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FOOD AND FEEDING HABITS OF *Raja* SPECIES (BATOIDEI) IN THE MEDITERRANEAN WATERS OF ALEXANDRIA.

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ABSTRACT

The analysis of the stomachs of the following species of rays: **R. radula** D., **R. miraletus** L. and **R. clavata** L. revealed the following points; within each species the size group to a large extent preyed on different items. Between species, diets of **R. clavata** and **R. radula**, were the most similar. The youngest individuals of these three species fed upon small benthic or nektobenthic crustacea. Crustaceans mainly shrimps and crabs were important to all three species. Fish, although also consumed by **R. radula** and **R. clavata** were the predominant food of large **R. miraletus**. It is concluded that all three species of rays are partially indiscriminate feeders whose selection of food items is dependent on the availability of potential preys, their speeds relative to that of the preys and the structure of their mouth parts.

INTRODUCTION

The study of food and feeding habits of rays (genus **Raja**) have received more attention than any other biological aspect of these fish. Much work has been done on the feeding habits of rays in the western Mediterranean and north western regions of the Atlantic ocean (Day, 1880 - 1884); (Clark, 1922); (Steven 1930, 1932, 1947); (Du Buit, 1969); (Holden and Tucker, 1974); (Capape, 1975 a, b); (Capape and Azouz, 1975); (Quiniou and Andriamirado,1979) and (Ajayi, 1982).

However, there is still a lack of knowledge on the food and feeding habits of rays in the south-eatern Mediterranean. The present work is deemed necessary to fill this gap.

MATERIAL AND METHODS

The genus **Raja** is represented in the Mediterranean waters of Egypt (South-Eastern Mediterranean) by six species namely, **Raja miraletus** L.,**R. radula** D., **R. clavata, R. asterias** D., **R. montagui** F. and **R. circularis**

C. (Hussein, 1985). The present study was carried on the following three species which are the most common of the genus Raja in Alexandria waters, **Raja miraletus** Linnaeus, 1758, **Raja radula** Delaroche, 1809 and **Raja clavata** Linnaeus, 1758

Rays were obtained from professional fishermen in the region of Alexandria. Monthly samples were taken throughout the peroid from September 1984 to October 1985. From **Raja radula** 457 of the length range 7 cm to 67 cm, 320 **R. miraletus** of length range 11 cm to 83 cm and 121 **R. clavata** ranging from 17 cm to 60 cm total length were studied during the course of this study.

The total and gutted weight to the nearest gm, as well as total length to the nearest mm were recorded for each fish.

The stomach contents were rinsed in fresh water and identified to the lowest possible taxonomic category. A gravimetric determination was made on all taxonomic categories.

Four criteria were used in determining the importance of various food items eaten (Brook, 1985); 1. Simple enumeration of individual prey items; 2. The number of stomachs in which an item appeared (irrespective of its quantity), from which the frequency of occurrence was computed; 3. The total aggregate weight of that item found in all stomachs (expressed as percentage to the total weight of all food materials); and 4. The number of full stomachs from which the fullness coefficient was computed. Mouth index, was found for each fish. This was obtained using the formula, L_m / TL x 100 , where, L_m = length of mouth , and T.L. = Total lenbth of fish.

All data for each species were studied for combined sexes. No significant differences are known to occur, in stomach contents of males and females (Quiniou and Andriamiradc, 1979; Ajayi, 1982; Ezzat et al., 1986).

RESULTS

Raja radula D.

Raja radula is predominantly a crustacean feeder. As shown in Fig. (1), crustaceans constituted on the average 83% by weight of its diet varying between 90.4% in small fishes (<20 cm) and 73.2% in larger fish. On the average, members of this class occurred in 87% of the stomachs examined (Fig. 2). Of the crustacea, brachyuran crabs and the caridean shrimps were the most important. However, the abundance and weight percentage of crustacea varied with the size of the fish. Small crustacea like shrimps (Crangonids), Mysidacea and Amphipods constitute the main diet of smaller fish and their contribution to diet decreased gradually with the increase of fish size. On the contrary, the contribution of crabs (Portunidae) increased with increasing size of the predator fish (Figs.1 and 2).

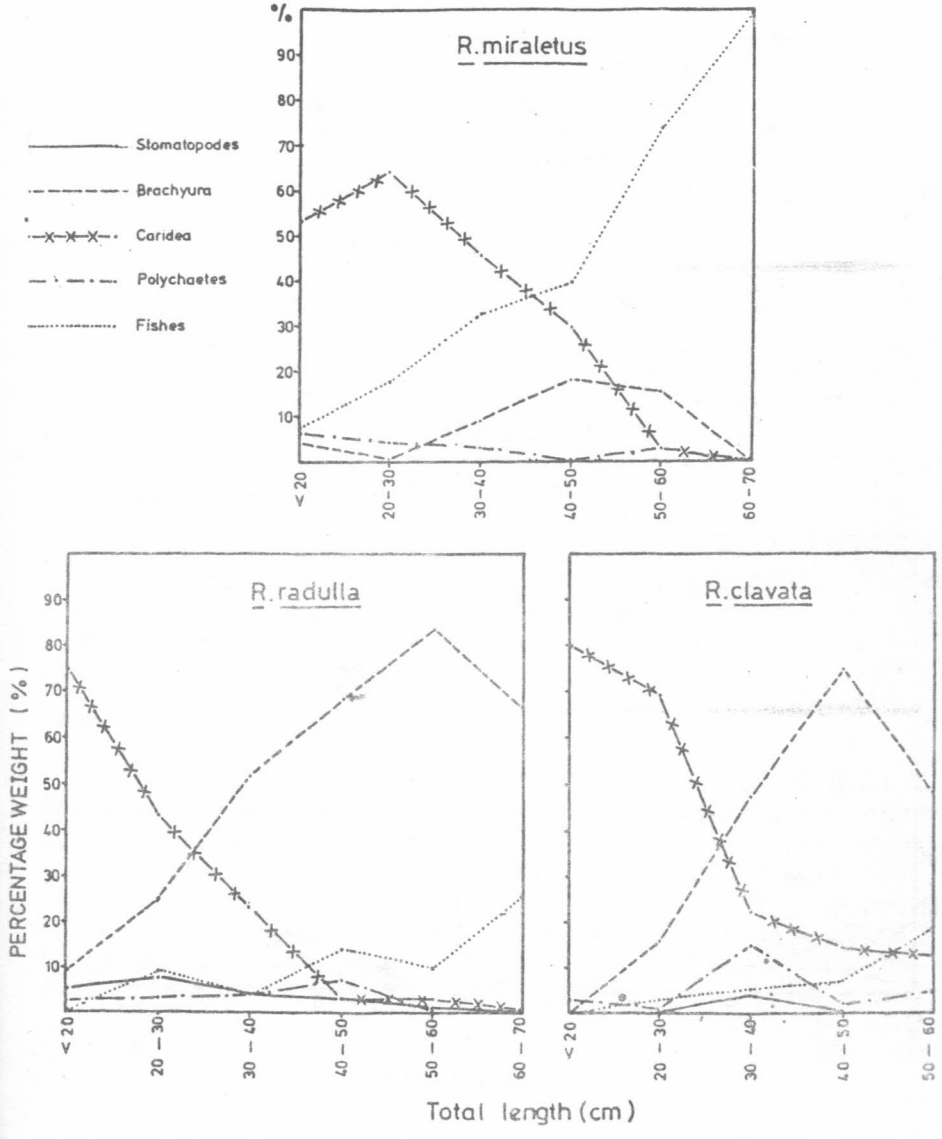

Fig. (1)
Percentage by weight of food items in the stomachs of **Raja** species.

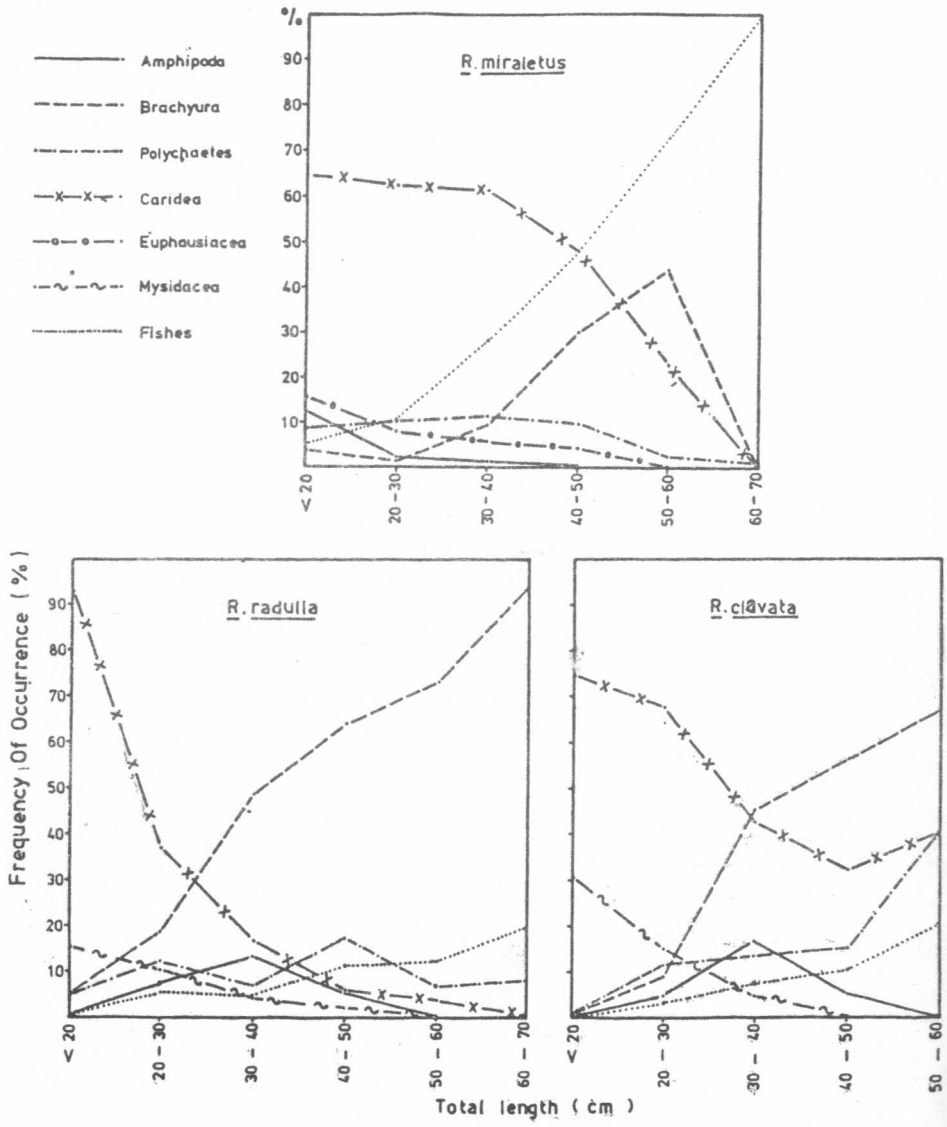

Fig. (2)
Frequency of occurrence (percentage) of food items in the stomachs of **Raja** species.

Fish constitute the second important food item occuring in about 10.3% of the stomachs examined and formed about 11.6% by weight of all food ingested. As shown in Figs. 1 and 2, the abundance of fish roughly increased with the size of the fish. Teleosts were represnted essentially by Trigliae and Soleidae which are favoured by larger fish.

Polychaetes mainly Nereids constituted on the average 3.2% by weight and showed no size preference.

Bivalvia (Donax) were rare and their average percentage did not exceed 1.3% by weight and were favoured by larger fish.

Figure (3) shows the seasonal variation of the food items injested by the species. Caridea and Brachyura by far dominated the food items injested in all seasons, though Brachyura was the leadering group with insignificant seasonal variations (mean 53.3% ± 2common6). Caridean shrimps on the other hand were particularly common in autumn and winter and less in summer. Mysidacea and Amphipods were particularly important in winter. No significant seasonal variations were observed in the frequency of occurrence of fish, polychaetes and molluscs.

The fullness coefficient (F.C.) of **Raja radula** was high in all seasons varying between 88% in autumn and 84% in summer with a mean of 86.5% (Table 1). With respect to the fish siz, the F.C. decreased more or less gradually with increasing size of the fish, it varied from 98% in fish with size <20 cm to 76% in large fish (>50 cm), (Table 2).

Raja miraletus L.:

The food preference of **R. miraletus** is rather different from **R. radula**. Crustacea and fish were the most dominent food items, both shared nearly equally 96.7% by weight of all food ingested, (Fig. 1). Crustaceans occured in 61% of the stomachs examined, (Fig. 2). Of the crustacea, the Caridean shrimps were the most important (23.3%) followed by Brachyuran crabs (19.6%). However, the abundance and weight percentage of both groups varied with the size of the fish. As in **R. radula**, shrimps (Crangonids) constituted the main diet of smaller fish and their contribution as diet decreased gradually with the increase of fish size. On the contrary, the contribution of crabs (Portunidae) increased with increasing size of the predator up to 60 cm., (Figs. 1 & 2).

Small crustacea mainly Amphipods, Euphausiacea and shrimps constituted the main diet of ray less than 20 cm. and occured in 93.4% of the stomachs of this length group, (Fig. 2).

Fish constituted the second important food item occurring in 44.2% of the stomachs examined and formed on the average 48% by weight of all food ingested. As shown in Figs. 1 and 2 the abundance of fish item clearly increased with the size of the fish, reaching 75% or more in large

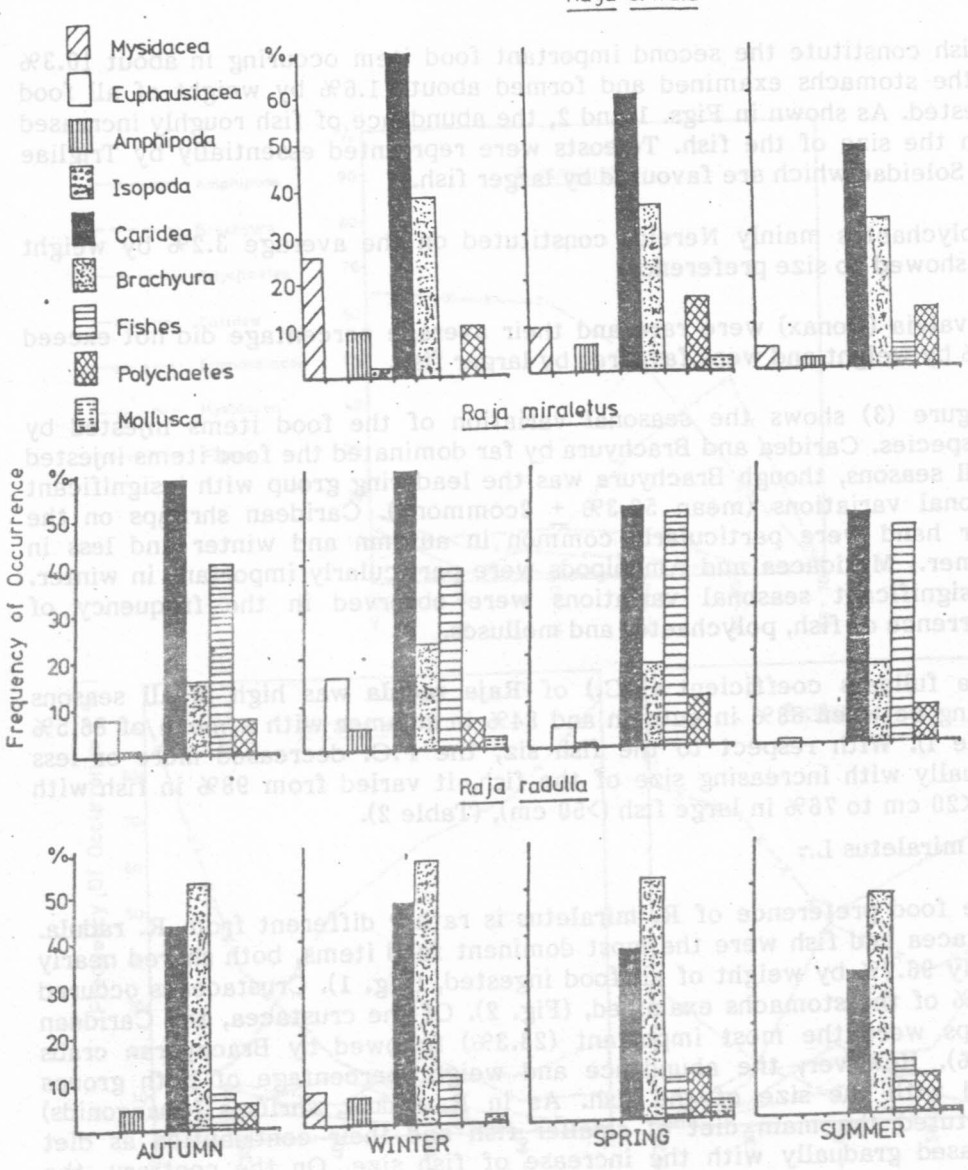

Fig. (3)

Histogram of seasonal variations in percentage fecundity of occurrence of the different food items ingested by *Raja* species.

Table (1)
Seasonal variation of fullness coefficient (%) of the different Raja species.

Species	Seasons			
	A	W	Sp.	S
Raja radula	88.16	87.21	86.22	84.24
Raja miraletus	91.61	100	94.81	80.83
Raja clavata	-	90.69	86.32	76.08

fishes (50 - 60 cm.). The food of **R. miraletus** larger than 60 cm. long is totally composed of fishes and rays became piscivorous. Sparidae (mainly **Boops boops**) and Gadidae (**Merluccius merluccius**) are important in smaller and median sized rays but the largest rays feed more on demersal fish, Pleuronectidae and Triglidae. The size of the consumed fish ranged from 3 to 21 cm. Small fishes were not mengled but larger round fish, such as Pleuronectidae and Soleidae were compressed perior to swallowing.

Polychaetes entirely Nereids constitute on the average 2% by weight and showed no size preference.

Cephalopods (**Sepia sp.** and **Octopus sp.**) were rare and their average percentage did not exceed 0.4% by weight and were recorded in larger fish.

Regarding the seasonal variation of the food items injested by **Raja** species, Caridea was the leadering group in all seasons (Fig. 3), its frequency varied between a maximum of 60.1% in winter and a minimum of 48.00% in summer. The small crustacea shrimps, Euphausiacea and Amphipods were particularly important in winter. Fish items came next in abundance with a maximum in spring (50.1%) and a minimum frequency in winter (38.80%). No significant seasonal variation was observed in the frequency of occurrence of Polychaetes and Cephalopods.

The fullness coefficient of **R. miraletus** was high in all seasons with a mean of 91.8%, varying between 100% in winter and 81% in summer, (Table 1). With respect to the fish size, the fullness coefficient slightly decreased with increasing size of the fish, it varied from 100% in fish with size <20 cm. to 90% in large fish (>50 cm.), (Table 2).

Table (2)
Summary of main variations in the frequency of occurrence of food items with increasing size of rays.

Food Items	Length Groups (cm.)								
	Raja radula			Raja miraletus			Raja clavata		
	<20	20-50	≥50	≤20	20-50	>50	<20	20-50	>50
Generally decreasing frequency of occurrence with increasing size of rays:									
Shrimps	94.05	21.13	4.31	64.90	58.16	22.73	75.33	48.04	40.66
Amphipods	0.05	8.46	0	12.16	1.72	0	0.35	9.57	0
Mysidacea	14.76	5.66	0				30.92	10	0
Euphausiacea				16.38	6.40	0			
Isopoda							0.85	3.57	0
Stomatopods	1.66	2.86	0.42	0	1.07	0			
Always increasing frequency of occurrence with increasing size of rays:									
Crabs	3.57	43.19	78.52	4.05	13.64	40.94	0	37.02	68.20
Pisces	0	6.89	15.49	6.05	29.94	86.12	0	7.42	21.52
Mouth Index	1.23	2.51	3.61	1.63	2.91	4.1	1.15	2.31	3.21
Fullness Coefficient	97.62	89.54	76.25	100	96.09	90.31	90.67	85.19	75.62

Raja clavata. :

Raja clavata is predominantly a crustacean feeder (Figs.1 and 2). Crustaceans constitute on the average 87% by weight of its diet (Fig. 1). Members of this class occurred in 93.6% of the stomachs examined. Of the crustacea, brachyuran crabs and the caridean shrimps were the most important. However, the abundance and weight percentage of both group varied with the size of the fish. Shrimps constituted the main diet of smaller fish, and their contribution as diet decreased gradually with the increase of fish size, (Fig. 1). On the contrary, the contribution of crabs increased with increasing size of the predator fish. It seems that the individuals less than 20 cm, total length, hunt first active preys like Mysidacea and shrimps and then consume crawling preys like amphipods and isopods (Fig. 2).

Polychaetes, mainly Nereidae and Sabellidae, constitute the second important food item, occurring in 13.5% of the stomachs examined and formed on the average 6.3% by weigth of all food ingested. As shown in Fig. 2, the abundance of polychaetes roughly increased with the size of the fish.

Fish, mainly Triglidae and Sparidae, constituted on the average 5.4% by weight and occurred in 8.8% of the stomachs examined; their importance clearly increased with the size of the fish.

Cephalopods (Sepia sp.) were rare and their occurrence did not exceed 0.5%.

As shown in Figure 3, Caridea and Brachyurans by far dominated the food items ingested in all seasons, with caridean shrimps the leadering group. However the abundance of these shrimps showed a slight decrease in summer. Mysidacea and amphipods were particularly important in winter and their abundance decreased successively reaching its minimum in summer. No seasonal variation was observed in the abundance of fish and polychaetes.

The fullness coefficient of Raja clavata was highest in winter (90.69%) and least in summer (76.08%), (Table 1). With respect to the fish size, the Fullness Coeffitient decreased more or less gradually with increasing size of the fish, it varied from 90.67% in fish with size <20 cm to 75.62% in large fish, (>50 cm.), (Table 2).

Mouth Index:

In order to have a good understanding of the relation between fish size and ingested food size, we made some measurements on mouth index. This index varies between 1.23 and 3.61 for R. radula and 1.63 to 4.1o for R. miraletus and 1.15 to 3.21 for R. clavata. Table (2) shows clearly that these indices increase with fish length.

DISCUSSION

The most common food items recorded in rays from Alexandria water are crustaceans, fish, polychaetes and molluscs. This accords with the results of studies made on various Raja species elsewhere (Steven, 1930; Lazaretto, 1964; Du Buit 1968, 1969; Holden and Tucker, 1974; Capape 1975 a, b; Capape and Azouz 1975; Ajayi 1982).

The analysis of injested crustacea in the stomachs of Raja species indicate that smaller rays feed on small crustacea like shrimps, amphipods, Mysidacea and Euphausiacea. Adult fish feed mainly on crabs and fishes (Table 2). The present results indicate that the three species of rays, although they are feeding primarily on benthic species, they can feed on semipelagic fauna as they become larger. Larger fish show increasing ability to catch more active prey, not only fish but the larger active crustacea, such as Portunus spp.

On the other hand, it was found that smaller fish feed on small preys and the size of their preys increasing more or less gradually with the size of the fish. This may be correlated with the mouth index as shown in Table 2.

Several authors mentioned that young rays feed on small crustaceans such as Mysidacea, amphipods and crangonids and later changed to crab such as Upogebia.spp. and Portunus spp, the adults were highly piscivorous and sometimes cannibalistic (Clark, 1922; Steven, 1930, 1932, 1947; Kalmijan 1966; Du Buit 1969; Holden and Tucker, 1974; Quiniou and Andriamirado 1979 and Ajayi, 1982).

In the Mediterranean, Capape (1975 a) and Capape and Azouz (1975) found that in Tunisian waters, young R. miraletus feed on small crustacea, teleosts and molluscs while older fish consume mostly teleosts.

The present study has confirmed the dietary similarity between Raja radula and R. clavata (crustacean feeder) a condition which may reflect the similarty in teeth structure and the habitats favoured by the two species. The diet of both species in general is composed of crustacean organisms. The use of smaller fish as diet start to feature in young rays. It is a more predominant constituent of the diet of Raja miraletus.

Clark (1926) recorded differences in the teeth structure of Raja clavate, R. montagui, R. naevus and R. brachyura which is apparently reflected on the general type of food upon which they can feed. Du Buit (1968) has mentioned the presence of sexual dimorphism in the form of teeth in Raja montagui where the male have pointed teeth and hence feed more on fish than the female.

In the present study, all **Raja clavata** and **R. radula** which we have examined (both males and females) have flat, pavement-like teeth in the upper jaw adapted for crustacea feeder while **R. miraletus** have pointed teeth. This clearly explains the preponderance of fish diet in **R. miraletus.**

Regarding the seasonality of the different diet components, caridean shrimps, Mysidacea, Euphausiacea and amphipods were important in winter. Brachyuran crabs were eaten with no seasonality. No significant seasonal variation in frequency of occurrenec of fishes, polychaetes and molluscs was noted. These data may be in accordance with some authors who stated that seasonal variation in the diet of rays may depend on food availability. (Steven, 1930; 1947; Holden and Tucker, 1974; Ajayi, 1982).

Steven (1930) found that Ampelisca (amphipoda) eaten in winter was almost entirely replaced by megalopa larvae of Corystes in summer in the stomachs of both **Raja clavata** and **R. montagui.** In the stomachs of **R. clavata** pandalidae, occuring in winter was largely raplaced by Galathea in summer. Capapa (1975 b) concluded that there are no important seasonal variations in the nutrition of **Raja clavata, R. montagui** and **R. microocellata** found that crangon and brachyurans were eaten with no seasonality. Mysidacea were important from October to December and pandalidae from October to February.

The present study indicates that the three species of rays are voracious. The stomachs of over 80% of fish examined contained food (Table 2). The intensity of feeding showed a slight decrease during summer which coincides with the spawning season in these species. In many rays the feeding intensity decreases gradually during the spawning season (Capapa 1974; Capapa and Quignard, 1974; Ajayi, 1982 and abd El-Aziz, etal., 1986).

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