

**INTERANNUAL CHANGES IN THE DIET OF THE ALMACO JACK,
SERIOLA RIVOLIANA (PERCIFORMES: CARANGIDAE)
FROM THE AZORES**

by

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ABSTRACT. - The food habits of 232 almaco jack (*Seriola rivoliana*) were investigated in the Azores (NE Atlantic) between 1997 and 2000. Fish length ranged from 23 to 134 cm (SL), and 83.2% of the stomachs contained food. Their diet was exclusively piscivorous and dominant prey were juveniles of *Trachurus picturatus* (1997 to 1998) and *Scomber japonicus* (1999 to 2000). An apparent decrease of *T. picturatus* stock is interpreted as the main cause for the detected diet shift.

RÉSUMÉ. - Changements interannuels de l'alimentation de la sériole *Seriola rivoliana* (Perciformes: Carangidae) aux Açores.

Les habitudes alimentaires de 232 sérioles (*Seriola rivoliana*) ont été étudiées aux Açores (Atlantique NE) entre 1997 et 2000. La taille des individus varie entre 23 et 134 cm (LS) et 83,2% des estomacs contenaient de la nourriture. Leur alimentation était exclusivement piscivore et les proies dominantes étaient des juvéniles de *Trachurus picturatus* (1997 à 1998) et *Scomber japonicus* (1999 à 2000). L'apparente diminution des stocks de *T. picturatus* est interprétée comme la raison principale du changement observé dans l'alimentation.

Key words. - Carangidae - *Seriola rivoliana* - Azores - ANE - Food habits - Interannual changes.

In recent years, the diets of medium size pelagic fish have been the focus of considerable studies (e.g., Buckel *et al.*, 1999a; Deudero, 2001; Harding and Mann, 2001). This is particularly true for species of economic value in areas where there is considerable fishing activity. Some studies have demonstrated the important impact of pelagic fish predation on their prey and the resulting competition between predators and commercial fisheries (Buckel *et al.*, 1999b). These findings highlight both the need of implementing multispecies approaches in the management of fisheries resources and the need for studies on feeding habits of fish species, mainly those with high trophic levels.

The almaco jack, *Seriola rivoliana* Cuvier, 1833, is a common coastal pelagic predator in the Azores where it occurs with its congeneric *S. dumerili* (Risso, 1810) (Santos *et al.*, 1997). This species is known for inhabiting coastal reef areas and offshore banks down to 160 m or more (Smith-Vaniz, 1986a). They usually form small groups and juveniles are often seen around floating objects (Honebring, 1990). The global geographic distribution of the almaco jack is not well established, however it is known for dis-

playing a circumtropical and temperate distribution (Smith-Vaniz, 1986b). In the western Atlantic, this species occurs from Cape Cod, USA, down to Argentina (Nakamura, 1980). Blume and Barea (1980) report a concentration area of almaco jack in the South Atlantic (35°52'S, 54°45'W). In the eastern Atlantic, it is only known from the Azores, Madeira and Portugal mainland waters. The species is occasional in southern England (Wheeler, 1986), Gulf of Biscay (Quéro *et al.*, 1992) and was recently reported off Lampedusa Island, in the Mediterranean (Castriota *et al.*, 2002). Almaco jacks are also found in the Indian (Smith-Vaniz, 1986b) and Pacific Oceans (Eschmeyer *et al.*, 1983; Shameem and Dutt, 1986).

The scientific literature on *S. rivoliana* is very scarce and reduced to occurrence notes and checklists. One of the few exceptions is the paper by Manooch and Haimovici (1983), which deals with its natural food in the south Atlantic. In this paper, we present and discuss data on the natural food habits of *S. rivoliana* in the North Atlantic islands of the Azores, emphasising an interannual change in the main prey of this species.

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MATERIAL AND METHODS

Collection of specimens

Almaco jacks were caught by spearfishing in order to prevent regurgitation of stomach contents (Bowen, 1983) and to allow an easier selection of fish individual size (Derbal and Kara, 1996). A total of 232 almaco jacks were sampled from May 1997 to September 2000 around the Azorean islands of Santa Maria, Terceira, Faial, Pico, Flores and Corvo (Fig. 1) at depths ranging from the surface to 30 m. Their sizes ranged from 24 to 134 cm (SL).

Food habits

After collection the fish were weighed, and their standard (SL) lengths recorded. Specimens were preserved frozen. Food items were macroscopically identified to the lowest taxonomic level possible and weighed, after superficial drying.

The frequency of occurrence (%O), percentage number (%N) and weight (%W) for each prey type were used to describe the diet of this species (for a review of dietary indexes see Hyslop, 1980; Cortés, 1997). Wet weight was used to determine the latter. Ontogenetic differences in the diet of almaco jack were examined by grouping fish into four size classes [< 30 (n = 53); 30 - 59 (n = 77); 60 - 99 (n = 59); 100 - 140 (n = 43) cm SL], which were arbitrarily assumed to express shifts in prey composition.

In order to determine if the most important preys were similar for different groups of almaco jacks, the weighted correlation and concordance analysis were used (Zar, 1999). These methods were preferred to traditional rank correlation methods (e.g., Spearman) as they emphasize the high ranking given to the most important prey categories. Differences in the rankings of %O values for prey categories between paired-groups (e.g., years) were tested using the Top-down Correlation method (r_T = the top-down correlation coefficient) (Quade and Salama, 1992; Zar, 1999).

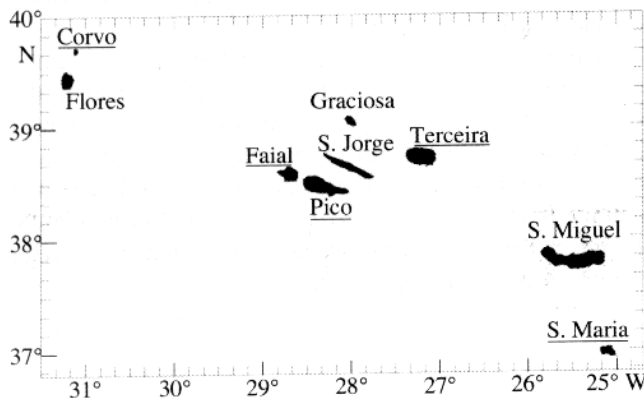


Figure 1. - The Azores Archipelago. Islands where collections were made are underlined.

Schoener's dietary overlap index (Schoener, 1970) as

$$C_{xy} = 1 - 0.5 \sum_{i=1}^n |P_{xi} - P_{yi}|$$

where P_{xi} was the proportion - based on %O - of food category i in the diet of x ; and P_{yi} was the proportion of food category i in the diet of y) was used to measure the diet overlap between almaco jacks caught in different periods, and between this species and another medium size pelagic fish studied in the Azores, yellowmouth barracuda *Sphyræna viridensis* (Barreiros *et al.*, 2002).

RESULTS

Out of 232 stomachs examined, 39 were empty (16.8%) and 193 contained food (83.2%). Almaco jacks with food present measured from 23 to 134 cm SL. There were no differences in the predator size among periods.

The diet of almaco jacks was composed exclusively by fish. Recognizable prey from 9 different taxa were identified. The diet of almaco jacks caught on 1997/1998 and 1999/2000 were not significantly correlated ($p > 0.05$) and are significantly different ($r_T = 0.008$), meaning that this species fed upon different prey during the two periods. In 1997 and 1998, juveniles of the blue jack mackerel, *Trachurus picturatus* (Carangidae), was the most important prey, accounting for 86.7% of food by number (%N), 63.1% by weight (%W) and occurred in 83.0% of stomachs that contained food (%O) (Tab. I). The second most important prey item was the bogue, *Boops boops*, which represented 0.6% of food by number and 14.3% by weight.

In 1999 and 2000 the most important prey of almaco jack was juveniles of the chub mackerel, *Scomber japonicus* (Tab. II). This prey occurred in 68% of the stomachs with food, represented 56.8% of the total number of prey identified, and 58.8% of the total prey weight. Other occasional prey for the period 1999/2000 were the blue jack mackerel (%O = 11.2), the European pilchard, *Sardina pilchardus* (%O = 4.5), the snipefish, *Macroramphosus scolopax* (%O = 3.5) and the bogue, *B. boops* (%O = 3.5).

The diet overlap between the almaco jacks caught in different periods (1997/1998 and 1999/2000) and the diet overlap between the almaco jack (1999/2000) and the yellowmouth barracuda (1997/1998) were very small (0.06 and 0.09 respectively). However, the diet overlap between the two different species caught in the same period (1997/1998) was very high (0.97).

Table I. - Diet of *Seriola rivoliana* caught in the Azores between 1997 and 1998 (n = 112). %N is the percent by number, %W is the percent by weight, and %O is the frequency of occurrence for each prey item identified.

Prey items	%N	%W	%O
<i>Trachurus picturatus</i>	86.7	63.1	83.0
Unid. Teleostei	2.5	9.8	6.2
<i>Boops boops</i>	0.6	14.3	1.5
<i>Anthias anthias</i>	3.8	8.4	1.5
<i>Macroramphosus scolopax</i>	2.5	1.5	1.5
<i>Symphodus mediterraneus</i>	1.3	1.2	1.5
<i>Mullus surmuletus</i>	1.3	0.8	1.5
<i>Sardina pilchardus</i>	0.6	0.6	1.5
<i>Pagellus bogaraveo</i>	0.6	0.4	1.5

Table II. - Diet of *Seriola rivoliana* caught in the Azores between 1999 and 2000 (n = 81). %N is the percent by number, %W is the percent by weight, and %O is the frequency of occurrence for each prey item identified.

Prey items	%N	%W	%O
<i>Scomber japonicus</i>	56.8	58.8	68.0
<i>Trachurus picturatus</i>	21.2	20.9	11.2
<i>Sardina pilchardus</i>	9.1	9.5	4.5
<i>Macroramphosus scolopax</i>	5.3	3.4	3.5
Unid. Teleostei	3.0	2.7	5.3
<i>Boops boops</i>	3.0	2.4	3.5
<i>Pagellus bogaraveo</i>	0.8	1.4	1.5
<i>Mullus surmuletus</i>	0.8	1.0	1.5

DISCUSSION

Almaco jacks from the Azores prey mainly upon juvenile pelagic fishes. The contribution of small demersal or benthic fish species in the diet of this species is relatively low. Similar results were observed for the yellowmouth barracuda, *S. viridensis*, in the same region (Barreiros *et al.*, 2002).

Jacks are known to be opportunistic predators and to prey upon a wide range of food items. *Seriola dumerili* has been studied in several sites, and at different life stages, and has showed a highly diverse diet which includes both fish and invertebrate species (Manooch and Haimovici, 1983; Badalamenti *et al.*, 1995; Matallanas *et al.*, 1995; Pipitone and Andaloro, 1995; Andaloro and Pipitone, 1997). Ram suspension feeding was also detected in this species by Sanderson *et al.* (1996). The sample of *S. rivoliana* studied by Manooch and Haimovici (1983) showed the occurrence of 14 fish families, 2 families of cephalopods and 6 of crustaceans whilst in this study only fish (8 families, 9 species) were detected. The presence of benthic/demersal prey is also greater in the studies mentioned above, while in the Azores, dominant prey are juvenile pelagic fish. A fact also

detected in *S. viridensis* by Barreiros *et al.* (2002).

During the period 1997/1998, almaco jacks from the Azores fed mainly upon small juveniles of *T. picturatus*. A similar situation was referred by Aron *et al.* (1992) while reporting *Trachurus symmetricus* as the main prey of *Seriola peruana* in northern Chile. However, the apparent decrease in the abundance of juveniles of *T. picturatus* close to the Azorean coasts, and the increase in numbers of small *S. japonicus* and, to a lesser extent, of *S. pilchardus* (JPB, pers. obs.) was reflected in the diet composition of *S. rivoliana* for the period 1999/2000. A small sample (n = 21) of *S. viridensis* also showed a high presence of *S. japonicus* in their stomachs for the period 1999/2000 (Barreiros, unpubl.).

Juvenile *T. picturatus* have been intensively fished in the Azores, both for human consumption and for usage as live bait for tuna fishing (Isidro, 1990). On the other hand, environmental conditions are known to have a wide effect on the abundance of pelagic fish species (Kramer *et al.*, 1997). Thus, overfishing and environmental shifts can be responsible for the apparent decrease of the *T. picturatus* stock and force pelagic predators to shift their diets to other available prey. Diet of pelagic predators, such as *S. rivoliana* or *S. viridensis*, can thus be used as indicators of the status of small pelagic fish stocks.

This insight into Azorean coastal food webs needs to be supplemented with more studies, both on the species and on the community levels.

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