FEEDING HABITS OF THE SADDLED BREAM, *OBLADA MELANURA* (SPARIDAE), IN THE ADRIATIC SEA

by

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ABSTRACT. - The feeding habits of the saddled bream, *Oblada melanura* (Linneaus, 1758), from the Adriatic Sea were investigated with respect to fish size and season. Stomach contents of 926 specimens, 11.3-29.3 cm TL, collected by beach seine from 1992 to 1993, were analyzed. Of the total number of examined stomachs, 87 were empty (9.4%). This percentage varied significantly over the year, with a maximum number of empty stomachs recorded during the winter and a minimum number recorded during the summer. Copepods constituted the main prey in all size-classes. With fish growth, the proportion of planktonic organisms decreased, while that of fish and benthic organisms increased. The mean weight of stomach contents increased significantly for fish larger than 22.0 cm TL. Diet composition showed little seasonal variation, copepods were the most prey item important in all seasons, especially during the warmer part of the year. Higher intensities of feeding activity in spring and summer could be related to temperature and maximal abundance of zooplankton and benthic organisms. The results indicated that the saddled bream fed on a wide range of prey items and could be considered an opportunistic predator.

RÉSUMÉ. - Alimentation de l'oblade, *Oblada melanura* (Sparidae), en mer Adriatique.

Les habitudes alimentaires de l'oblade, *Oblada melanura*, de la mer Adriatique ont été étudiées en fonction de la taille des poissons et de la saison de prélèvement. Les contenus stomacaux de 926 spécimens, 11,3-29,3 cm LT, capturés par seine de plage de 1992 á 1993 ont été analysés. Au total, 87 estomacs étaient vides (9,4%). Ce pourcentage a changé de manière significative au cours de l'année, avec un nombre maximum d'estomacs vides enregistré pendant l'hiver et un nombre minimum enregistré pendant l'été. Les copépodes ont constitué les proies principales dans toutes les classes de taille. La proportion d'organismes planctoniques a diminué avec la croissance, tandis que celle des poissons et des organismes benthiques a augmenté. Le poids moyen du contenu stomacal a augmenté de manière significative pour les poissons de taille supérieure à 22,0 cm LT. La composition du régime alimentaire a montré peu de variation saisonnière ; les copépodes ont été dominants quelles que soient les saisons, et particulièrement pendant la partie plus chaude de l'année. Des intensités plus élevées d'activité d'alimentation au printemps et en été ont pu être liées à la température et à l'abondance maximale de copépodes. Les résultats ont indiqué que l'oblade s'alimente à partir d'un large éventail de proies, et qu'elle peut être considérée comme un prédateur opportuniste.

Key words. - Sparidae - *Oblada melanura* - MED - Adriatic Sea - Food - Feeding habits.

The saddled bream *Oblada melanura* (Linnaeus, 1758) is common throughout the Mediterranean and eastern Atlantic, inhabiting littoral waters above rocky bottoms and *Posidonia* beds, up to 30 m depth (Bauchot and Hureau, 1986). This species is also very common in the Adriatic Sea (Jardas, 1996). In spite of its wide distribution and commercial importance, published information on its biology and ecology is limited. Jardas (1996) reported that the annual catch of the saddled bream in the eastern Adriatic is around 200 tonnes.

Previous study on this species looked at the age, growth and mortality in the eastern Adriatic (Pallaoro *et al*., 1998). In addition, Cavallaro *et al*. (1984, 1985), and Cefali *et al*. (1987) studied growth of the different developmental stages in Sicilian coastal waters. Data on feeding habits of *Oblada melanura* in the Tyrrhenian Sea were presented by Ara (1937), and the only data on feeding habits of their juveniles (Mediterranean coast of France) were reported by Lenfant and Olive (1998).

However, very little is known about the trophic ecology of the saddled bream in the Adriatic Sea. The present study deals with food and feeding habits of this species. The purpose was to examine the feeding habits of *Oblada melanura* in the Adriatic Sea, including the influence of predator size and seasonal variations in the stomach contents.

MATERIAL AND METHODS

Samples of saddled bream were taken from six localities in the Adriatic Sea (Fig. 1). They were collected by a stretched beach seine (12 mm mesh-size) that was 150 m long and 10 m deep. A total of 926 specimens were collected, all year round during 1992 and 1993. During the winter and spring, 230 specimens were caught, while 242 specimens were caught in summer and 224 in autumn. Total

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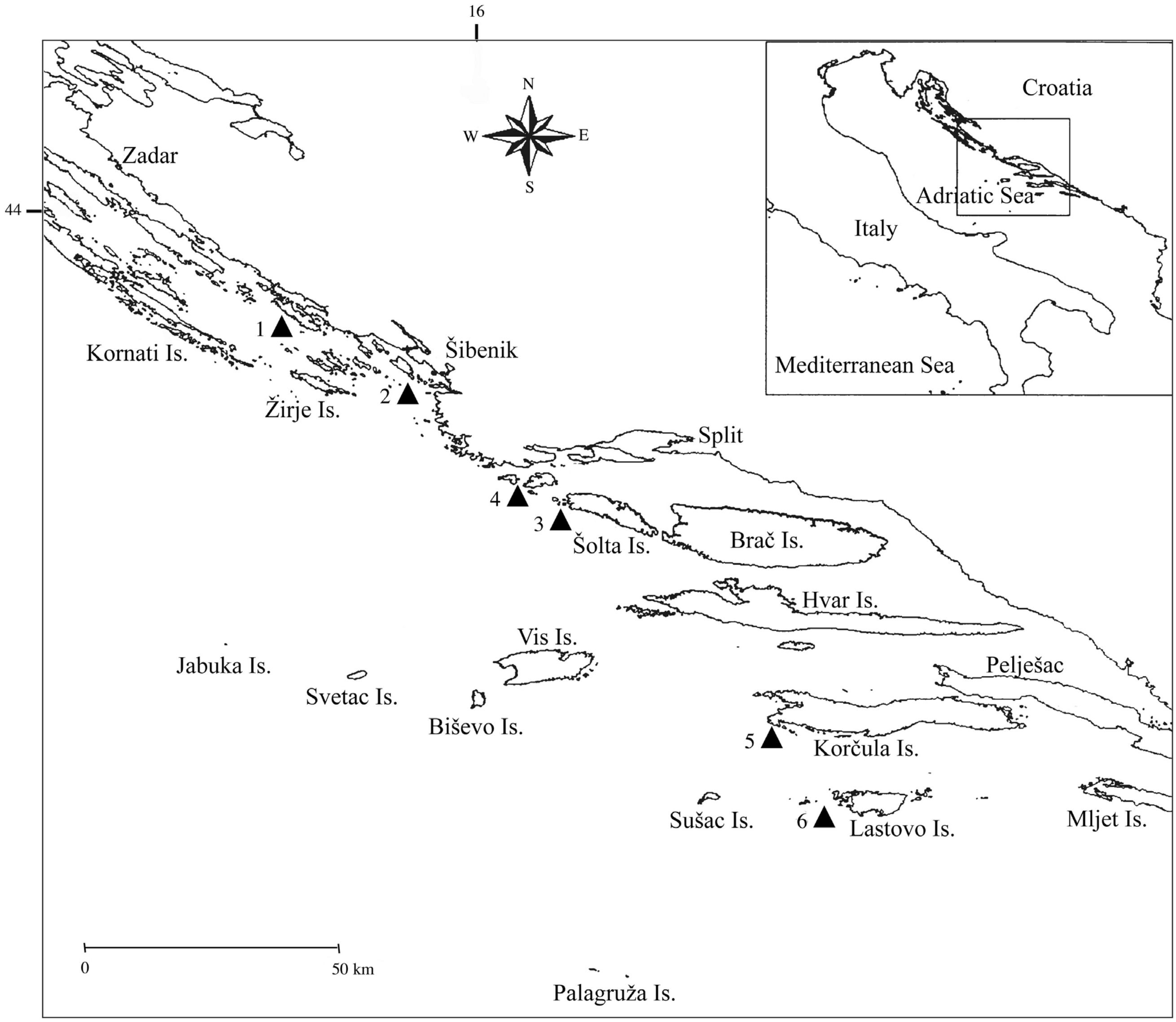

Figure 1. - Study area and sampling localities of *Oblada melanura* in the Adriatic Sea: 1- Murter island; 2 - Zlarin island; 3 - Šolta island; 4 - Drvenik island; 5 - Korčula island; 6 - Lastovo island.

length (TL) was measured to the nearest 0.1 cm and weighted to the nearest 0.1 g. Immediately after capture, fish were dissected and the gut removed and preserved in a 4% formalin solution to stop digestion. In the laboratory, prey identification was carried out to the lowest possible taxonomy level. Species abundance and wet weight, to the nearest 0.001 g after removal of surface water by blotting on tissue paper, were recorded.

Total length of the fish examined ranged from 11.3 to 29.3 cm ($\bar{x}$ = 19.1 cm) (Fig. 2). To asses for possible changes in diet with respect to size, fish were divided into three size-classes: small (< 17 cm, N = 298), medium (17 - 22 cm, N = 360) and large (> 22 cm, N = 268).

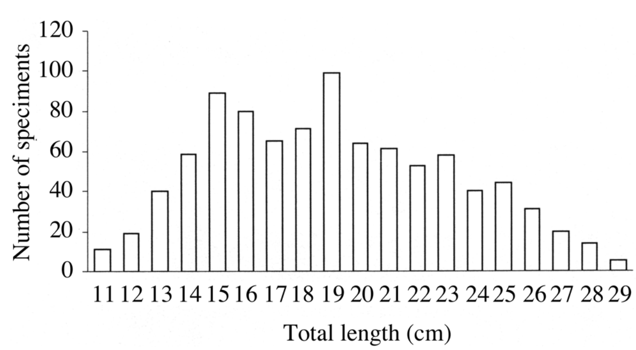

Figure 2. - Length frequency distribution of 926 individuals of *Oblada melanura* caught in the Adriatic Sea.

Numerous indices have been described for quantitavely expressing the importance of different prey in the diets of fish (Berg, 1979; Hyslop, 1980; Tirasin and Jørgensen, 1999). Those used in the present study were:

Vacuity index (VI), *i.e.* number of empty stomachs divided by total number of stomachs multiplied by 100;

Percentage frequency of occurrence (%F), based on the number of stomachs in which a food item was found, expressed as the percentage of total number of non-empty stomachs;

Percentage numerical abundance (%Cn), *i.e.* the number of each prey item in all non-empty stomachs, expressed as the percentage of total number of food items in all stomachs in a sample;

Percentage gravimetric composition (%Cw), *i.e.* the wet weight of each prey item, expressed as the percentage of total weight of stomach contents in a sample.

The main food items were identified using the index of relative importance (IRI) of Pinkas *et al.* (1971), as modified by Hacunda (1981):

$$IRI = \%F \times (\%Cn + \%Cw)$$

This index has been expressed as:

$$\%IRI = (IRI / \sum IRI) \times 100$$

Prey were sorted in decreasing order according to their percentage IRI contribution and then cumulative %IRI was calculated.

Statistical differences ($p < 0.05$) in diet composition with respect to size and season, were assessed by a chi-square test (Sokal and Rohlf, 1981), applied on the frequency of a given prey. The variation of the vacuity index was also tested by a chi-square test. The significance of variation of mean number (Nm/ST) of prey items and mean weight per stomach (Wm/ST) among size classes and seasons was tested by analysis of variance (ANOVA) while Tukey's test was employed to locate the source of any differences (Zar, 1984).

RESULTS

Feeding intensity

Of the 926 stomachs examined, 87 were empty (9.4%). This percentage varied significantly over the year ($\chi^2 = 46.1$, $p < 0.05$), with a maximum of 20.8% during the winter and a minimum of 4.1% during the summer (Fig. 3). Vacuity index (8.7% in small size-class, 10% in medium size-class and 9.3% in large specimens) did not differ significantly among the size classes ($\chi^2 = 0.5$, $p > 0.05$).

Diet composition

The stomach contents of the saddled bream consisted of at least 45 different prey species belonging to nine major groups: Copepoda, Mysidacea, Decapoda, Amphipoda, Polychaeta, Tunicata, fish eggs, Teleostei and Mollusca larvae. Table I shows the frequency of occurrence, numerical and biomass composition and the Index of Relative Importance of different prey groups and prey species found in stomachs. Crustaceans were the most important ingested prey, constituting 94.7% of the total IRI. Among the crustaceans, copepods made the most important contribution to the diet (%IRI = 92.7). Other prey groups found in the stomach contents were comparatively low and of less importance. At the species level two copepods *Lucicutia flavirostris* (%IRI = 25.9) and *Paracalanus parvus* (%IRI = 8.2) were the most frequent prey.

Food in relation to fish size

Diet composition for size classes of the nine main prey groups is shown in table II. Copepods were the most important prey group in all fish size-classes. Index of Relative Importance of other prey groups varied with saddled bream size. The IRI of decapods, amphipods, polychaetes and teleosts increase with saddled bream size whereas the IRI of mysids, tunicates, fish eggs and mollusca larvae decreased.

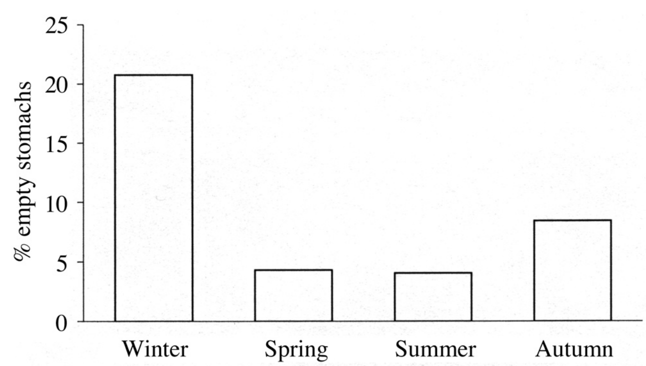

Figure 3. - Seasonal variation in percentage of empty stomachs for *Oblada melanura*.

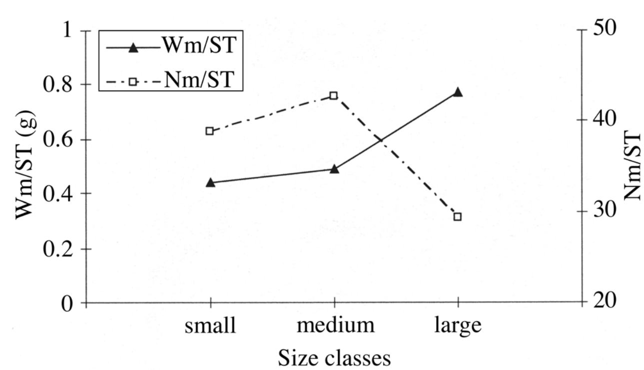

Figure 4. - Mean weight of prey per stomach (Wm/ST) and mean number of prey items per stomach (Nm/ST) as function of *Oblada melanura* size.

Table I. - Diet composition of 926 *Oblada melanura* containinig food (%F = frequency of occurrence; %Cn = percentage of numerical composition; %Cw = percentage of gravimetric composition; IRI = Index of Relative Importance. Only prey species with a contribution to the %IRI of more than 0.1 are listed (+ indicates less 0.1%).

	Food items	%F	%Cn	%Cw	IRI	%IRI
CRUSTACEA	Copepoda					
	Paracalanus parvus	77.47	8.61	2.84	887.0	8.2
	Lucicutia flavirostris	87.12	19.98	12.14	2798.2	25.9
	Acartia clausi	37.42	5.58	3.39	335.6	3.1
	Centropages typicus	29.32	2.63	0.89	103.2	0.9
	Clausocalanus furcatus	15.85	2.81	0.90	58.8	0.5
	Clausocalanus pergens	14.42	1.77	0.49	32.5	0.3
	Calanus helgolandicus	0.59	0.32	0.14	0.27	+
	Unidentified Copepoda	89.63	40.08	24.37	5776.6	53.6
	Total Copepoda	78.71	81.78	45.16	9992.1	92.7
	Cladocera					
	Ewadne tergestina	7.38	0.15	0.04	1.4	+
	Ewadne sp.	5.12	0.41	0.10	2.6	+
	Unidentified Cladocera	3.93	0.31	0.07	1.5	+
	Total Cladocera	5.09	0.87	0.21	5.5	+
	Unidentified Cirripedia	7.15	0.24	0.31	3.9	+
	Unidentified Euphausiacea	4.88	0.18	0.95	5.5	+
	Unidentified Mysidacea	10.96	0.31	1.62	21.1	0.2
	Decapoda					
	Unidentified larvae	27.4	2.90	1.70	126.0	1.1
	Decapoda adulti					
	Gnathophyllum elegans	3.45	0.08	4.61	16.1	0.1
	Alpheus sp.	0.59	0.01	0.32	0.19	+
	Macropipus sp.	0.37	0.007	0.40	0.15	+
	Ethusa mascarone	0.11	0.002	0.08	0.009	+
	Pisa nodipes	0.47	0.01	1.57	0.74	+
	Inachus thoracicus	1.07	0.02	1.98	2.14	+
	Macropodia rostrata	0.95	0.02	0.25	0.25	+
	Ebalia granulose	0.23	0.05	0.05	0.02	+
	Pisidia longicornis	0.23	0.05	0.16	0.04	+
	Galathea intermedia	0.37	0.007	0.33	0.12	+
	Upogebia litoralis	0.23	0.007	0.16	0.03	+
	Unidentified Decapoda	1.43	0.03	0.64	0.95	+
	Total Decapoda adulti	1.91	0.22	10.60	20.9	0.2
	Amphipoda					
	Caprella acanthifera	0.37	0.007	0.10	0.04	+
	Elasmopus rapax	1.19	0.02	0.13	0.17	+
	Unidentified Amphipoda	9.71	0.44	2.30	26.6	0.2
	Total Amphipoda	8.96	0.46	2.53	26.7	0.2
	Isopoda					
	Idothea sp.	0.37	0.02	0.19	0.07	+
	Unidentified Isopoda	1.90	0.12	1.06	2.2	+
	Total Isopoda	1.66	0.14	1.25	2.3	+
	Unidentified Cumacea	0.83	0.03	0.06	0.07	+
POLYCHAETA	Unidentified Polychaeta	13.23	0.45	4.19	61.3	0.5
BIVALVIA	Unidentified larvae	5.84	0.24	0.88	6.5	+
GASTROPODA	Unidentified larvae	8.70	0.29	1.07	11.8	0.1
TUNICATA	Unidentified Thaliacea	6.07	0.17	0.09	1.5	+
	Unidentified Appendicularia	22.05	1.52	0.50	44.5	0.4
TELEOSTEI	Eggs					
	Oblada melanura	8.22	0.80	0.89	13.9	0.1
	Serranus hepatus	5.00	0.73	0.76	7.4	+
	Cepola rubescens	6.79	0.34	0.32	4.5	+
	Sardina pilchardus	12.99	1.66	2.66	56.1	0.3
	Engraulis encrasicolus	12.27	1.85	1.81	44.9	0.2
	Unidentified eggs	29.79	1.23	1.36	77.1	0.2
	Total teleostei eggs	14.11	6.61	7.80	203.4	1.9
	Postlarvae and juvenile					
	Chromis chromis	2.50	0.21	0.43	1.6	+
	Serranus hepatus	1.19	0.12	0.10	0.2	+
	Gobius sp.	4.68	0.44	0.60	4.8	+
	Atherina hepsetus	12.15	0.78	8.20	109.1	1.2
	Engraulis encrasicolus	15.61	0.95	4.99	92.7	1.2
	Sardina pilchardus	17.87	0.73	0.38	19.8	0.2
	Unidentified species	5.36	0.37	2.35	14.5	0.4
	Total postlarvae and juvenile	11.75	3.60	17.05	242.8	2.2

Table II. - Dietary groups for each size range of *Oblanda melanura* with regard to the frequency of occurrence (F), numerical composition (Cn), biomass composition (Cw) and Index of Relative Importance.

	< 17 cm				17 - 22 cm				> 22.0 cm			
	F	Cn	Cw	IRI	F	Cn	Cw	IRI	F	Cn	Cw	IRI
Copepoda	92.26	84.66	76.23	14843.7	84.10	80.67	75.31	13117.9	66.83	75.98	47.95	8282.2
Mysidacea	48.70	1.80	2.32	200.6	39.87	1.81	2.30	163.8	13.22	0.66	1.47	28.1
Decapoda	18.81	1.69	3.04	88.9	49.07	5.76	5.03	529.4	44.62	1.35	14.97	728.1
Amphipoda	1.84	0.05	0.66	1.3	5.52	0.32	1.12	7.9	42.56	2.42	5.45	334.9
Polychaeta	3.32	0.11	0.05	0.5	25.76	1.24	0.21	37.3	59.09	5.36	0.57	350.4
Tunicata	18.42	0.78	5.20	101.1	5.76	0.27	0.40	2.5	2.29	0.18	0.17	0.8
Fish eggs	61.99	9.46	10.07	1210.6	28.22	5.40	4.28	273.1	13.63	3.30	1.33	18.2
Teleostei	5.16	0.49	1.31	9.2	19.93	3.64	10.34	278.6	45.45	10.03	27.19	1619.6
Mollusca larvae	10.10	0.96	1.12	21.0	9.50	0.89	1.01	18.0	6.65	0.72	0.90	8.2

A chi-square revealed non-significant differences only between ingestion of mollusca larvae ($\chi^2 = 4.2$, $p > 0.05$).

The total amount of food ingested as shown by the mean weight of stomach contents (Wm/ST) varied significantly among size classes ($F = 6.3$, $p < 0.05$). Tukey's test revealed that mean weight of stomach contents for specimens in large size-classes differed significantly from the others (Fig. 4).

The mean number of prey (Nm/ST) significantly declined in the large size-class ($F = 7.9$, $p < 0.05$). Tukey's test revealed that the mean number of stomach contents for specimens in small and medium size-classes differed significantly from large size group (Fig. 4).

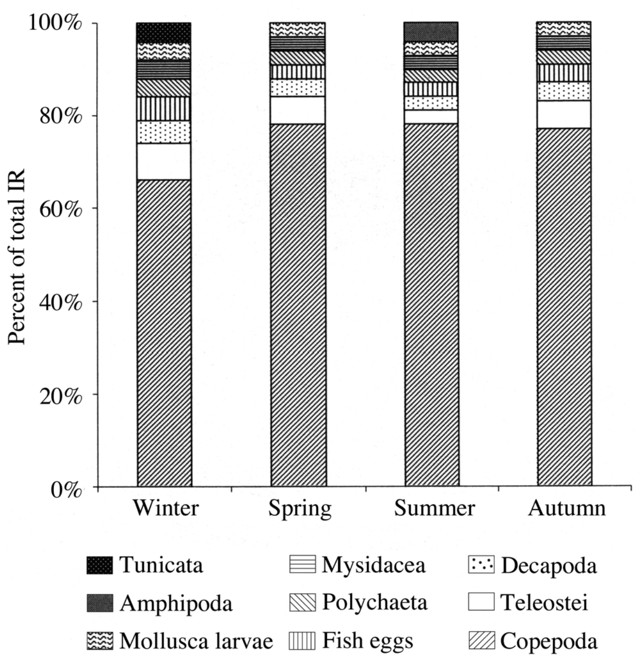

Figure 5. - Seasonal variation of *Oblada melanura* diet based on the% IRI values of the major prey groups.

Seasonal variation in the diet

Copepods were the dominant prey group in all seasons, particularly from spring to autumn (%IRI > 78). Teleosts and decapods were present in the diet throughout the year with a peak in winter. Mysids, Polychaeta, fish eggs and Mollusca larvae were present in the contents during all seasons, but in smaller quantities (Fig. 5).

Significant differences among seasons were found for copepods ($\chi^2 = 17.7$, $p < 0.05$), mysids ($\chi^2 = 41.3$, $p < 0.05$), decapods ($\chi^2 = 16.8$, $p < 0.05$) and fish eggs ($\chi^2 = 39.4$, $p < 0.05$).

Mean weight and mean number of prey significantly increased to spring-summer period ($F = 19.7$, $p < 0.05$; $F = 5.1$, $p < 0.05$). In both cases, Tukey's test showed that spring and summer samples differed significantly from those of winter (Fig. 6)

DISCUSSION

In general, the diversity of prey groups and species found in the saddled bream stomachs implies that this species is an opportunistic predator that feeds on forage from various

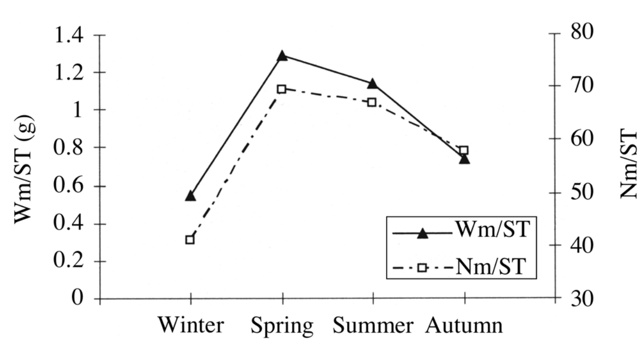

Figure 6. - Mean weight of prey per stomach (Wm/ST) and mean number of prey items per stomach (Nm/ST) of *Oblada melanura* through the year.

trophic levels, including pelagic and benthic organisms, and a wide range of prey size and morphology. This finding is in accordance with results of Ara (1937). Small and medium size classes of the saddled bream from the Adriatic Sea are exclusively planktophagous, while large specimens (> 22.0 cm LT) eat both planktonic and benthic prey. According to our data the main prey species are plankton copepods, such as *Lucicutia flavirostris*, *Paracalanus parvus*, and less commonly *Acartia clausi*, *Centropages typicus*, *Clausocalanus furcatus* and *C. pergens*. The prey group which represents 50% or more of total IRI can be classified as main food (Rosecchi and Nouaze, 1987). Other prey groups, *i.e.* teleosts, fish eggs, decapods, polychaetes, mysids and tunicates, were less important in the diet of saddled bream.

Copepods are the most numerous and diverse zooplankton group present in coastal and pelagic waters of the eastern Adriatic Sea. The number of species increases from northern to central and southern Adriatic and from the coast to the open sea (Gamulin, 1979). With respect to the depth, saddled bream mainly inhabits shallow littoral waters to 30 m (Bauchot and Hureau, 1986). Species has relatively big eyes (32% of head length), which might be an adaptation to twilight and nocturnal activity near sea bottom, as well as to the forage of smaller planktonic organisms (Pallaoro, 1995). The gut content observations of individuals of small and medium size show that these fish are not dependent on substrate organisms and substrate such as caves and crevices serve them only as shelters from sun and from predators during the daylight (Pallaoro, 1995). Since benthic fauna is well represented in food of only largest size-classes, it is possible to conclude that these specimens, change their behaviour and relationship in the bottom biocenoses as they grow.

The data of Ara (1937), about the food composition of saddled bream (range of 12.0-20.0 cm TL) collected from the Tyrrhenian Sea (coast of Napoli gulf) confirm the hypothesis of its opportunistic behaviour. Namely, in 80 specimens, the stomachs were dominated by benthic organisms: Polychaeta (5 species), Mollusca (2 species of Polyplacophora, 16 species of Gastropoda, 9 species of Bivalvia) and Crustacea (12 species of Decapoda, 6 species of Amphipoda and 5 species of Isopoda). Of sparsely represented planktonic organisms, only few copepods were recorded. The differences in food composition between saddled breams from the Tyrrhenian Sea and the eastern Adriatic are mainly due to different distribution, abundance, density and availability of prey.

Even though copepods constitute the bulk of food for all size classes, food content partially changes as saddled bream grow. Apart from copepods, their food contains planktonic crustaceans (such as mysids, cladocerans, euphausids), mollusca larvae and fish eggs. The data of Lenfant and Olive (1998), on the feeding habits of juvenile saddled breams collected from the Mediterranean coast of France, agree with ours. In their report, planktonic copepods constituted 90% of total stomach content, while Mysidacea, Ostracoda, Amphipoda and larval stages of ascidians and Annelida constituted the rest.

With growth, the presence of copepods, fish eggs and other planktonic organisms diminished in importance, while proportion of bigger prey increased. In this respect, the mean weight of prey (Wm/ST) significantly increases towards the large size-classes as a consequence of the presence of decapods, amphipods, polychaetes and teleosts. Due to the diminishing presence of plankton crustaceans the prey numbers per stomach (Nm/ST) significantly decreases in the large size-classes. Mean prey size increase with increasing predator size in order to optimize the energy per unit effort (Ware, 1972; Stoner and Lingvinston, 1984). Trophic ontogeny in saddled bream could be explained in terms of fish morphology. Width and the gape of mouth are linearly related to the fish size (Ross, 1978; Stoner, 1980) and increased body and mouth size permit fish to capture a broader range of prey size.

Feeding intensity is negatively related to the percentage of empty stomachs (Bowman and Bowman, 1980). Even though the feeding intensity was high during the study period, the percentage of empty stomachs was significantly higher during winter. This assumption may be confirmed by the values of mean weight (Wm/ST) and mean number (Nm/ST), which were highest in spring and summer, and were lowest in winter. Different factors may cause a reduction in the feeding activity in fish (Nikolsky, 1976). Many demersal fish show a decrease in the feeding rate when the temperature drops (Tyler, 1971), particularly those with thermophilous characteristics and with summer spawning. Saddled bream spawns during June and July in the Adriatic Sea (Grubišić, 1988; Pallaoro, 1995; Jardas, 1996). In the study area, the lowest water temperatures happen in winter (February) and in the beginning of spring (Zore-Armanda *et al.*, 1991). Because of the reduced abundance of prey and the lowered metabolism of the fish, predation on plankton and benthos was probably at a minimum during winter. This assumption broadly agrees with the model of thermophilous fish growth from seas of medium geographic latitudes (Cefali *et al.*, 1987), which shows lowest growth rate in winter and in the beginning of spring. In the Adriatic Sea copepods and other dominant zooplankton groups (Appendicularia, Thaliacea, Decapoda, Cladocera), eggs and postlarvae of *Engraulis encrasicolus*, postlarvae of *Sardina pilchardus* and many groups of benthic organisms, are present in higher abundance and density during warmer part of year (Vučetić, 1970; Regner, 1985a, 1985b; Regner *et al.*, 1987; Baranović *et al.*, 1992) This occurrence of a larger number and higher density may be attributed either to natural fluctuations or to the nutrient enrichment of coastal area, as well as to the sufficient food available over a larger part of the year. Favourable environmental conditions, during the warmer months, and abundant food supply support the larger expanded fish community without competitive interactions. However, the effects of temperature may be confounded with the effects on other abiotic factors and/or a change in food availability (Worobec, 1984). Warren and Davis (1967) discussed the profound effects of temperature and seasonality on food consumption rates. More food is consumed in summer than in winter, this was demonstrated from the experiment with *Cottus perplexus* (Davis and Warren, 1965).

Similarly to saddled bream, high degrees of stomach fullness were reported for other demersal fish in the same area, such as *Scorpaena porcus* (Jardas and Pallaoro, 1991) and *Chromis chromis* (Dulčić, 1996). This indicates an abundance of food in this region even though this region belongs, according to Buljan and Zore-Armanda (1976) to relatively oligotrophic part of the Adriatic Sea. The abundance of food in this region is connected with upwellings in the area of Palagruža, which is in vicinity of the studied area (Regner *et al*., 1987). This phenomena is more pronounced during years with increased Mediterranean inflow at the time of strong advection of intermediary water and also during upwelling periods in spring and summer (Buljan, 1965). Upwelling may also be caused later in the spring-summer period by dominant coastward wind direction (the maestral).

In summary, *Oblada melanura* is an opportunistic predator whose diet in the Adriatic Sea, as well as in the Gulf of Napoli, consists of many pelagic and benthic animal groups. Copepods were the dominant prey in all analysed size-classes, and they were, with other planktonic groups (Cladocera, Mollusca larvae, fish eggs) the most important prey items. In addition, many exclusively benthic organisms (Crustacea, Mollusca, Polychaeta) were found in analysed specimens, particularly in gut of large-size specimens.

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