

## NOTES ON THE BIODIVERSITY AND TAXONOMY OF BIVALVE MOLLUSCS IN THE MEDITERRANEAN COAST OF MOROCCO

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### SUMMARY

Bivalve biodiversity and taxonomy of the Mediterranean coast of Morocco from Cap Spartel (Tangier region) to the seaside resort of Saidia (near the Algero-Moroccan frontiers) has been studied from different samplings carried out between October 2000 and May 2002. The present work is focused particularly on a first and original exploration of bivalves species associated with different biotopes in the Mediterranean coast of Morocco and establishes an inventory of bivalve species harvested along the coast of the studied area. We have been able to establish the distribution of species along the coast in the four sampling zones: Tangier, Al-Hoceima, Nador and Saidia. Among the 73 species listed during this study, two of them are declared new species for the first time from the Mediterranean coast of Morocco, 17 rare species occur in the zone of Tangier, 9 rare species in Al-Hoceima, 3 rare species in Nador, 18 rare species in Saidia, and two endemic and threatened species from the Mediterranean coast of Morocco. Of the 22 bivalve mollusc families present, five are of an economic importance: *Cardiidae*, *Donacidae*, *Mytilidae*, *Ostreidae*, and *Veneridae*. Specific richness affected to the whole region of study was higher in Tangier close to the Atlantic Ocean than in the more internal zones.

**Keywords:** Molluscs, bivalves, systematic, biodiversity, Mediterranean coast, Morocco.

### 1. INTRODUCTION

Bivalve molluscs of the Mediterranean coast of Morocco have been the subject of studies with topics that are rather general and often incomplete, such as Pallary (1902), Hidalgo (1909), Alluaud (1925), Gofas (1972). To the best of our knowledge, no global systematic study has been achieved so far in northern Atlantic or Mediterranean coasts of Morocco. The only systematic references are those of Laazouzi (1999) and Schafee (1999). The scarcity of works related to the bivalve molluscs of the Mediterranean coast of Morocco prompted us to undertake a research work concerning the systematic and biodiversity of these species.

The objective of the present study was to: (i) to identify the different species associated with different biotopes in the Mediterranean coast of Morocco, (ii) to establish an inventory of bivalve species harvested along the coasts of the studied area, and (iii) to evaluate the specific richness in each explored zone. The present work is based on studies of four geographical zones from Cap Spartel in the west (Tangier zone) to Saidia in the east. The topography of the studied zones varies depending on the biotope related to each zone. A comparison of the specific richness between the four specific geographical zones was also established.

The present paper is devoted to the presentation of the overall results of samplings and their discussion. In addition, it complements the previous taxonomic studies of the region (Poutiers, 1987; Laazouzi, 1999; Shafee, 1999), adds new information on the geographical zones of the Mediter-

anean coast of Morocco and constitutes a baseline reference for the taxonomic diversity and specific richness of bivalve mollusks in these zones.

## 2. MATERIALS AND METHODS

### 2.1. Characterization of the studied zones

The Mediterranean coast of Morocco, with a length of 512 km, is limited in the west by the coastline of Cap Spartel, in the north by the Betic chain (Iberian peninsula), and the east by Saidia city on the Algero-Moroccan frontiers (Fig. 1).

Four geographical zones were explored with a total of sixteen sampling sites distributed as follows: Tangier zone (coasts of Cap Spartel, Ksar-es-Sghir, M'diq, Cabo Negro, Martil and Oued Laou), Al-Hocima zone (coast of Sfiha and its neighboring seashores of Tara Youssef, El Mood, Timchdine, Sabadia and Kimado), Nador zone (coast of Kariat Arakmane), and Saidia zone (coasts of Ras Kabdana, Moulouya estuary and Saidia). Geographical and climatic characteristics of sampling sites are summarized in Table 1.

### 2.2. Sampling

The period of sampling was spread out over a period of 20 months from October 2000 to May 2002 during summer, winter and spring, particularly during low tides. The choice of sampling sites was based on their accessibility and their distribution along the Mediterranean coast. For the prospection of different biotopes and in order to establish an inventory of bivalve species and their specific richness, qualitative sampling was carried out along the Mediterranean coast including live specimens or simply the shells.

### 2.3. Methodology

Samples of bivalve molluscs were collected in a transect of approximately 1 km along each of the studied sites and were obtained by: (i) hand collecting in beaches (zone of foreshore), particularly after storms; (ii) contents of trawls; (iii) and bivalves dredges; (iv) prospection of bivalves exposed by shellfish vendors; and (v) past collections housed in laboratories of zoology in the Faculties of Sciences in Tetouan and Oujda (northwestern and northeastern of Morocco, respectively).

The different samplings resulted in a total of 2933 individuals. A systematic sorting of the collected species according to their families was carried out using several references (Hidalgo, 1917; Llabador, 1935; Arrecgros, 1958; Pasteur-Humbert, 1962; Bellon-Humbert, 1973; Lecointe-Hogrel, 1974; Parenzan, 1974; Bellon-Humbert and Gofas, 1977; Riedl, 1983; Phillips, 1987; Poutiers, 1987;

Benmoussa, 1994; Lloris and Rucabado, 1998; Hayward et al., 1998; Shafee 1999).

## 3. RESULTS AND DISCUSSION

### 3.1. Inventory of bivalve species

Considering the near absence of studies on mollusc biodiversity and particularly of bivalves found on the Mediterranean coast of Morocco, the present work provides first observations on this subject. Along the four sampling zones, the systematic key highlights a total of 22 bivalve families including 45 genera and 73 species (Table 2). Of the 2933 individuals sampled, 46% were collected in Tangier zone, 13% in Al-Hoceima zone, 28% in Nador zone, and 13% in Saidia zone.

The present study revealed the presence of two previously unrecorded bivalve species for the Mediterranean coast of Morocco. They are: (i) *Arca lactea* (Arcidae), collected in the western zone at Cap Spartel, and (ii) *Cardium paucicostatum* (Cardiidae), found in Ras Kabdana in the eastern zone.

Among the identified bivalves species, we found 17 rare species in Tangier zone. These are: *Arca lactea*, *Cardium costatum*, *Cardita calyculata*, *Glycymeris bimaculata*, *Diplodonta rotundata*, *Mytilaster minimus*, *Crassostrea gigas*, *Pandora inaequalis*, *Crassadoma multistriata*, *Pinna nobilis*, *Solecurtus antiquatus*, *Tellina pulchella*, *Tellina incarnata*, *Tellina tenuis*, *Venerupis pullastra*, *Clausinella fasciata*, and *Ruditapes decussatus*. Similarly, they were 9 rare species in the region of Al-Hoceima (*Arca noe*, *donax trunculus*, *Lima squamosa*, *Diplodonta rotundata*, *Lucinomorpha borealis*, *Lucina lactea*, *Mytilus galloprovincialis*, *Chlamys varia*, *Ensis siliqua*), 3 rare species in the region of Nador (*Cardium costatum*, *Mytilus galloprovincialis*, *Spondylus gaederopus*), and 18 rare species in the eastern region of Saidia (*Laevicardium oblongum*, *Cardium paucicostatum*, *Laevicardium crassum*, *Glycymeris bimaculata*, *Lima hians*, *Spisula solida*, *Mactra glauca*, *Ostrea angulata*, *Pandora inaequalis*, *Pecten jacobaeus*, *Barnea candida*, *Pinna nobilis*, *Gari fervensis*, *Spondylus gaederopus*, *Tellina nitida*, *Tellina incarnata*, *Tellina tenuis*, *Clausinella fasciata*).

In addition, two threatened species for the Mediterranean coast of Morocco were identified. They are: (i) *Pinna nobilis* (Pinnidae), collected in the western zone at Martil, in the Al-Hoceima zone at Kimado, and in the eastern zone at Ras Kabdana, and (ii) *Lithophaga lithophaga* (Mytilidae), which was not found at any of the prospected zones because of its prohibited local collection due to the

ecological damage caused by its excessive exploitation.

### 3.2. Specific richness and relative abundance

A total of 73 bivalve species were present in the samples from the four zones of study. This overall level of specific richness appeared, however, very variable depending on the zone of sampling and their environmental characteristics (Table 3). Therefore, the zone of Tangier was rich in some species from families such as the *Cardiidae*, the *Donacidae*, the *Glycymeridae*, the *Macridae*, the *Mytilidae*, the *Ostreidae*, the *Pectinidae*, and the *Veneridae*. Similarly, abundant families in the zone of Al-Hoceima were: the *Cardiidae*, the *Donacidae*, the *Glycymeridae*, the *Macridae*, and the *Veneridae*. The zone of Nador was rich in species from the *Cardiidae*, the *Donacidae*, the *Glycymeridae* and the *Veneridae*. Dominant families encountered in the zone of Saidia were: the *Cardiidae*, the

*Donacidae*, the *Glycymeridae*, the *Macridae*, the *Mytilidae* and the *Veneridae*.

On a taxonomic scale, the most diverse bivalve families (Table 2) were the *Cardiidae* containing ten species, the *Macridae* with six species, the *Mytilidae* composed of five species, the *Tellinidae* which included six species, and the *Veneridae* containing eight species. Furthermore, specific richness varied also between zones (Table 3). Thus, the Tangier zone was the richest and most diversified containing a total of six families (*Cardiidae*, *Macridae*, *Mytilidae*, *Pectinidae*, *Tellinidae*, *Veneridae*) followed by the zone of Al-Hoceima with five families (*Donacidae*, *Lucinidae*, *Macridae*, *Mytilidae*, *Veneridae*), the zone of Saidia with four families (*Cardiidae*, *Macridae*, *Tellinidae*, *Veneridae*), and finally the zone of Nador which was the poorest one with 3 families (*Cardiidae*, *Donacidae*, *Veneridae*).

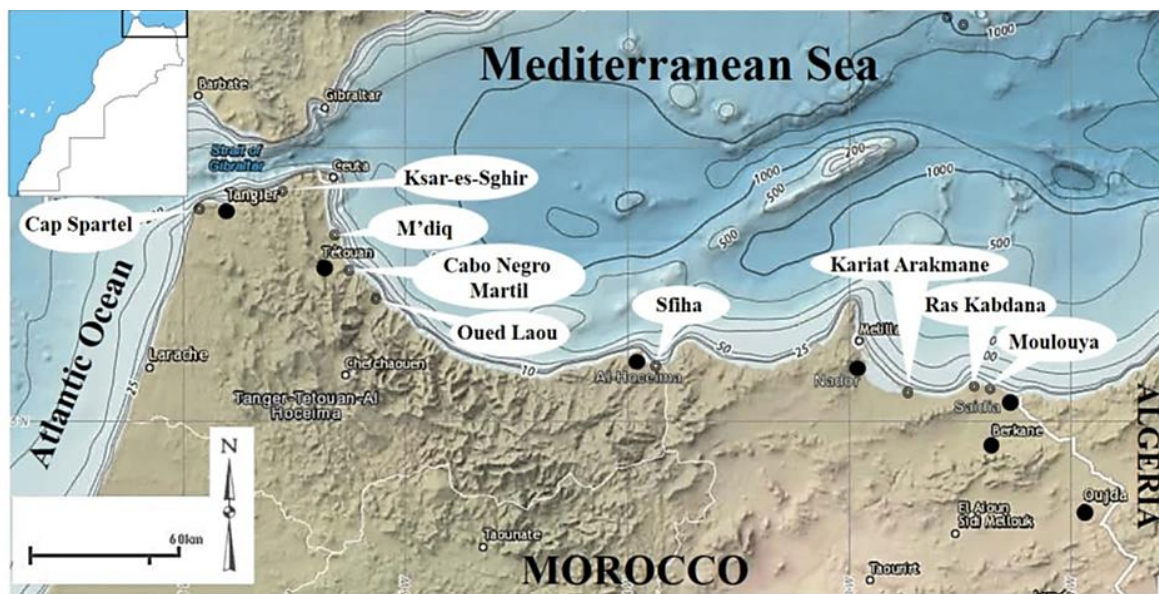


Fig. 1. Localization of sampling sites.

Table 1. Geographical and climatic characteristics of sampling sites.

Coasts	Latitude	Longitude	Annual precipitation (mm)	Average temperature(°C)
Cap Spartel	35°11' N	06°10' W	765	17.6
Ksar-Es-Sghir	35°50' N	05°33' W	785	18
M'diq	35°41' N	05°18' W	710	19
Cabo Negro	35°41' N	05°16' W	601	19.6
Martil	35°37' N	05°16' W	601	19.6
Oued Laou	35°28' N	05°06' W	440	21.6
Sfiha	35°12' N	03°54' W	500	20
Karyat Arakman	35°10' N	02°56' W	208	20
Ras Kabdana	35°08' N	02°25' W	300	19
Moulouya estuary	35°07' N	02°21' W	327	17.5
Saidia	35°05' N	02°15' W	336	20.5

**Table 2. Taxonomic diversity of bivalve families in the four zones of study along the Mediterranean coast of Morocco.**

Families / Species	Number of Individuals			
	TNG	ALH	NAD	SAD
ANOMIDAE				
<i>Anomia ephippium</i> (Linnaeus, 1758) <sup>+</sup>	50	11	10	20
ARCIDAE				
<i>Arca lactea</i> (Linnaeus, 1758)*	3	0	0	0
<i>Arca barbata</i> (Linnaeus, 1758)	13	15	18	25
<i>Arca noae</i> (Linnaeus, 1758)	5	2	10	12
CARDIIDAE				
<i>Cardium tuberculatum</i> (Linnaeus, 1758) <sup>+</sup>	45	30	20	42
<i>Laevicardium oblongum</i> (Gmelin, 1791)	16	0	6	4
<i>Cardium paucicostatum</i> (Sowerby, 1839)*	0	0	0	1
<i>Cardium costatum</i> (Linnaeus, 1758)	2	0	5	7
<i>Cardium echinatum</i> (Linnaeus, 1758)	20	0	0	0
<i>Cardium aculeatum</i> (Linnaeus, 1758) <sup>+</sup>	50	6	30	45
<i>Laevicardium crassum</i> (Gmelin, 1791)	30	0	7	5
<i>Cardita calyculata</i> (Linnaeus, 1758)	2	0	?	0
<i>Cerastoderma glaucum</i> (Poiret, 1789) <sup>+</sup>	50	0	20	60
<i>Cerastoderma edule</i> (Linnaeus, 1758)	45	0	12	10
CHAMIDAE			0	
<i>Chama gryphoides</i> (Linnaeus, 1758)	42	20	0	8
DONACIDAE				
<i>Donax semistriatus</i> (Poli, 1795) <sup>+</sup>	40	35	30	50
<i>Donax trunculus</i> (Linnaeus, 1758)	30	3	10	25
<i>Donax venustus</i> (Poli, 1795)	15	20	10	15
GLYCYMERIDAE				
<i>Glycymeris glycymeris</i> (Linnaeus, 1758) <sup>+</sup>	50	40	30	42
<i>Glycymeris bimaculata</i> (Poli, 1795)	2	0	0	2
<i>Glycymeris violacescens</i> (Lamarck, 1819)	18	10	20	15
LIMIDAE				
<i>Lima hians</i> (Gmelin, 1791)	10	0	10	2
<i>Lima squamosa</i> (Lamarck, 1801)	25	2	12	20
LUCINIDAE				
<i>Diplodonta rotundata</i> (Montagu, 1803)	2	3	0	0
<i>Lucinoma borealis</i> (Linnaeus, 1767)	20	2	0	0
<i>Lucina lactea</i> (Linnaeus, 1758)	10	2	0	0
MACTRIDAE				
<i>Lutraria lutraria</i> (Linnaeus, 1758)	10	0	0	0
<i>Lutraria oblonga</i> (Gmelin, 1791)	10	0	0	0
<i>Spisula solida</i> (Linnaeus, 1758)	25	0	0	3
<i>Mactra glauca</i> (Born, 1778)	25	12	0	5
<i>Mactra stultorum</i> (Linnaeus, 1758) <sup>+</sup>	40	20	0	40
<i>Spisula subtruncata</i> (da Costa, 1778) <sup>+</sup>	45	22	0	38
MYTILIDAE				
<i>Lithophaga lithophaga</i> (Linnaeus, 1758)	0	0	0	0
<i>Perna picta</i> (Born, 1780)	16	0	0	0
<i>Mytilaster minimus</i> (Poli, 1795)	1	0	0	0
<i>Mytilus edulis</i> (Linnaeus, 1758) <sup>+</sup>	20	15	0	60
<i>Mytilus galloprovincialis</i> (Lamarck, 1819)	30	4	2	8
OSTREIDAE				
<i>Ostrea edulis</i> (Linnaeus, 1758) <sup>+</sup>	70	0	8	30
<i>Ostrea angulata</i> (Lamarck, 1819)	17	0	0	5
<i>Crassostrea gigas</i> (Thunberg, 1793)	5	0	0	0
PANDORIDAE				
<i>Pandora inaequalis</i> (Linnaeus, 1758)	3	0	0	2

PECTINIDAE				
<i>Crassadoma multistriata</i> (Poli, 1795)	5	0	0	0
<i>Chlamys varia</i> (Linnaeus, 1758)	15	5	7	10
<i>Aequipecten opercularis</i> (Linnaeus, 1758)	20	0	0	12
<i>Pecten jacobaeus</i> (Linnaeus, 1758)	20	0	9	1
<i>Pecten maximus</i> (Linnaeus, 1758)	10	0	0	0
PHOLADIDAE				
<i>Barnea candida</i> (Linnaeus, 1758)	8	0	0	5
<i>Pholas dactylus</i> (Linnaeus, 1758)	12	0	0	9
PINNIDAE				
<u><i>Pinna nobilis</i></u> (Linnaeus, 1758)	2	6	0	5
PSAMMOBIDAE				
<i>Gari fervensis</i> (Gmelin, 1791)	13	0	0	2
SCROBICULARIDAE				
<i>Scrobicularia plana</i> (da Costa, 1778)	20	0	0	0
SOLENIDAE				
<i>Ensis siliqua</i> (Linnaeus, 1758)	25	2	0	20
<i>Ensis ensis</i> (Linnaeus, 1758)	10	0	0	15
<i>Solen marginatus</i> (Pulteney, 1799)	20	0	0	15
SOLECURIDAE				
<i>Solecurtus antiquatus</i> (Pulteney, 1799)	3	0	0	0
<i>Solecurtus strigilatus</i> (Linnaeus, 1758)	10	0	0	0
<i>Azorinus chamasolen</i> (da Costa, 1778)	10	0	0	0
<i>Pharus legumen</i> (Linnaeus, 1758)	12	0	0	0
SPONDYLIDAE				
<i>Spondylus gaederopus</i> (Linnaeus, 1758)	6	0	5	3
TELLINIDAE				
<i>Gastrana fragilis</i> (Linnaeus, 1758)	10	0	0	6
<i>Tellina planata</i> (Linnaeus, 1758)	12	0	0	20
<i>Tellina pulchella</i> (Lamarck, 1818)	3	0	0	0
<i>Tellina nitida</i> (Poli, 1795)	10	0	0	3
<i>Tellina incarnata</i> (Linnaeus, 1758)	3	0	0	4
<i>Tellina tenuis</i> (da Costa, 1778)	2	0	0	4
VENERIDAE				
<i>Chamelea gallina</i> (Linnaeus, 1758) <sup>+</sup>	62	50	45	55
<i>Venus verrucosa</i> (Linnaeus, 1758)	15	0	8	0
<i>Circomphalus casina</i> (Linnaeus, 1758)	10	10	0	0
<i>Venerupis pullastra</i> (Montagu, 1803)	5	0	0	0
<i>Clausinella fasciata</i> (da Costa, 1778)	5	0	0	1
<i>Callista chione</i> (Linnaeus, 1758)	40	10	8	15
<i>Dosinia lupinus</i> (Linnaeus, 1758)	40	13	10	15
<i>Ruditapes decussatus</i> (Linnaeus, 1758)	2	10	8	10

TNG: zone of Tangier; ALH: zone of Al-Hoceima; NAD: zone of Nador; SAD: zone of Saidia.

Dominant species are followed by the symbol <sup>+</sup>. Asterisks (\*) indicate new species signaled for the zones of Tangier and Saidia. Threatened and overexploited species are underlined.

**Table 3. Specific richness (SR) and relative abundance (RA) among bivalve families sampled in the four zones of study along the Mediterranean coast of Morocco. Richer families in each zone are underlined. Dominant families in each zone are presented in bold.**

Bivalve families	% (ni/N) (TNG)		% (ni/N) (ALH)		% (ni/N) (NAD)		% (ni/N) (SAD)	
	SR	RA	SR	RA	SR	RA	SR	RA
ANOMIIDAE	1.4	3.7	3.4	2.9	3.6	2.7	1.9	2.4
ARCIDAE	4.2	1.6	6.9	4.5	7.1	7.6	3.8	4.5
CARDIIDAE	<u>12.5</u>	<b>19.2</b>	6.9	<b>9.5</b>	<u>25.0</u>	<b>27.0</b>	<u>15.4</u>	<b>20.9</b>
CHAMIDAE	1.4	3.1	3.4	5.3	0.0	0.0	1.9	1.0

DONACIDAE	4.2	<b>6.3</b>	<u>10.3</u>	<b>15.3</b>	<u>10.7</u>	<b>13.5</b>	5.8	<b>10.8</b>
GLYCYMERIDAE	4.2	<b>5.2</b>	6.9	<b>13.2</b>	7.1	<b>13.5</b>	5.8	<b>7.1</b>
LIMIDAE	2.8	2.6	3.4	0.5	7.1	5.9	3.8	2.6
LUCINIDAE	4.2	2.4	<u>10.3</u>	1.8	0.0	0.0	0.0	0.0
MACTRIDAE	<u>8.3</u>	<b>11.5</b>	<u>10.3</u>	<b>14.2</b>	0.0	0.0	<u>7.7</u>	<b>10.3</b>
MYTILIDAE	<u>6.9</u>	<b>5.0</b>	<u>10.3</u>	5.0	7.1	0.5	5.8	<b>8.2</b>
OSTREIDAE	4.2	<b>6.8</b>	0.0	0.0	3.6	2.2	3.8	4.2
PANDORIDAE	1.4	0.2	0.0	0.0	0.0	0.0	3.8	0.2
PECTINIDAE	<u>6.9</u>	<b>5.2</b>	3.4	1.3	7.1	4.3	5.8	2.8
PHOLADIDAE	2.8	1.5	0.0	0.0	0.0	0.0	3.8	1.7
PINNIDAE	1.4	0.1	3.4	1.6	0.0	0.0	1.9	0.6
PSAMMOBIDAE	1.4	1.0	0.0	0.0	0.0	0.0	1.9	0.2
SCROBICULARIDAE	1.4	1.5	0.0	0.0	0.0	0.0	0.0	0.0
SOLENIIDAE	4.2	4.1	3.4	0.5	0.0	0.0	5.8	6.0
SOLECURIDAE	5.6	2.6	0.0	0.0	0.0	0.0	0.0	0.0
SPONDYLIDAE	1.4	0.4	0.0	0.0	3.6	1.4	1.9	0.4
TELLINIDAE	<u>8.3</u>	3.0	0.0	0.0	0.0	0.0	<u>9.6</u>	4.5
VENERIDAE	<u>11.1</u>	<b>13.2</b>	<u>17.2</u>	<b>24.5</b>	<u>17.9</u>	<b>21.4</b>	<u>9.6</u>	<b>11.6</b>
<i>Total species (individuals)</i>	72	1352	29	380	28	370	52	831

TNG: zone of Tangier; ALH: zone of Al-Hoceima; NAD: zone of Nador; SAD: zone of Saidia.

#### 4. DISCUSSION

Earlier quantitative studies on bivalve molluscs of the Mediterranean basin were achieved by several authors such as Moueza (1972), Amouroux (1974), Moueza and Chessel (1976), Bodoy and Massé (1978), Ansell and Bodoy (1979), Ansell *et al.* (1980), Bayed (1980), Bitar (1987), Menioui (1988), Naciri (1990), Ramón *et al.* (1995), Chraïbi (2001). However, the results from these works could not be compared to our results obtained by a semi-qualitative approach.

As universally observed in marine ecosystems, bivalve molluscs of the Mediterranean coast of Morocco exhibit a large specific richness. This is particularly true of the family of *Cardiidae*, where 260 individuals sampled in Tangier zone belong to nine species that are much exploited on Moroccan coasts. We can hold up as examples of exploited species: *Cardium aculeatum*, *Cardium echinatum*, *Cardium tuberculatum*, and *Cerastoderma glaucum*. Other families also appear to have an important specific richness and present some exploited species such as the *Glycymeridae* (*Glycymeris bimaculata*, *Glycymeris glycymeris*, and *Glycymeris violascens*), the *Donacidae* (*Donax trunculus*), the *Mytilidae* (*Lithophaga lithophaga*, and *Perna picta*), the *Pectinidae* (*Pecten opercularis*, and *Pecten maximus*), the *Solenidae* (*Ensis ensis*), and the *Veneridae* (*Cytherea chione*, *Venus gallina*, *Ruditapes decussatus*). Similar observations on exploited bivalve species were also

reported by Laazouzi (1999) and Shafee (1999).

Our results reveal that the four zones of the Mediterranean coast of Morocco are characterized by a high specific richness. We counted 72 species in Tangier zone, 29 species in Al-Hoceima, 28 species in Nador and 52 species in Saidia. It was to be expected that the Occidental zone (Tangier) could be the most diversified and rich in bivalve species because of a large diversity of habitats typical of this zone. In addition, the influence of water currents originating from the Atlantic Ocean through the Gibraltar strait favors bivalve larval dispersion into the western part of Moroccan Mediterranean coasts. In the eastern part, the zone of Saidia was second in terms of specific richness. With some 14 km in length, it is the longest stretch of sandy coast in northern Morocco. This zone is also characterized by the presence of an important river, which delimits the Moulouya estuary, which connects the coastlines of Saidia and Ras Kabdana. The Al-Hoceima zone is ranked third in diversity. However, the diversity is not high, rocky beaches are quite frequent; their coasts are very small and occur near a station for wastewater treatment (Sabadia beach) or near a touristic club in the case of the Sfiha coastline. The Nador zone was the poorest in specific richness and biodiversity. In fact, the coast of Karyat Arakmane is located at the border of a lagoon ecosystem (the lagoon of Nador) characterized by an intense containment of its water masses that impacts negatively on the biochemical quality of the overall ecosystem

(Menioui and Zine, 1992; Zine and Menioui, 1998). Finally, it should be mentioned that we did not find *Lithophaga lithophaga* at any site, but taking into account its economic importance, we have included it in this work. A study by the FAO in 1999 indicated that this species was harvested along the Mediterranean coasts of Morocco and sold to Spanish wholesalers, even though it is protected by law in Morocco (Shafee, 1999). This species is also encountered in identification guides prepared for the needs of fishing, which suggests that it could be an important fishery resource (Fischer *et al.*, 1987). According to Gonzales *et al.* (2000), an illicit trade of this bivalve is observed between Morocco and Spain although recorded data are not available.

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