FEEDING HABITS OF THE BIGEYE SCAD, *SELAR CRUMENOPHTHALMUS* (CARANGIDAE), IN LA RÉUNION ISLAND WATERS (SOUTH-WESTERN INDIAN OCEAN)

by

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ABSTRACT. – *Selar crumenophthalmus*, the bigeye scad, is a coastal pelagic fish, which feeds mostly at night on large planktonic animals. Young scads prey mostly on crustaceans (euphausiids, decapods) and adults are active predators of fish larvae and early juveniles. The large size of the eyes could be an adaptation to night predation.

RÉSUMÉ. - Comportement alimentaire du pêche-cavale, *Selar crumenophthalmus* (Carangidés) sur les côtes de La Réunion (sud-ouest de l'océan Indien).

Selar crumenophthalmus est un poisson pélagique côtier prédateur qui se nourrit, surtout la nuit, de la fraction la plus grosse du plancton. Les jeunes individus consomment principalement des crustacés (Euphausiacés, Décapodes) et les adultes sont surtout prédateurs de larves et juvéniles de poissons. La grande taille des yeux pourrait être une adaptation à la chasse nocturne.

Key words.- Carangidae - *Selar crumenophthalmus* - ISW - La Réunion - Feeding - Predation - Diet.

The bigeye scad, *Selar crumenophthalmus* (Bleeker, 1861), is a small coastal pelagic fish, which is common in the tropical and subtropical belt of all oceans. This species is fished either for human consumption or as bait for tuna fishing. In some places it can be of major importance to fisheries and seems to be especially important in the coastal waters of islands with no continental shelf and no large populations of clupeids. This is the case in La Réunion Island where it is the most important small pelagic fish, with the annual catch estimated at 100 tonnes.

The biology of the bigeye scad has been studied in many different countries, the most recent of which were conducted in Hawaii (Clarke and Privitera, 1995, Iwai *et al*., 1996) and the Philippines (Dalzell and Penaflor, 1989). Some other studies on coastal pelagic fisheries include this species, but little research has been carried out on the ecology of the bigeye scad. In 1994, Roux studied the growth and biology of the bigeye scad, showing that, in La Réunion Island, this species has an annual reproductive cycle. Spawning occurs mostly from October to December with the legth of one-year old individuals averaging 215 mm (fork length). Few survive longer than one year.

The importance of the bigeye scad in the food chain of coastal areas and the prospect of possible culture development prompted this detailed first studyinto the nutrition and feeding behaviour of that species.

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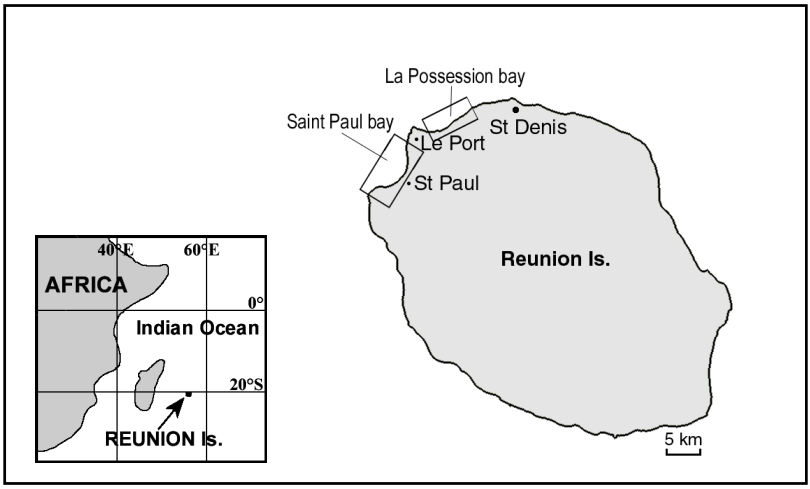

Figure 1. - Location of La Réunion Island and of sampling stations.

MATERIAL AND METHODS

SAMPLING AND PREY ANALYSES

Bigeye scads were sampled from catches in two locations where the fishing gear is different (Fig. 1). At night, in the Bay or in the harbour of La Possession, fish are attracted by light and caught with lines from a skiff. In Saint Paul Bay, scads are caught during the day, usually in the morning, with a beach seine. Although sampling of fish caught with a beach seine is relatively simple, the fish usually remain at least one hour in the net during the fishing operation during which time regurgitation may occur, biasing the observations. Therefore, only samples resulting from very fast operations were used for this study.

The content of a total of 182 stomachs was examined. For hand line night fishing, between 4 and 5 a.m.,a total of 138 scads were collected, from February to May. For beach seine during the light, between noon and 2 p.m., 44 scads were collected in 4 samples at various months of the year.

Fork length was measured, and stomachs - from oesophagus to pylorus - were collected from freshly killed fish. They were preserved in 8% formalin. The number of stomachs of each sample varied between 15 and 20. This sample size is recommended by Bell and Harmelin-Vivien (1983) who showed that beyond this number no new prey category usually appears and the diversity index reaches a platform. The different prey categories were sorted by taxonomic groups for each stomach's contents and further determination was made whenever possible.

For prey counting, each individual was considered as an item, except for colonial organisms or algae, which were counted as one item per colony. Unidentifiable prey fragments found in stomachs were also considered as one item. Each prey category for each stomach was weighed separately, at a precision level of 0.1 mg. This wet weight was measured after wiping the prey on soft filter paper, as recommended by Windell (1971). Using that wet weight allows for a better account of the real bulkiness of prey items in the digestive tract.

Feeding activity

Various methods can be used to estimate the feeding activity. Basic information is given by the percentage of empty stomachs, E_r :

E_r = 100 x number of empty stomachs / number of stomachs sampled

Other useful information is the repletion level of the stomach of fish, given by the repletion index, Ri :

Ri = 100 x weight of stomach contents (g) / fork length of fish (mm)

This index was originally defined by Berg (1979), who used the weight of the fish instead of its fork length. The use of length avoids the influence of the fat level, the state of the gonads and the weight of the food in the stomach.

Determination of diet

Three primary indices N, W and P were calculated for each prey item (I) and for each size class of fish:

N_I = 100 x number of individuals of item I / total number of prey

W_I = 100 x weight of one item I / total weight of prey

F_I = 100 x number of stomachs containing item I / number of non empty stomachs examined

Following Zander (1982), the Main Food Item index (MFI) which combines these 3 indices, was used for each item :

$$MFI_I = \sqrt{\frac{N+F}{2}} \times W$$

The use of this index was improved by Rosecchi and Nouaze (1987) in the following way. The MFI was summed and for each prey item was expressed as the ratio (%) of the total. Prey items are then classified by decreasing relative values and cumulated ratios are calculated. From these cumulated ratio, they proposed the following classification:

main prey:	the prey of the first rank, and cumulated ratio MFI < 50%
secondary prey :	cumulated ratio MFI between 50 and 75%
accessory prey :	cumulated ratio MFI > 75%

RESULTS

Feeding activity

Fish caught during the day often have empty stomachs with a mean empty ratio of $E_{r\ (day)} = 88 \pm 32\%$, confidence interval at $\alpha = 0.05$. At night most of the fish have food in their stomachs and the mean empty ratio is $E_{r\ (night)} = 11 \pm 8\%$. Considering the non empty stomachs only, the mean repletion index with confidence interval at $\alpha = 0.05$, is $Ri_{(day)} = 0.02 \pm 2\%$ during the day, and $Ri_{(night)} = 0.49 \pm 10\%$ at night. These two results show that most individuals are feeding actively at night.

Diet

The food found in the stomachs was only composed of pelagic animals. No mineral material (sand, shell fragments), algae or benthic animals were found. Ten prey categories were observed (Table I). The analysis shows that the diet composition varies with scad size. Hence MFI was computed by size classes with 20 mm intervals. Preliminary results showed that some size classes have similar diets and could be pooled. Three size classes were retained: 100-119 mm, 120-159 mm, 160-219 mm. The contribution of each category, expressed as percentage of total MFI and cumulated MFI are given in table II. It appears that: (1) small scads feed mainly on euphausiids, shrimps and crabs, (2) crab and fish are the main preys of medium size fish, and (3) fish are the main preys of the larger individuals (Table III). Shrimps and other crustaceans are the secondary categories of prey in all size classes.

The fish found in stomach contents were mostly juveniles of clupeids and pelagic post larvae of balistids and serranids. Their size was usually between 1 and 5 cm. The crabs were megalops larvae of various unidentified species. All the other food items were also pelagic animals from the macroplankton.

DISCUSSION

The study of feeding activity of *Selar crumenophthalmus* in La Réunion Island, shows that empty stomachs are common during the day but not at night, indicating that the bigeye scad mainly feeds during the night. The same observation was made in Hawaii by Kawamoto (1973) and by Tobias (1987) in the Virgin Islands. Pillay (1952) stressed the fact that the stomach repletion level can be biased by the sampling method because fish can regurgitate, or ingest food during capture. Given that night samplings using line and hooks do not show regurgitation, the observation of night feeding cannot be refuted. For fish caught with the beach seine, there is no proof that there is no regurgitation and the assumption of little feeding during the day has still to be investigated.

Table I. - Prey items found in the stomachs of *Selar crumenophthalmus* in La Réunion Island.

Prey items	Mean weight (g) with confidence interval at $\alpha = 0.05$	Remarks
Fish	0.457 ± 0.090	Mostly, larvae and juveniles of fish: Clupeidae, Balistidae, Serranidae, Leptocephals.
Crab larvae	0.041 ± 0.009	Planktonic megalops.
Euphausids	0.009 ± 0.002	
Shrimps	0.070 ± 0.024	Swimming species of decapods.
Stomatopods	0.214 ± 0.026	Planktonic larvae of Squillidae.
Amphipods	0.004 ± 0.001	Planktonic animal living in patches; only 4 occurrences, but great number of individuals.
Crustacean fragments	0.101 ± 0.021	Mainly chitinous debris.
Coleoptera	0.018 ± 0.001	From terrestrial origin.
Cephalopods	0.293 ± 0.061	Mostly octopus.
Unidentified	0.132 ± 0.059	

Night feeding is not common for epipelagic fish although it is not an exception. Small plankton feeders, like sprats and anchovies, can feed at night (Milton et al., 1990). Predators like tunas and large pelagic fish, usually do not prey at night (Reintjes and King, 1953; Buckley and Miller, 1994), because these fish need to see their prey for the chase (Marsac and Cayré, 1998).

Table II. - Prey classification obtained with the Main Food Item index (MFI) in the three defined size classes of *Selar crumenophthalmus* in La Réunion Island.

100-119 mm (n = 8)	**MFI**	**% of total MFI**	**% of cumulated MFI**
Euphausiids	0.715	59.6	59.6
Shrimps	0.152	12.7	72.3
Crab larvae	0.119	9.9	82.1
Stomatopods	0.095	7.9	90.1
Crustacean fragments	0.071	5.9	96.0
Unidentified	0.049	4.0	100
Fish	0	0	100
Amphipods	0	0	100
Coleoptera	0	0	100
Cephalopods	0	0	100
120-159 mm (n = 59)	**MFI**	**% of total MFI**	**% of cumulated MFI**
Crab larvae	0.345	28.8	28.8
Fish	0.214	17.9	46.7
Shrimps	0.176	14.7	61.4
Euphausiids	0.155	13.0	74.4
Crustacean fragments	0.110	9.2	83.6
Stomatopods	0.104	8.7	92.3
Cephalopods	0.046	3.5	95.8
Unidentified	0.042	3.8	99.6
Amphipods	0.002	0.2	99.8
Coleoptera	0.002	0.2	100
160-219 mm (n = 63)	**MFI**	**% of total MFI**	**% of cumulated MFI**
Fish	0.464	40.1	40.1
Crab larvae	0.200	17.2	57.3
Shrimps	0.140	12.1	69.3
Crustacean fragments	0.120	10.4	79.7
Cephalopods	0.076	6.6	86.3
Stomatopods	0.062	5.4	91.7
Unidentified	0.052	4.4	96.1
Amphipods	0.036	3.1	99.3
Euphausiids	0.007	0.6	99.9
Coleoptera	0.002	0.1	100

Table III. Main and secondary preys in the three size classes of the *Selar crumenophthalmus* in La Réunion Island.

Size classes	**Main prey categories**	**Secondary prey categories**
100 - 119 mm	Euphausiids	Shrimps
120 - 159 mm	Crab, fish	Shrimps, euphausiids
160 - 219 mm	Fish	Crab, shrimps

Exceptions however were observed, when there was a bright moon light, which confirms the need of light for predation in tunas. The comparatively large size of the eyes of the bigeye scad probably explains their ability to prey at night in the dark and particularly on slow swimming animals from the macroplankton.

The composition of the food of *Selar crumenophthalmus* showed that this species is zooplanktivorous as a juvenile and predominantly piscivorous when adult. The absence of mineral material excludes the possibility of a benthic food intake (Harmelin-Vivien, 1979). In some instances, the occurrence of insects in the diet confirms the general observation of fishermen that *Selar crumenophthalmus* often feeds near the surface. This predatory behaviour is characteristic of small carangids and was also observed in *Trachurus* spp. (Ben Salem, 1988).

The catch of small coastal pelagic fish in Réunion Island waters is estimated to 160 tonnes (catch statistic for 1997 from the fishery administration). The bigeye scad is the most common fish with a catch of 100 tonnes, other scads contributing with 50 tonnes, and sardines representing only 10 tonnes. The absence of a continental shelf, estuaries and protected areas like other volcanic islands (Cabo Verde, Hawaii), could be an explanation of the low abundance of sardines, which feed mainly on phytoplankton and small zooplankton. The opposite is generally observed around islands with an extensive continental shelf.

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