Acta Adriatica 65 (2024): 33-49
https://doi.org/10.32582/aa.65.1.5
ORIGINAL ARTICLE

www.izor.hr

Distribution and species composition of planktonic cnidarians in the Algerian coastal waters (SW Mediterranean Sea)

Aldjia Kherchouche-Ait Ouadour[1*], Yacine G. E. Khames[1] and Aziz Hafferssas[1]

[1] *University of Sciences and Technology Houari Boumediene, Faculty of Biological Sciences, Laboratory of Biological Oceanography and the Marine Environment, Algiers, Algeria*

Abstract: This study presents an inventory of planktonic cnidarian species collected in Algerian coastal waters (1°10'00" W - 6°52'37" E and 35°37'42" N - 37°01'16" N) from May 2012 to February 2017. The aim was to analyse the qualitative distribution and identify the main components of this gelatinous fauna in different coastal ecosystems in western, central and eastern regions. A total of 60 taxa of planktonic cnidarians were identified, including 57 hydrozoans and three scyphozoans. The class Hydrozoa were represented by 34 hydromedusae, primarily belonging to orders Anthoathecata (15 taxa) and Siphonophorae (23 taxa). Several reported hydrozoan species were recorded for the first time in the southwestern Mediterranean Sea. These new regional records include the hydromedusae *Kantiella enigmatica, Leuckartiara octona, Proboscidactyla ornata, Cunina globosa, Lovenella cirrata, Cirrholovenia tetranema, Phialella quadrata*, *Homoeonema platygonon* and the siphonophore *Forskalia contorta*. Seasonal fluctuations were observed in biodiversity, with the highest species richness in spring and summer. The most common species are the calycophorous siphonophores *Abylopsis tetragona, Muggiaea atlantica, Lensia subtilis Muggiaea kochii* and the holoplanktonic medusae *Aglaura hemistoma, Rhopalonema velatum, Solmundella bitentaculata, Liriope tetraphylla* and *Pelagia noctiluca*. The species' occurrence frequency exhibited seasonal and spatial variability. These distribution patterns were primarily determined by meroplanktonic hydrozoans (Anthoathecata and Leptothecata).
Keywords: Algerian coast; Hydromedusae; Siphonophorae; Scyphomedusae; biodiversity; spatial distribution; seasonal variability

Sažetak: RASPROSTRANJENOST I SASTAV VRSTA PLANKTONSKIH ŽARNJAKA U OBALNIM VODAMA ALŽIRA (JZ SREDOZEMNO MORE). Ova studija donosi popis planktonskih žarnjaka prikupljenih u alžirskim obalnim vodama (1°10'00" W - 6°52'37" E i 35°37'42" N - 37°01'16"N) u razdoblju od svibnja 2012. do veljače 2017. godine. Cilj je ovog istraživanja analizirati raspodjelu te utvrditi glavne komponente želatinozne faune u obalnim ekosustavima zapadne, središnje i istočne regije. Tijekom istraživanja određeno je ukupno 60 svojti planktonskih žarnjaka, uključujući 57 obrubnjaka (Hydrozoa) i tri režnjaka (Scyphozoa). Razred obrubnjaka bio je zastupljen s 34 hidromeduze, prvenstveno iz redova Anthoathecata (15 taksona) i Siphonophorae (23 taksona). Nekoliko zabilježenih vrsta obrubnjaka prvi je put nađeno u jugozapadnom Sredozemnom moru. Ovi novi regionalni nalazi uključuju hidromeduze *Kantiella enigmatica*, *Leuckartiara octona*, *Proboscidactyla ornata*, *Cunina globosa*, *Lovenella cirrata*, *Cirrholovenia tetranema*, *Phialella quadrata*, *Homoeonema platygonon* i sifonoforu *Forskalia contorta*. Bioraznolikost oscilira na sezonskoj skali, s najvećim bogatstvom vrsta u proljeće i ljeto. Najčešće zabilježene vrste su kalikoforne sifonofore *Abylopsis tetragona*, *Muggiaea atlantica*, *Lensia subtilis*, *Muggiaea kochii* te holoplanktonske meduze *Aglaura hemistoma*, *Rhopalonema velatum*, *Solmundella bitentaculata*, *Liriope tetraphylla* i *Pelagia noctiluca*. Učestalost pojavljivanja vrsta varira na sezonskoj i prostornoj skali, a obrasci rasprostranjenosti prvenstveno su određeni varijabilnošću meroplanktonskih obrubnjaka iz redova Anthoathecata i Leptothecata.
Ključne riječi: alžirska obala; Hydromedusae; Siphonophorae; Scyphomedusae; bioraznolikost; prostorna raspodjela; sezonska varijabilnost

INTRODUCTION

The Mediterranean Sea is one of the world's most biodiverse marine ecosystems, with over 16000 documented species (Coll *et al.*, 2010). Despite the Mediterranean Sea accounting for less than 0.8% of the world's ocean surface area, this biodiversity accounts for approximately 5% of all known marine species (Templado, 2014). Furthermore, one-quarter of the species are endemic to this marine basin (Lejeusne *et al.*, 2010). The Mediterranean Sea has been designated a hotspot for marine biodiversity (Coll *et al.*, 2010). Overall, there is significant heterogeneity in the distribution of species richness in the Mediterranean Sea (Gueroun *et al.*, 2022). The uneven distribution of research efforts could explain this. Most studies in the Mediterranean have been conducted on the basin's northern shore, as opposed to the southern shore, which has received less attention.

**Corresponding author:* aldjia.kherchouche_fsb@usthb.edu.dz
Received: 11 September 2023, accepted: 29 February 2024
ISSN: 0001-5113, eISSN: 1846-0453

The Algerian coast is strategically located in the southwestern Mediterranean Sea. It forms a wide coastal strip spanning 2148 km from east to west and represents a particularly dynamic ecosystem influenced by Atlantic waters. As these waters move eastwards, their oceanic properties change due to mixing with the warmer and saltier underlying Mediterranean waters. This oceanic circulation creates an increasing thermal and salinity gradient along the Algerian coastal waters from west to east (Millot and Taupier-Letage, 2005). Unlike these two parameters, chlorophyll *a* concentrations are lower in the eastern part of the Algerian coastal waters than in the western and central parts (Boudjenah *et al.*, 2019; Ali and Bachari, 2021). Furthermore, like most Mediterranean waters, the coastal waters are oligotrophic, with chlorophyll *a* concentrations rarely exceeding 1 mg m^{-3} (Hafferssas and Seridji, 2010; Ali and Bachari, 2021). The Algerian coast is distinguished by a high diversity of coastal ecosystems that promote an exceptional marine biodiversity due to the interaction with these hydrodynamic characteristics. Like other areas in the southern Mediterranean, these are still relatively unexplored despite their ecological importance. This research gap has resulted in an underestimation of biodiversity in the region. This pattern is especially noticeable in zooplanktonic groups.

On the Algerian coast, studies on zooplankton populations have primarily focused on the copepod group (Seguin, 1973; Seridji and Hafferssas, 2000; Hafferssas and Seridji, 2010; Hafferssas *et al.*, 2010; Ounissi *et al.*, 2016; Chaouadi and Hafferssas, 2018; Mellak and Hafferssas, 2022). Other groups, such as gelatinous carnivorous zooplankton, have received insufficient attention. Indeed, only a few studies have been conducted on these planktonic organisms. The initial inventories of these species were carried out as part of broader studies on various zooplankton groups. The oldest of these studies is that of Seguin in 1973, carried out at a station in Algiers Bay. Ounissi *et al.* (2016) recently investigated the eastern region of the Algerian coast. However, research on gelatinous zooplankton along the Algerian coast is relatively new. Only recently some research has been dedicated to study of these zooplankton communities, such as the study on medusae collected from the central and eastern Algerian coast (Kherchouche and Hafferssas, 2020) and the studies of other gelatinous groups conducted mainly in the western and central regions of the Algerian coast (Khames and Hafferssas, 2018, 2019; Khames *et al.,* 2023).

Comprehensive inventories and long-term monitoring of gelatinous zooplankton are required to assess marine biodiversity and detect changes affecting these organisms. Gelatinous zooplankton is a diverse group of organisms characterized by gelatinous and transparent bodies. Taxonomically, these organisms belong to various phyla: Cnidaria, Ctenophora, Mollusca, Chaetognatha and Chordata (Thaliacea and Appendicularia). The cnidarians, represented by their planktonic forms such as medusae and siphonophores, are the most diverse. The latter have traditionally been grouped under the

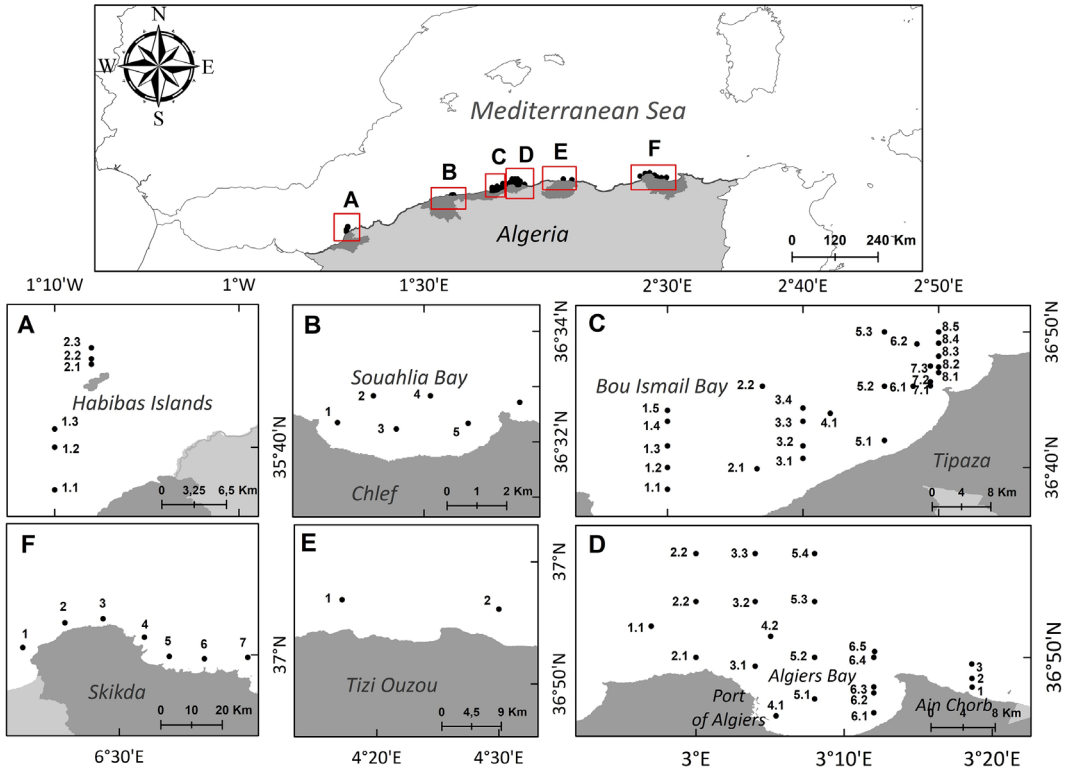

Fig. 1. Map of the sampling stations in Algerian coastal waters. Western region**:** Habibas (**A**) islands, Souahlia Bay (**B**); Central region: Bou Ismail Bay (**C**), Algiers Bay and Ain Chorb coast (**D**), Tizi Ouzou coast (**E**); and Eastern region Jijel and Skikda coasts (**F**).

name Medusozoa. It includes the classes of Hydrozoa (hydromedusae and Siphonophorae), Scyphozoa (Scyphomedusae) and Cubozoa (Cubomedusae). The fauna of planktonic cnidarians in the world's oceans comprises more than 1000 species, including about 840 species of hydromedusae (Bouillon and Boero, 2000), 190 species of Scyphomedusae (Arai, 1997), 20 species of Cubomedusae (Mianzan and Cornelius, 1999) and 200 species of Siphonophorae (Pugh, 1999).

In the Mediterranean Sea, diversity has been estimated at 457 species of hydrozoans (Bouillon *et al.*, 2004), 20 species of scyphozoans, and one cubozoan species (Acevedo *et al.*, 2019). Planktonic cnidarians are the most abundant non-crustacean invertebrate predators (Pugh *et al.,*1997). They play an important role in the controlled functioning of pelagic ecosystems (Hosia *et al.,*2014). These organisms have become increasingly abundant in recent decades (Malej *et al.*, 2012), resulting in various environmental and socioeconomic impacts. They are associated with human activities and climate change (Richardson *et al.*, 2009). Thus, these zooplanktonic organisms can be used to assess the impact of global change on marine ecosystems (Beaugrand *et al.*, 2002). This study aims to compile a list of planktonic cnidarian species found in the Algerian coastal waters. We also aimed to analyse the qualitative distribution of this fauna and to identify its main components.

MATERIAL AND METHODS

Study area

From May 2012 to February 2017, the organisms were collected at various locations along the Algerian coastal waters between 1°10'00" W - 6°52'37" E and 35°37'42" N - 37°01'16" N. A total of 66 stations were sampled in three regions (Table 1; Fig. 1). Stations were distributed between two sites in the western region: the Habibas Archipelago (Fig. 1A), the largest insular ensemble off the Algerian coast, located in the Alboran Sea and designated as the country's first marine protected area, and Souahlia Bay (Fig. 1B), located northwest of the Algerian coast in the region of Ténès, Wilaya of Chlef. In the central region, sampling encompassed four

Table 1. Metadata for the spatio-temporal distribution of sample data series in Algerian coastal waters from 2012 to 2017
F: February; **Mr**: March; **Ap**: April; **M**: May; **J**: June; **Jl**: July; **A**: August; **S**: September; **N**: November; **D**: December

Region	Site	Radial	Station	Longitude	Latitude (N)	Sampling period [month (year)]
Western region	Habibas islands (HI)	1	1.1; 1.2; 1.3	1°10'00''W	35°37'42"- 35°41'00"	M (2012); Jl (2012)
		2	2.1; 2.2; 2.3	1°08'00"W	35°44'30"- 35°45'24"	
	Souahlia Bay (SB)		1; 2; 3; 4; 5	1°28'26" E -1°30'48" E	36°32'21"- 36°32'20"	Jl (2015); A (2015)
Central region	Bou Ismail Bay (BB)	1	1.1; 1.2; 1.3; 1.4; 1.5	2°30'00" E	36°38'24"- 36°44'12"	Ap (2016)
		2	2.1; 2.2	2°37'00" E	36°39'55"- 36°46'48"	D (2016)
		3	3.1; 3.2; 3.3; 3.4	2°40'00" E	36°40'00"- 36°44'23''	Ap (2016)
		4	4.1	2°42'00" E	36°44'48"	D (2016)
		5	5.1; 5.2; 5.3	2°46'00" E	36°42'48"- 36°50'00"	D (2016)
		6	6.1; 6.2	2°48'07" E	36°46'36"- 36°49'06"	D (2016)
		7	7.1; 7.2; 7.3	2°49'23" E	36°46'01"- 36°47'29"	J (2015)
		8	8.1; 8.2; 8.3; 8.4; 8.5	2°50'00" E	36°47'12''- 36°50'00"	J, N (2012); Ap, Jl (2013); Mr (2014); J (2015)
	Algiers Bay (AB)	1	1.1	2° 56'59" E	36°52'06"	S (2014)
		2	2.1; 2.2; 2.3	3°00'00" E	36°50'00"- 36°57'00"	Ap (2017)
		3	3.1; 3.2; 3.3	3°04'00" E	36°49'24"- 36°57'00"	F (2012); J (2016); Ap (2017)
		4	4.1; 4.2; 4.3; 4.4	3°08'00" E	36°47'12''- 36°57'00"	Mr (2016); J (2016); Ap (2017)
		5	5.1; 5.2	3°05'24" E	36°46'36"- 36°51'25"	D (2015); Mr, J (2016); Mr, Ap (2017)
		6	6.1; 6.2; 6.3; 6.4; 6.5	3°12'00" E	36°46'38" - 36°50'23"	S (2014); F, Ap (2017)
	Ain Chorb (AC)		1.1; 1.2; 1.3	3°18'36" E	36°47'53" - 36°48'52"	F, Mr, Ap, M, S (2016)
	Tizi Ouzou (TO)		1; 2	4°17'10" E-4°30'01" E	36°56'54" - 36°56'08"	S (2014)
Eastern Region	Skikda gulf		1; 2; 3; 4; 5; 6; 7	6°13'03" E -6°52'37" E	36°59'32" - 37°01'16"	S (2014)

sites: Bou Ismail Bay in Wilaya of Tipaza, west of the capital Algiers (Fig. 1C), subjected to anthropogenic pressure due to its touristic and agricultural vocation; Algiers Bay (Fig. 1D), into which several major wadis flow, including El Harrach and El Hamiz, situated in a highly urbanized coastal zone and a site of intense harbour and industrial activities, resulting in significant pollution (Houma *et al.*, 2013). According to Ali and Bachari (2021), chlorophyll *a* concentrations in Algiers Bay are higher than those measured at other sites in the central region. The Ain Chorb coast, located 25 km east of Algiers Bay (Fig. 1D), is used for mussel farming, the Tizi Ouzou coast, located further to the east and characterized by a narrow continental shelf (Fig. 1E), is the last site in this central region. Sampling on the eastern Algerian coast took place between the gulfs of Jijel and Skikda, approximately 500 km from the capital, Algiers (Fig. 1F). This region is characterized by relatively high temperature and salinity values compared to the central and western parts of the Algerian coast. However, the chlorophyll *a* concentrations appear to be lower (Ali and Bachari, 2021). Table 1 summarizes information about the various sampling sites, including their geographical location, the number of sampling stations at each site, and the periods during which the samples were collected.

Zooplankton sampling

A total of 119 zooplankton samples were collected from the epipelagic layer during the day. According to the bathymetry of the stations, the samples were taken by vertical hauls from a maximum depth of 100 m to the surface. For this purpose, a standard Working Party 2 (WP2) plankton net with a mesh size of 200 µm was used (UNESCO, 1968). After collection, the organisms were immediately fixed with a 4% formaldehyde seawater solution. In the laboratory, the planktonic cnidarians were identified to species level whenever possible using a stereomicroscope (Zeiss Stemi SV 6) at 8-50x magnification and taxonomic references (e.g. Trégouboff and Rose, 1957; Bouillon, 1999; Pugh, 1999; Bouillon *et al.*, 2006). Identification was only achieved for the nectophores within the order of siphonophores. Using the specialized database World Register of Marine Species (www.marinespecies.org), all specimens were systematically classified into their respective taxonomic categories (suborder, order, subclass and class).

Although the current taxonomy of planktonic cnidarians does not accept the terms hydromedusae and Scyphomedusae, we used them in this study to emphasize the ecological differences between the groups. The hydromedusae are thus a non-systematic category that includes the orders Anthoathecata and Leptothecata from the subclass Hydroidolina and the orders Trachymedusae and Narcomedusae from the subclass Trachylina. The second term, Scyphomedusae, refers to members of the class Scyphozoa (Table 2).

Data analysis

The non-parametric Cochran Q test was used to compare the various faunal inventories. The frequency of occurrence (*Fr*) was also calculated, and taxa were classified into three classes based on their frequency of occurrence: frequent ($Fr>75\%$), common ($25\%<Fr\leq75\%$), and rare ($Fr\leq25\%$). The frequency of occurrence was calculated as follows: $Fr=P_i/P \times 100$ where P_i is the total number of samples in which the taxon/species occurs and P is the total number of samples. The Jaccard index was used for the multivariate analysis (Ascending Hierarchical Classification based on presence/absence transformed data matrix) to describe the similarities between inventory compositions. The final results were interpreted using dendrograms with agglomerative links and minimum variances (Ward method) (Ward, 1963). The statistical software R and OriginPro 9.0 were used for all analyses. The samples were labelled with the following codes: abbreviated site name_radial (transect) number.station number_sampling date (month and year) (Table 1). For example, HI_1.1_M2 corresponds to the Habibas Islands, radial 1, station 1, sampled in May 2012.

RESULTS

Taxonomic diversity and biogeographical affinity

A total of 60 planktonic cnidarian taxa (52 species) from the classes Hydrozoa and Scyphozoa were identified (Table 2). The hydromedusae show the greatest taxonomic diversity within the class Hydrozoa, with 34 taxa (27 species) distributed among four orders (Anthoathecata, Leptothecata, Narcomedusae and Trachymedusae). The order Anthoathecata was the most diverse with 15 taxa (12 species). The orders Leptothecata and Narcomedusae comprise six and five species, respectively, while the order Trachymedusae has only four identified species. The siphonophores from the subclass Hydroidolina mostly belong to the suborder Calycophorae, with 15 species distributed in 10 genera. The suborder Physonectae shows less diversity with only seven species distributed in five genera. *Lensia* was the most species-rich Hydrozoa genus with three species. Only three Scyphozoa species were identified from the orders Rhizostomeae, Semaeostomeae and Coronatae.

The most frequently identified planktonic cnidarian is *Abylopsis tetragona*, which was found in 89.08% of the samples. Other common species such as the siphonophores *Muggiaea atlantica* (68.91%), *Lensia subtilis* (63.03%), *Muggiaea kochi* (52.10%), and the holoplanktonic hydromedusae *Rhopalonema velatum* (66.67%), *Aglaura hemistoma* (61.11%), *Liriope tetraphylla* (42.86%) and *Solmundella bitentaculata* (42.06%) were also detected. The meroplanktonic forms were mainly represented by *Obelia* spp. which was identified in 39.68% of the samples. Among the

Table 2. List of planktonic cnidarian taxa identified in the western, central and eastern regions of Algerian coastal waters in 2012-2017 period. (+ present; - absent)
(**1**: Picard (1958), **2**: Goy (1991), **3**: Boero and Bouillon (1993), **4**: Goy et al. (2016))
(**W**: western region; **C:** central region; **E:** eastern region; **sp:** spring; **s:** summer; **a:** autumn; **w:** winter)

Taxons	W		C				E	Geographical and climatic affinity
	sp	s	sp	s	a	w	a	
Class: Hydrozoa								
Sub-Class: Hydroidolina								
Order: Anthoathecata								
Sub-Order: Aplanulata								
Corymorpha nutans M. Sars, 1835	-	-	+	+	-	+	-	North Atlantic [1]; Boreal [3]
Euphysa aurata Forbes, 1848	-	-	+	-	-	-	-	Boreal [3]
Paragotoea bathybia Kramp, 1942	-	-	+	-	-		-	Atlantic [2]; Tropico-Atlantic [3]
Ectopleura dumortierii (Van Beneden, 1844)	+	-	-	+	-	-	-	North Atlantic [1]; Circumtropical [4]
Sub-Order: Filifera								
Eucodonium brownei Hartlaub, 1907	-	+	+	-	-	-	-	North Atlantic [1]; Atlanto-Mediterranean [3]
Podocorynoides minima (Trinci, 1903)	-	-	-	-	+	-	-	North Atlantic [1]; Atlanto-Mediterranean [3]
Hydractina sp. Van Beneden, 1844	-	-	-	+	-	-	-	
Kantiella enigmatica Bouillon, 1978	-	-	+	-	-	-	-	Indo-Pacific [3]
Leuckartiara octona (Fleming, 1823)	-	-	+	+	-	-	-	Cosmopolitan [1]
Koellikeria fasciculata (Péron and Lesueur, 1810)	-	-	-	+	-	-	-	Endemic [1]
Lizzia blondina Forbes, 1848	+	+	+	+	+	+	-	Boreal [3]
Proboscidactyla ornata (McCrady, 1859)	-	-	+	-	-	-	-	Circumtropical [1; 3;4]
Sub-Order: Capitata								
Stauridiosarsia gemmifera (Forbes, 1848)	-	-	+	-	-	-	-	Cosmopolitan [1]; Tropico-Atlantic [3]
Sarsia sp. Lesson, 1843	-	-	-	-	+	-	-	
Zanclea sp. Gegenbaur, 1856	+	-	-	-	+	-	-	Circumtropical [3]
Order: Leptothecata								
Eucheilota paradoxica Mayer, 1900	-	-	+	+	+	+	-	
Lovenella clausa (Lovén, 1836)	-	-	+	-	-	-	-	Atlanto-Mediterranean[3]
Lovenella cirrata (Haeckel, 1879)	+	+	-	+	-	-	-	Tropico-Atlantic [3]
Cirrholovenia tetranema Kramp, 1959	-	-	-	+	+	-	-	Indo-Pacific [1; 3]
Clytia spp.	-	+	+	+	+	-	+	
Clytia hemisphaerica (Linnaeus, 1767)	+	-	+	+	+	-	-	Cosmopolitan [3]
Obelia spp. Péron and Lesueur, 1810	+	-	+	+	+	+	-	
Phialella quadrata (Forbes, 1848)	-	-	+	+	-	+	-	Cosmopolitan [3; 4]
Order: Siphonophorae								
Sub-Order: Physonectae								
Agalma elegans (Sars, 1846)	-	-	+	+	-	-	+	Cosmopolitan [4]
Agalma sp. Eschscholtz, 1825	-	-	-	+	+	+	+	
Agalma okenii Eschscholtz, 1825	-	+	-	-	-	-	-	Cosmopolitan [4]
Halistemma rubrum (Vogt, 1852)	-	-	+	+	-	-	-	Cosmopolitan [4]
Nanomia bijuga (Delle Chiaje, 1844)	-	-	+	+	+	+	-	Cosmopolitan [4]
Athorybia rosacea (Forsskål, 1775)	-	-	-	-	-	-	+	

Taxons	W		C				E	Geographical and climatic affinity
	sp	s	sp	s	a	w	a	
Forskalia edwardsii Kölliker, 1853	-	-	-	+	-	-	+	Cosmopolitan [4]
Forskalia contorta (Milne Edwards, 1841)	-	-	-	+	-	+	-	
Sub-Order: Calycophorae								
Abylopsis eschscholtzii (Huxley, 1859)	-	-	+	+	+	+	+	Cosmopolitan [4]
Abylopsis tetragona (Otto, 1823)	+	+	+	+	+	+	+	Cosmopolitan [4]
Bassia bassensis (Quoy and Gaimard, 1833)	+	-	+	+	+	+	-	Cosmopolitan [4]
Lensia conoidea (Keferstein and Ehlers, 1860)	-	-	-	+	+	+	+	Cosmopolitan [4]
Lensia subtilis (Chun, 1886)	+	+	+	+	+	+	-	Cosmopolitan, tropical [4]
Lensia subtiloides (Lens and Van Riemsdijk, 1908)	+	+	+	+	+	+	-	Cosmopolitan, tropical [4]
Eudoxoides spiralis (Bigelow, 1911)	-	-	-	+	-	+	-	Semi-cosmopolitan [4]
Muggiaea atlantica Cunningham, 1892	+	+	+	+	+	+	+	Cosmopolitan [4]
Muggiaea kochii (Will, 1844)	+	+	+	+	+	+	-	
Sulculeolaria chuni (Lens and Van Riemsdijk, 1908)	-	-	-	-	+	-	-	
Chelophyes appendiculata (Eschscholtz, 1829)	+	-	+	+	+	+	+	Cosmopolitan [4]
Sphaeronectes irregularis (Claus, 1873)	-	+	+	+	+	+	-	
Sphaeronectes koellikeri Huxley, 1859	-	-	-	+	-	+	-	
Hippopodius hippopus (Forsskål, 1776)	-	-	+	+	+	+	+	Circumtropical [4]
Vogtia glabra Bigelow, 1918	-	-	-	+	+	+	+	Cosmopolitan [4]
Sub-Class: Trachylina								
Order: Trachymedusae								
Aglaura hemistoma Péron and Lesueur, 1810	-	+	+	+	+	+	+	Circumtropical [3; 4]
Rhopalonema velatum Gegenbaur, 1857	+	+	+	+	+	+	+	Circumtropical [4]
Liriope tetraphylla (Chamisso and Eysenhardt, 1821)	+	-	+	+	+	+	+	Circumtropical [3; 4]
Homoeonema platygonon Maas, 1893	-	-	-	+	-	-		Tropico-Atlantic [3]
Order: Narcomedusae								
Solmundella bitentaculata (Quoy and Gaimard, 1833)	+	+	+	+	+	+	+	Circumtropical [3; 4]
Cunina globosa Eschscholtz, 1829	-	-	-	-	-	+	+	Circumtropical [3; 4]
Cunina sp. Eschscholtz, 1829	-	-	-	-	-	-	+	
Solmissus albescens Haeckel, 1879	-	-	-	+	-	-	-	Endemic [2]
Solmaris leucostyla (Will, 1844)	-	-	+	-	-	-	-	Endemic [3]
Solmaris sp. Haeckel, 1879	+	+	+	+	+	+	+	
Aegina citrea Eschscholtz, 1829	-	-	+	+	-	-	-	Cosmopolitan [4]
Class: Scyphozoa								
Sub-Class: Discomedusae								
Order: Rhizostomeae								
Cotylorhiza tuberculata (Macri, 1778)	-	+	-	-	-	-	-	
Order: Semaeostomeae								
Pelagia noctiluca (Forsskål, 1775)	+	+	+	+	-	-	+	Semi-cosmopolitan [4]
Sub-Class: Coronamedusae								
Order: Coronatae								
Nausithoe punctata Kölliker, 1853	-	-	+	+	-	-	-	

Scyphozoa, *Pelagia noctiluca* was collected most frequently (40.48%). Some species were rarely observed, for example the hydromedusae *Euphysa aurata, Paragotoea bathybia, Podocorynoides minima, Kantiella enigmatica, Koellikeria fasciculata, Proboscidactyla ornata, Stauridiosarsia gemmifera, Lovenella clausa* and *Homoeonema platygonon* as well as the siphonophores *Athorybia rosacea* and *Sulculeolaria chuni.*

The planktonic cnidarian fauna present along the Algerian coast exhibits various affinities (Table 2). Most of the recorded hydromedusae were mainly represented by circum-tropical or sub-tropical (*Aglaura hemistoma, Rhopalonema velatum, Solmundella bitentaculata, Liriope tetraphylla*, *Ectopleura dumortierii, Proboscidactyla ornata, Zanclea* sp. and *Cunina globosa*) and cosmopolitan affinities (*Clytia hemisphaerica, Phialella quadrata, Leuckartiara octona* and *Aegina citrea*). The remaining taxonomic diversity was linked to additional affinities, namely Tropico-Atlantic (*Stauridiosarsia gemmifera, Lovenella cirrata, Homoeonema platygonon* and *Paragotoea bathybia*), Atlantic-Mediterranean (*Podocorynoides minima, Lovenella clausa* and *Eucodonium brownei*), boreal (*Corymorpha nutans, Euphysa aurata, Lizzia blondina*) and Indo-Pacific (*Cirrholovenia tetranema* and *Kantiella enigmata*). Some of the studied fauna was also classified as endemic, for example *Koellikeria fasciculata* and *Solmaris leucostyla* (Table 2).

The siphonophoran fauna was composed of cosmopolitan taxa, and characterised by a wide geographical distribution. Some of these species have an affinity for temperate (*Abylopsis tetragona, Abylopsis eschscholtzii* and *Bassia bassensis*) or warm (*Chelophyes appendiculata*) waters. In addition, tropical (*Lensia subtilis and Lensia subtiloides*) and sub-tropical species (*Hippopodius hippopus*), were detected in our samples (Table 2).

Geographical and seasonal patterns in the diversity of planktonic cnidarians

The results show that the number of taxa in the Algerian coastal waters varied depending on region and season (Fig. 2). Sampling effort and site location also affected these spatial and temporal variations. Given the heterogeneity of the sampling strategy, the main goal of this section is to describe the distribution of planktonic cnidarian diversity within each geographical area. Whenever possible, comparisons were made between regions to assess spatial and temporal variations in biodiversity.

Western region

A total of 24 planktonic cnidarian taxa were identified in the region, including 13 hydromedusae, nine Siphonophorae, and two Scyphomedusae (*Pelagia*

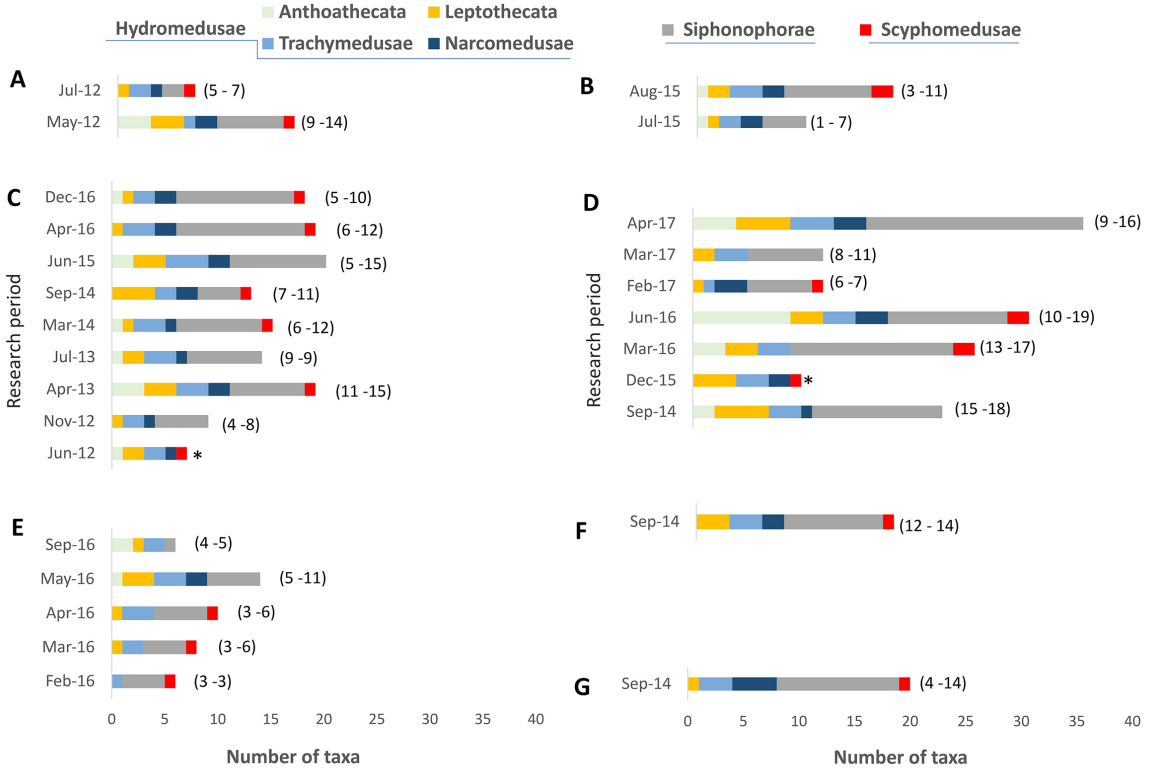

Fig. 2. Number of planktonic cnidarian taxa at different sites in Algerian coastal waters during the study period 2012-2017. The range of species richness (S) per station is given in brackets; the asterisk (*) means that no data are available for Siphonophorae. Western region: Habibas islands (**A**), Souahlia Bay (**B**); Central region: Bou Ismail Bay (**C**), Algiers Bay (**D**) Ain Chorb Coast (**E**), Tizi Ouzou Coast (**F**); and Eastern region: Jijel and Skikda Coast (**G**).

noctiluca and *Cotylorhiza tuberculata*). The hydromedusae consisted of four Anthoathecata (*E. dumortieri, E. brownei, L. blondina* and *Zanclea* sp.), four Leptothecata (*L. cirrata, Clytia* spp., *C. hemisphaerica* and *Obelia* spp.), three Trachymedusae (*A. hemistoma, R. velatum* and *L. tetraphylla*) and two Narcomedusae (*S. bitentaculata* and *Solmaris* sp.) (Fig. 2). Within the siphonophores, the suborder Calycophorae included eight species (*A. tetragona, B. bassensis, L. subtilis, L. subtiloides, M. atlantica, M. kochii, C. appendiculata* and *S. irregularis*). Seventeen taxa (10 hydromedusae, six Siphonophorae and one Scyphomedusae) were recorded from the Habibas Islands. The diversity of pelagic cnidarians in this region was greater in spring (16 taxa) than in summer (seven taxa) (Fig. 2A).

The distribution of species richness followed a similar seasonal pattern, with values ranging from nine to 14 taxa in spring. In summer, however, this value varied between five and seven taxa (Fig. 2A). More than half of the fauna was represented by hydromedusae and Scyphomedusae, with 10 taxa recorded in spring (*E. dumortieri, L. blondina, Zanclea* sp., *L. cirrata, C. hemisphearica, Obelia* spp., *R. velatum, S. bitentaculata, Solmaris* sp. and *P. noctiluca*) and five species in the summer months (*L. cirrata, A. hemistoma, R. velatum, S. bitentaculata* and *P. noctiluca*) (Fig. 2A). In Souahlia Bay, a significantly higher diversity ($p<0.05$) was observed during the summer compared to the Habibas Islands. Here, the assemblage comprised 19 taxa, including nine hydromedusae, belonging to three different orders: Anthoathecata (*E. brownei*, *L. blondina*), Leptothecata (*Clytia* spp., *Obelia* spp.), Trachymedusae (*A. hemistoma*, *R. velatum*, *L. tetraphylla*), Narcomedusae (*S. bitentaculata*, *Solmaris* sp.) and eight siphonophores (*A. okenii, A. tetragona, B. bassensis, L. subtilis, L. subtiloides, M. atlantica, M. kochii* and *C. appendiculata*). The Scyphomedusae were represented by two species (*C. tuberculata* and *P. noctiluca*). Most of these species were found in August (Fig. 2B).

Central region

A total of 56 taxa (49 species) of pelagic cnidarians were found in the central region at various sampling sites. The hydromedusae made up about 60% of the total, with 33 recorded taxa. The siphonophores were represented by 21 taxa (37.5%), most of which belong to the suborder Calycophorae (15 species). Only two out of three Scyphomedusae species were recorded in this area (Table 2). Algiers Bay is known for its extraordinary biodiversity, which is confirmed by the 49 taxa recorded between 2014 and 2017. The analysis of species richness revealed maximum values of up to 19 taxa in this Bay (Fig. 2D). Hydromedusae were represented by 26 taxa (Table 2). Anthoathecata were the most species-rich order with 10 taxa. Leptothecata and Narcomedusae were the next, with six taxa each, followed by Trachymedusae with four species. We recorded 21 siphonophoran taxa (20 species), of which 15 species belonging to Calycophorae. The Scyphomedusae, on the other hand, were represented by only two species. This bay was also characterised by the largest number of rare planktonic cnidarian species, whose frequency of occurrence was less than 25%. Ten taxa (*Eudoxoides spiralis, Sulculeolaria chuni, Euphysa aurata, Paragotoea bathybia, Podocorynoides minima, Kantiella enigmatica, Leuckartiara octona, Proboscidactyla ornata, Sarsia* sp. and *Aegina citrea*) were recorded exclusively in this area (Table 2). This cnidarian diversity showed significant seasonal variability ($p<0.05$). In spring and summer (September 2014, March 2016, June 2016, and April 2017), this fauna was significantly more diverse (over 20 taxa), and species richness reached maximum values (up to 19 species). In contrast, the winter season had the lowest values with 11 taxa (Fig. 2D).

In addition, 35 taxa were identified in Bou Ismail Bay. A total of 20 hydromedusae were collected, most of which were Leptothecata (seven taxa) and Anthoathecata (six taxa). Trachymedusae and Narcomedusae had four and three species, respectively, and *P. noctiluca* was the only Scyphomedusae species. Furthermore, 14 Siphonophorae were identified, of which ~79% (11 species) belong to the suborder Calycophorae. The number of taxa did not exceed 20 in the different seasons and although the biodiversity has not reached the level of Algiers Bay, it followed a similar seasonal pattern. This fauna was generally more diverse in spring (April 2013 and 2016) and summer (June 2015), when the number of taxa often exceeded 15. The decline in biodiversity was more pronounced in the autumn of 2012, when species richness dropped to less than 10 taxa (Fig. 2C). The pattern of variation in the number of species *per* station was similar.

The fauna collected along the Ain Chorb coast contained fewer taxa (21) than those collected further to the west (Bou Ismail and Algiers Bay). In contrast to other sites, the 11 hydromedusae found in this area were evenly represented in the four orders (three Anthoathecata, three Leptothecata, three Trachymedusae, and two Narcomedusae). In contrast to the hydromedusae, the taxonomic composition of the siphonophores in this area was consistent with that of other surveyed sites. Eight of the nine recorded siphonophoran taxa belong to the order Calycophorae, which accounts for 89% of the specimens observed. Only one species, *P. noctiluca*, was observed in the class Scyphozoa. The seasonal variability in the succession of planktonic cnidarians was confirmed by the monthly monitoring at this site between February and September 2016. The distribution patterns of these planktonic cnidarians were similar to those found in Bou Ismail and Algiers bays. The number of taxa increased from six in winter (February) to 14 taxa in spring (May), as follows: One hydromedusae, four Siphonophorae and one Scyphomedusae and nine hydromedusae and five Siphonophorae, respectively. In late summer, there was a qualitative decline (six taxa,

including five hydromedusae and one Siphonophorae) (Fig. 2E). The autumnal diversity in the coastal water of Tizi Ouzou was represented by 18 taxa (eight hydromedusae, nine Siphonophorae and one Scyphomedusae) (Fig. 2F).

Eastern region

During an oceanographic campaign in September 2014, 20 taxa of planktonic cnidarians were collected in the epipelagic layer of the eastern region. Although the overall species richness was comparable to that observed in Algiers Bay during the same campaign (23 taxa), this diversity distribution between the eastern stations was relatively low (Fig. 2G). The number of taxa per station did not exceed 14, while it varied between 15 and 18 in Algiers Bay (Figs. 2D and 2G). Moreover, the eastern region was characterised by the predominance of Narcomedusae (four taxa) and Trachymedusae (three species). The order Leptothecata, on the other hand, was the least diverse, with only one taxon found (*Clytia* sp.). With 11 recorded taxa, including seven calycophores, the siphonophores were relatively diverse than medusae. The Scyphomedusae were represented only by *P. noctiluca* at all investigated sites during this campaign.

Taxonomic composition and seasonal affinity of planktonic cnidarians

A multivariate Hierarchical Cluster Analysis (HCA) was performed to highlight the different sample groupings based on the taxonomic composition of the planktonic cnidarians. This HCA was combined with a heatmap to visualise the affinities of various taxa according to their frequency and seasonal occurrence (Figs. 3 and 4).

Western region

The (dis)similarities between the samples were determined on the basis of the faunistic composition of the planktonic cnidarians and the frequency of occur-

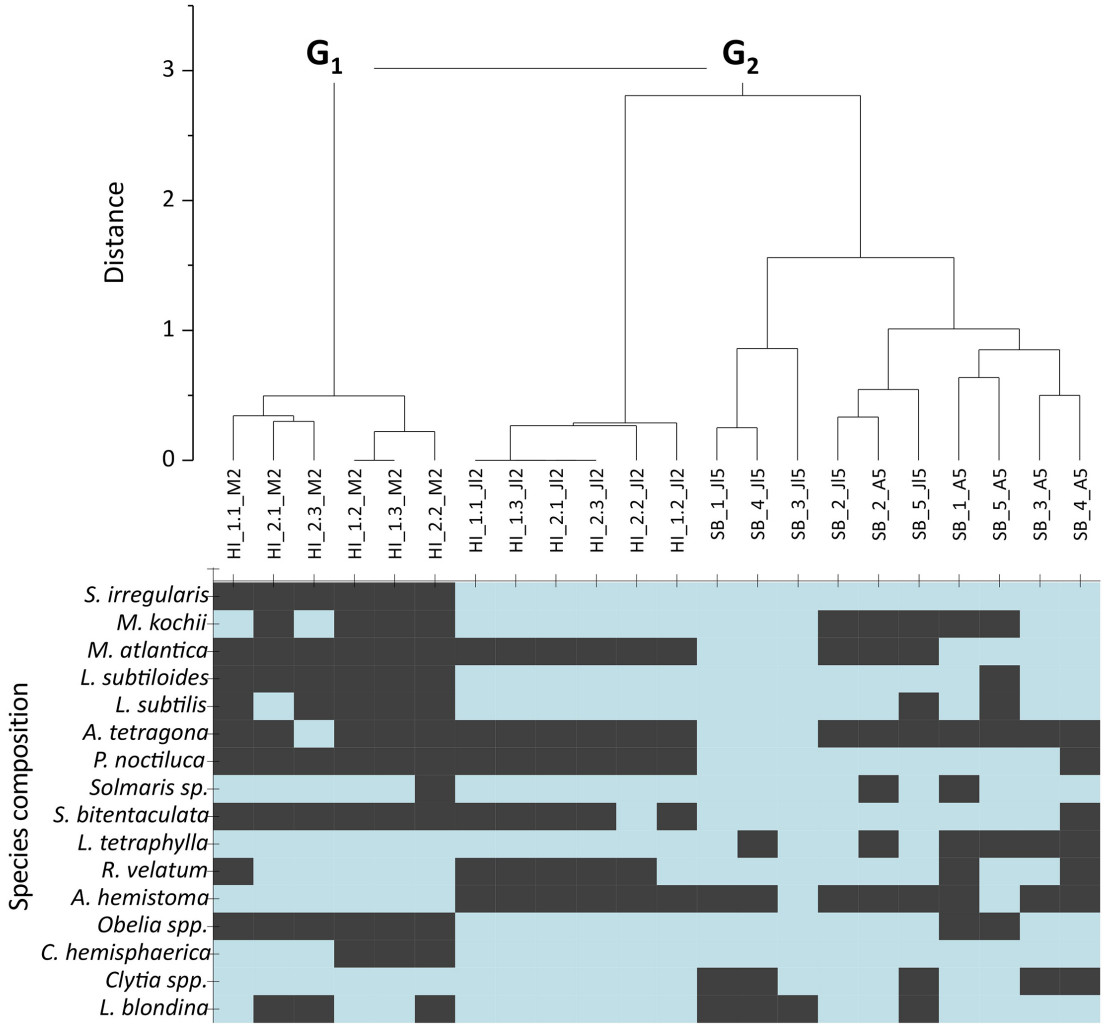

Fig. 3. Dendrogram for hierarchical clustering of sampling sites in western Algerian coastal waters based on presence/absence transformed data for planktonic cnidarians in relation to their taxonomic composition. (**HI**: Habibas islands; **SB**: Souahlia Bay)

rence of each respective taxon in the samples (Fig. 3). The first group, which corresponds to Habibas Islands' spring cluster (group G_1) shows the highest species richness (Fig. 2A). The most common siphonophoran species are *S. irregularis, A. tetragona, M. atlantica, M. kochii, L. subtiloides,* and *L. subtilis*. In addition, there are two orders represented by the meroplanktonic hydromedusae: Leptothecata with *Obelia* spp*., C. hemisphaerica,* and Anthoathecata with *L. blondina* in this cluster, as well as the two holoplanktonic species: narcomedusa *S. bitentaculata* and the scyphomedusa *P. noctiluca* (Fig. 3). A second cluster (group G_2) corresponds to the summer species and includes samples collected in the Habibas Islands and Souahlia Bay during the summer (July-August). This summer group was less diverse, and had an average richness of less than seven taxa. The siphonophores were dominated by *M. atlantica* and *A. tetragon*, while the medusae were qualitatively dominated by holoplanktonic forms in contrast to the spring group. The hydromedusae *A. hemistoma* and *R. velatum* (order Trachymedusae) as well as *P. noctiluca* (Scyphomedusae) were detected in more than 50% of the summer samples (Fig. 3).

Central region

The HC analysis was performed at all stations sampled in the central region in Bou Ismail Bay, Algiers Bay and in the coastal waters of Ain Chorb. The findings show two main qualitatively opposing clusters: G_1 and G_2 (Fig. 4). The cluster G_1 contains samples with large diversity of planktonic cnidarians. These are primarily associated with samples collected in the spring and summer months. These samples are characterized by a relatively constant group of species, mainly holoplanktonic siphonophora, such as *M. kochii, M. atlantica, L. subtilis, A. tetragona*, and Trachymedusae, such as *R. velatum* and *A. hemistoma* (Fig. 4). These taxa seem to prefer the spring and summer months, when they reach similar frequencies.

However, the presence of other taxa that prefer either summer or spring has divided this group into two sub-clusters, G_{1a} and G_{1b} (Fig. 4). The group of summer species (sub-cluster G_{1a}) included holoplanktonic forms of *S. bitentaculata* (Narcomedusae) and *L. tetraphylla* (Trachymedusae). The meroplanktonic species *Obelia* spp., *C. hemisphaerica, E. paradoxica* and *L. blondina* are also found in this group. They were mostly associated with coastal stations, particularly those in Algiers Bay (Fig. 4). The spring sub-cluster (G_{1b}) was linked to the most common species of siphonophora (*C. appendiculata, L. subtiloides, A. eschscholtzii, N. bijuga, H. hippopus* and *B. bassensis*). These species were generally more frequent in spring than in summer, especially in Algiers Bay (Fig. 4). The second cluster (Cluster G_2) consisted mainly of winter samples with less frequent taxa than group G_1. In this season, only the recurring specimens of *M. atlantica, L. subtilis, A. tetragona* and *R. velatum* can be considered as relatively common forms (Fig. 4).

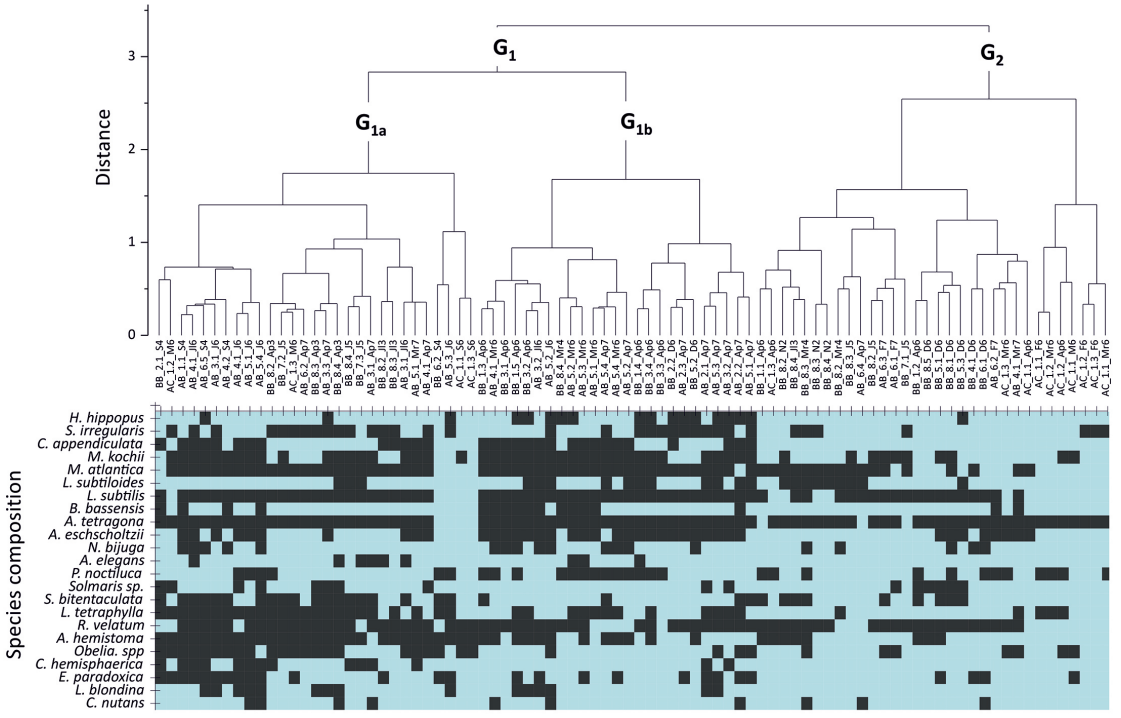

Fig. 4. Dendrogram for hierarchical clustering of sampling sites in central Algerian coastal waters based on presence/absence transformed data for planktonic cnidarians in relation to their taxonomic composition. (**BB**: Bou Ismail Bay, **AB**: Algiers Bay and **AC**: Ain Chorb Coast)

Eastern region

The five species *A. tetragona, M. atlantica, A. hemistoma, R. velatum, P. noctiluca* and the meroplanktonic *Clytia* spp. represented the planktonic cnidarian fauna during the 2014 autumn season in the eastern region of Algerian coastal waters.

DISCUSSION

For this study, we collected information on 60 planktonic cnidarians found between 2012 and 2017 in different locations in the Algerian coastal waters. A total of 34 taxa represented the class Hydrozoa from four orders (Anthoathecata, Leptothecata, Trachymedusae, and Narcomedusae). A total of 23 taxa were identified in the order Siphonophorae. The class Scyphozoa was less diverse with only three species identified. Based on the estimated planktonic cnidarian diversity in the Mediterranean of 478 species (Bouillon *et al.*, 2004; Acevedo *et al.*, 2019), the taxa recorded in Algerian coastal waters account for 12.5% of the total diversity in the Mediterranean. The recorded hydrozoans account for 12.47% of the hydrozoan diversity in the Mediterranean, while the scyphozoans account for 15%. A similar pattern of hydrozoan biodiversity (12.7% or 57 species) was recorded in Tunisian waters (Gueroun *et al.*, 2022). The diversity of scyphozoans is greater in Tunisian waters, with only seven species accounting for 30% of the scyphozoan diversity in the Mediterranean Sea (Gueroun *et al.*, 2022).

The cnidarian species recorded in this study have been previously identified in inventories of the northwestern Mediterranean and Adriatic Sea (Table 3). However, when compared to previous studies from the southwestern Mediterranean basin (Seguin, 1973; Dallot *et al.*, 1988; Daly Yahia *et al.*, 2003; Touzri *et al.*, 2010, 2012; Ounissi *et al.*, 2016), we report nine new species: *Forskalia contorta, Kantiella enigmatica, Leuckartiara octona, Proboscidactyla ornata, Cunina globosa, Lovenella cirrata, Cirrholovenia tetranema, Phialella quadrata* and *Homoeonema platygonon*. With reference to biogeographical studies on planktonic cnidarians (Boero and Bouillon, 1993), we identified two species of Indo-Pacific origin in Algiers Bay (central region): *Kantiella enigmatica* (Anthoathecata) and *Cirrholovenia tetranema* (Leptothecata), which are considered non-indigenous (Zenetos *et al.*, 2010; Occhipinti-Ambrogi *et al.*, 2011). The non-indigenous hydrozoan fauna in the western Mediterranean originate mainly from the central Indo-Pacific (24%) and the temperate North Atlantic (20%) (Gravili and Rossi, 2021). According to Occhipinti-Ambrogi *et al.* (2011), *C. tetranema* was first reported in the Mediterranean off the Italian coast in 1963. The status of this non-indigenous species is classified as "established" and its introduction presumably due to ballast waters (Occhipinti-Ambrogi *et al.* 2011), which would explain its accumulation in samples from Algiers Bay, collected near the port, an area suitable for colonization by non-indigenous species.

The comparison of the planktonic cnidarian diversity in the Algerian waters with adjacent Mediterranean regions is quite challenging due to the different sampling strategies. More than 30 species were sampled in the northern part of the western basin and in the Adriatic Sea (e.g., Gili *et al.,* 1988; Batistić *et al.,* 2007; Guerrero *et al.,* 2018) (Table 3). The higher speciosity of planktonic cnidarians seems to be related to the higher sampling effort. The same pattern is observed between the western and eastern Mediterranean (Bouillon *et al.*, 2004). Considering this heterogeneity, the biodiversity in the western region of Algerian coastal waters is significantly lower at the Habibas Islands and Souahlia Bay sites than in the Alboran Sea. Dallot *et al.* (1988) and Mills *et al.* (1996) reported 59 species (26 hydromedusae, 32 Siphonophorae and one Scyphomedusae) and 36 species (12 hydromedusae, 18 Siphonophorae and six Scyphomedusae), respectively, while in the present study, 17 taxa were collected in the Habibas Islands (10 hydromedusae, six Siphonophores and one Scyphomedusae) and 19 taxa in Souahlia Bay (nine hydromedusae, eight Siphonophorae and two Scyphomedusae).

The diversity of planktonic cnidarians was significantly higher in the central region of Algerian coastal waters. In fact, 93% of the identified taxa were observed in this region, a total of 56 taxa (33 hydromedusae, 21 Siphonophorae and two Scyphomedusae), of which 49 taxa (26 hydromedusae, 21 Siphonophorae and two Scyphomedusae) were associated with Algiers Bay. In the same bay, lower biodiversity (19 species: five hydromedusae, 13 Siphonophorae and one Scyphomedusae) was described by Seguin (1973). Seguin's faunal list also contained five species that were not identified in our study: *Pandea conica, Discomedusa lobata, Lensia campanella, Physophora hydrostatica* and *Sulculeolaria biloba*. Compared to previous work (Seguin, 1973) and our study, the sampling effort may explain the remarkable diversity in Algiers Bay. In contrast to other sites, this bay has already been studied several times. However, a comparison of biodiversity at three sampling sites (Algiers Bay, Bou Ismail Bay and Ain Chorb coast) during the same period (winter 2016) and an analysis of the distribution of specific richness along the transect revealed that planktonic cnidarians were more diverse in Algiers Bay than at other sites in the central region or in other regions. These observations led us to question the potential causes influencing this spatial distribution and its possible relationship with the environmental state of this area. The Algiers Bay, subjected to increasing anthropogenic pressures, shows a significant degradation of its ecosystem. This situation could explain the differences observed between the sampling sites. Houma *et al.* (2013) and Bahbah *et al.* (2020) confirmed, using different approaches, that Algiers Bay is heavily polluted. In contrast, the waters of Bou Ismail Bay are less polluted (Belkacem *et al.*, 2016).

Table 3. List of planktonic cnidarian taxa in Algerian coastal waters and their distribution in the western Mediterranean and Adriatic Sea based on literature data. (**A**: Dallot *et al.,* 1988; **B**: Boero and Bouillon, 1993; **C**: Gili *et al.,* 1988; **D**: Sabatés *et al.,* 2010; **E**: Buecher and Gibbons, 1999; **F**: Goy *et al.,* 2016; **G**: Mills *et al.,* 1996; **H**: Daly Yahia *et al.,* 2003; **I**: Touzri *et al.,* 2010, 2012; **J**: Seguin, 1973; **K**: Ounissi *et al.,* 2016; **L**: Khames and Hafferssas, 2019; **M**: Benović and Bender, 1987; **N**: Benović and Lučić, 1996; **O**: Benović *et al.,* 2000; **P**: Gamulin and Kršinić, 2000; **Q**: Benović *et al.,* 2005; **R**: Batistić *et al.,* 2007; **S**: Lučić *et al.,* 2009a,b; **T**: Pestorić *et al.,* 2012.)

	Western Mediterranean Sea												Adriatic Sea							
			Catalan Sea		Ligurian Sea		Alboran Sea	Tunisian waters		Algerian waters										
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Abylopsis eschscholtzii	-		+	-			-		-	-	+	-				-		-	-	-
Abylopsis tetragona	+		+	+			+		+	+	-	+				+		+	+	-
Aegina citrea	+	+	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-	-
Agalma elegans	+		+	+			+		-	+	-	+				-		-	-	-
Agalma okenii	-		+	-			-		-	-	-	-				-		-	-	-
Aglaura hemistoma	+	+	+	+	+	+	-	+	+	+	+		+	+	+		+	+	+	+
Athorybia rosacea	+		-	-			-		-	-	-	-				-		-	-	-
Bassia bassensis	+		-	-			-		+	-	-	-				+		-	+	-
Chelophyes appendiculata	+		-	+			-		+	+	-	+				+		+	+	-
Cirrholovenia tetranema	-	+	-	-	-	+	-	-	-	-	-		-	-	-		-	-	-	-
Clytia hemisphaerica	-	+	+	-	-	-	+	-	-	-	-		+	+	+		+	+	-	-
Clytia spp.	+	-	-	+	+	+	+	+	+	-	-		+	-	-		-	-	+	+
Corymorpha nutans	-	+	-	-	+	+	-	-	+	-	-		+	-	+		+	+	-	-
Cotylorhiza tuberculata	-	-	-	-	-	-	-	+	+	-	-		-	-	-		-	-	-	-
Cunina globosa		+	-	-	-	-	-	-	-	-	-		-	-	-		+	-	+	-
Cunina sp.	+	-	-	-	+	+	-	-	-	-	-		-	-	-		-	-	-	-
Ectopleura dumortieri	+	+	-	-	-	+	-	+	-	-	-		+	-	-		-	-	-	-
Eucheilota paradoxica	+	+	-	-	+	-	-	+	+	-	-		-	-	-		-	-	-	-
Eucodonium brownei	+	+	-	-	-	+	-	+	+	-	-		-	-	-		-	-	-	-
Eudoxoides spiralis	+		+	+			-		+	+	+	-				+		+	+	+
Euphysa aurata	+	+	+	-	+	+	-	-	+	-	-		+	-	-		-	+	-	-
Forskalia contorta	-		-	-			-		-	-	-	-				-		-	-	-
Forskalia edwardsii	+		+	-			-		-	-	-	-				-		-	-	-
Halistemma rubrum	-		+	-			-		-	-	-	-				-		-	-	-
Hippopodius hippopus	+		+	+			+		-	+	-	-				+		-	+	-
Homoeonema platygonon	-	+	-	-	-	-	-	-	-	-	-		-	+	-		-	-	-	-
Hydractina sp.	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	+	-	-
Kantiella enigmatica	-	+		-	-	-	-	-	-	-	-		-	-	-		-	-	-	-
Koellikeria fasciculata	+	+	+	-	+	+	-	-	-	-	-		-	-	-		-	-	+	-
Lensia conoidea	+		+	+			+		+	+	-	-				+		-	+	-
Lensia subtilis	+		+	+			-		-	+	+	+				+		+	+	+
Lensia subtiloides	-		+	-			-		-	-	-	+				+		-	+	-
Leuckartiara octona	-	+	+	+	+	+	-	-	-	-	-		+	+	-		+	-	+	-
Liriope tetraphylla	+	+	-	+	+	+	+	+	+	+	-		+	+	-		+	+	+	+
Lizzia blondina	+	+	+	-	+	+	+	+	+	-	-		+	-	+		-	-	-	-
Lovenella cirrata	-	+	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-	-
Lovenella clausa	-	+	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-	-
Muggiaea atlantica	+		+	+			+		+	+	+	+				+		+	-	+

	Western Mediterranean Sea												Adriatic Sea							
			Catalan Sea		Ligurian Sea		Alboran Sea	Tunisian waters		Algerian waters										
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Muggiaea kochii	+		+	+			-		+	+	+	+				+		+	-	+
Nanomia bijuga	+		+	+			+		-	-	-	+				-		-	-	-
Nausithoe punctata	+	-	-	+	+	-	-	-	-	-	+		-	-	-		-	-	+	-
Obelia spp.	+	-	+	+	+	+	-	+	+	-	+		-	+	+		+	+	-	+
Paragotoea bathybia	+	+	-	-	-	+	-	-	+	-	-		-	-	-		-	-	-	-
Pelagia noctiluca	-	-	+	+	+	-	-	+	+	-	+		-	-	-		-	-	-	-
Phialella quadrata	-	+	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-	-
Podocorynoides minima	+	+	+	-	+	+	-	-	+	-	-		+	+	+		-	+	-	+
Proboscidactyla ornata	-	+	-	-	-	+	-	-	-	-	-		-	-	-		-	-	-	-
Rhopalonema velatum	+	+	+	+	+	+	-	+	+	+	-		+	+	+		+	+	+	+
Sarsia sp. (tubulosa?)	-	-	+	-	+	-	-	-	-	-	-		-	-	-		-	-	-	-
Solmaris leucostyla	-	+	-	-	-	+	+	-	-	-	-		-	-	-		+	+	-	-
Solmaris sp. (flavescens?)	+	+	-	+	+	-	-	-	-	-	-		-	+	+		-	-	+	+
Solmissus albescens	+	+	+	-	+	+	+	-	-	-	-		+	+	-		+	-	+	-
Solmundella bitentaculata	+	+	+	+	+	+	-	+	+	+	-		+	+	-		+	+	+	-
Sphaeronectes irregularis	+		-	-			-		-	-	-	+				+		+	+	+
Sphaeronectes koellikeri	+		-	-			-		+	-	-	-				+		+	+	+
Stauridiosarsia gemmifera	+	+	-	-	+	+	-	-	-	-	-		+	+	+		-	+	-	+
Sulculeolaria chuni	-		-	-			-		-	+	-	+				+		+	+	-
Vogtia glabra	-		-	-			-		-	-	-	-						-	-	-
Zanclea sp. (costata?)	+	-	-	-	+	+	-	+	-	-	-		+	-	-		+	+	-	-

In the eastern coastal waters, 20 taxa of planktonic cnidarians (eight hydromedusae, 11 Siphonophorae and one Scyphomedusae) were recorded. A lower number (12 species: five hydromedusae, five Siphonophorae and two Scyphomedusae) was previously reported by Ounissi *et al.* (2016) from Annaba Bay. Along the Tunisian coast, more than 20 species of medusae and 11 species of Siphonophorae have been identified (Daly Yahia *et al.*, 2003; Touzri *et al.*, 2010, 2012). Gueroun *et al.* (2022) recently reported a significantly greater species richness (66 species) in Tunisian coastal waters. These various studies show that the inventory conducted on the eastern Algerian coast is far from complete, as a small number of samplings cannot represent the entire diversity of planktonic cnidarians in this region. The specific taxonomic composition of this group revealed the presence of meroplanktonic hydrozoans (15 Anthoathecata and eight Leptothecata), and the variability that characterizes the hydromedusae fauna of the western Mediterranean (Bouillon *et al.*, 2004; Sabatés *et al.*, 2010; Kherchouche and Hafferssas, 2020; Gueroun *et al.*, 2022). The coastal location of the sampling stations could explain the diversity of meroplanktonic taxa observed. However, this distribution, which is more marked in Algiers Bay, could also have another explanation related to the anthropogenic nature of this site. It is now recognized that the distribution of organisms, particularly at the polyp stage, may be a direct consequence of human impact on coastal ecosystems, particularly in response to environmental degradation (Cornelius, 1990; Boero *et al.*, 2008). Additionally, it is notable that anthropogenic constructions in the coastal area, such as port installations, furnish an advantageous substrate for the adhesion of polyp colonies (Duarte *et al*., 2013)

In terms of frequency, the most common medusae species are holoplanktonic forms such as *A. hemistoma, R. velatum, L. tetraphylla, S. bitentaculata,* and *P. noctiluca*. These species were present in more than 40% of the samples. This trend has also been described for the same species in the western Mediterranean and Adriatic Sea (Benović *et al.,* 2005; Touzri *et al.,* 2010). A previous study on medusae species off the central and eastern Algerian coast revealed that these holoplanktonic species are the most frequently observed overall (Kherchouche and Hafferssas, 2020). Moreover, according to quantitative analyses, they are numerically dominant in these waters (Kherchouche and Hafferssas, 2020). This holoplankton character is reinforced by a strong presence of siphonophores, mainly Calycophorae such as *A. tetragona, M. atlantica, L. subtilis* and *M. kochii.* The first three species are considered the most frequent populations of planktonic cnidarians along the

Algerian coast. Similarly, in the western Mediterranean and Adriatic Sea, *A. tetragona* and *L. subtilis* are among the most frequent carnivorous zooplankton (Mills *et al.,* 1996; Batistić *et al.,* 2007). The prevalence of either meroplanktonic or holoplanktonic hydrozoans may also be related to geomorphological characteristics of the continental margin, such as the extent and depth of continental shelf (Sabatés *et al.*, 2010; Kherchouche and Hafferssas, 2020).

In the western Mediterranean, another factor that influences the distribution of planktonic cnidarians is the Atlantic current. Along the Algerian coast, the genus *Muggiaea* is mainly represented by *M. atlantica*. This species is the second most common after *A. tetragona*. In this study, it was identified in about 70% of the samples, while *M. kochii* was recorded in 52% of the collections. In the Mediterranean region, the genus *Muggiaea* is mainly represented by *M. kochii*, which used to be considered the most common and dominant Calycophora (Touzri *et al.,* 2012; Batistić *et al.,* 2013). Since the 1980s, the Atlantic species *M. atlantica* has gradually colonized the western Mediterranean region. It spread to the Ligurian Sea (Licandro *et al.,* 2012), the Catalan Sea (Guerrero *et al.,* 2016) and the Adriatic Sea (Batistić *et al.,* 2007; Pestorić *et al.,* 2012).

The seasonal composition of the planktonic cnidarian fauna showed greater biodiversity in spring and summer. This seasonal affinity was also observed along Tunisian coastal waters (Daly Yahia *et al.,* 2003; Touzri *et al.,* 2010). Furthermore, this seasonal variability seems to be more pronounced in medusae populations, especially in the meroplanktonic species. Some species occur briefly in spring (*Ephysa aurata, Paragotoea bathybia, Kantiella enigmatica, Proboscidactyla ornata, Stauridiosarsia gemmifera* and *Lovenella clausa*) or in autumn (*Podocorynoides minima* and *Sarsia* sp.). In addition, the results of the cluster analysis indicated that the spring and late summer populations were characterized by common meroplanktonic species (*Obelia* spp., *L. blondina, Clytia* spp. and *E. paradoxica*). This variability likely reflects the biological responses of these populations to environmental changes (Benović *et al.,* 2005). Various environmental factors influence their benthic stages (polyps), including temperature, food availability, photoperiod, salinity, lunar cycle and possible combinations (Arai, 1992). In contrast, about 50% of the holoplanktonic hydromedusae (*A. hemistoma, R. velatum, L. tetraphyla, S. bitentaculata* and *Solmaris* sp.) were observed throughout the study period. The spring assemblage was also characterized by a large number of siphonophores, such as *L. subtiloides, N. bijuga, C. appendiculata, H. hippopus* and *B. bassensis*. The latter three species are widely distributed in the Adriatic Sea (Lučić *et al.,* 2009a). The population of *C. appendiculata* is the most abundant Calycophora, especially in the Ligurian Sea (Dallot *et al.,*1988; Collignon *et al.,* 2010).

CONCLUSION

This study allowed us to obtain one of the first records of the planktonic cnidarian fauna in Algerian coastal waters and to consolidate basic data on the species composition of hydromedusae, siphonophores and Scyphomedusae. We identified a total of 60 taxa, of which 57 belong to the class Hydrozoa (34 hydromedusae and 23 Siphonophorae) and three species are classified as Scyphozoa. Of these taxa, nine species were reported for the first time in the southernwestern Mediterranean waters (*Forskalia contorta*, *Kantiella enigmatica*, *Leuckartiara octona*, *Proboscidactyla ornata*, *Cunina globosa*, *Lovenella cirrata*, *Cirroholovenia tetranema*, *Phialella quadrata* and *Homoeonema platygonon*), including two non-indigenous species (*Kantiella enigmatica* and *Cirroholovenia tetranema*). The qualitative composition of the medusae is characterized by a greater diversity of meroplanktonic forms compared to holoplanktonic forms. However, the most prevalent species are holoplanktonic, including *A. hemistoma*, *R. velatum*, *L. tetraphylla*, *S. bitentaculata* and *P. noctiluca*, complemented by the siphonophores *A. tetragona*, *M. atlantica*, *L. subtilis* and *M. kochii*. In addition, we found that the cnidarian fauna is more diverse in the spring and summer months. The Gulf of Algeria had the highest number of taxa compared to the other areas studied. The results of this study serve as a first point of reference for future studies, for which a considerable amount of spatio-temporal data is required to fully document the taxonomic composition of this group of organisms and to understand the distribution patterns in relation to environmental factors, including human-induced factors. In the context of climate change, changes in the qualitative (species dominance, presence of non-indigenous species) and quantitative aspects (abundance, occurrence of blooms) of the cnidarian community can serve as an indicator of changes in the structure and consequently the ecosystem functioning.

ACKNOWLEDGEMENTS

The authors express their gratitude to the reviewers for their meticulous examination of the paper and their insightful comments, which greatly contributed to improving the manuscript. We would like to express our gratitude for the assistance provided by the National Higher School of Marine Sciences and Coastal Management (ENSSMAL), National Institute of Fisheries and Aquaculture (INSPA), National Center of Fisheries Aquaculture Development (CNRDPA), and National Coastal Commissariat (CNL) during the sampling operation.

REFERENCES

Acevedo, M., Straehler-pohl, I., Morandini, A.C., Stampar, S.N., Bentlage, B., Matsumoto, G.I., Yanagihara, A., *et al.* 2019. Revision of the genus Carybdea (Cnidaria: Cubozoa: Carybdeidae): clarifying the identity of its type species *Carybdea marsupialis*. Zootaxa, 4543, 515-548. https://doi.org/10.11646/zootaxa.4543.4.3.

Ali, L., Bachari, N.E.I. 2021. Spatio-temporal variation of sea surface temperature (SST) and marine chlorophyll concentrations along the Algerian coast (SE Alboran Sub-Basin and Algerian Sub-Basin). Analele Universitatii Din Oradea, Fascicula Biologie, 28(2), 184-193.

Arai, M.N. 1992. Active and passive factors affecting aggregations of Hydromedusae: a review. Scientia Marina, 56(2), 99-108.

Arai, M.N. 1997. A functional biology of Scyphozoa. Chapman and Hall, London. 316 pp.

Bahbah, L., Bensari, B., Chabane, K., Torras, X., Ballesteros, E., Seridi, H., 2020. Cartography of littoral rocky-shore communities to assess the ecological status of water bodies through the application of CARLIT method in Algeria (South-Western Mediterranean Sea). Marine Pollution Bulletin, 157, 111356. https://doi.org/10.1016/j.marpolbul.2020.111356

Batistić, M, Jasprica N., Carić, M., Lučić, D. 2007. Annual cycle of the gelatinous invertebrate zooplankton of the eastern south Adriatic coast (NE Mediterranean). Journal of Plankton Research, 29(8), 671-686. https://doi.org/10.1093/plankt/fbm048

Batistić, M., Lučić, D., Carić, M., Garić, R., Licandro, P., Jasprica, N. 2013. Did the alien calycophoran *Muggiaea atlantica* outcompete its native congeneric *M. kochii* in the marine lakes of Mljet Island (Croatia)? Marine Ecology, 34, 3-13. https://doi.org/10.1111/maec.12021

Beaugrand, G., Reid, P.C., Ibanez, F., Lindley, J.A., Edwards, M. 2002. Reorganization of North Atlantic marine copepod biodiversity and climate. Science, 296, 1692-1694 https://doi.org/10.1126/science.1071329

Belkacem, Y., Benfares, R., Houma Bachari, F. 2016. Potential impacts of discharges from seawater reverse osmosis on Algeria marine environment. Journal of Environmental Science and Engineering, 5, 131-138. https://doi.org/10.17265/2162-5263/2016.03.005

Benović, A., Bender, A. 1987. Seasonal distribution of Medusae in the Adriatic Sea. *In* Modern Trends in the Systematics, Ecology and Evolution of Hydroids and hydromedusae (eds. J. Bouillon, F. Boero, F. Cicogna, P.F.S. Cornelius). Oxford University Press. pp.117-131.

Benović, A., Lučić, D. 1996. Comparison of hydromedusae findings in the northern and southern Adriatic Sea. Scientia Marina, 60(1), 129-135.

Benović, A., Lučić, D., Onofri, V. 2000. Does change in an Adriatic hydromedusan fauna indicate an early phase of marine ecosystem destruction? Marine Ecology, 21(3-4), 221-231. https://doi.org/10.1046/j.1439-0485.2000.00712.x

Benović, A., Lučić, D., Onofri, V., Batistić, M., Njire, J. 2005. Bathymetric distribution of Medusae in the open waters of the Middle and South Adriatic Sea during spring 200. Journal of Plankton Research, 27(1), 79-89. https://doi.org/ 10.1093/plankt/fbh153

Boero, F., Bouillon, J. 1993. Zoogeography and life cycle patterns of Mediterranean hydromedusae (Cnidaria). Biological Journal of the Linnean Society, 48(3), 239-266. https://doi.org/10.1111/j.1095-8312.1993.tb00890.x

Boero, F., Bouillon, J., Gravili, C., Miglietta, M.P., Parsons, T., Piraino, S. 2008. Gelatinous plankton: irregularities rule the world (sometimes). Marine Ecology Progress Series, 356, 299-310. https://doi.org/10.3354/meps07368

Boudjenah, M., Mokrane, Z., Soualili, D. 2019. Diversity of Phytoplanktonic populations along the Algerian coastline. Biodiversity Journal, 10(2), 81-92. https://doi.org/10.31396/Biodiv.Jour.2019.10.2.81.92

Bouillon, J. 1999. Hydromedusae, Cubomedusae and Scyphomedusae. *In* South Atlantic Zooplankton (ed D. Boltovskoy). Backhuys Publishers. pp. 385-559.

Bouillon, J., Boero, F. 2000. The Hydrozoa: a new classification in the light of old knowledge. Thalassia Salentina, 24, 3-45. https://doi.org/10.1285/i15910725v24p3

Bouillon, J., Medel, M.D., Pagès, F., Gili, J.M., Boero, F., Gravili, C. 2004. Fauna of the Mediterranean hydrozoa. Scientia Marina, 68(S2), 5-438. https://doi.org/10.3989/scimar.2004.68s25

Bouillon, J., Gravili, C., Pagès, F., Gili, J.M., Boero, F. 2006. An introduction to Hydrozoa. Publications Scientifiques du Muséum, Paris, 591 pp.

Buecher, E., Gibbons, M.J. 1999. Temporal persistence in the vertical structure of the assemblage of planktonic Medusae in the NW Mediterranean Sea. Marine Ecology Progress Series, 189, 105-115. https://doi.org/10.3354/meps189105

Chaouadi, M., Hafferssas, A. 2018. Seasonal variability in diversity and abundance of the free-living pelagic copepod community of the Algerian coasts (SW Mediterranean Sea). Crustaceana, 91(8), 913-946.

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Lasram, F.B.R., Aguzzi, J., Ballesteros, E., *et al*. 2010. The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. PloS ONE, 5(8), e11842. https://doi.org/10.1371/journal.pone.0011842

Collignon, A., Goffart, A., Hecq, J.H. 2010. Interannual variation (2003-2008) of calycophoran siphonophores in the bay of Calvi (Corsica). Rapports et procès-verbaux des réunions Commission Internationale pour l'exploration scientifique de la Mer Méditerranée. 39, 480.

Cornelius, P.F.S. 1990. Evolution in leptolid-cycles (Cnidaria: Hydroida). Journal of Natural History, 24(3), 579-594. https://doi.org/10.1080/00222939000770391

Dallot, S., Goy, J., Carré, C. 1988. Peuplements de carnivores planctoniques gélatineux et structures productives en Méditerranée occidentale. Oceanologica Acta, Special issue, 193-209.

Daly Yahia, M.N., Goy, J., Daly Yahia Kéfi, O. 2003. Distribution et écologie des Méduses (Cnidaria) du golfe de Tunis (Méditerranée sud occidentale). Oceanologica Acta, 26(5-6), 645-655. https://doi.org/10.1016/j.oceact.2003.05.002

Duarte, C.M., Pitt, K.A., Lucas, C.H., Purcell, J.E., Uye, S.I., Robinson, K., Brotz, L., *et al*. 2013. Is global ocean sprawl a cause of jellyfish blooms?. Frontiers in Ecology and the Environment, 11(2), 91-97. https://doi.org/10.1890/110246

Gamulin, T. and Kršinić, F. 2000. Calycophores (Siphonophora, Calycophorae) of the Adriatic and Mediterranean Seas. Natura Croatica, 9 (2), 1-198.

Gili, J.M., Pagès, F., Sabatés, A., Ros, J.D. 1988. Small-scale distribution of cnidarian population in western Mediter-

ranean. Journal of Plankton Research, 10(3), 385-401. https://doi.org/10.1093/plankt/10.3.385

Goy, J, 1991. Hydromedusae of the Mediterranean Sea. Hydrobiologia, 216, 351-354. https://doi.org/10.1007/BF00026485

Goy, J., Dallot, S., Corre, A.M., Nival, P. 2016. A multi-year time series of Hydromedusae sampled in discrete depth strata at a deep water station off Villefranche Bay (Mediterranean Sea) from 1963 to 1966. Journal of Oceanography, Research and Data, 9(1), 1-13.

Gravili, C., Rossi, S. 2021. Who's next? Non-indigenous cnidarian and ctenophoran species approaching to the Italian waters. Water, 13(8), 1062. https://doi.org/10.3390/w13081062

Gueroun, S.K., Piraino, S., Kéfi-Daly Yahia, O., Daly Yahia, M.N. 2022. Jellyfish diversity, trends and patterns in Southwestern Mediterranean Sea: a citizen science and field monitoring alliance. Journal of Plankton Research, 44(6), 819-837. https://doi.org/10.1093/plankt/fbac057

Guerrero, E., Marrodán, A., Sabatés, A., Orejas, C., Gili, J. M. 2016. High spatial heterogeneity of two planktonic cnidarian species related to the variability of a shelf-slope front at short time scales. Scientia Marina, 80(4), 487-497. https://doi.org/10.3989/scimar.04452.03A

Guerrero, E., Gili, J.M., Grinyó, J., Raya, V., Sabatés, A. 2018. Long-term changes in the planktonic cnidarian community in a mesoscale area of the NW Mediterranean. PLoS ONE, 13(5), e0196431. https://doi.org/10.1371/journal.pone.0196431

Hafferssas, A., Seridji, R. 2010. Relationships between the hydrodynamics and changes in copepod structure on the Algerian coast. Zoological Studies, 49(3), 353-366.

Hafferssas, A., Seridji, R., Dallot, S. 2010. Mesozooplankton abundance and biomass related to hydrological structure along the Algerian coasts (SW Mediterranean Sea). Crustaceana, 83(11), 1281-1302.

Hosia, A., Augustin, C.B., Dinasquet, J., Granhag, L., Paulsen, M.L., Riemann, L., Rintala, J.M., *et al*. 2014. Autumnal bottom-up and top-down impacts of *Cyanea capillata*: A mesocosm study. Journal of Plankton Research, 37(5), 1042–1055. https://doi.org/10.1093/plankt/fbv046

Houma, F., Bachouche, S., Bachari, N.E.I., Belkessa, R. 2013. Contribution of satellite measurements to the modeling and monitoring of the quality of coastal seawater. In: Perspectives in Water Pollution. Intech Open, Imran Ahmad Dar, pp. 220. https://doi.org/10.5772/50060

Khames, Y.G., Hafferssas, A. 2018. Biodiversity and abundance of gelatinous zooplankton along Algerian coast. Revue d'Ecologie, Terre et Vie, 73(3), 211-226. https://doi.org/10.3406/revec.2018.1930

Khames, Y.G., Hafferssas, A. 2019. Abundance and species composition of gelatinous zooplankton in Habibas Islands and Sidi Fredj (Western Mediterranean Sea). Cahier de Biologie Marine, 60, 143-152. https://doi.org/10.21411/CBM.A.B67AE980

Khames, G.E.Y., Kherchouche, A., Alioua, Z., Hafferssas, A. 2023. Temporal patterns of gelatinous zooplankton distribution and environmental drivers in the south-western Mediterranean Sea. Biodiversity Data Journal, 11, e101790. https://doi.org/10.3897/BDJ.11.e101790

Kherchouche, A., Hafferssas, A. 2020. Species composition and distribution of Medusae (Cnidaria: medusozoa) in the Algerian coast between 2°E and 7°E (SW Mediterranean Sea). Mediterranean Marine Science, 21(1), 52-61. https://doi.org/10.12681/mms.20849

Lejeusne, C., Chevaldonné, P., Pergent-Martini, C., Boudouresque, C.F., Pérez, T. 2010. Climate change effects on a miniature ocean: the highly diverse, highly impacted Mediterranean Sea. Trends in Ecology & Evolution, 25(4), 250-260. https://doi.org/10.1016/j.tree.2009.10.009

Licandro, P., Souissi, S., Ibañez, F., Carré, C. 2012. Long-term variability and environmental preferences of calycophoran siphonophores in the Bay of Villefranche (north-western Mediterranean). Progress in Oceanography, 97, 152-163. https://doi.org/10.1016/j.pocean.2011.11.004

Lučić, D., Benović, A., Onofri, I., Batistić, M., Gangai, B., Miloslavić, M., Onofri, V., *et al.* 2009a. Planktonic cnidarians in the open southern Adriatic Sea: a comparison of historical and recent data. Annales. Series Historia Naturalis, 19(2), 27-38.

Lučić, D., Benović, A., Morović, M., Batistić, M., Onofri, I. 2009b. Diel vertical migration of medusa in the open Southern Adriatic Sea over a short time period (July 2003). Marine Ecology, 30(1), 16-32. https://doi.org/10.1111/j.1439-0485.2008.00264.x

Malej, A., Kogovšek, T., Ramšak, A., Catenacci, L. 2012. Blooms and population dynamics of moon jellyfish in the northern Adriatic. Cahiers de Biologie Marine, 53(3), 337-342.

Mellak, L., Hafferssas, A. 2022. Copepod communities of the Algerian coast (southwestern Mediterranean Sea, 2°-7° E) and their interaction with hydro-climatic variability. Crustaceana, 95(4), 457-482.

Mianzan, H., Cornelius, P.F.S. 1999. Cubomedusae and Scyphomedusae. *In* South Atlantic Zooplankton (ed. D. Boltovskoy). Backhuys Publishers. pp. 513-559.

Millot, C., Taupier-Letage, I. 2005. Circulation in the Mediterranean Sea. *In* The Mediterranean Sea. Springer. pp. 29-66. https://doi.org/10.1007/b107143

Mills, C.E., Pugh, P.R., Harbison, G.R., Haddock, S.H.D. 1996. Medusae, siphonophores and ctenophores of the Alboran Sea, south western Mediterranean. Scientia Marina, 60(1), 145-163.

Occhipinti-Ambrogi, A., Marchini, A., Cantone, G., Castelli, A., Chimenz, C., Cormaci, M., Froglia, C., *et al*. 2011. Alien species along the Italian coasts: an overview. Biological Invasions, 13, 215-237. https://doi.org/10.1007/s10530-010-9803-y

Ounissi, M., Laskri, H., Khélifi-Touhami, M. 2016. Net-Zooplankton and biomass from Annaba Bay (SW Mediterranean Sea) under estuarine influences. Mediterranean Marine Science, 17(2), 519-532. https://doi.org/10.12681/mms.1474

Pestorić, B., Krpo-Ćetković, J., Gangai, B., Lučić, D. 2012. Pelagic cnidarians in the Boka Kotorska Bay, Montenegro (South Adriatic). Acta Adriatica, 53(2), 291-302.

Picard, J. 1958. Origines et affinités de la faune d'hydropolypes (Gymnoblastes et Calyptoblastes) et d'hydrméduses (Anthoméduses et Leptoméduses) de la Méditerranée. Rapports et Procès-verbaux des Réunions Commission internationale pour l'Exploration Scientifique de la Mer Méditerranée, 14, 187-199.

Pugh, P.R., Pages, F., Boorman, B. 1997. Vertical distribution and abundance of pelagic Cnidarians in the eastern Weddell Sea, Antarctica. Journal of the Marine Biological Association of the United Kingdom, 77(2), 341-360. https://doi.org/10.1017/S002531540007171X

Pugh, P.R., 1999. Siphonophorae. *In* South Atlantic Zooplankton (ed. D. Boltovskoy). Blackhuys Publishers. pp. 467–511.

Richardson, A.J., Bakun, A., Hays, G.C., Gibbons, M.J. 2009. The jellyfish joyride: causes, consequences and management responses to a more gelatinous future. Trends in Ecology & Evolution, 24(6), 312-322. https://doi.org/10.1016/j.tree.2009.01.010

Sabatés, A., Pagès, F., Atienza, D., Fuentes, V., Purcell, J.E., Gili, J.M. 2010. Planktonic cnidarian distribution and feeding of *Pelagia noctiluca* in the NW Mediterranean Sea. Hydrobiologia. 645(1), 153-165. https://doi.org/10.1007/s10750-010-0221-z

Seguin, G. 1973. Cycles comparés du zooplancton dans l'Ouest Africain et la Méditerranée sud occidentale. PhD thesis, University of Lille, 120 pp.

Seridji, R., Hafferssas, A. 2000. Copepod diversity and community structure in the Algerian basin. Crustaceana, 73(1), 1-23.

Templado, J. 2014. Future trends of Mediterranean biodiversity. *In* The Mediterranean Sea: Its history and present challenges (eds. S. Goffredo, Z. Dubinsky). Springer. pp. 479-498. https://doi.org/10.1007/978-94-007-6704-1_28

Touzri, C., Daly Yahia-Kefi, O., Hamdi, H., Goy, J., Daly Yahia, M.N. 2010. Spatio-temporal distribution of Medusae (Cnidaria) in the Bay of Bizerte (South Western Mediterranean Sea). Cahiers de Biologie Marine, 51(2), 167-176.

Touzri, C., Hamdi, H., Goy, J., Daly Yahia, M.N. 2012. Diversity and distribution of gelatinous zooplankton in the Southwestern Mediterranean Sea. Marine Ecology, 33(4), 393-406. https://doi.org/10.1111/j.1439-0485.2012.00510.x

Trégouboff, G., Rose, M. 1957. Manuel de Planctonologie Méditerranéenne. Tomes 1 et 2, Edition CNRS, 587 pp.

UNESCO, 1968. Monographs on oceanographic methodology. UNESCO, 174 pp.

Ward, J. H., 1963. Hierarchical grouping to optimize an objective function. Journal of the American Statistical Association, 58(301), 236-244.

Zenetos, A., Gofas, S., Verlaque, M., Çinar, M.E., Raso, J. G., Bianchi, C.N., Morri, C., *et al.* 2010. Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. Mediterranean Marine Science, 11(2), 381-493. https://doi.org/10.12681/mms.87