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Feeding habits and condition of the seabream *Sparus aurata* Linnaeus, 1758 (Perciformes Sparidae) in the gulfs of Skikda and Annaba (Northeast of Algeria)

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ABSTRACT The Feeding habits of the royal seabream *Sparus aurata* Linnaeus, 1758 (Perciformes Sparidae) in the northeast of Algeria were continuously monitored from April 2013 to May 2014. A study was carried out on the digestive content of 380 specimens, with a total length ranging between 18.1 cm and 48 cm. Overall, 1615 preys belonging to ten different phyla (Chordata, Echinodermata, Crustacea, Chlorophyta, Mollusca, Annelida, Bryozoa, Platyhelmintha, Nemathelmintha, Tallophyta), were computed. The reoyal seabream *S. aurata* has a widely varied diet. At a juvenile stage it is omnivorous, feeding on different benthic preys (i.e. shellfishes, molluscs, annelids, plants), on pelagic ones (fishes, eggs and Copepods), and Chlorophycea algae, as well. On a further stage, it shows a predatory feeding behavior, with molluscs constituting its preferential food as shown by the Main food index (MFI) values.

KEY WORDS Algeria; Diet; preferential food; Sparidae; *Sparus aurata*.

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INTRODUCTION

The seabream *Sparus aurata* Linnaeus, 1758 (Perciformes Sparidae) is a marine fish species of a considerable commercial value, particularly appreciated all over the Mediterranean Sea, however its fishing has decreased throughout the years for many reasons (Wiefels, 2014). On the other hand, the growing trend of the aquacultural production reveals an increasing renewed interest for this species (Wiefels, 2014).

This study aims at broadening the acquired knowledge about this species' way of feeding in the gulf of Annaba with additional further data related to the gulf of Skikda, by analyzing the food spectrum in both areas by means of qualitative and quantitative methods.

MATERIAL AND METHODS

Fish sampling

The study deals with 380 individuals, whose length ranges between 17 cm and 48 cm, with a variable weight from 65 g to 1440 g. We removed and preserved the whole digestive tract in a 98% ethanol within a hermetic pill container. Fishing was carried out monthly by professional fisheries and the samples were taken in the gulfs of Annaba

(36°52'34"N, 6°54'33"E) and Skikda (Latitude of 36°53'59"N, 7°46'00"E).

Stomach content analysis

The digestive tract of the specimens was examined under A binocular magnifier (10x) to sort different taxa. The ingested preys were identified and classified, when possible, then counted and weighed with a Kern 770 balance (precision: 10^{-4} g). Preys were classified according to the morphological criteria for each species. Quantitative analysis was carried out to show the numerical importance of ingested items, in function of sex and different seasons. Several food indices, including Vacuity index (VI %), frequency of occurrence (Fo%), and numerical percentage of prey (N %) were computed with respect to the entire population and, in addition, to both sex (Hureau, 1970) and seasons (Berg, 1979). The mean values of the VI were subjected to statistical comparison using t-Student and Chi-square (χ^2) tests. Comparisons were realized by MINITAB (Inc, 2016) and XLSTAT (Microsoft, 2016) softwares. The various preys were classified according to their preponderance (frequency, number, weight) using the Main Food Index values "MFI" (Hand Food Index) (Zander, 1982). Spearman's coefficient of rank correlation (ρ), (Lebart et al., 1982), was used to analyze the variation of Feeding habits, statistically. The statistical significance of ρ was assessed through the Student distribution with n=2 degrees of freedom (Dagnelie, 1975).

RESULTS

Out of 380 examined fishes, 245 had full stomachs, corresponding to a mean annual vacuity index of 35.21%. Their increase starts from minimal value to higher amounts in November (65.63%), and January (81.82%) (Fig. 1). From February to June, it ranges between 13.33% and 5.88%.

Overall, the diet of seabream in the eastern coast of Algeria consists in 10 taxa (Table 1). 1615 preys were identified on a total mass of 1606.35 g with an average number of biomass, by each full stomach, of 5 ± 3.4 preys of 2.03 g each. Within these ten taxa, the shellfishes are best represented.

The identification made on the level of genus and species, showed the following species:

Parapenaeus longirostris (Lucas, 1847) (Decapoda Peneidae); *Pecten maximus* Linnaeus, 1758 (Bivalvia Pectinidae) and *Bothriocephaleus claviceps* (Goeze, 1782) (Cestoda Bothriocephalidae),

Items	Ni (%)	Pi (%)	Fo (%)	MFI
Crustacea	10.15	9.05	17.8	11.25
Amphipoda	0.87	0.29	2.86	0.739
Isopoda	0.06	0	0.22	0.004
Decapoda	9.23	8.76	14.73	10.24
Parapenaeus longirostris	0.37	0.39	0.88	0.495
Brachyura	1.18	3.99	2.2	2.2
Anomura	2.66	1.06	1.54	1.494
Decapoda Natantia	0.06	0	0.22	0.008
Decapoda pink	0.06	0	0.22	0.025
shellfish inferior cirriped	0.12	0	0.44	0.023
Echinodermata	0.19	0.29	0.66	0.347
Mollusca	61.36	59.12	28.13	51.436
Cephalopoda	0.25	0.11	0.44	0.19
Sepiidae	0.19	0.01	0.22	0.034
Cephalopoda	0.06	0.1	0.22	0.118
Gasteropoda	37.96	29.94	18.02	28.947
Lamellaridae	0.87	0.02	0.22	0.093
Turritellidae	7.74	28.95	10.99	16.466
Gasteropoda	29.35	0.97	6.81	4.182
Bivalvia	23.16	29.08	9.67	0.127
Flat Oyster	0.25	0.03	0.22	0.09
Bivalvia	22.72	28.95	9.01	21.434
Pecten maximus	0.06	0	0.22	0.011
Chordata	14.24	26.17	27.25	23.303
Osteichthyes	12.2	22.39	21.98	19.561
Clupeidea	2.04	3.78	5.27	3.72
Eumetazoa	11.39	3.23	16.04	6.66
Annelida	3.03	0.48	7.47	1.589
Bryozoa	0.06	0	0.22	0.018
Platelminta	7.86	2.73	8.13	4.669
Nematelminta	0,43	0,02	0,22	0,09
Macrophyta	0.19	0.13	0.66	0.232
Tallophyta	2.17	1.01	7.25	2.181
Algal Remains	0.06	0.1	0.22	0.118
Total	**455**	**1615**	**1606.35**	

Table 1. *Sparus aurata*'s food composition,in Skikda and Annaba Gulfs. Ingested preys classification according to the degree of importance by MFI: 'Main food index'. Fo: Prey's frequency of occurrence (items). Ni: Prey's numerical percentage (items). Pi: Prey's percentage by weight (items).

while the remaining preys' classification based on species and genus was impossible because of the advanced degree of digestion. The Chordata were represented as well, noticeably on the individuals of big size. There was also a significant mass of Bony Fish (Clupeidae) (see Table 1). Molluscs were the basic food (MFI = 51.43), then Chordata (MFI = 23.30), Shellfishes (MFI = 11.25) and plants (MFI = 2.55) with Macrophyta very slightly represented (MFI = 0.23). Other animals' presence (Isopoda, Bryozoa, Decapoda, Anomura and Brachyura, Annelida, Nematoda, eggs) in seabream food was insignificant, i.e. less than 1. Finally, the food index of Zander (1982) showed that all the ingested preys were additional (MFI < 0.25).

In winter, Eumetazoa and Platelminta show very close MFI values (= 14.74 and 13.46), and nearly the same one in autumn (MFI = 4.16). Plants residues are almost inexistent in both seasons and molluscs are slightly represented. The number and the mean weight of ingested preys during both seasons are Nm = 1.91; Pm = 1.85 g in winter and Nm = 2.77; Pm = 4.03 g in autumn. Amphipoda, Isopoda, Macroura, Brachyura and Echinodermata are totally absent during both seasons. It should be noted that seabreams decrease their feeding activity by consuming less variety of preys in winter. Spearman's coefficient values are insignificant ($\rho = 1.09$; tobs = 0.78; $p < 0.05$).

In spring and summer, the molluscs consumption is more important (MFI = 44.21 in spring; 36.41 in summer); fishes consumption is higher in spring (MFI = 32.63), tending to decrease significantly in favour of crustaceans (MFI = 10.62) in summer. Echinodermata, Macrophyta and Thallophyta are practically absent in spring. The remaining preys are supplementary (MFI < 0.25). During both seasons, *S. aurata* seems to consume more prey masses with a mean number of N = 4.97 (Pi = 5.86 g in spring) and N = 6.86 (Pi = 3.67 g in summer). However, similarities in feeding habits during different seasons are confirmed by the insignificant coefficient value of Spearman correlation ($\rho = 1.35$; $p < 0.05$).

In both sexes, molluscs are first ranked (MFI = 53.25 for females and 44.75 for males), followed by fishes (MFI = 25.33 and 33.31, respectively); Shellfishes are significant in both sexes (MFI = 9.21 and 9.45) (Table 3). For the remaining preys, females seem to consume Eumetazoa (MFI = 6.59) and Platelminta (MFI = 5.60) more than males do (MFI = 1.93 and 1.52, respectively). The plant fraction is significant for males (MFI =3.37) and almost zero for females. Apparently, the number and the mean weight of preys ingested by females (N= 1.98; P = 5.98 g) are different from those observed in males (N = 6.23; P = 5.01 g), nevertheless, despite of numerical and weight value differences among preys, statistical analysis shows no significant differences thus suggesting feeding homogeneity between both sexes ($\rho = 1.53$; tobs = 0.45; $p < 0.05$).

Condition coefficient IC (fitness)

The monthly values of IC condition index of the whole population of *S. aurata*, show a low variation, lying generally between 0.61 and 1.33 (0.3 ± 0.86). The monthly evolution of condition index reflects homogeneity (Fig. 2).

Low values are observed in autumn ($IC = 0.41 \pm 0.02$), but remain stable during the whole year with a mean value of $IC = 0.14 \pm 0.09$. This coefficient doesn't seem to vary in time and statistically is insignificant for both sexes: (tobs = 0.36 ; P = 0.25; and tobs = 0.82 ; P = 0.428).

DISCUSSION

The *Sparus aurata* of the eastern coast of Algeria, is a carnivorous predator. Its significant diversification reflects a mean annual stomach Vacuity index equal to 35.21 %, during the whole year. This coefficient varies during the reproduction period as well from November to January in the eastern area of Algeria. It reaches a significant value in January; this possible short fasting period in winter is closely related to the species sexual cycle and to hydroclimatic conditions (low temperature).

The monthly variations of Vacuity index show a seasonal food pace of a strong feeding activity in spring and summer, due to gametogenesis preparation and reserve accumulation of adiposity in autumn. Food declines without interruption; this reserve accumulation is followed by a short fasting period (in January) after reproduction.

However, from December to January, during its full egg-laying season, the stomach Vacuity index reaches a value of 81.82%. It should be noted that a part of the population continues to feed and seems

not to be concerned by reproduction. The varied values of the Vacuity index during the seasons reflect prey frequency and availability in the environment. Similar results have been reported for other coastal Sparidae, i.e. *Diplodus annularis* (Derbal et al., 2007) and *D. cervinus cervinus* (Derbal & Kara, 2006). Considering its functional feeding level (Pauly & Christensen, 2000), *Sparus aurata* feeds mainly on flesh. In the eastern coast of Algeria, the presence of food including Cephalopoda and Gasteropoda, in addition to a significant number of Bivalvia (which can be crushed by means of its powerful molars), benthic shellfishes, fishes (Osteichthyes, Clupeidae) and others (Cestoda, Amphipoda, eggs), implies the erratic aspect of this species, having the ability to move vertically

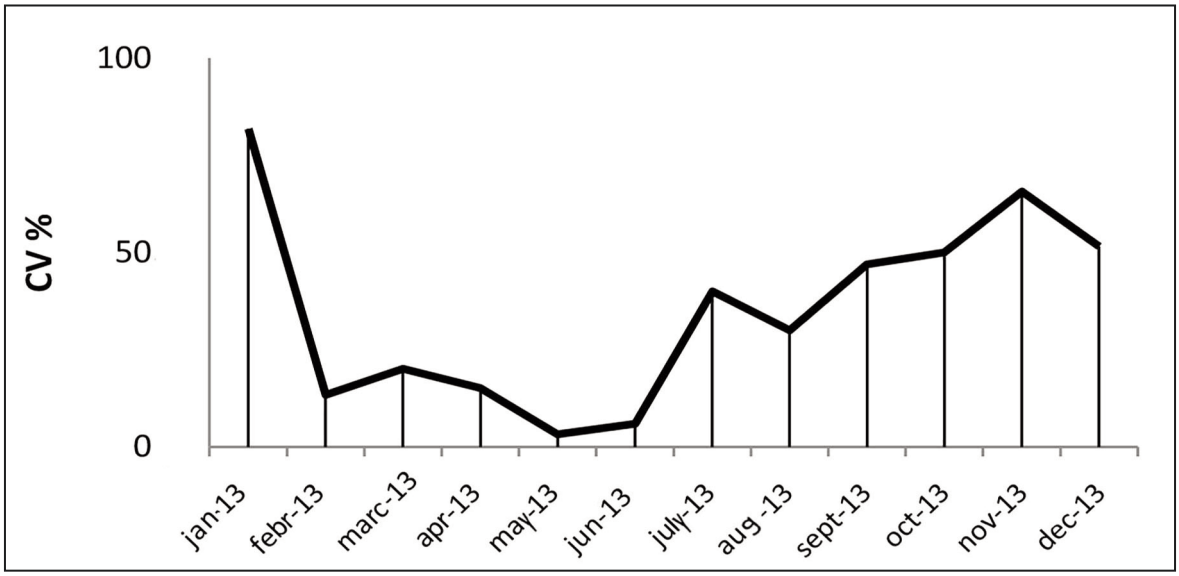

Figure 1. Monthly evolution of Vacuity index of *Spaurus aurata* of both Skikda and Annaba gulfs (Northeast of Algeria).

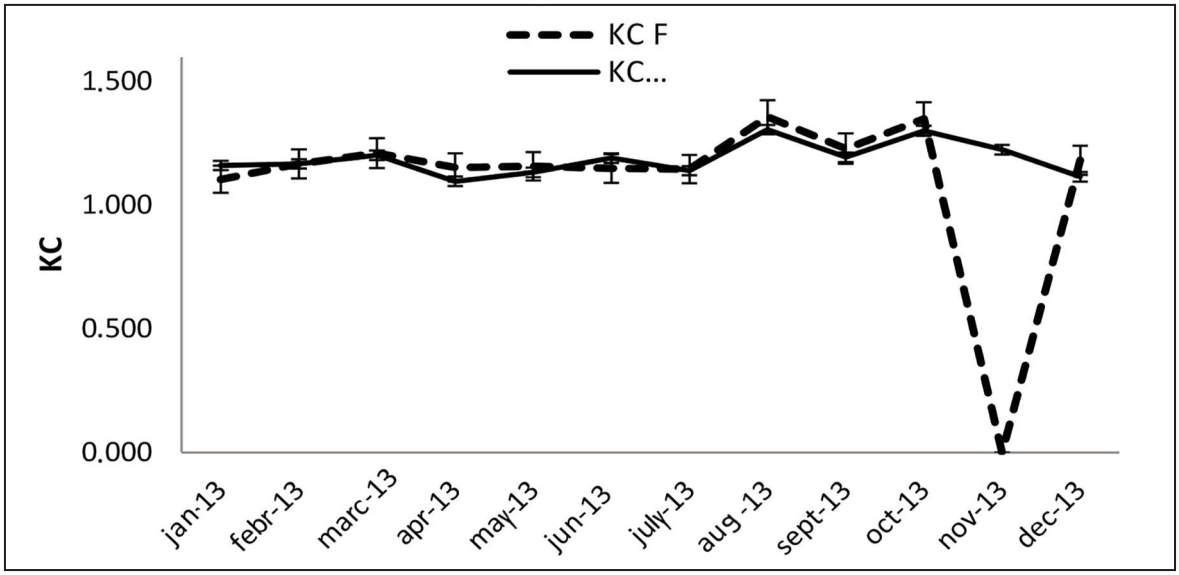

Figure 2. Monthly variation of the Algerian condition coefficient IC by both *Spaurus aurata* sexes in Eastern coast of Algeria.

(Harmelin, 1987), feeding basically on zooplanctonic preys, such as *Spicara* sp. (Harchouche, 2006), *Chromis chromis* (Dulčić, 2007), *Oblada melanura* (Pallaoro et al., 2003) and *Trachurus* sp. (Ben-salem, 1988; Šantić et al., 2003). Seabream food ethology approximates others Sparidae coastal ones, as *O . melanura* (Pallaoro et al., 2003).

Despite a diversification of 10 identified taxa, the feeding habits are basically made up of Gasteropoda, Bivalvia and Teleostei, in addition to Crustacea. This result, according to Arias (1980), is close to seabream's basic food in Cádiz estuary, based on molluscs, Bivalvia, Gasteropoda and shellfishes. Other different feeding habits are also described (Pita et al., 2002; Tancioni et al., 2003) and show that seabream is an opportunistic predator which

	Winter					Spring					Summer					Autumn				
Items	Ni(%)	Pi (%)	Fo (%)	MFI	IRI (%)	Ni(%)	Pi (%)	Fo (%)	MFI	IRI (%)	Ni(%)	Pi (%)	Fo (%)	MFI	IRI (%)	Ni(%)	Pi (%)	Fo (%)	MFI	IRI (%)
CRUSTACEA	38,04	25,44	31,25	29,68	5,82	8,52	8,51	18,00	10,62	9,41	21,41	24,05	21,87	22,81	3,47	7,01	8,43	14,41	9,50	0,80
ECHINODERMATA	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,78	0,96	2,34	1,22	0,01	0,00	0,00	0,00	0,00	0,00
MOLLUSCA	1,08	1,79	1,56	1,54	0,01	70,33	35,01	41,33	44,21	133,64	43,60	43,63	17,18	36,41	5,24	0,27	0,65	0,90	0,62	0,00
CHORDATA	28,26	61,07	28,12	41,49	7,37	13,14	54,41	26,00	32,63	53,90	16,71	16,38	27,34	18,99	3,16	19,95	73,27	27,03	41,48	9,04
EUMETAZOA	26,08	8,01	28,12	14,74	2,81	7,28	1,51	12,66	3,89	3,42	5,74	1,01	11,71	2,97	0,27	2,43	4,42	5,41	4,16	0,13
ANNELIDA	2,17	0,13	3,12	0,60	0,02	2,48	0,25	5,33	0,99	0,44	2,08	0,42	5,46	1,27	0,04	0,00	0,00	0,00	0,00	0,00
BRYOZOA	1,08	0,04	1,56	0,24	0,00	0,53	0,02	1,33	0,16	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
PLATELMINTA	22,82	7,83	23,43	13,46	2,11	3,02	1,10	5,33	2,14	0,67	3,65	0,58	6,25	1,70	0,09	2,43	4,42	5,41	4,16	0,13
NEMATELMINTA	0,00	0,00	0,00	0,00	0,00	1,24	0,13	0,66	0,35	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
MACROPHYTA	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,52	0,43	1,56	0,67	0,00	0,00	0,00	0,00	0,00	0,00
TALLOPHYTA	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,78	0,25	2,34	0,63	0,00	0,00	0,00	0,00	0,00	0,00
OTHERS	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,52	0,00	1,56	0,04	0,00	0,00	0,00	0,00	0,00	0,00

Table 2. Seasonal food composition of *Sparus aurata* in Skikda and Annaba Gulfs (Northeast of Algeria), [Fo: frequency of prey's occurrence. Ni: Prey's numeric percentage (items). Pi: Prey's weight percentage (items). MFI: Main Food Index.]

	male				female			
Items	MFI 1/2	IRI(%)	Rang	IP %	MFI 1/2	IRI(%)	Rang	IP %
CRUSTACEA	9.456	0.935	3	4.081	9.219	0.739	3	3.069
ECHINODERMATA	0.000	0.000	10	0.000	0.000	0.000	10	0.000
MOLLUSCA	44.758	12.831	1	51.022	53.256	14.126	1	70.085
CHORDATA	33.310	6.232	2	43.765	25.558	3.949	2	24.983
EUMETAZOA	1.931	0.111	6	0.182	6.591	0.673	4	1.594
ANNELIDA	0.186	0.007	9	0.002	0.477	0.011	7	0.008
PLATELMINTA	1.522	0.051	7	0.108	0.047	0.000	10	0.000
NEMATELMINTA	0.000	0.000	10	0.000	5.605	0.418	5	1.200
VEGETALIA	3.373	0.151	4	0.577	0.238	0.002	10	0.001
MACROPHYTA	0.000	0.000	10	0.000	2.417	0.085	6	0.269
TALLOPHYTA	0.496	0.003	8	0.013	0.000	0.000	10	0.000
OTHERS	2.669	0.047	5	0.374	0.000	0.000	10	0.000

Table 3. Change of *Spaurus aurata* feeding habits by sex in the gulfs of Skikda and Annaba (Northeast of Algeria). IP %: the preponderance index.

adapts its feeding habits to prey availability in its environment. Seabream of Skikda and Annaba gulfs show similar food habits, although in different quantities.

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