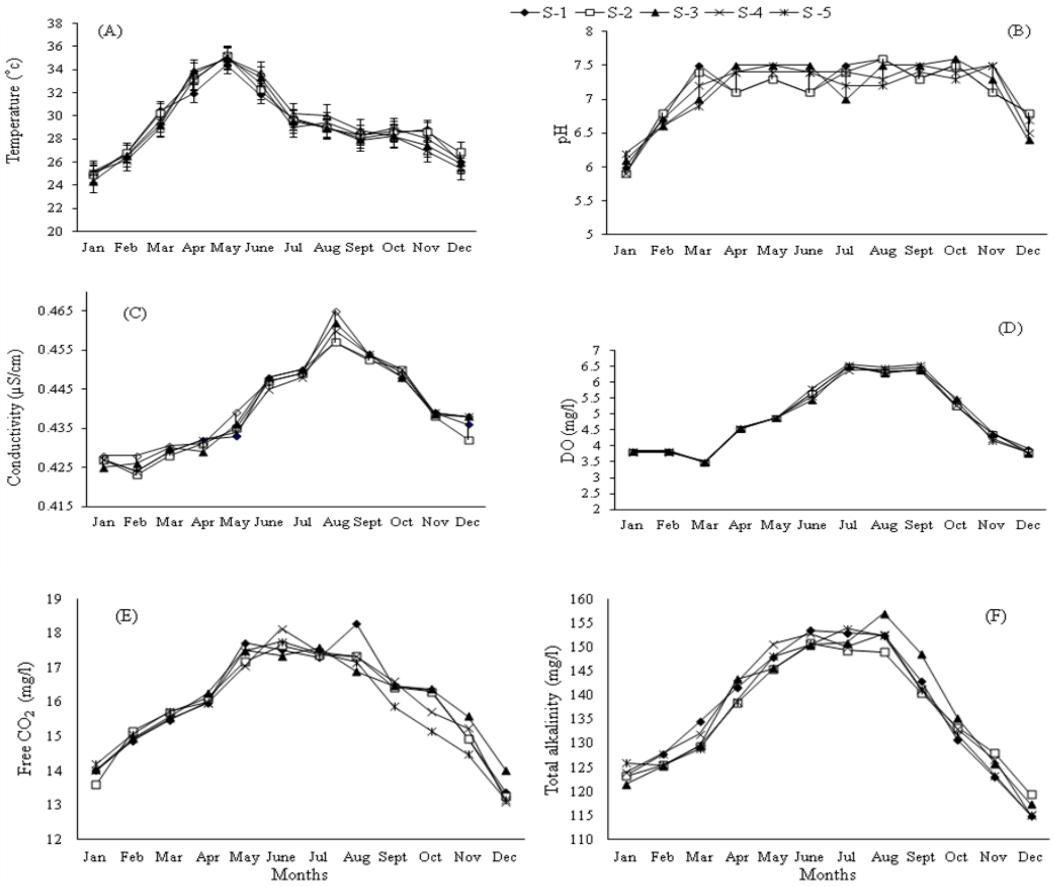

Fig.4. Monthly variations (mean values of each study sites of two years of study) in water parameters from canal and pond ecosystems situated in three districts of eastern Odisha, **(**A) temperature, (B) pH, **(**C) conductivity, (D) dissolved oxygen, (E) free CO_2 and (F) total alkalinity.

The maximum free CO_2 was 18.2 and 17.9 mg/l in May and July and the minimum was 13.3 and 14.0 mg/l in December of first and second year of study, respectively. The total alkalinity of water in the study sites ranged between 115 (December) to 156 mg/l (August). Comparatively higher values of phosphate (0.036 mg/l) were recorded in June and low levels (0.012 mg/l) in January. During the study period, the concentration of ammonia varied from 0.008 to 0.053 mg/l, whereas the concentration of nitrate varied from 0.041 to 0.054 mg/l in the crab habitats. Correlation between different parameters of water is shown in Table 1.

The estimated soil parameters are shown in Fig. 6. The value of soil pH ranged from 6.5 - 7.3. Maximum soil organic carbon was 0.63 mg/l and minimum was 0.45 mg/l. Similarly, other parameters of soil like nitrogen was observed to vary from 8.28-8.84 mg/l, phosphate from 1.23-1.86 mg/l and the soil conductivity from 0.053-0.072 µS/cm. The soil texture was studied in second year and the percentage of different components *viz.*, sand, clay and silt were estimated and the sand percentage was found to be maximum (53%) followed by silt (32%) and clay (15%).

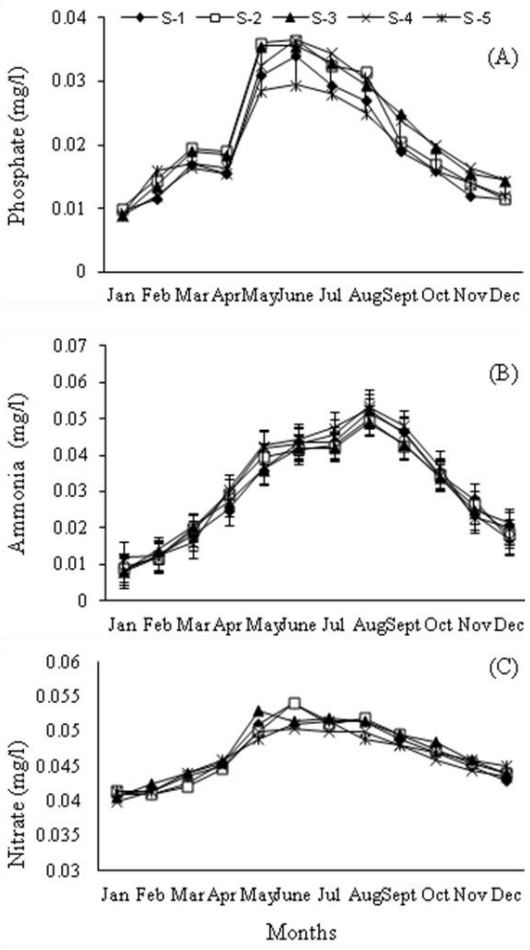

Fig. 5. Monthly variations (mean values of each study sites of two years of study) in water parameters from canal and pond ecosystems situated in three districts of eastern Odisha, **(**A) phosphate, (B) ammonia and **(**C) nitrate.

The analysis of water from all the selected sites showed a rich availability of micro flora and fauna (phytoplankton and zooplanktons). The available common phyto and zooplanktons found from the sites are listed in Table 2. The common phytoplanktons were diatoms (bacillariophyceae), green algae (chlorophyceae) and dinoflagellates (dinophyceae). The other benthic communities like smaller insects and larvae of crustaceans etc. were also observed. In both canal and pond waters there were different kinds of food chains observed which can be roughly divided into herbivore, carnivore, scavenger and parasites. In the canal ecosystem, the first trophic level (level 1) is phytoplankton that included chlorophyceae, bacillariophyceae, *Euglena* sp., dinoflagellates as well as aquatic plants and other species followed by herbivores (level 2) that included ostracods, copepods, amphipods, insects, crabs and molluscs and, then carnivores (level 3) that included frogs, fishes and water snakes. All these trophic levels constituted the food web of canal ecosystem. In pond ecosystems, the food chain consisted of primary producers like phytoplankton (chlorophyceae and bacillariophyceae), algae (*Spirogyra*, *Chlorella*, *Oedogonium* and *Zygnaema*), *Euglena*, many aquatic plants (*Hydrilla*, *Pistia*, *Lemna*, *Nelumbo*

Table 1. Correlation matrix of various physico-chemical parameters of canal water

	pH	DO	Temperature	Conductivity	Free CO_2	Total alkalinity	Phosphate	Ammonia Nitrogen	Nitrate Nitrogen
pH	1								
DO	0.880687	1							
Temperature	-0.04564	-0.5134	1						
Conductivity	-0.57793	-0.1224	-0.78886	1					
Free CO_2	-0.08941	0.393063	-0.99088	0.864486	1				
Total alkalinity	-0.10547	0.378546	-0.99886	0.872289	0.999876	1			
Phosphate	-0.95434	-0.98198	0.307756	0.307756	-0.21221	-0.19681	1		
Ammonia Nitrogen	0.687881	0.261987	0.693673	-0.98988	-0.78442	-0.79408	-0.43965	1	
Nitrate Nitrogen	-0.82341	-0.45636	-0.52928	0.938962	0.638796	0.650824	0.616294	-0.97828	1

and *Nymphaea*) and tall grasses representing the first trophic level (level 1); then herbivores (level 2) that included zooplanktons (copepods, amphipods, isopods, cladocera), larvae (naupli), insects (coleoptera) and then carnivores (level 3) like frogs, fishes, water snakes and water birds. All these trophic levels of different food chains constituted the food web of pond ecosystems.

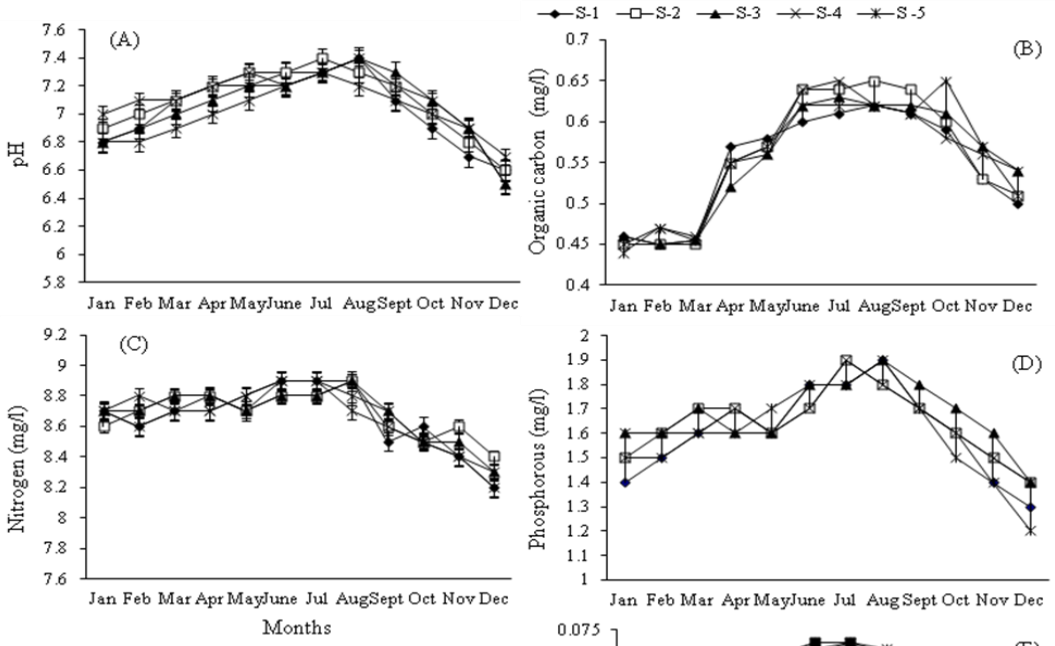

Fig. 6. Monthly variations (mean values of each study sites of two years of study) in soil parameters of canal and pond ecosystems situated in three districts of eastern Odisha, (A) pH, (B) organic carbon, (C) nitrogen, (D) phosphorous and (E) conductivity.

In the gut content analysis carried from the months of December to April of second year of study (Table 2), generally the frequency of presence of phytoplankton, algae, fungi, zooplankton, worms, crustacean larvae and their appendages, molluscan larvae, fish eggs and soil was more. The phytoplankton observed in the gut content analysis includes bacillariophyceae (diatoms) like *Navicula* and *Pinnularia*, chlorophyceae like *Chlorella*, *Spirogyra* and *Kirchneriella* as well as *Euglena* and *Paramecium*. Similarly, the zooplanktons observed were cyclopoid and calanoid copepods, amphipods, isopods, cladocerans like *Daphnia* and ostracods like *Cypris*. The gut content analysis also showed

Table 2. List of flora and fauna in study sites and in gut content analysis of *S. spinigera*

Organisms	Canal ecosystem (common organisms of 3 sites in 2nd Year of study)					Pond ecosystem (common organisms of 2 sites in 2nd Year of study)				
Flora and fauna	Dec	Jan	Feb	Mar	Apr	Dec	Jan	Feb	Mar	Apr
1. Phytoplankton										
a. Chlorophyceae	†	†	†	†	–	†	†	†	†	†
b. Bacillariophyceae	†	†	–	†	†	†	†	†	–	†
c. Dinoflagellate	†	†	†	†	†	†	†	†	–	–
d. *Euglena* sp.	†	†	†	–	†	†	†	†	†	†
e. Aquatic plants	†	†	†	–	–	–	–	–	–	–
f. Other species	†	†	–	–	–	†	†	†	†	†
2. Zooplankton										
a. Ostracod	†	–	–	–	–	–	–	†	†	†
b. Copepod	–	–	†	†	†	†	†	†	†	†
c. Amphipod	†	†	†	–	–	–	–	–	–	–
d. Larvae (glochidium)	†	†	†	†	†	–	–	–	–	–
3. Insects	†	†	†	†	†	†	†	†	–	†
4. Molluscs	†	†	†	–	–	†	†	†	†	†
5. Unidentified Organisms	†	†	–	†	†	†	†	–	–	†
Gut content analysis										
1.Phytoplankton	†	†	†	†	–	†	†	†	†	†
a. Chlorophyceae	†	†		†	†	†	†	†	–	†
b. Bacillariophyceae	†	†	†	†	†	†	†	†	–	–
c. Dinoflagellate	†	†	†		†	†	†	†	†	†
d. *Euglena* sp.	†	†	†	–	–	†	†	†	–	–
e. Aquatic plants	†	†	–	–	–	†	†	†	†	†
f. Other species	†	†	–	–	–	†	†	†	†	†
2.Zooplankton										
a. Ostracod	†	–	–	†	†	†	–	–	†	–
b. Copepod	–	†	–	–	–	†	–	†	†	–
c. Amphipod	†	†	†	†	†	†	†	†	†	†
d. Isopod	†	–	†	†	†	†	–		†	†
3. Larvae of crustaceans	†	†	†	†	†	†	†	†	–	†
4. Larvae of molluscs (glochidium)	†	†	†	†	–	–	–	†	–	†
5. Crustacean larval Appendages	†	†	†	†	–	†	†	†	†	†
6. Insects	†	†	†	–	†	†	†	–	–	–
7. Molluscs	†	†	†	†	†	–	–	–	–	–
8. Unidentified species	†	†	†	†	†	†	†	†	–	†

the presence of dinoflagellates, algae like *Spirogyra*, remains of some aquatic plants, round worms, crustacean larvae like nauplius larvae, zoea larvae and megalopa larvae along with their appendages, insects like water beetles, molluscan larvae like glochidium, eggs of fishes as well as some unidentified organisms, red blood drops and soil.

DISCUSSION

In our study, the availability of crab (*S. spinigera*) varied from year to year. The population of adult *S. spinigera* was found to reach a peak in monsoon seasons of the year. The findings of this study may be correlated to the observations on the ecology of the freshwater crab of Kawar lake wetland, Begusarai of north Bihar in India (Nayan *et al*, 2008). It has been reported that the population structure of adult *S. spinigera* in Kawar lake was maximum in August (Nayan *et al.,* 2008). According to water testing analyses, the temperature was found to affect directly on certain biological activities of the crabs in their habitat. Water temperature affecting the ecology of pond and canal varied and, were considered important for survival of flora and fauna. In this study, the recorded mean temperature of water in the crab habitat was 29°C. Similar observations on the water temperature of crab habitat have been reported earlier in Kawar Lake (Nayan *et al*., 2008), and in Sabarmati river and Kharicut canal at Ahemadabad (Kumar *et al*., 2011). The optimum pH of water of crab habitat was found to be 7.1 within a range of 5.9-7.6, which was similar to the studies reported for water pH 6.2-7.3 from Kawar lake (Nayan *et. al.,* 2008), 7.6-8.5 in Kharicut canal (Shah *et al*., 2008) and 7.03-7.23 of Sabarmati river (Kumar *et al*., 2011). The mean conductivity in two years of study ranged between 0.425-460 µS/cm. Here, the mean value of DO was estimated as 5 mg/l. Similar observations on DO were reported as 2.6-8.3 mg/l in Kawar Lake (Nayan *et al.,* 2008) and 4.9-7.7 mg/l in Sabarmati river and Kharicut canal (Kumar *et al*., 2011). The optimum value of total alkalinity of crab habitat in present study was 136 mg/l. Similar results were recorded as 78 to 114 mg/l in Mothronwala swamp, Dehradun (Uttarakhand) (Gupta *et al*., 2008). Again, the mean value of conductivity and free CO_2 of crab habitat of present study is similar to the values reported in Kawar Lake (Nayan *et al.,* 2008). The study of soil parameters in Mothronwala swamp of Dehradun (Uttarakhand) showed that the pH varied from 6.5 to 8.0, maximum organic carbon as 4.5%, nitrogen content as 0.41% and phosphorous as 2.61 ppm (Gupta *et al*., 2008). Here the results were also similar to these soil parameters and, this signifies that a similar type of freshwater habitat is required for this crab. The food web of canal water and the food web in pond water showed slight differences and the position of crab is different in the food chain of these ecosystems. The micro-flora and micro-fauna availability in the pond and canal ecosystems are mostly similar with reference to the gut content analysis of such crabs conforming their feeding habits. So this study gives information about the water parameters and food habits of crab, which is necessary for the propagation of freshwater crabs. The food web and the soil texture index values at different sites also revealed the requisites of crab habitat.

In summary, it can be said from the present studies that this freshwater crab requires an optimal habitat that comprises: a sandy clay soil, water having pH 7.1, DO 5 mg/l and alkalinity 134 mg/l. Further, it can be said that to support the food habits of these crabs, a rich growth of micro flora and fauna is essential in their habitat. Considering the present use of pesticides and insecticides in the agricultural field it is essential to protect these small scavenging animals from extinction.

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