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Structure of the community associated with the gilthead sea bream *Sparus aurata* Linnaeus, 1758 (Pisces Perciformes Sparidae) of the Algerian east coasts (Jijel, Skikda, Annaba, El-Taraf)

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ABSTRACT

The structure of the community associated with the gilthead sea bream *Sparus aurata* Linnaeus, 1758 (Pisces Perciformes Sparidae) of the Algerian east coasts is studied on the basis of data from the oceanographic campaign "ALDEM 2012" carried out in Algeria. The most characteristic species of the *S. aurata* are determined on the basis of three classification criteria, relative frequency (Fr), density (Dn) and biomass (Dw). These species are 88. Species diversity and evenness are calculated in the coasts of eastern Algeria taking into account the numbers and the weights. Distribution of specific abundance is studied from the models of Motomura, Mac Arthur and Preston. Determination of specific richness, specific diversity, equitability and use of abundance distribution models revealed a young (immature) community with one or more species that tend to dominate in number and weight. A principal component analysis (PCA) was carried out on a matrix of 88 species and 3 variables (Fr, Dn, Dw) in order to separate the species strongly associated with the gilthead sea bream. *Mullus barbatus* is the species most associated with *S. aurata* with a significant presence of *Trachurus trachurus* and *Pagellus acarne* and, to a lesser degree, *Pagellus erythrinus*.

KEY WORDS Community; *Sparus aurata*; Algerian east coasts; oceanographic campaign.

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INTRODUCTION

The sparids (Pisces Perciformes Sparidae) are abundantly represented on the Algerian coasts (Fischer et al., 1987; Djabali et al., 1993); they are sought-after by fishermen because of their high commercial value which makes them attractive economically. The sparid gilthead sea bream *Sparus aurata* Linnaeus, 1758 is common in the Mediterranean Sea; it is less prevalent in the east and southeast of this sea. It is also present in the eastern Atlantic, from the British islands to Cape Verde islands and Canaries (Fischer et al., 1987).

Gilthead sea bream *S. aurata* Linnaeus, 1758 has an ecological importance, both in Algeria and throughout the Mediterranean. Thus, numerous studies have been devoted to it, notably concerning its biology (Rønnestad et al., 1994; Magoulas et al., 1995; Pita et al., 2002; Stergiou & Karpouzi, 2002; Rossi et al., 2006; Parati et al., 2011).

In Algeria, the gilthead sea bream has been the subject of some studies in lagoon environment

(Chaoui et al., 2005; Chaoui et al., 2006; Chaoui et al., 2009; Chaoui et al., 2012). But in marine environment, apart from the ecological study of Chebel et al. (2014) on old data of the oceanographic campaign of Thalassa (Campillo, 1982), no recent work has been carried out on the gilthead sea bream in the Algerian coasts. Studies of the structure of marine communities have been the subject of much works (Jin & Tang, 1996; Lugendo et al., 2007; Won et al., 2007; Horinouchi et al., 2009).

Our study presents new data on the structure of the community associated with *S. aurata* in the coasts of eastern Algeria, based on the calculation of diversity indices, the application of some ecological models and the study of associated fauna from a principal component analysis (PCA).

MATERIAL AND METHODS

The data used in this study comes from the information gathered during the first campaign of assessment of demersal resources ALDEM 2012 of National Research and Development of Fisheries and Aquaculture Centre (CNRDPA), undertaken by the Grine Belkacem oceanographic boat, during the period from 03 May to 15 June 2012, on the whole Algerian coast. One hundred 100 trawl fisheries were made, from west to east (Ainouche, 2012). In our study area (Algerian east coasts), 33 trawl traits were made.

The fishing gear used is a bottom trawl whose bag mesh is 20 mm. Its horizontal opening is 22 meters and the vertical opening is 1.50 meters; the trawl body is made of polyethylene while the pocket is made of polyamide (Ainouche, 2012). All the specimens captured during the ALDEM 2012 campaign were identified, sorted, counted and weighed. Sex determination was made as soon as possible.

The specific richness S of the community associated with *S. aurata* was determined; it is the number of species found in a community. The calculation of the index of species diversity of Shannon (ISh) (Shannon, 1948) is made from formulas based on the abundance or specific weight.

This index is expressed in bits (binary digits):

$$\text{ISh} = -\Sigma(\frac{qi}{Q})\log_2(\frac{qi}{Q});$$

with qi: specific abundance and Q: total number of the community considered.

$$\text{ISh} = -\Sigma(\frac{wi}{Wt})\log_2(\frac{wi}{Wt});$$

with wi: specific weight and Wt: total weight of the community considered.

The equitability or evenness (E) (Pielou, 1966) is defined as the ratio of the real diversity to the maximum diversity ($\log_2 S$):

$$\text{E} = \frac{\text{ISh}}{\log_2 S};$$

The evenness varies from 0 to 1. It tends to be 0 when almost all of the strength is concentrated on a single species. It tends to be 1 when all the species have the same abundance (Daget, 1976).

We studied the distribution of specific abundance and specific weight by models of Motomura (1932), Mac Arthur (1957) and Preston (1962). Statistical tests such as: the correlation coefficient (r) between the observed values (qi and wi) and theoretical values (qth and wth); and the return between the variance of the observed values (V^2(qi) and V^2(wi)) and the variance of the theoretical values (V^2(qth) and V^2(wth) (Daget, 1976), were used in order to assess the degree of adjustment.

The study of associated fauna requires some indices such as:

Relative frequency of the species accompanist:

$$\text{Fr} = (\frac{\text{Sp+}}{\text{S+}})100;$$

Density of the species accompanist:

$$\text{Dn} = \frac{\text{qi}}{\text{SS+}};$$

Biomass of the species accompanist:

$$\text{Dw} = \frac{\text{wi}}{\text{SS+}};$$

where, Sp+: number of stations where the species accompanist is present; S+: number of stations where the target species is present; SS+: sum of the areas of S+ stations; qi: specific abundance; wi: specific weight (Hemida, 2005; Harchouche, 2006). These indices (Fr, Dn and Dw) were needed for principal components analysis (PCA).

RESULTS

Specific richness

In total, 88 species belonging to different zoological groups (Table 1) were retained for this study. These species are grouped into 63 families. The families accompanying *S. aurata* are: Aglajidae; Alcyoniidae; Aporrhaidae; Ascidiidae; Asteriidae; Astropectinidae; Axinellidae ; Bothidae; Carangidae; Cardiidae; Cassidae; Centracanthidae; Cepolidae; Citharidae; Clupeidae; Cymothoidae; Dactylopteridae; Dasyatidae; Diogenidae; Dorippidae; Engraulidae; Epialtidae; Epizoanthidae; Gobiidae; Gorgoniidae; Hormathiidae; Inachidae; Loliginidae; Merlucciidae; Mullidae; Muricidae; Octopodidae; Ommastrephidae; Ophichthidae; Ophiuridae; Ostreidae; Pectinidae; Pelagiidae; Penaeidae; Pennatulidae; Pleurobranchaeidae; Plumulariidae; Pteriidae; Rajidae; Rhizostomatidae; Scalpellidae; Scophthalmidae; Scorpaenidae; Sepiidae; Serranidae; Soleidae; Sparidae; Sphyraenidae; Spongiidae; Squillidae; Stichopodidae; Tethydidae; Torpedinidae; Triakidae; Triglidae; Tritoniidae; Uranoscopidae; Zeidae.

Diversity and evenness

The results of Table 2 indicate that in the eastern region, the values of the Shannon index show a slight variation according to specific abundance and specific weight (3.16 to 3.58 bits). The Shannon index calculated from the specific weights has a value of 3.58 bits, with an evenness of 0.55. This regularity value characterizes a little homogeneous community. Instead, the Shannon index calculated from specific abudance is lower (3.16 bits), affecting the value of equitability (0.49) which translates into the little homogeneity of community defined in the eastern region.

Models of abundance and weight distribution

Overall, the three mathematical models of Motomura, Mac Arthur and Preston satisfactorily describe the structure of the community associated with the gilthead sea bream (Figs. 1, 2).

The rank-frequency diagrams and the rank-weight diagrams show that the Preston model fits better with the observed values (correlation coefficient> 0.92 and the variance ratios which are not far from 1) (Tables 3, 4).

The community associated with *S. aurata*, which is relatively a little diversified, shows largely dominant species; with regard to specific abundances, *Mullus barbatus* dominates very largely, followed by *Pagellus acarne* and *Trachurus trachurus* and then by *Pagellus erythrinus* and *Spicara smaris*. With regard to specific weights, *T. trachurus* and *M. barbatus* dominate, followed by *P. erythrinus* and *P. acarne*.

Zoological groups	Number of species	Percentage (%)
Fishes	42	48
Mollusks	17	19
Cnidarians	11	13
Crustaceans	9	10
Echinoderms	5	6
Sponges	2	2
Ctenophores	1	1
Tunicates	1	1

Table 1. Zoological groups accompanying *Sparus aurata* in the Algerian east coasts.

Associated fauna

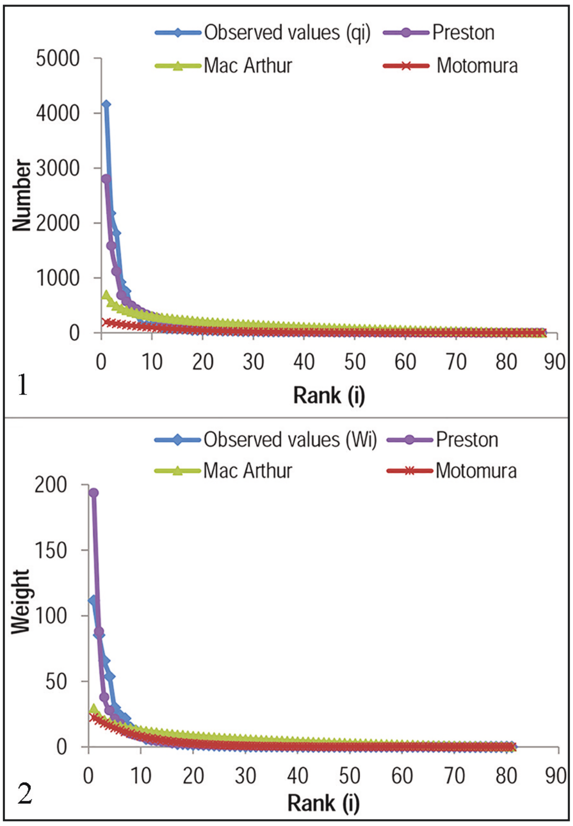
PCA was realized on a matrix of 88 lines (species) based on three initial variables: frequency, density and biomass. The first two axes explain more of 95% of the total variance (Table 5).

The correlation coefficient between the original variables and the principal axes (Table 6) highlights the contribution of each of these variables in the creation of these axes. The variable Fr contributes essentially to the creation of axis II, the factor II is therefore relative to the frequency. Axis I is constructed by the variables Dn and Dw, and it is therefore relative to abundances and biomasses.

The coordinates of the species allow their projection in the I-II factorial plane (Fig. 3). It should be noted that the most frequent species contribute weakly to axis I, they are therefore a little abundant with low biomasses; it is about: *Raja miraletus*, *Merluccius merluccius*, *Serranus hepatus*, *Citharus linguatula*, *Boops boops* and *S. smaris*. On the other hand, *M. barbatus*, *T. trachurus*, *P. acarne* and *P. erythrinus* show strong densities and biomasses, and low frequencies.

DISCUSSION

The result of the specific richness of the community associated with the gilthead sea bream *S. aurata* in the Algerian east coasts is 88 species. In the same region, the study on data of the oceanographic campaign of Thalassa highlights 58 species



Figures 1, 2. Adjustment of the models: number (Fig. 1) and weight (Fig. 2).

Index	Specific abundance	Specific weight
ISh	3.16	3.58
E	0.49	0.55

Table 2. Diversity index (ISh) and evenness (E) for community of the gilthead sea bream *Spaurus aurata* in the Algerian east coasts.

	Models		
Correlation coefficient	Motomura	Mac Arthur	Preston
r (qi,qth)	0.73	0.75	0.99
r (wi,wth)	0.91	0.83	0.92

Table 3. Adjustment of theoretical models (correlation coefficient).

	Models		
Correlation coefficient	Motomura	Mac Arthur	Preston
r (qi,qth)	0.73	0.75	0.99
r (wi,wth)	0.91	0.83	0.92

Table 4. Adjustment of theoretical models (variance ratio).

accompanying *S. aurata* (Chebel et al., 2014); this specific richness is much lower than our result. This difference could be explained by variations in environmental conditions occuring in the years between 1982 and 2012, which cause changes in the composition of populations living with *S. aurata*.

The values of the Shannon index and evenness are fairly low; they characterize a little homogeneous community. This situation is due to a large dominance of some species in the considered region. In the Algerian east coasts, Chebel et al. (2014) found almost the same values as our study; that is to say that the degree of diversity of the community associated with *S. aurata* is almost stable in the years between 1982 and 2012.

The application of abundance distribution models has allowed to highlight a young community with a dominance of *M. barbatus* for the specific abundances and a dominance of *T. trachurus* and *M. barbatus* for the specific weights. Chebel et al. (2014) mention that *M. barbatus* dominates for specific abundances and *P. acarne* and *M. barbatus* for specific weights. Thus, in relation to specific abundances, the dominance of *M. barbatus* did not change in the years between 1982 and 2012. On the other hand, the dominance of the species *P. acarne* has been replaced by that of *T. trachurus*; this could be related to the richness of nutrients and the good hydro-climatic conditions which are at the origin of the abundance of plankton, essential for the nutrition of the juveniles of *T. trachurus*.

Principal component analysis (PCA) shows that *M. barbatus* is the species most associated with *S. aurata* with a significant presence of *T. trachurus* and *P. acarne* and, to a lesser degree, *P. erythrinus*. This is explained by the feeding habits of these species which are close to that of the gilthead sea bream *S. aurata*; they feed on molluscs, decapods, annelids and fish (Stergiou & Karpouzi, 2002). The comparison between this result and that of Chebel et al. (2014) reveals that the species *M. barbatus* remains the most dominant species with the pres-

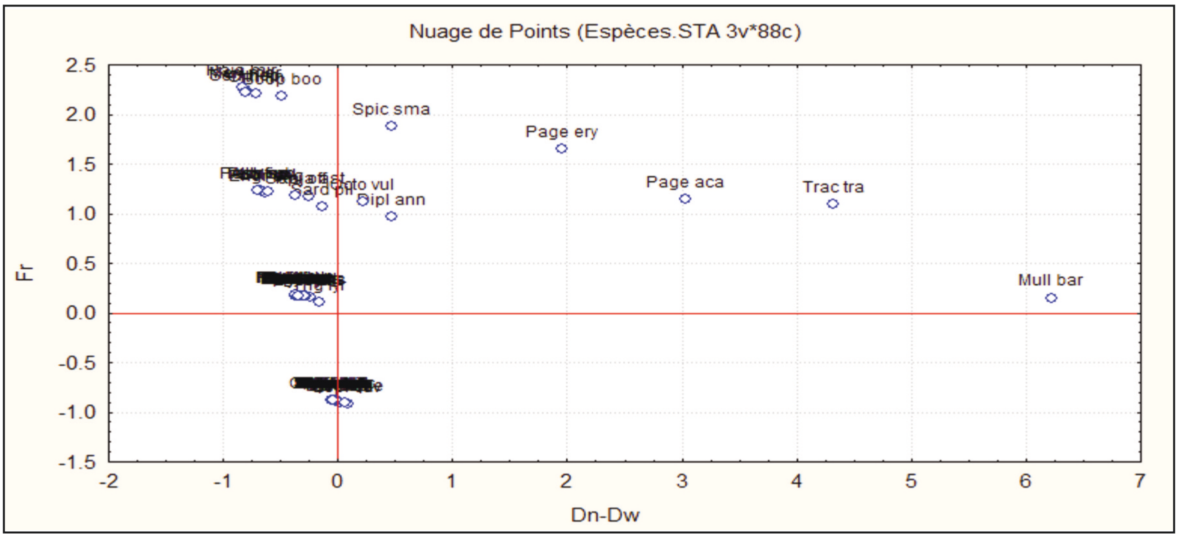


Figure 3. Projection of species in the plane I-II (Algerian east coasts).

Axes	Eigen values	Total percentage of variance	Cumulation of eigen values	Cumulation of percentage of variance
1	2.27	75.61	2.27	75.61
2	0.59	19.52	2.85	95.13
3	0.15	4.87	3	100

Table 5. Extraction of principal components and values of three axes (Algerian east coasts).

Initial variables	Factor 1	Factor 2
Fr	0.26	0.96
Dn	0.94	0.23
Dw	0.90	0.35

Table 6. Contribution of variables to the formation of axes I and II (weight marked>0.7).

ence of *T. trachurus* as a codominant species. This confirms the demersal character of *S. aurata* (Fischer et al., 1987; Djabali et al., 1993), but the prevalence of some semi-pelagic species such as *T. trachurus*, *B. boops* and *S. smaris* shows that the gilthead sea bream lives not only near the bottom but also in the semi-pelagic zone.

The results of this study allowed us to highlight a juvenile system. With regard to the associated fauna, it appears a little diversified but essentially composed by fish species.

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