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BIOLOGICAL OBSERVATIONS IN INDIAN MACKEREL, *RASTELLIGER KANAGURTA* (CUVIER) 1816, (PISCES: SCOMBRIDAE) FROM EAST AFRICAN WATERS

J. R. KAMANYI

East African Marine Fisheries Research Organization, Mombasa, Kenya

INTRODUCTION

The Indian mackerel is a pelagic schooling species occurring mainly in shallow waters close to the coast off East Africa. Preliminary observations have shown that *R. kanagurta* is widely distributed along the entire eastern coast of Africa (LOSSE, 1974; MERRETT and THORP, 1965), with a spawning season off East Africa falling in the north-east monsoon period, September to February, and seasonal abundance coinciding with this spawning season (MERRETT and THORP, 1965). MERRETT and THORP (1965) reported the fish to be feeding mainly on small planktonic crustacea, with occasional traces of fish remains occurring in the stomachs. LOSSE (1974) noted that the quantity of mackerel in catches increased towards the end of the south-west monsoon period (September/October) and that the species remained abundant throughout the north-east monsoon (November/December through March/April).

Although no specific fishery for *R. kanagurta* exists along the East African coast, the species is an esteemed table fish and, together with *Sardinella*, forms a valuable resource both as a food fish and as bait for larger species. The present study was undertaken to provide further and more detailed information on the apparent seasonal and relative abundance of the species, food and feeding habits, spawning season and size composition. The incidence of parasites, in relation to the month of the year and the fish length, was also examined.

MATERIAL AND METHODS

Monthly samples of *R. kanagurta* were obtained through the period December, 1972, to November, 1973, with the exception of June and August, 1973. Catches were made off the East African coast between latitudes 06° 04′ South and 08° 17′ South (Figure 1A) from the R. V. MANIHINE of the East African Marine Fisheries Research Organization. Most of the fishing stations were located in shallow waters within five miles from the shore, in depths not exceeding 24 metres. In all, 38 subsamples from dipnet catches and 3 from handline catches were taken (Table 1). These comprised 840 specimens measuring 9.5 cm fork length and weighing 15 to 205 grammes fresh weight. One subsample was taken from a single catch at each station, on a monthly basis.

The fishing gear used was the stick-held dipnet (bouke ami) introduced into these

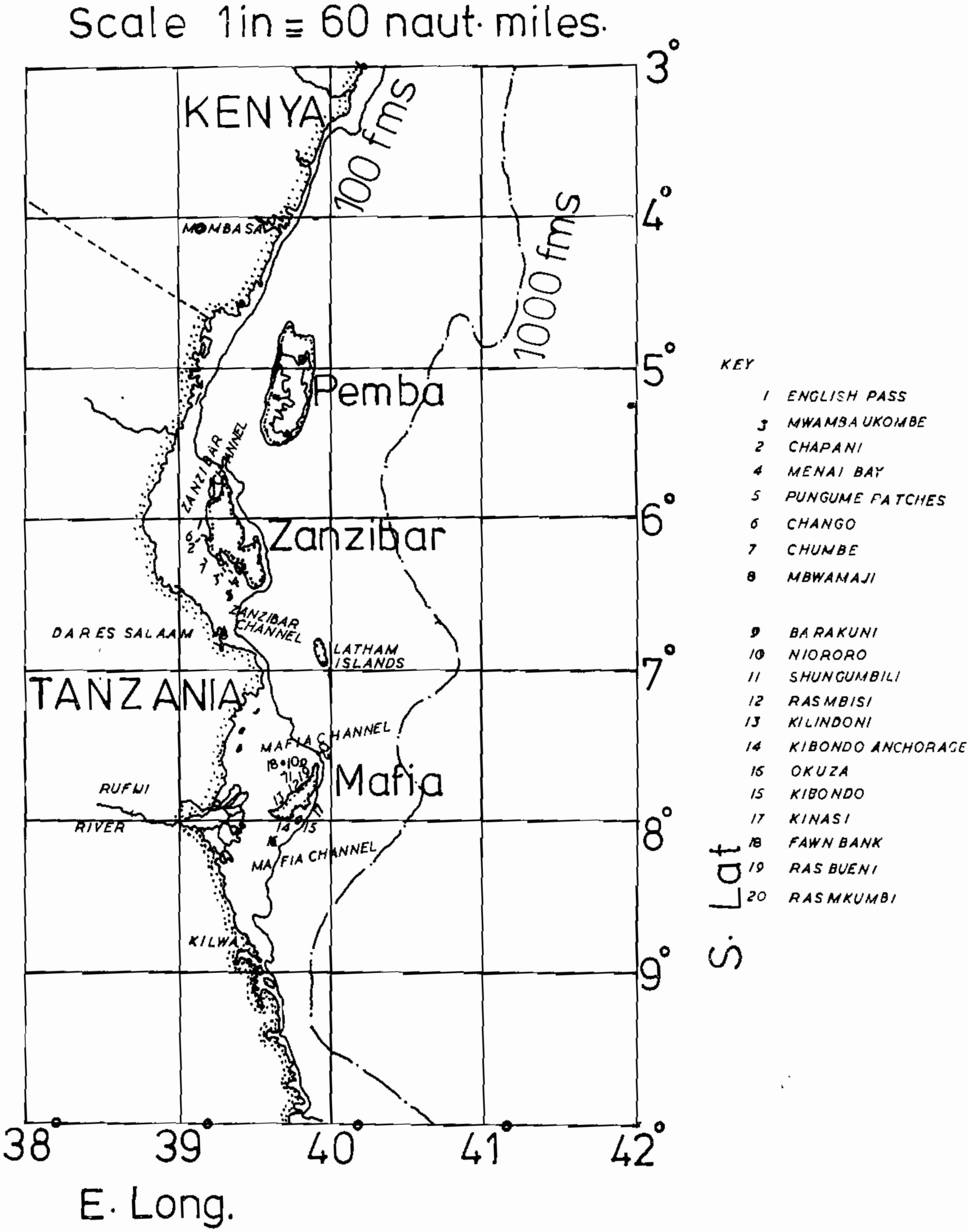

FIG IA. THE EAST AFRICAN COASTLINE STUDIED

Table 1. Dipnet Catches from R. V. Manihine during the Period December, 1972–November, 1973

	Location	Number of fish/operation (S. E. Monsoon)							Number of fish/operation (N. E. Monsoon)				
		Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Zanzibar Channel	English Pass					0				740		600	12
	Mwamba Ukombi		*							80		70	
	Zanzibar reef										1,251*		
	Pungume patches								7		1		
	Menai Bay	4			1		26	9					0
	Ras Chukwani	24 (H.L.) 923*											
	Chapani		50		30								
	Chumbe						0						
	Chango					0	21	2	628				
Dar es Salaam	Mbwamaji	600*			0		H.L. 83*	85* 35 (H.L.)	1,450*	69	202*	34	20

Table 1 *Continued*

	Barakuni									39			
	Okuza									0			
	Shungumbili									0	0		0
	Kinasi										21		
	Niororo										0	0	
Mafia	Kibonde enchorage	259*										612	
Channels	Kilindoni											280*	
	Fawn bank	0			14			0				0	
	Ras Mbisi												0
	Mkumbi	1					0	• 2					
	Kibondo				6		0						
	Ras Bueni						38; 830	520	600				

*Many fish around the ship.

H.L. = Handling.

waters from Japan by the East African Marine Fisheries Research Organization in 1965. Briefly, the fishing method depends on the gathering of small schooling pelagic fish to brightly illuminated areas on the darker nights. Descriptions of the fishing gear and the method of operation are given by CLELLAND (1972) and WILLIAMS (1974).

At each sampling station the prevailing weather conditions, water depth (sounding) and the number of mackerel caught was recorded. Fork length (L.F.) in centimetres, greatest body depth (cm) and weight (g) was observed for each fish in the fresh state, prior to the removal of the stomach. The stomach contents were then preserved in 5% formalin for subsequent analysis. The contents of each stomach was sorted and the food items identified in the laboratory. Food items were then estimated quantitatively and the point method was used. In this technique food items were allotted rank numbers or "points" depending upon abundance and size, then scaled down to percentage composition of food for all the fish examined. Essentially, this is an approximate volumetric method. Some items could not be fully identified due to partial digestion, thus losing identifying features.

All mackerel from the subsamples were examined for parasites. Parasitic cysts, mainly around the gut, were removed and preserved in 70% alcohol. Similarly, worms found embedded in peritoneal tissues and others loose in the body cavity were preserved for later identification.

Female gonads were examined for sexual maturity using the key given in JONES and ROSA (1965) for the stages of sexual maturity of *R. kanagurta.*

RESULTS

Apparent Distribution

Mackerel were caught off the coast during all sampling periods. The highest catch rates (number of fish/dipnet operation) occurred from September to February (Table 1). In September and October, large specimens measuring 17.0–23.3 cm (mean 19.1 cm) fork length represented 96.9% of the total examined. Few mackerel were caught in March, but dense schools occurred again in April. The period September to February corresponds to the north-east monsoon season when winds were generally light. The results show that Fawn Banks, Shungumbili, Niororo and Mkumbi were not favourable fishing grounds. Large schools occurred off Zanzibar harbour, Mbwamaji and Ras Bueni during most of the year.

Length Frequency distribution

The length frequency distribution of the 840 specimens measured is shown in Figure 1B. The frequency distribution is approximately unimodal, modal size 18.0/19.0 cm, median 16.0/17.0 cm, mean absence of mackerel measuring less than 9.0 cm fork length could be due either to absence of small fish from the areas fished or that below this length fish were not recruited to this fishery. The 16.8 cm, standard deviation 5.77 and standard error of the mean 0.20.

Weight-length and Weight-depth Relationships

The general weight-length and weight-depth relationships of mackerel, based on average weight, length and body depth values of samples from each station, with sexes combined, is shown in Figures 2 and 3. The weight-length relationship was calculated in the normal manner:

Log $W = \log a + b \log L$
where W = weight in grammes
L = fork length in cm

The calculated regression line, males and females combined, is as follows:

$$\log W = -2.3317 + 3.4443 \log L$$

SEKHARAN (1962), working in the Gulf of Mannar, gave the following regression equations for *R. kanagurta:*

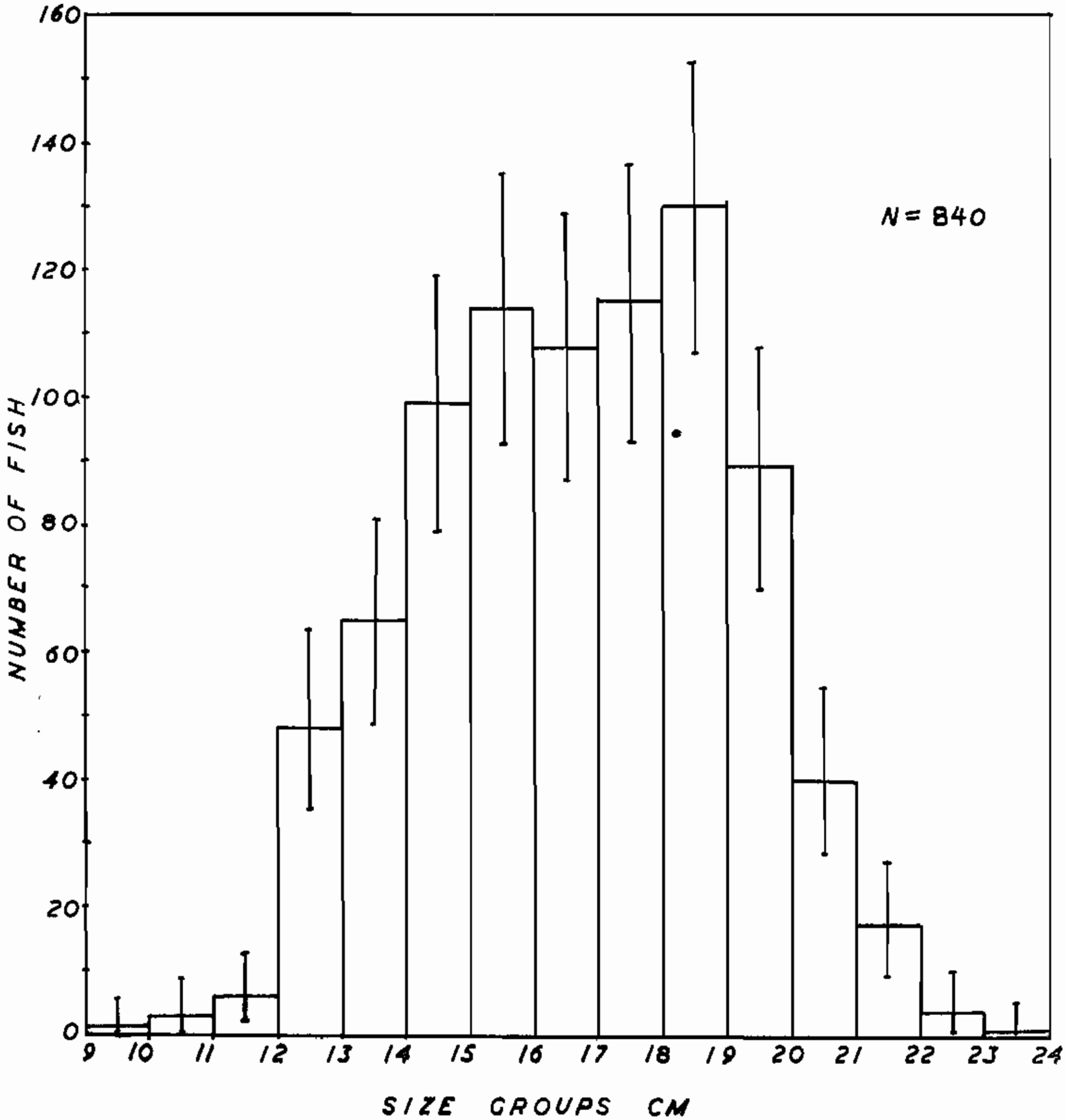

FIG 1B SIZE COMPOSITION OF THE MACKEREL (R. KANAGURTA) SHOWING THE 95% CONFIDENCE LIMITS.

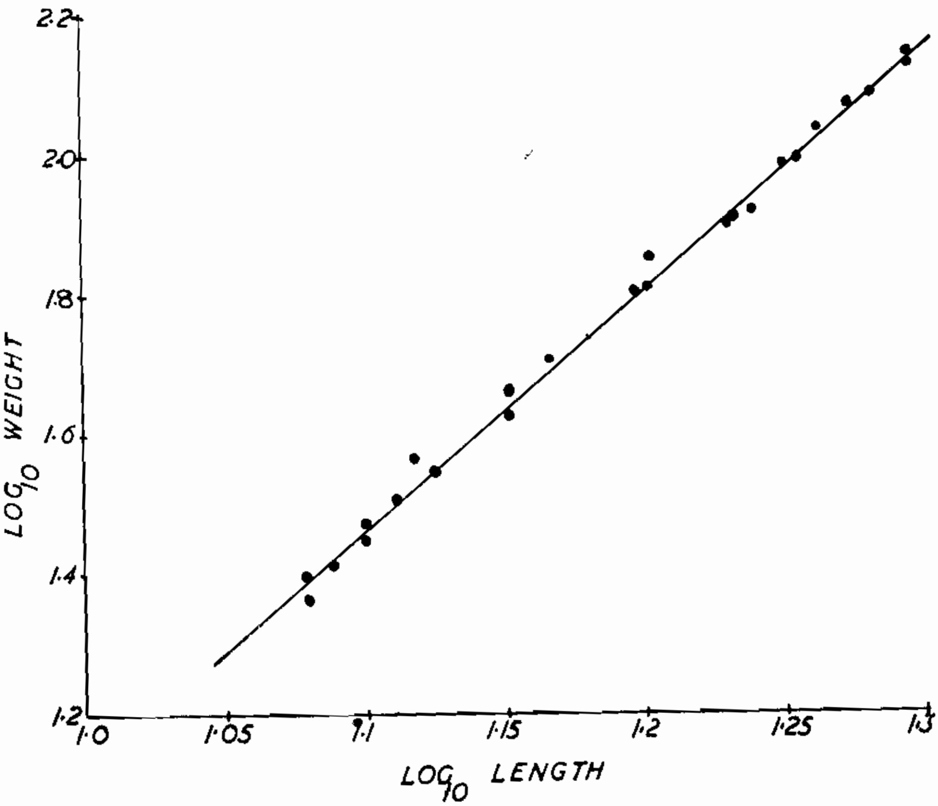

FIG 2. RELATIONSHIP BETWEEN LOG_{10} WEIGHT AND LOG_{10} LENGTH

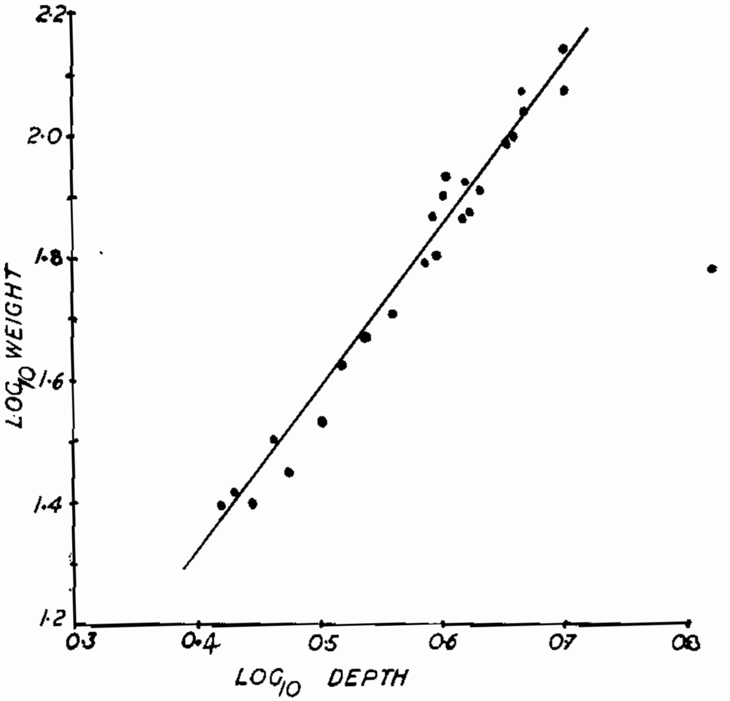

FIG 3. RELATIONSHIP BETWEEN LOG_{10} WEIGHT AND LOG_{10} DEPTH

day hauls—log W = $\bar{6}.2161$ + 3.3390 log L

night hauls—log W = $\bar{6}.5662$ + 3.1571 log L

where W = weight (units not specified)

L = total length (mm)

PRADHAN (1956) at Karwar obtained the following relationship for *R. kanagurta*:

W = 0.005978 × L3.1737

where W = weight (units not specified)

L = total length (cm)

For comparative purposes (Table 2), the Sekharan and Pradhan equations have been presented in the form: log W = log a + b log L. Direct comparisons of East African data with the Gulf of Mannar and Karwar equations are not possible since the latter were reported in terms of total length and again Sekharan reported total length in mm. However, a general resemblance can be seen.

Regression equations, exhibiting slight differences, for the same location in different months and different locations in the same month are shown as examples in Table 2. Application of a Null Hypothesis to the mean weights for further comparison and t-tests using P = 0.01 and 0.05, show that significant differences were found in four samples as shown below:

Location(s)	Year 1973 month(s)	Mean weight (g)	Degrees of freedom (N_1+N_2-2)	Significant at p = 0.01	Significant at p = 0.05
Mbwamaji	Feb. and Apr.	52.8 and 73.6	48	No.	Yes.
Mbwamaji	Feb. and Nov.	52.8 and 74.2	48	No	Yes
Mwamaji	Apr. and Nov.	73.9 and 74.2	58	No	No
Mwamba Ukomba and Mbwamaji	Feb.	52.8 and 33.6	38	Yes	Yes
Mwamba Ukombe and Kibondo	Feb.	51.2 and 33.6	48	Yes	Yes
Kibondo and Mbwamaji	Feb.	52.8 and 51.2	48	No	No

In the regression equations and results from the t-test differences between samples from various locations in the same season and from the same location at different seasons are detectable.

The regression line for log weight on log depth is as follows:

Log W = 0.2555 + 2.6597 log D

where W = average weight (g)

D = Average body depth (cm)

Sex and maturity: The occurrence of females in the majority was observed during September to December as follows:

	% males	% females
September	11.7	88.3
October	17.9	82.1
November	10.5	89.5
December	23.8	76.2

The majority of female gonads showed advanced stages of development (maturity) stages IV, V and a few in VIa and VIb).

In January, a few females had ripe gonads (Stage V) but the majority were in stage III to IV. Male gonads were not examined.

Food and Feeding

The results of the analysis of stomach contents is shown in Figure 4. Food items consisted almost entirely of crustacea (51.6%; decapoda, stomatopoda, amphipoda, crustacean eggs and egg cases and cepepoda), fish larvae (18.1%), small fish Dussumieriidae (8.1%) and Polychaetes (3.3%).

Table 3 shows the percentage composition of stomach contents for various months. Decapod crustacea, represented by *Leptochela*

Table 3. Percentage Composition of the Stomach Contents of the Indian Mackerel, *Rastrelliger kanagurta*, in Various Months

Year	1972	1973								
Month	December	January	February	March	April	May	July	September	October	November
Number of specimens examined	100	80	130	24	115	30	51	120	93	97
Mean volume (ml.)	3.1	1.3	1.6	2.2	1.7	5.1	1.2	3.8	2.2	1.0
Mean fresh body weight (g)	80.4	58.5	50.7	60.7	66.5	99.8	77.0	115.0	117.0	72.6
Mean vol. in ml/mean g fresh body weight (ml/g)	0.039	0.022	0.032	0.036	0.026	0.051	0.016	0.033	0.019	0.014
DECAPODS										
Shrimps (*leptochela*)	21.8	24.5	16.0	17.6	16.0	18.4	27.4	13.4	30.0	15.1
Phyllosoma, Brachyuran, Brachyuran (*megalopa*), *Zoea*, Poreellanid } larvae	7.9	10.4	7.6	8.8	14.6	10.7	19.3	10.7	16.8	10.9

Table 3 *Continued*

Eggs and egg cases	6.2	2.7	2.8	2.4	4.8	0	3.3	2.6	4.2	0.6
STOMATOPOD LARVAE	4.2	17.6	6.1	3.2	2.4	1.4	0.9	4.0	4.9	14.8
AMPHIPODS	2.2	11.8	6.1	13.6	12.0	11.2	11.8	6.6	10.6	10.0
COPEPODS	1.0	2.2	0.2	0	7.6	0.5	0.9	0.8	2.6	1.5
Dussumieria acuta	10.6	0.9	0	0	1.3	0	0	0.5	0	0.6
Spratelloides delicatulus	5.1	8.4	13.8	0.8	4.4	0	2.4	8.9	0.2	4.8
Unidentified fish larvae	15.4	1.5	16.4	40.0	13.8	55.0	18.4	28.0	12.8	13.8
Eel larva	3.2	0.2	0	0	0	0	0.5	0.5	0.9	0.3
Fish scales	16.6	14.4	26.3	12.8	15.2	1.4	13.6	6.1	6.2	21.5
Fish eggs	0	0	0	0	2.0	0	0	1.4	4.8	0
Squid and Octopus larvae	0.4	0	0.4	0	0	0	0	0.3	0.4	0
Gastropods	0.1	0.2	0	0	0	0	0	0.1	0.2	0
Elephant tusk shells	1.4	0.2	0	0	0.9	0	0	0	0.2	2.6
Polychaetes and Polychaete larvae	1.7	1.1	0.4	0	2.9	1.4	0.5	7.0	8.4	2.3
Marine Insects (*Holobates* sp.)	1.0	0	0.2	0.8	0.8	0	0	2.3	0.5	0.6
Tunicates	0.4	1.4	0.4	0	1.0	0	0	0.1	0.2	0
Jellyfish larvae	0.4	0.8	0	0	0	0	0	0	0	0
Soft corals	0	0.4	0	0	0	0	0.5	0.3	0.2	0.6
Sea weeds	0.4	1.3	3.3	0	0.3	0	0.5	0.3	1.8	0

Table 4. Relation of the Mean Volume of Stomach Contents to Length

L.F. (cm)	Number of fish	Mean volume per stomach (ml)	Standard deviation	Standard error of mean
10.1–12.0	9	0.356	0.450	0.159
12.1–14.0	113	0.872	1.022	0.096
14.1–16.0	213	1.640	1.477	0.100
16.1–18.0	223	2.070	1.819	0.122
18.1–20.0	219	3.017	3.570	0.243
20.1–22.0	57	3.847	3.160	0.422
22.1–24.0	5	1.180	0.483	0.242

sp., were very abundant throughout the period of observation but with seasonal and local variations. Decapod larval stages, such as the zoe, phyllosoma, megalopa, brachyura and porcellana were also represented throughout the period of observation.

Of the other important crustaceans, amphipods, represented mainly by *Hyperia galba* and *Tulbergella* were regularly represented. Stomatopod alima and erichthus larvae were also represented throughout the period of observation but not commonly as amphipods. Copepods contributed to a lesser extent to the stomach contents of the mackerel, as did crustacean eggs and egg cases. Other crustacea items of lesser importance were the mysids and euphausiids, the latter represented by *Pseudoeuphausia latifrons*.

Fish larvae were second in importance to crustacea as a food item. Fish eggs were occasionally represented. Small fish of the family Dussumieriidae were among the food items represented with *Spratelloides delicatulus* being more abundant than *Dussumieria acuta*.

Molluscs were a minor food element. Gastropoda rarely occurred, but Elephant tusk shells (*Laevidentalium subtorquitum*), squids and octopus larvae were occasionally represented in the stomachs.

Polychaetes and their larvae were present throughout the period December, 1972 to November, 1973, excepting March. Marine insects (*Holobates* sp.), eel larva, tunicates (represented by Thalia democratica), medusae, soft corals, sea weed stalks and diatoms were rarely found as constituents of the diet.

In addition to the items mentioned above, almost all the stomachs contained partly digested food material and in some stomachs all the items were completely digested. Fish scales including scales of mackerel, sardine and others which were not identified were commonly observed in the stomach contents of both small and large mackerel. The variations of the average volume of stomach contents on a monthly basis (Table 3) indicates that there are periods of active and periods of reduced feeding. The greatest mean volume per stomach (5.1 ml), for example, was noted in May from specimens taken off Zanzibar Harbour; the stomach contents contained almost exclusively fish larvae.

Table 4 shows the relation between the fork length of the fish and the mean volume of stomach contents. With an increase in fish length, a general increase in the mean volume of stomach contents, to a maximum of 3.85 ml in specimens measuring 20.1–22.0 cm, was evident, but a decrease was then noted in larger specimens.

Abnormally high volumes noted in some specimens, compared with some specimens from Karwar and Bombay, are shown below:

Fork length (cm)	Volume of Stomach contents (ml)	Location	Source
21.0	11.5	Zanzibar channel	This study
13.0	3.8	Barakuni channel	This study
Not given	3.5	Karwar	NOBLE (1962)
23.7	4.0	Bombay	KUTTY (1962)

The mean volume of stomach contents per unit of body weight for various length groups is shown in Table 5. A general increase in the volume of stomach contents per unit body weight with an increase in fish length, up to 0.03 ml. of food/gramme body weight in the 14.1–16.0 cm length group, and then a decrease in subsequent groups, is indicated.

Table 5. Relation of Mean Volume of Stomach Contents per Gramme body Weight (ml/g) to Length

L.F. (cm)	Number of fish	Mean weight (g)	ml of food per gramme body weight (ml/g)
10.1–12.0	9	20.889	0.017
12.1–14.0	113	32.458	0.027
14.1–16.0	213	53.498	0.031
16.1–18.0	223	81.101	0.026
18.1–20.0	219	113.556	0.027
20.1–22.0	57	152.793	0.025
22.1–24.0	5	175.200	0.007

Incidence of Parasites

Of the 840 mackerel examined, parasites were detected in 246 (29.3%) specimens. Considering the parasites by groups, 221 (26.3%) of the total specimens were infected with cestode cysts which occurred around the alimentary system. 63 specimens (7.5%) were parasitised by Isopods, which were attached to the gut or lying within the stomach. Only 18 (2.1%) mackerel contained a few adult cestodes or nematodes embedded in the peritoneal tissues, other nematodes oecurred free in the body cavity.

The percentage incidence of parasites by groups on a monthly basis is shown in Table 6. The greatest incidence of parasites was found in May specimens. The percentage incidence of parasites in relation to fork length is shown in Table 7. An increase in the percentage incidence of parasites with an increase in fish length was noted, except in the 22.1–24.0 cm group. No parasites were found in small fish measuring 8.1–12.0 cm. Numerous cestode scolices were recorded by DEVANSAN and JOHN (1940) at Madras from the pyloric caecae and gut of the mackerel. Trematodes and cestodes were also reported by RAO (1962) from Madras specimens.

Table 7, The percentage incedence of parasites in relation to fork length

L.F. (cm) group	Number examined	Percentage incidence of parasites
8.1–10.1	1	0
10.1–12.0	9	0
12.1–14.0	113	9.5
14.1–16.0	213	23.0
16.1–18.0	223	32.7
18.1–20.0	219	41.3
20.1–22.0	57	47.5
22.1–24.0	5	20.0

Table 6. Incidence of Parasites

Month/Year	1972	1973										
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
Number of mackerel examined	100	80	130	24	115	30	—	51	—	120	93	97
% infection (cestode cysts)	17.0	31.2	21.0	16.5	15.9	63.2	—	48.9	—	31.4	10.6	16.6
% infection (parasitic isopods)	1.0	0	0	0	35.0	50.0 •	—	5.9	—	19.2	10.6	7.2
% infection (cestodes/nematodes)	4.0	2.4	0	0	5.6	3.5	—	4.0	—	0	0	2.1

DISCUSSION AND CONCLUSION

The Indian mackerel occurred off the coast of East Africa during the period of observation (December, 1972, to November, 1973) and abundance of the species was marked from the end of south-east monsoon period (September/October through February).

A spawning season of the mackerel was indicated during the north-east monsoon period and coincided with the species abundance. The occurrence of females in the majority was observed from September to December and indicated that females probably aggregated for breeding purposes.

Food of the mackerel was mainly composed of crustacea and fish larvae. Fish scales observed in the stomach contents were probably either swallowed as they were shed from mackerel and sardine during capture, or were taken in along with the food. Feeding at the sea-bed has not yet been demonstrated but the presence of molluscan shells, tunicates and brachyuran larvae suggests that the mackerel may occasionally enter deeper waters or sandy bays for feeding.

Mackerel under the light actively preyed on small organisms by filter feeding and selective visual feeding for large items during the night. The quantity and quality of stomach contents varied with the season and location. With increase in fish size an increase in feeding intensity was apparent, followed by a decrease in the largest fish. The food and feeding habits discussed relate to the dip-netting technique and may not reflect the actual food and feeding habits of the fish under natural conditions, for the light produces an abnormal concentration of zooplankton, and, therefore, perhaps an unnatural choice of food. Cestode cysts were the main parasites of the mackerel examined; the greatest incidence of parasites occurred in the large fish. The occurrence of cestode cysts along the alimentary system seem to show that the mackerel is an intermediate host of cestodes.

SUMMARY

Rastrelliger kanagurta was abundant from the end of south-east monsoon (September/October) through the north-east monsoon period (November to February, and also in April) during the period of observation (December, 1972 to November, 1973). The highest catch rate, in terms of the number of fish caught per dipnet operation, occurred from September to February; large mackerel were caught in September and October. Abundance coincided with part of the spawning period (September to December), and the majority of female gonads showed advanced stages of gonad development (stage IV and V).

The length frequency distribution of 840 specimens was approximately unimodal, with a mean length of 16.8 cm fork length and standard deviation 5.77. The general regression equation for the weight-length relationship, sexes combined, was:

$$\text{Log } W = -2.3317 + 3.4443 \log L$$

and that for weight-depth was:

$$\text{Log } W = 0.2555 + 2.6597 \log D$$

Variation of the size of the mackerel from the same location during the same period and from different locations during the same season was detected.

Mackerel under the light at night were observed to feed actively on small organisms both by filter feeding and visual selection of large items. From the analysis of stomach contents, mackerel had primarily fed on crustacea (51.6%) and fish larvae (18.1%). The food items showed a real and seasonal variations.

A general increase in the mean volume of stomach contents with an increase in fish size was noted, but then a decrease was observed in larger specimens. The volume of stomach contents per unit body weight increased with an increase in fish size, up to 0.03 ml of stomach contents per unit body weight at 14-1-16-0 cm fork length.

Of the 840 mackerel examined, parasites

were found in 246 (29.3%) specimens. The commonest parasites were cestode cysts occurring around the alimentary system. The greatest incidence of total parasites was observed in May specimens. An increase in the incidence of parasites with increase in fish fork length, except in the 22.1–24.0 cm length group, was observed.

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