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Research Article.

Biosystemaic study of clupeidae from the West coast of Algeria

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Abstract

One of the taxonomically complex families that has not been the subject of significant research in Algeria is that of the Clupeidae, which are extremely varied in terms of both morphology and anatomy: Many uncertainties persist in their classification, in particular *S. aurita* and *S. pilchadus*. The main objective is to contribute to the systematics of the family and to the precise identification of the species of this genus targeted by fishing. An examination of faunistic notes and treatises shows a heterogeneity in the inventories carried out on clupeidae populations in the Mediterranean and leads to an extremely confused synonymy. Morphological, morphometric and geomorphometric analyses were carried out. Data were collected during regular outings from July 2014 to May 2016 in various fishing ports and sales outlets in the western region of Algeria. A sample of 520 specimens was obtained from commercial catches. A Principal Component Analysis (PCA) was performed on the biometric data. The cephalic skeleton (neurocranium and splanchnocranium) was taken into consideration. The various methods used enabled inter and intraspecific comparisons to be made. The PCA clearly separates the genera and species of scorpionfish, and highlights the differences between representatives of *S. aurita* and *S. pilchardus*. This discontinuity is confirmed by morphology and geomorphology.

Keywords

Clupeidae;
Morphology;
Morphogeometry;
Oosteology.

1 Introduction

The Clupeidae are small to medium-sized fish, with bodies that are generally fusiform and subcylindrical, but sometimes very compressed laterally; a row of scouts is present on the ventral profile (Fischer *et al.,* 1987).

The Clupeidae family, best known for its marine forms (sardines, herring and anchovies), includes several genera and species that have adapted to fresh and brackish waters, and others that enter lagoons.

Clupeidae are characterized by an apophyseal connection between the swim bladder and the inner ear, which greatly enhances auditory perception. Most Clupeidae have one or more ventral or pelvic escutcheons, allowing rapid identification of the family (Leveque *et al*., 1989).

Gourene (1988) carried out a systematic review of the freshwater Clupeidae of West and Central Africa. Six genera were selected from the area under consideration: four from freshwater and two from brackish water (Teugels *et al*., 1988; Leveque *et al*., 1989).

Many species of Clupeidae, particularly those from tropical and subtropical waters where diversity is highest, are difficult to identify, as their identification requires microscopic observation (for the number of branchiospines, shape of the second supra-maxillary, etc.) and the taxonomy of some genera is not sufficiently well understood (e.g. the Clupeidae genera Sardinella and Herklotsichthys, Anchoviella) (Fischer *et al.,* 1987).

This family has attracted our particular attention for several reasons: its economic importance, the difficulty of recognizing the species belonging to this family due to the strong resemblance, and the fact that each species has been described by most professionals under different names. This leads us to consider the possibility of recognizing the frontier of a typological concept of the species, according to which it is possible to define a standard type of the species from an individual chosen as a type.

Examination of faunistic notes and treatises (Fisher *et al*., 1987; Bauchot, 1980) show that there are three genera comprising 5 species of Clupeidar in the Algerian basin: *Alosa alosa, Alosa fallax, Sardina pilchardus, Sardinella aurita*, and *Sardinella maderensis*.

We will try to answer the above-mentioned questions in the following sections: (**1**) a morphometric study using a multivariate analysis method (Principal Component Analysis or PCA); (**2**) a morphogeometric study's benchmarks used for all individuals in the MorphoJ program®.

2 Materials and methods

2.1 Sampling site

Five hundred and twenty (520) individuals belonging to 4 species of Clupeidae were collected from sales outlets in the western region (landings came from Oran, Ain témochante, Tlemcen and Mostaganem).

2.2 Characteristics studied

All race differentiation criteria within a species define the notion of meristic characters. Many authors have noted variations in vertebral mean, fin radii or branchiospines within independent populations (Brahimi, 2009). These latter characters were the focus of this study. Some twenty individuals were processed for *Sardinella aurita* and *S. pilchardus*. A single individual was analyzed for *A. fallax* and eleven for *S. maderensis*.

2.2.1 Branchiospines

The number of gills on the dorsal and ventral branches was determined from the first right gillarch.

2.2.2 Vertebrae

To count the number of vertebrae, we boiled the individuals for a few minutes, making it easy to separate the vertebral column from the flesh using a scalpel. We counted all vertebrae from the occipital condyle to the urostyle.

2.3 Morphometric characteristics

The main characters that have been considered are shown in figure 1, 306 observations and 14 quantitative variables have been analyzed morphometrically: (1) STL: standard length, from tip of muzzle to base of caudal fin; (2) FL: fork length, from tip of muzzle to fork; (3) TL: total length, from tip of rostrum to tip of longest lobe of extended caudal fin; (3) Pd: pre-dorsal distance, from tip of rostrum to anterior end of dorsal fin; (5) rd: dorsal ray length; (6) Ld: length of dorsal fin, from base of first spiny ray to last soft ray; (7) Pplv: pre-pelvic length from tip of rostrum to anterior end of pelvic fin; (8) plv: length of pelvic fin, from base to tip; (9) Pa: pre-anal length from tip of rostrum to anterior end of anal fin; (10) La: length of anal fin, from the base of the first spiny ray to the last; (11) Lt: length of head, from tip of snout to tip of horizontal opercular spine; (12) LO: eye length; (13) LC: body width, greatest distance between flanks; and (14) HC: body height.

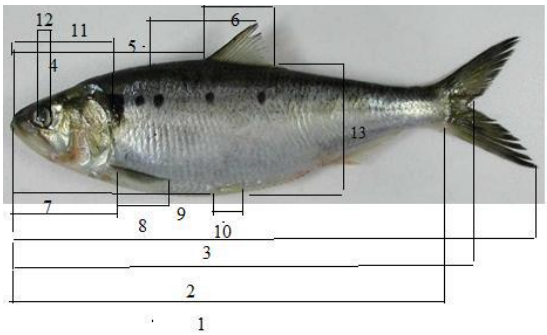

Figure 1. Morphometric characteristics measured on representatives of the Clupeidae

We chose to standardize our variables, using the Bacha *et al.* (2014) method described by Lleonart *et al.* (2000) to eliminate the effect of individual size and relative growth from a matrix of multi-variate morpho-metric data. The standardization relationship is described by the following relation:

$$MS = MO\ (\frac{Tl}{TL})^b$$

where, **MO**: the original morphometric measurement, **Tl**: average total length of all individuals, **TL**: total length, and **b**: slope.

2.4 Morphogeometry

A morphogeometric study was carried out using MorphoJ ®, an integrated software package for geometric morphometric operations.

2.5 Statistical analysis

A Principal Component Analysis (PCA) was performed on these standardized morphometric data. The analysis was carried out using Statistica 5, a software package capable of performing analyses on matrices. These methods are particularly powerful for exploring the structure of data, taking into account their multidimensional nature. They have been described by several authors, including Daget (1976), Legendre and Legendre (1979, 2006), Dagnelie (1973, 1975), Gilbert (1978), Laforge (1981), Philipeau (1986), Lagarde (1983), Bouroche and Saporta (1992), Georgin (2007), and others cited by Ladoul (2011): Schwartz (1983), Duby and Robin (2006).

PCA is a technique for reducing a complex system of correlations to a smaller number of dimensions. The principal components method is also known as the principal axis's method.

3 Results and Discussion

The table 1 shows the numbers of different species and their size ranges.

3.1 Characteristic features

3.1.1 Branchiospines

The number of branchiospines is shown in Table 2; the number of branchiospines on the gill arch varies from 47 to 96 in *S. pilchardus*, with an average of 78.1 branchiospines; while for *S. aurita*, it fluctuates around an average of 104. from 54 to 186 cm.

The average branchiospines established from the individuals sampled characterize the populations of clupeidae, living in the Algerian basin (Table 1). The range of variability of branchiospines in *S. aurita* is very large and probably distinguishes the two sardinella populations.

Table 1. Number of branchiospines and vertebrae for Clupeidae

Species	*S. pilchardus*		*S .aurita*		*A. falax*		*S. maderensis*	
			Branchiospines					
Size range	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
	47	96	54	186	52	90	82	96
Mean	54	186	104.13		71		88.5	
s.d.	9.12		36.18		12.67		3.56	
FAO	44	106	> 80		30	80	>70	
			Vertebrae					
Size range	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
	26	56	24	56	49	55	30	36
Mean	35.00		48.69		52.00		28.95	
s.d.	6.76		2.98		2.00		1.87	

3.1.2 Vertebrae

The number of vertebrae for each species are shown in Table 2. The number of vertebrae varies from 26 to 56 in *S. aurita*, with an average of 35, while in *S. pilchardus* it fluctuates between 24 and 56, with an average of 48.

The average number of vertebrae established from the individuals sampled characterizes the population of clupeidae, living in the Algerian basin (table. 2); the extent of variability of vertebrae in *S. aurita* and *S. pilchardus*, is very important and probably distinguishes the two populations of sardinella and sardine.

3.2 Morphometric analysis

Principal component analysis was performed on 306 observations and 14 quantitative variables. Analysis of the correlation matrix shows that some variables are highly correlated, generating redundant information. From this point of view, only 6 variables were considered. The first two axes generate 67% of the information. For our analysis, we will consider axes I, II and III (81% of total variance) forming factorial planes I-II, I-III.

The projection of individuals (Table 2) on the I-II plane (LC, Ol and HC) highlights Clupeidae species with morphometric similarities (Figure. 2, 3): these are *Sardina pilchardus*, *Sardinella aurita*. While *Alosa fallax* and *S. madernsis* are well individualized.

Table 2. Contribution of initial variables to the formation of axes 1, 2 and 3

	Axe 1	Axe 2	Axe 3
LT	0.479	0.314	0.198
Rd	0.199	0.171	0.122
Lt	0.083	0.060	0.986
LC	0.746	-0.270	0.060
HC	0.091	0.936	0.070
Ol	0.861	0.316	0.106

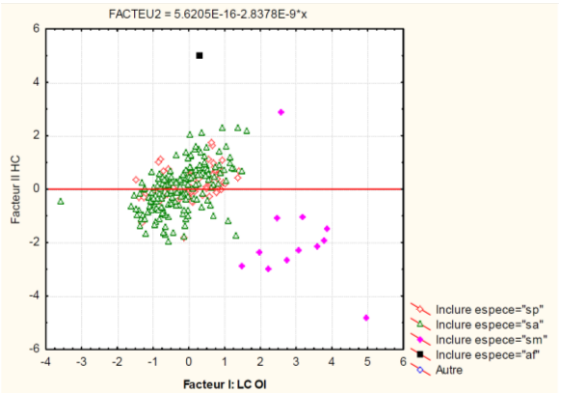

Figure 2. Projection of individuals on the factorial plane I-II

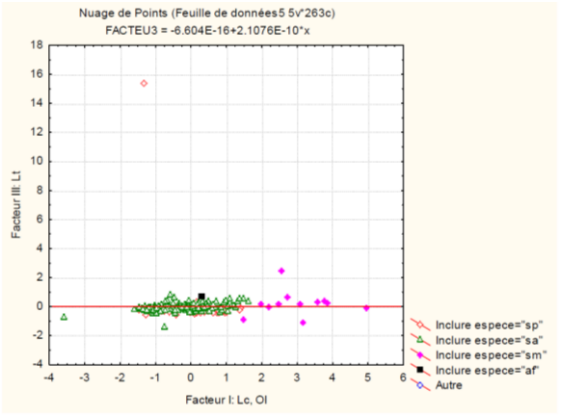

Figure 3. Projection of individuals on the factorial plane I-III

3.2.1 Morphogeometric analysis by gender

According to the projection on the CVA1 axis, which explains 94% of the variance, we distinguished two groups (Figure 4): A first group represented by the species *Alosa fallax*, and a second group comprising two species *Sardinella aurita* and *Sardina pilchardus*.

The Mahalanobis distance (Table 3) is a distance measure based on the correlation between variables by which different models can be identified and analyzed.

The closest species are *S. aurita* and *S. pilchardus* with the smallest distance (39.02) and the farthest are A. *fallax* with a distance of (927.83).

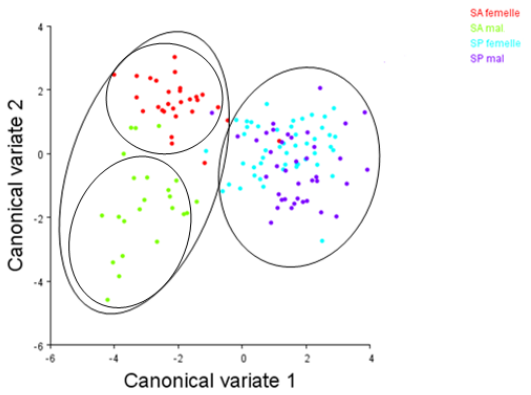

Figure 4. Morpho-geometry results by sex

According to the projection on the CVA1 axis, which explains 89.48% of the variance, we have distinguished two distant groups; *A. fallax* clearly separates itself from the other species, although there is an overlap between the two other clupeidae species, with discrimination between the two sexes (Figure. 4).

According to Table. 3, the closest species are male *S. pilchardus* and female *S. pilchardus* with the smallest distance (16.43) and the farthest are female *A. fallax* and female *S. pilchardus* with a distance of (775.66).

Table 3. Mahalanobis distance between species by sex

	1. SA	2. SP ind	3. SP femelle	4. SP mal	5.SM
1. SA	33.48				
2. SP ind	37.54	47.05			
3. SP femelle	42.55	49.84	16.43		
4. SM	769.01	767.51	775.66	767.96	

When projected on the CVA1 axis, which explains 89.48% of the variance, we distinguished two groups (Figure. 4). Group one *S. aurita* and a second group comprising *S. pilchardus.*

3.2.2 Morphogeometric analysis by region

According to the projection on the CVA1 axis, which explains 46.94% of the variance, we have distinguished three groups (Figure. 4). A first group identifies the species *A. fallax* center, a second group characterizes *S. aurita* center and west and S. pilchardus center and a third group represents S. pilchardus west.

In our case study, our results demonstrated the existence of at least two different morphotypes in S. pilchardus. Morphological observation and analysis of meristic and morphometric characters revealed a fairly marked discontinuity in *S. pilchardus* and *S. aurita.* Morphometric analysis confirmed the morphological observation.

According to the results we have obtained, we conclude that there is a separation between the two sexes of the *Sardinella aurita* species, but we note that there are a few individuals that do not follow the norm, proving the morphometric discontinuity.

The morphometric study confirms the morphological observations. The results of the biometric analysis enable us to identify Clupeidae species on the basis of a few characteristic mophometric parameters: head length and body height. The morphometric study reveals a morphometric similarity between the species S. pilchardus and S. aurita; and a fairly pronounced morphometric discontinuity, especially in S. aurita. The explanation for the intraspecific variability could be explained by the region according to the biometric analysis; the morphometric difference according to sex seems less obvious and has been reinforced by morphogeometry. Morphometric analysis reveals a separation between two different regions (central, western) of the same species (Sardina pilchardus), but we note that there are a few individuals that do not correspond to the standard prototype of the species that asserts morphometric discontinuity, so it goes

without saying that a separation between individuals of the two species *Sardina pilchardus* and *Sardinella aurita.*

The results obtained from the morpho-geometric analysis show a clear difference between two groups for each species. One group encompassing the populations of the western region, and a second encompassing the population of the central region for *S. pilchardus* and *S. aurita*, for its part, showed a distance between the two sexes. This spatial inconsistency could be explained by environmental conditions, notably pollution and feeding conditions.

Our results need to be backed up by genetic studies to settle the issue.

4 Conclusion

The Clupeidae are small fish with oblong bodies that are more or less compressed. Little research has been done on them in the Algerian basin. The morphological similarity of this family has always been a problem. Our work was inspired by this problem, which led us to tackle the problem of intra- and inter-specific comparison of the analysis of morphological, meristic and morphometric characteristics. It was important to determine an exhaustive list of Clupeid species caught by all types of fishing gear and from all over the region: *Alosa fallax, Sardina pilchardus, Sardinella aurita and S. maderensis.*

The problem with this family stems from the confusion that arises between the species: the sardine can be confused with young shad, because of its striated operculum. It can be distinguished from them by the last two rays of its anal fin, which are longer than the others, and by the posterior end of its mouth located in front of the vertical line passing through the centre of the eye. As well as the notch in the snout of *A. fallax*.

We attempted to describe the intraspecific morphological variability observed in the *S. pilchardus* species, which shows two forms: the presence of one or two lines of dark black spots along the lateral line.

The meristics study revealed fairly pronounced intra- and inter-specific variability in the number of vertebrae, branchiospines and fin rays.

Morphometric examination using principal component analysis clearly separates the Clupeidae species, but reveals great similarity between *S. aurita* and *S. pilchardus*, and clear discrimination from the other species. Similarly, the PCA affirms the morphological observation, clearly highlighting the intra-specific variability of the Clupeidae.

It was difficult to separate these two species thanks to some of the mophometric parameters that characterise them: body height, width, eye diameter, etc. However, it should be emphasised that the length of the head is characteristic of each species.

In addition, the results obtained by morphogeometric analysis show a difference between the two species, and highlight a discrimination between males and females of *Sardinella aurita* as well as a clear distinction between western and central sardines.

- **Conflict interest**

No conflict interest.

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Research Article.

Biological parameters of cultivated *Mytilus galloprovincialis* in two shellfish farms in Bou Ismail Bay, Tipaza

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Abstract

This study aims to determine the morphometric and physiological parameters between *Mytilus galloprovincialis* mussels at two farms located in Bou Ismail Bay, Tipasa (Algeria). A sexual comparison between these parameters was taken into consideration. Results show dominance of females over males on both farms, with an overall sex ratio (F/M) of 2.65±0.16. A minorant growth (b<1) of the shell is recorded for all studied morphometric couples (H-L, W-L and W-H). Moreover, the mussels of the farm of Culte Mare are the largest according to their factor of shell size (FTC=96.94±12.69 cm^3), On the other hand, the mussels of the farm of Ain Tagourait are the most filled by the flesh according to the condition index (IC=0.144±0.052).

Keywords

Mussel farming;
Morphometry;
Sex ratio;
Condition index;
Algeria.

1 Introduction

Aquaculture in Algeria is a recent activity, it is rapidly evolving with multiple environmental and socio-economic impacts. The huge lack of scientific and precise data on the dynamics of the cultivated species, the state of health of the breeding environment and the nutritional quality of the livestock products, requires the implementation of a control strategy, analysis and monitoring for responsible and sustainable aquaculture development.

Moreover, mussel farming in Algeria is mainly based on the breeding of a single species, the Mediterranean mussel *Mytilus galloprovincialis* (Lamarck, 1819). This activity, which is currently small, seems to attract investors. M. galloprovincialis mussel is the species chosen by Algerian investors for its presence on the Algerian coast, its resistance and its rapid growth (Brahimi *et al*., 2021).

The Mediterranean mussel Mytilus galloprovincialis is widely studied at the Mediterranean scale both in the natural environment and on farms, it is well studied by its biology, physiology, reproduction, population dynamics, its ecology, and its behaviour towards pollution (Guendouzi *et al*., 2021a).

The main aim of this work is to study the sex distribution (sex ratio); the shell morphometric parameters; the shell growth model; the physiological index (Condition Index) for the whole population and in relation to sex.

2 Materials and methods

2.1 Sampling sites

From two mussel farms (located in Bou Ismail Bay, Algeria): (**1**) Culte Mare farm located in Tipasa city (coordonnee) and (**2**) Ain Tagourait Farm (coordonnee), a sample is taken during the month of April and May 2022, respectively. Forty (40) commercial-sized *Mytilus galloprovincialis* were sampled. The biological parameters are measured in the laboratory «Laboratory Management and Valorization of Agricultural and Aquatic Ecosystems» of the University Center of Tipaza, Algeria.

2.2 Morphometry of the species

Using a caliper with a precision of 1/10 mm, the morphometric parameters considered are Length (L: maximum measurement of the anteroposterior axis), Height (H: maximum measurement of the dorsoventral axis) and Width (W: maximum lateral axis measurement) of the shell (Rouane-Hacene *et al*., 2015).

Values obtained by direct reading with a caliper are subject to error, so these variables are random. In this case, the regression model used is that of the reduced main axis (Scherrer, 1984). For this, we calculated the regression line by the method that is most frequently used, that of least squares that allowed us to estimate the correlation between these parameters using the power model.

The allometric relationships obtained $H = a\,L^b$, $W = a\,L^b$, and $W = a\,H^b$, characterize the entire population of *M. galloprovincialis*, and define the type of growth on the three growth axes of the mussel shell.

The calculation of the shell size factor (FTC) follows the following formula (Guendouzi *et al*., 2021b; Rouane-Hacene *et al*., 2015; Soto *et al*., 2000):

$$FTC\ [cm3] = Length \times Height \times Width\ of\ the\ shell$$

2.3 Sex ratio

The monitoring of the sex ratio index is one of the parameters that contribute to maintaining a certain limit the reproductive capacity of the species, and is expressed in different forms (Guendouzi, 2019). The sex ratio is an index of sex-to-sex abundance in a population of a given species (Kartas and Quignard, 1984)

$$Sex-ratio = \frac{Nombre\ des\ femelles}{Nombre\ des\ males} \pm 1.96\sqrt{\frac{Male\ (\%)*Femelle\ (\%)}{n}}$$

with n ≥ 30.

Figure 1. M. galloprovincialis mussel gonad: pink to orange (female) left, creamy-white to yellow (male) right

Individuals' sex can be determined prior to spawning by the color of their gonadal follicles formed in the mantle (pink to orange for females and creamy-white to yellow for males) (Fig. **1**; Richir and Gobert, 2014).

2.4 Condition index

The physiological index (condition index IC) is the ratio of the dry weight of the flesh (g) to the dry weight of the shells (g). (Andral *et al*., 2004; Galgani *et al*., 2014; Guendouzi *et al*., 2021a).

This index has the advantage (**1**) of being an index that encompasses several physiological factors (nutrition, reproduction) and (**2**) disregard variations due to water content (Kantin and Pergent-Martini, 2007). It is the one that is least subject to the hazards of inter-cellular water loss.

3 Results and discussion

3.1 Morphometry of M. galloprovincialis

According to the morphometric parameters of the shell measurements of length (L), height (H) and width (W), the individuals from the farm of Culte-mare (Tipasa) are larger than those taken from the farm of Ain Tagourait (p<0.05). As a result, mussels from the Culte-Mare farm are the largest with a maximum value of shell size factor, equal 96.94 ± 12.69 cm³ compared to mussels from the Ain Tagourait farm with 74.39 ± 17.27 cm³ (Fig. **2**).

The individuals used in our study are larger than those used by Soto *et al*. (2000) in Menakoz (Bizkaia, Spain), and by Rouane-Hacene *et al*. (2015) in Kristel, (Oran, Algeria) and by Guendouzi *et al*. (2021b) in Oran, Algiers and Skikda (Algeria).

The reading of the power curves (Tab. 1), between the length (L), the height (H) and the width (W) of the shell, on both farms, gives us an overview of the growth of *M. galloprovincialis* individuals.

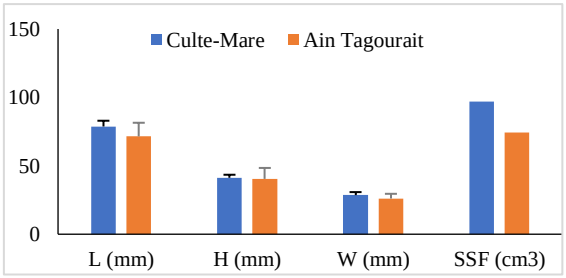

Figure 2. Length (L), Height (H), width (W) and shell size factor (SSF) of M. galloprovincialis shell

A strong correlation between height and thickness (61%), then length and height (58%), is recorded in individuals grown on the farm of Culte Mare. On the other hand, the correlation between the length and the highest thickness (32%) is recorded in the individuals cultivated on the farm of Ain Tagourait.

According to the slope values (b), the growth between each pair of parameters studied (L/H), (L/W) and (H/W) of the shell of the mussel *M. galloprovincialis*, is minorant (b < 1) for both farms.

3.2 Sex ratio

One of the primary characteristics of a population is its sex structure, or sex ratio. It also plays a major role in the mechanisms that control the number of species and rate of reproduction within populations (Chelyadina *et al*., 2021).

The sex ratio (F/M) values calculated in the mussels of the two farms (n = 30) are close, with 2.33±0.18 in the farm of Culte Mare and 2.75±0.14 in the farm of Ain Tagourait. For both farms, there is a dominance of females over males.

Table 1. Parameter values of the correlation equation (power equation) of the morphometry of M. galloprovincialis mussels from Culte Mare and Ain Tagourait (Bou Ismail Bay, Algeria). n=30.

Parameters	Farm	a	b	Growth type between X and Y	r^2
H-L	Culte Mare	8.83	0.35	Minorante	0.11
	Ain Tagourait	314.21	-0.49	Minorante	0.58
E-L	Culte Mare	0.43	0.96	Minorante	0.32
	Ain Tagourait	78.48	-0.26	Minorante	0.28
E-H	Culte Mare	20.15	0.09	Minorante	0.09
	Ain Tagourait	3.36	0.55	Minorante	0.61

This gender imbalance may be explained by: environmental conditions; increasing anthropogenic effects on mussel populations (Chelyadina *et al.*, 2021).

3.3 Condition index

The condition index is a robust index, it is often used to describe the biological state of the mussel, whose growth and physiology of the individuals (Andral *et al.*, 2004; Bajt *et al.*, 2019).

Mussels from the Culte Mare farm have a condition index of order 0.093±0.028; although mussels from the Ain Tagurait farm had a condition index of order 0.144±0.052. The CI calculated on the Culte Mare farm is lower than the condition index calculated by Benedicto *et al.* (2011) in the Mediterranean basin. On the other hand, this index is higher in the farm of Ain Tagourait. The difference in this index may be explained by the environmental conditions of the medium (nutrient availability) For both farms, the calculated condition index for females is higher than that calculated for males, the difference in CI between the sexes may be due to population dynamics (reproduction).

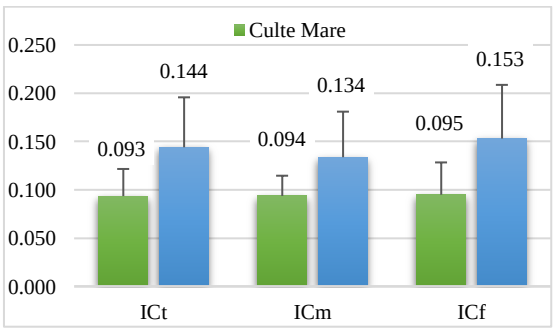

Figure 3. Total condition index (ICt), condition index for males (ICm) and for females (ICf) of M. galloprovincialis from Culte Mare and Ain Tagourait Farms (n=30)

4 Conclusion

Local comparison (between the two farms) reveals dominance of females over males, with a sex ratio (F/M) of order 2. All individuals undergo a type of minorant shell growth (b<1). According to the values of the shell size factor (SSF), the mussels of the farm Culte mare are the largest. However, their condition index (CI) is lower compared to Ain Tagourait mussels. As a result, CI is a key factor in classifying cultured mussels in terms of nutritional quality. In addition, Ain Tagourait mussels have a higher index at the Mediterranean scale according to the reference CI calculated by Benedicto *et al.* (2011). Females have the highest CI values, the sexual gap in CI requires a specific study in this context in the future.

- **Conflict interest**

The authors confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. Also, there are no funding was received for this work.

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OCEANOGRAPHIA JOURNAL

Research Article.

Evaluation of the implementation of the coastal law in the communes of West Algiers

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Abstract

The Mediterranean represents only 0.7% of the ocean's surface area, but is one of the major biodiversity hotspots, with 28% of endemic species, 7.5% of the world's marine fauna and 18% of the world's marine flora (RAC/SPA, 2015). As a mediterranean country, Algeria with its coastline is rich and diverse: 1,622 km of coastline alternates between rocky shores, sandy beaches and wetlands. The major part of the population is concentrated there, and activities are dense. Indeed, in 1998, the population of the coastal wilayas was estimated at 12564151, or 43% of the national population permanently residing within a 50 km strip of coastline, and the number of industrial units was 5242, or 51% of the national total (MATE, 2000). In response to all the environmental problems created by this high concentration, the Algerian state has introduced a specific law for the coastline: law no. 02-02 of 22 Dhou El Kaada 1422 - corresponding to February 5, 2002 - relating to the protection and enhancement of the coastline. The aim of this article is to assess the implementation of the coastal law in the wilaya of Algiers through the use of indicators relating to the measures set out in the law.

Keywords:
Coastal law, Sustainability assessment; Algeria.

1 Introduction

In Algeria, the importance of managing coastal areas is a relatively recent concern. Law 90-29 of December 1, 1990 on urban planning and development is the first legislation to define "special provisions for certain parts of the territory", in particular the coastal zone.

The law 02-02 is the first regulatory instrument dedicated to coastal areas in Algeria. Its promulgation in 2002 marked the beginning of the era of national management of coastal environmental issues.

The law is divided into 3 main chapters: the first part contains definitions, followed by a chapter entitled "Fundamental principles", which explains the broad outlines of coastal protection and enhancement, a second chapter entitled "Littoral", which sets out the scope of the law.

In this article, we will limit ourselves to a description of the following parameters, which will be the main focus of the indicators used for the assessment.

Law 02-02, comprises 46 articles divided into 3 main headings: a section dedicated to definitions of the components of the coastal domain, a section detailing the means of implementing the law, and finally a section grouping together the coercive measures for enforcing the established rules.

The provisions of this text apply to all islands and islets, as well as to any strip of land with a minimum width of 800 meters along the sea, and to all wetlands and their shores over a width of 300 meters, as soon as part of these areas is a coastline as defined.

Furthermore, any construction on a strip of land 100 meters wide from the shore is subject to a non-edificant servitude, although constructions requiring the immediate proximity of water are authorized on this strip.

The provisions of this law have not, however, prevented urbanization from spreading into areas close to the shore. These areas have also suffered considerable degradation due to unauthorized sand extraction and uncontrolled beach use.

2 Materials and methods

In order to assess the effectiveness of the implementation of the littoral law in the communes of West Algiers, the indicator tool was chosen. Depending on the relevance and availability of data from the administrations concerned, the following indicators were chosen to assess compliance with the littoral law:

1. Population of the coastal commune / population of the wilaya;
2. Population density of the commune;
3. Urbanized area of the commune;
4. Number of discharges in the commune / number of kilometers of coastline in the commune;
5. Number of beaches closed to bathing/total number of beaches in the municipality;
6. Urbanized servitude area;
7. Linear urbanized coastline / Linear coastline of coastal municipality.

3 Results and discussion

The results obtained are presented in the table 1.

The analysis summarized here shows that 3 sectors have been singled out for non-application of the coastal law:

The first sector includes the following communes: Algiers center, la Casbah, Bab el Oued, Bologhine, the coastal law is coming a bit too late. The findings show the highest number of infractions of the coastal law and the near-saturation of all communal space. These infractions in terms of urbanization of the coastline and the servitude zone (300 m) existed long before the introduction of the Coastal Law, but after its promulgation no legal provisions were taken into account; for example, for urban wastewater treatment (22), which provides for a wastewater treatment plant to be installed in every agglomeration with more than 100,000 inhabitants. There are no wastewater treatment plants, and all wastewater is discharged directly into the sea, causing the disappearance of ecosystems, not to mention the human health problems that arise, particularly during the summer season.

Table 1. Conformity of the communes of West Algiers with the coastal law

Indicators / Coastal communities	1	2	3	4	5	6	7	Sum Indicators	Comments
Alger centre	-	-	-	-	-	-	-	0	No conformity
La Casbah	-	-	-	-	-	-	-	0	No conformity
Bab el Oued	-	-	-	-	-	-	-	0	No conformity
Bologhine	-	-	-	-	-	-	-	0	No conformity
Rais Hamidou	+	-	-	-	-	-	-	0	No conformity
Hammamet	+	+	+	-	-	-	-	0	No conformity
Ain Benian	-	-	-	-	+	-	-	0	No conformity
Cheraga	-	+	-	-	+	-	-	0	No conformity
Staoueli	+	+	+	-	+	-	-	1	No conformity
Zéralda	+	+	+	+	-	-	+	3	Low conformity

List of Indicators : 01: Population of the coastal municipality / population of the wilaya - 02: Population density of the municipality - 03: Urbanized surface area of the municipality - 04: Number of discharges in the municipality / coastal linear length of the municipality - 05: Number of beaches closed to bathing / total number of beaches in the municipality - 06: Urbanized easement surface area - 07: Urbanized coastal linear length / coastal linear length of the coastal municipality. (+) : indicator complies with standard; (-) : indicator does not comply with standard.

Scale: (0 - 1) : Non-compliant / (2 and 3): Low compliance / (4- 5) : Compliant.

The second sector includes the following communes: Rais Hamidou, Hammamet, Ain Benian, Cheraga, Staoueli, where there are also fairly significant infractions, but a certain percentage of the surface is non urbanized. Many of the infractions in this sector took place after the introduction of the coastal law, such as the urbanization of the servitude zone and the linear coastline.

Nevertheless, we can cite one example of compliance: the presence of two wastewater treatment plants in the communes of Ain Benian and Staoueli. In the case of the Ain Benian , a second plant is currently under construction. There are also a number of industrial units and zones in this sector, particularly in the Rais Hamidou and Ain Benian coastal community, where small-scale industrial zones discharge effluent containing certain hazardous chemicals without treatment. What's particularly noteworthy in these communes is the presence of two small islands (Rais Hamidou); according to Article 8 of the Coastal Law, this type of ecosystem should be the subject of general protection and enhancement measures, as well as the *Posidonia oceanica* meadow, the most important ecosystem in the Mediterranean, representing the nursery for numerous species of commercial interest in the area. Actually, nothing has been done, even worse the presence of industry and waste disposal is causing the disappearance day by day of a biodiversity that is still poorly known.

Finally, the third sector includes a single municipality: Zéralda, where there are fewer infractions of the coastal law, and where the percentage of urban development in the servitude zone is the lowest in the whole of West Algiers. However, even if the Zeralda ZET is the only one to have benefited from a planning document., a large number of 'heavy' infrastructures are planned in a very sensitive area of the commune (presence of dune belts), which risks compromising the sustainability of the commune's ecosystems.

4 Conclusion

The wilaya of Algiers, faces a number of development challenges, especially after the recession of the 90s. This development must be sustainable.

The Algerian government seems to be aware of this, having ratified numerous international conventions and enacted numerous laws, notably the Coastal Act. But the reality on the ground shows that economic and social issues take precedence over environmental ones. We are witnessing some of the most alarming anarchic development of coastal areas.

More than 3/4 of the coastline in the wilaya of Algiers is urbanized, causing countless problems: pollution, erosion, destruction and disappearance of sites of ecological interest that are still little known in the wilaya.

Even though the 02-02 coastal law is innovative in that it revalues the naturalist dimension of coastal areas, it does not define "coastal development" precisely, but rather shows that protection and enhancement make a general contribution to development. Its application in the field seems to be non-existent at commune level. None of the communes in West Algiers complies with the provisions of the Coastal Act. For some communes: Algiers Centre, Casbah, Bab El Oued and Bologhine, the Coastal Act comes after the anarchic exploitation of all the spaces and resources of these communes. The communes of : Rais Hamidou, El Hammamet, Ain Benian, Cheraga and Staoueli, the Coastal Act does not seem to have had any impact on urbanization, land use or decision-making in terms of management and sustainable development. The commune of Zéralda appears to be the only commune that complies to a greater or lesser extent with the provisions of the Coastal Act.

It would appear that the non-application of the coastal law is due to the reluctance it arouses in local administrations (town planning, tourism, etc.). Also, there is no hierarchical control, and the central administrations that create the legislation do not ensure follow-up at local level. Finally, implementing decrease are slow in coming.

- **Conflict interest**

The authors confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. Also, there are no funding was received for this work.

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OCEANOGRAPHIA JOURNAL

Research Paper.

Reproductive biology of four small pelagic fish from the Algerian basin

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Abstract

Small pelagic fish are among the main target species of commercial fisheries in the Algerian region. In this study, the reproduction of four small pelagic species in the Algerian basin was investigated. To this, 2053 individuals were sampled, including 996 individuals of *Sardina pilchardus*, 487 individuals of *Sardinella aurita*, 494 individuals of *Boops boops* and 505 individuals of *Trachurus trachurus* from the Algerian basin between July 2014 and May 2016. Sex ratio results reveal male dominance, except for *S. aurita* and *T. trachurus*. Size at first sexual maturity revealed values of 9.41, 13.79, 12.77 and 11.42 cm for *S. pilchardus*, *S. aurita*, *B. boops* and *T. trachurus*, respectively. The highest absolute fecundity was observed in *T. trachurus*, followed by *B. boops*, *S. aurita* and *S. pilchardus*.

Keywords

Sex-ratio;
Length at first maturity;
Oocyte diameter;
Absolute fecundity.

1 Introduction

In Algeria, small pelagic fisheries are mixed, that is to say that several fleets exploit the same resource in competition and one fleet exploits several resources at the same time, making their management difficult. To ensure the sustainability of these national resources and ensure rational exploitation of these species, it is essential to determine the main biological parameters of the species including the study of reproduction and the evaluation of the exploitable biomass (Farrag, 2010).

In Algerian waters, several small pelagic species of commercial interest coexist and are present in fisheries in relatively large quantities. Among these species are two representatives of the Culpeidae family: *Sardina pilchardus* and *Sardinella aurita*, a species of the Sparidae family: Boops boops and a representative of the Carrangidae family: *Trachurus trachurus*. These species have been the subject of several researches in different regions of the Algerian coast covering different aspects of their biology, ecology and exploitation.

The aim of this study is to contribute to the knowledge of the reproduction of these four small pelagic species of the Algerian basin by abording the sex ratio, the length at first maturity and the absolute fecundity.

2 Materials and methods

2.1 Sampling

Sampling of the four studied species was carried out between July 2014 and May 2016 from the fishmongers of the Wilaya of Tiaret and Algiers, where fishes from the entire Algerian coast are landed. A total of 2053 individuals were sampled, distributed as follows: 996 individuals of *S. pilchardus*, 487 individuals of *S. aurita*, 494 individuals of *B. boops* and 505 individuals of *T. trachurus*. Samples were transported to the laboratory, where they were weighed and measured. Gonads from mature females (stages II, III and IV) were weighed and preserved in Gilson.

2.2 Sex-ratio

Sex and gonad maturity stage were determined macroscopically on the basis of appearance (coloration, size, shape and relative gonad size). Maturation stages were determined according to the Lamrini (1998) maturation scale, modified and reduced to five stages by Boufersaoui (2016). The sex ratio is expressed in different forms (Kartas and Quignard, 1984). It has been calculated using the following complementary expressions:

$$\%\ Female = \frac{N_f}{N_t} \times 100$$

$$\%\ Male = \frac{N_m}{N_t} \times 100$$

$$Sex - ratio = \frac{N_m}{N_f}$$

where, **Nf**: Number of females; **Nm**: Number of males and **Nt**: Number of females and males.

A comparison test $|\varepsilon_{cal}|$ at a risk of 5% between the theoretical (50%) and observed percentage was used to verify the results.

2.3 Length at first maturity

The length at first maturity (L50) was determined by grouping the sampled individuals during the study period according to size class. The proportion of mature individuals in each size class was then calculated. The threshold for sexual maturity is set at stage II which is the beginning of the gonad development phase (FAO, 1978).

The sigmoid function is selected for the graphical representation (Pope *et al.*, 1983) according to the equation:

$$P = \frac{1}{1 + e^{-(a+bL)}}$$

where, **P**: Proportion mature by size class, **L**: Total length, **a**: Intercept and **b**: Slope.

The parameters a and b are obtained after a logarithmic transformation of the previous expression using the method of least squares, *i.e.*:

$$-Ln\frac{100-P}{P} = a + bL$$

Based on parameters a and b of the logistic equation, the length at which 50% of individuals are sexually mature was determined $L_{50} = a/b$.

2.4 Oocyte diameter

The measurement of oocyte diameter was carried out on eight (08) females of each species after a few days of gonad conservation in the Gilson. A total of 513478 and 475 eggs were measured for *S. pilchardus*, *B. boops* and *T. trachurus,* respectively. Observations and measurements were made with a binocular magnifier (X15) equipped with a camera connected to a computer running TSView image analysis software (V_6.2.3.5) ®.

2.5 Absolute fecundity

Absolute fecundity (F) was studied using the gravimetric sampling method from 43, 55 and 28 females for *S. pilchardus*, *B. boops* and *T. trachurus* respectively. The mature oocytes were placed in absorbent paper and different weights were taken, namely the total weight of the oocytes (Wg), the smallest possible weight of the oocytes (Wi) and the number of oocytes contained in this fragment (Ni). The operation was repeated 3 times for each female and the average W_m and Nm were calculated.

$$W_m = \frac{\sum_1^n W_i}{n}$$

$$N_m = \frac{\sum_1^n N_i W_i}{\sum_1^n W_i}$$

where, **n**: number of replicates, **Ni**: number of oocytes contained in the weight Wi, **Wm**: average weight of replicates.

Fertility was then calculated using the following formula:

$$F = \frac{N_m \times W_g}{W_m}$$

where, **F**: absolute fertility, **Nm**: average number of oocytes contained in an average weight Wm; **Wg**: total oocyte weight.

Fertility was also expressed as a function of total length (Lt), total weight (Wt) and ovary weight (Wg). Linear and power regressions were tested to establish least-squares and least-rectangles equations.

3 Results and discussion

Macroscopic observation of the gonads enabled the identification of different gonads: female (Figure 1A), male (Figure 1B), hermaphrodite (Figure 1C), immature and indeterminate (Table 1).

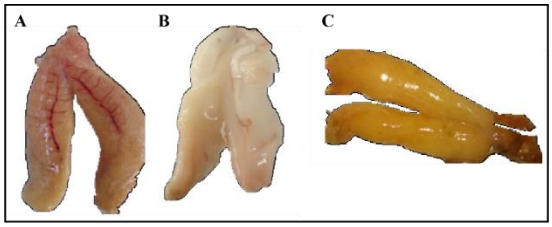

Figure 1. The different types of gonads observed. A: Female. B: Male. C: Hermaphrodite

Table 1. Distribution of species according to gonads observation

Species	N	F	M	H	IM	IND
S. pilcardus	996	345	540	-	58	3
S. aurita	487	136	234	-	95	22
B. boops	494	168	257	8	24	37
T. trachurus	505	133	240	-	77	55

N: Total number, **F**: Number of females, **M**: Number of males, **H**: Number of hermaphrodites, **IM**: Number of immature and **IND**: Number of indeterminate

The stages of sexual maturity used to study fecundity are stage II (Figure 2A), III (Figure 2B) and IV (Figure 2C).

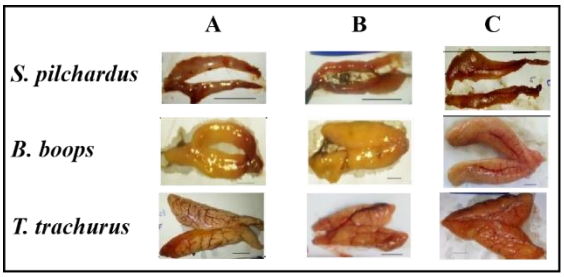

*Figure 2. Macroscopic appearance of mature ovaries used for fecundity studies. **A:** Stage II. **B:** Stage III. **C:** Stage IV. Scale bar = 1 cm.*

Table 2. Sex-ratio of the studied species

Species	*S. pilcardus*	*S. aurita*	*B. boops*	*T. trachurus*
% Female	39.05	63.24	39.53	64.34
% Male	60.95	36.76	60.47	35.66
Sex-ratio	0.64	1.72	0.65	1.80
Comparison test |Ɛcal|	NSD	SD	NSD	SD

SD: significant difference, **NSD**: non-significant difference.

Table 3. Length at first sexual maturity of the studied species compared to others from different regions

Species	L_{50} (cm)	Region	Reference	Species	L_{50} (cm)	Region	Reference
S. pilchardus	**9.41**	**Algerian basin**	**Present study**	*S. aurita*	**13.79**	**Algerian basin**	**Present study**
	12.2	Oran Bay	Bouchereau, (1981)		♀14.1	Bou-Ismail Bay	Bouaziz *et al.* (2001)
	♀ 12.6 ♂11.9	Bou-Ismail Bay	Mouhoub, (1986)		♀ 14.14 ♂13.64 13.93	Algiers	Bouaziz (2007)
	♀ 11.5 ♂11.28	East Algerian coast	Bouhali *et al.*, (2015)		♀ 13.9 ♂13.64 13.78	Annaba Golf	Belouahem, (2010)
	11.3	Tunis Golf	Khemiri, (2006)		♀ 13.5 ♂12.5	Tunisia	Gaamour et *al.* (2001)
B. boops	**12.77**	**Algerian basin**	**Present study**	*T. trachurus*	**11.42**	**Algerian basin**	**Present study**
	17.1	Oran Bay	Kherraz, (2010)		♀ 14.2 ♂ 13.5	Bou-Ismail Bay	Korichi, (1988)
	♀ 14.6 ♂13 13.6	Bou-Ismail Bay	Benina, (2015)		♀ 25.4 ♂ 22.3	North East Atlantic	Kerstan, (1985)

3.1 Sex-ratio

The sex-ratio of the studied species is shown in Table 2. The populations of *S. pilcardus* and *B. boops* show a trend in favor of males. Unlike *S. aurita* and *T. trachurus* where the female ratio slightly exceeds the male ratio. Application of the reduced difference test gives a non-significant difference ($|Ɛ_{cal}| < 1.96$) only for *S. aurita* and *T. trachurus*. Thus, we can conclude that the *B. boops* and *S. pilcardus* stocks are made up of as many males as females.

3.2 Length at first maturity

Length at first sexual maturity is 9.41, 13.79, 12.77 and 11.42 cm for *S. pilchardus*, *S. aurita*, *B. boops* and *T. trachurus,* respectively (Table 3). Length at first sexual maturity varies from year to year and from zone to zone. This inter-annual variability is due to the temporal variability of the spawning initiation date (early or late spawning, depending on the year) and the corresponding annual recruitment (Abad and Giraldez, 1993). L50 may also vary according to sex.

The results obtained in the present study for *S. pilchardus* are lower than those obtained by other researchers (Table 3). For *S. aurita*, the results are similar to those obtained in the Algerian and Tunisian regions. The L_{50} values obtained for *T. trachurus* are close to those found by Kerstan (1985) in the North-East Atlantic. For *B. boops*, our results are higher than those calculated by authors who have worked on this species, whatever the region studied.

Abed and Giraldez (1993) explain that variations in length at first maturity are apparently attributable to the different strategies developed by fish in different environments for better adaptation to environmental conditions such as temperature.

3.3 Oocyte diameter

The frequency distribution histograms of oocyte diameters showed distinct batches of oocytes. The modal value of the first batch (01) of oocytes represents the reserve stock. The upper diameter of these eggs is 189±11.76 μm, 356.5±16.17 μm and 337±21.36 μm for *S. pilcardus*, *T. trachurus* and *B. boops,* respectively, and corresponds to the mesh size of the filter chosen to eliminate reserve eggs. The remaining oocytes (batches 2, 3, 4 and 5) are mature eggs likely to be laid within the year and can therefore be used to estimate fecundity.

According to Mellinger (2002), the heterogeneity and multimodal distribution of oocyte diameters indicate a continuous recruitment of vitellogenic oocytes, which are not all released at the same time. Reproduction in the three species studied, even in *S. aurita* according to Bouaziz (2007), is asynchronous, fractionated, with mature oocytes emitted in small quantities over a long period of time, followed by very rapid recovery of the ovary. This asynchronous reproduction is characteristic of partial reproducers (Holden and Rait, 1974).

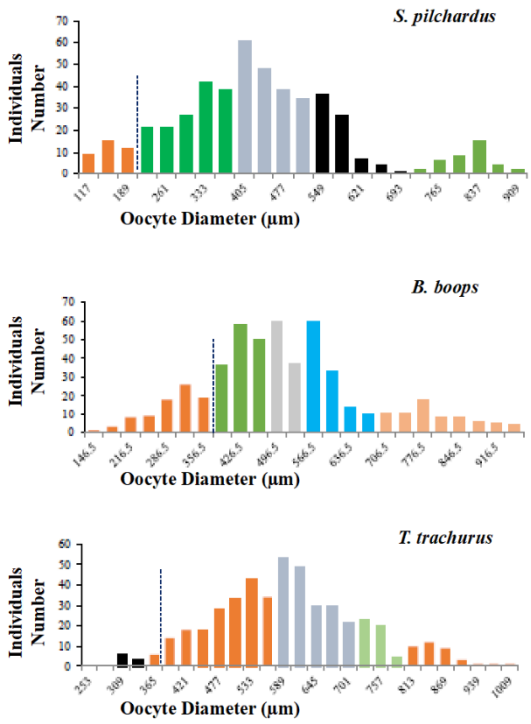

Figure 3. Histogram of oocyte diameter frequencies for the three studied species

3.4 Absolute fecundity

Absolute fecundity was carried out on individuals with length ranging from 11.7 to 18 cm and with weights varying from 10.5 to 47.58 g for *S. pilchardus*, as for *B. boops*, the estimate was made on individuals of length between 19.4 to 29.5 cm, with weights from 71.5 to 239.35 g, while *T. trachurus* was represented by females ranging in length from 18.7 to 32.5 cm, with weights from 54.94 to 307.75 g.

The average number of oocytes emitted per female is 6856±1614 oocytes for S. pilchardus, 34349±6468 oocytes for *B. Boops* and 38392±12395 oocytes for *T. trachurus* (Table 4).

Table 4. Extreme and mean values of oocytes emitted by females for the four species.

Species	Absolute fecundity		
	Minimal	Maximal	Mean±s.d.
S. pilcardus	421	35787	6856±1614
B. boops	9973	119153	34349±6468
T. trachurus	2544	136812	38392±12395
S. aurita (Bouaziz, 2007)	11680	40348	25001±2413

Table 5 shows that the correlation between fertility and the various parameters relating to individual height and weight, as well as gonad weight, is significant, especially for gonad weight. Thus, it appears that the power-type model fits the observed data better, and it follows that the power-type is the best model for expressing absolute fecundity as a function of total height, total weight and gonad weight in females of the studied species.

4 Conclusion

Macroscopic determination of sex and maturity stage presents difficulties, especially for young individuals where gonads are difficult to identify due to their size. For these reasons, and because the macroscopic scale of sexual development is based on external gonadal characteristics that can be ambiguous, the study of the microscopic scale is necessary and provides a more reliable methods to follow the evolution of ovarian development.

Table 5. Relationships between absolute fecundity and the different parameters in the studied species

Species		Linear relationship			Power relationship		
		$F=aL_T+b$	**$F=aW_T+b$**	**$F=aW_g+b$**	**$F=aL_T^b$**	**$F=aW_T^b$**	**$F=aW_g^b$**
S. pilcardus	MC	$876.9L_T-6690$	$123.7W_T+3105$	$17592W_g-4626$	$14.68L_T^{2.232}$	$668.5W_T^{0.68}$	$11490W_g^{0.977}$
	MR	$1055.44L_T-9278.46$	$199.84W_T+824.11$	$12494.68W_g-5092.25$	$2.76L_T^{1.289}$	$0.87W_T^{5.876}$	$0.68W_g^{9.098}$
	R	0.83	0.618	0.848	0.809	0.781	0.915
B. boops	MC	$2313L_T-16679$	$84.7W_T+26627$	$4871W_g+16247$	$430.9L_T^{1.409}$	$7590W_T^{0.33}$	$12122W_g^{0.739}$
	MR	$3106.64L_T-35717.87$	$102.13W_T+23639.71$	$535894W_g+11929.87$	$1.88L_T^{4.566}$	$0.4W_T^{8.566}$	$0.64W_g^{-674}$
	R	0.744	0.83	0.91	0.748	0.82	0.93
T. trachurus	MC	$6024L_T-12082$	$6024W_T-12082$	$8224W_g-10787$	$0.03L_T^{4.208}$	$0.03W_g^{4.21}$	$6690W_g^{0.997}$
	MR	$6964.84L_T-145738.6$	$385.86W_T-27705.92$	$8650.79W_g-14413.5$	$4.5L_T^{-4.45}$	$1.53W_g^{2.613}$	$1.03W_g^{8.742}$
	R	0.724	0.896	0.95	0.745	0.91	0.966

a, b: coefficients of the equations, **R**: Correlation coefficients

- **Conflict interest**

The authors confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. Also, there are no funding was received for this work.

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Research Paper.

Nutrient level in Algerian coastal waters: Algiers, Bou-Ismail and Zemmouri bays

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Abstract

During sprint cruise (2013), numerous measurements of nutrient levels were conducted across the Algiers region (Algiers Bay, Bou-Ismail Bay and Zemmouri Bay) in order to assess the state of pollution by nutrient salts. Twelve stations were sampled along the Algiers coast using a NISKIN bottle. The nutrients (*e.g.*, nitrates NO_3^-, nitrites NO_2^-, ammonium NH_4^+, orthophosphate PO_4^{3-} and silicates SiO_2) were analyzed in the laboratory. the results show fluctuations with measured concentrations of nitrate (1.81-3.39 µmol/L), of nitrite (0.18-0.28 µmol/L), of ammonium (1.23-33.93 µmol/L), of orthophosphate (0.89-5.08µmol/L), and of silicate (2.55-7.64 µmol/L). The non-significant correlation between nitrate and phosphate data ($R^2 = 0.0366$) allows us to estimate an N/P ratio of -0.071.

Keywords

Nutrients;
Algiers coast;
Water pollution;
Eutrophication.

1 Introduction

The Mediterranean is a sea subject to very high human pressure, chronically receiving wastewater from large urban and industrial units with a high pollution load. The various types of plastic waste from coastal dumps and ships can threaten coastal wildlife (Abd elguerfi, 2003).

Faced with these threats of pollution, mankind is mobilized to fight to preserve heritage, limit and study their effects by measuring physico-chemical and chemical parameters used as tracers in seawater, so they are a very important tool for the study of phenomena and processes taking place within the ocean. Like most Mediterranean coastal areas, the Algerian coast and coastline are experiencing serious environmental problems. The Algerian region is certainly one of the areas where the deterioration in the quality of coastal marine waters is most perceptible.

Knowledge of water quality and the monitoring of pollution levels in the coastal environment appear to be a priority for the preservation of the marine environment and its resources. This is the aim of this study. The present investigation concerns the waters of the Algiers coastline (Algiers Bay, Bou-Ismail Bay and Zemmouri Bay), which are subject to continental water discharges (wadis).

2 Materials and methods

2.1 Samples collection

In order to monitor the state and quality of sea water in the Algerian region (Bou-Ismail Bay, Algiers Bay and Zemmouri Bay), more specifically at the level of Oueds discharges, urban and industrial outfalls, we took several samples at stations that had been selected in advance; During a sea trip aboard the small boat El Awras (ENSSMAL) on May 20, 2013, we took samples at four stations (S1, S2, S3 and S4). In order to complete our study, eight (08) samples were entrusted by the CNRDPA. These samples were taken in our study area during March 2013 by CNRDPA researchers during a mission aboard the Grine vessel. These stations are as follows: S5 and S6 in Bou-Ismail Bay, S7 and S8 in Algiers Bay and S9, S10, S11, S12 in Zemmouri Bay (Figure 1).

2.2 Sea water sampling

Seawater was sampled using a 5-liter NISKIN bottle.

2.3 Analysis of nutritive elements

The nutrient (*e.g.*, nitrates NO_3^-, nitrites NO_2^-, ammonium NH_4^+, orthophosphate PO_4^{3-} and silicates SiO_2) were analyzed in the laboratory using the Aminot and Chaussepied (1983) method.

Figure 1. Location of stations in the study area

3 Results and discussion

In the following, we present the nutrient levels. Dissolved nutrient concentrations (NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, SiO_2) are presented in Table 1 and Figures 2 - 6.

3.1 Nitrates (NO_3^-)

Analysis of nitrate concentrations in the Algiers region reveals levels ranging from 1.81 to 3.39 µmol/l, with an average of 2.54±0.48 µmol/l (Figure 2). These values remain low compared with the nutrient content observed by Boulahdid (2003), which was 5.36±6.69µmol/l in Bou-Ismail Bay, due to the consumption period and low continental inputs (spring). The high levels observed, particularly at the surface near the mouth of Oued El-Harrach and the port of Dellys (station 07 and station 12), are linked to the high inflow of water during this period. The surface minimum is located off Zemmouri Bay (station 11), due to the dilution effect and the absence of coastal contribution, but the influence of Atlantic waters via the Algerian current should also be noted.

Table 1. Nutrient concentrations (µM) in the Algiers coastal seawater

Stations	Latitude	Longitude	NO_3^- (µM)	NO_2^- (µM)	NH_4^+ (µM)	PO_4^{3-} (µM)	SiO_2 (µM)
S1	36.7900°N	2.8700°E	2.18	ND	1.54	1.77	3.18
S2	36.7500°N	2.8200°E	2.06	ND	1.4	5.08	4.27
S3	36.7300°N	2.8100°E	2.35	ND	1.57	2.61	7.64
S4	36.8000°N	2.8900°E	2.67	ND	1.68	2.05	6.45
S5	36.8258°N	2.6570°E	2.71	ND	1.23	1.01	4.36
S6	36.8938°N	2.7720°E	2.24	ND	1.51	0.97	3.64
S7	36.7600°N	3.1740°E	3.38	0.24	2.33	1.29	2.55
S8	36.8364°N	3.1767°E	2.71	ND	1.51	0.89	5.36
S9	36.8646°N	3.6775°E	2.48	0.28	1.75	2.21	3.64
S10	36.8403°N	3.5091°E	2.46	0.20	33.93	4.00	4.82
S11	36.9498°N	3.7831°E	1.81	0.18	1.33	1.69	4.27
S12	36.9135°N	4.1133°E	3.39	ND	1.75	2.93	4.00
		Max	3.39	0.28	33.93	5.08	7.64
		Min	1.81	0.18	1.23	0.89	2.55
		Mean ± sd	2.54±0.48	0.08±0.11	4.29±9.34	2.21±1.28	4.52±1.41

3.2 Nitrites (NO_2^-)

Nitrite ion concentrations at the various stations in the study area are undetectable, with the exception of S07, S09, S10 and S11, where values vary between 0.18 and 0.28 µmol/l (Figure 3). These values are logical, as nitrite ions are intermediate forms, and their presence in the marine environment in significant quantities is generally due to the presence of a polluting source of nitrite.

3.3 Ammonium (NH_4^+)

Ammonium levels observed in spring 2013 (1.23-33.93 µmol/l) show little fluctuation over the study period, with the exception of the suspected high value at station S10 (Figure 4), contamination and/or poor sample preservation are thought to be responsible for this high concentration. The highest levels of ammonium in the various stations are found in particular at stations receiving inputs from the wadis, mainly El-Harrach, El-Hamiz and Mazafran, as well as the station near the port of El Djamila. These areas are generally enriched in ammonium by domestic and industrial wastewater discharges.

3.4 Orthophosphate (PO_4^{3-})

Phosphate concentrations range from 0.8 to 5.08 µmol/l, with an average of 0.54±0.58µmol/l, reflecting the variation from station to station (Figure 5). Fluctuations follow those observed for nitrates, *i.e.* a clear difference in concentration between consumption, regeneration and input periods. Station 2 (ilots Sidi Fredj) has the highest orthophosphate levels, linked to an inflow of wastewater laden with polyphosphate-rich detergent.

3.5 Silicates (SiO_2)

Silicate levels observed in March and May 2013 ranged from 2.55 to 7.64 µmol/L, with an average of 4.52±1.41 µmol/L (Figure 6). With the exception of station S7, where silicate levels are low, fluctuations are less significant and follow those observed for nitrates and phosphates, *i.e.* occasional enrichment opposite the mouths of the main wadis during periods of direct inflow, and depletion during periods of consumption and low inflow of continental water.

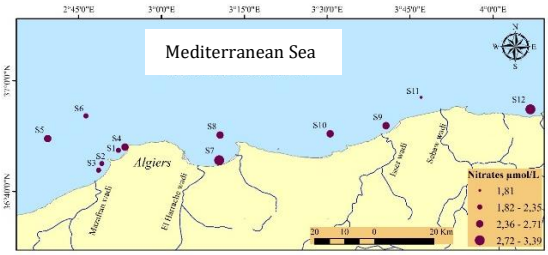

Figure 2. Spatial variation of NO_3^- concentrations

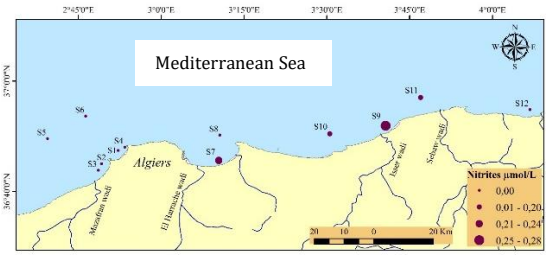

Figure 3. Spatial variation of NO_2^- concentrations

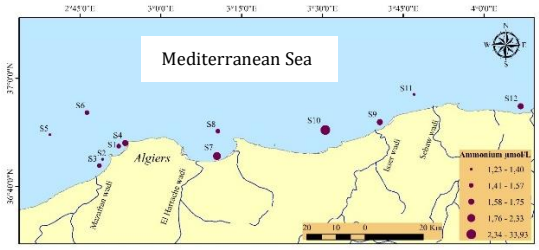

Figure 4. Spatial variation of NH_4^{3+} concentrations

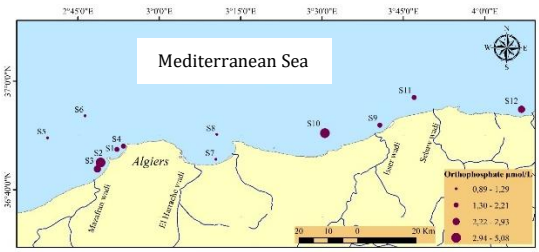

Figure 5. Spatial variation of PO_4^{3-} concentrations

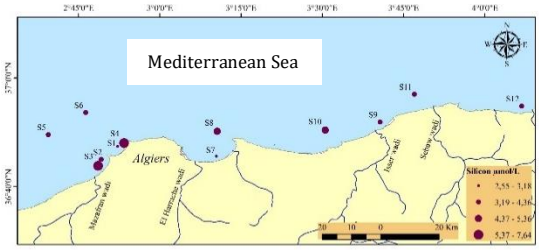

Figure 6. Spatial variation of SiO_2 concentrations

3.6 Nitrate/Phosphate diagram and N/P ratio

The Mediterranean ecosystem, in addition to its relative nutrient poverty, its waters are characterized by values of the Redfield N/P biochemical ratio different from those reported for the world ocean. Indeed, it is found with a rather high value of the order of N/P = 21 (Raimbault *et al.*, 1990; Benhalima *et al.*, 2014).

The nitrate-phosphate correlation diagram shows the nitrate/phosphate abundance ratio (N/P) characterizing the stocks of these two elements over the period studied (Figure 7). The value of the N/P ratio (-0.071) for the whole period indicates a scattered and insignificant distribution, and is well below the value generally accepted for Mediterranean waters (20-27) according to Gomez (2003) and for the world ocean 16 (Redfield *et al.*, 1963). The N/P ratio is unstable due to the influence of water inputs and the general circulation of water along the coast. Urban and agricultural activities are the main causes of the imbalance in the N/P ratio. It would appear that this general imbalance at all stations is more related to phosphate enrichment than to nitrate deficiency.

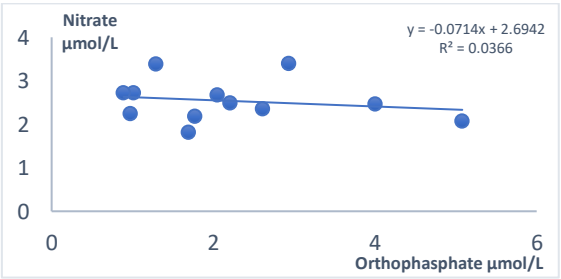

Figure 7. Nitrate-Phosphate diagram (during spring 2013)

4 Conclusion

The Algerian coastline appears to be a series of bays with different physical and chemical characteristics in relation to the importance of urban and agricultural inputs and activities:

The hydrological characteristics of the Algerian coastline are determined by the influence of offshore waters and continental waters, in particular the contributions of the main wadis (El-Harrach, Mazafra,

Isser and Sebaw), as well as meteorological conditions. The imprint of continental waters is marked by the varying degrees of surface desalination observed in front of wadi mouths and outfalls.

Analysis of the chemical substrate has highlighted the importance of exogenous inputs and upwelling of deep waters in enriching coastal waters with nutrient salts. This enrichment, particularly in phosphate, by wastewater from the Mazafran wadi, is causing a deterioration in the chemical quality of the water in Bou Ismail Bay. This is reflected in the permanent nature of the pronounced imbalance in the nitrate/phosphate ratio, which reaches very low levels at all stations. Nevertheless, water mixing and the influence of offshore waters keep concentrations of these two elements below those that could lead to eutrophication.

Following on from this state of pollution, it is important to emphasize that pollution assessment at any site requires continuous monitoring, which is only meaningful if it is complemented by an estimate of inputs and a reduction in pollutant discharges. In this respect, the sampling strategy needs to be improved to meet the specific needs of the site, and to provide additional information (study of wadi inputs and their effluents, currentology and more precise identification of the origin and source of pollutants).

- **Conflict interest**

The authors confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. Also, there are no funding was received for this work.

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