Species composition and distribution of Medusae (Cnidaria: medusozoa) in the Algerian coast between 2°e and 7°e (SW Mediterranean Sea)

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Abstract

The species composition, abundance and distribution of the medusa community along the Algerian coast (between 2°E and 7°E) were investigated during the autumn of 2014. Zooplankton sampling was performed in the upper layer (0-100 m) at 14 stations. Fourteen species of hydromedusae and scyphomedusae were identified. The hydromedusae populations were represented by Leptomedusae (5 species), Narcomedusae (3 species), Trachymedusae (3 species) and Anthomedusae (2 species). Some species, such as Cirrholovenia tetranema and Cunina globosa, were new species records for the sampling areas. The total abundance of medusae was less than 10 individuals.m⁻³. The areas with the highest concentrations (> 4 ind.m⁻³) were located along the central coast between the Bou Ismail (2.6° E) and Algiers (3.2° E) Bays. Here, the populations of Aglaura hemistoma and Liriope tetraphylla were dominant (≈ 40%). A quantitative variability was recorded for three species, Liriope tetraphylla, Pelagia noctiluca and Rhopalonema velatum, of which the first two species were particularly abundant in the central region and the latter species was particularly abundant in the eastern region. The distributions of these species were analysed in relation to the environmental parameters (temperature, salinity and chlorophyll a) and their interaction with copepod prey.

Keywords: Medusae; Algerian coast; biodiversity; distribution.

Introduction

“Medusae” is a generic term referring to free-floating gelatinous carnivorous zooplankton belonging to the phylum Cnidaria. Medusae are the most well-known group of gelatinous zooplankton and include three classes: hydromedusae, which is the most diverse gelatinous group, and scyphomedusae and cubomedusae (Bouillon & Boero, 2000). The group is widely distributed in all of the world’s oceans and its members are recognized as efficient pelagic predators that can exert significant predation pressure on the other zooplanktonic groups (Purcell, 1997; Richardson et al., 2009). Highest abundances of medusae have a significant impact on the pelagic food web and on the structure and dynamics of pelagic communities, particularly on ichthyologic fauna (Purcell et al., 2007). During the past three decades, jellyfish populations have shown increases in diverse marine areas (Purcell, 2012; Condon et al., 2014), causing detrimental effects on fisheries, aquaculture and tourism (Purcell et al., 2007).

The spatiotemporal distribution of jellyfish can be explained by environmental and trophic factors. High phytoplanktonic densities can cause an increase in mesozooplankton, which can induce an increase in medusa fauna (Mills, 2001). However, climate change, pollution, over-fishing and habitat modifications may lead to changes in population production (Purcell et al., 2007; Richardson et al., 2009; Purcell, 2012).

In the Mediterranean Sea, jellyfish have been most closely studied in the northwestern basin (Goy, 1997; Buecher & Gibbons, 1999; Sabatés et al., 2010; Goy et al., 2016) and the eastern basin (Batistic et al., 2007; Lučić et al., 2009; Pestorić et al., 2012). In the southwestern Mediterranean Sea, there have been few studies and investigations. Some investigations have been performed along the Tunisian coast (Daly Yahia et al., 2003; Touzri et al., 2010, 2012). These studies have mainly described the biodiversity and quantitative distribution of jellyfish in relation to the seasonal variation associated with hydrological parameters.

Along the Algerian coast, the majority of zooplankton studies have focused on mesozooplankton groups
(Seridji & Hafferssas, 2000, Hafferssas & Seridji, 2010, Ounissi et al., 2016; Chaouadi & Hafferssas, 2018), and a fewer observations of diversities and abundances have been reported for gelatinous plankton (Khames & Hafferssas, 2018, 2019).

The aim of this study was to provide complementary information about gelatinous zooplankton on the Algerian coast by describing the main patterns of medusan biodiversity and their quantitative distributions in relation to environmental parameters.

Material and Methods

Sampling areas

The oceanographic cruise was carried out during September 2014 on board the oceanographic vessel Grine Belkacem of the National Center of the Research and Fisheries and Aquaculture Development (CNRDPA). This study was conducted between 2°E and 7°E; the study area included 14 stations, with 7 in central areas and 7 in eastern areas (Fig. 1 and Table 1).

Environmental parameters measurement and zooplankton collection

Zooplankton samples were collected with vertical hauls during the day between depths of 0 and 100 m using a Working Party II net (200 µm mesh size).

The zooplankton samples were fixed by adding formaldehyde to reach a final concentration of 4%. Species identifications were performed under a stereomicroscope (Zeiss Stemi SV 6/ Germany) and completed according to appropriate taxonomic references (e.g., Tregouboff & Rose, 1957; Bouillon, 1999; Bouillon et al., 2006). The medusan abundances were calculated as the number of individuals per cubic metre of filtered sea water. For the scyphomedusae Pelagia noctiluca, only ephyrae were counted. The larger individuals that were occasionally collected were not included in the abundance data because the net used in this study was inappropriate for large medusa (Sabatés et al., 2010). The biogeographical affinity was defined for each collected species (Boero & Bouillon, 1993). The species were classified according to their occurrence frequency (Fr), which was the ratio between the number of samples that contained an individual of species i and the total number of samples. Three groups were formed: frequent (Fr > 50%), common (25% < Fr < 50%) and rare species (Fr < 25%) (Dajoz, 2006).

Biological sampling was followed by temperature (T) and salinity (S) measurements with a multiparameter (HI 9828-12202/ Romania) and chlorophyll a (Chl a) measurement using the spectrophotometric method.

Data analysis

To compare the differences in medusan abundance between the two regions (central and eastern), a non-parametric Mann – Whitney test (z) was used (Pestorić et al., 2012). This test was also used to compare the variability of environmental parameters.

To identify the species that contributed most to the total abundance, correspondence analysis (CA) was performed. The populations that showed occurrence frequencies above 25% were used in the analysis (Hafferssas & Seridji, 2010).

The spatial segregation between the species compositions was analysed as follows: the $D$ index $= 1/2 \sum |(N_{1i}/N_{1})-(N_{2i}/N_{2})|$ (Fenaux, 1963, Flores-Coto et al., 2016), where $N_{1i}$ and $N_{2i}$ represent the number of individuals of species 1 and species 2, respectively, at station $i$ and $N_{1}$ and $N_{2}$ are the total numbers of individuals of species 1 and species 2, respectively.

Spearman’s rank correlation coefficient ($\rho$) was used to analyse the relationships among total medusan abundance, copepod abundance and environmental variables. However, to describe the relationships between the latter factors and the medusa species, principal component analysis (PCA) was used. All data were log ($x+1$) transformed to avoid strong influences from the most abundant populations and to test for a normal distribution (Hafferssas & Seridji, 2010). All analyses were performed with the STATISTICA 10 software.
Results

Environmental data

The sea surface temperature ranged between 24.50°C (Station AB) and 26.50°C (EBJ, BBS1, BBS2, BC1, BC2 and GS). Indeed, from station AB, an increasing gradient was observed from the central region to the eastern region (Table 1 and Fig. 2a). A significant difference ($\chi = -3.12$, $p = 0.002$) was found between these two regions.

The sea surface salinity fluctuated between 36.40 (stations ET and EBJ) and 37.50 (BBS3) (Table 1 and Fig. 2b). The chlorophyll $a$ concentrations ranged between 0.021 mg.m$^{-3}$ and 0.265 mg.m$^{-3}$ (Table 1 and Fig. 2c). Chlorophyll $a$ concentrations greater than 0.10 mg.m$^{-3}$ were generally observed in the central region in the Bay of Bou Ismail (BB1), Bay of Algiers (BA1, BA2) and Tizi Ouzou coast (ET, EA). In the eastern region (EBJ, BBS1, BBS2, BBS3, BC1, BC2 and GS), the Chl $a$ concentrations were low (less than 0.05 mg.m$^{-3}$). Overall, the Chl $a$ values were significantly different ($\chi = 2.17$, $p = 0.03$) between the two regions.

Biodiversity composition

A total of 14 species of medusa were identified during the cruise (Table 2). These species were distributed in two classes (hydromedusae and scyphomedusae) and five orders (Anthomedusae, Leptomedusae, Narcomedusae, Trachymedusae and Semaeostomeae).

Among the hydromedusae group, the Leptomedusae order was composed of $C$. hemisphaerica, $Clytia$ spp., $Obelia$ spp., $C$. tetranema and $E$. paradoxica. These populations were widely distributed in the central region of the Algerian coast. Anthomedusae were characterized by low diversity, with only two species ($L$. blondina and $P$. minima) reported. Narcomedusae and Trachymedusae were each represented by 3 species: $S$. bitentaculata, $C$. globosa and $Solmaris$ sp. and $R$. velatum. $A$. hemistoma

Table 1. Locations and hydrological characteristics of the sampling stations along the Algerian coast.

| Stations                          | Longitude ($^\circ$E) | Latitude ($^\circ$N) | Date       | T ($^\circ$C) | S | Chl $a$ (mg.m$^{-3}$) |
|----------------------------------|----------------------|----------------------|------------|--------------|---|-----------------------|
| Central coast of Bou Ismail Bay  | 2.610                | 36.665               | 26/09/2014 | 26.00        | 36.70 | 0.210                 |
| Eastern coast of Bou Ismail Bay  | 2.807                | 36.818               | 26/09/2014 | 25.30        | 37.10 | 0.116                 |
| Ain Benian offshore coasts       | 2.950                | 36.868               | 25/09/2014 | 24.50        | 37.5  | 0.021                 |
| Western coast of Algiers Bay     | 3.084                | 36.857               | 25/09/2014 | 25.20        | 37.0  | 0.244                 |
| Eastern coast of Algiers Bay     | 3.201                | 36.840               | 25/09/2014 | 25.10        | 36.9  | 0.265                 |
| Eastern coast of Tizi Zerz (ET)  | 4.286                | 36.948               | 23/09/2014 | 25.4         | 36.4  | 0.137                 |
| Eastern coast of Arzef (EA)      | 4.500                | 36.935               | 23/09/2014 | 25.4         | 37.0  | 0.146                 |
| Eastern coast of Jijel Bay (EBJ) | 6.218                | 37.021               | 21/09/2014 | 26.4         | 36.4  | 0.037                 |
| Western coast of Beni Said Bay   | 6.341                | 37.094               | 21/09/2014 | 26.4         | 37.4  | 0.035                 |
| Western coast of Beni Said Bay   | 6.453                | 37.106               | 21/09/2014 | 26.4         | 37.4  | 0.033                 |
| Offshore coast of Beni Said Bay  | 6.574                | 37.051               | 21/09/2014 | 26.4         | 37.5  | 0.031                 |
| Offshore coast of Collo Bay (BC1)| 6.647                | 36.995               | 21/09/2014 | 26.5         | 37.4  | 0.029                 |
| Offshore coast of Collo Bay (BC2)| 6.750                | 36.988               | 21/09/2014 | 26.5         | 37.5  | 0.027                 |
| Gulf of Stora (GS)               | 6.877                | 36.992               | 21/09/2014 | 26.5         | 37.4  | 0.025                 |

Fig. 2: Fluctuation of the environmental parameters at the sampling stations along the Algerian coast (a: temperature; b: salinity; c: chlorophyll $a$).
and L. tetraphylla, respectively. Scyphomedusae were only represented by the species P. noctiluca in the order Semaeostomeae in the two regions (Table 2).

More species (R. velatum, A. hemistoma, L. tetraphylla, S. bitentaculata, Solmaris sp., C. hemisphaerium, Clytia spp., Obelia spp. C. tetranema, E. paradoxica, L. blondina, P. minima and P. noctiluca) were found in the central region. In the eastern region, 8 species (S. bitentaculata, C. globosa, Solmaris sp., R. velatum, A. hemistoma, L. tetraphylla, Clytia spp. and P. noctiluca) were sampled (Table 2).

The most frequent species (Fr > 50%) were A. hemistoma, R. velatum, S. bitentaculata and L. tetraphylla. The populations of Clytia spp., P. noctiluca, E. paradoxica, Obelia spp. and P. hemisphaerium were common, with occurrences of less than 50%. On the other hand, six species were considered rare (F < 25%). Generally, these populations were found in the central region (EA, BA1, BA2, BB2 and BB1).

Fauna were classified as having several biogeographical origins: (i) cosmopolitan species (P. hemisphaerium), which were widely distributed throughout world ocean; (ii) circumtropical species (A. hemistoma, R. velatum, S. bitentaculata, L. tetraphylla and C. globosa); (iii) Mediterranean-Atlantic species (P. minima); (iv) Indo-Pacific species (C. tetranema); and (v) boreal species (L. blondina).

Table 2. Biodiversity of the medusae populations along the Algerian coast (2° E and 7° E) in relation to their frequencies of occurrence (F = frequent, C = common, R = rare) and biogeographical affinities.

| Species                  | Biogeographical Affinity | Occurrence frequencies (%) |
|--------------------------|--------------------------|-----------------------------|
| Anthomedusae             |                          |                             |
| Lizzia blondina          | Boreal[1]                | +                           |
| Podocorynoides minima    | Mediterranean Atlantic[2] | +                           |
| Leptomedusae             |                          |                             |
| Clytia hemisphaerica     | Cosmopolitan[1][2]       | +                           |
| Clytia spp.              | -                        | +                           |
| Obelia spp.              | -                        | +                           |
| Cirrholovenia tetranema  | Indo-Pacific[1]          | +                           |
| Eucheilota paradoxica    | ?                        | +                           |
| Tachymedusae             |                          |                             |
| Rhopalonema velatum      | Circumtropical[1][3]     | +                           |
| Aglaura hemistoma        | Circumtropical[1][3]     | +                           |
| Liriope tetraphylla      | Circumtropical[1][3]     | +                           |
| Narcomedusae             |                          |                             |
| Solmundella bitentaculata| Circumtropical[1][3]     | +                           |
| Solmaris sp.             | +                        | +                           |
| Canina globosa           | Circumtropical[1]        | +                           |
| Semaeostomeae            |                          |                             |
| Pelagia noctiluca        | Cosmopolitan[2]          | +                           |
| Total number of species  |                          | 7                           |

[1] Boero & Bouillon, 1993; [2] Purcell, 2005; [3] Pestorić et al., 2010.
With the use of Spearman correlation, a strong relationship was found between the abundances of medusa and copepods ($\rho = 0.56$, $p < 0.05$).

Species composition

Based on the multivariate analysis (correspondence analysis) results, different species were selected as the predominant species (Fig. 4). Correspondence analysis allowed comparison and separation of the faunal groups in relation to their geographical distributions. The contribution to the total inertia of the first and second axis was 72.30% (Fig. 4). CA revealed two groups of variables.

The negative part of the first axis (44.91% of total inertia) was linked to $L. \text{tetraphylla}$ (relative contribution of 46.32%). The populations of $R. \text{velatum}$ (relative contribution of 20.60%) and $P. \text{noctiluca}$ (relative contribution of 9.10%) were found in the positive part. This axis represented a gradient of dominance in these populations. In fact, we found that the stations in the central region, BA1 (34.78%), BB1 (6.91%) and EA (2.79%), had high numbers of $L. \text{tetraphylla}$ (negative side of axis 1). The stations in the eastern region, BBS 3 (17.64%), BC2 (14.99%), GS (7.53%) and EBJ (6.95%), showed high abundances of $R. \text{velatum}$ and $P. \text{noctiluca}$ (positive side of the axis).

The second axis (27.39% of total inertia) showed the opposite trend for the populations belonging to the same geographical area (eastern coasts). The second axis separated $R. \text{velatum}$ (negative side of axis 2) from $P. \text{noctiluca}$ (positive side).

All these populations, which were identified by correspondence analysis, were considered main species as a result of their abundances and their frequencies.

In fact, Trachymedusae ($A. \text{hemistoma}$, $L. \text{tetraphylla}$ and $R. \text{velatum}$) and the Semaestomeae ($P. \text{noctiluca}$) were the most common groups, making up more than 70% of the total abundance at all stations. Leptomedusae were essentially represented by $E. \text{paradoxa}$ (0.02 ind.m$^{-3}$ - 0.54 ind.m$^{-3}$) and $Obelia$ spp. (0.02 ind.m$^{-3}$ - 0.28 ind.m$^{-3}$) in the central coast. In the eastern region, this group was rare and only included $Clytia$ spp. (0.02 ind.m$^{-3}$ - 0.08 ind.m$^{-3}$). Narcomedusae were less abundant and were essentially represented by $S. \text{bitentaculata}$ (0.02 ind.m$^{-3}$ - 0.18 ind.m$^{-3}$). However, the lowest abundances were found for the order Anthomedusae (0.02 ind.m$^{-3}$).

Distribution of the main species

$A. \text{hemistoma}$ was considered a cosmopolitan form and was widely distributed. In the present study, $A. \text{hemistoma}$ was the most abundant medusa found at all stations (Fig. 5a), which justified its position in the factorial plan (Fig. 4). The values of $A. \text{hemistoma}$ fluctuated between 0.26 ind.m$^{-3}$ (BBS3) and 3.68 ind.m$^{-3}$ (BC2).

$L. \text{tetraphylla}$ was the second most abundant species (Fig. 5b). $L. \text{tetraphylla}$ showed a variable distribution in both regions and tended to be most numerous (10% to 89% of total) in the central region, with a maximum abundance of 6.28 ind.m$^{-3}$ (BA2). However, in the eastern region, the contribution of this population was less than 2%, with a significantly lower maximum abundance of 0.02 ind.m$^{-3}$ (BBS1 and GS).

$R. \text{velatum}$ appeared at the majority of stations. The concentrations of $R. \text{velatum}$ varied from 0.02 ind.m$^{-3}$ to 0.44 ind.m$^{-3}$ (Fig. 5c).

In this study, the most common Semaestomeae species ($P. \text{noctiluca}$) in the Mediterranean was the only scyphomedusae inventoried in the central region (BB2, ET) and in the eastern region (BBS1, BC1, BC2 and GS). The abundances of $P. \text{noctiluca}$ fluctuated between 0.04 ind.m$^{-3}$ (BB2) and 0.48 ind.m$^{-3}$ (GS) (Fig. 5d).

To confirm the spatial pattern association among the dominant species, the segregation index (D) seemed to indicate a high separation between the main populations (Table 3):

$L. \text{tetraphylla}$ (central coast) and $P. \text{noctiluca}$ (eastern
coast), with $D = 0.92$; 
$L. tetraphylla$ (central coast) and $R. velatum$ (eastern coast), with $D = 0.86$ 
$R. velatum$ (eastern coast) and $P. noctiluca$ (eastern coast), with $D = 0.76$.

**Relationship between the species and environment factors**

To identify the relationships between the medusae and environmental parameters, principal component analysis was used (Fig. 6). This analysis revealed the following three groups of variables:

Group 1 was composed of $P. noctiluca$ and $R. velatum$, and they seemed to be associated with high temperature and high salinity.

Group 2 was composed of $A. hemistoma$, $S. bitentaculata$, $Clytia$ spp. and $P. hemisphaericum$, and they seemed to be negatively correlated with temperature and salinity.

Group 3 was composed of the characteristic species of the central region, $L. tetraphylla$ and the $E. paradoxica$ and $Obelia$ spp., and the distribution of these species was positively correlated with the chlorophyll a concentrations and mesozooplankton prey abundance (copepods) (Fig. 6).

**Table 3.** Segregation values ($D$ index) recorded between pairs of dominant species along the Algerian coast.

| Species                  | Segregation Index |
|--------------------------|-------------------|
| $P. noctiluca$ - $L. tetraphylla$ | 0,92              |
| $R. velatum$ - $L. tetraphylla$       | 0,86              |
| $R. velatum$ - $P. noctiluca$         | 0,76              |
| $A. hemistoma$ - $P. noctiluca$       | 0,55              |
| $A. hemistoma$ - $R. velatum$         | 0,50              |

**Fig. 6:** Principal component analysis (PCA) showing the relationships between the medusae species and the environmental variables.
Discussion

Biodiversity composition

Altogether, 14 species were sampled and identified that belonged to hydromedusae (13 species) and scyphomedusae (one species was P. noctiluca). The recorded species have previously been found in the Mediterranean Sea (Table 4). However, in the present study, in comparison with other investigations (Dallot et al., 1988; Daly Yahia et al., 2003; Touzri et al., 2010, 2012), two species (Cirrholovenia tetranema and Cunina globosa) were recorded for the first time in the southwestern Mediterranean Sea.

Comparisons with the other studies from the adjacent areas of the Mediterranean were very delicate due to the different efforts and sampling periods. However, in the southwestern Mediterranean Sea (Alboran Sea), 27 species (Dallot et al., 1988) and 18 species (Mills et al., 1996) were counted. Along the Algerian coast, a lower biodiversity (6 species) was found in Algiers Bay (Seguin, 1973) and Annaba Bay (Ounissi et al., 2016). Along the Tunisian coast, the biodiversity was composed of more than 20 species (Daly Yahia et al., 2003; Touzri et al., 2010). In the northern region (Ligurian Sea), more than 30 species were identified within the community (Berhaut, 1969; Goy, 1972; Buecher & Gibbons, 1999; Goy et al., 2016). In the eastern Mediterranean Sea, more than 25 species were inventoried in the Adriatic Sea (Benović et al., 2004; Lučić et al., 2009) and 71 species were identified along the Lebanese coast (Goy et al., 1991).

Medusa were mainly represented by holoplanktonic species. Certain species, such as A. hemistoma and R. velatum, were frequent and others were common (S. bitentaculata, L. tetrphylla and P. noctiluca). This trend was also reported for the same populations in the western Mediterranean Sea (Buecher et al., 1997; Daly Yahia et al., 2003; Colin et al., 2005; Benović et al., 2004; Touzri et al., 2010). On the other hand, except the populations of Clytia spp., E. paradoxica, and Obelia spp., meroplanktonic medusae, such as C. tetranema, C. globosa, L. blondina, and P. minima, were rarely sampled.

The most important forms identified in the present study were circumtropical species (A. hemistoma, R. velatum, S. bitentaculata, L. tetrphylla and C. globosa). In the Mediterranean Sea, medusa communities are strongly represented by species of this biogeographical origin (Boero & Bouillon, 1993) and are frequently dominated by a small number of highly adaptable species (Gili et al., 1988).

Dominant populations and their variability

The total medusa abundances were less than 10 individuals.m⁻³. Multivariate analysis showed two different clusters: the central area (Bou Ismail and Algiers Bays; Tizi Ouzou coast), with up to 2 individuals.m⁻³, and the eastern area (Jijel coast; Beni Said and Collo Bays), which was characterized by low abundances (less than 2 ind.m⁻³). This quantitative difference was related to the higher contributing holoplanktonic species (A. hemistoma, R. velatum, L. tetrphylla, P. noctiluca). A similar result was reported in the other Mediterranean regions, including in Marseille (Berhaut, 1969), the Ligurian Sea (Goy, 1972), the Catalan Sea (Gili et al., 1987), the Adriatic Sea (Benović & Bender, 1987; Lučić et al., 2009) and the Tunisian coast (Touzri et al., 2010).

The narrowness of the continental shelf could explain the dominance of these populations along the central part.
of the Algerian coast. Holoplanktonic species are known to be most abundant in open waters (Trachymedusae and Narcomedusae). The same pattern has been reported in the South Adriatic (Pestorić et al., 2012), the southern Benguela waters (Pagès & Gili, 1992) and the shelf area off the Mexican coasts (Seguar-puerta et al., 2010).

Within the epipelagic layer (0-50 m), except during spring, Trachymedusae populations were the most represented (more than 50%). Holoplanktonic forms (Trachymedusae and Narcomedusae) appeared dominant during the oligotrophic period of the year. However, meroplanktonic species (Anthomedusae and Leptomedusae) were dominant during spring. The life cycles of meroplanktonic species are dependent on benthic food sources (Goy, 1997; Goy et al., 2016).

The typical open-water species A. hemistoma (Touzri et al., 2010) was the most abundant and widely distributed species in the two studied areas. Among hydromedusae, this species is the most abundant and is present year-round (Bouillon et al., 2004; Sabatès et al., 2010). Unlike most other medusae, A. hemistoma occupies a large trophic niche as an omnivore that feeds on microphytoplankton and protists (Colin et al., 2005).

In contrast to the previous species, the population of L. tetraphylla, which is an oceanic and epipelagic species (Kramp, 1961), was mainly found in the central region, where it occurred in the highest numbers (0.74 ind.m-3 to 6.28 ind.m-3). L. tetraphylla represented up to 89% of the total abundance in the central region. In the eastern region, the contribution of this population was less than 2%. In the Mediterranean Sea, this medusa is among the most common epipelagic species and shows large interannual variations in both abundance and seasonality in relation to hydroclimatic conditions (Buecher et al., 1997).

Furthermore, populations of warm-water oceanic species, such as R. velatum and P. noctiluca, (Russell, 1953; Goy et al., 1989a), were common in the eastern region and represented up to 20% of the medusan abundance. The mauve stinger P. noctiluca is the most well-known medusae in the Mediterranean Sea. P. noctiluca has been reported to be the most abundant gelatinous predator characterized by decadal blooming periods (Morand et al., 1992; Buecher et al., 1997). The segregation index D among L. tetraphylla - P. noctiluca (0.32) and among L. tetraphylla - R. velatum (0.85) reflected the trend in their geographical distributions between the central and eastern regions. This species separation, which was especially recorded for more abundant and frequent species, is not specific to these pairs. This trend has also been observed between other medusa species, such as L. tetraphylla - Nausithoe punctata and A. hemistoma - Nausithoe punctata (Flores-Coto et al., 2016).

In the Ligurian Sea, this phenomenon was documented for P. noctiluca in particular (Goy et al., 1989b). The pullulation of this scyphomedusa is more pronounced in summer and autumn and is accompanied by low Geryonia proboscidalis (Trachymedusae) and Hippododius hippocus (Siphonophore) populations.

**Relationships with hydrological parameters and food availability**

Multivariate analysis indicated that temperature, salinity, chlorophyll a and copepod abundance were affected by the quantitative distributions (Fig. 6). Many investigations have found relationships between biological and hydrological parameters (Benović & Bender, 1987; Buecher et al., 1997; Daly Yahia et al., 2003; Purcell et al., 2007).

The quantitative distributions of the medusae were positively correlated with the copepod community (Spearman rho $p = 0.56$). This result has been previously found in the Mediterranean (Gili et al., 1988; Batistic et al., 2004; Benović et al., 2004). This mesozooplanktonic group has been recognized as important prey for medusan fauna (Colin et al., 2005). In the central region (2.61° to 4.50° E), the greatest abundances of medusae (up to 2 individuals.m-3) were linked to the highest levels of mesozooplankton (up to 50 individuals.m-3). The lowest values (less than 2 individuals.m-3) reported in the eastern region (6.61° to 6.65° E) were associated with the lowest levels of mesozooplankton (< 50 individuals.m-3). These results explain the statistical differences between the two sampling regions ($p = 0.029$).

The greatest abundances of the most common species, such as L. tetraphylla, were linked to the chlorophyll a concentrations and copepods abundance. These populations are known to be associated with enriched waters with enhanced zooplanktonic production (Buecher et al., 1997). Other populations (Obelia spp.) were associated with the chlorophyll a concentrations. This genus omnivorously feeds on planktonic and bacterial prey (Boero et al., 2008). This relationship could explain the predominance of these populations in the central region, where the highest chlorophyll a concentrations, probably due to anthropogenic eutrophication, were recorded.

In addition, the low abundance (< 10 ind.m-3) of medusae was a response to a decrease in the abundance of mesozooplanktonic prey (< 50 ind.m-3). This decrease was linked to the low chlorophyll a values (Mills, 2001). In the Algerian basin, except in the inshore cyclonic eddy and frontal area (1°E – 4°E), the concentration of chlorophyll a (< 1 mg.m-3) was representative of an oligotrophic ecosystem (Taupier-Letage et al., 1988; Raimbault et al., 1993).

The abundance of P. noctiluca was associated with warm water (> 26°C). The same results were reported in the northern Mediterranean Sea (Goy et al., 1989a). The evolution of their biological cycle from eggs to the adult stages was faster as the temperature increased (Morand et al., 1992). This parameter was most important because it controlled the temporal and spatial distributions of the populations (Buecher et al., 1997; Purcell et al., 2007).

On the other hand, concerning the segregation observed between the populations of L. tetraphylla and P. noctiluca that was previously reported in the Mediterranean Sea (Buecher et al., 1997), food availability, either through competitors or predators, could explain the distributions of these species (Legovic, 1987; Buecher et al., 1997). L.
tetraphylla and P. noctiluca, at the same size, they have similar trophic regimes. Nevertheless, during different biological activities (reproduction or growth), the trophic behaviours of the two jellyfish populations are different. L. tetraphylla mostly feeds on copepods, but P. noctiluca can catch a large prey, including medusae (e.g., L. tetraphylla) and meso–macrozooplankton (Buecher et al., 1997).

The present study provides the first report on the composition and quantitative repartition of the medusa community along the Algerian coast. The biodiversity of this fauna in the autumn of 2014 included fourteen species. The results obtained in this study indicate that the distribution pattern of this gelatinous group can be linked to environmental conditions. The dominant and most common species were abundant due to their life cycle characteristics, environmental conditions and food availability.

This knowledge should be considered as complementary to anterior zooplankton studies along the Algerian coast and the southwestern Mediterranean Sea. However, the accumulation of sampling series across different regions and seasons remains necessary to better understand the distribution pattern in relation to environmental and climatological factors and to allow the understanding of the role and the impact of these zooplankton on the pelagic ecosystem.

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