

Article

Inventory and Geographical Affinities of Algerian Cumacea, Isopoda, Mysida, Lophogastrida and Tanaidacea (Crustacea Peracarida)

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Abstract: This study records the number of Peracarida (Cumacea, Isopoda, Mysida, Lophogastrida and Tanaidacea) from Algerian coastal waters. A total of 170 species are reported with the highest richness observed in the Isopoda (71 species), then the Cumacea with 43 species, the Mysida and Tanaidacea with 27 species each and the Lophogastrida with only two species. The diversity of Peracarida in Algeria is high, corresponding to 60% of the species recorded for the Mediterranean Sea. A geographical analysis of the distribution of the species shows that the Algerian fauna has a close similarity with taxa reported from both the European and African coasts of the Atlantic Ocean. This reflects the influence of Atlantic waters along the North African coasts extending from Morocco to Tunisia in the south of the Mediterranean Sea, which is related to the connection via the Strait of Gibraltar. For the Algerian coasts only five Peracarida species may be considered as Non-Indigenous Species.

Keywords: Peracarida; Algeria; diversity; geographical distribution; fauna affinities



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1. Introduction

The Mediterranean Sea is recognized as a hot spot of marine biodiversity [1,2]. Coll et al. [1] reported 10,902 invertebrate marine species, including 2239 crustacean species, of which 858 belong to the Peracarida (8% of the diversity). The most diversified Peracarida group is the Amphipoda with 443 species, while other Peracarida account for 415 species (165 Isopoda, 102 Mysida, 99 Cumacea, 43 Tanaidacea and only six Lophogastrida) [1]. Moreover, these authors [1] highlighted that the diversity was probably still underestimated and incomplete. This Peracarida biodiversity needs to be supplemented with additional species found in some southern areas of the Mediterranean Sea as well in the deeper parts of the eastern basin; this gap in our knowledge concerns mostly the coasts of North Africa (Morocco, Tunisia, Algeria, Libya and Egypt).

As regards the Peracarida, the first inventory of marine Amphipoda on the Algerian coast was provided by Chevreux [3]. More recently, Bakalem and Dauvin [4], Bakalem et al. [5] and Grimes et al. [6] compiled a more exhaustive inventory of the benthic marine amphipods of the Algerian coast, recording a total of 332 species (75% of the Mediterranean Amphipoda Fauna).

Nevertheless, numerous publications report inventories at local, national and regional scales for the Mediterranean Sea and have notably contributed to our knowledge of Peracarid groups (see [1], for references before 2008). Some inventories cover the entire Mediterranean Sea [7–10], while others are limited to certain areas: the Alboran Sea [11–14], the Mediterranean coasts of Spain [9,15–21] and France [22,23], Italian waters [24–29], the Adriatic Sea [30], as well as the coasts of Tunisia [31–40], Malta [41], Libya [42], Greece [43–45], Turkey [46–50], the Levantine Sea [10,51–57] and the Black Sea [58]. Thus, publications over

the last decade have contributed to an increased knowledge of the diversity of Peracarida. For example, Coll et al. [1] estimated the isopod diversity at 165 species, ten years later this diversity was evaluated at 295 species [10].

The first inventory of the Algerian marine Crustacea (mainly Decapoda; Isopoda and Tanaidacea) was given by Lucas [59]. Later on, Monod [60], Seurat [61] Nouvel & Hoemigman [62], Dion & Nouvel [63] and Nouvel [64] supplemented the list of reported Isopoda, Mysida and Tanaidacea. In their studies of the soft-bottom benthic macrofauna of Algeria, Dieuzeide [65], Vaissière & Fredj [66], Le Gall [67], Falconetti [68], Petit [69] reported Cumacea, Isopoda, Mysida, and Tanaidacea.

Original inventories of the marine invertebrates and studies of the marine soft-bottom macrobenthic habitats of Algerian coasts were conducted from the end of the nineteenth century up until the 1970s. Subsequently, between 1975 and 2015, a wide range of soft-bottom communities along the 1200 km of the Algerian coastline were sampled in 27 areas (12 bays or gulfs, two insular environments and 13 harbours) (Figure 1) [see [70,71] and references therein]. Dauvin et al. [72] recorded 1642 macrofauna species from the soft-bottom communities of the Algerian coast, with two dominant groups: the Crustacea with 603 species and the Polychaeta which currently account for 534 species [73]. The studies of Bakalem [70] and Grimes [71] reported, respectively, 103 and 101 Cumacea, Isopoda, Lophogastrida, Mysida and Tanaidacea species, while Ramdane et al. [74,75] and Ramdane & Trilles [76] inventoried the parasitic Isopoda species of the Algerian coasts.

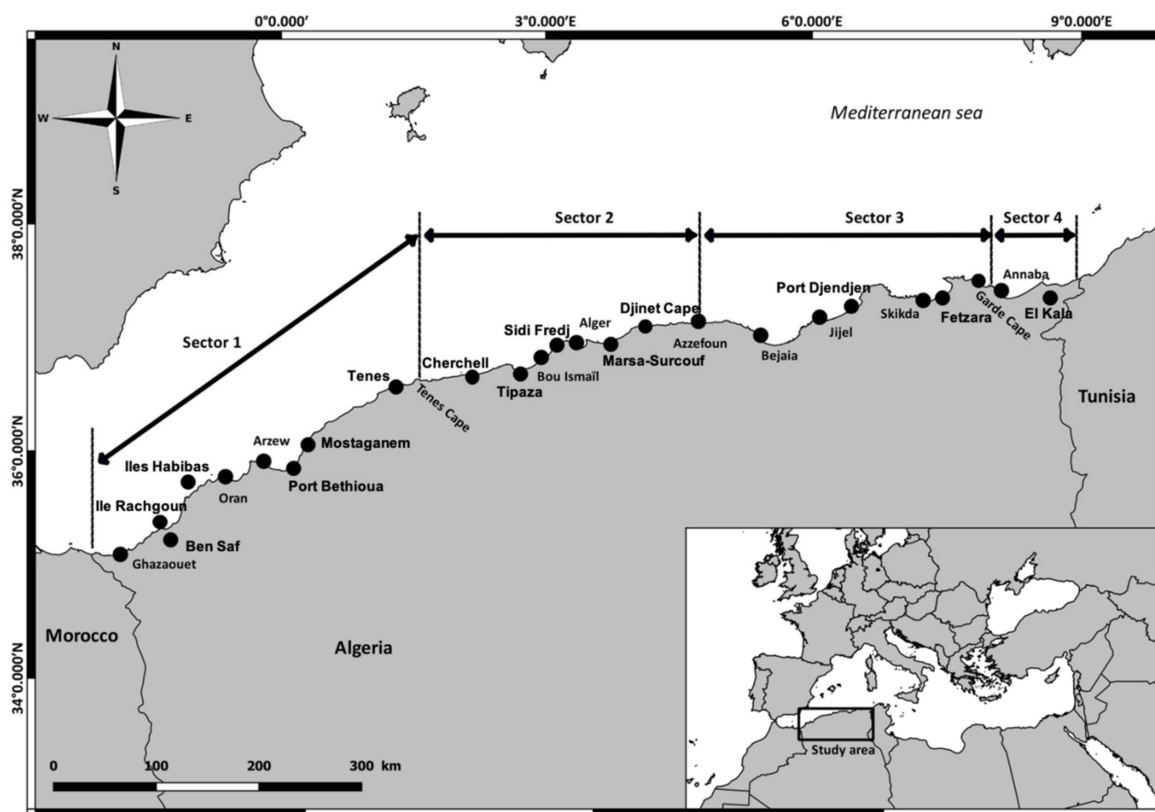


Figure 1. Main location of the Peracarida records.

The main objectives of this study are: (1) to present the status of the Peracarida, including species belonging to the Cumacea, Isopoda, Lophogastrida, Mysida and Tanaidacea recorded along the Algerian coastline; (2) to attribute geographical affinities for each of these Algerian Peracarida species; and (3) to compare the inventory reported from coastal waters off Algeria with similar inventories compiled for other areas of the Mediterranean Sea, and some neighbouring zones of the World Ocean.

2. Materials and Methods

2.1. General Characteristics of the Algerian Coastal Zone

The main characteristics of the Algerian coastline are given in [70,72,73] and can be summarized as follows: the continental shelf is narrow with rocky shores made up of alternating bays and gulfs; the silt content of sediments increases with depth; remarkable habitats are present in shallow waters, including *Posidonia oceanica* meadows and coral-ligenous formations; the surface sea circulation is mainly influenced by North Atlantic surface waters.

2.2. Geographical Patterns of the Peracarida Species

The distribution of species found in Algerian waters is categorized taking into account the distinct biogeographical zones or regions of the Mediterranean and related maritime areas as proposed [1] and modified by [73]. The areas considered here are: 1: African Atlantic Coast (from Cap Spartel to Cap Blanc); 2: North-Eastern Atlantic European waters; 3: Alboran Sea; 4: North-Western Mediterranean; 5: South-Western Mediterranean (Algerian coasts); 6: Ionian Sea; 7: Tunisian shelf and Libya; 8: Adriatic Sea; 9: Aegean and Marmara Seas; 10: Black Sea; 11: Levantine Sea; 12: Red Sea; 13: Indo-Pacific oceans; 14: Indian Ocean and 15: Pacific ocean. Each species found on the Algerian coast is classified into one of fourteen groups reflecting their geographical repartition [73]: EAM (European and African Atlantic, Mediterranean); EM (European Atlantic and Mediterranean); AM (African Atlantic coast and Mediterranean); E (endemic species); C (cosmopolitan species); EMR (European Atlantic, Mediterranean and Red Sea); AMIP (African Atlantic, Mediterranean and Indo-Pacific); EAMIP (European and African Atlantic, Mediterranean and Indo-Pacific); EAMR (European and African Atlantic, Mediterranean and Red Sea); EAMP (European and African Atlantic, Mediterranean and Pacific); EAMRI (European and African Atlantic, Mediterranean, Red Sea and Indian Ocean); EAMI (European and African Atlantic, Mediterranean, and Indian Ocean) and MWAR (Mediterranean, Western Atlantic and Red Sea).

Hierarchical Cluster Analysis (HCA) was carried out on the 15 groups cited above based on Sorensen's coefficient for the Presence/Absence of the species found in four west-east sectors of the Algerian coasts defined in [72,73], with the construction of dendrograms using the group average algorithm generated from the PRIMER V6 software [77].

2.3. Nomenclature and Peracarida Classification

The species are classified by order (Cumacea, Isopoda, Lophogastrida, Mysida and Tanaidacea), and in alphabetical family order (Table 1). The World Register of Marine Species was used to update data from the literature (WoRMS Editorial Board (2021). World Register of Marine Species. Available from <http://www.marinespecies.org> at VLIZ. Accessed on 25 January 2021, doi:10.14284/170). Some species considered *taxa inquirenda* (species of doubtful identity needing further investigation) and *nomina dubia* (name of unknown or doubtful application) as defined by the International Commission on Zoological Nomenclature (ICZN, 1999) are included in our inventory.

To assign the status of Non-Indigenous Species (NIS) to certain species found in Algerian waters, we based ourselves on the work of [78–81]. Castelló et al. [10] studied the distribution of isopods from the Mediterranean biogeographical sub-regions and the Red Sea; in their study, they identified “Lessepsian species” and “anti-Lessepsian species”. The term “Lessepsian” (L) is applied, according to [82], to species crossing the Suez Canal by their own means and reaching the Mediterranean Sea. Por [82] also used the term “anti-Lessepsian” (Anti-L) for species that follow a path opposite to Lessepsians. For the identification of “Lessepsian species” and “anti-Lessepsian species” from the Algerian coast, we refer to the studies of these authors [10,78–81].

Table 1. List of the Peracarida excluding Amphipoda recorded along the Algerian coast. The species are classified following the alphabetical order of the families. 1: present species, 0: absent species. S1: Sector 1; S2: Sector 2; S3: Sector 3; S4: Sector 4. Geo. Dist., Geographical Distribution: EM: European Atlantic and Mediterranean species; EAM: European and African Atlantic and Mediterranean species; E: endemic species; C: cosmopolitan species; NIS: non-indigenous species; EAMR: European and African Atlantic, Mediterranean and Red Sea species; EMR: European Atlantic, Mediterranean and Red Sea species; EAMRI: European and African Atlantic, Mediterranean, Red Sea and Indian Ocean species; EAMI: European and African Atlantic, Mediterranean, and Indian Ocean species; MWAR: Mediterranean, Western Atlantic and Red Sea; EAMP: European and African Atlantic, Mediterranean and Pacific species; EAMIP: European and African Atlantic, Mediterranean and Indo-Pacific species; AMIP: African Atlantic, Mediterranean and Indo-Pacific species; MIP: Mediterranean and Indo-Pacific species; AM: African Atlantic coast and Mediterranean species. Biogeographical Area, 1: African Atlantic Coast (from Cap Spartel to Cap Blanc); 2: North-Eastern Atlantic European waters; 3: Alboran Sea; 4: North-Western Mediterranean; 5: South-Western Mediterranean (Algerian coasts); 6: Ionian Sea; 7: Tunisian shelf and Libya; 8: Adriatic Sea; 9: Aegean and Marmara Seas; 10: Black Sea; 11: Levantine Sea; 12: Red Sea; 13: Indo-Pacific oceans; 14: Indian Ocean and 15: Pacific ocean.

Species	Status Success	Geo. Dist.	Sectors				Biogeographical Areas														
			S1	S2	S3	S4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cumacea																					
Familie Bodotriidae																					
<i>Bodotria gibba</i> (Sars, 1878)		E	1	1	1	0				1	1									1	
<i>Bodotria pulchella</i> (Sars, 1878)		EAM	1	1	0	0	1	1	1	1	1					1				1	
<i>Bodotria scorpioides</i> (Montagu, 1804)		EAMR	1	1	1	0	1	1	1	1	1	1	1	1	1				1	1	
<i>Cumopsis goodsir</i> (Van Beneden, 1861)		EAM	0	0	1	0	1	1	1	1	1					1	1				1
<i>Cumopsis longipes</i> (Dohrn, 1869)		EM	1	1	0	0		1		1	1		1						1	1	
<i>Cyclaspis longicaudata</i> Sars, 1865		EAM	0	1	0	0	1	1	1	1	1	1	1	1		1				1	
<i>Eocuma dollfusi</i> Calman, 1907		EAM	0	1	0	0	1	1				1									
<i>Eocuma ferox</i> (Fischer, 1872)		EM	1	1	1	0		1		1	1					1					
<i>Eocuma sarsii</i> (Kossmann), 1880	Alien Casual	MIP	1	0	0	0				1	1					1			1		1
<i>Iphinoe acutirostris</i> Ledoyer, 1965		E	1	1	0	0				1	1										
<i>Iphinoe armata</i> Ledoyer, 1965		E	0	1	1	0				1	1				1					1	
<i>Iphinoe douniae</i> Ledoyer, 1965		EM	1	1	1	0		1		1	1		1			1				1	
<i>Iphinoe elisae</i> Băcescu, 1950		E	0	1	0	0			1	1	1			1	1	1					
<i>Iphinoe inermis</i> Sars, 1878		E	1	1	1	1	1		1	1	1			1					1		
<i>Iphinoe maculata</i> Ledoyer, 1965		E	0	1	0	0			1	1	1										
<i>Iphinoe serrata</i> Norman, 1867		EAM	1	1	1	0	1	1	1	1	1		1	1	1	1	1	1	1	1	1
<i>Iphinoe tenella</i> Sars, 1878		EAM	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Iphinoe trispinosa</i> (Goodsir, 1843)		EAM	1	1	1	0	1	1	1	1	1		1	1	1					1	
<i>Vaunthompsonia cristata</i> Bate, 1858		EAMP	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Familie Diastylidae																					
<i>Diastylis bradyi</i> Norman, 1879		EM	1	0	0	0		1		1	1										
<i>Diastylis cornuta</i> (Boeck, 1864)		EM	1	1	1	0	1	1	1	1	1	1	1	1		1				1	
<i>Diastylis laevis</i> Norman, 1869		EAM	1	0	0	0	1	1		1	1									1	
<i>Diastylis neapolitana</i> Sars, 1879		E	1	1	0	0				1	1					1				1	
<i>Diastylis rugosa</i> Sars, 1865		EM	1	0	0	0		1		1	1	1	1	1	1	1	1	1	1	1	1
<i>Diastylis tumida</i> (Liljeborg, 1855)		EAM	1	0	0	0	1	1	1		1										
<i>Diastylodes bacescoi</i> Fage, 1940		EAM	1	1	1	0		1	1	1	1	1				1				1	
<i>Diastylodes biplicatus</i> (Sars G.O., 1865)		EM	1	0	0	0		1	1		1									1	
<i>Diastylodes serratus</i> (Sars G.O., 1865)		EM	1	0	1	0		1	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Ekleptostylis walker</i> (Calman, 1907)		EAM	1	0	0	0	1	1	1	1	1					1					
<i>Leptostylis macrura</i> Sars, 1870		EAM	1	0	0	0	1	1	1	1	1				1	1					
Familie Leuconidae																					
<i>Leucon (Epileucon) longirostris</i> Sars, 1871		EAM	0	1	1	0	1	1	1	1	1	1	1		1	1	1	1	1	1	1
<i>Leucon (Leucon) affinis</i> Fage, 1951		EM	0	1	0	0		1	1	1	1	1	1		1					1	1

Table 1. Cont.

Species	Status Success	Geo. Dist.	Sectors						Biogeographical Areas					
<i>Leucon (Leucon) mediterraneus</i> Sars, 1878		E	0	1	1	0	1	1	1	1	1	1	1	1
<i>Leucon (Macrauloleucon) siphonatus</i> Calman, 1905		EM	1	0	0	0	1	1	1	1	1	1	1	1
Famille Nannastacidae														
<i>Campylaspis macrophthalma</i> Sars, 1878		EM	1	0	0	0	1	1	1	1	1	1	1	1
<i>Campylaspis sulcata</i> Sars, 1870		EM	0	1	0	0	1	1	1	1			1	1
<i>Cumella (Cumella) limicola</i> Sars, 1879		EAM	1	0	0	0	1	1	1	1	1	1	1	1
<i>Cumella (Cumella) pygmaea</i> G.O. Sars, 1865		E	1	0	0	0	1	1	1	1			1	1
<i>Procampylaspis bonnieri</i> Calman, 1906		EM	0	1	0	0	1	1	1	1	1		1	1
<i>Scherocumella longirostris</i> (Sars, 1878)		E	1	0	0	0	1	1	1				1	1
Famille Pseudocumatidae														
<i>Pseudocuma (Pseudocuma) ciliatum</i> Sars, 1879		E	1	1	1	0	1	1	1				1	1
<i>Pseudocuma (Pseudocuma) longicorne</i> (Bate, 1858)		EAM	1	1	1	0	1	1		1	1	1	1	1
<i>Pseudocuma (Pseudocuma) simile</i> G.O. Sars, 1900		EM	0	1	0	0	1		1	1			1	
Isopoda														
Famille Aegidae														
<i>Aega psora</i> (Linnaeus, 1758)		EM	1	0	0	0	1	1	1	1				
<i>Aega bicarinata</i> Leach, 1818		E	1	0	1	0				1	1	1	1	
<i>Aegiochus ventrosa</i> (M. Sars, 1859)		EM	1	1	0	0	1			1				
<i>Rocinela danmoniensis</i> Leach, 1818		EM	1	1	0	0	1	1	1	1				
<i>Rocinela dumerilii</i> (Lucas, 1849)		EM	1	0	0	0	1		1	1		1	1	1
Famille Anthuridae														
<i>Amakusanthura libyana</i> (Negoescu, 1980)		E	1	1	0	0				1		1		
<i>Anthura filiformis</i> Lucas, 1846		E	0	0	0	1			1	1				1
<i>Anthura gracilis</i> (Montagu, 1808)		EAM	1	0	0	1	1	1	1	1	1	1	1	1
<i>Apanthura corsica</i> Amar, 1953		E	1	1	1	0			1	1	1		1	1
<i>Cyathura carinata</i> (Krøyer, 1847)		EAMI	0	1	0	1	1	1	1		1	1	1	1
<i>Pilosanthura fresii</i> (Wägele, 1980)		EM	1	1	0	0	1		1	1			1	1
Famille Arcturidae														
<i>Astacilla dammoniensis</i> (Stebbing, 1874)		EM	0	1	0	0	1	1	1	1				
<i>Astacilla dilatata</i> G. O. Sars, 1883		EM	1	1	1	1	1	1	1	1		1		
<i>Astacilla longicornis</i> (Sowerby, 1806)		EM	1	1	0	0	1	1		1		1	1	1
Famille Cirolanidae														
<i>Cirolana cranchii</i> Leach, 1818		EAMI	0	1	0	0	1	1	1	1	1	1	1	1
<i>Cirolana parva</i> Hansen, 1890		EWA	1	1	0	0				1	1			1
<i>Conilera cylindracea</i> (Montagu, 1804)		EM	0	1	0	0	1	1	1	1		1		
<i>Eurydice affinis</i> Hansen, 1905		EAM	1	0	0	1	1	1	1	1	1	1	1	1
<i>Eurydice dollfusi</i> Monod, 1930		EAM	1	0	1	0	1	1		1	1	1	1	1
<i>Eurydice pulchra</i> Leach, 1815		EAMRI	1	1	1	0	1	1		1	1	1	1	1
<i>Eurydice spinigera</i> Hansen, 1890		EAM	0	0	1	0	1	1	1	1	1	1	1	1
<i>Eurydice truncate</i> (Norman, 1868)		EAM	1	1	0	0	1	1	1	1	1	1	1	1
<i>Natanolana borealis</i> (Lilljeborg, 1851)		EM	1	1	1	0	1	1	1	1	1		1	1
<i>Natanolana neglecta</i> (Hansen, 1890)		EM	0	1	0	0	1	1	1	1	1		1	1
Famille Cymothoidae														
<i>Anilocra frontalis</i> H. Milne Edwards, 1840		EM	1	0	0	0	1	1	1	1	1	1	1	1
<i>Ceratothoa parallela</i> (Otto, 1828)		EM	1	0	0	0	1	1	1	1	1	1	1	1
<i>Nerocila bivittata</i> (Risso, 1816)		EMR	1	0	0	0	1	1	1	1	1	1	1	1
Famille Gnathiidae														

Table 1. Cont.

Species	Status Success	Geo. Dist.	Sectors										Biogeographical Areas								
Tanaidacea																					
Famille Akanthophoreidae																					
<i>Parakanthophoreus longiremis</i> (Lilljeborg, 1864)		EM	1	0	0	0	0	1	1	1	1	1	1	1	1						
Famille Anarthruridae																					
<i>Anarthrura simplex</i> Sars, 1882		EM	1	0	0	0	0	0	0	1	1	0	0	0	0						
Famille Apseuidae																					
<i>Apseudes africanus</i> Tattersall, 1925		AM	0	1	0	0	0	1	1	1	1	1	1	1	1						
<i>Apseudes grossimanus</i> Norman & Stebbing, 1886		EM	1	0	0	0	0	1	1	1	1	1	1	1	1						
<i>Apseudes holthuisi</i> Bacescu, 1961		E	1	1	1	0	1	1	1	1	1	1	1	1	1						
<i>Apseudes misarai</i> Bacescu, 1980		E	0	1	0	0	0	0	1	1	1	1	1	1	1						
<i>Apseudes orientalis</i> Bacescu, 1961		E	1	1	0	0	0	0	1	1	1	1	1	1	1						
<i>Apseudes robustus</i> Sars, 1882		E	0	1	0	0	0	0	1	1	1	1	1	1	1						
<i>Apseudes spinosus</i> (M. Sars, 1858)		EM	1	1	1	1	1	1	1	1	1	1	1	1	1						
<i>Apseudes talpa</i> (Montagu, 1808)		EAM	1	0	0	0	1	1	1	1	1	1	1	1	1						
<i>Apseudopsis annabensis</i> (Gutu, 2002)		E	0	0	0	1	0	0	1	1	1	1	1	1	1						
<i>Apseudopsis elisae</i> (Bacescu, 1961)		EM	0	1	0	0	0	1	1	1	1	1	1	1	1						
<i>Apseudopsis latreillii</i> (Milne Edwards, 1828)		EAM	1	1	1	0	1	1	1	1	1	1	1	1	1						
<i>Apseudopsis mediterranea</i> (Bacescu, 1961)		EM	1	1	1	0	0	1	1	1	1	1	1	1	1						
<i>Paradoxapseudes intermedius</i> (Hansen, 1895)		AMIP	0	1	0	0	1	0	1	1	1	1	1	1	1						
<i>Tuberapseudes echinatus</i> (Sars, 1882)		E	1	1	1	0	0	1	1	1	1	1	1	1	1						
<i>Zeuxo coralensis</i> Sieg, 1980	Alien Established	AMIP	1	0	0	0	0	0	1	1	1	1	1	1	1						
<i>Zoidbergus tenuimanus</i> (Sars, 1882)		E	0	1	0	0	0	0	1	1	1	1	1	1	1						
Famille Leptocheiliidae																					
<i>Chondrochelia dubia</i> (Krøyer, 1842)		C	0	1	0	0	1	1	1	1	1	1	1	1	1						
<i>Chondrochelia savignyi</i> (Krøyer, 1842)		C	0	1	0	0	1	1	1	1	1	1	1	1	1						
<i>Heterotanais oerstedii</i> (Krøyer, 1842)		EM	1	1	1	1	1	1	1	1	1	1	1	1	1						
<i>Leptognathia manca</i> Sars, 1882		E	0	0	1	0	0	0	1	1	1	1	1	1	1						
Famille Paratanaoidea incertae sedis																					
<i>Pseudoparatanais batei</i> (Sars, 1882)		EM	1	1	1	1	1	1	1	1	1	1	1	1	1						
Famille Pseudotanaididae																					
<i>Pseudotanaais macrocheles</i> Sars, 1882		EM	1	0	0	0	0	0	1	1	1	1	1	1	1						
Famille Sphyrapodidae																					
<i>Pseudosphyrapus anomalus</i> (Sars, 1869)		EM	1	0	1	0	0	0	1	1	1	1	1	1	1						
Famille Tanaididae																					
<i>Parasinelobus chevreuxi</i> (Dollfus, 1898)		EM	0	1	0	0	1	1	1	1	1	1	1	1	1						
<i>Tanais dulongii</i> (Audouin, 1826)		EAM	1	1	1	1	1	1	1	1	1	1	1	1	1						
Total			102	113	56	22	76	126	105	150	170	63	98	82	110	44	112	21	11	6	4

2.4. Data Sources

This study covers all the Cumacea, Isopoda, Lophogastrida, Mysida and Tanaidacea Peracarida recorded along the Algerian coastline (1200 km) from Morocco to Tunisia. The study is restricted to soft-bottom (depth 0 to 200 m) and hard-bottom (depth 0 to 15–20 m) habitats of the continental shelf (bays, gulfs and harbours) since there is no data available for the continental slope and the bathyal zones (Figure 1). For the sampling technique See Bakalem [70] and Grimes [71]; for the soft-bottom, samples are taken with Smith Mc Intyre grab or Van Veen grab [70,71] or with dredge [66,68,69]. It includes species recorded in

scientific papers, the grey literature and unpublished data as well as personal observations and communications.

3. Results

3.1. Species List General and by Sector

Nowadays, our records contain 170 species for the whole of the Algerian coastline (Table 1). The most diversified group is the Isopoda with 71 species belonging to 34 genera and 15 families, and then the Cumacea with 43 species belonging to 16 genera and 5 families. The numbers of species of Mysida and Tanaidacea are similar (27 species), with 15 genera and 1 family and 16 genera and 8 families respectively. The Lophogastrida accounts for only two species from two genera and two families.

In the four sectors studied here, the western sectors show the highest richness, with 103 species in sector 1 and 113 species in sector 2, while the eastern sectors 3 and 4 account for 56 and 22 species, respectively (Table 2).

Table 2. Number of Peracarida species in the four sectors of the Algerian coast.

Order \ Sector	Sector 1	Sector 2	Sector 3	Sector 4
Cumacea	31	28	18	3
Isopoda	41	50	12	11
Lophogastrida	1	1	1	-
Mysida	13	16	15	3
Tanaidacea	15	18	10	5
Total	101	113	56	22

For all groups, there is a decline in diversity from west to east, with sector 2 being the richest and sector 4 the poorest. The Sorensen similarity analysis (dendrogram not shown here) is used here to compare the similarities between the four sectors; sector 4 is very different from the three other sectors, with a similarity of 23%, whilst sectors 1 and 2 (in the western and central parts, which display the richest diversity) have the highest similarities (60%) and sector 3 shows a similarity of 58% with groups in sectors 1 and 2.

3.2. Family Distribution Pattern

Figure 2 shows the number of species per family. Apart for the Isopoda where the number of species is distributed among several families, only one or two families dominate in the other groups.

3.3. Non-Indigenous Species (NIS)

Five species out of the recorded 170 species may be considered as NIS for the Algerian coasts: the Cumacea *Eocuma sarsii* (Kossmann) 1880, the Isopoda *Paracerceis sculpta* (Holmes, 1904) and *Sphaeroma venustissimum* Monod, 1931, the mysid *Neomysis integer* (Leach, 1814) and the tanaid *Zeuxo coralensis* Sieg, 1980. The NIS status of these species in the Mediterranean Sea was confirmed by [78–81]. *Eocuma sarsii*, *Paracerceis sculpta* and *Neomysis integer* have an established species status in the Mediterranean Sea [81] and also in the Algerian coasts except *Eocuma sarsii* casual species status.

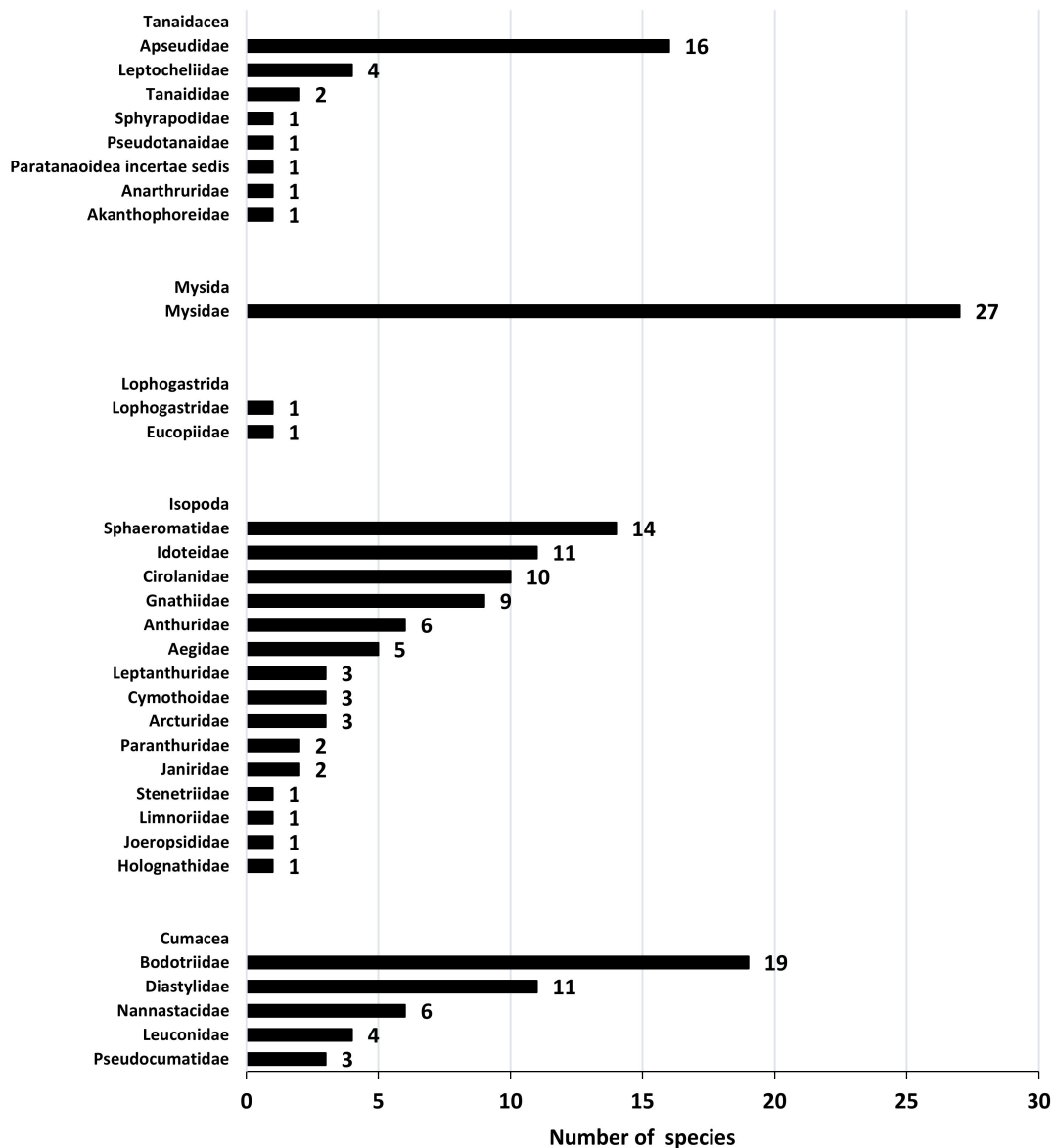


Figure 2. Number of species per family recorded along the Algerian coast.

3.4. Geographical Distribution of Species

The species recorded along the Algerian coast belong to three main biogeographical groups (Figure 3): species common to the Mediterranean Sea and the North-Eastern Atlantic coasts (em), species common to the Mediterranean Sea, the North-Eastern Atlantic and African Atlantic coasts (eam) and species endemic to the Mediterranean Sea (e), with 54, 45 and 38 species, respectively.

There are only eight recorded cosmopolitan species, i.e., accounting for only 5% of the Peracarida diversity, while the NIS and the species common to the Mediterranean Sea, the North-Eastern Atlantic, African Atlantic coast and the Red Sea (eamr) are each represented by six species (3% of the Peracarida diversity). Most of the Isopoda, the Cumacea and the Tanaidacea found in Algerian waters have a North-Eastern Atlantic-Mediterranean origin (from 33 to 41% of the species) and the Mysida species come from the North-Eastern Atlantic, African Atlantic coast and Mediterranean (44% of the species).

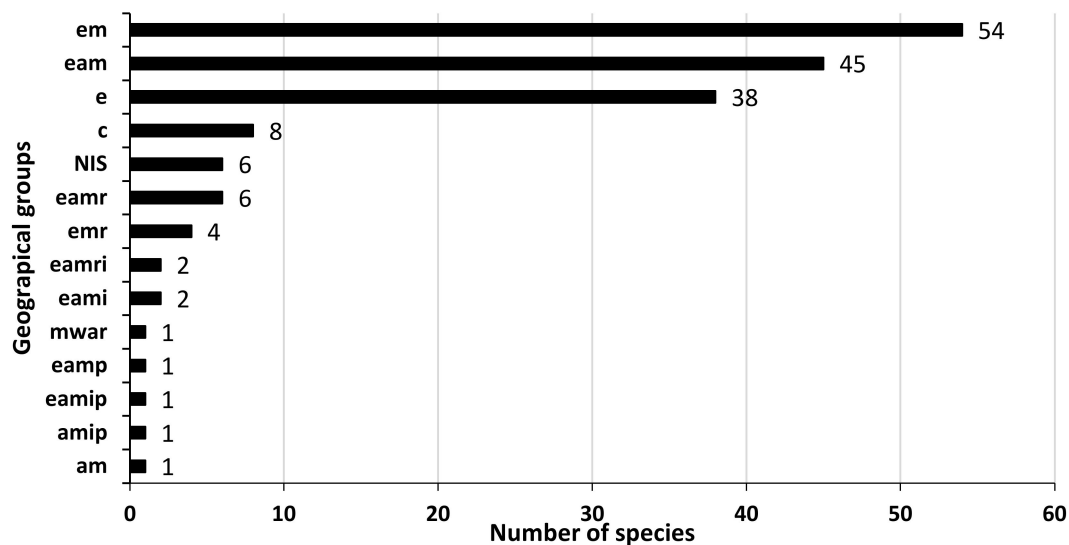


Figure 3. Number of species present in the different geographical groups. Legend: EM: European Atlantic and Mediterranean species; EAM: European and African Atlantic, and Mediterranean species; E: endemic species; C: cosmopolitan species; NIS: non-indigenous species; EAMR: European and African Atlantic, Mediterranean and Red Sea species; EMR: European Atlantic, Mediterranean and Red Sea species; EAMRI: European and African Atlantic, Mediterranean, Red Sea and Indian Ocean species; EAMI: European and African Atlantic, Mediterranean, and Indian Ocean species; MWAR: Mediterranean, Western Atlantic and Red Sea; EAMP: European and African Atlantic, Mediterranean and Pacific species; EAMIP: European and African Atlantic, Mediterranean and Indo-Pacific species; AMIP: African Atlantic, Mediterranean and Indo-Pacific species; MIP: Mediterranean and Indo-Pacific species; AM: African Atlantic coast and Mediterranean species.

Using the Presence/Absence Sorensen similarity coefficient the geographical distribution of the 170 species recorded from the Algerian coast (geographical area: South-Western Mediterranean, 5) is compared with the 14 other geographical areas (Table 1, Figure 4) At a level of 50% similarity, the dendrogram shows a group of two areas: Red Sea (12) and Indo-Pacific oceans (13), plus three isolated areas: the Indian Ocean (14), the Pacific Ocean (15) and the Black Sea (10). The remaining ten areas display a high level of similarity and form a distinct pattern with the following numbers of species given in brackets: the Ionian Sea (6), Adriatic Sea (8), African Atlantic coast (1), Tunisian shelf and Libya (7), Alboran Sea (3), Aegean-Marmara Seas (9), Levantine Sea (11), North-Eastern Atlantic European (2), North-Western Mediterranean (4) and Algeria (South-Western Mediterranean) (5). The highest similarities (>85%) are found between the Aegean, Marmara and Levantine Seas, and also between the North-Eastern Atlantic European waters, the North-Western Mediterranean and the South-Western Mediterranean (Algerian coasts). The African Atlantic coasts, the Tunisian shelf, Libya and the Alboran Sea show high similarities with certain areas of the Western Basin (4 and 5) and Eastern Basin of the Mediterranean (9 and 11), and also with North-Eastern Atlantic European waters.

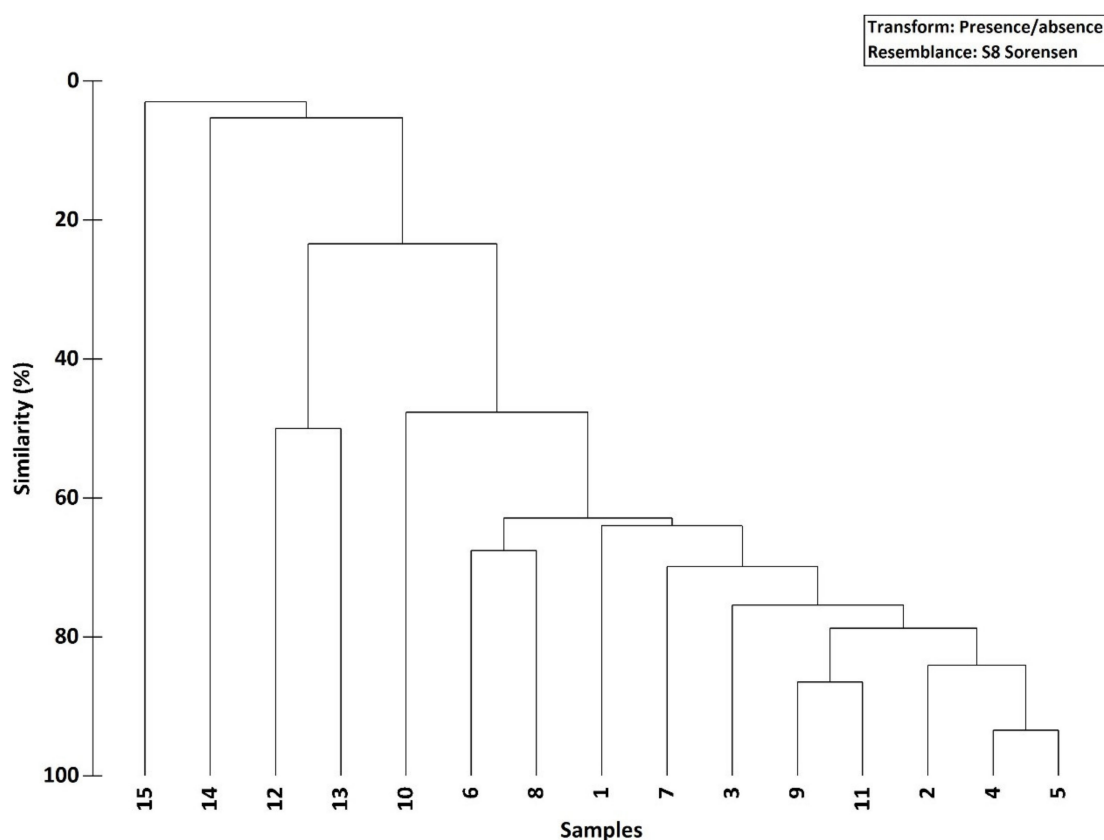


Figure 4. Results of cluster analysis (Sørensen similarity) on the species presence and absence in 15 geographical regions (1: African North-Eastern Atlantic (from Cap Spartel to Cap Blanc); 2: European North-Eastern Atlantic; 3: Alboran Sea; 4: North-Western Mediterranean Sea; 5: Algerian coasts (South-Western Mediterranean); 6: Ionian Sea; 7: Tunisian Shelf and Libya coastline; 8: Adriatic Sea; 9: Aegean and Marmara Seas; 10: Black Sea; 11: Levantine Sea; 12: Red Sea; 13: Indo-Pacific areas; 14: Indian Ocean and 15: Pacific Ocean).

4. Discussion

4.1. General Pattern of the Peracarida Fauna

From 1849 to 1971, only 56 species were recorded belonging to 32 genera and 17 families [59–69]. During this period, the most highly diversified group was the Isopoda with forty species, then the Tanaidacea with eight species, the Mysida with six species, and the Cumacea and Lophogastrida with only one species each.

The Algerian coasts show 502 species of Peracarida, including 332 Amphipoda [4–6] and 170 species for the other groups (Table 1). Apart from the Amphipoda, the next most diversified group is the Isopoda with 71 species, then the Cumacea with 43 species, the Mysida and Tanaidacea with 27 species each and the Lophogastrida with only two species. In comparison, Coll et al. [1] recorded 443 Amphipoda, 165 Isopoda, 102 Mysida, 99 Cumacea, 43 Tanaidacea and 6 Lophogastrida for a total of 858 species in the Mediterranean Sea. The Peracarida diversity in Algerian waters is high, with 59% of the species recorded for the Mediterranean Sea. Surveys in the deep waters off the Algerian coast are insufficient to establish the total marine diversity of this southern part of the Mediterranean Sea; nevertheless, the records on other groups such as the Decapoda with 253 species [83] and the Polychaeta with 534 species [73] of shallow waters highlight the rich biodiversity of this part of the Mediterranean Sea and the need to record other marine groups to assess the current overall diversity along the Algerian coast as well as increase our knowledge of the deeper zones. This high diversity is due to the presence of a mixture of fauna having two main origins: Mediterranean and North-eastern Atlantic species plus a few

Non-Indigenous Species coming from the Gibraltar Strait or the Suez Canal via the eastern basin of the Mediterranean.

There is a close similarity between the Cumacea, Isopoda, Mysida, Tanaidacea and Lophogastrida from Algerian waters and the Peracarida found along the European and African coasts of the Atlantic Ocean. This reflects the influence of Atlantic waters along the North African coasts extending from Morocco to Tunisia in the south of the Mediterranean Sea, which is related to the connection via the Strait of Gibraltar [72]. Similarities are more marked between the Western Basin (Northern and Southern areas) and the North-Eastern Atlantic European coasts, the latter having slightly less similarities with the Eastern Basin (Figure 4). A biogeographic affinity between the Mediterranean and the eastern Atlantic regions has been observed also for other peracarids, amphipods [11,84], and other invertebrate groups: ascidians [85], anthozoans [86], and opisthobranch molluscs [87]. In their study of the assemblage patterns of amphipods associated with the macroalgae *Corallina elongata* along the north-south and Atlantic-Mediterranean axes across the Strait of Gibraltar, Guerra-Garca et al. [11] found that 64% of species have an Atlantic-Mediterranean distribution; these authors considered the Mediterranean-Atlantic axis to be a relatively homogeneous zone, i.e., without a distinct change in the distribution pattern of peracarid assemblages. The high similarities between fauna in the Aegean-Marmara and the Levantine Seas indicate that they belong to biogeographical zones in close proximity [1,2,10,43–46,50,88].

The Peracarida fauna along the Algerian coasts is similar to that found in the North-Western basin of the Mediterranean Sea (Spain, France and Italy). Moreover, this Algerian fauna displays a great similarity with that of the Aegean, Marmara and Levantine Seas, suggesting a high level of similarity of Peracarid fauna at the scale of the Mediterranean Sea. The same observation has been highlighted for all the macrobenthic species along the Algerian coasts [72] and recently for the Algerian polychaete fauna as well [73].

The biogeographical zones of the eastern basin are of particular interest, especially the Levantine Sea because the Mediterranean Sea has been open to the Red Sea and Indo-Pacific waters via the Suez Canal since 1869. The Levantine Sea is a hot spot of NIS (Lessepsian species), and has become the main entrance pathway for alien species [81,89], species which will then spread to the western basin [90,91] and in particular the Algerian coasts. On the other hand, The NIS species found along the Algerian coast have two main origins: Atlantic species entering via the Strait of Gibraltar and Lessepsian species coming from the Levantine Sea via the Sicily Strait.

4.2. Main Particularities of the Algeria Peracarida Fauna

For the comparison of the diversity of peracarids from the Algerian coasts with those of other Mediterranean areas, synthetic Table 3 was produced from main data available and accessible in the literature (See legend Table 3). For the whole Mediterranean Sea, the diversity of Cumacea is estimated at 99 species [15], of which 44% are present on the Algerian coasts, where this group is represented by 43 species (Table 3).

Table 3. Diversity of cumacea, isopoda, lophogastrida, mysidace and tanaidcea of different Mediterranean areas and whole Mediterranean Sea. (Data of bibliography consulted synthesised [1,7,8,10–15,17–20,23–28,31–38,40–48,50–52,54–56,58,59,67–72,92–101]).

Order	Aera	Alboran Sea	North Western Mediterranean	South Western Mediterranean	Ionian Sea	Tunisia-Libya	Adriatic Sea	Aegean and Marmara Seas	Black Sea	Levantine Sea	Mediterranean Sea
Cumacea		69	78	43	28	18	13	62	26	48	99
Isopoda		120	174	71	61	64	80	96	45	105	295
Lophogastrida		1	5	2	1	1	2	2	-	1	7
Mysidacea		19	62	27	31	34	47	49	44	48	102
Tanaidacea		7	51	27	3	15	17	20	7	23	69
Total Species		216	370	170	124	132	159	229	122	225	572

The North-western Mediterranean is the region with the highest diversity (78 species). Moreover, the Cumacea diversity in the Alboran Sea, Aegean-Marmara Seas and Levantine

Sea is higher than that recorded along the Algerian coasts. Other biogeographical zones (Ionian Sea, Tunisia-Libya, Adriatic Sea and Black Sea) show lower diversity than that observed in Algerian waters. The Cumacea of diversity from the Algerian coasts in comparison to other biogeographical areas is low, except the Ionian Sea, Tunisia-Libya, the Adriatic Sea and the Black Sea having lower diversity. Among the three Cumacea Mediterranean species *Eocuma rosae* Corbera and Galil, 2007, *Eocuma sarsii* and *Scherocumella gurneyi* (Calman, 1927) are NIS [81], only *E. sarsii* is present on the Algerian coasts.

Our knowledge of Isopoda diversity in the Mediterranean Sea and the occurrence of NIS in this group has increased significantly in recent years. Nevertheless, the Isopoda diversity varies according to different authors, i.e., 165 species including 9 NIS [1,89], while Castelló et al. [10] listed 295 Isopoda in the Mediterranean Sea, including 23 NIS; this is indicative of the lack of knowledge of this group in the past and that in the future exploration efforts must be implemented. Only two Isopoda NIS, *Paracerceis sculpta* and *Lekansphaera bocqueti*, are present on the Algerian coast, but *L. bocqueti* was not considered as NIS by [10] because for these authors the identifications or records in the Mediterranean Sea are doubtful. A total of 71 species have been reported from the Algerian coast (24% of the Mediterranean species).

Generally the Isopoda diversity in different biogeographical areas (except Black Sea) is greater than that of the Algerian coasts. Castelló et al. [10] regroup Algeria, Tunisia, Libya and Malta in the same biogeographical area with an Isopoda diversity of 108 species, whereas in the present study these countries belong to two different biogeographical areas: South Western Mediterranean Algeria (71 species) and Tunisia-Libya (64 species).

As regards the parasitic Isopoda, adaptations to ectoparasitism are found among the Cymothoidae and Aegidae, which feed on the blood and tissues of diverse hosts, mainly fish, endoparasitism is also observed among the Epicaridea [10]. Such parasitic species have been reported historically from diverse localities along the Algerian coasts [59,102,103], and recently [74–76,104–109]. The present study has mainly studied the diversity of free-lives Isopoda, however it should be noted that studies on parasitic species have been carried out in Algeria [59,74–76,102–109], and record 16 species of Cymothoidae and 3 species of Aegidae.

In the Mediterranean Sea, Coll et al. [1] listed 102 species of Mysida and two species of Lophogastrida, while Zenetos and Galidini [81] reported one NIS Mysida, *Neomysis integer* (Leach, 1814), which has also been recorded in Algeria. A total of 27 Mysida have been recorded in Algeria (26% of the Mysida diversity of the Mediterranean Sea). The highest diversity of Mysida (62 species) is observed in the North Western Mediterranean followed by Adriatic Sea, Aegean-Marmara Seas, Black Sea and Levantine Sea. Mysida diversity of the Ionian Sea and Tunisia-Libya biogeographical zones is quite close to the diversity in Algerian waters.

Lophogastrida diversity in the Mediterranean Sea is rather weak, with seven recorded species: five species in the North Western Mediterranean, absent species in the Black Sea, and one or two species in the other biogeographical areas [1].

Koulouri et al. [45] for the Mediterranean Sea estimated the number of Tanaidacea species at 69, of which 27 have been reported in Algeria (39%). The Tanaidacea diversity of Algerian waters is lower than that revealed in the North Western Mediterranean Sea (51 species), and greater than that observed in the Adriatic, Aegean-Marmara and Levantine seas (17 to 23 species). By contrast, diversity is even lower in the Ionian and Black seas as well as in the Tunisia-Libya region, with 3, 7 and 15 recorded species, respectively. But the low diversity of Tanaidacea in some biogeographical zones is mainly due to the scarcity of inventory studies of this zoological group. The Tanaidacea, *Zeuxo (Parazeuxo) coralensis* Sieg, 1981 considered by Zenetos et al. [89] as NIS in Mediterranean Sea is present in Algeria.

4.3. Species Described from Algerian Material

The first studies of crustaceans in Algerian waters were carried out at the beginning of the 19th century during the Scientific Exploration of Algeria (1840 to 1842) [57] which

described seven new species of Isopoda along the Algerian coasts: *Anthura filiformis* (Lucas, 1849), *Dynamene edwardsi* (Lucas, 1849), *Gnathia vorax* (Lucas, 1849), *Paranthura nigropunctata* (Lucas, 1846), *Rocinela dumerilii* (Lucas, 1849), *Stenetriidae incertae sedis longicornis* (Lucas, 1849) and *Stenosoma carinata* (Lucas, 1846). Later, a new Mysida *Rhopalophthalmus mediterraneus* was described by [64], the Tanaidacea *Apseudopsis annabensis* (Guțu, 2002) by [94], and, more recently a new Isopoda *Stenosoma stephensi* Santos & Xavier, 2011 by [110].

The isopods *Dynamene edwardsi*, *Gnathia vorax* and *Rocinela dumerilii* were described by Lucas [59] from individuals sampled in the Gulf of Annaba. Castelló et al. [10] reported the presence of *D. edwardsi* and *R. dumerilii* from North-East Atlantic coasts and throughout the Mediterranean (except the Ionian Sea and Black Sea), *D. edwardsi* has long been present in the Suez Canal and in the Red Sea and was classified as an anti-Lessepsian species, while *G. vorax* shows a wide occurrence in the North East Atlantic and Mediterranean Sea.

The genus *Paranthura* is represented on the Algerian coasts by two species: *P. nigropunctata* (Lucas, 1849) and *P. costana* Bate and Westwood, 1868, both native to the Mediterranean Sea and North-Eastern Atlantic and common in these zones [10]. *P. nigropunctata* was described by Lucas [59] from specimens sampled in macro-algae from the bays of Oran, Annaba and Skikda. This species was also sampled in the bays of Bejaia (two individuals on fine sand) [70] and Bou Ismail (six individuals) [68,70].

The Isopoda *Stenetriidae incertae sedis longicornis* was described by [59] under the name *Jarea longicornis* from material collected at Beni-Saf and Cape Djinet, as well as in the bays of Oran and Bou Ismail and in Arzew harbour. This species under the name *Tristenium longicornis* (Lucas, 1849) was reported in the Western Mediterranean, the Atlantic Morocco coast [111,112], in the Adriatic Sea and the Levantine Sea [10]. Nevertheless, in the WORMS list, the Isopoda *Anthura filiformis* (Lucas, 1849) is currently considered as *nomen dubium* as it seems inadequately described, but the species was again dubiously reported in the Levantine Basin by Castelló et al. [10]. Furthermore, *A. filiformis* is maintaining its presence along the Algerian coast, and future collections should provide an occasion to redescribe the species.

The Isopoda *Stenosoma carinata* was described by Lucas [59] under the name *Idotea carinata* from the Bays of Oran, Algiers and Annaba. In their review on Mediterranean Isopoda Castelló et al. [10] mentioned the presence of this species limited to the Algerian coasts. The Isopoda *Stenosoma stephensi* Santos & Xavier, 2011 was described by Santos et al. [110] from specimens collected on intertidal algae on Alboran Island and in Algeria (sector 2: extending from Cap Djinet to Tigzirt); currently these are the only areas where this species has been reported.

The mysid *Rhopalophthalmus mediterraneus* was described by Nouvel [62] from specimens collected in the Bay of Algiers, but this species has not been recorded elsewhere on the Algerian coasts. Hence, it is the only known record for this species in the Mediterranean Sea. On the other hand, Cuesta et al. [113] has reported this species in the Guadalquivir Estuary (Atlantic coast of SW Spain), while its presence is also reported by Drake et al. [114] in the tidal channels of the Bay of Cádiz (SW Spain).

The description of the Tanaidacea *Apseudopsis annabensis* by Guțu [94] was based on one specimen sampled in the Bay of Annaba. Recently, this species was reported in the tidal channels of the Gulf of Gabès [39,115]; this was the first record of the species outside its native range; thus its distribution is limited to Algerian and Tunisian waters.

4.4. Non-Indigenous Species (NIS)

For the whole Mediterranean Sea, 23 Isopoda NIS are reported [10], while [81] reported three Cumacea, one Mysida and two Tanaidacea as NIS. A significant number of NIS are found on the Algerian coast (106 species) (Bakalem unpublished data), including two Crustaceans Peracarida (*Elasmopus pecteniscrus* and *Eocuma sarsii*) [4,116]. Recently, Bensari et al. [117] identified two new NIS Peracarida: the Tanaidacea *Zeuxo coralensis* Sieg, 1980 (12 individuals) and the Isopoda *Paracerceis sculpta* (Holmes, 1904) (419 individuals) in the

harbour of Arzew, species observed on the hulls of fishing ship and on a tyre-buoy; these authors attributed an established status to these species.

For the Algerian coasts, there are currently six reported NIS belonging to the Peracarida: one Amphipoda, one Cumacea, two Isopoda, one Mysida and one Tanaidacea. The Mysida *Neomysis integer* and the Isopoda *Sphaeroma venustissimum* are the new NIS recorded in the present study. The Amphipoda *Elasmopus pectenicrus* (Spence Bate, 1862), a circumtropical species first recorded in 1984 in fine sand of the Bay of Algiers and now attributed an established status [4,116], and the Cumacea *Eocuma sarsii* (Kossmann, 1880), which appears to have a casual status in Algeria [71].

The species *Eocuma sarsii*, *Paracerceis sculpta*, *Zeuxo coralensis* and *Neomysis integer* (Leach, 1814) first arrived due to maritime traffic, natural corridors or aquaculture [79,90] and have spread secondarily to further Mediterranean areas [91,118–120]. Martinez-Laiz et al. [9] and Ulman et al. [91] proposed that recreational boating in the Mediterranean provides an important vector for numerous Peracarida NIS exchanging fauna between marina assemblages.

The areas of origin of the Cumacea *Eocuma sarsii* (Kossmann, 1880) are in temperate Southern Africa and the Western Indo-Pacific [89]. This species was recorded (two individuals) in Arzew Harbour in 1996–1997 [71] and has a casual status [116], while [81] assigned an established status for the Mediterranean Sea. For the Isopoda *Paracerceis sculpta* (Holmes, 1904), the type locality is San Clemente Island (California, USA) and its native range includes the Northeastern Pacific region including California and Mexico. Currently, this species is very widespread in the world [121], and recently recorded as NIS in the Argentinian waters [122]. *P. sculpta* is present over the whole Mediterranean Sea [10]. It was reported for the first time in the Tunis Lagoon (Tunisia) [123], and afterwards in the eastern [124] and in the western Mediterranean [21,125]. Martinez-Laiz et al. [9,21] considered *P. sculpta* as a potential invasive species and as a well-established NIS in the Mediterranean Sea.

The Tanaidacea *Zeuxo coralensis* was discovered for the first time in the Mediterranean Sea in the Bay of Algeciras [95]. This species has a circumtropical distribution [96,126,127]). Zenetos et al. [84] considered *Zeuxo coralensis* as an established NIS in the Mediterranean Sea; however, Zenetos & Galadini [81] did not report *Z. coralensis* in their list of NIS.

The Mysida *Neomysis integer* has a North-eastern Atlantic origin; it is a common species in shallow coastal waters of temperate to boreal zones ranging from southern Spain to Norway. The presence of this species in the Mediterranean Sea is relatively recent [97,128–130]. For the Algerian coast, *N. integer* was reported for the first time (1985) on a fine sand bottom in the Gulf of Arzew (three individuals) [70] and then in Arzew Harbour (three individuals) [71]; this species has an established status in Algeria.

The Isopoda *Sphaeroma venustissimum* was described from specimens collected off the Mauritanian coast [131]. The species was found along the Atlantic coasts of North-West Africa [132] and the Atlantic coasts of the Iberian Peninsula [132–134]. The species was first recorded in the Mediterranean Sea by [98] in Tunis Southern Lagoon (Tunisia). On the Algerian coasts, *S. venustissimum* was reported for the first time (1966–1967) among the endofauna of an eelgrass meadow in the Bay of Bou Ismail [67]. The introduction of *S. venustissimum* into the Mediterranean Sea was assumed to be via the Strait of Gibraltar, and the species was considered as alien by [89]. However, this species was removed from NIS lists because its presence in the Mediterranean Sea could be explained by a natural range expansion rather than a human mediated introduction [10,90].

4.5. Notes on Some Other Species

The isopoda *Lekanesphaera bocqueti* (Daguerre de Hureauux, Hoestlandt & Lejuez, 1961) was collected on the Atlantic coasts of Morocco [135] and in the South of Portugal) [132]. *L. bocqueti* was reported for the first time among the endofauna of an eelgrass meadow in the Bay of Bou Ismail [67]. The Isopoda *Synischia hectica* (Pallas, 1772) is an Atlanto-Mediterranean species which has a rare occurrence in the North Atlantic Ocean [134]

and over the entire Mediterranean Sea [10]. On the Algerian coast, this species has been reported in the Gulf of Oran [59] and in the Bay of Bou Ismail [61]. The Isopoda *Eurydice pulchra* Leach, 1815 is present in the North-East Atlantic and in the Mediterranean except for the Alboran, Ionian and Adriatic seas, where its absence is probably due to a lack of sampling [10]. *E. pulchra* probably reached the Red Sea through the Suez Canal and it is considered as an anti-Lessepsian [10]. It has been recorded from different parts of the Algerian coast (sector 1 to sector 3).

The distribution of the Isopoda *Dynamene bidentata* (Adams, 1800) is restricted to the Atlantic Ocean [99,136], and its presence in the Mediterranean Sea should be considered doubtful or inaccurate due to misidentifications [10]. *D. bidentata* has been reported in the area of Beni Saf (one individual) and in Bejaia Harbour (one individual); Castelló et al. [10] mentioned that, according to different authors, this species has been reported in many Mediterranean regions (Alboran Sea, Western Mediterranean, Aegean Sea and Levantine Sea) and considered that many of the Mediterranean records of *D. bidentata* were doubtful. The Isopoda *Cirolana parva* Hansen, 1890 has been reported on the Algerian coast (Gulf of Arzew, Bay of Bou Ismail) [70]; Ayari and Afli [137] reported this species in the Gulf of Tunis (Tunisia). Castelló et al. [10] considered the Mediterranean records (Tunisia) as well as the records from the Suez Canal and the Red Sea as inaccurate, due to misidentifications, because the distribution of *C. parva* is restricted to the Caribbean region and the Pacific coast of Panama. However, the presence of this species in the Mediterranean Sea remains an open question.

The Tanaidacea *Parasinelobus chevreuxi* Dollfus (1898) has been described from specimens collected in Brittany (France) and recorded along the European Atlantic coasts from the United Kingdom to Morocco [138,139]. In their inventory of Italian Tanaidacea, Argano et al. [140] mentioned the presence of *P. chevreuxi* in Italian waters, but considered its presence as questionable and needs to be verified. In Algeria, *P. chevreuxi* was reported by Le Gall [67] among the endofauna of a *Posidonia* meadow in the Bay of Bou Ismail; however this presence was doubtful and remains to be confirmed.

The Isopoda *Limnoria lignorum* (Rathke, 1799) is widely distributed in the temperate and boreal Northern hemisphere: eastern North Atlantic and North Sea coasts (Iceland to southern England) [141]. These authors state that the southern distribution limit of *L. lignorum* is the southern Netherlands. Castelló et al. [10] mention that this species is present throughout the Mediterranean Sea (except the Ionian Sea). While some authors also report this species along the Mediterranean Spanish coasts, Castelló [100] has pointed out that this species was confused with *Limnoria mazzellae*. *L. lignorum* has been reported only in the Bay of Bou Ismail. Taking into account the biogeographical distribution of *L. lignorum*, the Mediterranean records may be considered doubtful or inaccurate, due to misidentifications [10,100,141].

The distribution of the mysid *Pseudomma affine* G.O. Sars, 1870 is quite wide [142], covering the North Atlantic, from northern Norway to the Bay of Biscay, as well as Iceland, Greenland and east coast of North America Cartes & Sorbe [143] recorded *P. affine* in their study of mysids of the Catalan Sea (France); this record was the first for the Mediterranean Sea. Grimes [71] reports *P. affine* has been identified in the Port and the Gulf of Arzew with respectively two and one individuals.

Castelló et al. [10] noted the wide distribution of the isopod species *Cymodoce pilosa*, *C. spinosa*, *C. truncata*, *Dynamene edwardsi*, *Idotea balthica*, *I. metallica* and *Sphaeroma serratum* on the Atlantic European coasts and in the Mediterranean before the opening of the Suez Canal. This implies that these species present on the Algerian coasts could be classified as anti-Lessepsian. Although *Cymodoce pilosa* has a wide distribution in the Mediterranean Sea. *Gnathia inopinata*, endemic species of the Mediterranean Sea, is present in the NorthWestern Mediterranean Sea, in the Alboran and Aegean Seas, and only recently report in Levantine Sea [10]; this species is present only in the sector 2 of Algerian coast.

The Isopoda *Dynamene edwardsi*, *Idotea balthica* and *Sphaeroma serratum*, as well as the Tanaidacea *Tanais dulongii*, are species present on Algerian coasts which are considered as

native to the biogeographical zones of the Atlantic European coasts and Mediterranean. However, these species can be considered as NIS when they are present outside their biogeographical ranges [144]. In their study of Peracarida species in two harbours of Argentina (Southwestern Atlantic), Rumbold et al. [144] reported *Dynamene edwardsi* and *Sphaeroma serratum* as exotic species. These authors [144] also consider that *Idotea balthica* and *Tanais dulongii* are cryptogenic species.

For species of parasitic isopods, a delicate question arises concerning their biogeographical range since their distribution is closely related to that of their host. The dispersal capacity increases greatly in the case of ectoparasitic species of other organisms at particular stages of their biological cycle, for example, the Aegidae, Cymothoidae and Gnathiidae which parasitize fish [10]. It was worth highlighting the case of *Nerocila bivittata* and *Ceratothoa oxyrrynchaena*, which are parasitic Isopoda present in Algeria, whose propagation is linked to the movements of their fish hosts. *N. bivittata* has an Atlanto-Mediterranean distribution and is profusely recorded in the Mediterranean [10], even reaching the Suez Canal [101]. Castelló et al. [10] considered *N. bivittata* as an Anti-Lessepsian species. *Ceratothoa oxyrrynchaena* (type locality: Japan), present in the Red Sea but absent in the Indian Ocean, has a wide distribution in the Mediterranean [10,145]; for Castelló et al. [10], it is difficult to know if its dispersal in the Mediterranean occurred via the Suez Canal or whether its dispersal in the Red Sea occurred from the Mediterranean Sea via the Suez Canal.

In fact, most of the western Mediterranean species have a native range in the North-Atlantic region and have penetrated into the Mediterranean Sea via the strait of Gibraltar. Some of these NIS are called Herculean species, as in the case of the Mysida *Neomysis integer* and the Isopoda *Sphaeroma venustissimum* [89].

5. Conclusions

Ferrario et al. [119], Lo Brutto and Iacifano [146] had underlined the need to establish inventories of marine invertebrates and their survey as a prerequisite for biodiversity knowledge and ecological studies. The inventory of peracarida is a mandatory passage for better knowledge and management of Algerian marine biodiversity. As a result of the present study, the species diversity of Cumacea, Isopoda, Mysida, Tanaidacea and Lophogastrida known on the Algerian coasts is increased from 56 to 170. The Scientific Exploration of Algeria [59] represents the first major study of the Isopoda in this region (40 species), but the diversity of this group is currently assessed at 71 species. For the other groups, the new diversity values presented here are much higher than those noted before 1970: Cumacea 43 versus one species, Mysida 27 versus three species, Tanaidacea 27 versus six species. However, in the future, a greatly increased research effort is needed to improve our knowledge of the biodiversity of certain groups such as the Mysida and Tanaidacea, and for the deeper waters of the Algerian Exclusive Economic Zone.

Coleman [147] points out that a good estimate of the diversity of a zoological group depends primarily on the research effort implemented and local taxonomic expertise; this is really true in the case of our inventory of peracarids on the Algerian coast. Moreover, the diversity values of the Peracarida can be considered as under-estimated due to: (1) the small number of studies and low level of sampling on the eastern part of the Algerian coastline (sectors 3 and 4); (2) the few studies of remarkable habitats (including the phanerogams, coralligenous formations, deep soft bottom, shallow and deep hard substratum and the bathyal benthic zone), and (3) the lack of specialists in taxonomy, in particular for the identification of NIS and species classified as cosmopolitan.

With a total of at least 295 Isopoda, 102 Mysida, 99 Cumacea and 69 Tanaidacea species, the Mediterranean Peracarida fauna is more diverse than previously suggested [1,88]. The highest species richness is observed in the North Western Mediterranean, Aegean, Marmara and Levantine Seas, and the lowest in the Black Sea. The appreciable number of species recorded in the North African region (Morocco, Algeria, Tunisia and Libya) is especially due to recent studies and listings of diversity. Coleman [147] and Faulwetter et al. [148] pointed out that regional inventories of species inevitably reflect the research and sampling effort,

and the availability of experts for taxonomic identification; in this case Coleman [147] used the term “taxonomic impediment” which is widely used in the biodiversity literature. In our study for the subject “taxonomic impediment” we referred to the work of Coleman [147]. The taxonomic impediment in the present study of Cumacea, Mysida, Isopoda, Tanaidacea and Lophogastida of Algerian coasts consists of three main problems: (1) the incomplete knowledge of Algerian marine biodiversity in general and incomplete for the groups of small invertebrates as peracarida in particular; (2) the insufficient number of experts in the taxonomy of peracarida and also of experts familiarized to new techniques such as molecular biology and (3) the lack of taxonomic infrastructure in Algeria (reference collections, databases, taxonomic documentary funds). Such a situation is not unique to Algeria, Coleman [147] notes that this is also the case in much of the world for cumacea and mysida, and to lesser degree for amphipoda.

In the westernmost Mediterranean Sea, close to the Strait of Gibraltar in particular the Alboran Sea and the western Algerian coasts, there are numerous species of Atlantic origin or of Atlantic-Mediterranean affinity. In contrast, the presence of species of Indo-Pacific origin or affinity is more marked in the eastern regions.

Shallow habitats and biodiversity in the Mediterranean Sea are impacted by a range of damaging factors such as habitat loss and degradation, climate change, pollution and the invasion of NIS [1,2,146]. A periodic evaluation of the marine biodiversity of Peracarida in certain Algerian target areas is recommended. Such monitoring activities could reveal the long-term changes in biodiversity under the increased influence of climatic and increasing human pressures on Algerian coastal environments.

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