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Food and feeding habits of the amberjack, *Seriola dumerili* in the Central Mediterranean Sea during the spawning season.

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Abstract : The stomach contents of 308 adult amberjack, *Seriola dumerili* (Osteichthyes, Carangidae) were analysed to investigate the food and feeding habits of this species. Fish occurred in 79.7% of non-empty stomachs, accounting for 79.5% of prey in number and 71.0% in weight; cephalopods occurred in 26.8% of non-empty stomachs, accounting for 20.5% of preys in number and 29.0% in weight. The prey items occurring most frequently were *Boops boops, Loligo* spp., *Sardinella aurita, Sardina pilchardus* and *Sepia officinalis*. Pelagic preys occurred overall less frequently and in lesser amounts than demersal ones; moreover males fed much more intensely on demersal preys than females. The amberjack is an essentially piscivorous predator. Though commonly considered a "pelagic" species, it does not seem dependent on pelagic food sources in the central Mediterranean, at least during the spawning season.

Résumé : Les estomacs de 308 sérioles adultes, *Seriola dumerili*, ont été analysés afin de connaître les habitudes alimentaires de cette espèce. Des poissons étaient présents dans 79,7% des estomacs contenant de la nourriture, ce qui représente 79,5 % des proies en nombre et 71,0 % en poids ; des céphalopodes étaient présents dans 26,8 % de ces estomacs, représentant 20,5 % des proies en nombre et 29,0 % en poids. Les proies les plus fréquentes étaient *Boops boops, Loligo* spp., *Sardinella aurita, Sardina pilchardus* et *Sepia officinalis*. Les proies pélagiques étaient dans l'ensemble moins fréquentes et en quantités moindres que les proies démersales, et celles-ci étaient plus fréquentes chez les sérioles mâles que chez les femelles. La sériole est essentiellement un prédateur piscivore. Bien que communément considérée comme espèce "pélagique", la sériole ne dépend pas des sources de nourriture pélagique dans la Méditerranée centrale, au moins durant le frai.

Keywords : Seriola dumerili, diet, spawning, Mediterranean Sea.

Introduction

The amberjack, *Seriola dumerili* (Risso, 1810) is a widely distributed carangid fish. Its occurrence around promontories, small islands and rocky banks during the spawning period supports an important seasonal fishery in some central Mediterranean localities, where it is exploited by fishermen using purse seines and, to a lesser extent, trolling lines. This species has also been acknowledged as a suitable species for intensive aquaculture (Cavaliere *et al.*, 1989; Porrello *et al.*, 1993).

As far as we know, only Lazzari & Barbera (1989) and Matallanas *et al.* (1995) dealt with the diet of adult amberjack in the Mediterranean (the latter analysed the stomach contents of 31 adults and 354 juveniles). Mazzola *et al.* (1993), Pipitone & Andaloro (1995) and Badalamenti *et al.* (1995) dealt with the diet of juveniles.

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In the framework of a research concerning distribution, biology and eco-ethology of *S. dumerili* in Sicilian waters (Andaloro, 1993), the natural diet of adult specimens was studied. Since the availability of adults is almost entirely restricted to the spawning season, i.e. from late spring to early summer (Sanzo, 1933; Lazzari & Barbera, 1989), data were collected in June each year.

Materials and methods

Fish were caught by purse seiners operating above rocky banks 20-35 m deep around the Pelagie Islands and at Banco Alluffo (approximately 35°40'N, 12°00'E, central Mediterranean Sea) (Fig. 1). This is considered one of the main spawning areas of amberjack in the Mediterranean (Lazzari & Barbera, 1989). Fishing operations took place diurnally (between 07:00h and 17:00h) in June each year from 1989 to 1992. The choice of diurnal sampling was forced by the fishing method, based on eye-inspection of the rocky banks. Further, some evidence of diurnal feeding activity of amberjack was suggested by the Pelagie Islands artisanal fishermen, who did not report any night catch of this species by trolling line and live bait. The temperature of the water column was recorded over the banks during the sampling period.

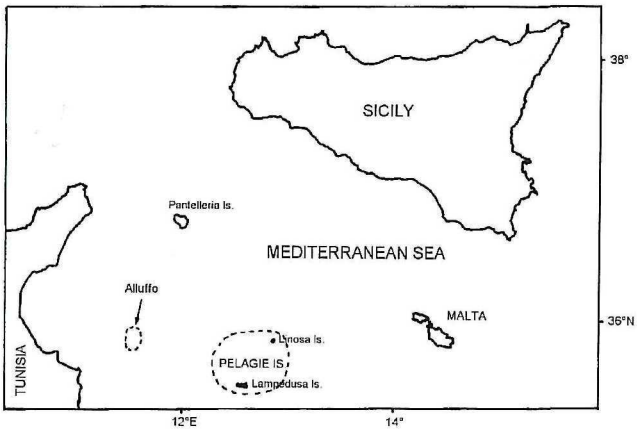

Figure 1. Map showing the study area. Inside the broken lines: sampling sites (Pantelleria Is., Pelagie Is, and Sicily belong to Italy).
Figure 1. Carte indiquant la zone étudiée. Les sites d'échantillonnage correspondent aux zones en pointillés (les Iles de Pantelleria, de Pelagie et la Sicile sont italiennes).

Standard length (SL) at the nearest cm below was recorded for each specimen. Four size groups were distinguished in order to compare the diet of fishes of different size classes: 52-80 cm, 81-100 cm, 101-120 cm and 121-148 cm. Fish were eviscerated on board the ship and sex determined by macroscopic examination of the gonads; the maturity stage was assessed by means of a four-stage scale for males and a five-stage scale for females (Marino *et al.*, 1995). Stomachs were dissected on board the ship immediately after the catch. The prey items were identified at the lowest possible taxonomic level, counted and weighed, then grouped in two ecological categories: demersal (D = benthic plus benthopelagic species) and pelagic (P). One prey item (*Boops boops*) was not included in either category, since it tends to have both demersal and semi-pelagic habits (Tortonese, 1975; Bauchot & Hureau, 1986; Fischer *et al.*, 1987), thus making hard a clear-cut assignment to any category.

The vacuity coefficient *V%* (= percentage of empty stomachs) was calculated. Furthermore the following alimentary indexes were computed for each prey item *i*, in order to detect food preferences in the diet of *S. dumerili*:

- percent frequency of occurrence *F%* (= number of stomachs containing prey item *i*/total number of non-empty stomachs x 100);
- percentage by number *N%* (= number of individuals of prey item *i*/total number of all prey items x 100);
- percentage by weight *W%* (= weight of prey item *i*/total weight of all prey items x 100);
- dietary index $Q=N\%xW\%$ (Hureau, 1970).

The index *Q*, that takes into account both number and weight of prey items, was chosen because prey had comparable sizes and abundance in the stomach contents. For this reason there was no risk neither to underestimate very large but rare items nor to overestimate very small but abundant ones (see also Rosecchi & Nouaze, 1987 for a comparison of various feeding indexes).

Non-parametric ANOVA (Mann-Whitney and Kruskall-Wallis tests) was used to test the differences in the values of *Q*, whereas the normal test (Fleiss, 1981) was used to test the differences in the values of *F%*.

Results

The stomach contents of 308 amberjack (149 females and 159 males, mean SL=109.1 cm) were analysed. The composition and location of samples per year, along with the surface temperature, are indicated on Table 1. Temperature ranged in the sampling sites between 19.0°C and 22.4°C; thermocline was always about 35 m deep.

Sixty percent of stomachs were empty. As shown in Table 2, the vacuity coefficient was higher in males (*V%*=68) than in females (*V%*=51). The highest vacuity coefficient was found in fully mature specimens (11 females, *V%*=82 and 61 males, *V%*=82). The values of vacuity also varied according to fish size (Table 3). The lowest value (*V%*=29) was found in specimens of 52-80 cm SL, the highest (*V%*=70) in specimens of 81-100 cm SL. The importance of emptiness due to regurgitation during the

Table 1. Stomach content analysis in the amberjack *Seriola dumerili*: composition of each sample per year and per sampling area. F: females; M: males; SL: standard length (cm).

Tableau 1. Analyse des contenus stomacaux des sérioles *Seriola dumerili* : composition des échantillons par année et par zone d'étude. F: femelles; M: mâles; SL: longueur standard (cm).

Year	Sampling area	Surface temperature range	Sex	N	SL range	Mean SL
			F	41	86-148	118.6
1989	Banco Alluffo	19.3-21.6°C	M	43	86-139	116.1
			F	12	97-134	112.4
1990	Banco Alluffo	19.9-22.0°C	M	11	80-124	98.5
			F	10	107-126	116.3
1990	Pelagie Is.	19.2-22.1°C	M	8	56-118	97.9
			F	69	59-132	116.1
1991	Banco Alluffo	19.8-21.6 °C	M	72	54-131	108.7
			F	6	72-88	80.0
1991	Pelagie Is.	19.0-21.8°C	M	13	58-87	81.1
			F	5	58-117	81.6
1992	Banco Alluffo	19.2-22.4°C	M	10	55-115	90.3
			F	6	76-115	94.0
1992	Pelagie Is.	20.0-22.3°C	M	2	52-86	69.0
SUBTOTAL			F	149	58-148	113.0
			M	159	52-139	105.5
TOTAL			F+M	308	52-148	109.1

fishing operations was not quantified. Remains of digested food observed in the water and in nets suggested that a certain amount of fish vomited when fished, so the occurrence of empty stomachs have been likely overestimated.

Composition of diet

The specific composition of preys recorded in amberjack stomach contents is indicated in Table 4. As a whole, fish occurred in 79.7% of non-empty stomachs (*N*%=79.5, *W*%=71.0), cephalopods in 26.8% (N%=20.5, *W*%=29.0). No crustacean prey was found. *Boops boops* was the most frequent item (*F*%=22.0), followed by *Loligo* spp. (*F*%=17.1), *Sardinella aurita* (*F*%=13.8), *Sardina pilchardus* (*F*%=10.6) and *Sepia officinalis* (*F*%=9.8). *Trachurus* spp., *Pagellus erythrinus* and *Spondyliosoma cantharus* occurred less frequently (*F*%=4.9, 4.9 and 3.3 respectively). The remaining prey may be considered as occasional. When the dietary index *Q*, which is an overall index of feeding preference, is taken into consideration, *Boops boops* gained the highest value (*Q*=749.8), followed by *Sardina pilchardus* (*Q*=318.7), *Sepia officinalis* (*Q*=199), *Sardinella*

Table 2. Stomach content analysis in the amberjack *Seriola dumerili*: vacuity coefficient (*V*%) in the two sexes and in each sexual maturity stage. (no.): number of stomachs examined.

Tableau 2. Analyse des contenus stomacaux des sérioles *Seriola dumerili* : coefficient de vacuité (*V* %) pour chacun des sexes et des différent stades de maturité sexuelle. (no.) : nombre d'estomacs examinés.

Maturity stage	Females V% (no.)	Males V% (no.)
I	33 (3)	57 (21)
II	33 (12)	50 (2)
III	44 (27)	61 (75)
IV	51 (96)	82 (61)
V	82 (11)	—
TOTAL	51 (149)	68 (159)
Females+Males	60 (308)	

Table 3. Stomach content analysis in the amberjack *Seriola dumerili*: vacuity coefficient (*V*%) in each size group. (no.): number of stomachs examined.

Tableau 3. Analyse des contenus stomacaux des sérioles *Seriola dumerili* : coefficient de vacuité (*V*%) pour chaque groupe de taille. (no.): nombre d'estomacs examinés.

Size group	V% (no.)
52-80 cm	29 (21)
81-100 cm	70 (47)
101-120 cm	61 (170)
121-148 cm	60 (70)

Table 4. Stomach content analysis in the amberjack *Seriola dumerili*: composition of diet. E.C.: ecological category (D: demersal; P: pelagic; *F%:* percent frequency of occurrence; *N%:* percentage by number; *W%:* percentage by weight; *Q:N%xW%;* n.: number of stomachs examined; *V%:* vacuity coefficient. (*): *Boops boops* was included neither among demersal nor pelagic prey (see text).

Tableau 4. Analyse des contenus stomacaux des sérioles *Seriola dumerili* : régime alimentaire. E.C. : catégorie écologique; (D: démersal; P: pélagique); *F %:* pourcentage de présence; *N%:* pourcentage en nombre; *W%:* pourcentage en poids; *Q: N%xW%;* n: nombre d'estomacs examinés; *V %* = coefficient de vacuité. (*): *Boops boops* inclus ni parmi les proies démersales ni parmi les proies pélagiques (voir le texte).

E.C.	Prey	*F%*	*N%*	*W%*	*Q*
	CEPHALOPODA				
D	*Sepia officinalis*	9.8	12.2	16.3	199.0
D	*Loligo* spp.	17.1	8.2	12.8	105.1
	Total Cephalopoda	26.8	20.5	29.0	594.2
	PISCES				
D	*Raja* spp.	0.8	0.3	1.7	0.5
P	*Sardina pilchardus* (Walbaum, 1792)	10.6	14.6	21.8	318.7
P	*Sardinella aurita* Valenciennes, 1847	13.8	13.3	9.2	121.7
D	*Merluccius merluccius* (L., 1758)	0.8	0.3	0.9	0.2
D	*Trachurus* spp.	4.9	2.7	2.8	7.4
D	*Mullus* spp.	2.4	0.8	1.2	0.9
(*)	*Boops boops* (L., 1758)	22.0	31.6	23.7	749.8
D	*Dentex dentex* (L., 1758)	0.8	0.3	0.3	0.1
D	*Pagellus erythrinus* (L., 1758)	4.9	2.4	2.5	6.0
D	*Pagrus pagrus* (L., 1758)	1.6	0.5	0.7	0.4
D	*Spondyliosoma cantharus* (L., 1758)	3.3	1.1	1.2	1.3
D	*Spicara* spp.	1.6	1.3	0.4	0.6
P	*Scomber* spp.	0.8	0.3	0.02	0.01
D	*Trigla lucerna* L., 1758	0.8	0.3	0.1	0.04
	unidentified Pisces	14.6	9.8	4.5	44.5
	Total Pisces	79.7	79.5	71.0	5644.8
			n:308	*V%:* 60	

aurita (2=121.7) and *Loligo* spp. *(Q=* 105.1). *Sardina pilchardus* occurred significantly (P<0.05) more frequently in females, whereas *Pagrus pagrus, Spicara* spp. and *Spondyliosoma cantharus* occurred more frequently in males (P<0.05, P<0.05 and P<0.01 respectively). With respect to the quantity of each prey, a significant difference (P<0.05) was found only in *Spondyliosoma cantharus,* which was fed in larger amounts by males. The four size groups fed often on significantly different amounts of the various prey items: such differences do not seem referable to any distinct pattern in the feeding behaviour.

Ecological category of prey

Twelve prey species were classified as demersal and three as pelagic (Table 4); the latter displayed lower values of both *F%* (=25.2) and *Q* (=873.2) than the former (F%=42.3, 2=1237.5). Differences between the two sexes are summarized in Figure 2. Demersal prey occurred more frequently than pelagic in both sexes: *F%=35.6* and 52.0 in females and males respectively for demersal prey (P<0.01), vs. E%=28.8 and 20.0 for pelagic prey. Pelagic prey were slightly more abundant than demersal ones in females (N%=32.8 and W%=36.3 vs. *N%=26.5* and *W%=35.8).* Thus in females pelagic prey displayed a slightly higher *Q* value than demersal ones (=1191.4 vs. 948.5), whereas in males the same index was much higher for demersal prey (2142.1 vs. 274.6, P<0.05). Overall, females fed on significantly higher amounts of pelagic prey than males (2=1191.4 vs. 2=274.6, P<0.001), whereas males ate more demersal prey (Q=2142.1 vs. Q=948.5). As already stated above, differences between size groups do not seem ascribable to precise differences in feeding behaviour.

Discussion and conclusions

At present the knowledge on the food and feeding habits of adult amberjack outside the spawning season is very poor, since they usually disappear in October-November from their summer occurrence areas. They probably descend to deeper waters (Tortonese, 1975), though occasional catches of isolated large specimens in coastal areas sometimes occur in wintertime (Andaloro, 1993 and

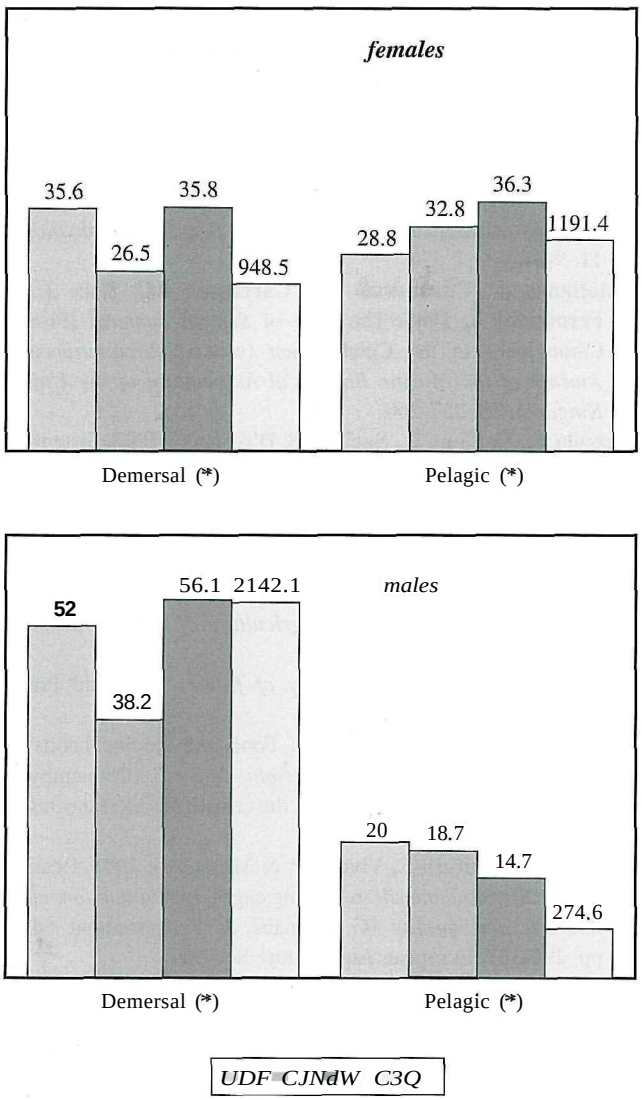

Figure 2. Alimentary indexes of the two ecological categories of prey calculated for female and male amberjack (n = 149 and 159 respectively). *F%:* percent frequency of occurrence; *N%:* percentage by number, *W%:* percentage by weight; *Q: N%xW%*, (*): ecological categories do not include neither *Boops boops* nor unidentified Pisces. N.B.: *Q* is plotted on a different scale.

Figure 2. Index alimentaires des deux catégories écologiques de proies calculés pour les sérioles mâles et femelles (respectivement, 149 et 159 individus). *F%:* pourcentage de présence; *W%:* pourcentage en poids; *Q: N%xW%*. (*): *Boops boops* et les poissons non identifiés ne sont pris en compte dans aucune des deux catégories écologiques considérées. N.B.: *Q* est rapporté à une autre échelle.

unpublished data). At the onset of the spawning period, when reproductive activity forces amberjack towards superficial warm waters (Lazzari & Barbera, 1989), they frequently occur near rocky reefs and banks in the water column above the thermocline, where fishing is usually carried out.

As can be drawn from previous studies, amberjack seem to undergo a diet shift at a size of about 15-20 cm, after an initial period of strictly pelagic life in which holoplanktonic and meroplanktonic crustaceans are the main food items (Mazzola et *al.,* 1993; Badalamenti et *al.,* 1995; Pipitone & Andaloro, 1995). From that size onward, the diet of this species is based mainly on fish. According to Matallanas et *al.* (1995), which analysed the stomach contents of 385 specimens of various sizes caught in the Catalan Sea at a depth of 25-30 m, adult amberjack feeds almost exclusively on teleosts, whereas invertebrates occur only in small amounts. Lazzari & Barbera (1989), which reported a few observations on the diet of an unknown number of adults collected in the same area as the present study, found that *Scomber scombrus* and *Loligo vulgaris* were the most abundant prey items. Our data agree to some extent to the results of these authors: the adult amberjack, like the congeneric species S. *quinqueradiata* (see Mitani, 1960) and *S. peruana* (see Aron et *al.,* 1992) is essentially a piscivorous predator. Fish were by far the dominant prey item in the stomachs we examined, while cephalopods occurred in one fourth of non-einpty stomachs. The main difference lays in the specific composition of the diet: the dominant prey in our samples was *B. boops,* which played only a negligible role in the diet of the adult amberjack studied by Matallanas et *al.* (1995).

The importance of demersal prey in the diet of a species often considered as having pelagic habits is worthy of mention. Adult amberjacks do not seem to depend on pelagic resources in the central Mediterranean, at least during the reproductive season. They reach areas like promontories and rocky banks where, while remaining above the thermocline, they feed upon a wide spectrum of species, mostly demersal ones. Numerous pelagic fish species rely on benthic or on coastal food sources during some periods of their life cycle. As a consequence, trophic links between different environments (benthic/pelagic, neritic/offshore) may play an important part in the fisheries of such species. The decrease in benthic resources of many coastal areas might have an unforeseen crucial impact on the dynamics of some pelagic species.

The different contributions of pelagic and demersal preys in the diet of amberjack males and females remain still unclear, though it can be seen as an adaptation towards increasing the range of food supply of the population (Nikolsky, 1963). Females seem to feed closer to the sea surface, thus preying mostly upon pelagic fish (high *Q* value), whereas males seem to dwell near the bottom, where they are able to catch a great variety of benthic and benthopelagic species. No relationship seems to exist between the sea temperature and such surface-related habits of females, since no thermic gradient was detected between the surface and the bottom in the sampling zones.

Knowledge of amberjack's diet could provide useful information for aquaculture purposes. This robust species is easily adaptable to a diet based on low-price food items when reared in floating cages, with a good conversion index (Porrello et *ai,* 1993). Studying its feeding habits could give a further contribution to a topic of such a high practical interest.

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