Indian J. Fish., 73 (3): 24-34, 2026 doi:10.21077/ijf.2026.73.3.179433-03

Available online at: epubs.icar.org.in/index.php/IJF

Feeding dynamics and reproductive biology of Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1816) off Ratnagiri coast, India

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Abstract

The feeding dynamics and reproductive biology of the Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1816), along the Ratnagiri Coast, Maharashtra, were investigated during September 2024 to May 2025. A total of 830 individuals ranging from 5.9 to 27.3 cm total length (TL) were examined. Gut content analysis showed phytoplankton as the dominant dietary component, occurring in 82.4% of non-empty stomachs and contributing 48.75% of the food items, followed by zooplankton, which occurred in 67.1% of non-empty stomachs and contributed 31.2%. The relative contribution of phytoplankton and zooplankton varied among months, indicating seasonal variation in feeding composition. The overall male to female sex ratio was 1:1.46, with significant female bias observed in March and May. The length at first sexual maturity (Lm_{50}) was estimated at 20 cm TL for females. Monthly variation in the occurrence of mature, ripe and spent ovaries indicated reproductive activity throughout the study period, with a pronounced reproductive peak during March–May. Fecundity ranged from 12,657 to 132,739 oocytes per female, with a mean of 52,765±5,020.3 oocytes per female.

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Keywords:
Frequency of occurrence, Gut content analysis, Numerical method, Stomach contents

Received : 25.05.2026
Accepted : 28.09.2026

Introduction

Family Scombridae is a highly diverse group of important food fishes like tunas (skipjack, yellowfin, bigeye, albacore, bluefin), mackerels (Atlantic, Indian, Spanish), and bonitos. Globally, this consists of 15 genera and 51-54 species (Collette *et al*., 2001). About nine genera and 19 species of scombrids have been reported from Indian waters, with 16 species recorded from the Andaman and Nicobar Islands (Purkayastha *et al*., 2023; Rajan and Sreeraj, 2013). *Rastrelliger kanagurta* (Cuvier, 1816), a small pelagic fish, is an important pelagic fishery resource in India and contributes substantially to the livelihoods and food security of coastal communities (Yohannan and Sivadas, 2003). The species inhabits warm marine waters of the Indo-West Pacific and is widely distributed from the eastern coast of Africa and the Persian/ Arabian Gulf eastward to the western Pacific, including Indonesia, Australia, Melanesia and Samoa (Bogorodsky *et al*., 2025). Recent taxonomic reassessment of the genus *Rastrelliger* has recognised *R. chrysozonus* (Ruppell, 1836) as a distinct species restricted to the Red Sea, whereas *R. kanagurta* is the widespread Indo-West Pacific species (Bogorodsky *et al*., 2025). The Indian mackerel is one of the major marine fishery resources of India, with an estimated landing of 269,757 t in 2025, accounting for approximately 7.55% of the total marine fish landings of 3,574,226 t in the country (CMFRI, 2026). It is widely distributed throughout the country's east and west coasts as well as the Andaman and Nicobar islands (Ganga, 2010). The south-west coast of India accounted for the largest share of Indian mackerel landings, contributing an average of 64.7% of the national catch during 1997–2001 (CMFRI, 2003). Owing to its great nutritional content, this fish is highly prized and its oil has been extracted for use in the food and pharmaceutical industries (Ferdosh *et al*., 2012). Studies on the fishery and biology of *R. kanagurta* have been reported from the Mangalore–Malpe coast of Karnataka (Rohit and Gupta, 2004) and the northeast coast of India (Ghosh *et al*., 2016), while

studies on maturation and spawning have been conducted along the Tuticorin coast, Tamil Nadu (Abdussamad *et al*., 2010). Studies on food and feeding habits have been reported from the Goa coast (Mascarenhas and Desai, 2023), coastal waters of West Bengal (Das *et al*., 2016), the Massawa coast of Eritrea, southern Red Sea (Nath *et al*., 2015), and the Ratnagiri coast, Maharashtra (Bhendarkar *et al*., 2014).

The Indian mackerel is an important fishery resource along the Ratnagiri coast of Maharashtra, with substantial landings reported from the region. In 2022, Maharashtra recorded landings of 80,000 t, which declined to 66,000 t in 2023. At Mirkarwada Fishing Harbour, Ratnagiri, Indian mackerel is landed by different fishing gears, including purse seines, trawls and gillnets. Purse seines are an important gear for harvesting shoaling pelagic fishes, including Indian mackerel, along the Ratnagiri coast (Nakhawa *et al*., 2018). Ring seines have also been documented off Ratnagiri targeting oil sardine and mackerel shoals (Jadhav, 2017). Studies on fish biology provide baseline information for scientific fisheries management through insights into trophic interactions, prey-predator relationships, maturity, spawning and reproductive potential. Accordingly, the present study was undertaken to investigate the feeding and reproductive biology of *R. kanagurta* landed along the Ratnagiri coast, Maharashtra. The study also aimed to confirm fishermen's observations that mackerels have changed their feeding habits, specifically exhibiting more carnivorous behaviour in their diet.

Materials and methods

Sampling area and sampling methodology

Mirkarwada (16°59'42" N; 73°16'14" E), a major fishing harbour situated in Ratnagiri in Maharashtra state (Fig. 1) was selected for weekly collection of samples of *R. kanagurta* during the period from September 2024 to May 2025 (approximately 39 weeks of sampling)

Samples were randomly selected from the available *R. kanagurta* puirse seine landings at Mirkarwada, ensuring representation of different size groups. About 830 individuals comprising 358 females, 246 males and 226 indeterminate individuals were examined. Total length (TL) was measured to the nearest 0.1 cm using a measuring board, and body weight was recorded to the nearest 0.1 g using a digital balance. Sex was identified by macroscopic examination of the gonads. The indeterminate individuals were generally too small or immature for reliable sex identification, and were included in the pooled length–weight relationship analysis but were excluded from the sex-wise length–weight relationship analyses. The length–weight relationship was estimated using the equation $W=aL^b$, where W is the body weight (g), L is the total length (cm), a is the intercept and b is the regression coefficient.

Stomach content analysis

The frequency of occurrence method was used to assess the occurrence of different food items in the stomach contents. The frequency of occurrence of each food item was expressed as a percentage of the total number of non-empty stomachs examined (Hynes, 1950; Biswas, 1993), using the following equation:

$$O_i\ (\%) = (J_i / P) \times 100$$

where, O_i = Frequency of occurrence of food item *i*; J_i = Number of fish containing food item *i*; and P = Total number of fish with food in their stomachs.

In the numerical method, the number of individuals of each identifiable food item was recorded and expressed as a percentage of the total number of identifiable food items recorded from non-empty stomachs, following Hynes (1950):

$$N_i\ (\%) = (N_i / N_t) \times 100$$

where, N_i = Number of individuals of food item *i*; and N_t = Total number of identifiable food items recorded.

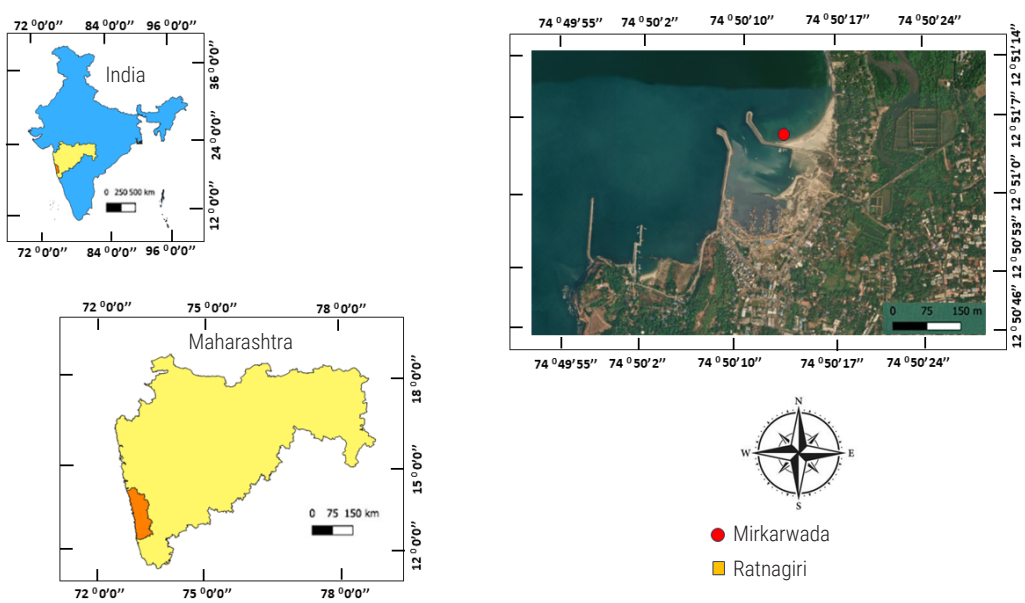

Fig. 1. Map depicting sampling location

Food items were identified under a compound microscope (AmScope B120C) at 10x objective using appropriate taxonomic keys and reference works for phytoplankton, zooplankton and other dietary components (Biswas, 1993). Identification was done to the lowest taxonomic level possible.

Stomach fullness was visually classified into five levels: Empty (0%), 25% Full, 50% Full, 75% Full and 100% Full. For presentation of feeding intensity, the 25% and 50% fullness classes were pooled as semi-full, while the 75% and 100% classes were pooled as full.

Sex determination and ovarian maturity

Sex was determined by macroscopic examination of the gonads after dissection. Female ovaries were examined based on their size, colour, vascularisation, occupancy of the body cavity and visibility of oocytes. The presence of ripe/ovulated ova and post-spawning condition was also considered where applicable. Based on these macroscopic characteristics, female maturity was classified into seven stages: Immature (I), Maturing 1 (II), Maturing 2 (III), Maturing 3 (IV), Mature (V), Ripe (VI) and Spent (VII), following the maturity scale reference adopted in the present study (Bal and Rao,1984). The size and developmental condition of the ova were further examined microscopically. Oocyte diameter was measured using a calibrated ocular microscope. Oocytes were measured along their longest axis. The calibration of the ocular micrometer was performed using a stage micrometer before measurements.

Gonadosomatic index

Gonadosomatic index (GSI) was calculated separately for males and females using the gonad weight relative to total body weight, following Bal and Rao (1984):

$$GSI (\%) = (\text{Gonad weight} / \text{Total body weight}) \times 100$$

where gonad weight and total body weight are expressed in grams.

Length at sexual maturity

Length at 50% sexual maturity (Lm_{50}) was estimated from the proportion of mature females in each length class using a logistic relationship following King (1995). During the present study, sampling was done only during September–May, and therefore the estimate was based on individuals collected during this sampling period, with length classes covering the transition from predominantly immature to mature individuals.

For the present analysis, females belonging to maturity stages V (Mature), VI (Ripe) and VII (Spent) were considered sexually mature, whereas stages I–IV were considered immature. The proportion of mature females in each length class was calculated and fitted to the logistic equation:

$$P(L) = 1 / [1 + \exp\{-r(L - L_{50})\}]$$

where P(L) is the proportion of mature females at length L, r is the slope of the logistic curve and L_{50} is the length at which 50% of females are sexually mature. The value of Lm_{50} was obtained from the fitted logistic relationship (King, 1995).

Fecundity

Fecundity was estimated from fresh, ripe ovaries following the gravimetric method described by Sinha (1995). The ovaries were carefully removed, gently blotted to remove surface moisture and weighed to the nearest milligram. A representative subsample of known weight was taken from the ovary, and the mature ova in the subsample were counted. Absolute fecundity was calculated as:

$$F = (TW / SW) \times N$$

where F = Absolute fecundity (Number of eggs per female);

TW = Total weight of the ovary; SW = Weight of the ovary subsample;

and N = Number of mature ova counted in the subsample.

Results

Stomach content analysis

Phytoplankton was the most important dietary category, occurring in 82.4% of non-empty stomachs and contributing 54.7% of the total number of food items. Zooplankton occurred in 67.1% of non-empty stomachs and accounted for 31.2% of the numerical composition. Miscellaneous items and partially digested matter contributed 8.6 and 5.5%, respectively. Phytoplankton occurred in the highest proportion of stomachs during most months, ranging from approximately 42% in February to 61% in November (Fig. 2). Its occurrence was highest in November and remained relatively high during March-May. Zooplankton occurred in approximately 32-47% of the stomachs and was most frequent in February, when it exceeded phytoplankton occurrence, and was nearly equal to phytoplankton in April. Miscellaneous matter occurred at moderate frequencies, ranging from approximately 11% in February to 25% in March, whereas semi-digested matter occurred at low frequencies throughout the study period. The seasonal variation in occurrence of phytoplankton and zooplankton suggests that feeding composition may vary with seasonal changes in prey availability, particularly between the post-monsoon, winter and pre-monsoon periods along the Ratnagiri coast.

The numerical method showed monthly variation in the relative contribution of phytoplankton and zooplankton (Fig. 3). Phytoplankton was numerically dominant during September-December and March-April, contributing approximately 41-68% of the total food items, with the highest contribution in November (about 68%) followed by April (about 65%). Zooplankton was numerically dominant in January, February and May, contributing approximately 45, 57 and 67%, respectively. In December, phytoplankton and zooplankton contributed nearly equally (about 47% each). Miscellaneous matter contributed 6-21%, with the highest contribution in March, whereas semi-digested matter contributed less than 4% throughout the study period. The alternating dominance of phytoplankton and zooplankton across months indicates opportunistic utilisation of available planktonic food resources and suggests that seasonal prey availability may influence the feeding composition of *R. kanagurta* along the Ratnagiri coast.

For pooled analysis, stomach fullness data from all sampling months were combined to calculate the overall proportion of full,

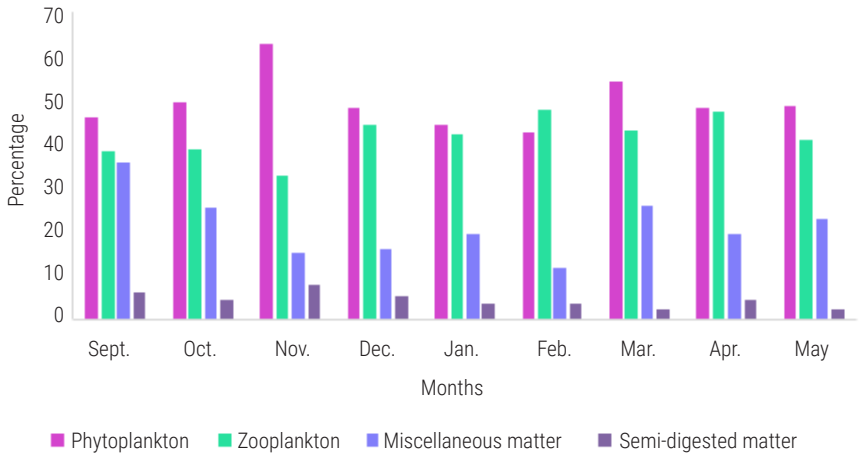

Fig. 2. Month-wise food composition in *R. kanagurta* (Frequency of occurrence method)

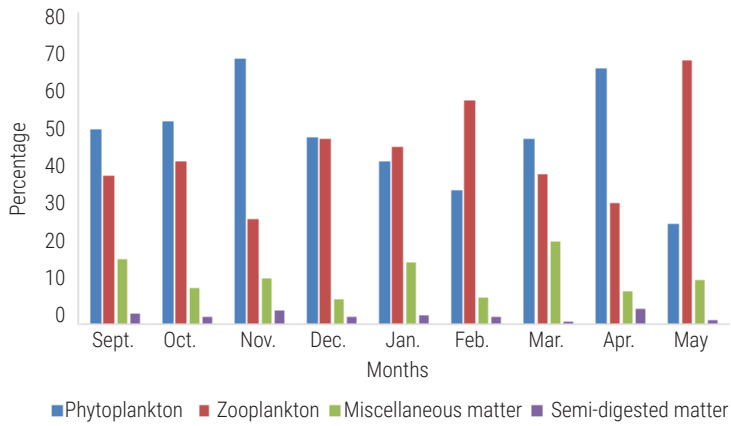

Fig. 3.-Month-wise food composition in *R. kanagurta* (Numerical method)

semi-full and empty stomachs. Out of the 830 samples analysed, 1.35% of the stomachs were full, 32.72% were semi-full and 65.94% were empty. The highest percentage of full stomachs was observed in May (3.06%), followed by March (3.03%) and December (2.02%). The highest percentages of semi-full stomachs were recorded in March (71.72%), April (46.00%) and November (43.00%), whereas empty stomachs were most prevalent in September (96.67%), January (87.13%) and December (82.83%). Mean GaSI was highest in March, followed by February and April, and lowest in September (Fig. 4).

Among the phytoplankton, diatoms belonging to the genera *Coscinodiscus*, *Planktoniella*, *Thalassionema*, *Pleurosigma*, *Biddulphia*, *Rhizosolenia*, *Navicula*, *Chaetoceros* and *Ditylum* were commonly recorded. Dinoflagellates belonging to the genera *Ceratium*, *Peridinium*, *Dinophysis* and *Ornithocercus* were also present. *Noctiluca* was recorded as a dinoflagellate/microplankton component of the diet. The zooplankton fraction was represented mainly by the copepod *Calanus*, molluscan larvae, crustacean nauplii, tintinnid ciliates including *Favella*, and mysids. Miscellaneous items consisted mainly of crustacean appendages or remains, fish eggs and fish scales. Partially digested and unidentifiable material contributed only a small proportion of the gut contents during the study period.

For pooled analysis, stomach fullness data from all sampling months were combined to calculate the overall proportion of full, semi-full and empty stomachs. Out of the 830 samples analysed, 1.35% of the stomachs were full, 32.72% were semi-full and 65.94% were empty. The highest percentage of full stomachs was observed in May (3.06%), followed by March (3.03%) and December (2.02%). The highest percentages of semi-full stomachs were recorded in March (71.72%), April (46.00%) and November (43.00%), whereas empty stomachs were most prevalent in September (96.67%), January (87.13%) and December (82.83%). Mean GaSI was highest in March, followed by February and April, and lowest in September (Fig. 4). As indicated in Fig. 5., stomach fullness in *R. kanagurta* varied with size. Throughout the study period, juveniles (6-20 cm) had the greatest proportion of empty stomachs, while adults (>20 cm) had the highest proportion of semi full stomachs.

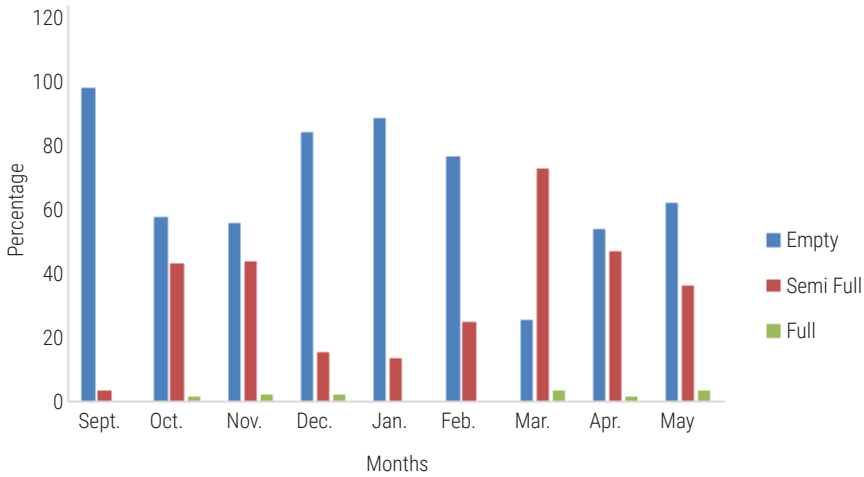

Fig. 4. Month-wise and pooled distribution of stomach fullness and feeding intensity in *R. kanagurta*

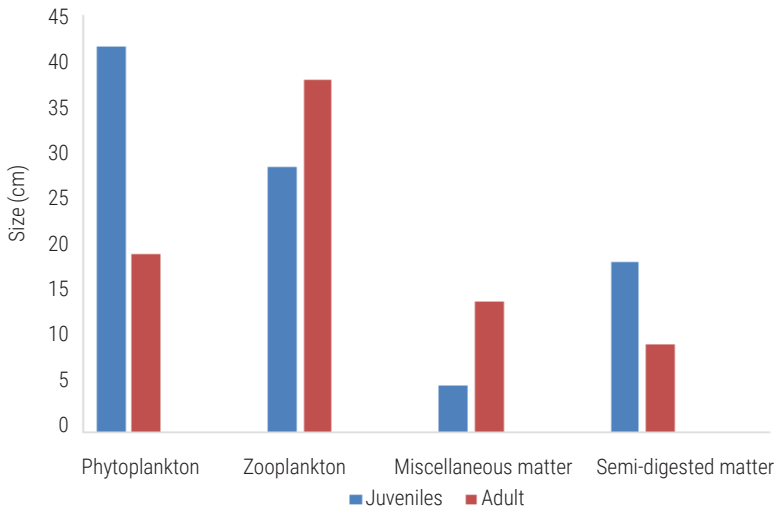

Fig. 5. Size-wise distribution of degree of feeding intensity in *R. kanagurta*

Sex ratio

In this study, the average sex ratio between males and females was 1:1.46 (Table 1). The chi-square test (χ^2) showed no significant departure from the anticipated 1:1 ratio with the exception of March and May ($p>0.05$). The strongest female bias was observed in March, followed by May.

Maturity stages

The maturity stages of 358 ovaries were analysed (Fig. 6). Stage I (Immature) occurred throughout the nine-month sampling period, ranging from 70.59% in September to 6.67% in May, while Stage II (Maturing 1) occurred from October to May (4.44-34.62%). Stage III (Maturing 2) occurred during September-November and January-April (2.33-27.14%), and Stage IV (Maturing 3) from October to May (3.70-13.64%). Mature females (Stage V) occurred during September–December and March-May (3.85-57.78%), ripe females (Stage VI) during September-January and May (2.04-17.78%), and spent females (Stage VII) from February to May (4.55-10.81%). These observations indicate a prolonged reproductive season, with spawning activity likely extending from at least September to May.

Gonadosomatic index (GSI)

The gonadosomatic index (GSI) was calculated for each individual and the monthly mean GSI was determined separately for males and females (Fig. 7). Monthly mean GSI differed between sexes. Female GSI was highest in May (4.82%) and lowest in February (0.49%), whereas male GSI was highest in March (1.93%) and lowest in January (0.372%). The overall mean GSI across the nine sampled months was 1.500±0.427 for females and 1.044±0.185 for males.

Length at first maturity(Lm_{50})

The proportion of mature females increased with increasing total length, and the length at sexual maturity (Lm_{50}) was estimated at 20 cm TL (Fig. 8)

Table 1. Sex ratio and chi-square test for male and female *R. kanagurta* along the Ratnagiri coast

Month	Male	Female	Total	Sex ratio (M: F)	df	Chi-square (χ^2)	p value (0.05)	Significance
September	10	17	27	1:1.7	1	0.90	0.34	NS
October	42	49	91	1:1.16	1	0.26	0.604	NS
November	47	43	90	1:0.91	1	0.088	0.76	NS
December	16	26	42	1:1.62	1	1.19	0.27	NS
January	23	27	50	1:1.17	1	0.16	0.68	NS
February	29	37	66	1:1.27	1	0.4848	0.486	NS
March	27	70	97	1:2.59	1	9.53	0.002	SS
April	31	44	75	1:1.42	1	1.12	0.28	NS
May	21	45	66	1:2.14	1	4.36	0.037	SS
Total	246	358	604	1:1.46	1	2.01	0.38	NS

*$p < 0.05$ = Significant (SS); $p > 0.05$ = Not significant (NS)

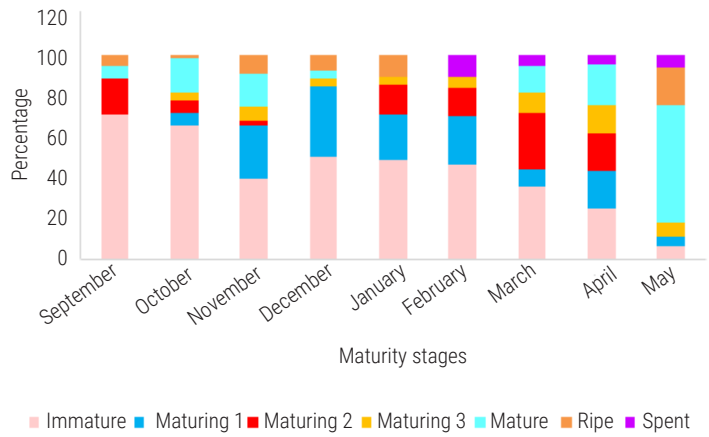

Fig. 6. Monthly variation in maturity stages of *R. kanagurta* females

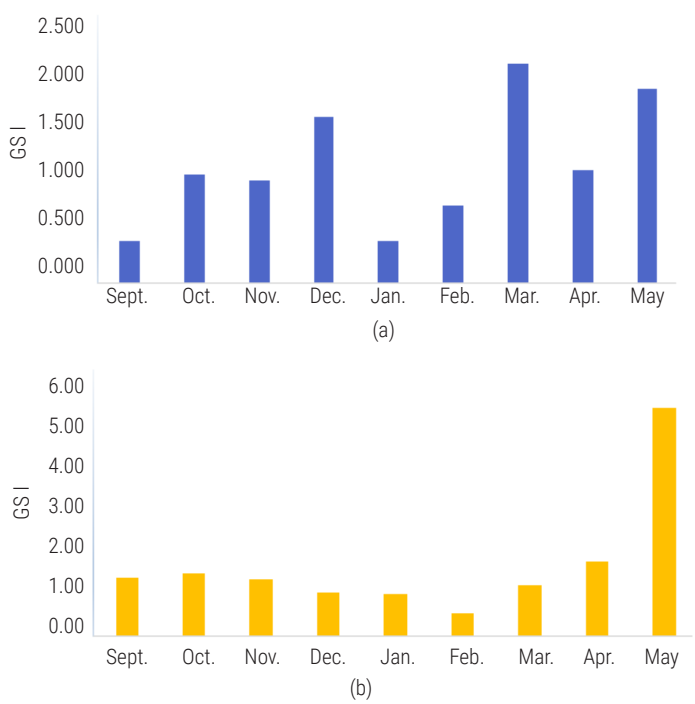

Fig. 7. Monthly GSI in (a) males and (b) females of *R. kanagurta*

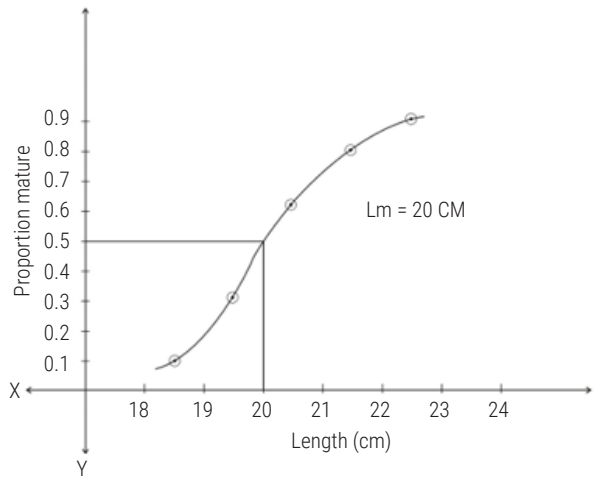

Fig. 8. Length at sexual maturity of *R. kanagurta* along the Ratnagiri coast

Fecundity

The fecundity of *R. kanagurta* ranged from 12,657 to 132,739 oocytes per female, with a mean of 52,765 ± 5,020.3 oocytes per female (Table 2).

Ova diameter

Representative ovaries from each of the seven maturity stages were examined, and frequency polygons of ova diameter were constructed (Fig. 9). Ova diameter increased progressively from Stage I (0.05-0.27 mm; mode: 0.16 mm) to Stage VI (0.75-0.85 mm; mode: 0.80 mm), indicating progressive oocyte development. Stage III showed a bimodal distribution (0.43 and 0.56 mm), suggesting the presence of more than one oocyte size group. Stage VII ova ranged from 0.20 to 0.37 mm, with a mode of 0.28 mm, indicating the presence of smaller ova following the mature stages. The observed oocyte size distributions demonstrate progressive ovarian development and the presence of more than one oocyte group at the same time support the observation that *R. kanagurta* has a prolonged spawning season.

Table 2. Individual fecundity estimates of female *R. kanagurta* along the Ratnagiri Coast

S. No	TL (cm)	BW (g)	OW (g)	No. of ova	S. No.	TL (cm)	BW (g)	OW (g)	No. of ova
1	21.3	156	6.24	72800	20.	21.8	144	9.13	116164
2	19.8	97	2	17473	21.	22.1	154	3.94	41159
3	18.5	90	1.73	19554	22.	27.3	262	11.85	74062
4	19.4	92	2.12	19899	23.	20.4	130	5.17	50510
5	21.4	137	4.27	32594	24.	21.3	108	4.65	47538
6	20.7	122	5.35	57690	25.	21.5	115	1.4	14308
7	19.9	112	2.8	30128	26.	21.1	116	1.15	12657
8	22.4	142	6.97	74160	27.	19.6	96	1.52	13137
9	22.3	155	9.34	119801	28.	21.4	123	1.77	15912
10	21.4	127	2.82	28369	29.	19.7	95	2.59	29949
11	22.1	145	5.44	67401	31.	20.1	117	13.25	64836
12	21.8	133	7.54	90857	32.	19.2	94	6.17	29143
13	22.2	157	6.07	70108	33.	19.3	93	5.79	27811
14	21.6	143	4.4	35185	34.	18.7	89	4.54	22004
15	22.3	159	12.67	132739	35.	20.3	109	9.09	45965
16	23	160	5.95	60769	36.	20.2	110	10.58	53887
17	20.8	116	6.3	80619	37.	20.7	118	11	100686
18	20.2	123	7.96	67978	38.	20.2	113	11.53	50732
19	21.6	126	6.12	58323					

Discussion

The current study investigated the feeding habits of *R. kanagurta* along the Ratnagiri Coast, confirming its planktivorous nature. Both, frequency of occurrence and numerical methods indicated that phytoplankton and zooplankton were the predominant components of the diet during the study period (September–May), with their relative dominance varying among months. The frequency of occurrence method revealed phytoplankton (48.39%), zooplankton (40.84%), miscellaneous matter (20.84%), and semidigested matter (4.38%). The numerical method also showed similar dominance with phytoplankton (47.73%), zooplankton (43.45%), miscellaneous matter (11.82%), and semidigested matter (2.04%). Bhendarkar *et al*. (2014) reported a higher percentage of zooplankton (43.56%) and lower algae content (2.89%) in Ratnagiri waters. In contrast, the present study observed a higher presence of phytoplankton and absence of algae, but recorded fish species such as *Encrasicholina* sp. and *Bregmaceros* sp. in the gut content, in February. Previous studies by Sivadas and Bhaskaran (2009) on *R. kanagurta* from Calicut, Kerala, reported copepods as the dominant food item, with *Bregmaceros* sp. also occurring in the stomach contents. Daghooghi *et al*. (2019) also reported the occurrence of fish in the diet of *R. kanagurta* from the Persian Gulf. In the present study, the occurrence of animal matter during February indicates occasional feeding on animal prey; however, this single occurrence does not provide sufficient evidence to confirm a change in the feeding habits of *R. kanagurta*.

Geographical and seasonal variation plays a key role in dietary composition. Studies from the Eritrean Red Sea (*R. kanagurta*) (Nath *et al*., 2015), West Bengal (Das *et al*., 2016), and Goa (Mascarenhas and Desai, 2023)

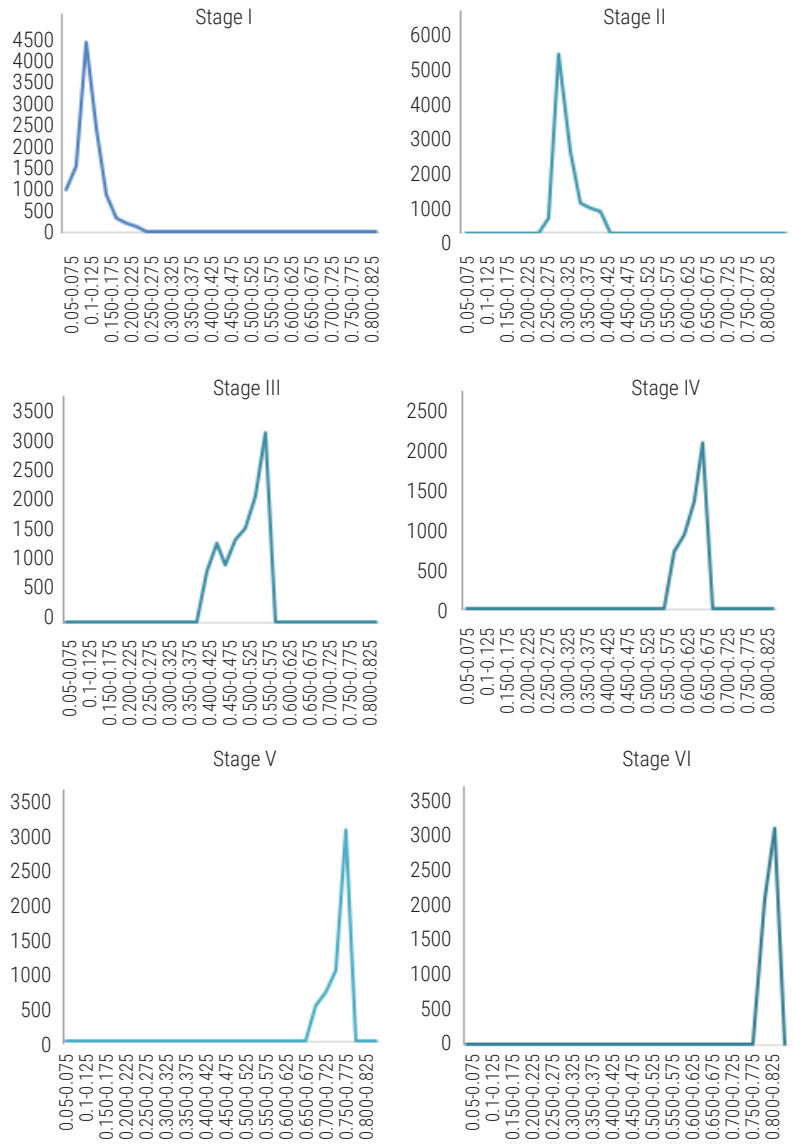

Fig. 9. Ova diameter frequency distribution in ovaries of *R. kanagurta* at different maturity stages along the Ratnagiri coast

have also confirmed plankton dominance, with occasional ingestion of crustaceans, fish larvae, eggs and other vertebrates. Diatoms and dinoflagellates were identified as the dominant phytoplankton groups, while *Calanus* was the most frequent zooplankton taxon in the present study. Size-wise variation was observed in stomach fullness between juveniles (6-20 cm) and adults (>20 cm), indicating differences in feeding intensity with size. This observation is consistent with the regional and seasonal variation reported for *R. kanagurta*. Purkayastha *et al*. (2023) reported moderate feeding intensity in *R. kanagurta* from South Andaman, with half-filled stomachs being most common, while the gut contents comprised mainly crustaceans, fishes, scales, shrimp and larvae. Their findings therefore indicate a more carnivorous prey composition in that locality, whereas the present study showed predominantly planktonic feeding with fish prey occurring only occasionally. Such differences may reflect variation in prey availability and feeding conditions among regions. Overall, the study confirms *R. kanagurta* as predominantly planktivorous, occasionally feeding on fish species, in this case, in the month of February.

The study observed seasonal variation in stomach fullness in *R. kanagurta*. Empty stomachs were most prevalent during September, December and January, with relatively higher occurrence also observed in February and May. Semi-full stomachs occurred throughout the study period, with the highest proportion in March (71.72%), whereas full stomachs were recorded only occasionally. Hakimelahi *et al*. (2020) reported seasonal variation in stomach fullness around Qeshm Island, Persian Gulf, with higher proportions of empty, semi-full and full stomachs during winter, autumn and summer, respectively. The present findings also indicate seasonal variation in feeding intensity, although the pattern differed from that reported from the Persian Gulf. Mascarenhas and Desai (2023)

reported peak feeding in December and minimum feeding in April along the Goa coast, further indicating regional variation in feeding activity. In the present study, 65.94% of stomachs were empty, 32.72% were semi-full and 1.35% were full, indicating comparatively low feeding intensity during the study period. Bhendarkar *et al*. (2014) reported active feeding during November, May, August and February, whereas the present study showed greater occurrence of empty stomachs during several months. Such differences may be related to seasonal availability of prey, environmental conditions, feeding periodicity and differences in sampling period and location.

The overall male to female ratio in the present study was 1:1.46, with females more abundant than males. The sex ratio did not differ significantly from the expected 1:1 ratio in the overall sample ($p>0.05$), although significant monthly deviations were observed in March and May. The female-biased ratio was higher than that reported by Bhendarkar (2013) along the Ratnagiri coast (1:1.29). Variations in sex ratio among regions may be associated with differences in fishing grounds, seasonal aggregation, fishing selectivity, size structure and reproductive migration. Fecundity in the present study ranged from 12,657 to 132,739 eggs, with a mean of 52,765 eggs. Fecundity varied widely among studies, reflecting differences in fish size, environmental conditions, sampling regions and estimation methods. Arrafi *et al*. (2016) reported 28,542-123,760 eggs (mean 56,635) for *R. kanagurta* from Aceh, Indonesia, while Das *et al*. (2016) reported 17,321-51,399 eggs from West Bengal, India. Ghosh *et al*. (2016) recorded 13,800-252,000 eggs from the north-east coast of India, and Win *et al*. (2023) reported 2,300-78,000 eggs from Myanmar. Thus, the fecundity observed in the present study falls within the broad range reported for the species, although the mean value was comparatively lower than some reported estimates. Such variation may be influenced by fish size, environmental conditions and reproductive status. Gonadosomatic index (GSI) showed seasonal variation in the present study, with the highest female GSI recorded in May (4.82%) and the highest male GSI in March (1.93%). The higher female GSI in May indicates greater reproductive development during this period; however, GSI values alone are insufficient to confirm a single spawning event. The observed pattern should therefore be considered indicative of a major reproductive peak during the study period, requiring further validation through year-round sampling and complementary reproductive observations. Bhendarkar (2013) also noted spawning activity in April along Maharashtra coast. Arrafi *et al*. (2016) observed two peaks (Jan-Mar and Aug-Oct) in Aceh, while Das *et al*. (2016) reported a primary peak in August and a minor one in April in West Bengal. Ghosh *et al*. (2016) recorded extended spawning from July-October and February-April along the north-east coast. Win *et al*. (2023) reported four peaks (May, August, October and December) in Myanmar. Siddique *et al*. (2024) noted spawning between March-August and August-October. The size at sexual maturity for females was 20 cm TL in the current study. Bhendarkar (2013) reported 20.6 cm, Hulkoti *et al*. (2013) observed 21 cm along Mangalore, and Ghosh *et al*. (2016) recorded 18.86 cm (females) and 18.32 cm (males) along West Bengal coast. Arrafi *et al*. (2016) found 19.58 cm, while Zaki *et al*. (2016) reported 257 mm (females) and 252 mm (males). Bintoro *et al*. (2019) found maturity at 22.5 cm (females), and Shahina and Shivakumar (2023) noted 17.85 cm (females) from Uttara Kannada. Asni *et al.* (2024) reported 17.98-19.28 cm in Makassar Strait. These variations may be linked to differences in stock structure, growth rates, environment and food availability (Pawase *et al*., 2017; Bandkar *et al*., 2022).

The study categorised ovarian maturity into seven stages. Stage I ova ranged from 0.05-0.27 mm (mode: 0.16 mm), progressing to 0.32 mm in Stage II. Stage III showed bimodal values at 0.43 and 0.56 mm, while Stages IV and V had modal values of 0.62 and 0.72 mm, respectively. Stage VI ranged from 0.75–-0.85 mm, with a mode of 0.80 mm. The single modal value observed in Stage VI alone does not establish total spawning behaviour, particularly as Stage III showed a bimodal distribution. Similar observations were reported by Bhendarkar (2013). The present oocyte size frequency pattern may serve as a hypothesis regarding spawning mode, which requires validation through year-round sampling and histological studies. Hulkoti *et al*. (2013) observed progressive modal values from Stage I (0.037 mm) to Stage VI (0.57 mm) in Mangalore, supporting a single spawning season. Ghosh *et al*. (2016) reported ova sizes ranging from 0.3-0.7 mm on the north-east coast. Zaki *et al*. (2016) measured ova diameter in m.d. (micrometer divisions) units, ranging from 3-45 m.d. across stages, indicating batch spawning. Nurfaiqah *et al*. (2023) found ova diameters of 0.025-0.840 mm in West Java, with one mode per stage, also supporting total spawning.

This study along the Ratnagiri coast confirmed that the Indian mackerel *R. kanagurta* is primarily a planktivorous fish, feeding mainly on phytoplankton and zooplankton. Fish prey were observed only during February, indicating occasional opportunistic feeding. However, the present study did not provide sufficient evidence to establish a significant shift towards a more carnivorous diet. The feeding behaviour observed in the present study is consistent with the reported opportunistic feeding nature of *R. kanagurta*, whose diet may vary with season, habitat and food availability. However, the present study did not examine larvae and all juvenile stages and therefore cannot confirm feeding behaviour throughout the entire life cycle. The feeding observations in the present study should therefore be interpreted within the scope of the sampled size groups and study period. The reproductive observations suggest seasonal reproductive activity along the Ratnagiri coast; however, the sampling period from September to May does not permit confirmation of a complete annual spawning cycle. Therefore, the reproductive pattern observed in the present study should be considered representative of the sampling period, rather than evidence of a single spawning season or total spawning behaviour. Previous studies have reported variation in spawning seasons and spawning patterns of *R. kanagurta* among regions. Environmental factors, regional differences and biological variations may influence feeding intensity, fecundity and reproductive timing, emphasising the need for continued monitoring and localised fishery management strategies.

Acknowledgements

The authors are grateful to the Associate Dean, College of Fisheries Ratnagiri, for the encouragement and facilities provided.

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