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Feeding Biology of *Diplodus sargus* and *Diplodus vulgaris* (Teleostei, Sparidae) in Egyptian Mediterranean Waters

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Abstract: This study aimed to determine the stomach contents of *Diplodus sargus* and *Diplodus vulgaris* and find their preferred food items in Abu Qir Bay. Stomach contents of 403 samples of *D. sargus* and 98 *D. vulgaris* were analyzed. The diet of the two species consisted of crustacea (amphipoda, isopoda and prawn), fish, polychaeta and echinoderms. In addition to those food items, the stomachs of *D. sargus* contained mollusca (bivalves and gastropods) and algae. Interspecific competition between the two species revealed that *D. sargus* is in search for bivalves, while *D. vulgaris* is in search of polychaeta and isopoda. Five indices were studied to determine the preferential food items for each species. Bivalves were the preferred food items for *D. sargus*, while polychaetes were the preferred for *D. vulgaris*. Seasonal variations studies on *D. sargus* showed that echinoderms appeared in spring only, while amphipoda and isopoda appeared in spring and summer only. The diet of *D. sargus* varied with the fish size, the abundance of polychaeta decreased with increasing the fish size, while the highest occurrence in larger fish was for fish and prawn. The diet of *D. sargus* varied slightly with sex. Prawn had the highest values of occurrence in the stomachs of males and females, while polychaeta had the highest occurrence in the stomachs of hermaphrodites. In conclusion, both *Diplodus sargus* and *Diplodus vulgaris* feed on the same food items and each species search for certain food item.

Key words: Feeding % *Diplodus sargus* % *Diplodus vulgaris* % Sparidae % Mediterranean % Egypt

INTRODUCTION

Fishes of family Sparidae are the most dominant group of demersal fish in the coastal Mediterranean waters off Alexandria. Many species of this family are of significant commercial value. Fishes of family Sparidae under study live in littoral waters on rocky bottoms and sand close to rocks to 50 m depth in case of *D. sargus* and 70 m in case of *D. vulgaris* and live deeper in Atlantic [1].

Gerking [2] stated that a large number of species in many taxonomic fish groups have the ability to adapt to a variety of food sources, as well as to switch their feeding habits to respond to seasonal, diurnal and temporal changes in food availability.

The purpose of this study was to examine the diet of *D. sargus* and *D. vulgaris* and to determine the preferred food items and the interspecific competition between the two species understudy which are considered economically important in Alexandria fish market.

MATERIALS AND METHODS

Monthly fish samples were collected from the fishermen just after the fishing process in Abu Qir Bay (from August 2008 to July 2009) along the Mediterranean coasts off Alexandria, Egypt. The relative abundance of *D. vulgaris* in the catch was much less than *D. sargus*.

A total of 403 stomachs of *D. sargus* and 98 stomachs of *D. vulgaris* were examined. For each fish, the total length, gutted weight and sex were determined. Stomachs were dissected in freshly thawed condition and the number and weight of each food item were obtained. Their volumes were determined by water displacement. The following indices were obtained for the study of feeding habits:

1- Vacuity index (% VI) [3]:

% VI = 100 x (number of empty stomachs / number of examined stomachs)

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2- Frequency of occurrence (Co) for food items [4]:

Co = 100 x (number of stomachs containing certain food item / number of examined full stomachs).

3- Numerical abundance (% Cn) [4]:

% Cn = 100 x (number of food item concerned / total number of food items observed).

4- Gravimetric index (%W) [4]:

%W= 100 x (weight of certain food item / total weight of food items).

5- Volumetric index (% Cv) [5]:

%Cv = 100 x (volume of certain food item / total volume of food items).

6- Interspecific competition between the two species under study (CI) [6]:

$$CI = (Pi^2 / \sum Pi \times \sum Ri) \times 10^3$$

Where, CI: is interspecific competition.

Pi is the number of individuals of a certain prey found in the stomach contents of a certain species.

$\sum$ Pi is the number of preys of the same given category in all fishes examined.

$\sum$ Ri is the total number of all preys eaten by the studied species.

According to Richard [6], the value of CI can vary between 0- 1000, so that the prey is considered to be consumed only by the predator understudy. For CI = 0, the prey under consideration is not eaten by the predator, if CI is superior to hundred, we can say that there is a trophic competition between the two predators for the same prey.

For studying food preference, five indices have been calculated. These indices were proposed by various authors. All these indices have different scales, so Rosecchi and Nouaze [5] proposed a certain method in order to compare their values for each food item. Hence the total for each index was calculated and the index value of each prey was then expressed as a percentage of that total. In that way all indices have been reported to the same scale. Once this transformation is done, the indices are arranged in a decreasing order. According to Rosecchi and Nouaze [5], the preys adding to 50% of the total index are considered preferential, while those adding from 50-75% are secondary and the rest are considered as accidental. These indices are:

1- Absolute importance index (RI) [7]:

AI = Co + %Cn + %W RI = 100 x (AI / $\sum$ AI)

2- The index of relative importance (IRI) [8]:

IRI = (%Cn+ % Cv) x Co

3- Feeding coefficient (Q) [4]:

Q = %Cn x %W

4- Main food item (MFI) [9]:

$$MFI = \sqrt{(\%Cn + \% Co/ 2) \times \% W}$$

5- Alimentary index (IA) [10]:

IA = (Co x % Cv) / 100

The variations of food items with season, size and sex were studied for *D. sargus* only due the limited number of the sample of *D. vulgaris*.

RESULTS

The abundance (% Cn) and occurrence (Co) of food items in the studied stomachs were calculated for both *D. sargus* and *D. vulgaris*. From (Table 1), it appears that *D. sargus* feeds on crustacea (amphipoda, isopoda and prawn), mollusca (bivalves and gastropods), fish, polychaeta, algae and echinoderms. The most abundant of these items was bivalves (% Cn = 54.0), followed by polychaeta (% Cn = 12.0) and prawn (% Cn = 11.4). However, prawns were the most frequent food items in the examined stomachs of *D. sargus* (Co = 46.3), followed by bivalves (Co = 26.7) and polychaeta (Co = 22.1).

The food items in the studied stomachs of *D. vulgaris* (Table 1) were crustacea (amphipoda, isopoda and prawn), fish, polychaeta and echinoderms. The most abundant food item was polychaeta (% Cn = 61.2) and the most frequent food item was prawn (Co = 50).

In the present study the value of CI was studied for *D. sargus* and *D. vulgaris*, this index helps in the comparison of preference of certain prey between two or more species. According to the present results which are represented in Table 2, it is clear that *D. sargus* is in search to get more bivalves in its feeding (CI = 540.18), while *D. vulgaris* is in search for polychaeta (CI = 501.9) and isopoda (CI = 122.1).

In the present study, in order to find out the preferential food items for both *D. sargus* (Table 3) and *D. vulgaris* (Table 4), five indices were calculated.

Table 1: % abundance (Cn) and occurrence (Co) for *D. sargus* and *D. vulgaris*

	D. sargus			*D. vulgaris*		
Food items	No. of food items	Cn	Co	No. of food items	Cn	Co
Amphipoda	47	3.7	9.6	128	11.4	34.6
Isopoda	32	2.6	4.6	164	14.6	38.5
Prawn	143	11.4	46.3	52	4.6	50
Bivalves	679	54.0	26.7	-	-	-
Gastropods	60	4.8	5.7	-	-	-
Fish	93	7.4	14.9	24	2.1	19.2
Polychaeta	151	12.0	22.1	688	61.2	42.3
Algae	46	3.7	11.7	-	-	-
Echinoderms	6	0.5	1.1	68	6.1	42.3
No. of stomachs examined	403			98		

Table 2: Interspecific competition (CI) between *D. sargus* and *D. vulgaris*

Food items	*D. sargus*	*D. vulgaris*
Amphipoda	10.04	83.29
Isopoda	4.16	122.10
Prawn	83.43	12.34
Bivalves	540.18	-
Gastropods	47.73	-
Fish	58.81	4.38
Polychaeta	21.62	501.94
Algae	36.59	-
Echinoderms	0.39	55.59

Table 3: Food preference using the five indices for *D. sargus*.

	Indices				
Food Items	% RI	% IRI	% Q	% MFI	% IA
Amphipoda	3.90	0.80	1.90	0.95	0.04
Isopoda	2.14	0.30	1.30	0.75	0.04
Prawn	20.47	22.70	11.90	19.40	24.00
Bivalves	33.00	47.80	43.30	37.10	36.50
Gastropods	3.26	0.65	2.70	1.98	0.20
Fish	17.89	14.40	23.20	21.30	24.80
Polychaeta	14.12	12.40	13.10	15.90	14.10
Algae	4.69	1.10	2.20	2.30	0.30
Echinoderms	0.47	0.01	0.30	0.20	0.004

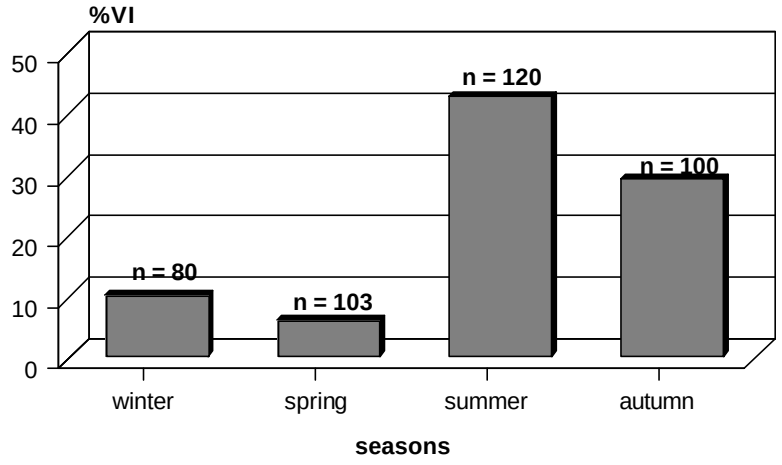

Fig. 1: Seasonal variations in vacuity index (%VI) for *D. sargus* in Abo Qir Bay

Table 4: Food preference using the five indices for *D. vulgaris*

	Indices				
Food Items	% RI	% IRI	% Q	% MFI	% IA
Amphipoda	10.88	5.05	5.90	3.10	0.35
Isopoda	12.70	7.40	7.80	4.90	0.90
Prawn	14.10	6.34	5.10	12.30	7.10
Fish	7.90	3.60	7.20	11.40	6.20
Polychaeta	42.90	74.10	70.56	63.90	84.80
Echinoderms	11.50	3.50	3.40	4.30	0.70

Table 5: Seasonal variations in % abundance (Cn) and occurrence (Co) for *D. sargus*

	Season							
	Spring		Summer		Autumn		Winter	
Food items	Co	Cn	Co	Cn	Co	Cn	Co	Cn
Amphipoda	21	15.8	9.7	4.2	-	-	-	-
Isopoda	8	5.9	8.1	5.6	-	-	-	-
Prawn	31	5.4	33.9	10.0	91.5	25.1	48.6	7.4
Bivalves	21	36.6	58.1	61.8	42.6	29.8	23.6	68.9
Gastropods	9	4.5	3.2	5.6	6.4	3.6	2.8	4.9
Fish	8	7.4	3.2	6.1	29.8	10.5	25.0	6.7
Polychaeta	12	18.3	16.1	6.1	53.2	17.7	20.8	10.7
Algae	6	2.9	3.2	0.6	40.4	12.9	8.3	1.3
Echinoderms	3	2.9	-	-	-	-	-	-
Number of stomachs examined	104		118		102		79	

Table 6: Variations in occurrence (Co) and % abundance (Cn) of food items with size in *D. sargus*

	Length (cm)					
	10-15		15-20		20-25	
Food Items	Co	Cn	Co	Cn	Co	Cn
Amphipoda	-	-	-	-	20	6
Isopoda	-	-	-	-	20	8
Prawn	11.11	19.2	60.2	43.3	40	4
Bivalves	33.3	11.5	20.7	31.6	20	54
Gastropods	-	-	3.8	4.9	20	8
Fish	33.3	11.5	16.9	5.3	40	14
Polychaeta	1.9	38.5	9.4	13.3	20	4
Algae	33.3	19.2	3.8	1.5	20	2
Echinoderms	-	-	1.9	0.4	-	-
Number of stomachs examined	54		319		30	

Table 7: Variations in occurrence (Co) and % abundance (Cn) of food items with sex in *D. sargus*

	Sex					
	Males		Females		Hermaphrodites	
Food Items	Co	Cn	Co	Cn	Co	Cn
Amphipoda	4.29	4.14	12.12	4.36	5.26	2.04
Isopoda	9.29	6.31	-	-	-	-
Prawn	42.14	14.00	35.61	10.72	26.32	12.24
Bivalves	24.29	38.46	34.85	66.33	42.11	42.86
Gastropods	9.29	5.72	2.27	5.19	-	-
Fish	9.29	5.92	16.67	4.36	5.26	2.00
Polychaeta	32.86	17.95	7.58	7.54	52.60	34.70
Algae	13.57	6.31	6.82	1.51	15.79	6.12
Echinoderms	2.14	1.18	-	-	-	-
No. of stomachs examined	206		169		28	

In *D. sargus*, (Table 3), the preferential food items were bivalves and prawn according to % RI and bivalves and fish according to % MFI & % IA. According to % IRI and % Q, bivalves only were the preferential food item. The secondary food items were fish only (% RI), fish and prawn (% IRI & % Q) and prawn only (%MFI & %IA). Amphipoda, isopoda, polychaeta, algae and echinoderms were considered as accidental food items.

In *D. vulgaris* (Table 4), the preferential food item was polychaeta according to the five indices. The secondary food item was isopoda according to (% RI, % IRI & %Q) and prawn according to the values of (% MFI & % IA). Amphipoda, fish and echinoderms were considered as accidental food items.

Vacuity index (% VI) was studied for the stomachs of *D. sargus* (Fig. 1). This study revealed that the rate of feeding increased in winter and spring. This species does not undergo complete fasting, but a depression in the feeding intensity occurred in summer and autumn as the vacuity index increased in them. In *D. vulgaris* the rate of feeding was more or less constant throughout the year.

Seasonal variations in food items for *D. sargus* (Table 5) showed that echinoderms appeared in the examined stomachs in spring only, while amphipoda and isopoda appeared in the examined stomachs in spring and summer only. Prawn had the highest occurrence and abundance in autumn (Co = 91.5& % Cn = 25.1), while bivalves had the highest occurrence in summer (Co = 58.1) and the highest abundance in winter (% Cn = 68.9).

Analysis of the major food items by size for *D. sargus* (Table 6) show that polychaeta constituted the highest abundance (% Cn = 38.5) in smaller fish (10-15 cm). In sizes (15-20 cm) prawn constituted the major food item in the diet with the highest abundance (% Cn = 43.3) and the highest occurrence (Co = 60.2). In the stomachs of larger fish (20-25 cm), prawn and fish were the most occurred food item and bivalves were the most abundant.

Variations of food items in function of sexual state in *D. sargus*, (Table 7) revealed that prawn had the highest occurrence among the other food items in the stomachs of males and females, but polychaeta had the highest values of occurrence in the stomachs of hermaphrodites. Bivalves had the highest abundance in the stomachs of males, females and hermaphrodites.

DISCUSSION

Feeding and searching for food are factors which regulate or at least influence the distribution, migration and growth of fish. Fish can change their behavior according to food availability. Various methods have been developed for the quantitative estimation of diet composition in fishes. Among these, the abundance and Occurrence of different food items are the most popular. The present study revealed the presence of crustacean (amphipoda, isopoda and prawn), fish, polychaeta and echinoderms in the stomachs of *D. sargus* and *D. vulgaris*. In addition to those food items, the stomachs of *D. sargus* contained mollusca (bivalves and gastropoda) and algae. Miguel *et al.* [11] mentioned that the diet of *D. sargus* was dominated by algae and benthic invertebrates.

Interspecific competition (CI) between two species is a phenomenon cited by various authors [12-14]. This competition between the two species understudy revealed that *D. sargus* is in search for bivalves and *D. vulgaris* search for obtaining polychaeta and isopoda. Lahlah [15] in his study on *D. sargus* showed that this fish is more dependent on bivalves.

In studying the food preference, five indices were calculated. According to these indices, it appeared that for *D. sargus* bivalves are the preferential food item and this is in accordance with the results of CI, followed by fish and prawn which were secondary food items. Lahlah [15] mentioned that polychaeta was the preferential food item for *D. sargus* and bivalves were secondary. Rosecchi and Nouaze [5] in their study on the diet of sparid fish showed that different indices can produce different results, so the preferential food item for *D. sargus* according to the last authors was amphipoda according to IRI, mollusca, following the indices (Q & MFI) and fish, according to the value of IA. Miguel *et al*. [11] observed that algae were the most consumed food item by that species.

Concerning *D. vulgaris*, the present study clarified that the preferential food item was polychaeta according to the five indices and this also confirms the result of CI, while, Rosecchi and Nouaze [5] showed that *D. vulgaris* prefer amphipoda according to IRI & RI and echinoderms according to Q, IA & MFI. Nikolsky [16] explained that selectivity of any food item may be attributed to the abundance of this food in the surrounding environment.

In studying the vacuity index (%VI) for *D. sargus*, it appeared that the rate of feeding decreased in summer and autumn. Lahlah [15] stated that this species is a protandrous hermaphrodite and the spawning season lasted from January to March. So sex reversal might exert physiological stress on the fish and they decrease the rate of feeding before the spawning season. Spring appeared to be the highest season in feeding intensity that is the fish increased the rate of feeding after the spawning

season. In winter the rate of feeding was also high (%VI = 10). Miguel *et al.* [11] mentioned that the feeding intensity of this species was relatively constant throughout the year with slight increase during the winter. There are various causes for the decease of feeding intensity in fish species, among these the low feeding availability [17]. According to Hureau [4], Brule and Canche [18] and Goncalves *et al.* [19], the high vacuity index could be related to daily feeding cycle together with availability of prey and reproductive activity of predator.

Seasonal variations in food spectrum were suggested to be linked to a change in the habitat or to seasonal abundance of various food items [20]. In the present study on *D. sargus*, stomach contents were affected by season. Echinoderms appeared in the examined stomachs in spring only, while amphipoda and isopoda appeared in spring and summer only. Seasonal variations of food items in the stomachs of *D. sargus* were mentioned by various authors [11, 15].

Some fish change their diet as they grow in length. In the present study on *D. sargus*, polychaeta had the highest abundance in smaller fish and decreased with fish size, while the highest occurrence in larger fish was for fish and prawn. This is in accordance with Miguel *et al.* [11] who observed the decrease of worms in the stomachs of *D. sargus* with the increase in fish size. Several studies have related an increase in prey size as the fish increase in size [12, 21, 22].

Sex differences in the type of food were recorded in different fish species [23, 24]. The present study on *D. sargus* show slight variations in the food items due to sex. Prawn had the highest occurrence in the stomachs of males and females, but polychaets had the highest occurrence in the stomachs of hermaphrodites. This may suggest the presence of different niches for hermaphrodites, or the hermaphrodites may be exhausted physiologically and hence can not dig deep in the bottom and only take animals present in the upper layers of the bottom sediment. Recent ecosystem modeling support this hypothesis and showed that shift of food may be due to change in the availability of the prey [25].

In conclusion the present study on feeding biology of *D. sargus* and *D. vulgaris* revealed that both species feed on the same food items and The diet of *D. sargus* was affected by season, size and sex.

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