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Depth segregation phenomenon and the macrofaunal diversity associated to *Acanthocardia tuberculata* (Linné, 1758) and *Callista chione* (Linnaeus, 1758), populations of the Northwest of Morocco.

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Abstract

Being a part of the Mediterranean ecosystem, the maritime zone included between M' Diq and Ouad Laou is characterized by a biodiversity which has not hitherto been studied, making difficult the implementation of suitable management measures. A study was undertaken to evaluate the existence of depth segregation between *Acanthocardia tuberculata* and *Callista chione* adults and juveniles in populations the Northwest of Morocco, on the West part of its Mediterranean facades, and the macrofaunal diversity associated to this two species.

Samples were collected from the infra-littoral zone between December 2009 and April 2010 at two sampling stations situated in the M'diq lagoon and Kkaa srass. Sampling was undertaken at increasing depths (one tow per depth), between 0 metres and 20 depth, the tows were performed parallel to the shoreline. The size frequency distribution showed the predominance of smaller individuals (<50 mm) in the intermediate depth area (5-10 m depth) and the prevalence of larger individuals (≥ 50 mm) at greater depths (15 m depth). The classic numeric descriptors were used for the characterization of the entities fauna and they indicated naturally disturbed habitat, and that the species met in all of the stations resorts are fairly distributed.

Key words: Acanthocardia tuberculata, Callista chione, depth segregation, macrofauna, Morocco.

1. Introduction:

Acanthocardia tuberculata and *Callista chione* are two of the most characteristic groups of soft-bottom benthic communities in the Northwest of Morocco, on the West part of its Mediterranean facades (Fig1). These two species often dominates benthic macrofauna in M'diq and Kaa srass and has been shown to constitute a good surrogate for describing the distribution of macrobenthic communities at least when it is the dominant component of macrofauna [1]. These species are commercially exploited in the north west of Morocco by a dredge fleet, but despite its commercial importance, its bioecology has not hitherto been studied [2]. In this context, the aims of the present study were to study the variations touching the bathymetric distribution of *Acanthocardia tuberculata* and *Callista chione*. As well as their relation with the species which occupied with them the same ecological nest, to be able to learned more about the diversity of the autochthon benthic macrofauna and to identify the relationships between the (*Acanthocardia tuberculata* and *Callista chione*) and the others species in different biotopes.

2. Materials and Methods

The sampling operations were carried out between December 2009 and April 2010 at two sampling stations situated in the M'diq bay and Kaa srass (Northwest of Morocco, on the West part of its Mediterranean facades) (Figure 1).

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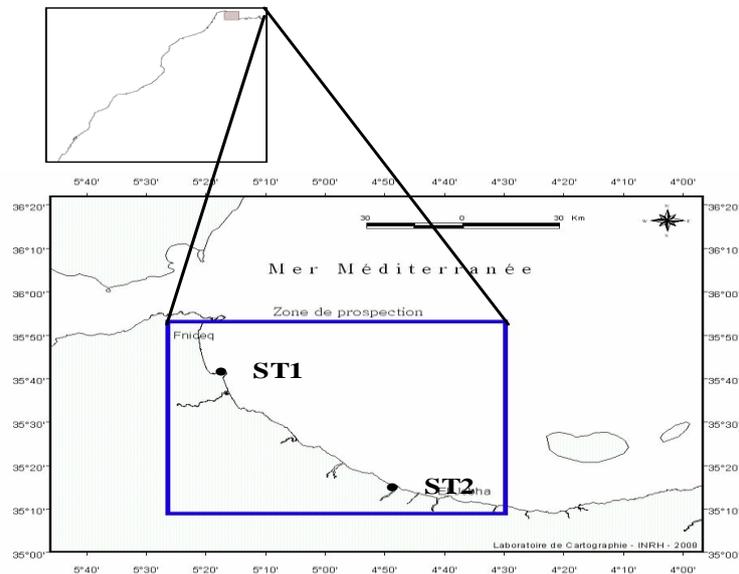


Figure 1: The map of the sampling zone in the Northwest of Morocco (Mediterranean sea), ST1:M'diq; ST2: Kaa srass.

The sampling was undertaken using a commercial fishing boat equipped with an artisanal dredge. The dredges used in this study were similar to the ones used by professional fishermen. A toothed lower bar (with tooth length of 16-18 cm, spaced 22 cm) at the dredge mouth. In order to catch the smaller individuals the net bag was changed with another one with a smaller stretched mesh size (2,5mm). (Figure 2)

The position of each station was calculated using a handheld Magelan satellite navigator and depth was measured by means of a ballasted and marked rope. One transect per site was established perpendicular to the shoreline [2]. Samples were collected from the infra-littoral zone between 0 metres and 20 metres depth, the tows were performed parallel to the shoreline. Sampling was undertaken at increasing depths (one tow per depth). The dredged distance was estimated by measuring the cable of drive at the end of the operation.

The seabed consists of coarse to fine-grained sand is distributed along the coast from 0 to 26 m depth, followed by a clear narrow fringe of shell-sand sediments between 26 and 70 m [1].



Figure 2: Moroccan dredge of *Callista chione* and *Acanthocardia tuberculata*.

Station 1: M'diq bay

The slope is less pronounced and the sediments consist basically on alternation of admixture shell debris, gravel and sand sediment, characterized by contents in sand superior to 70 %. Shell-sand sediments occupy a band parallel to the shoreline which can go on until 75 m of depth [1].

Station 2: Kaa srass

This station, was located in front of the river zone, and is influenced by sediment resuspension and is characterized by a mud-sand composition with haloes of muddy sand, but they do not overtake 20m ([3]; [1]).

The organisms retained by the sieve were counted and classified to the lowest possible taxonomic level for polychaetes, bivalves and echinoderms. The rest of the taxa were classified only to major groups.

The three following parameters were used to calculate the Shannon's diversity index, the equitability and Richness [S] (number of species).

The formulas used are:

- Diversity index of Shannon (Shannon & Weaver, 1963)

$$H' = -\sum q_i \text{Log}_2 q_i, q_i = \text{relative abundance of each species};$$

- Index of equitability:

$$E = H' / H_{\text{max}}, H' \text{ is the Shannon-Weaver Index and } H_{\text{max}} \text{ is the maximum possible assuming equal representation of all species.}$$

3. Results and discussion:

3.1. Length frequency distribution:

The length frequency distribution and mean length variation against depth for *Callista chione* and *Acanthocardia tuberculata* populations at the two sampling areas are shown in Figure 1.

In this study both species in both sites showed a decrease in the number of smaller individuals and an increase in the number of larger individuals with depth. Indeed, the mean length variation with depth confirmed previous results, revealing an increasing length gradient with depth (Figure 3).

Distribution and density of clams are influenced by environmental changes, whether abiotic and biotic factors as well as to human activity. Food webs of sandy beaches are mainly based on marine sources, such as phytoplankton, stranded algae, sea grasses and carrion [4]. A study by [5], [12] and [6], revealed an intimate correlation between temperature and depth segregation in *Donax serra*, where juveniles are positioned higher in the mid-tide zone.

Several studies refer to the existence of intraspecific competition, mostly between larvae and adults, in which larval settlement contributes to the different depth distribution of juveniles and adults [8], [9], [10], [11] and [2]. The [12] explain that the number of juveniles per adult was even higher in the uppermost parts, i.e. the parts that warm up most during summer. The highest densities of juveniles in the uppermost parts of the intertidal zone can be the result of upshore transport during the first months of life. Thus, spatial segregation phenomena with depth become more evident in recruitment period due to the presence of juvenile specimens. As maintained by [8], the relative proportions between juveniles and adults with depth fluctuate seasonally; the population structure was composed mostly of adult [2].

According to [13] and [14], burrowing time of *D. trunculus* in relation to wave period determines to what extent individuals are drifted from the zone where they preferentially live. The shorter burrowing time of smaller clams, and their ability to burrow faster than larger individuals in coarse sands suggest that juveniles may be able to withstand more reflective morphodynamic conditions than adult individuals.

Species, *Chamelea gallina*, caught simultaneously by this multispecific dredge fishery, using the same fishing gear, in the same area size frequency is always dependent of depth distribution, showing tendency for spatial and depth segregation phenomenon [11] like *Callista chione* and *Acanthocardia tuberculata*.

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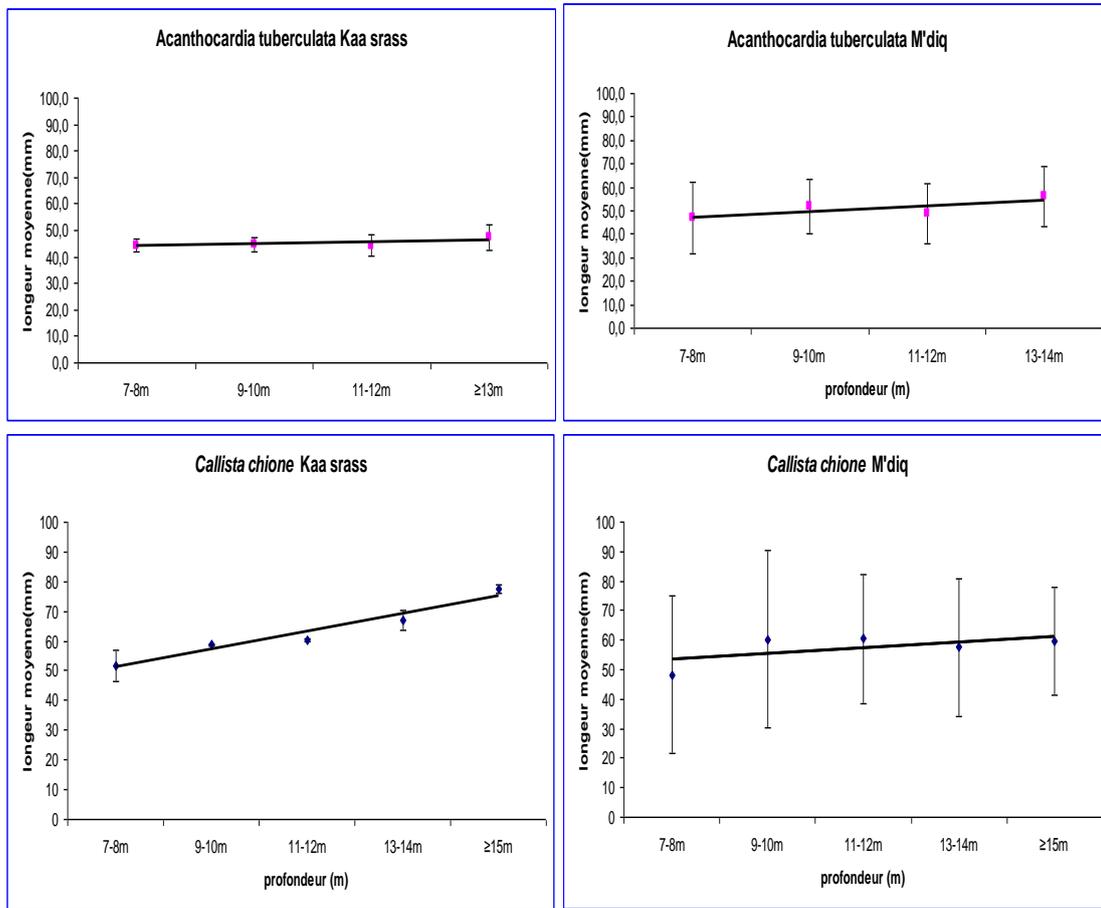


Figure 3: Mean length variation with depth for *Acanthocardia tuberculata* and *Callista chione* populations at two station M'diq and Kaa sraas in the Northwest of Morocco.

3.2. Associated species:

In total, 42 species belonging to seven zoological groupes, associated to *Callista chione* and *Acanthocardia tuberculata*, were identified. In both sites Mollusks (27- 22 %) were the most representative group followed by echinoderms (10-12 %), and crustaceans (6-8%). The polychetes and others groups, they establish averaged 4 %.

As expected, *Callista chione* and *Acanthocardia tuberculata* were the species that dominate benthic communities in both station 1(M'diq) and station 2 (Kaa sraas). Suspension feeders and deposit were numerically the two main functional group accounting higher abundances, followed by carnivore and herbivores.

Species richness was higher in station of M'diq at depth 10-15m (15 species) and lower in Kaa sraas (> 15m) (8 species) (Table 1). The variations of the Species richness seem to be related to fluctuations in environmental factors.

The values of the dominance (Table.1) reveal that *Echinocardium mediterraneum* always counts among the most dominant species in four depth stations of M'diq with a maximal percentage of 31 % in the shallower station at ≤5m. At M'diq, *Acanthocardia tuberculata* was the clear dominant species, in intermediate depth stations at 5-10m and 10-15m with (23 and 39%, respectively).

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The abundance of *Callista chione* was maximal in M'diq and Kaa srass at the deeper station $\geq 15m$ and in M'diq at intermediate depth 10m-15m with respectively value: 40%, 35% and 24%. Maximal abundance of *Spisula subtruncata* (62%) was observed at Kaa srass in intermediate depth station at 5-10m.

These results (Table 1) plead in favour of a trophique and spatial competition between these species, *Acanthocardia tuberculata* and *Callista chione*. It can therefore be seen that, this species share the same biotope with *Acanthocardia tuberculata* and *Callista chione*. The cockle (*A. tuberculatum*) and the smooth clam (*C. chione*) are essentially suspension-feeders as the most of other species and present all the same trophiques requirements and so occupy the same ecological niche. Some of them use shell, of cockle and smooth clam, as substratum; it is the case of patellidea. Macroinfauna participating specially arthropods and other types of molluscs compete with clams, where as these animals' increased clams' movements to other places.

Station	M'diq	Kaa srass
$\leq 5m$	<i>Echinocardium mediterraneum</i> (31%) <i>Macra corallina</i> (29%) <i>Donax trunculus</i> (10%)	
5--10m	<i>Acanthocardia tuberculata</i> (23%) <i>Acanthocardia echinata</i> (19%) <i>Echinocardium mediterraneum</i> (7%)	<i>spisula subtruncata</i> (62%) <i>Acanthocardia tuberculata</i> (17%) <i>Callista chione</i> (8%)
10m-15m	<i>Acanthocardia tuberculata</i> (39%) <i>Callista chione</i> (24%) <i>Echinocardium mediterraneum</i> (4%)	<i>Callista chione</i> (24%) <i>Acanthocardia tuberculata</i> (23%) <i>spisula subtruncata</i> (13%)
$\geq 15m$	<i>Callista chione</i> (40%) <i>Ensis siliqua</i> (12%) <i>Echinocardium mediterraneum</i> (7%)	<i>Callista chione</i> (35%) <i>Pagurus bernhardus</i> (12%) <i>Patel</i> (12%)

Table1: Spatial variations of the dominance.

Callista chione and *Acanthocardia tuberculata*, are commonly the main primary consumers in soft bottom communities, while they are in turn subject to predation by a wide variety of invertebrates, fish and mammals [4]. Larger macrobenthic invertebrates burrow actively and include representatives of many phyla, but crustaceans, molluscs and polychaete are usually dominant and encompass predators, scavengers, filter and deposit feeders [15].

		<5m	5-10m	10-15m	>15m
M'diq	H'	2,71	2,99	2,44	2,80
	S	14	15	13	11
	E	0,72	0,77	0,69	0,81
Kaa srass	H'	-	1,81	2,57	2,40
	S	-	11	11	8
	E	-	0,53	0,78	0,85

Table2: Spatial variations of the the Shannon Weaver index (H'), spécifique richness (S) and equitability (E)

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During the present study, the Shannon-Weaver index per site was between 1,81bits as a minimal value registered in Kaa srass at intermediate deeper station 5-10m, and 2,99bits the maximal value registered in M'diq at the same deep (5-10m).

The distribution of macroinfaunal species in all of stations shows that they are frequented by normal communities, so translating stability. The equitability varied between 0,53bits at Kaa srass at depth of 5-10m depth and 0.85 bits as a higher value registred at Kaa srass at the deeper station >15m.

Variations of species richness showed the same pattern along the two stations. The higher values were recorded in M'diq at the intermediate depth (5 to 10m). These results showed that the communities belonging to these various ecosystems are in a state of balance and that the species met in all the stations resources are fairly distributed (Table 1).

This analysis brings to light the presence of the populating benthique structured and balanced for the totality of stations.

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