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Monsoon fishery of juvenile ginger prawns at Little Rann of Kutch, Gujarat in relation to environmental parameters

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ABSTRACT

Juveniles of ginger prawn, *Metapenaeus kutchensis* (George, George and Rao, 1963), form monsoon fishery in shallow estuarine waters of the Little Rann of Kutch. The catch data were collected from Tikar, Mandrakhi, Cherowari and Surajbari landing centres during 2004 to 2009. The annual average catch was 2406 t, of which the bulk was contributed by Mandrakhi and Tikar. The catch correlated well with the amount of rainfall (r = 0.97). The length-weight relationships were expressed as: Log W = -2.367 + 3.1204 log TL for males (r = 0.81) and Log W = -2.868 + 3.7098 log TL for females (r = 0.88). All the water quality parameters including ammonium nitrogen, nitrate nitrogen and phosphate phosphorus were within safe limits and congenial for growth of ginger prawn juveniles and post-larvae. The water and sediment bacteriology revealed that both proteolytic and lipolytic bacteria were present in considerable quantities for efficient recycling. The chemical and biological parameters of water apart from monsoon rains, appear to contribute to the rapid growth of this species from post-larvae to juveniles.

Keywords: Ginger prawn, Little Rann of Kutch, *Metapenaeus kutchensis*, Monsoon fishery, Water quality

Introduction

The Little Rann of Kutch has an area of approximately 3000 sq km, bordering Rajkot and Surendranagar districts on the southern side and Kutch district on the northern side of Gujarat. The Little Rann is dry during October - June. However, with the onset of monsoon in July, the rivers Banas, Saraswati and Machchu discharge into the Little Rann. By the end of July and beginning of August, the monsoon gains momentum and the Little Rann gets flooded. The Little Rann gets connected to the Gulf of Kutch, facilitating entry of post-larvae of *Metapenaeus kutchensis* (George, George and Rao, 1963) into the Rann. The juveniles of ginger prawn, *M. kutchensis*, form a significant seasonal fishery in shallow estuarine waters of the Little Rann of Kutch during the monsoon months. There are studies, dating back to five decades, on the juvenile ginger prawn fishery of this area (Ramamurthy, 1963a, b; 1967; Deshmukh, 1975; Sarvaiya, 1981; Rao, 1983) and its correlation with rainfall. However, apart from the onset of monsoon rains, other chemical and biological parameters of water also have a role to play in the rapid growth of this species from post-larvae to juveniles and the flourishing fishery of this region. Studies have not been carried out so far in this regard and hence an attempt was made to correlate the rapid growth of this species to chemical and biological parameters of water quality.

Materials and methods

Post-larvae of *M. kutchensis* growing to juveniles were caught using bag nets (*gunja*) in August, September and October. Data on catch was collected in these months from Tikar, Mandrakhi, Cherowari and Surajbari landing centres during 2004 to 2009. The annual estimates of catch were made following the stratified random sampling design, as adopted by CMFRI. Annual rainfall data were obtained from the Tehsildar Office at Maliya. Among the four landing centres *viz.*, Tikar, Mandrakhi, Cherowari and Surajbari, Tikar and Mandrakhi contributed major share of the catch. A total of 1211 specimens, collected randomly from Tikar and Mandrakhi, were measured for total length (in cm from the tip of rostrum to the end of telson) and body weight (in g). The sexwise length-weight relationship was calculated following the formula $W = aL^b$ (Le Cren, 1951).

Water quality parameters from Tikar were monitored at regular fortnight intervals in the months from August to October for the years 2007, 2008 and 2009. Water samples were collected aseptically in sterile polypropylene bottles of 250 ml capacity. The sediment samples were collected using sterilized plastic corers and transferred immediately to UV sterilized polythene bags. All the samples were placed in insulated containers and brought to the laboratory within 24 h of collection. The surface water temperature was recorded by a mercury centigrade thermometer and the pH measured by a digital pH meter (Hanna, Portugal). The salinity was measured using refractometer (Erma, Japan). Dissolved oxygen (DO) content of water samples was estimated following the iodometric method, gross primary productivity (GPP) and net primary productivity (NPP) were estimated by the light and dark bottle method, total ammonium nitrogen and phosphate phosphorus were estimated spectrophotometrically by the phenate and stannous chloride methods, respectively and nitrate nitrogen concentration of water was also measured by the spectrophotometric method (APHA/AWWA/WEF, 1998). Aliquots of water and sediment samples diluted in 1% saline were spread plated in triplicate on to Zobell Marine Agar (ZMA) (Hi-Media, Mumbai, India) and incubated at 30 ^{0}C for 48 h for the enumeration of total heterotrophs (THC). The enumeration of total proteolytic count (PC) and total lipolytic count (LC) were done by spread plating in triplicate on to Calcium Caseinate Agar (Hi-Media, Mumbai, India) and Spirit Blue Hiveg Agar (Hi-Media, Mumbai, India), respectively, followed by incubation at 30 ^{0}C for 48 h. The results of the bacterial counts were processed by log transformation. The significance of differences in the physico-chemical and bacteriological parameters between the years and also between days were analysed by one way ANOVA followed by Duncan's multiple range test (DMRT) to examine which of them varied significantly (SPSS ver. 10.0 software, SPSS, Chicago, IL, USA). The correlation coefficient values between the total catch and various parameters were calculated using Microsoft Excel package.

Results and discussion

The total annual catch exhibited fluctuation over the years, with minimum catch of 1589 t recorded in 2004 and maximum of 4162 t recorded in 2006 (Table 1), with an average catch of 2406 t during the period of study. Mandrakhi contributed 47% of the catch, Tikar 41% and the rest was from Cherowari and Surajbari. At all places the catch showed good correlation with the total amount of rainfall (r = 0.83 – 0.99) (Fig. 1 and 2). Similar views were expressed by Deshmukh (2006) and Ramamurthy (1967), who stated that the success of shrimp fishery in the Little Rann of Kutch, which was constituted almost entirely by the juveniles of *M. kutchensis,* depended on rainfall and the consequent lowering of salinity. Rao (1983) reported similar enormous magnitude of seasonal shrimp fishery in 1980, which harvested 2312 t of juveniles.

Table 1. Catch of *Metapenaeus kutchensis* and monsoon rainfall at Little Rann of Kutch during 2004 – 2009

Total catch (t)	Monsoon rainfall (mm)
1589	428
2256	591
4162	848
2721	686
1970	491
1740	421

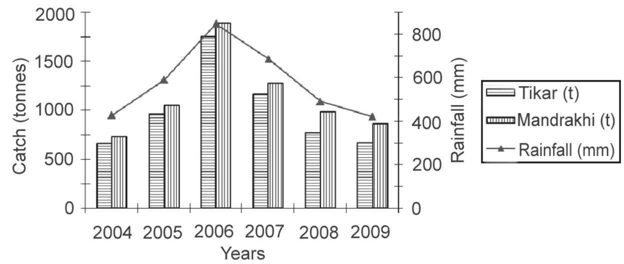

Fig. 1. Trend in catch of *M. kutchensis* and monsoon rainfall at Mandrakhi and Tikar during 2004 - 2009

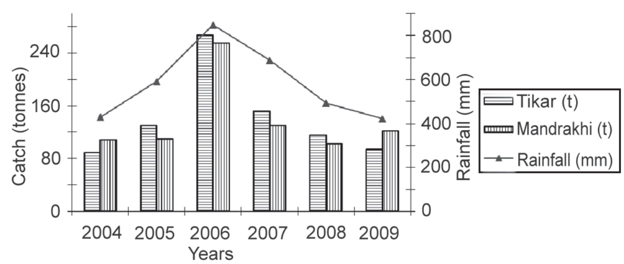

Fig. 2. Trend in catch of *M. kutchensis* and monsoon rainfall at Cherowari and Surajbari during 2004 – 2009

Deshmukh (2006) stated that spawning of *M. kutchensis* takes place mainly in May – August along the shelf waters north-west of Mumbai, resulting in massive recruitment of post-larvae and juveniles in the creeks and the Little Rann of Kutch. According to him, strong south-west monsoon winds commencing in May – June produce large scale near surface currents over the oceanic and shelf waters, which drifts the planktonic larvae northwards to the mouth of Gulf. The circulation in the Gulf is entirely influenced by the tidal currents owing to very high tidal amplitude and these currents during spring tides transport the larvae towards the head of Gulf and subsequently to the Little Rann of Kutch. Hence with the onset of monsoon in July and subsequent flooding, large scale immigration of post-larvae of *M. kutchensis* occurs to the Little Rann of Kutch and the adjoining creeks where they grow rapidly to juveniles. This immigration continues as long as the connection between the Gulf and the Little Rann remains established. However in the middle of monsoon, invariably there is cessation of rains and the area gets land locked restricting the emigration of juveniles. When the rain resumes in late monsoon, the connection between Rann and Gulf gets re-established and the residual juveniles advances to the Gulf and from there to the shelf waters, where they grow to subadults and adults contributing to the trawl fishery of the north-west coast of India.

Males ranging in size (TL) from 4.4 – 10.3 cm in length and from 0.5 – 6.5 g in weight (n=327) and females of size range (TL) 4.2 – 10.3 cm in length and from 0.5 – 7 g in weight (n=874) were measured for establishing length weight relationship. The exponential relation between total length (TL) and body weight (W) for males and females was expressed as:

Log W = -2.367 + 3.1204 log TL for males (r = 0.81)

Log W = -2.868 + 3.7098 log TL for females (r = 0.88)

There were significant differences in the slopes of the regression lines for males and females at 5% level. However, slightly different b values for males (3.335 and 2.94) and females (3.488 and 3.35) were reported by Deshmukh (2006) as well as Joseph and Soni (1986). The mean length for males caught in the month of August for all the years was 7.03 cm which gradually progressed to 7.72 cm in the month of September and 8.21 cm in the month of October. For females, the mean length of 6.08 cm recorded in August increased to 6.69 cm and 7.23 cm in September and October. Ramamurthy (1967) worked out the monthly growth rate of post-larvae and juveniles of *M. kutchensis* to be 6.7 mm from Cherowari which are in perfect agreement to the present findings.

All the physico-chemical parameters were well within the optimum levels recommended for shrimp culture (Chien, 1992), thereby, revealing the overall wellbeing of the system (Table 2). There were no observable differences (p>0.05) in water temperature, pH, DO, GPP, NPP, total ammonium nitrogen, nitrate nitrogen and phosphate phosphorus concentrations between the years. But salinity of water in 2007 differed significantly (p<0.05) from that of 2009. The salinity was low in 2007 because of good rainfall recorded during that year. Water salinity was found to be negatively correlated (r = -0.978) with the total amount of catch. Water temperature was nearly the same in all the years and varied between 33.8 °C and 35 °C. The levels of pH (p<0.05) and salinity (p>0.05) exhibited an increase with days in all the years (Table 3). With the commencement of monsoon in July and August, the rivers Banas, Saraswati and Machchu discharge into the Little Rann which gets flooded and gets connected to the Gulf of Kutch facilitating entry of ginger prawn seeds. Hence pH and salinity are less to begin with but increases with days due to evaporation as the area gets land locked when rain stops in the middle of monsoon. On the contrary, the levels of dissolved oxygen and gross and net primary production decreased (p<0.05) with days in all the years (Table 3). This decrease could be attributed to the gradual replacement of the phytoplankton community dominant during the monsoon period by the

Table 2. Physico-chemical characteristics (Range and Mean±SD) of water at Tikar during 2007 - 2009

Parameters	2007	2008	2009
Temperature (^{0}C)	33.8 – 34.2	34-34.5	34.2-35
	34.05±0.19	34.33±0.22	34.6±0.34
pH	7.6 – 7.8	7.7 – 8.3	7.8 – 8.3
	7.68±0.10	7.95±0.26	8.03±0.21
Salinity (ppt)	30 - 35	32 - 39	35 - 40
	32.25±2.06	35.25±2.99	37.25±2.06
DO (ppm)	3.3 – 4.5	3.2 – 4.3	3.3 – 4
	3.8±0.56	3.8±0.5	3.63±0.33
GPP (mg C l^{-1} h^{-1})	0.06 – 0.14	0.04 – 0.10	0.03 – 0.10
	0.11±0.04	0.08±0.03	0.06±0.03
NPP (mg C l^{-1} h^{-1})	0.03 – 0.07	0.03 – 0.06	0.01 – 0.06
	0.05±0.02	0.04±0.02	0.03±0.02
Ammonium Nitrogen (ppm)	0.03 – 0.21 0.09±0.09	0.04 – 0.24 0.13±0.09	0.03 – 0.26 0.15±0.1
Nitrate Nitrogen (ppm)	0.1 – 0.16 0.13±0.03	0.07 – 0.13 0.10±0.03	0.05 – 0.15 0.11±0.04
Phosphate Phosphorus (ppm)	0.0003 – 0.0016	0.0002 – 0.0009	0.0002 – 0.0007
	0.0009± 0.0007	0.0005± 0.0003	0.0004± 0.0002

Table 3. Physico-chemical characteristics (Range and Mean±SD) of water during 2004-2009 at Tikar before and after 30 days of culture

Parameters	< 30 days	> 30 days
Temperature (^{0}C)	34 – 35	33.8-34.5
	34.47±0.36	34.18±0.26
pH	7.6 – 8	7.7 – 8.3
	7.75±0.15	8.02±0.25
Salinity (ppt)	30 - 37	32 - 40
	33.33±2.5	36.5±2.88
DO (ppm)	3.8 – 4.5	3.2 – 3.6
	4.12±0.25	3.37±0.14
GPP (mg C l^{-1} h^{-1})	0.06 – 0.14	0.03 – 0.10
	0.10±0.03	0.06±0.02
NPP (mg C l^{-1} h^{-1})	0.03 – 0.07	0.01 – 0.06
	0.05±0.01	0.03±0.01
Ammonium nitrogen (ppm)	0.03 – 0.1 0.05±0.03	0.11 – 0.26 0.20±0.05
Nitrate nitrogen (ppm)	0.11 – 0.16	0.05 – 0.13
	0.14±0.02	0.09±0.03
Phosphate phosphorus (ppm)	0.0004 – 0.0016 0.0009±0.0004	0.0002 – 0.0003 0.0003±0.0001

zooplankton community. The total ammonium nitrogen increased ($p<0.05$) in all the years with days and this increase is because of the production of metabolic wastes by ginger prawns and other dead and decaying matter that are present in the system (Table 3). But the values of nitrate nitrogen and phosphate phosphorus exhibited a decrease with days ($p<0.05$) for all the years. The concentrations are highest at the beginning because of surface run offs during monsoon from the rivers Banas, Saraswati and Machchu but decreases gradually as it is used for plankton production. When rain stops in the middle of monsoon, the area gets landlocked preventing replenishment of these nutrients.

The THCs recorded in sediment samples were higher than in water, as reported by earlier workers (Sung *et al*., 2001; Abraham *et al*., 2002). The mean counts were around 10^5 ml^{-1} for water and 10^6 g^{-1} for sediment (Table 4). Similarly, the counts of proteolytic (PC) and lipolytic (LC) bacteria were also higher in sediment than in water. In sediments, their counts ranged from 1.1×10^4 - 1.45×10^6 g^{-1} for proteolytic bacteria and from 3.1×10^4 - 2×10^6 g^{-1} for lipolytic bacteria, while in water their counts ranged from 5×10^3 - 2×10^5 ml^{-1} for proteolytic bacteria and from 3.47×10^3 – 8.9×10^4 ml^{-1} for lipolytic bacteria (Table 4). The fact is that sediment gives shelter to both planktonic and biofilm forming bacteria; while the water column contain only planktonic bacteria. Besides this, pond sediment provides more nutrients for bacterial growth in comparison to overlying water. The bacteriological parameters were found to differ insignificantly ($p>0.05$) between the years except for sediment LC, where in the counts recorded in 2007 differed significantly ($p<0.05$) from that of in 2008. The bacterial counts increased ($p<0.05$) with days for all the years (Table 5). This increase is because of the increased availability of substrate (protein and lipid) with days due to increased metabolic release and dead and decaying matter. THC, PC and LC of water and sediment were found to be positively correlated with total ammonium nitrogen concentration (r = 0.932 and 0.998 for THC; r = 0.608 and 0.870 for PC and r = 0.646 and 0.716 for LC) of water and negatively correlated with nitrate nitrogen (r = -0.712 and -0.89 for THC; r = -0.243 and -0.994 for PC and r = -0.29 and -0.935 for LC) and phosphate phosphorus (r = -0.911 and -0.993 for THC; r = -0.564 and -0.9 for PC and r = -0.603 and -0.754 for LC) concentration of water. The result of the present study Indicates that through the activities of the heterotrophic decomposers which are present in the system in considerable quantities, nitrogen and phosphorus are recycled effectively to stimulate primary production.

Table 4. Bacteriology (Log counts: Range and Mean±SD) of water and sediment at Tikar during 2007 - 2009

Parameters	2007	2008	2009
Water			
THC (per ml)	4.8 – 5.3 5.11±0.28	4.7 – 5.68 5.21±0.48	4.85 – 5.8 5.4±0.42
PC (per ml)	3.7 – 4.71 4.27±0.47	3.81 – 4.85 4.14±0.48	4.2 – 5.3 4.82±0.55
LC (per ml)	3.54 – 4.46 4.10±0.41	3.6 – 4.52 4.05±0.41	3.81 – 4.95 4.40±0.52
Sediment			
THC (per g)	5.72 – 6.61 6.2±0.45	5.75 – 6.73 6.34±0.45	6.2 – 6.62 6.43±0.18
PC (per g)	4.04 – 5.63 4.83±0.74	4.66 – 6.16 5.47±0.67	4.83 – 5.69 5.34±0.38
LC (per g)	4.49 – 4.75 4.64±0.12	4.98 – 6.3 5.75±0.56	4.7 – 5.86 5.26±0.6

Table 5. Bacteriology (Log counts: Range and Mean±SD) of water and sediment during 2004 – 2009 at Tikar before and after 30 days of culture

Parameters	< 30 days	> 30 days
Water		
THC (per ml)	4.7 – 5.28 4.91±0.2	5.25 – 5.8 5.56±0.2
PC (per ml)	3.7 – 4.52 4.04±0.3	3.98 – 5.3 4.78±0.49
LC (per ml)	3.54 – 4.14 3.83±0.24	4.25 – 4.95 4.54±0.25
Sediment		
THC (per g)	5.72 – 6.4 6.04±0.28	6.49 – 6.73 6.61±0.08
PC (per g)	4.04 – 5.2 4.73±0.47	5.26 – 6.16 5.70±0.3
LC (per g)	4.49 – 5.75 4.88±0.46	4.71 – 6.3 5.55±0.66

The chemical and biological parameters of water quality were optimum for shrimp culture and hence the post-larvae of ginger prawn grow to juveniles in the Little Rann within a couple of month's time. The quantum of catch depended on the amount of monsoon rains and the subsequent lowering of salinity favoring increased availability of nutrients resulting in high primary production. The rich phytoplankton growth in the monsoon months favors the consequent production of zooplanktonic crustaceans which are the preferred food item of post-larvae and juveniles of ginger prawn (Deshmukh, 2006). Thus, the Little Rann of Kutch provides congenial feeding (nursery) ground and the ginger prawn grows very rapidly. The safe levels of ammonium nitrogen, nitrate nitrogen and phosphate phosphorus recorded in the present study coupled with rich counts of proteolytic and lipolytic bacteria both from water and sediment clearly demonstrated that the recycling of nitrogen and phosphorus occurs actively.

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