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Fishery and biology of the ginger prawn, *Metapenaeus kutchensis* George, George and Rao, 1963 along the northwest coast of India

V.D.Deshmukh

Mumbai Research Centre of C.M.F.R.Institute, CIFE Old Campus Building, University Road, Seven Bungalows, Versova, Mumbai 400 061, India
e-mail: vindeshmukh@rediffmail.com

Abstract

Studies on the fishery and biology of *Metapenaeus kutchensis* exploited off the northwest coast of India during 1991-2000 indicated that the average annual catch of the species was 605 t, which contributed 4% to the total penaeid shrimp landings at New Ferry Wharf in Mumbai. The species was found to feed on polychaetes (45%), *Acetes* spp. (20%) and benthic crustaceans (14%). Dimensional relationships between total length, carapace length and total weight and tail weight are given for the two sexes separately. Size at maturity was 103.1 mm for the males and 135.5 mm for the females. Fecundity and total length were exponentially related by the equation $F = 0.0000012*L^{5.1}$. Wide continental shelf of the northwest coast in the depth range of 40-80 m is the spawning ground, where the females emigrating from Gulf of Kutch spawned from December-August at about bimonthly intervals. However, spawning during May-August contributed to successful generation of the stock. It is construed that strong wind driven surface currents during monsoon drift the larvae to the Gulf waters and subsequently to the Little Rann, where the estuarine conditions in the adjoining creeks following monsoon rains create nursery ground for the juveniles and support the seasonal fishery there.

Keywords: Fishery, biology, ginger prawn, *Metapenaeus kutchensis,* northwest coast, India

Introduction

The ginger prawn, *Metapenaeus kutchensis* George, George and Rao 1963, is a commercially important penaeid shrimp endemic to the Gulf of Kutch along the northwest coast of India. The juveniles of the species have been reported to support seasonal fishery in the shallow waters of Gulf of Kutch (Ramamurthy, 1963a, 1963b, 1967; Deshmukh, 1975) and Little Rann of Kutch (Sarvaiya, 1981; Rao, 1983), and sub-adult and adults contributed to trawl fishery in the Kutch region (Kagwade, 1967) and at the mouth of the Gulf of Kutch (Joseph and Soni, 1990). Based on the trawl landings at Mumbai, penaeid shrimp fishery of the northwest coast has been described for the period 1979-85 (Ramamurthy, 1994); however, the species was not reported in the catch, perhaps due to its negligible contribution. But from late eighties, the species was landed in significant quantity at New Ferry Wharf (NFW) in Mumbai, where the trawlers largely operating from Gujarat waters land their catch.

The adult shrimps, especially the females, are pinkish and exported as 'red' or 'pink' medium, which command a price comparable to *Penaeus* spp. in local and overseas markets (exported as 'red medium'). The juveniles of the species are however, unattractive, muddy and called 'Surajbari' prawns, as the fish processing units in Gujarat procure them from Surajbari (Cherowari) in the Little Rann of Kutch.

Biological studies such as food and feeding, size composition, age, growth and sex-ratio based on the juveniles collected from the estuarine conditions of the Little Rann have been reported (Ramamurthy, 1967; Deshmukh,1975; Sarvaiya, 1981; Rao, 1983). Information on size composition, length-weight relationship and condition factor is available from the trawl fishery at Okha (Joseph and Soni, 1986, 1990) and laboratory spawning and rearing of the species from the mouth of the Gulf (Gopalakrishnan *et al.*, 1985, 1987). However, detailed information on the biology of the species from the shelf off the northwest coast is wanting. As the shrimp trawlers operating off the northwest coast of the country catch substantial quantity, a comprehensive account of the fishery and biology of adults *M. kutchensis* is presented and possible routes of migration of the stock are discussed.

Materials and methods

Data on catch and effort of shrimp trawlers landed at

New Ferry Wharf (NFW) in Mumbai were collected for 16-18 days in a month by the Fishery Resources Assessment Division of CMFRI, while species composition of penaeid shrimps and biological data were recorded once every week to obtain their monthly estimates during 1991-2000.

Month-wise rainfall data from Kandla Harbour in the Gulf of Kutch for 1991-2000 were obtained from Indian Meteorological Department (IMD) Pune and annual catch of the species (1992-93 to 2000-01) from the landing centres surrounding the Little Rann of Kutch and Surendranagar districts were obtained from the Commissioner of Fisheries, Gujarat State.

Random samples of *M. kutchensis* were taken from NFW for recording sexwise size and maturity. The maturity stages were noted by morphological examination of the ovary. Size of prawn was recorded (in millimeters) from the tip of rostrum to the end of telson and grouped into 5 mm class intervals. For detailed biological studies, a random sample consisting of 40-60 specimens was collected every month. Total weight and tail weight (in gram) were determined by weighing in a digital balance. Foregut contents were analysed and their occurrence and volume examined by points method to calculate the Index of Preponderance (Natarajan and Jhingran, 1961). The feeding intensity was tested by x^2 test while the indices of preponderance of the gut contents of the sexes were compared by non-parametric Spearman rank correlation coefficient (Zar, 1974). Maturity stages of females were identified following Rao (1967) while length at first maturity was estimated by logistic curve (King, 1995). Fecundity was studied by gravimetric method.

Results

Fishery: About 800-1000 wooden shrimp trawlers registered in south Gujarat ports operate from NFW in Mumbai and their fishing grounds stretch from Porbundar (Gujarat) in the north to Mumbai (Maharashtra) in the south (19-22° N, 69-72°30'E) in the depth range of 20-90 m covering an area of about 55,000 km² (Fig. 1). During 1991-2000 the trawlers undertook multi-day fishing, each trip varying from 4-7 days and actual trawling hours ranging from 35-75. Majority of trawlers commenced fishing operations from late August to end of May but a few continued during rough weather monsoon conditions prevailing from June to August in some years.

The annual catch (1991 to 2000) of the species showed wide fluctuations from 291t in 1995 to 1,778t in 1993

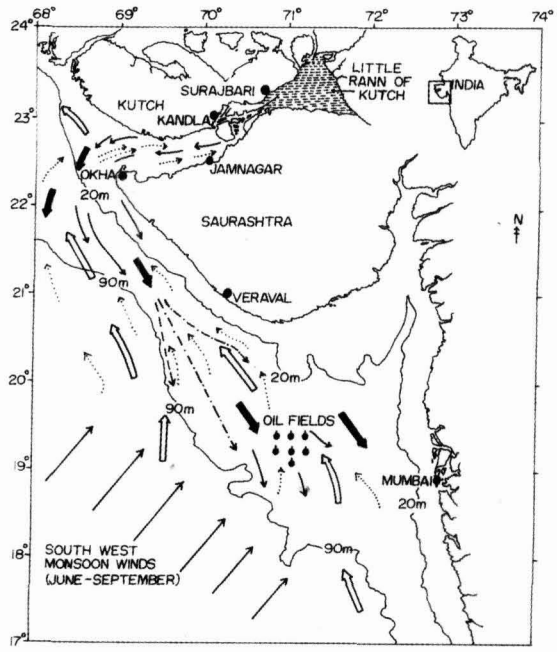

Fig. 1. Map showing surface currents (hollow arrows), continental shelf currents (Solid arrows), larval drift (dotted arrows) and route of migrating sub-adults and adults of *M. kutchensis*.

while the average catch of the species was 605t, which contributed 4% to the total penaeid shrimp catch (Table 1). The annual catch rate during the period was 0.43 kg/hr. The pooled monthly catch for the ten years showed that it increased form 4 t at the beginning of the fishing season in August to 77 t in November, but declined in December and January as the trawling operations in the latter months were targeted for either ribbonfishes or cephalopods (Fig. 2). The catch reached the maximum in February (104t) and declined from March to July. The catch rate of the species also showed similar trend with a peak in February.

***Rainfall and fishery*:** Rainfall in Kutch inundates Little Rann and the adjacent creeks of the Gulf of Kutch. The rainfall and catch in the Little Rann showed good correlation ($r^2 = 0.74$) but between rainfall and the catch at NFW in Mumbai showed very poor correlation ($r^2 = 0.03$). The catch of the species in the Little Rann and at NFW Mumbai also showed poor correlation ($r^2 = 0.14$). Therefore, it is inferred that there is no relationship between rainfall and catch of *M. kutchensis* in the trawling grounds of shelf waters off the northwest coast; so also

Table 1. *Yearwise estimated catch, cpue and % of* M. kutchensis *in total penaeid shrimps at NFW, Mumbai during 1991-2000.*

Year	Trawling hours in millions	Catch (t)	cpue in kg/hr	% in penaeid shrimps
1991	1.03	618	0.60	3.7
1992	1.22	800	0.65	4.7
1993	1.21	1778	1.47	10.0
1994	1.35	453	0.32	2.2
1995	1.57	292	0.19	2.6
1996	1.48	396	0.27	2.8
1997	1.62	367	0.23	1.8
1998	1.45	380	0.25	3.7
1999	1.60	612	0.38	5.2
2000	1.48	352	0.24	2.9
Average	1.40	605	0.43	4.0

the quantity of shrimps caught in the Little Rann and that landed at NFW Mumbai are not directly linked (Table 2).

***Food and feeding*:** A total of 485 shrimps comprising of 199 males and 286 females in the size range 84-154 mm and 85-198 mm respectively were analysed during 1993-94 for intensity of feeding and their foregut contents. Among the males 13.6% were poorly fed, 59.9% moderately fed and 26.5% well fed while the same for females were 6.5%, 45.8%, and 47.7% respectively, which indicated that feeding intensity was significantly higher in females than males ($p<0.01$).

The Nonparametric Spearman rank correlation coefficient for the sex-wise comparison of volume ($r_s = 0.96$), occurrence ($r_s = 0.90$) and index of preponderance ($r_s = 0.92$) of various food items did not reveal significant difference ($p < 0.05$) in their feeding preference (Table 3).

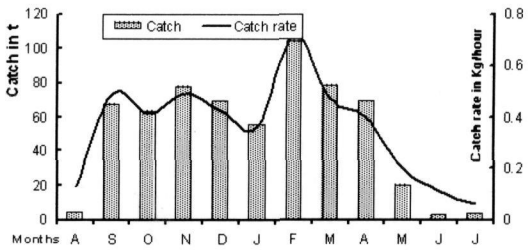

Fig. 2. Monthwise catch and catch rate of *M. kutchensis* (Av. 1991-2000)

Table 2. *Monsoon rainfall at Kandla and catch of* M. kutchensis *(juveniles) from Little Rann and NFW Mumbai (adults) during the fishing year.*

Year	Rainfall (mm)	Catch* (t) in little Rann	Catch** (t) at NFW, Mumbai
1990	229	N.A.	225
1991	158	N.A.	1004
1992	422	5969	1648
1993	137	1777	477
1994	1019	10925	414
1995	276	4086	452
1996	336	2935	354
1997	719	4730	249
1998	345	4297	466
1999	277	176	582
2000	324	2260	359

* Fishing year: June-May
** Fishing year: September- August
N.A. data not available.

It is seen that polychaetes were the most preferred food item in both the sexes with ponderal index of 45.1%

Table 3. *Volume, occurrence and Index of Preponderance (IP) of food items of* M.kutchensis

Food items	Male			Female			Sexes pooled		
	Σ Vi	Σ Oi	% IP	Σ Vi	Σ Oi	% IP	Σ Vi	Σ Oi	% IP
Fish	45	26	1.9	78	42	3.0	123	68	2.6
Cephalopods	71	19	2.3	119	26	2.8	190	45	2.6
Bivalves	9	6	0.1	13	12	0.1	22	18	0.1
Gastropods	1	1	0.0	6	3	0.0	7	4	0.0
Acetes spp.	170	62	17.9	277	82	20.9	447	144	20.2
Other crustaceans	140	59	13.9	191	70	12.3	331	129	13.4
Polychaetes	259	101	44.3	352	133	43.2	611	234	45.0
Sponges	6	6	0.1	8	7	0.1	14	13	0.1
Foraminifers	45	26	1.9	113	72	7.5	158	98	4.8
Semi-digested matter	43	33	2.4	52	41	1.9	95	74	2.2
Detritus, mud & sand	76	62	7.9	97	88	7.8	173	158	8.6

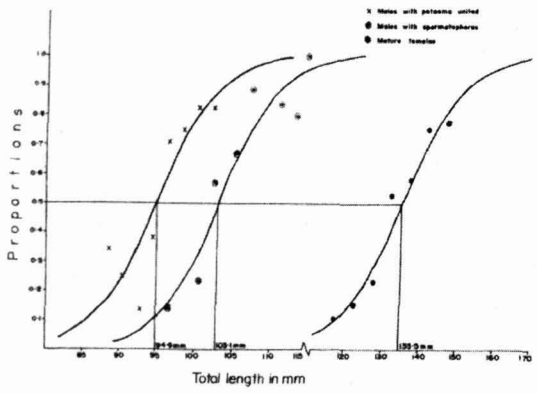

Fig. 3. Size at maturity of males and females of *M. kutchensis*.

followed by *Acetes* spp. (20.3%) and benthic crustaceans (13.5%) that included amphipods, isopods and tanaeidaceans and harpacticoid copepods (Table 3). Detritus (8.6%) mixed with sand and mud along with foraminifers (4.9%) is ingested while browsing at the bottom. The food occasionally consisted of cephalopods (2.7%), bivalves (0.1%) and gastropods (0.01%). Ramamurthy (1967) and Rao (1983) observed algae, detritus and crustaceans as the major food items in the juveniles caught from Little Rann, but the present study revealed that the adult prawns are carnivorous predators consuming primarily polychaetes, *Acetes* spp. and benthic crustaceans.

Dimensional relationships: A total of 233 males in the size range of 83-155mm and 320 females in the size range 80-200mm were measured for the carapace length (CL) - total length (TL), total length - total weight (W) and tail weight (TLW) - total weight relationships. They are expressed as follows:

Carapace length/total length:

Male : $TL = 19.03 + 3.79*CL$ ($r^2 = 0.96$)

Female : $TL = 30.74 + 3.25*CL$ ($r^2 = 0.98$)

Total length/total weight:

Male: $W = 0.0000012034*L^{3.335}$ ($r^2 = 0.98$)

Female: $W = 0.0000006016*L^{3.488}$ ($r^2 = 0.98$)

Tail weight/total weight:

Male : $TWL = 0.13 + 0.65\ W$ ($r^2 = 0.97$)

Female : $TWL = 0.60 + 0.58\ W$ ($r^2 = 0.96$)

Although Joseph and Soni (1986) reported sex-wise length-weight relationship for the species, the logarithmic parameter 'a' has been improperly estimated resulting in unrealistic weight for a given length.

Size at maturity: In males, attainment of maturity is associated with the development and union of petasmal endopodites, but such males in the smaller sizes lacked development of spermatophores in the terminal ampoules of their *vasa deferentia*. This indicated that they attained physical maturity but not yet reached the physiological sexual maturity. The male prawns larger than 120 mm in total length had fully developed petasma and distinct spermatophore while smaller ones exhibited union of petasma and presence of spermatophore at varying sizes. Therefore, in order to find out the size at which both physical as well as physiological maturity is reached, the males with petasmal union alone and those with both petasmal union and presence of spermatophores in the terminal ampoules were grouped into 2 mm size class intervals separately. Among them smallest male having united petasmal endopodites measured 88 mm while the one with petasmal union as well as presence of spermatophores measured 97 mm. The proportion of males with only petasmal union and those with fully formed petasma and spermatophores increased to reach 50% at 94.7 mm and 103.1mm respectively (Fig. 3).

The juvenile and sub-adult shrimps were recruited to the fishery during September-November and it was noticed that the females matured for the first time in December. Therefore, data on females with mature, ripe and spent ovaries in December during 1996-2000 were pooled for the size at maturity by logistic curve method. The smallest mature female measured 120 mm in total length but the proportion of mature females increased gradually to reach the first peak at 153 mm which was considered cent percent for the cohort, and accordingly the proportion of mature females was adjusted to calculate the proportion of mature females in different size groups. The proportion of mature females increased to 50% when they attained 135.5 mm size (Fig. 3).

Spawning period and frequency: The maturity distribution of females during 1996-2000 showed that mature ones were present in most of the months. When the mature, ripe and spent females representing the breeding population were pooled for the period, their percentage was maximum in May followed by August, October and December (Fig. 4). However, during 1995 and 1998 minor peaks of spawning were noticed in February followed by April and a major one in June indicating spawning activity at the intervals of two months. Joseph and Soni (1986) attributed high fluctuation of *Kn* in December to the commencement of spawning. Therefore, it is likely that juveniles and sub-adults emigrating from Rann of

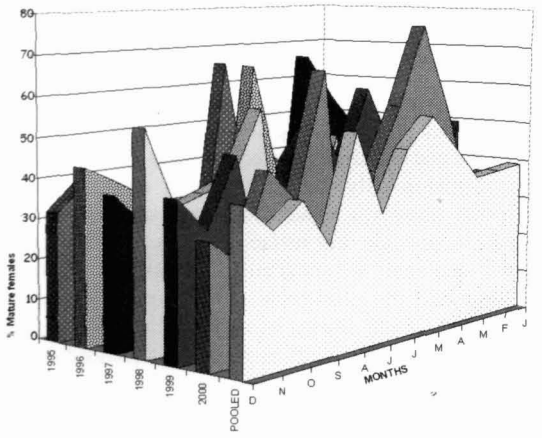

Fig.4. Monthwise percentage of mature females of *M. kutchensis* during 1991-2000.

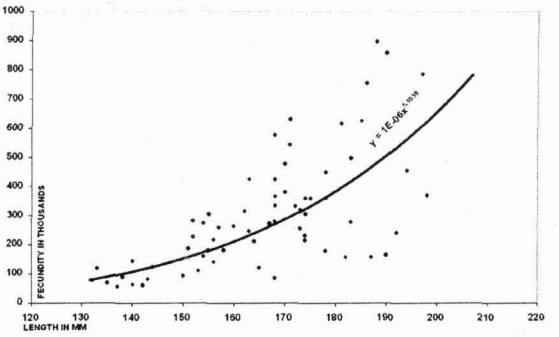

Fig. 5. Relation between fecundity and length of *M. kutchensis*.

Kutch to the fishing grounds mature and spawn for the first time in December and subsequently in February, April, May or June, August and in October. Gopalakrishnan *et al.* (1987) also noticed that the seed of *M. kutchensis* in the creeks of Gulf of Kutch followed bimonthly peaks of abundance in January, March, May/ June, and in August/September. It may be inferred that the species spawns six times during its life but an individual shrimp spawns at an interval of about two months.

Fecundity: A total of 67 ripe females in the size range of 132-194 mm and weighing15.9-58.1 g were analysed for fecundity studies. The best relationship between fecundity and total length was a power function (Fig. 5), which can be presented as:

$$F = 0.0000012*L^{5.1} \quad (r^2 = 0.564),$$

Where, F is fecundity and L is total length.

A female emerging from previous year's cohort and attaining 180-195 mm length (about a year old) produces about 0.38-0.57 million eggs from May to August.

Sex-ratio: Annual sex-ratio estimated from the sum of length-frequencies of males and females raised to the catch during 1996-2000 ranged from 1: 1.7 in 1999 to 1:2.3 in 1996 which showed that females dominated the catch in all the years. The percentage of females in different sizes pooled for the 5 years showed that among the smaller sized prawns (<100mm), mostly entering the fishing grounds during September-November, the males were almost equal in proportion with females (49.8%) but in larger sizes, the females outnumbered the males in all the rest of the months (Fig. 6). Males larger than 176 mm were not observed; therefore the catch consisted of only females beyond this size.

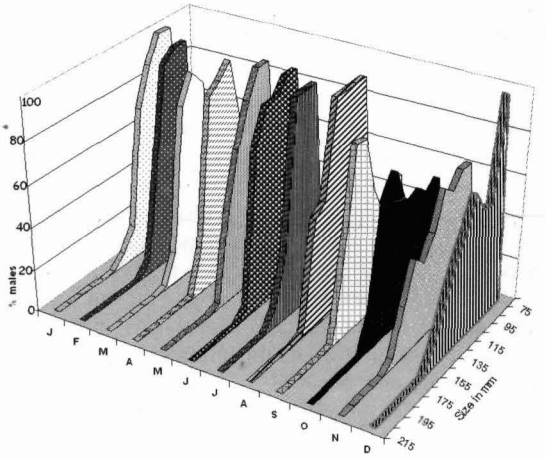

Fig.6. Monthwise percentage of males of *M. kutchensis* in different size groups.

Discussion

Ramamurthy (1967) remarked that the success of shrimp fishery in the Little Rann of Kutch that was constituted almost entirely by the juveniles of *M. kutchensis*, depended on the rainfall. Deshmukh (1975) noticed that success or failure of recruitment of larvae and juveniles influenced the abundance of shrimps in the Gulf, but rainfall and the consequent lowering of salinity of the creek waters were more important and affected the shrimp landings in the Little Rann of Kutch. The present study also showed that there is a direct relation between rainfall in Kutch region and the juvenile shrimp fishery in the Little Rann. It is obvious that a good rainfall in Kutch

ensures flooding and large scale immigration of post-larvae to the Little Rann of Kutch and the adjoining creeks, where under the estuarine conditions they grow rapidly to juveniles and support a seasonal fishery during July-September. Rao (1983) reported enormous magnitude of seasonal shrimp fishery in 1980, which harvested 2,312 t of juveniles. This shows that a good seasonal fishery in the Little Rann of Kutch also exploits juveniles intensively as a result only a residual quantity is left which emigrate to the Gulf by August or early September, as long as the connection between the Gulf and the Little Rann remains established. Inundation of the Little Rann, covering vast water spread area of about 1200-3000 km^2 changes the peculiar physicochemical conditions, which are perhaps conducive for supporting the post larvae and juveniles. Zingde *et al.* (1988) observed that low salinity of the creeks and the Little Rann during July-September together with rich standing stock of zooplanktonic crustaceans *Streptocephalus dichotomus* and *Caenestheriella indica* provided congenial feeding ground (nursery ground) for the shrimps and, as a result they grew to marketable size within three months.

In the Little Rann of Kutch, invariably there is cessation of rains in the middle of monsoon and it gets land locked, restricting the emigration of juveniles to the Gulf (Ramamurthy, 1963b). If the rains resume in late monsoon and the connection is reestablished between Rann and the Gulf, the residual juveniles have a chance to advance to the Gulf, from where they migrate to the shelf waters of the northwest coast to support the trawl fishery. Thus, abundance of adult *M. kutchensis* in the shelf waters is not determined by the rainfall in the Kutch area alone, but the magnitude of the residual emigrant stock from the Little Rann and the adjoining creeks of the Gulf.

Although incidences of females of *M. kutchensis* maturing in the Gulf (Ramamurthy, 1967) and the trawling grounds off Jakhau (Gopalakrishnan *et al.*, 1985) and Okha (Joseph and Soni, 1990) have been reported, occurrence of 60-70% females in ripe condition in the trawl catches clearly indicated that spawning of the species takes place mainly in the shelf waters northwest off Mumbai. From the periodicity of spawning it is evident that females exhibited bimonthly spawning peaks from December to August. However, spawning from December to April appears to be infructuous, as it does not result in large-scale recruitment of the species. The subsequent spawning in May-August with the onset of monsoon could be productive resulting in massive recruitment of the post-larvae and juveniles in the creeks and the Little Rann of Kutch. Despite spawning in the shelf waters, there is no fishery reported for the species either in the Gulf of Khambhat (Patel and Balapatel, 1982) or along the coast of Maharashtra (Ramamurthy, 1994). Therefore, it is most likely that the post-larvae must arrive at the Little Rann and the creeks of Gulf of Kutch for their juvenile phase.

Paulinose *et al.* (1998) pointed out that in the interior of the Gulf and the adjoining creeks, larvae of *M. kutchensis* were available only during monsoon months. Strong southwest monsoon winds commencing in May-June produce large-scale near surface currents (Fig. 1) over the oceanic and shelf waters (Patil *et al.*, 1964), which are likely to drift the planktonic larvae northwards to the mouth of the Gulf. Owing to very high tidal amplitude, the circulation in the Gulf is entirely influenced by the tidal currents (Anon, 1985) and possibly these currents during spring tides transport the larvae towards head of the Gulf and subsequently to the Little Rann of Kutch. Absence of larvae of *M. kutchensis* during August at Sartanpur near Bhavnagar in the Gulf of Khambhat despite low salinity and suitable estuarine conditions (Trivedi *et al.*, 1982) evidently shows that the larval transport is neither southwards nor eastwards along the southerly oceanic current which prevails during monsoon (Varadachari and Sharma, 1967). Therefore, larvae may be transported in northward direction along the Saurashtra coast by the wind driven surface currents during May-August.

A good rain during June-July in Kutch would bring about flooding of the Little Rann and provide suitable estuarine habitat for the survival and growth of the post-larvae and juveniles for 2-3 months. Later, with the reversal of winds from November, although oceanic circulation is in anticlockwise direction (Varadachari and Sharma, 1967), the circulation on the continental shelf of Saurashtra region is largely influenced by the coastal topography, tides and local winds (Shetye, 1999). As a result, southwardly flowing coastal counter currents enable large scale migration of sub-adult prawns from the mouth of the Gulf to the vast shelf south of Saurashtra coast, where they disperse and invariably reach waters off Mumbai covering a distance of almost 600-700 km (Fig. 1). These sub-adults grow, mature and spawn largely in the shelf waters. Thus, synchronization of life history stages with the oceanographic conditions of the northwest coast is responsible for the species to be endemic to Gulf of Kutch waters.

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