ECOLOGICAL STUDY OF THE FAUNA ASSOCIATED WITH *PERINEREIS CULTRIFERA* ON THE ALGERIAN COAST

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ABSTRACT

To evaluate the impacts of anthropogenic activities on the ecological diversity of fauna associated with annelids in Algeria, seven sites were included in this study: Saint-Cloud beach (Annaba), Stora beach (Skikda), Figuier beach (Boumerdes), Pointe-Pescade (Algiers), Stidia beach (Mostaganem), Bomo beach (Oran), and El-Mordjène beach (El-Kala), which served as the reference site. Water samples, polychaetes, and associated fauna were collected monthly from February 2016 to January 2017. The findings show that the collected specimens (N = 40,411) belong to 25 taxa, primarily including polychaete annelids, arthropods, molluscs, Plathelminthes, Sipuncula, and echinoderms. In conclusion, the studied sites are similar in faunal composition but different in the distribution of taxa and ecological conditions, which are influenced by the physico-chemical characteristics of the water.

RÉSUMÉ: etude ecologique de la faune associée à *Perinereis cultrifera* sur la côte algérienne.

Afin d'évaluer les impacts des activités anthropiques sur la diversité écologique de la faune associée aux annélides en Algérie, sept sites ont été inclus dans cette étude: plage de Saint-Cloud (Annaba), plage de Stora (Skikda), plage du Figuier (Boumerdes), Pointe-Pescade (Alger), plage de Stidia (Mostaganem), plage de Bomo (Oran), et plage d'El-Mordjène (El-Kala) utilisée comme site de référence. De plus, des échantillons d'eau, de polychètes et de faune associée ont été collectés mensuellement de février 2016 à janvier 2017. Les résultats montrent que les spécimens collectés (N = 40.411) appartiennent à 25 taxons, principalement: annélides polychètes, arthropodes, mollusques, Plathelminthes, Sipuncula et echinodermes. En conclusion, les sites étudiés sont similaires en termes de composition faunistique mais différents sur la repartition des taxons et présentent des différences dans les conditions écologiques, qui sont influencées par les caractéristiques physico-chimiques de l'eau.

REZUMAT: studiu ecologic al faunei asociate cu *Perinereis cultrifera* pe coasta algeriană.

Pentru a evalua impactul activităților antropice asupra diversității ecologice a faunei asociate cu anelidele din Algeria, șapte situri au fost incluse în acest studiu: plaja Saint-Cloud (Annaba), plaja Stora (Skikda), plaja Figuier (Boumerdes), Pointe-Pescade (Alger), plaja Stidia (Mostaganem), plaja Bomo (Oran) și plaja El-Mordjène (El-Kala) utilizată ca sit de referință. Probele de apă, polichetele și fauna asociată au fost colectate lunar din februarie 2016 până în ianuarie 2017. Descoperirile arată că exemplarele colectate (N = 40.411) aparțin la 25 de taxoni, incluzţnd în principal polichete anelide, artropode, moluște, platelminți, Spincula și echinoderme. Ȋn concluzie, siturile studiate sunt similare în ceea ce privește compoziția faunei, dar diferite în ceea ce privește distribuția taxonilor și prezintă diferențe în ceea ce privește condițiile ecologice, care sunt influențate de caracteristicile fizico-chimice ale apei.

INTRODUCTION

Algeria has a wide Mediterranean coastline stretching 1,622.48 km, characterized by the diversity of its physical and natural environment, as well as the variety of its natural resources, flora, and fauna (Bouroumi, 2014). The coastline is also marked by a concentration of industrial activities. Approximately 66.7% of all industrial units are located in the north of the country, with 45.22% of these units are located on the coast (Dahlab, 2023). As of the most recent estimation, more than 4,302 industrial units are located in coastal cities (year of the last estimation), compared to only 1,202 in 1993 (Bouroumi, 2014). Over a period of 20 years, the number of industrial units has almost quadrupled, demonstrating the increasingly strong pressure exerted by industrial activities on this very sensitive area. Currently, the coast is even more exposed to many forms of degradation, leading to an accelerated habitat loss, and consequently, a loss of biodiversity. These pressures are driven by anthropic induced effects of chemical pollution, high population density, and urbanization, which increased from 26% in 1962 to 61.4% in 2010 (Bencheikh et al., 2022; Bouroumi et al., 2020;Ahmed et al., 2018).

Biological indicators are increasingly used to asses environemental statues of various ecosystems (Casazza et al. 2002). Among the most important species for assessing the health of coastal ecosystems, polychaete annelids appear to be a good candidate (Sebbih et al., 2023; Bouziane et al., 2020; Del-Pilar-Ruso et al., 2008). Previous studies suggest that polychaete worms can provide baseline information to evaluate demersal fish stocks, as they are an important food source for bottom feeders and are biological parameters that show the overall fertility of aquatic sediments (Patel and Desai, 2009).

Similarly, in recent decades, the use of bioindicators in ecotoxicological studies has grown as means to estimate aquatic environments and assess the level of pressure exerted by pollution on the health of habitats before entire populations or ecosystem are affected (Sebbih et al., 2023; Boucetta et al., 2019; Amira et al., 2018).

From a technical standpoint, ecological indices are among the most effective metrics for recording changes in the composition of biological communities and for establishing the relationship between exposure (or pressure) sources and ecosystem responses (Harold, 2010).

This study aims were: a) monitor the distribution patterns of *Perinereis cultrifera* and determine the annelid-associated fauna, as well as the biodiversity characteristics of the studied sites; and b) to conduct a qualitative and quantitative analysis of the collected organisms. The specimens were collected and meticulously identified and categorized based on zoological classification. This allowed us to create a taxonomic inventory, establish their spatial distribution according to ecological factors, and analyze the structure of the populations.

MATERIAL AND METHODS

Study area

The study was conducted at seven geographically distinct sites along the Algerian coast (Fig. 1). Based on anthropogenic characteristics, the sampling sites were described as follows.

The first sampling site was El-Mordjane beach (El-Kala), the second was Saint-Cloud beach (Annaba), the third was Stora beach (Skikda), the fourth was Figuier beach (Boumerdes), the fifth was Pointe-Pescade (Algiers), the sixth was Stidia beach (Mostaganem), and the seventh was Bomo beach (Oran).

The El-Mordjane site is on the beach near the town of El-Kala, approximately 25 km from the Tunisian border. This site is characterized by the dominance of granite in the composition of the rocks in the intertidal zone, and by Numidian sandstones (Baoult, 1974). It is known for its high biological diversity and is therefore considered a reference station in our present work and in several other studies (Meghlaoui, 2015; Daas et al., 2011).

The Saint-Claud site in Annaba is located 80 km west of El-Kala. The pavement and benches are composed of metamorphic rocks, primarily gneiss and quartzite. This site is located in the heart of the city, close to urban waste during the winter and to a large population in the summer (Khaled-Khodja and Rouibah, 2018). Stora beach, located in Skikda near the town's fishing port, is primarily composed of Paleozoic and Proterozoic gneiss from the Kabyle basement (Baoult, 1974). This beach is affected by pollution from port activities and urban waste.

Figuier beach in Boumerdes is located 60 km east of the capital. This beach is a strip of coarse sand rich in shellfish, with a low population during the autumn, winter and spring seasons, far from urban discharges.

In Algiers, the capital of the country, where urban density is highest, the Pointe-Pescade site is located in the city center, on one of Algiers' former communes. This site is characterized by large slabs of rock and urban waste.

Stidia Beach in Mostaganem, 80 km from Oran, features a diverse substrate of sand, mud, and stones. This station is known for its high biological diversity and low neighboring population density, making it a popular area for amateur line fishing.

Finally, Oran, located 100 km from the Moroccan border, is the most important city in the west. The Bomo site is a wide beach with fine sand rich in shell debris, with large rocks, and several sources of urban waste, particularly during the winter.

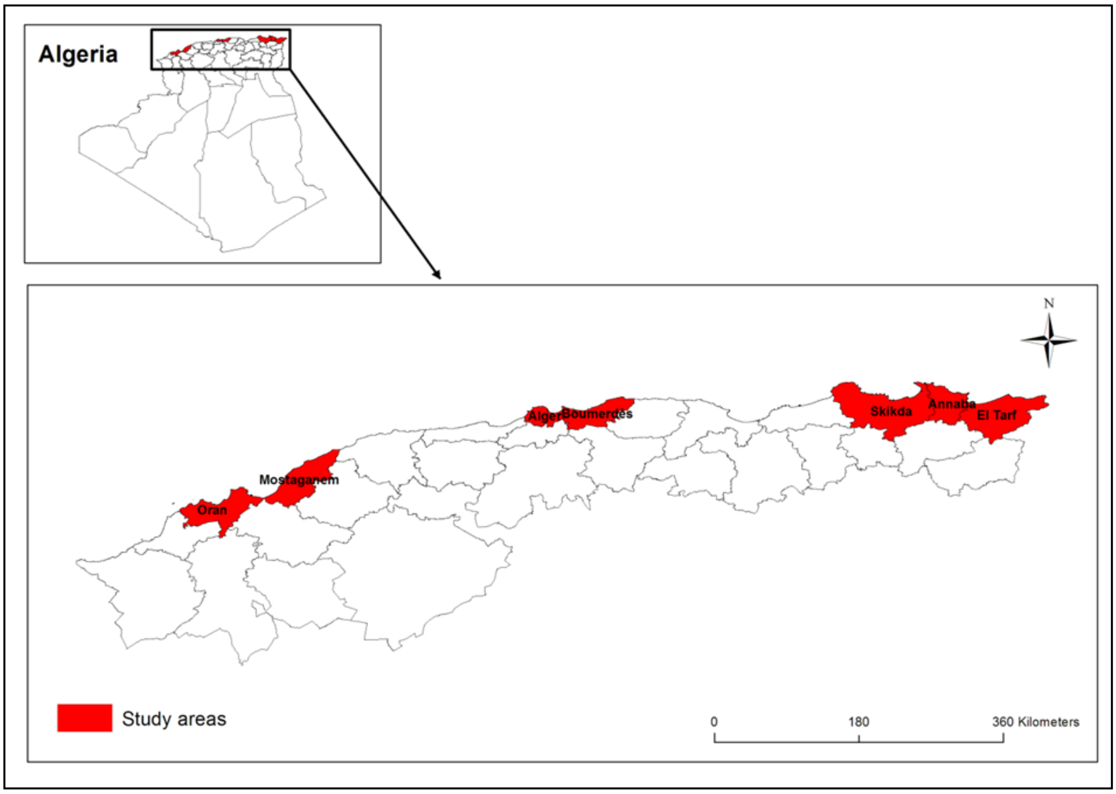

Figure 1: Map showing the locations of the coastal sites investigated;
map created using the Free and Open Source QGIS.

Physicochemical characteristics of seawater

During sampling, the maximum tidal range in these regions was approximately one meter (Rouabah and Scaps, 2003). Four physico-chemical parameters were recorded: daytime temperature, seawater temperature, pH, and salinity. Temperature and pH were measured using a thermometer and pH meter (pHep 5 –HANNA), while salinity was measured with a salinometer (Inolab 7110 W.T.W). Water samples were stored in plastic bottles and transported in a cool box to the biology laboratory for analysis.

Sampling collection

Monthly collections were conducted over a one year period, from February 2016 to January 2017, at all sites. The individuals were found among the Rhodophyceae (red algae) growing on pavements and rocky banks composed of various rock types, depending on the region. Sampling was carried out in intertidal and shallow subtidal zones during low tide at the seven sites. For species abundance studies, one-square-meter areas were marked out in advance. The seaweed was harvested at the base, either by hand or with a scraper. Specimens were stored in containers with cardboard galleries or natural algae at a temperature between 4°C and 12°C in iceboxes, with collection times ranging between three to five hours, depending on the weather conditions.

Systematic study method taxonomic analysis

The collected specimens were subjected to taxonomic examination at the "Biology, Water, and Environment" research laboratory at the University 8 Mai 1945 Guelma, Algeria. To create a comprehensive faunal catalogue of the taxa collected during the field survey and to determine the associated fauna, each individual organism was meticulously observed.

Polychaete annelids were classified based on their morphological characteristics, observed under a binocular magnifying glass, while detailed examination of parapodia and setae was coducted using a light microscope, following the methods described by Wilson et al. (2003), Fauchald (1977), Rouse and Fauchald (1997), and Fauvel (1923).

Ecological indices

The structure of these assemblages was examined, and various indices were calculated to assess the significance of the species, their distribution, and their affinities with other species:

- Abundance*:* number of individuals N of a species in a stand;
- Density*:* number of individuals N of a species per m^2;
- Frequency*:* ratio (%) of the number of stations where the species has been found to the total number of stations;
- Relative frequency*:* ratio (%) of the frequency of one species to the sum of the frequencies of all the species;
- Partial dominance*:* ratio (%) of the number of individuals of one species to the number of individuals of all species;
- Species richness (S): represents the number of species in the stand;
- Shannon and Weaver diversity index (H): takes into account the number of species present (n) and their respective abundance (pi),
$$H = -\sum i{=}1\ piLog2pi$$
- Equitability (E): represents the ratio between the specific diversity measured using the Shannon and Weaver Index (H) and the maximum diversity Log2 S,
$$H = H/Log2S.$$

Data analysisls

The descriptive analyses (physicochemical properties and species distribution) were expressed as means ± standard deviation (SD). Results were analyzed using a comparison of the means and an analysis of variance (ANOVA), followed by Tukey's test when the conditions of normality and homogeneity of variances were met.

In order to identify the different relationships between sites, centered and reduced Principal Component Analyses (PCAs) were applied. Active individuals were introduced according to the sample grouping criteria, projecting the observations from a p-dimensional space with p variables to a k-dimensional space (where $k < p$) in such a way as to retain the maximum amount of information from the initial dimensions. For each PCA, the principal components were sufficiently explanatory if their explained variance exceeds 60%. The data were processed using IBM SPSS Statistics package, version 25 (IBM SPSS, 2017). The minimum threshold of significance retained was $p < 0.05$.

RESULTS AND DISCUSSION

Distribution of *Perinereis cultrifera*

Perinereis cultrifera has a cosmopolitan distribution (Fig. 2), and this distribution varies with human activity. Annaba and Mostaganem show the highest concentrations, while Algiers has the lowest ($p < 0.05$).

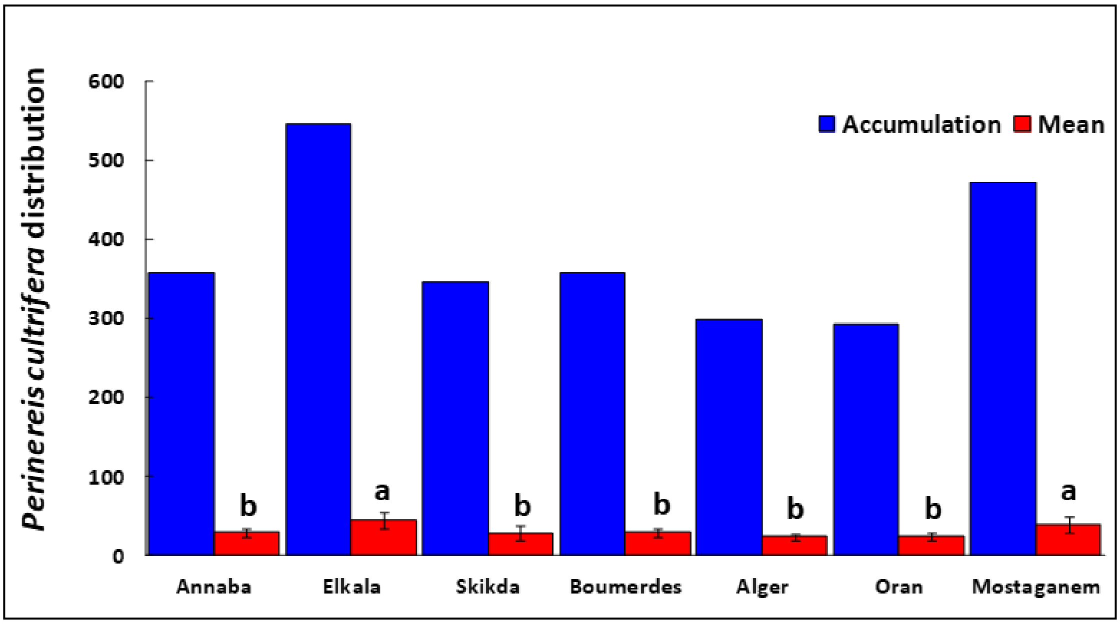

Figure 2: Distribution of *Perinereis cultrifera*.
Means are denoted by capital letters (A and B)
and indicate significant difference between locations
(Annaba, El Kala, Skikda, Boumerdes, Alger, Oran, and Mostaganem)
(Tukey's post-hoc test, $p < 0.05$).

Physico-chemical analyses

Temperature levels (Fig. 3) show variation from site to site and across seasons. The highest values were recorded at the El-Mordjène site (El Kala), ranging from an average of 19°C to 33°C in the summer. The lowest temperatures were observed at the Skikda site, ranging from 16°C to 26°C. However, the amplitudes of seawater temperature variations closely mirros the dialy variations. On average, temperatures range from 10°C in winter to 28°C in summer, with a mean annual seawater temperature of 17-21°C at the seven sites (Fig. 3).

As figure 3 shows, pH levels vary between sites. The Saint-Cloud site (Annaba) recorded the lowest average pH value over the study period, with an average of 7.51. The pH to approach normal value for seawater levels as one moves farther from industrial and urban discharge sources.

Regarding the salinity registered values, the measurements recorded during the research period varied based on geographical location. The Skikda site exhibited high salinity during the summer and autumn seasons, with a peak of 37.5 g/L in August. In contrast, salinity at the Boumerdes site decreased during the autumn and winter, reaching a lower value of 31.2 g/L in March. Overall, the water salinity measurements at the studied stations were consisten with the average salinity of Mediterranean marine waters, ranging between 33 to 37 g/L (Fig. 3).

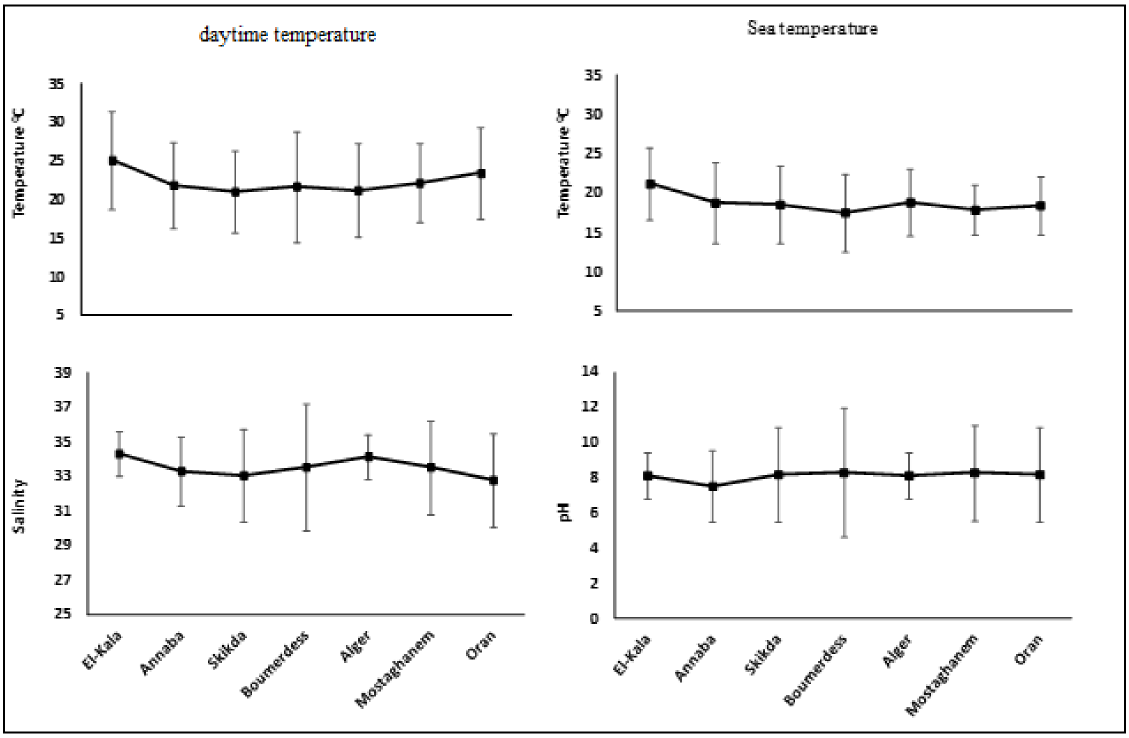

Figure 3: Variations in daytime temperature and seawater pH, and salinity at the studied sites.

The results presented in figure 4 of the Principal Component Analysis (PCA) involve seven variables (sampling sites) and four modalities (physico-chemical parameters). The first two principal components, F1 and F2, account for 50.91% and 37.27% of the variance, respectively, explaining a combined total of 88.18% of the total variability.

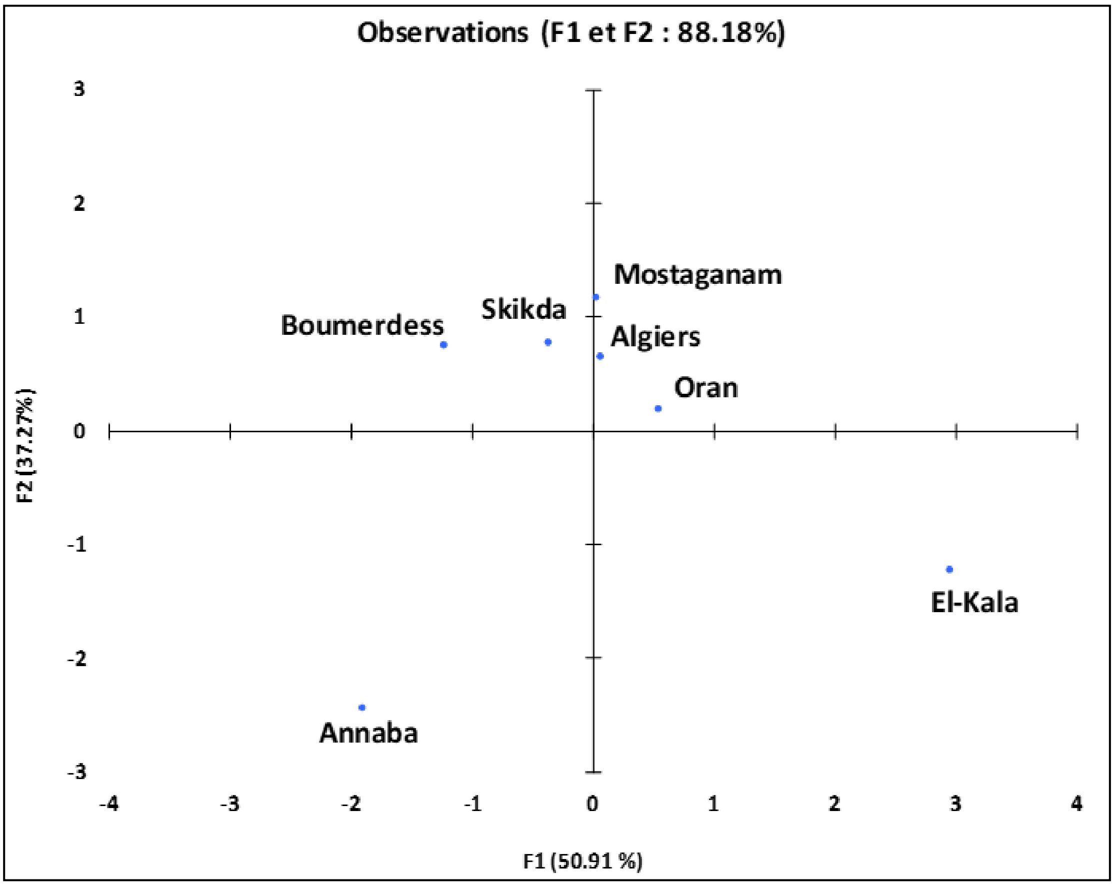

Figure 4: Principal Component Analysis (PCA).

Looking at the F2 factorial axis, we can observed that the sites are grouped into two distinct clusters. The first group consists of five sites: Skikda, Boumerdes, Algiers, Mostaganem, and Oran, which share relatively similar abiotic characteristics. The second group includes the Annaba and El Kala sites, which are geographically close to the sites in the first group.

These obtained results indicate that the physico-chemical characteristics of the Skikda, Boumerdes, Algiers, and Mostaganem researched sites are comparable, qualifying them as analogous in terms of environmental conditions. Similarly, the Annaba and El Kala sites exhibit similar characteristics that set them apart from the first identified group (Tab. 1).

Table 1: Participation rate of each factorial axis in the establishment of projection plans; Fn represents the PCA factorial axes.

F1	F2	F3	F4	F5
Eigenvalue	2.037	1.491	0.396	0.077
Variability (%)	50.915	37.265	9.893	1.927
Cumulative	50.915	88.180	98.073	100.000

The reason why the variability (%) of F1 is equal to the cumulative of F1 is due to the manner in which these values were calculated. Variability (%) of F1: The variability of F1 represents the proportion of the total variance in the data explained by the first factor (F1). In this case, F1 explains 61.059% of the total variance. Cumulative of F1**:** The cumulative for F1 is simply the sum of the variability explained by all factors up to and including F1. Since F1 is the first factor, there are no preceding factors to cumulate. Therefore, the cumulative for F1 is the variability explained by F1, which is 61.059%. For the other factors, the cumulative is the sum of the variability explained by all preceding factors plus that of the factor in question. For example, the cumulative for F2 (77.110%) is the sum of the variability explained by F1 (61.059%) and F2 (16.050%). In summary, for the first factor, the variability explained is identical to the cumulative because there is no preceding variability to add.

Ecological study

Table 2 shows a species richness of 25 taxa, distributed across the next zoological groups: polychaete annelids, arthropods, molluscs, Plathelminthes, Sipuncula, echinoderms. A comparison of species richness reveals seasonal variations and differences between the sampling sites. Arthropods and molluscs show the greatest diversity across all sites.

Table 2: Overall fauna list.

Branch	Classes	Families	Taxa
Annelids	Polychaetes	Nereidae	*Perinereis cultrifera*
			Nereis falsa
			Platynereis dumerilii
			Terebella lapidaria
		Serpulidae	*Lumbrineris* sp
			Hydroides elegans
Sipuncula	Phascolosomatidea	Phascolosomatidae	*Phascolosoma granulatum*
Plathelminthes	Rhabditophora	Pseudocerotidae	*Pseudoceros maximus*
Arthropod	Crustaceans	Malacostraca	*Paracerceis sculpta*
			Sphaeroma serratum
			Ampeliscide sp
			Eriphia verrucosa
			Gammarus pulex
		Amphithoidae	*Cymadusa hirsuta*
		Gammaridae	*Elasmopus rapax*
Molluscs	Gastropods	Mytilidae	*Modiolus modiolus*
			Mitylus galloprovincialis
			Fissurella radiosa
		Fissurellidae	*Diadora graeca*
		Veneridae	*Venerupis rhomboides*
		Patellidae	*Patella vulgata*
	Bivalves	Arcidaé	*Arca noae*
		Ostreidae	*Ostrea edulis*
	Newts	Acanthochitonidae	*Acanthochitona crinita*
Echinoderms	Echinoides	Arbaciidae	*Arbacia lixula*

Table 3 displays the distribution of species richness by species and site. *P. cultrifera* is found at all the sites, with other species whose densities vary on the locations. Based on this table, the collected taxa can be ecologically classified as follows: very low abundance taxa, such as Sipuncula and Plathelminthes, and abundant taxa, including arthropods and molluscs.

Table 3: Species distribution according to Algerian coastal sites.

Species	Sites						
	El-Kala	Annaba	Skikda	Algiers	Boumerdes	Oran	Mostaganem
Perinereis cultrifera	+++	+	+	+	+++	+	+++
Nereis falsa	+	++	+	–	–	–	–
Platynereis dumerilii	+	+	–	–	–	–	–
Terebella lapidaria	+	+	–	–	–	–	+
Lumbrineris sp.	+	–	–	–	–	–	–
Hydroides elegans	++	–	–	–	–	–	–
Phascolosoma granulatum	+	+	+	+	+	+	+
Pseudoceros maximus	+	–	–	–	–	–	+
Paracerceis sculpta	+	+	–	–	–	–	-
Sphaeroma serratum	+	+	+	+	++	+	++
Ampeliscide sp.	+	+	+	–	+	+	+
Eriphia verrucosa	++	+	+	–	-	-	+
Gammarus pulex	+	+	+	–	+	+	+
Cymadusa hirsuta	+	–	–	–	–	–	–
Elasmopus rapax	+++	+	+	–	++	+	+++
Modiolus modiolus	+	+++	++	++	++	+	+
Mytilus galloprovincialis	+	++++	++	+	+	+	+
Fissurella radiosa	++++	+	+	-	++	-	+
Diodora graeca	++	+	+	+	+	+	+
Venerupis rhomboides	+	+	+	+	+	+	+
Patella vulgata	+	+	+	+	+	+	+
Arca noae	+++	–	–	–	+	–	++
Ostrea edulis	+	+	–	–	+	+	+
Acanthochitona crinita	+++	+	+	+	++	+	+
Arbacia lixula	+	+	+	+	–	+	–

El-Kala site is notable for the high presence of *Perinereis cultrifera* within the phylum of annelids, while *Elasmopus rapax* exhibits significant density among the arthropods of this site. Among the molluscs, *Fissurella radiosa* demonstates the greatest species richness. At the Annaba site, *Nereis falsa* is the most abundant annelid, and this site is distnguished by the richness of two species: *Modiolus modiolus* and *Mytilus galloprovincialis*.

In Skikda, Algiers, and Oran, species diversity and the presence of individuals are lower compared to the two previous sites.

The last site, Mostaganem, is characterised by the dominant presence of *Perinereis cultrifera, Elasmopus rapax*, and *Arca noae*.

At the Boumerdes site, *Perinereis cultrifera, Elasmopus rapax, Modiolus modiolus, Fissurella radiosa*, and *Acanthochitona crinita* are found in large numbers. This specific species composition is unique to Boumerdes. The last site, Mostaganem, is characterised by the dominant presence of *Perinereis cultrifera, Elasmopus rapax*, and *Arca noae*.

Figure 5 illustrates the species collected along the Algerian coast, representing: annelids, molluscs, arthropods, echinoderms, Plathelminthes, and Sipuncula. The population structures vary between sites. As shown in (Fig. 5), the percentages are significantly different, with molluscs dominating at El-Kala (49%), followed by arthropods (39%), and annelids (11%), with the remaining phyla contributing smaller proportions.

At Skikda, molluscs represent the highest percentage of the total population (74%), followed by annelids (19%) and arthropods with the lowest percentage (4%). At Boumerdes, the most abundant phyla are molluscs (51%), arthropods (42%), and annelids (6%).

At the Algiers site, molluscs and annelids dominate the population, representing 45% and 40% respectively, followed by arthropods with 6%.

On the west coast, the Mostaganem and Oran researched sites show distinct population distribution. At Mostaganem arthropods consitiute 49% of the total population, with molluscs at 42% and a low presence of annelids at 8%. In contrast, at the Oran site, arthropods are the dominant phylum at 71%, followed by annelids (11%) and molluscs (9%).

Each Algerian coastal site exhibits a unique distribution of species and phyla.

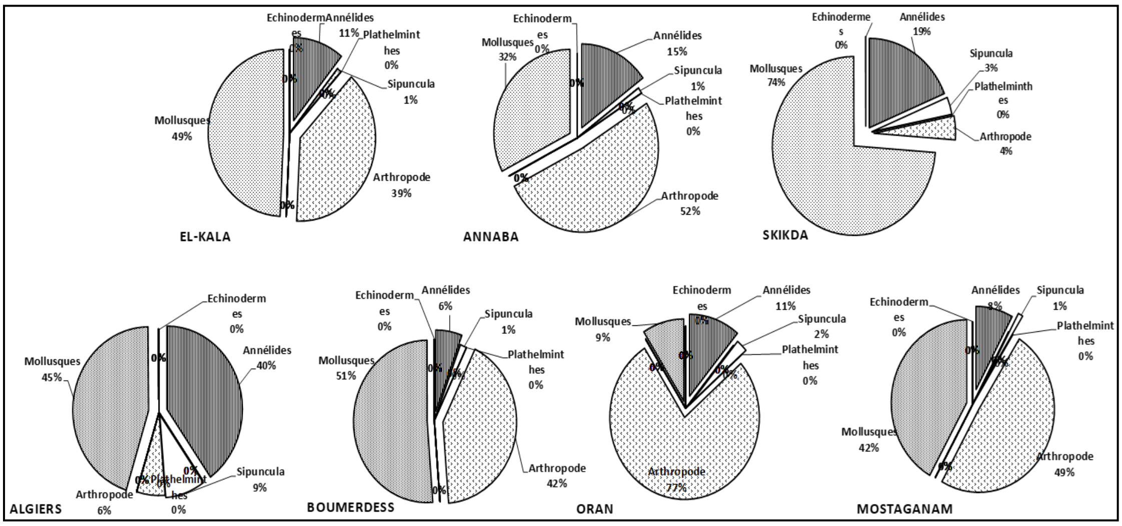

Figure 5: percentage of Algerian coastal species branches.

Abundance was highest at the El-Kala site, while the Algiers site had the lowest. El-Kala serves as the reference site, hosting 25 species, due to its geographical position and low pollution levels. In contrast, the Algiers site, with only 10 species, is located in an area with significant accumulation and high pollution.

Species diversity, as estimated by the Shannon and Weaver Index (H), ranged from 1.019 at the Oran site and 1.871 at the Annaba site. Equitability (E) varies from 0.26 at Oran to 0.43 at Annaba (Tab. 5). The Algiers site, sheltered by a natural dyke, promotes the sedimentation of organic matter, contributing to increased organic pollution.

Table 5: Abundance, richness, and specific diversity of species at Algerian coastal stations.

Sites								
	El-Kala	Annaba	Skikda	Algiers	Boumerdes	Oran	Maostagnam	Total
Abun-dance	25	20	16	10	16	14	17	–
S	4.64	4.321	4	3.321	4	3.807	4.087	–
Log2S	1.787	1.871	1.641	1.677	1.5	1.019	1.462	–
H	0.3851293	0.4330016	0.41025	0.5049684	0.375	0.2676648	0.357719599	–
E	25	20	16	10	16	14	17	–

The coenotic affinity illustrates the degree of faunal similarity between the different sites, as represented by a dendrogram (Fig. 6), which distinguishes three distinct groups of sites. The first group includes the Algiers, Skikda, and Oran sites, with an affinity of 90% between Skikda and Oran, explained by the common species present at both sites. The second group consists of the Boumerdes and Mostaganem sites, where the affinity reaches nearly 95%. The third group comprises the Annaba and El-Kala sites. These two sites do not form a group but are linked to the previous groups, with an affinity of 25% for Annaba, and less than 10% for El Kala.

The results shown in figure 7 reflect a Principal Component Analysis (PCA) involving seven variables (sites) and twenty-five modalities (number of species). The first two axes account for 61.06% and 16.05% of the information, respectively, totaling 77.11% of the total variability. The distribution of the points on the PCA plot allows the grouping of the sites into two groups, with two additional outliers, Annaba and El-Kala. The first group consists of the Boumerdes and Mostaganem sites, while the second group includes the Algiers, Oran, and Skikda sites.

These findings align with the results of the dendrogram (Fig. 5) and the PCA of the physico-chemical parameters (Fig. 3). Additionally, the physico-chemical parameters play a crucial role in shaping distribution, presence, and abundance.

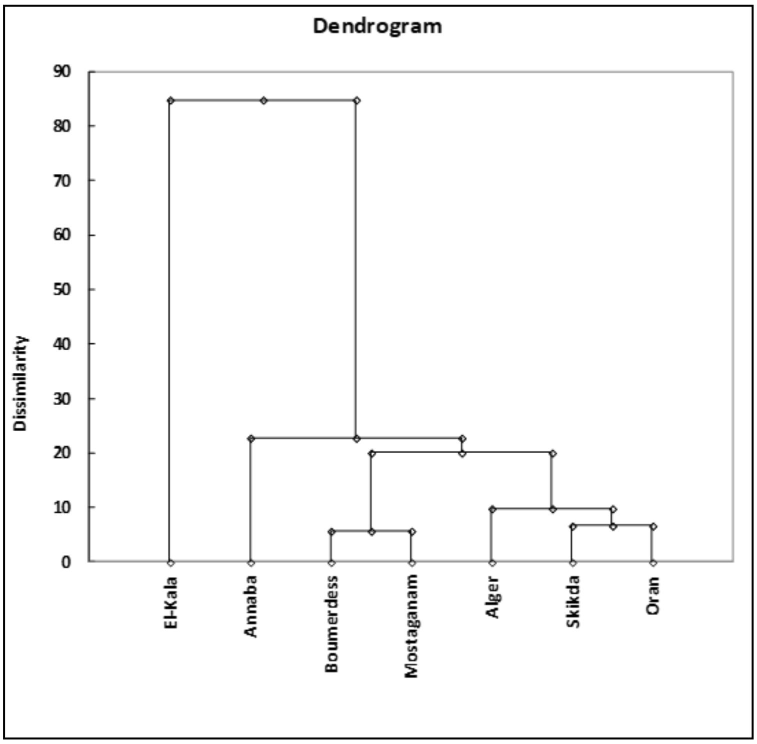

Figure 6: Inter-station dendrogram
of the Algerian coastline.

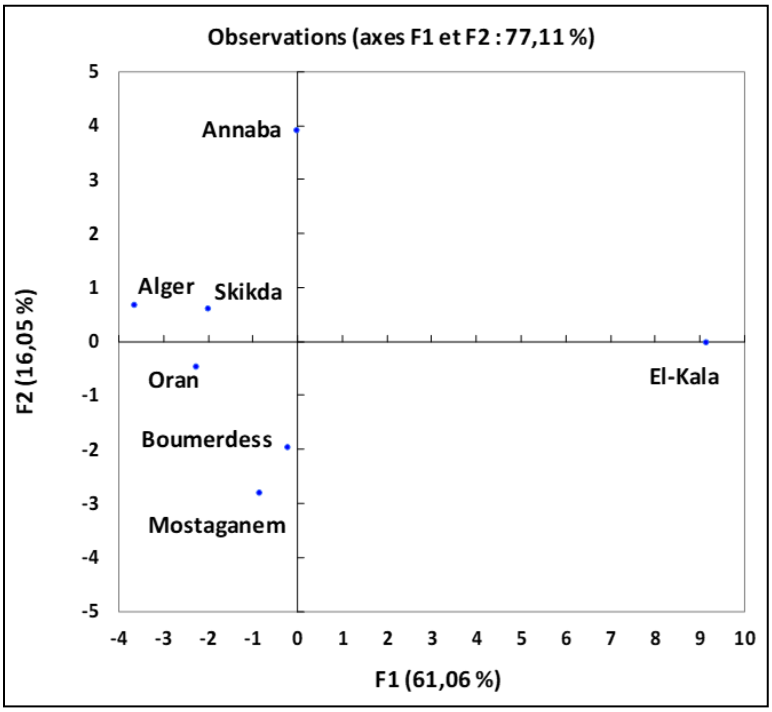

Figure 7: Principal Component Analysis (PCA).

Table 6: Participation rate of each factorial axis in the establishment of projection plans; Fn represents the PCA factorial axes.

	F1	F2	F3	F4	F5	F6
Eigen value	15.265	4.013	3.094	1.145	1.068	0.415
Variability (%)	61.059	16.050	12.376	4.582	4.272	1.660
Cumulative	61.059	77.110	89.486	94.068	98.340	100.000

The reason why the variability (%) of F1 is equal to the cumulative of F1 is due to the manner in which these values were calculated. Variability (%) of F1: The variability of F1 represents the proportion of the total variance in the data explained by the first factor (F1). In this case, F1 explains 61.059% of the total variance. Cumulative of F1: The cumulative for F1 is simply the sum of the variability explained by all factors up to and including F1. Since F1 is the first factor, there are no preceding factors to cumulate. Therefore, the cumulative for F1 is the variability explained by F1, which is 61.059%. For the other factors, the cumulative is the sum of the variability explained by all preceding factors plus that of the factor in question. For example, the cumulative for F2 (77.110%) is the sum of the variability explained by F1 (61.059%) and F2 (16.050%). In summary, for the first factor, the variability explained is identical to the cumulative because there is no preceding variability to add.

DISCUSSION

In this study, we report on the distribution of *Perinereis cultrifera* and examine the associated annelid fauna and biodiversity across seven coastal sites in Algeria. We classify the organisms by zoological group, detailing their taxonomic listing and spatial distribution. The findings indicate a cosmopolitan distribution of *Perinereis cultrifera*, which is directly linked to annual temperature variations and human activities. These results are consistent with the observations of Guemouda et al. (2014), who emphasized that habitat and pollution can significantly affect species distribution. Notably, the Annaba and Mostaganem sites show the highest densities, while Algiers exhibits the lowest. This distribution is influenced by several factors, primarily water temperature, as highlighted by Durou (2006).

Water temperature is directly linked to atmospheric temperature. The lowest temperatures were recorded in winter at the Skikda site, while the highest were observed in summer at the El-Kala site. The moderate temperatures recorded at the Stora site (Skikda) during the warm season can be attributed to marine currents that bring in masses of cold water (Bouras et al., 2007). The low pH values observed at the Annaba site can be attributed to discharges from the nearby industrial complex, which are rich in acid. In contrast, the pH trend at the other sites remains consistent with the typical values (Mehtougui et al., 2013). This finding has been corroborated by other researchers who have studied these regions (Dilem et al., 2014).

There was little variation in surface water salinity across different sites in the study area. According to the specific literature, salinity values are influenced by rainfall, industrial, and urban discharges (Remili and Kerfouf, 2013).

The Principal Component Analysis of the physico-chemical data from the seven studied sites revealeded obviously a strong correlation among the studied variables. The research results identified two principal groups of sites, with the first group consisting of five sites (Skikda, Boumerdes, Algiers, Mostaganem, and Oran) that share similar physio-chemical characteristics. The second identified group, consisting of Annaba and El Kala, displayed geographical proximity to the first found group. These findings highlight the significance of abiotic characteristics in distinguishing ecological sites, which may have important implications for species distribution and environmental specific management. These results a line with those reported by Zaabi et al. (2012, 2009). Remarkably, most of the species encountered are commonly found along all the Algerian coast. This research demonstrates the rich diversity of marine fauna along the studied Algerian coast. A total of 40,411 individuals were sampled, representing 25 species across various zoological groups. The results indicate considerable variations in diversity based on the studied sites and seasons, with certain species dominating at specific locations. The El-Kala site is characterized by its geographical position and low level of human induced pollution, as mentioned by Daas et al. (2011). Here, molluscs dominate the community, comprisisng 49% of the total, followed by arthropods at 39% and annelids at 11%. This site benefits from being naturally open with many marine currents and low annual human induced pollution (Guendouzi 2011). In contrast, the Annaba studied site is characterized by a higher presence of arthropods (52%) than molluscs (32%), with human induced pollution levels primarirly stemming from wastewater discharges from the local town and port (Guendouzi, 2011). Additionally, the population structure varies significantly among sites, resulting in significantly different percentages for the various phyla. In related research conducted among the north coast of Tunisia (Zaabi et al. 2012, 2009), a total of 88 species belonging to 29 families were recorded.

The Nereididae family accounted for only 4% of the total identified species, while Eunicidae represented 11%. In shallow water sectors, the dominant species are *Protodorvillea kefersteini* and *Malacoceros fuliginosus*, while in deep water sectors, *Aponuphis fauveli* and *Euclymene palermitana* are the most common. The main parameters influencing the distribution of benthic macrofauna along sandy coasts include physico-chemical factors, hydrodynamics, and food availability (Chaibi et al., 2018, Zaabi et al. 2009).

In summary, this research has improved our understanding of biodiversity and species distribution along the studied Algerian coast, highlighting the importance of conserving these specific ecosystems. The findings underscore the specific diversity of marine fauna in the region. The Shannon-Weaver index varies between sites, with the highest value recorded in Annaba and the lowest in Oran. Moreover, this study highlights the impact of pollution on species diversity, as evidenced by the difference between the El-Kala and Algiers sites. These results aline with those reported by Sif et al. (2012) and Rouhi et al. (2007).

CONCLUSIONS

In conclusion, the study demonstrates that abiotic factors play a significant role in shaping species distribution and abundance across various sites along the Algerian coast. The Principal Component Analysis (PCA) enabled us to identify two groups of sites, with Annaba and El-Kala notably distinct from the others. These results are consistent with those obtained in a presented dendrogram and the PCA of the physico-chemical parameters. Taking these abiotic parameters into account is essential for understanding the distribution of marine fauna along the Algerian coast, which may help in the implementation of effective conservation strategies.

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