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Feeding habits and diet overlap of juveniles of 2 sparids, *Diplodus puntazzo* (Walbaum, 1792) and *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817), from the North Aegean Sea of Turkey

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Abstract: The stomach contents of juvenile sharpsnout seabream, *Diplodus puntazzo*, and juvenile two-banded seabream, *Diplodus vulgaris*, were investigated in order to determine feeding habits and diet overlap among them. Fish were collected from October 2008 to August 2009 using a beach seine net from the Çanakkale coasts of Turkey. A total of 129 juvenile *D. puntazzo* (ranging from 13 mm to 77 mm total length) and 951 *D. vulgaris* (ranging from 15 mm to 97 mm total length) were collected during the sampling periods in the study area. The stomach content analyses showed that the diet of both species mainly comprised copepods and amphipods. In addition, algae were found in the stomach contents. No significant differences were found between the feeding habits of juvenile *D. vulgaris* and *D. puntazzo* (ANOSIM; global R statistic = –0.0158; P > 0.05). An important overlap in the diet calculated using the Schoener index was recorded as 0.75 for *D. puntazzo* and *D. vulgaris*. Consequently, there was a significant diet overlap and competition for available resources among the feeding habits of *D. vulgaris* and *D. puntazzo* in juvenile periods.

Key words: *Diplodus vulgaris*, *Diplodus puntazzo*, juvenile, feeding habits, diet overlap, North Aegean Sea, Çanakkale

1. Introduction

The family Sparidae is represented by 10 genera and 22 species that usually inhabit coastal areas in the Mediterranean Sea. Sharpsnout seabream *Diplodus puntazzo* (Walbaum, 1792) and common two-banded seabream *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817) have commercial value and are found in all the coastal areas of Turkey. These 2 species are important for fisheries and fishery management in Turkey, especially in the Aegean Sea. The North Aegean Sea is a very important area for the demersal and small-scale fisheries in Turkey (Benli et al., 1999). The total commercial catch of sharpsnout seabream and common two-banded seabream are around 8.8 and 195.2 t in Turkey, respectively (TÜİK, 2012).

Sharpsnout seabream is found close to rocky bottoms, from shallow waters to a maximum depth of 150 m. Spawning periods of this species have been reported between September and December and first maturity length was found as 220 mm total length (TL) (3 years old) (Dominguez-Seoane et al., 2006; Mouine et al., 2012). Common two-banded seabream lives near rocky and sandy bottoms, at depths ranging from 0 to 160 m (Bauchot and Hureau, 1986). Spawning periods of this species have been found between October and February in the Mediterranean Sea and first maturity length was determined as 170 mm TL (2 years old) (Bauchot and Hureau, 1986; Mouine et al., 2012). Both species settle in shallow waters at approximately 2–2.5 months old in January and February (Harmelin-Vivien et al., 1995; Matić-Skoko et al., 2007; Cheminee et al., 2011).

Juveniles of Sparidae species are usually found in shallow waters with relatively bigger groups. Group sizes decrease when the juveniles get older and they scatter around reaching about 4.5–5 cm in length (Macpherson, 1998). These species that share the same habitats may be in competition for limited resources and food availability (Vigliola et al., 1998). Association with similar species in the same ecosystem results in the division of available resources (Mariani et al., 2002). In this sense, analysis of the diet of similar species is important in understanding their competition for resources within an ecosystem.

Although data on the feeding habits and diet overlap during the juvenile life stage are very important for understanding ecosystems, published information on feeding habits of the juvenile common two-banded seabream and sharpsnout seabream are very scarce and are

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generally focused on adult populations (Rosecchi, 1987; Goncalves and Erzini, 1998; Lapiano et al., 2001; Mariani et al., 2002; Horta et al., 2004; Dulcic et al., 2006; Pallaoro et al., 2006; Amany and Hatem, 2009; Dobroslavić et al., 2013). Furthermore, there are no studies focusing on the diet overlap of juvenile individuals of either species and surprisingly no study has been conducted on the feeding habits of the aforementioned species in either the Aegean Sea or the Sea of Marmara.

The aim of this study was to determine the feeding habits and seasonal variations of juvenile common two-banded seabream and sharpsnout seabream. Dietary overlaps among juveniles of these 2 species, distributed along the Çanakkale coast of Turkey (North Aegean Sea), were also analyzed. The results of this study will provide the background for future fishery management investigations in the area.

2. Materials and methods

2.1. Study area

The study area was located in the North Aegean Sea. Three different stations were selected: station 1, Abide (40°03′06″N, 26°12′12″E); station 2, Güzelyalı (40°02′22″N, 26°20′16″E); and station 3, Kerevizdere (40°03′38″N, 26°14v9″E) (Figure 1). All stations were located in shallow nursery areas <2 m from Çanakkale, Turkey. Surface water temperature was recorded between 10.4 to 24.9 °C on a monthly basis during the year.

2.2. Sampling

Samplings were carried out monthly between October 2008 and August 2009. Samples were collected with beach seine with a total wing length of 32 m, a height of 2 m, and a 2-m-long bag with 13-mm mesh size at the wing and 5-mm mesh at the bag. Beach seine operations were carried out according to Able et al. (2003) and Wilber et al. (2003).

Fish were killed with an overdose of quinaldine and stored in 4% formaldehyde. Fish species were determined according to Bauchot and Hureau (1986) and Mater and Çoker (2004). The TL of specimens was measured in millimeters.

2.3. Stomach content analysis

Stomach samples were removed and put into a 70% alcohol solution. Stomach contents were identified to the lowest taxonomic level possible (Hayward and Ryland, 1995) and then counted and weighed (wet mass: 0.0001 g). Frequency of occurrence (F%), numerical (N%) and weight percentages (W%) (Hyslop, 1980; Cortés, 1997), index of relative importance (IRI) (Pinkas et al., 1971), and percentage of IRI (IRI%) were calculated (Cortés, 1997).

In order to assess the proportions of empty stomachs of fishes, the vacuity index was used. The vacuity index was calculated according to Berg's (1979) formula: VI = (number of empty stomachs / number of total stomachs) × 100. The vacuity index of fishes was calculated according to seasons.

2.4. Statistical analysis

A chi-square test was applied to determine vacuity index changes according to the seasons. ANOSIM and SIMPER statistical analyses were used in order to determine similarities between the diet of species and seasonal feeding habits. All statistical analyses were performed with PAST version 2.17b (http://palaeo-electronica.org/2001_1/past/issue1_01.htm). Statistical significance level was accepted as α = 0.05.

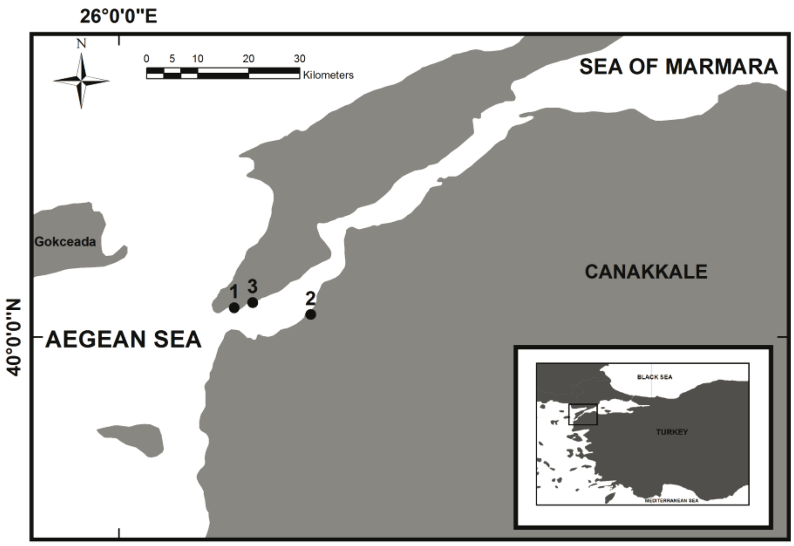

Figure 1. Sampling stations (1: Abide, 2: Güzelyalı, 3: Kerevizdere).

Diet overlap between the 2 species was calculated using the Schoener index (Schoener, 1974), defined as: C = 1 – 0.5 × (S(P*xi* – P*yi*)), where P*xi* and P*yi* are the proportions of prey *i* in the diets of species *x* and *y*. Values range from 0 (no food overlap) to 1 (all food items in equal proportions) with values greater than 0.6 being considered as biologically important (Zaret and Rand, 1971).

3. Results

A total of 129 juvenile *D. puntazzo* (ranging from 13 mm to 77 mm TL) and 951 *D. vulgaris* (ranging from 15 mm to 97 mm TL) were collected during the sampling periods in the study area. In this study, *D. puntazzo* specimens were obtained in all seasons, whereas *D. vulgaris* was not caught in autumn (Table 1).

3.1. Feeding intensity and diet composition

The vacuity index reached the highest value (27.6) in winter for *D. vulgaris*, while the highest level was reached in summer (21.1) for *D. puntazzo* (Figure 2). All stomachs of *D. puntazzo* were found to be full in autumn.

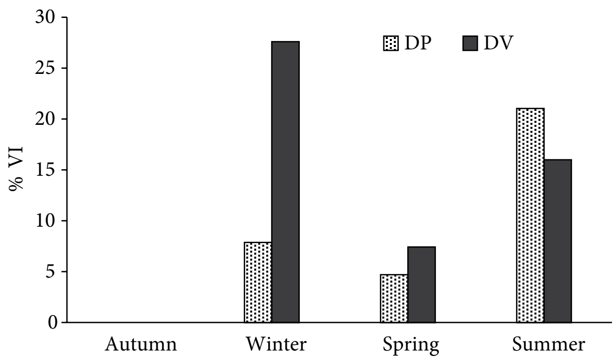

Figure 2. Vacuity index (VI) of juvenile *D. vulgaris* (DV) and *D. puntazzo* (DP) according to season.

No significant differences were found between seasonal changes of the vacuity index for either of the species ($\chi^2 = 17.3$, $P > 0.05$ and $\chi^2 = 4.9436$, $P > 0.05$, respectively).

The diet of juvenile *D. vulgaris* consisted mainly of Crustacea (IRI% = 82.7), Annelida (IRI% = 8.11), and Mollusca (IRI% = 3.62) species. Copepods were the most common prey (IRI% = 64.08) in their stomach contents. Amphipods (IRI% = 15.5), polychaetes (IRI% = 4.43), and oligochaetes (IRI% = 3.6) were also well represented in the diet. The principal prey group for *D. puntazzo* was determined as Crustacea according to IRI. The diet consisted of Amphipoda (IRI% = 46.46), Copepoda (IRI% = 43.5), algae (IRI% = 1.13), and Annelida (IRI% = 0.25) (Table 2).

No significant differences were found between the feeding habits of juvenile *D. vulgaris* and *D. puntazzo* (ANOSIM; global R statistic = –0.0158; $P > 0.05$). Furthermore, the Schoener index showed that there was a significant overlap (C = 0.75) between both species.

3.2. Seasonal variation in the diet

Copepods were the dominant prey group in winter (IRI% = 87.92) and spring (IRI% = 84.02) for *D. vulgaris*. However, the amounts of copepods decreased from winter to summer (Figure 3). In contrast to copepods, the amounts of amphipods increased from winter to summer. Furthermore, amphipods were the most important prey (IRI% = 38.54) in summer. The biodiversity of stomach contents of *D. vulgaris* reached the highest level (33 species) in summer. The ANOSIM analysis showed significant differences between seasons for feeding habits of juvenile *D. vulgaris* (R = 0.1482; $P < 0.05$). The results obtained from the SIMPER analysis showed that the seasonal variety of feeding habits was composed of copepod (contribution = 53.13), Amphipoda (contribution = 9.59), and Foraminifera (contribution = 7.31) species (Table 3).

Table 1. The number and length range of fish examined for stomach contents according to seasons.

	Season	N	L_{min}	L_{max}	L_{mean}	SD
D. vulgaris	Autumn	0	-	-	-	-
	Winter	29	1.5	2.9	2.1	0.3803
	Spring	296	1.6	6.7	3.08	0.8012
	Summer	626	3.5	9.7	5.87	1.2744
D. puntazzo	Autumn	8	1.3	3.1	2.16	0.5805
	Winter	38	1.6	4.1	2.94	0.6198
	Spring	64	2.1	5.8	3.95	0.8687
	Summer	19	4	7.7	5.67	1.0016

N: Number of individual, SD: standard deviation.

Table 2. General feeding habits of juvenile *D. vulgaris* and *D. puntazzo* (F%: frequency percentages, N%: numerical percentages, W%: weight percentages, IRI: relative importance, IRI%: relative importance percentages).

Taxa	*Diplodus vulgaris*				*Diplodus puntazzo*			
	N%	F%	W%	IRI%	N%	F%	W%	IRI%
Annelida	1.64	17.42	50.69	8.11	0.38	5.13	6.50	0.25
Polychaeta	0.79	9.02	22.61	4.43	0.14	2.56	1.24	0.05
Oligochaeta	0.68	6.39	26.16	3.60	0.24	2.56	5.26	0.20
Unidentified Annelida	0.16	2.01	1.93	0.09				
Crustacea	73.01	138.97	35.86	82.70	93.16	187.18	77.96	97.16
Amphipoda	8.01	41.10	9.97	15.50	14.26	58.12	41.55	46.46
Gammaridae	0.06	0.63	0.22	*	3.06	13.68	18.40	4.20
Hyale sp.	0.02	0.25	0.02	*	0.05	0.85	0.04	*
Ampelisca sp.	0.03	0.38	0.05	*	0.10	1.71	0.15	0.01
Atylus sp.	0.01	0.13	0.04	*				
Dexamine cf. *spinosa*	0.01	0.13	0.01	*				
Apherusa sp.	0.04	0.25	0.06	*				
Caprellida	0.20	2.01	0.10	0.01	0.57	5.98	1.50	0.18
Ericthonius brasiliensis	0.02	0.25	0.06	*	0.05	0.85	0.13	*
Isopoda	0.91	9.02	3.50	0.83	2.39	17.09	5.14	1.85
Idotea balthica	0.01	0.13	0.33	*				
Mysidae	0.78	5.01	2.68	0.36	0.05	0.85	0.66	0.01
Siriella jaltensis					0.10	0.85	1.38	0.02
Cumacea	0.21	2.38	0.19	0.02	0.57	7.69	0.91	0.16
Tanaidacea	0.11	1.13	0.15	0.01	0.67	5.98	0.94	0.14
Unidentified Peracarida	2.03	15.41	2.40	1.43	0.57	5.98	1.58	0.18
Copepoda	58.51	48.37	4.69	64.08	64.07	44.44	4.26	43.50
Calanoida	0.48	0.63	0.03	0.01	2.63	5.13	0.15	0.20
Acartia sp.	0.05	0.13	0.01	*	2.06	2.56	0.29	0.09
Acartia clausii					0.05	0.85	0.01	*
Oithona similis					0.29	0.85	0.10	*
Harpacticoida	0.19	0.25	0.01	*	0.57	0.85	0.05	0.01
Microsetella sp.	0.03	0.25	0.01	*				
Decapoda	0.02	0.25	0.97	0.01				
Anomura	0.11	1.38	7.49	0.22				
Brachyura	0.03	0.38	0.92	0.01				
Dendrobranchiata	0.04	0.50	0.72	0.01	0.10	0.85	0.09	*
Ostracoda	0.57	3.51	0.12	0.05	0.14	2.56	0.04	0.01
Nauplius	0.08	0.50	0.01	*	0.10	1.71	0.02	*
Unidentified Crustacea	0.47	4.64	1.11	0.15	0.72	7.69	0.58	0.14
Mollusca	9.32	18.67	3.57	3.62	3.21	7.69	4.25	0.67
Gastropoda	1.05	2.26	0.81	0.09				
Bivalvia	0.07	0.75	0.07	*				
Mytilus galloprovincialis	0.01	0.13	0.06	*	0.72	0.85	0.03	0.01
Unidentified Mollusca	8.19	15.54	2.64	3.53	2.49	6.84	4.22	0.66
Unidentified egg	0.45	1.25	0.06	0.01	1.34	2.56	0.05	0.05
Foraminifera	12.06	6.14	0.85	1.66	0.19	0.85	0.01	*
Platyhelminthes	0.22	2.13	0.12	0.02				
Nematoda	0.48	2.13	0.06	0.02				
Algae	0.95	11.28	3.29	1.00	0.48	8.55	8.77	1.13
Zostera	0.04	0.50	0.02	*	0.10	1.71	0.05	*
Digested	1.73	20.80	4.79	2.84	0.96	17.09	1.96	0.71
Insecta	0.05	0.63	0.09	0.00	0.05	0.85	0.25	*
Unidentified	0.05	0.50	0.58	0.01	0.14	1.71	0.21	0.01
Sand	0.01	0.13	0.02	*				

*: Prey category present but made up <0.01%.

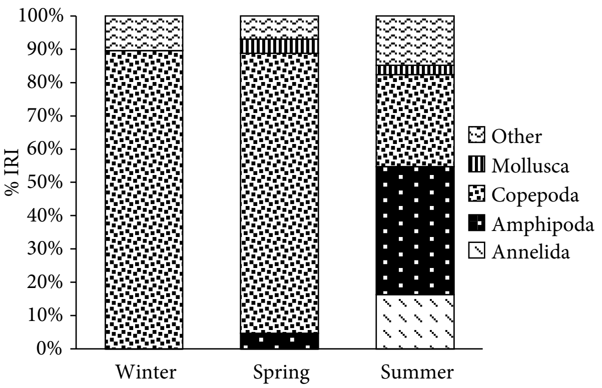

Figure 3. Seasonal feeding habits of juvenile *D. vulgaris* (IRI: index of relative importance).

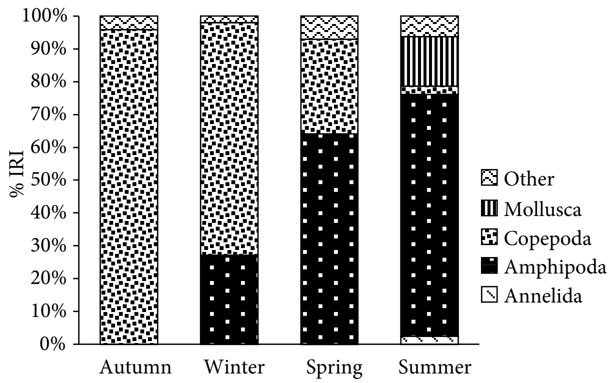

Figure 4. Seasonal feeding habits of juvenile *D. puntazzo* (IRI: index of relative importance).

Copepods were the most important food item for *D. puntazzo* in autumn (IRI% = 95.42) and winter (IRI% = 68.73). In addition, Amphipoda (IRI% = 26.64) was also observed in stomach contents in winter. Amphipoda species were also the most important prey items in spring and summer (IRI% = 54.71 and IRI% = 73.57, respectively). In addition, Mollusca (IRI% = 15.11) and Annelida (IRI% = 2.45) species were included within feeding habits in summer. However, copepods had the lowest value (IRI% = 2.53) in summer (Figure 4). The results of ANOSIM analyses showed that there are significant differences between seasons in the means of feeding habits (ANOSIM; R = 0.8328, P < 0.05). The results obtained from the SIMPER analysis indicated that differences between seasons were caused by changes in the amount of copepods (contribution = 45.87), Amphipoda (contribution = 19.34), and Isopoda (contribution = 3.36) (Table 3).

4. Discussion

4.1. Feeding habits

The diet of *D. vulgaris* was characterized by algae and invertebrate species (Harmelin-Vivien et al., 1995; Costa and Cataudella, 2007). This species was described as omnivorous and opportunist (Sala and Ballesteros, 1997; Macpherson, 1998; Horta et al., 2004; Pallaoro et al., 2006; Costa and Cataudella, 2007). In contrast to this, the feeding habits of *D. vulgaris* were reported as being based on meat (Costa and Cataudella, 2007). The results of this study indicate that the diet of *D. vulgaris* consists mainly of Crustacea, Annelida, and Mollusca. Algae species were found in lower rates in the stomach contents. Copepods were the most important prey item of *D. vulgaris*. In addition, Amphipoda, polychaete, and oligochaete species were also included in their stomach contents. Horta et al. (2004) reported that juvenile individuals of *D. vulgaris* generally feed on Amphipoda, mysids, and algae.

Table 3. Groups of prey that constitute the differences in seasonal feeding habits of juvenile *D. vulgaris* (DV) and *D. puntazzo* (DP), according to SIMPER analysis.

				Mean abundance							
Contribution		Cumulative %		Autumn		Winter		Spring		Summer	
DP	DV	DP	DV	DP	DV	DP	DV	DP	DV	DP	DV
45.87	53.13	58.93	63.08	36.80		19.70	27.60	8.44	16.40	1.07	2.28
19.34	9.59	83.78	74.47	0.00		1.47	0.06	4.33	0.57	4.53	1.51
	7.31		83.14				0.00		4.40		0.01
3.36	1.60	88.10	88.42	0.00		0.03	0.00	0.72	0.10	0.40	0.15
1.88	1.55	90.51	90.26	0.00		0.06	0.00	0.10	0.05	0.27	0.20

Dobroslavić et al. (2013) observed that the diet of juvenile *D. vulgaris* was based on bivalve larvae and copepods between March and May. In the present study, copepod amounts decreased, whereas the amphipods increased from winter to summer. Food availability is one of the most important parameters affecting feeding habits of species (Wassef and Eisawy, 1985). Büyükateş and İnanmaz (2010) reported that 2 peaks were observed in zooplankton abundance, the first in early spring and the second in midsummer, in the Çanakkale Strait. However, copepod species were present throughout the year, dominating the surface and the mixed layer in the Çanakkale Strait. The feeding habits of *D. vulgaris*, whose mean length was the minimum, was based on relatively smaller preys in winter. Different factors, such as length, may cause changes in the feeding habits of fishes (Rosecchi, 1987; Sala and Ballesteros, 1997; Santos et al., 1998; Horta et al., 2004; Costa and Cataudella, 2007; Amany and Hatem, 2009).

The feeding rates of many demersal fish species decrease when the temperature drops and feeding intensity is negatively related to the percentage of empty stomachs (Tyler, 1971; Bowman and Bowman, 1980). In this study, the higher vacuity index of juvenile *D. vulgaris* corresponded to lower water temperature in winter. Spawning periods of *D. vulgaris* occurred between autumn and winter in the Mediterranean and fish grew slowly in the settlement period (Francesco et al., 1983). The low feeding intensity may have a negative effect on the mortality rate of this species in the settlement period.

The head morphology and jaw structure of *D. puntazzo* are more inclined to feeding on algae (Palma and Andrade, 2002; Costa and Cataudella, 2007). In the Medes Islands of Spain, *D. puntazzo* was reported to feed primarily on algae and bivalves (Sala and Ballesteros, 1997). Costa and Cataudella (2007) defined this species as omnivorous, rather than herbivorous. Mariani et al. (2002) reported that the diet of *D. puntazzo* comprised algae, polychaetes, and bryozoans. The results of this study indicate that the diet of juvenile *D. puntazzo* consists mainly of crustaceans, algae, and Annelida. Feeding habits of juvenile *D. puntazzo* were especially based on Amphipoda and copepod species. Copepods were the most important prey items for *D. puntazzo* in autumn, while Amphipoda was dominant in summer. Ateş et al. (2012) recorded 50 Amphipoda species in shallow water (0–5 m) in the Çanakkale Strait. In addition, a total of 110 peracarid species were identified and amphipods were the dominant group both in terms of species richness and abundance in the Çanakkale Strait. Furthermore, peracarid species increased from winter to summer and decreased in autumn in the strait (Aslan-Cihangir and Pancucci-Papadopoulou, 2011). Although no significant differences were found in the abundance of molluscan species in the Çanakkale Strait (Aslan-Cihangir and Panayotis, 2013), the intensity of Annelida and Mollusca in the stomach contents of *D. puntazzo* increased after autumn in this study. Dulcic et al. (2006) reported that individuals shorter than 240 mm feed on Ophiuroidea and macrophytes while larger individuals feed on bivalve species, and significant differences were found between seasons.

4.2. Diet overlap

The mean total lengths of *D. puntazzo* and *D. vulgaris* were close to each other in autumn and winter and both species generally fed on copepods. In the spring and summer, relatively larger food amounts increased in the stomach contents, parallel to the increase of the sizes of both species. In contrast to the current study, Costa and Cataudella (2007) reported that adult individuals of *D. vulgaris* and *D. puntazzo* lived in the same environment but their feeding habits differed from each other. In addition, Sala and Ballesteros (1997) observed that there was no diet overlap between adult individuals of either species. However, these differences in the diets of adult individuals from the aforementioned studies could be explained by the different sizes of species. Morphology has a great influence on feeding strategy. The feeding strategy of juvenile individuals that have small jaws is to access food resources with minimum energy consumption in the settlement period (Costa and Cataudella, 2007). Settlement periods of both species were close to each other and they settled in the same areas (Vigliola et al., 1998). Therefore, they have to share available resources in the periods when the mortality rate is highest. According to Matthews (1998), when one or more types of food are abundant in coastal areas, many kinds of fish may consume these resources as opportunists. Moreover, fish species that are fed in coastal areas demonstrate feeding flexibility and niche width (Whitfield, 1999). In this sense, diet overlap is expected among juvenile individuals of the congener species.

The results of this study indicate that there was a significant diet overlap and competition for available resources among feeding habits of *D. vulgaris* and *D. puntazzo* in juvenile periods. Further studies should be conducted to determine the food web and trophic levels of fishes to better understand the ecosystem.

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