OBSERVATION ON THE FOOD OF DEEP SEA SHARKS *HALAELURUS HISPIDUS* (ALCOCK), *ERIDACNIS RADCLIFFEI* SMITH AND *IAGO OMANENSIS* COMPAGNO AND SPRINGER.

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ABSTRACT

The food and feeding habits of three deep sea sharks *Halaelurus hispidus*, *Eridacnis radcliffei* and *Iago omanensis* were studied based on the specimens obtained from trawl catches off Mandapam, Gulf of Mannar at a depth ranging from 150 to 200 fathom. The percentage of volume and occurrence of each item of food was found separately to determine the importance and abundance of the various food items in the diet of these sharks. They were found to be carnivorous, feeding chiefly on fishes, crustaceans and squids. Squids were conspicuously absent in the food of juveniles. An interesting phenomenon of segregation by sex was noticed in *H. hispidus* and *E. radcliffei* with the males dominating in the catches.

INTRODUCTION

A review of the literature on sharks from Indian region shows that the information on the biology of this group is scanty, being restricted to the studies by Aiyar and Nalini (1938), Mahadevan (1940), Sarangdhar (1943) Chidambaram and Menon (1946) and Setna and Sarangdhar (1948, 1948a, 1949, 1950). The available literature of feeding habits of sharks from Indian coasts is mainly on *Galeocerdo tigrinus* from Bombay waters (Sarangdhar, 1943), *Rhincodon typus* from Tuticorin (Silas and Rajagopal, 1963) and *Chiloscyllium indicum* and *Scoliodon sorrakowah* from trawl catches off Waltair (Rao, 1964). It would appear from the above references that very little work has been done on the food and feeding habits of sharks from the Indian region. Information on the deep sea sharks from Indian coasts is confined to the work of Alcock (1891, 1899), Misra (1950) Misra and Menon (1955), Silas *et al* (1969), Silas and Prasad (1969) and Nair and Lal Mohan (1971, 1972, 1973). These accounts deal mainly with the taxonomic details and distribution of various species. Our knowledge of the biology of deep sea shark is very meagre. Except for the note on food of *Iago omanensis* by Compagno and Springer (1971) there is no information on the feeding behaviour of *Halaelurus hispidus*, *Eridacnis radcliffei* and *Iago omanensis*. This paper deals with the feeding habits of the three species collected from south east coast of India.

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MATERIAL AND METHODS

The material for the present study was obtained from the deep sea trawl catches off Mandapam in Gulf of Mannar (08° 50. N, 79° 05 E), south east coast of India at a depth ranging from 150 to 200 fathom. Along with these sharks deep sea lobster *Puerulus sewelli*, prawns *Solenocera hextii*, *Heterocarpus gibbosus* and a variety of small fishes were caught from the locality. Lobster and prawns formed the bulk of the catch while sharks ranked first among the miscellaneous items. A total number of 241 specimens of *H. hispidus*, 318 *E. radcliffei* and 27 *I. omanensis* were examined for this study on the food and feeding habits. In evaluating the importance of the various food items volumetric method was found suitable. The different food organisms were sorted out and the volume of each item was determined. The data thus obtained are given in Table 1. The total volume of each item is expressed as

TABLE 1. *The percentage of volume and occurrence of different food items in* R. hispidus, *and* E. radcliffei I. omanensis

	Halaelurus hispidus(241)		*Eridacnis radcliffei* (318)		*Iago omanensis* (27)	
	of % volume	of % occurrence	of % volume	of% occurrence	of % volume	of % occurrence
Fishes:						
Myctophum sp.	13.4	8.9	14.6	10.8	2.0	7.4
Gonostoma sp.	4.3	3.1	2·1	3.1	—	—
Eels	1.2	1.0	1.0	0.3	—	—
Flat fishes	0.4	0.5	—	—	—	—
Unidentified and digested fishes	41.2	51.8	37.8	37.2	40.3	40.7
Crustaceans:						
Solenocera hextii	14.0	12.6	16.5	14.9	12.1	22.2
Alima of stomatopod	0.4	3.1	6.7	13.0	09	7.4
Zoea of crab	0.2	1.0	0.6	1.5	—	—
Digested crustaceans	1.5	6.3	4.4	13.6	—	—
Squids	17.5	16.9	13.7	11.2	31.4	11.1
Bivalves	—	—	0.6	0.3	4.9	3.7
Gastropods	0.2	0.5	—	—	0.9	3·7
Mud	5.6	5.2	2.0	1.5	7.2	7.4
Algae	0.1	1.5	—	—	0.3	3.7

percentage of the total volume of food from all stomachs examined for each species. The occurrence of each item is expressed as percentage of total number of stomachs examined. The occurrence of major food items *viz.* fishes crustaceans and squids is shown in Fig. 1. The sharks were broadly classified into juveniles and adults to determine the differences, if any, in the food composition. Well developed vasa deferentia and the presence of sperm in the sperm sac were the criteria followed in differentiating mature males while females with developed ovary and distended uterine tube were considered as mature females.

Halaelurus hispidus (Alcock)

A total number of 241 specimens ranging in size from 121 to 276 mm was examined to study the food and feeding habits. The analysis has shown that 57 stomachs were empty and the rest contained food in different stages of fullness. Detailed examination, revealed that *H. hispidus* is carnivorous, feeding mostly on fishes squids and crustaceans. A complete list of food items with their percentages of volume and occurrence is given in Table 1, which shows their relative importance. Generally food was found in a highly macerated conditon and most of the components were in advanced stages of digestion rendering the specific identification of the different items difficult.

Fishes constituted the major item of food and they formed 60.5% of the total volume of stomach contents. 72.6% of the stomachs examined had fishes as an important item of food and some of the common fishes observed were *Myctophun* sp., *Gonostoma* sp., flat fishes and eels. *Myctophum* sp. ranked high amongst the fishes and its volume percentage was 13.4%. *Gonostoma* sp. was found occasionally constituting 4.3 % of the total volume. Eels formed 1.2% and the percentage of flat fishes was very low being 0.4 % of the total food. Apart from these fishes there were other unidentified digested fishes, digested fish remains like fish bones, scales and eye lenses and these formed 241.2% of the total volume. Generally small sized fishes dominated in the food.

Squids ranked second in importance and they were also found to be in an advanced stage of digestion and consequently their identification was found difficult. Their percentages by volume and occurrence were 16.9% and 17.5% respectively. While taking the volume of squids the eye lenses of squids found separately in the food were also included.

The next important item of food of *H. hispidus* was the crustaceans including the deep sea prawn *Solenocera hextii* alima larvae of stomatopods, zoea larvae and other unidentified and digested crustaceans. They formed as much as 16.17% of total volume of food and their percentage of occurrence was 23%. *Solenocera hextii* showed a high percentage amongst the crustaceans constituting 14% of the total volume. Among the other crustaceans observed rarely, alima and zoea formed 0.4 % and 0.2% by volume respectively. The digested and unidentified crustaceans were 1.5 % of total volume including exoskeleton and broken appendages of prawns and other crustaceans.

Amongst the miscellaneous items of food, gastropdos formed 0.2% and sea grass 0.1% of the total volume. Mud was present in 10 specimens and formed 5.6% of total volume of stomach contents.

To determine the differences if any in the composition of the food elements in the juveniles and adults, the data were examined by separating the fishes into two

size groups, viz., 121 to 180 mm juveniles and 181 to 280 mm adults. It may be mentioned here that out of 241 specimens examined only 81 were females showing a preponderance of males in the ratio 2:1. Among the 81 females examined 26 specimens were immature. The food composition of the juveniles and adults shows intersting differences. In the adults, fishes dominated in the food followed by squids and crustaceans while in juveniles the crustaceans were found to rank first followed by fishes, whereas squids were conspicuously absent in the dietary. Significant differences in the feeding activity were also observed among the juveniles and the adults, fishes dominated in the food followed by squids and crustaceans while in juveniles the crustaceans were found to rank first followed by fishes, whereas squids were conspicuously absent in the dietary. Significant differences in the feeding activity were also observed among the juveniles and the adult. Out of 45 juveniles examined 14 were with empty stomachs, 14 with traces of food, 16 quarter full and 1 gorged with food. Among the 196 adults examined only 38 stomachs were empty while 22 showed traces of food, 44 stomachs were quarter full, 43 half full, 17 three fourth full, 23 were full and 9 were gorged with food. It is obvious from the above figures that there is high feeding activity among the adults compared with the juveniles which showed more empty stomachs than the adults.

Eridacnis radcliffei Smith

318 specimens of *E. radcliffei* measuring 131 to 211 mm in total length were examined in detail. 41 stomachs were found empty. The percentage of volume and occurrence of important food constituents for all the stomachs examined are given in Table 1. Fishes, crustaceans and squids formed the principal food items the percentage of occurrence of these items is shown in Fig. 1. As observed in *Halaelurus hispidus* the food items were in an advanced stage of digestion and hence specific identification was not possible.

In this species also, fishes ranked first in abundance constituting 55.4% of total volume of food and 58% of the total number of stomachs and of this food items *Myctophum* sp. dominated among the fishes and it formed 14.6% of the total volume of food. *Gonostoma* sp. and eels were occasionally encountered forming 2% and 1% of total volume respectively. Apart from these fishes the stomach contents of *E. radcliffei* included fish skeleton, scales, eye lenses and other unidentified and digested fishes forming 37.8% by volume.

Crustaceans constituted the next important food item forming 28.3% of the total volume of stomach contents and they occurred in 42.1% of the specimens examined. Crustaceans were mainly represented by deep sea prawn *Solenocera hextii* in considerable quantities and alima of stomatopod and zoea larvae in lesser magnitude. *S. hextii* formed 16.5% of the total voulme while alima of stomatopod constituted 6.7% and zoea 0.6%. Digested crustanceans including exoskeleton and broken appendages of prawn formed 4.4 % of food.

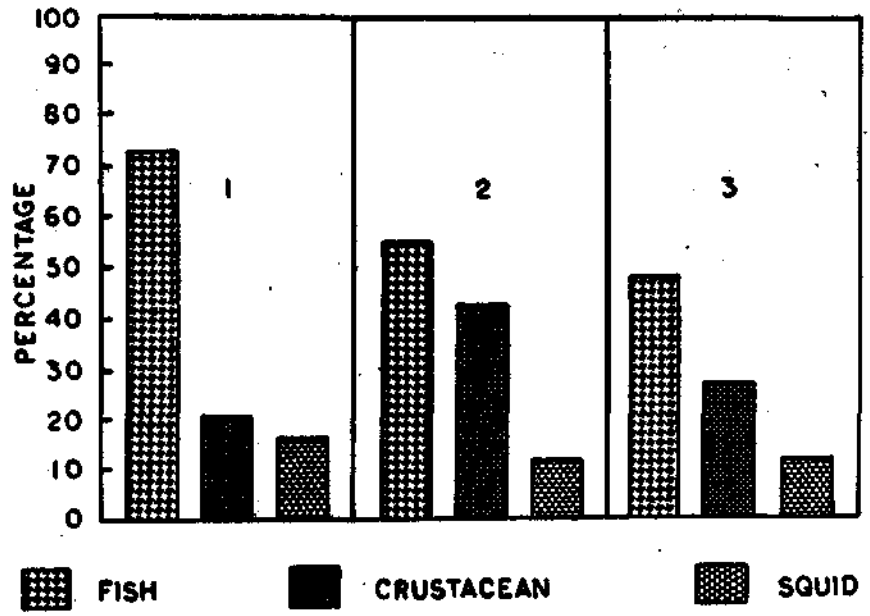

FIG. 1. Histogram showing the percentage occurrence of major food constituents in 1. *Halaelurus hispidus*, (2) *Eridacnis radcliffei* and (3) *Iago omanensis*.

Squids were the next important food of this shark and 36 stomachs of 318 examined showed this food item. Squids formed 13.7% of the total volume of stomachs examined.

Amongst the other recognisable food of this species bivalves, found in one stomach, formed 0.6% of the total volume, mud formed 2% of the total volume of stomach contents and was observed in 5 stomachs out of 318 examined. The comparatively low percentage of occurrence of the former shows that it does not form an important food of *E. radcliffei*.

Only three juveniles in the size group 131 to 170 mm were available and the chief food items noticed were fishes and crustaceans, while squids were not observed 315 adults with the size ranging from 171 to 211 mm were examined and found that the major food components of this group were fishes, crustaceans and squids. One specimen with a total length of 211 mm had traces of digested fishes alone in the stomach. As in the previous species, the feeding intensity is more in the larger size groups shown by the amount of food in juveniles and adults. In the juveniles the stomachs were either empty or with traces of food while many adult stomachs were either full or gorged. Out of the 315 adults 41 were empty, 93 with traces of food, 79 were quarter full, 58 half full, 19 three fourth full, 23 full and 2 gorged.

Iago omanensis Compagno and Springer

Compagno and Springer (1971) examined only two specimens of *I. Omanensis* and observed an unidentified fish estimated to be more than 200 mm long in the stomach as the only food item.

27 specimens ranging from 215 to 368 mm were examined for this study. As observed in *H. hispidus* and *E. radcliffei* fishes, crustaceans and squids formed the main food items of *I. omanensis* also. The percentage of occurrence of various food items of this species is shown in Table 1. Out of 27 stomachs examined 4 were empty and others were in different stages of fullness.

It can be seen from the Table 1, that fishes ranked in importance as food in *I. omanensis* also and their percentage of occurrence was 48.1% and the volume percentage was 42.3%. *Myctophum* sp. was the only fish which could be identified and this formed 2% of the total volume. Digested fish, which could not be identified owing to the advanced stage of digestion, formed 40.3% of the total volume of food. This also included fish bones, scales and eye lenses.

The next important food of *I. onanensis* were squids. They formed 31.5% by volume of total food and occurred in 11.1% of stomachs examined. The deep sea squids were the main constitutent.

Crustaceans ranked third in abundance as noticed in *H. hispidus* and the most important crustacean was *Solenocera hextii*. Crustaceans as a whole formed 13% of stomach contents and the percentage of occurrence was 25.9%. *S. hextii* alone contributed 12.1% of the total volume while alima of stomatopod constituted 0.9% only.

Miscellaneous items of food of this species were bivalves,gastropods and pieces of sea grass. Bivalves formed 4.9% of volume occurring in a single stomach while gastropod formed 0.9 by volume and sea grass recorded 0.3% of total stomach contents. Mud observed in two stomachs contributed 7.2% of food.

Examination of juveniles of this species ranging from 221 to 260 mm showed that squids were absent in all of them while in higher size groups it formed one of the important food items.

General Remarks

In the present study it is seen that the feeding habits of *H. hispidus*, *E. radcliffei* and *I. omanensis* are remarkably similar consisting of fishes, crustaceans and squids. Fishes rank first in abundance in all the three species and *Solenocera hextii* as a single item stood first among the crustaceans both in percentage of volume and occurrence. The food components are the same in juveniles and adults with the squids conspicously absent in the juveniles. It is evident that all the three species are carnivorous and the presence of mud, bivalve shells and gastropods indicate that they are occasional bottom feeders.

Bigelow and Schroeder (1948) observed that the chief food items of *Mustelus canis* (Family Triakidae) from Western Atlantic are larger crustaceans, with crabs of one species or the other ranking first. It also feeds on lobsters and constitutes perhaps the most destructive enemy. It feeds on whatever small fishes available and also on squids espacially in Spring. Molluscs, both univalve and bivalve and worms (*Nereis*) also form the food of *M. canis* in lesser magnitude. This shark consumes considerable quantitites of sea grass *Zostera* which the authors consider as accidental entry. In the case of *I. omanensis* Compagno and Springer (1971) have observed an unidentified fish alone as food. But in the present study, fishes crustaceans and squids are the principal food items in the same order of preference. Algae observed in *H. hispidus* and *I. omanensis* can be atributed as accidental entry since the percentage of volume and occurrence is very low being 0.1% and 0.3% respectively. Though *Puerulus sewelli* formed the bulk of the landings in the deep sea trawl from where the present material was also collected, in none of the specimens examined the spiny lobster was found to occur as a food item and unlike *M. canis* these sharks are not destructive to the lobster population. The occurrence of deep sea prawns Solenocera hextii in *H. hispidus* (12.6%), *E. radcliffei* (14.9%) and *I. omanensis* (22.8%) was high compared with all the other food items and this indicates that these sharks regularly feed on the deep sea prawn stock found in the environment.

An interesting feature noticed in the present study was the sex segregation in *H. hispidus* and *E. radcliffei* as evidenced by the dominance of males in the samples. In the former species 160 out of 241 specimens and in the latter 315 out of 318 were males. Ford (1921), while tracing the life histories of the dogfishes at Plymouth, observed a similar phenomenon and suggested that the size and sexual conditions are important factors in the constitution of shoals in dogfishes, the former probably being the more influential one. In *Squalus acanthias* Ford (1921) has observed four different types of shoals showing segregation by sex. Ford (1921) noted that in *Scyliorhinus caniculus* there is a curious alternating predominance of the sexes in the adults; in winter males were found to be the predominent sex whereas in summer females were numerous. Springer(1960) noted segregation of sexes in relation to depth and also to a certain extent to temperature in the case of the shallow water carcharhinid shark *Eulamia milberti*. Three theoretical explanations put forth by Springer for dominance of femals in the species are; mating pattern appears to be particularly dangerous to males, higher death rate for males and males occypying wider geographical and vertical ranges of distribution. Springer (1965) while reviewing the western Atlantic cat shark Scyliorhinidae suggested that the sexual segregation is true also of some of the cat sharks.

Ford (1921) noticed that in *Squalus acanthias* males and females were equally represented in the embryonic condition, but there was a tendency for segregation by sex in the adult sharks governed by factors like size and sexual condition. Springer (1960) observed, that, although approximately equal number of males and females

were born in *Eulamia milberti*, the catches indicate a much larger proportion of adult females than males. In the present study it is interesting to note that the males dominated in the population whereas the examination of 5 pregnant females of *E. radcliffei* showed that out of 8 embryos 6 were females and 2 males. However, in the absence of more data it is not possible to ascribe precisely the factors responsible for the dominance of the males and probably the segregation of sexes in *H. hispidus* and *E. radcliffei* is influenced by depth and sexual condition.

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