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A study on seasonal change in feeding habit, health status and reproductive biology of Indian Mackerel (*Rastrelliger kanagurta,* Cuvier) in coastal water of West Bengal.

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In this study, seasonal change in feeding habit, health status and breeding season of Indian mackerel (*Rastrelliger kanagurta,* Cuvier) have been observed in the coastal water of West Bengal. Gut contents were analyzed to check its feeding habit. Exponential value, condition factor and breeding habits were also examined. Study on feeding habit establishes Indian mackerel to be a selective plankton feeder. During pre-monsoon season; diatoms, copepods, rotifers and green algae were dominant, while blue green algae (BGA) and dinoflagellates had highest percentage of occurrence during the monsoon season. Feeding habit study of Indian mackerel in long term basis may further help in determining its trophic level position and locating its probable fishing ground.

[Keywords**:** Indian mackerel (*Rastrelliger kanagurta),* Feeding habit*,* Exponential value, Condition factor, GSI.]

Introduction

Indian mackerel (*Rastrelliger kanagurta*, Cuvier) shows a worldwide distribution and forms a part of commercial fisheries in countries bordering Red Sea, Oman Sea, Arabian Gulf, Pakistan, India, Sri Lanka, Bangladesh, Myanmar, Thailand and Malaysia[1-3]. India contributes 90% of the world mackerel production, out of which 77% is from west coast and 23% is from east coast of India. Its fishery is second in importance to that of oil sardine in the multispecies structure of Indian marine fishery[4]. From the point of fisheries management, a holistic knowledgebase on biology, life history and behaviour of species in the region is crucial[5-7]. Age, growth and fishery related work about Indian mackerel has been done in several countries[3, 8-11].

In west coast of India, extensive work has been done on the fishery and health status of Indian mackerel[12-19]. Study on mackerel from Indian Ocean as a whole, has also been done[20, 21]. Fewer studies related to its feeding habits[22, 23] have been done in the south-east coast of India. But no such work has been done along the West Bengal coastal region.

In West Bengal, Indian mackerel is showing an increasing catch trend over the last decade[24]. This fish is not in much demand in West Bengal, but is highly popular in southern states of India. If transported to Southern states, fishery of Indian mackerel may emerge as an earning source for West Bengal. A knowledge base about the biology and fishery of this fish will be helpful to manage the fish stock for prolonged exploitation. The present study was to get information about the feeding habit, health status and reproductive biology of Indian mackerel in West Bengal coastal province. Objective of the present study is to observe the seasonal variation of feeding habit of Indian mackerel with respect to salinity and rainfall and to examine the health status and breeding habit of Indian mackerel in West Bengal coastal water.

Materials and Methods

Fish samples were collected from Frazerganj and Digha fish landing centers as shown in Fig. 1. The study area was specified depending on the fishing zone; the latitude- longitude was N 21° 30’ to N 20° 30’and E 87° 30’ to E 89° 00’ (approximately 18,480 sq. km).

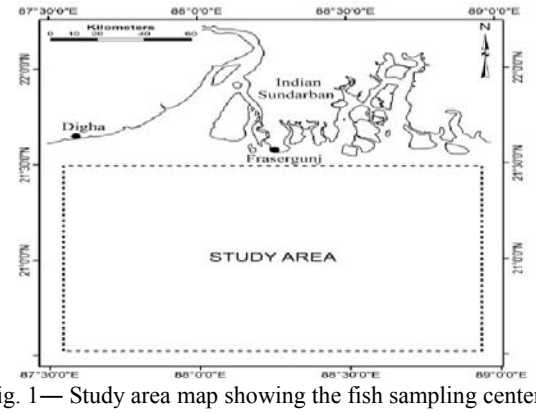

Fig. 1— Study area map showing the fish sampling centers.

Monthly collected fish samples were identified by the key provided in 'The Illustrated Guide on Commercial Fishes and Shell Fishes of India', published by Marine Products Export Development Authority (MPEDA)[25]. The study was carried out from January to December, 2012 (except the fishing ban period of the West Bengal coastal water). Table 1 represents the date of sampling for each month. Fish samples were stored in ice boxes and transported to the laboratory for analysis. To get a statistically significant data, 30-35 fishes were randomly sampled for each month. Weight of the fish samples were measured in nearest gram (g) (using digital scale 0.01g; EXCELL®) and total length (TL) was measured in millimeter (mm).

Table 1— Table showing the date of sampling in each month during the Study period.

Month	Date of Sampling
January	05.01.2012
February	03.02.2012
March	06.03.2012
April	02.04.2012
May	Fishing Ban Period
June	05.06.2012
July	04.07.2012
August	03.08.2012
September	03.09.2012
October	05.10.2012
November	02.11.2012

For gut content analysis, the guts were cut out and weighed in wet condition. The contents were taken out and preserved in 4% neutral buffered formalin (NBF) in such a manner so that the total volume of the mixture would be 20 ml. Thereafter, the ovary/ testes were dissected out, weighed after removing the excess water and stored in buffer solution.

The gut content was examined by using single drop of the preserved sample under microscope. Identification of planktons was done following Newell and Newell[26]. Different algae and zooplanktons were counted through tally marking and percentage occurrences were calculated for each of the components.

Length- weight relationship was calculated using the formula provided by Anderson and Neumann[27]

$W = a*L^b$ ……..……..... Eq. 1

Where, W= Total body weight (g); L= Total length (mm); a and *b* are coefficients of the functional regression between W and L.

Fulton's condition factor was calculated[28, 29] using the following equation;

$CF = (W_a/TL^3)*10^5$ .....…….. Eq. 2

Where, CF= the condition factor; W_a= average weight (g); TL= total length (mm).

Monthly changes in Gonado- Somatic Index (GSI) were calculated using the given formula[33]

GSI= (Weight of Ovary/ Weight of Fish) *100……....……..…….. Eq. 3

Sea surface salinity (SSS) was measured in a monthly basis during the study period, from January to December, 2012. Monthly rainfall data of the study area was downloaded from the TRMM- NASA (Tropical Rainfall Monitoring Mission) website[31].

Results

The food constituents that were encountered throughout the study period in Indian mackerel can be broadly divided into following groups, diatoms, other algae group, blue green algae, dinoflagellates, copepod, green algae, rotifer and fish egg (Fig. 2). Observed diatoms were *Biddulphia sp.*, *Fragillaria sp., Chaetoceros sp., Coseinodiscus sp., Nitzchia sp.*, *Pleurosigma sp., Skeletonems sp., Asterionella sp., Nevicula sp., Rhizosolenia sp., Bacteriastrum sp., Tetraselmis sp., Dicrateria sp.,* formed the other algae group, while, filamentous algae and *Chlorella sp.,* formed the green algae group. Three types of copepods *viz.* calanoid, cyclopoid and herpecticoid were also observed.

Changes in food composition of Indian mackerel have been noticed during pre-monsoon, monsoon and post-monsoon season as has been presented in Fig. 3, 4 and 5. Diatom, copepod, rotifers and green algae showed highest percentage of occurrence during pre-monsoon season. These were lowest during monsoon season. BGA and dinoflagellates had highest percentage of occurrence during monsoon, while throughout pre-monsoon these had the lowest percentage of occurrence. All through post-monsoon, other algae group had highest percentage of occurrence. No significant change in percentage occurrence of fish eggs have been encountered during the study period.

Seasonal changes in the food constituents with salinity and rainfall is presented in Fig 6 and 7. Green algae, copepod and rotifers showed significant positive correlation with salinity ($r= 0.99, 0.92$ and 0.90, $p<0.01$ respectively), while those were negatively correlated with rainfall ($r= -0.81, -0.64$ and -0.60; $p<0.01$ respectively).

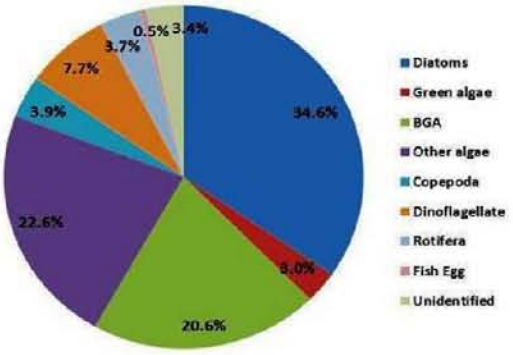

Fig. 2— Pi chart showing food constituents of Indian mackerel during the study period.

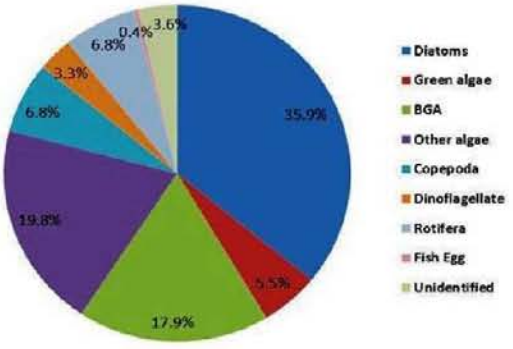

Fig. 3— Food composition of Indian mackerel during pre-monsoon season.

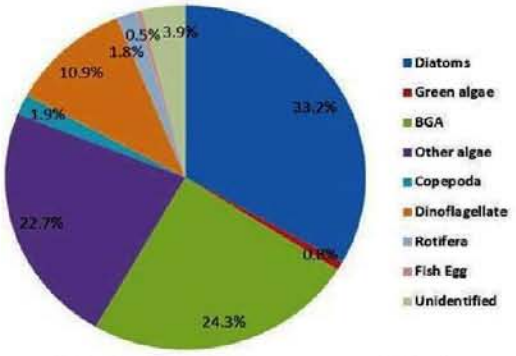

Fig. 4— Percentage occurrence of food constituents of Indian mackerel during monsoon season.

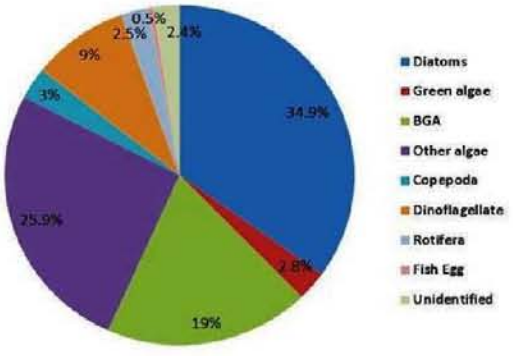

Fig. 5— Occurrence percentage of food constituents of Indian mackerel during post-monsoon season.

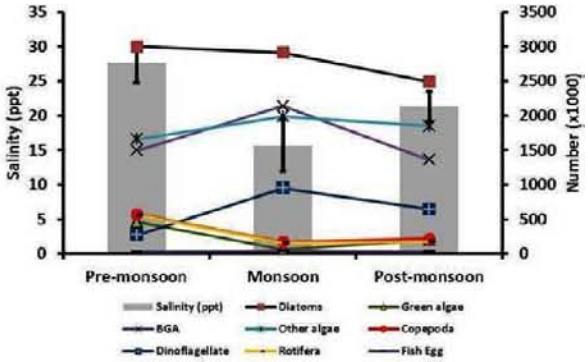

Fig. 6— Seasonal changes of food constituents of Indian mackerel with salinity during the study period.

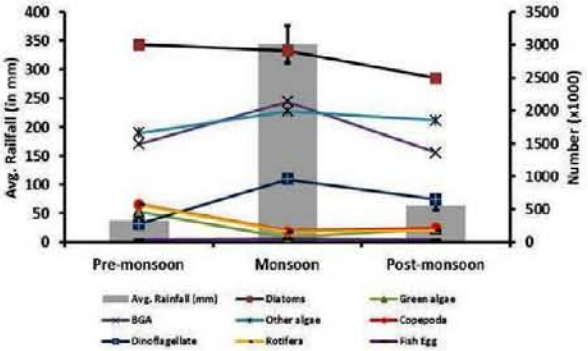

Fig. 7— Changes in food constituents of Indian mackerel with rainfall during the year 2012.

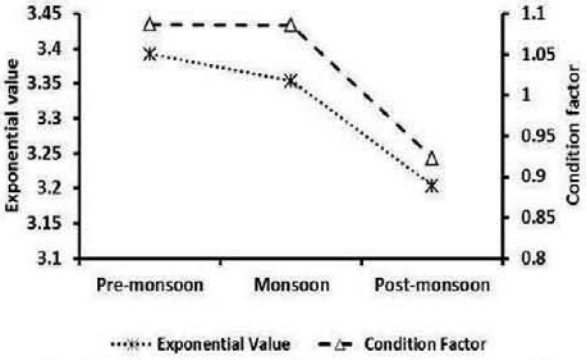

Fig. 8— Seasonal changes in exponential value and condition factor during the year 2012.

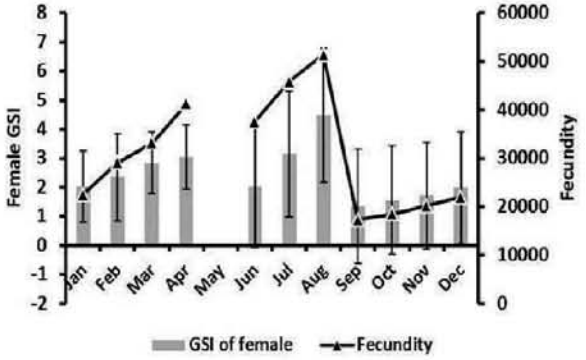

Fig. 9— Gonado Somatic Index (GSI) and fecundity of Indian mackerel in West Bengal coastal water.

Table 2— Pearson correlation matrix of food constituents, fish health parameters, rainfall and salinity.

	Diatoms	Green algae	BGA	Other algae	Copepoda	Dinoflagellate	Rotifera	Egg	Unidentified	LWR exponential value (*b*)	Fultons condition factor (F)	GSI of female	Fecundity	Salinity (ppt)	Avg. Rainfall (mm)
Diatoms	1.00														
Green algae	0.34	1.00													
BGA	0.50	-0.65	1.00												
Other algae	-0.25	-0.99	0.72	1.00											
Copepoda	0.55	0.97	-0.44	-0.94	1.00										
Dinoflagellate	-0.21	-0.99	0.74	0.99	-0.93	1.00									
Rotifera	0.60	0.96	-0.39	-0.92	0.99	-0.91	1.00								
Egg	0.40	-0.73	0.99	0.79	-0.55	0.81	-0.50	1.00							
Unidentified	0.93	-0.05	0.79	0.14	0.20	0.18	0.25	0.72	1.00						
LWR exponential value (*b*)	0.99	0.37	0.47	-0.28	0.58	-0.24	0.62	0.36	0.91	1.00					
Fultons condition factor (F)	0.99	0.19	0.63	-0.09	0.42	-0.06	0.47	0.53	0.97	0.98	1.00				
GSI of female	0.99	0.19	0.63	-0.09	0.42	-0.06	0.46	0.53	0.97	0.98	0.99	1.00			
Fecundity	0.94	-0.01	0.77	0.10	0.23	0.14	0.28	0.69	0.99	0.93	0.98	0.98	1.00		
Salinity (ppt)	0.19	0.99	-0.76	-0.99	0.92	-0.99	0.90	-0.83	-0.20	0.22	0.04	0.03	-0.16	1.00	
Avg. Rainfall (mm)	0.29	-0.81	0.97	0.86	-0.64	0.88	-0.60	0.99	0.63	0.25	0.43	0.43	0.60	-0.89	1.00

BGA, other algae, dinoflagellates and fish egg showed significant positive correlation with rainfall (r= 0.97, 0.86, 0.88 and 0.99; p<0.01 respectively) and those were negatively correlated with salinity (r= -0.76, -0.99, -0.99 and -0.83; p<0.01 respectively).

Pearson correlation study, as presented in Table 2, reveals that diatoms and green algae showed significant positive correlation with copepod (r= 0.55, p<0.05 and 0.97, p<0.01 respectively). Dinoflagellates showed similar with BGA (r= 0.74, p<0.01) and other algae (r= 0.99, p<0.01); while that showed significant negative correlation with copepod (r= -0.93, p<0.01) and green algae (r= -0.99, p<0.01). Diatom, green algae and copepod significant positive correlation with rotifer (r= 0.60, 0.96 and 0.99; p<0.01 respectively).

Diatoms showed significant positive correlation with exponential value of length-weight relationship (*b*) (r= 0.99, p<0.01) and condition factor (r= 0.99, p<0.01) of Indian mackerel. Copepods (r= 0.58, p<0.05) and rotifers (r= 0.62, p<0.01) have positive impact on fish health as BGA (r= 0.63, p<0.01) and fish egg (r= 0.53, p<0.05).

Mean length and weight of the studied samples were 22.79± 6.33 mm and 131.56± 13.00 g respectively. The calculated exponential value of length-weight relationship (*b*) ranged from 3.159 to 3.572 (average 3.316± 0.158). During pre-monsoon season the average was 3.392. In monsoon and post- monsoon season it was 3.354 and 3.204 respectively.

Fulton's condition factor ranged from 0.917 to 1.190, mean value being 1.067± 0.100. The calculated value of condition factor was 1.087, 1.086 and 0.923, respectively during pre-monsoon, monsoon and post- monsoon season (Fig. 8).

Gonado-somatic index (GSI) of female (Fig. 9) ranged from 1.339 to 4.477 (average 2.659± 0.950). Throughout the study period gravid ovary was observed. Fecundity ranged from 17,321 to 51,399 numbers; mean value being 34,778 ± 11,581 numbers. However, when plotted graphically two spawning seasons were detected. A minor peak was observed during the month of April and a major peak during August.

Diatoms, BGA and fish eggs had significant positive impact on fecundity and GSI (r= 0.94, 0.77 and 0.69; p<0.01 and r= 0.99, 0.63; p<0.01 and 0.53, p<0.05 respectively) of female Indian mackerel. Fecundity showed positive correlation with rainfall (r= 0.60, p<0.01). No significant correlation of GSI was observed with salinity and rainfall.

Discussion

Previous studies on feeding habit of Indian mackerel depicted it as an exclusively plankton feeder. Mackerel at Karwar was reported to feed on both phyto- and zooplanktons, and they were not at all carnivorous, but occasionally fish eggs were observed in the stomach[12]. Hardenberg[32] reported Indian mackerel as a surface feeder, while mackerel from Madras presidency was found to supplement its diet occasionally by feeding in the bottom on dead and decaying fishes[33].

The present study on feeding habit of Indian mackerel shows that it is a plankton feeder and feeds chiefly on diatoms, BGA, copepods dinoflagellates, rotifers, fish egg etc. Except dinoflagellates, all these have positive correlation with fish health. Higher density of these constituents provides better health condition and gonadal maturity of the fish.

Several authors have reported Indian mackerel as a selective feeder[19, 34]. According to them, Indian mackerel is able to distinguish between edible and non- edible algae, as they did not notice a single non- edible alga in the stomach content of the fish. In the present study also, no such non- edible algae was found. This corroborates with the earlier studies of the Indian mackerel being a selective feeder. Though in the west coast, piscivory was observed[35], no such record was found in the fishes caught along the east coast[18]. The present study also supports the non- piscivory feeding habit of Indian mackerel along the West Bengal coastal water.

Seasonal changes in feeding habit have been reported in different fishes[36-38]. Stomach content analysis of Indian mackerel from Kerala coast showed foraminifera, algae, sand and detritus as dominant stomach content during pre- monsoon season[39]. Copepod, crustaceans, and digested matter were in maximum abundance during the monsoon and post- monsoon seasons.

However, in the present study, percentage of occurrence of diatoms, green algae, rotifers and copepods are higher during the pre- monsoon season, while BGA, dinoflagellates etc. are found to be dominant all through monsoon season. *Bacteriastrum sp., Tetraselmis sp., Dicrateria sp.* (other algae group) are found to be maximum in percentage occurrence during post- monsoon season. Fish eggs are found throughout the year as a diet component but no trend has been observed regarding this. This indicates difference in feeding ecology of Indian mackerel in West Bengal coastal water compared to other parts of India which might have been influenced by

differences in availability. It proves adaptability of this fish to different ecological conditions.

The exponential value of LWR (*b*) reveals that Indian mackerel shows positive allometric pattern of growth, i.e. the weight increased faster than the cube of its total length. The condition factor depicts a good health condition of Indian mackerel as these values represent the general wellbeing of this fish[34].

Indian mackerel showed prolonged breeding in Mangalore- Malpe coast, since gravid ovaries had been encountered throughout the year[7]. The present study also supports this finding. However, peaks in spawning of Indian mackerel indicate two breeding periods. While a minor breeding period is observed during April, the major one is during August. Similar results had been reported from Kerala coast[39]. Diatoms, BGA, other algae group, copepod, and rotifers are found to be preferred food items during minor spawning season. During the major breeding period in August, dinoflagellates are found in addition to the other food constituents.

Conclusion

During the study period, Indian mackerel shows seasonal changes in feeding habit. Diatoms, copepod, rotifers, green algae are the preferred food items during the pre- monsoon season. Throughout the monsoon, BGA and dinoflagellates are preferred mostly as food constituents, while, the other algal groups are found to be dominant in the stomach content of the fish during post-monsoon season. Apart from diatoms; green algae, copepod and rotifers are more preferred during the minor breeding season. Dinoflagellates, BGA and other algae group are chosen over other food constituents during the major breeding season (August). The study shows a significant seasonal variation in feeding habit of Indian mackerel.

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