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Community Structure of a Molluscan Assemblage in an Anthropized Environment, Hammamet Marina, North-Eastern Tunisia

Refka Elgharsalli[1,*], Lotfi Rabaoui[2,3], Nejla Aloui-Bejaoui[1]

[1] Institut National Agronomique de Tunisie, 43, Avenue Charles Nicolle, 1082 Tunis, Tunisia.
[2] University of Tunis, Research Unit of Integrative Biology and Evolutionary and Functional Ecology of Aquatic Systems, Faculty of Science of Tunis, 2092, El Manar, Tunisia.
[3] University of Gabes, Higher Institute of Applied Biology of Medenine, El Jorf Street Km 22.5 – 4119 Medenine, Tunisia

* Corresponding Author: Tel.: +21.620 951116
E-mail: refkagr@yahoo.fr

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Abstract

Hammamet Marina is the most important touristic port in the Gulf of Hammamet (Tunisia). The present work is a contribution to the knowledge of the functional diversity and structure of the malacofauna community in this area. Three different stations (A, B and C) within the port were sampled seasonally for a year (2005-2006). The mollusc assemblage studied was represented by 14 species (in totally 2669 ind. were found). Among the four mollusc classes recorded, bivalves were the best represented (73.76% of the total number species), followed by gastropods (22.02%), cephalopods (2.42%) and polyplacophores (1.80%). Atlanto-Mediterranean (42.85%) and Endemic Mediterranean (39.28%) taxa prevailed in the community, followed by Indo-Pacific (7.14%) and cosmopolitan species (3.57%). A clear spatial zonation was distinguished. The station B hosted the highest abundance of gastropods (309±19.92 ind. m^{-2}) and a species richness of 6±0.40. The station station A hosted the most equilibrated trophic structure, with a higher bivalve abundance (1378±99.23 ind. m^{-2}) and a species richness of 6±0.1. Station C, located close to the mooring boats, presented the lowest abundance (230±17.47 individuals m^{-2}) and the most affected assemblage. This station seemed to be affected by the higher anthropogenic pressure assessed compared to the other two stations, mainly oil pollution, due to the large quantities of hydrocarbon discharged from the boats.

Keywords: Malacofauna, Yasmine Hammamet harbor, community structure.

Introduction

The marine biodiversity changes in the Mediterranean Sea are of major concern. In fact, while this small semi-enclosed sea is characterized by a high degree of endemism and unique communities, it is also the sea receiving the highest number of alien species (Drake and Lodge, 2004; Flagella and Abdulla, 2005; Streftaris *et al*., 2005; Galil, 2007a, 2008a, 2008b). Within this context, it is well known that the Suez Channel which was founded in 1869 between the Mediterranean and the Red Sea has enhanced the introduction to the Mediterranean Sea of hundreds of exotic marine species which were reported to have significant ecological and economic effects on the local communities (Zenetos *et al*., 2012; Katsanevakis *et al*., 2013 ; Lefkaditou *et al.*, 2009; Galil, 2000). However, while no extinction of a native species has not yet been reported as a consequence of these introductions, sudden declines in abundance and even local disappearances of native species concurrent with the proliferation of alien species have been recorded (Galil, 2007a).

In the Mediterranean Sea, macrofaunal communities play a crucial role in the balance of the benthic ecosystem (Barnes, 1980). Due to the richness of this zoological group, numerous studies dealt with macrofaunal communities in different Mediterranean areas (Vieira and Amat, 1997; Pavlova *et al*., 1998; Zammouri-Langar *et al*., 2001; Ayari and Afli, 2003). Molluscs are among the dominant and most important components of the benthic macrofauna (Barnes, 1980; Guellorget and Perthuisot, 1992). It deals also with one of the most intensively studied groups (Savatore and Paola, 2002; Baldrighi, 2013) which are has often used as zoological model that had better inform on the general ecological trends of the benthos (Lardicci *et al*., 1997; Erhan and Mehmet, 2012).

Along the Tunisian coastline, many studies have been carried out on molluscan fauna (e.g. Zamouri-langar *et al*., 2001; Ayari and Afli, 2003; Aloui-Bejaoui and Afli, 2012). Various fishing and touristic ports are spread along the Tunisian coastline, and these areas are known to host a lot of mollusc species. However, there is still a knowledge gap on the influence of maritime port activity and its related hazards on the biodiversity of the hosted molluscan assemblages. The present study investigated the

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functional diversity of the molluscan fauna for the first time in Yasmine Hammamet harbor during a year of study and determine the spatio temporal distributions of mollusks.

Materials and Methods

Study Area

The large Gulf of Hammamet is located in north-east Tunisia between 36°52′N and 8°45′E; it lies at the south of Cap Bon peninsula (Figure1). It is characterized by coastal sandy beaches, strong currents, and high-energy waves (Oueslati, 1993). The seawater temperature and salinity were reported to range between 10.3 and 29.78°C and between 37.1 and 38.8‰ respectively (Chouba *et al*., 1996). The Gulf of Hammamet is an area with important tourism development, in particular along the coasts of Hammamet city which hosts a huge Marina, Hammamet Marina located in the northern part of the Gulf at 36°22′N and 10°33′E. It was built in 2001 and it covers an area of 27.8 ha with a maximum depth of 9 meter. Fluvial input is ensured through four small inlets at the western and eastern part of the Marina.

Field Sampling and Processing

The sampling survey of this study was conducted in Hammamet Marina. In order to cover the entire area of the port, three stations (A, B and C) were defined and sampled. Station A is located at the entrance of the channel surrounding the artificial island (maximal depth: 6 meters) and near of seawater injection point (1000 liter/sec). Station B is located at the main entrance of the harbor (maximal depth: 9 meters). As for station C, it is located at the boat-docking structures in the main basin (maximal depth: 6 meters). For each station, samples taken for mollusks and environmental parameters were collected seasonally in July 2005, October 2005, January 2006 and April 2006. At each sampling survey, three replicate samples of mollusks were collected at each station with the use of a hand-operated van Veen. The samples collected were sieved through a 0.5 mm mesh, fixed in 5% neutralized formalin and preserved thereafter in alcohol (70%). After transporting the sampled to the laboratory, all living mollusc specimens were sorted according to the systematics of animals, identified to the species level under a stereoscopic microscope, counted and dry-weighed. The samples are grouped into mollusks class in order to have a clearer idea on their distribution at the Yasmine Hammamet harbor and to determine the possible relationship between these class and the parameters of the study station.

In parallel, sediment and water samples were taken monthly from each station for the analysis of abiotic parameters: temperature, salinity (Practical Salinity Scale), dissolved oxygen, pH and mean diameter of sediment particles. Sediment grain size was analyzed through sieving and expressed as proportions. To do so, sediment samples were dried at 60°C for 48 hours. In order to make the sediment free of fine fraction (Afli, 1999), 100 g subsamples were thereafter washed and sieved through a 63 micron

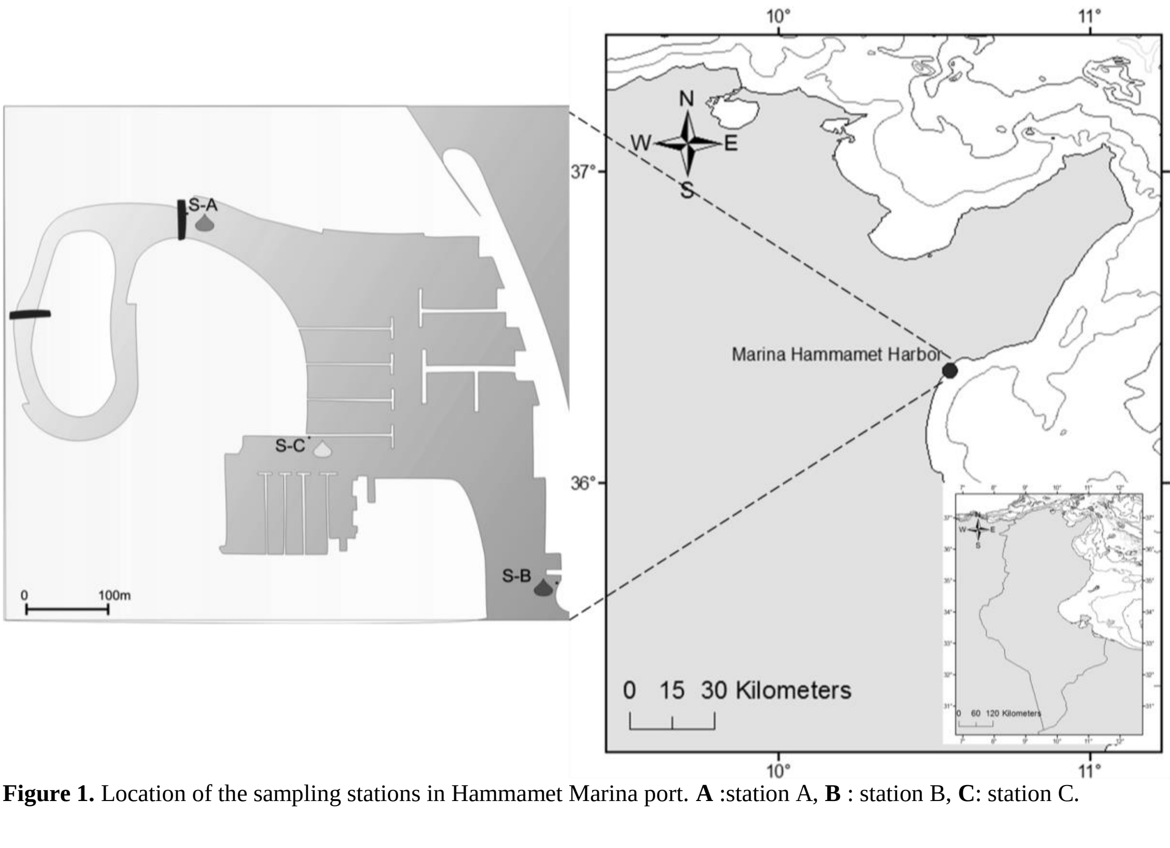

Figure 1. Location of the sampling stations in Hammamet Marina port. **A** :station A, **B** : station B, **C**: station C.

mesh. The sediment retained in the sieve was again dried at 60°C for 48 hours and sieved through an AFNOR sieve series. Based on the relative proportions of the three fractions, mud, sand and gravel, the samples analyzed can be placed in the corresponding triangular diagram of Shepard (1954) allowing to determine the corresponding sediment type according to the classification of Chassé and Glémarec (1976).

Data Analysis

All mollusc individuals were classified with respect to the environment affinity, organismic assemblage, life mode, feeding habit and zoogeographical category (*origin*: AM Atlanto-Mediterranean, E Mediterranean Endemic, C Cosmopolite, TINDO Tropical Indo–Pacific; *occurrence*: ATC All Tunisian Coasts, NTC North Tunisian Coasts). The categories considered in each of these latter factors are summarized in Table 1. The structure and dynamics of molluscan communities were assessed using some of the widely used ecological descriptors including the total number of species (S), average density (average number of individuals m^{-2}), and Shannon Wiener diversity index (H', $\log_2$ basis).

Molluscs species distribution, depending on the station and season were analysed by One-way ANOVA to assess the significant differences ($P<0.05$) between either seasons (4 levels) and stations (3 levels). Differences were considered significant with a probability (P) value of 0.05 or less. The Molluscs species distribution, abiotic parameters according to station and season were visualized and characterized by a Factorial Correspondence Analysis (FCA), which was conducted in order to figure the spatio-temporal clustering of the samples analyzed. All statistical analyses were carried out using XLSTAT Software (version 2015.4.01 Addinsoft™ SARL).

Results

Abiotic Data

Even though the environmental data showed large variations, some distinct temporal variability patterns were observed (Figure 2). Sea surface temperature varied from 16.2°C (in October 2005) to 28.9°C (in August 2006), with an annual average value of 21.30±4.05°C. The average value of dissolved oxygen was estimated of 4.35±0.90 mg L^{-1} and it was found to range between a maximum of 6.29 mg L^{-1} recorded in November 2005 and a minimum of 3.15 mg L^{-1} recorded in July 2006. As for the salinity, it ranged between 36.1 in December 2005 and 37.8 in August 2006 with an average value of 36.87±0.58. The pH varied between 6.9 (in October 2005) and 8.09 (in April 2006).

Granulometry

The method of Shepard triangular diagram represents the sediment types corresponding to the three stations sampled. This method (Afli, 1999) allowed attributing the station A to the "fine sand" category because the mud proportion was found to be less than 10% and that of gravel did not exceed 5%. In station B, mud and gravel fractions did not exceed the proportion of 20%; whereas the sand fraction represented more than 60% leading thus to rank this station between two categories, "sandy-muddy" and

Table 1. Autoecological and zoogeographical attributes of mollusc species found in Marina Hammamet Harbor

Species	Stations	Environment	Origin	Occurence	Life Mode	Feeding Habit
Truncularioposis trunculus (Linnaeus, 1758)	B	MS-CSFG	AM	ATC	SB	C
Chlamys varia (Linnaeus, 1758)	A	AFS	AM	ATC	INF	SUSP
Pinna nobilis (Linnaeus, 1758)	A	AFS	E	ATC	SB	SUSP
Patella caerula (Linnaeus, 1758)	A-B-C	AFS-MS	E	ATC	SB	H
Thais haemastoma (Linneaus, 1767)	A-B	AFS- MS	E	ATC	SB	C
Cerithium vulgatum (Bruguière, 1792)	A-B-C	AFS- MS	AM	ATC	EPI	BROW
Arca noae (Linnaeus, 1798)	A-B	AFS- MS	AS	ATC	EPI	SUSP
Octopus vulgaris (Lamarck, 1798)	B	MS - CSFG	C-E	ATC	HR	C
Lepidochitona cinerea (Cuvier, 1803)	B	MS - CSFG	AM	ATC	SB	BROW
Aplysia punctata (Cuvier, 1803)	B	MS - CSFG	AM	NTC	EPI	H
Pinctada radiata (Leach, 1814)	A-B-C	AFS- MS	TINDO	ATC	SB	SUSP
Mytilus galloprovincialis (Lamarck, 1819)	A-C	AFS- AG	E	ATC	SB	SUSP
Ostrea stentina (Payraudeau, 1826)	A-B-C	AFS- MS	E	ATC	SB	SUSP
Glossodoris valenciennesi (Cantraine, 1841)	B	AFS	AM	NTC	EPI	C

MS: muddy sands, AFS: assemblage of fine sands, AG: assemblage of gravels; CSFG: assemblage of coarse sand and fine gravels; EPI: vagile epifaunal, INF: vagile infaunal, SB: sessile benthic, H: herbivore , BROW: browser herbivore, CARN: carnivore, SUSP: suspension feeder, C: cosmopolite, E: Mediterranean endemic, AM: Atlanto- Mediterranean; TINDO: tropical indo–pacific, ATC: all Tunisian coasts, NTC: north Tunisian coasts.

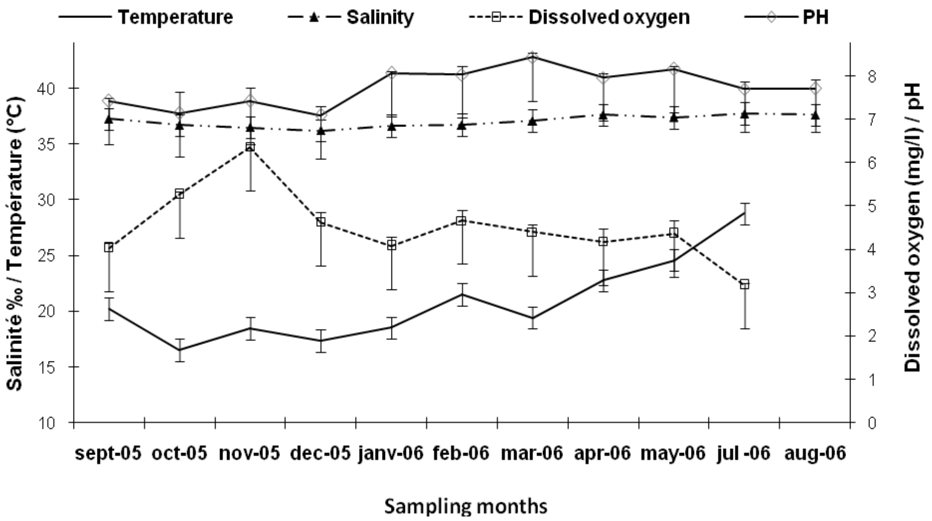

Figure 2. Monthly variations of physic-chemical parameters, temperature, salinity, dissolved oxygen and pH, monitored from September 2005 to August 2006 in the gulf of Hammamet.

"gravel". As for station C, its sediment grain analysis showed that the proportion of sand and gravel exceeds 45%, and it was then grouped in the "assemblage of coarse sand and fine gravels" (Figure 3).

Malacological Diversity

A total 2669 individuals belonging to 14 mollusc species were collected from Marina Hammamet. Zoogeographical categories of the collected mollusc species are presented in Table 1. Atlanto-Mediterranean and Mediterranean endemic species prevailed in term of number of species accounting for 50% and 39.28% respectively, followed by Indo-Pacific (7.14%) and Cosmopolitan taxa (3.57%). The trophic structure of the molluscan community examined was found to be more represented by suspension feeders which prevailed in terms of number of species. However, in terms of density and presence of species along the year, suspension feeder was found to be more represented (42.86%) than carnivores which represented only 28.57%. Taking into account the number of individuals (n), bivalves were the most abundant (73.76%) compared to gastropods (22.02%), cephalopods (2.42%), and also polyplacophores (1.80%).

With respect to number of species, bivalves and gastropods prevailed (6 gastropods and 6 bivalves) compared to other taxa; however in term of average density of individuals, bivalves were found to be better represented than gastropods (603.33±51.16 individuals m^{-2} *versus* 284±24.93 individuals m^{-2}). Within this context, it is worth noting that five species, *Hexaplex trunculus (Gastropoda; Linnaeus, 1758)*, *Felimare picta* (*Gastropoda;* Schulz in Philippi, 1836*)*, *Aplysia punctata* (*Gastropoda;* Cuvier, 1803), *Octopus vulgaris* (*Cephalopoda*; Cuvier, 1797), *and Lepidochitona cinerea* (*Polyplacophora*; Linnaeus, 1767) were represented by only few individuals (altogether represented 1.08 % of the total number of species along the year) of the total number of species along the year and were not encountered in all the sampling stations, depending on the sampling season (Figure 4).

According to the three stations sampling, the abundance of individuals showed that station C was marked mainly by the presence of *Ostrea stentina* (Payraudeau, 1826); *Pinctada imbricata radiata* (Leach, 1814); *Cerithium vulgatum* (Bruguière, 1792) *and Patella caerulea* (Linnaeus, 1758). The station A was dominated by bivalve species including *O. stentina, P. imbricata radiata, M. galloprovincialis* and *Mimachlamys varia* (Linnaeus, 1758). According to Factorial Correspondence Analysis (FCA) results, station B was dominated by gastropod including *C. vulgatum, H. trunculus, Stramonita haemastoma* (Linnaeus, 1767), *Aplysia punctata* (Cuvier, 1803). The grouping of station B, located to the main entrance of the port and in direct contact with open sea water, was found to be due to the abundance of gastropods with a few species of cephalopods and polyplacophores individuals (*L. cinerea, O. vulgaris*).

The ANOVA test showed a significant difference between seasons ($P<0.001$). The average seasonal density of individuals was estimated of 892±43.001 individuals m^{-2}. During the summer period from July to October, the density of individuals decease significantly ($P<0.001$; $F= 102.63$). The total number of species (N) ranged from 8 at station A (in July 2005) to 2 at station C (in October 2005 and April 2006) (Figure 4). It is worth noting that the highest number of species (N=10 species) were recorded in July and the highest density (n=1067±120.94 individuals m^{-2}) were recorded in autumn. Density of mollusks species in autumn were significantly larger than those in other season

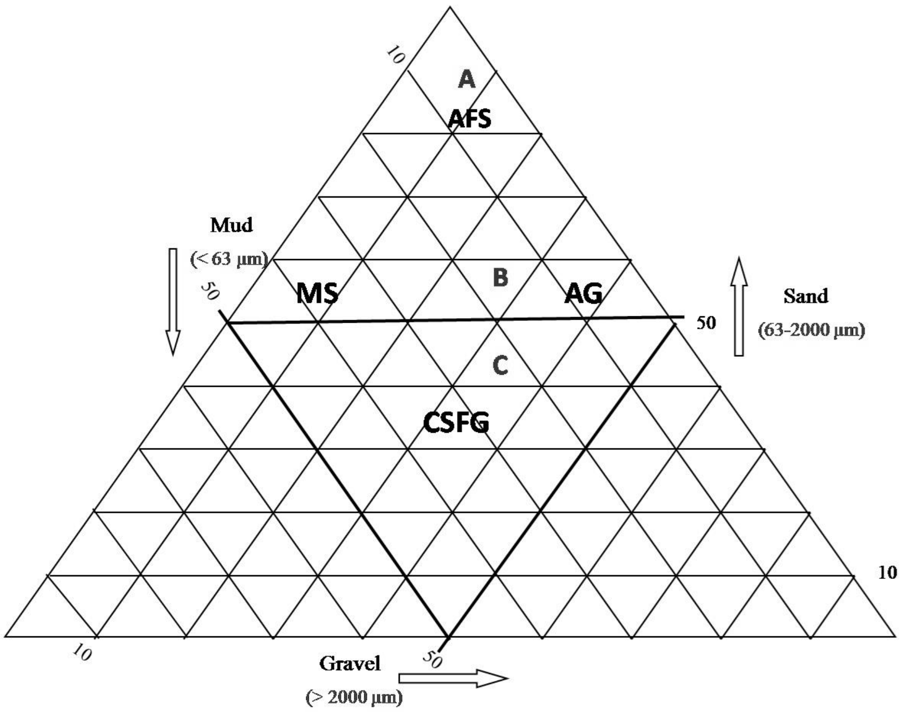

Figure 3. Grouping of the sampling stations in Hammamet Marina port in different sediment types based on their sediment grain analysis and according to the Triangular diagram of Shepard. **MS** muddy sands, **AG** assemblage of gravels, **AFS** assemblage of fine sands, **CSFG** assemblage of coarse sand and fine gravels, **A:** station A, **B:** station B, **C:** station C.

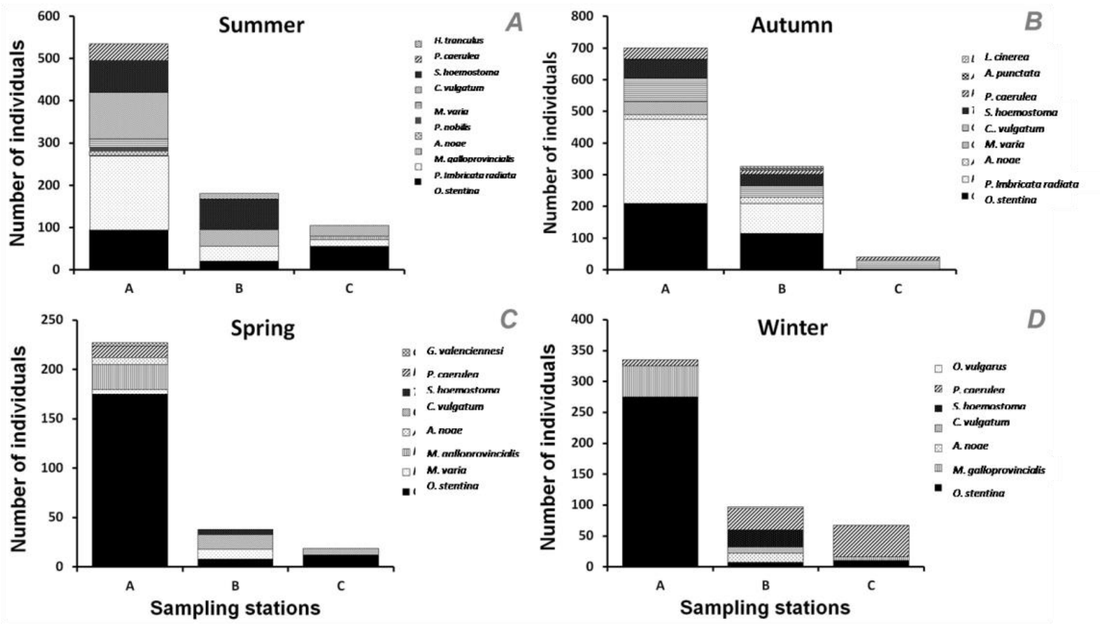

Figure 4. Seasonal and spatial variations of species composition of Mollusc community and species abundances in Hammamet Marina port. **A :** summer, **B** : autumn, **C** : winter, **D**: spring.

(ANOVA Autumn-Winter; F=55.83; P<0.001) whereas the lowest values of density (n=284±51.01) were noted in April (Table 2). During this period, the density of individuals decreased significantly (F=115.39; P<0.0001).

The spatial and temporal population structure of mollusks is displayed in a FCA plot based on frequencies of species in a two- dimensional graphical space. FCA analysis revealed three main clusters, with station A differentiated from the other stations (Figure 5), Station B forming a second cluster overlapped with station C which forms the third cluster.

It reveals that the first two axes contribute to

Table 2. Seasonal and spatial changes in total number of species (*S*), individuals' density (*A*/m^2), Shannon Wiener diversity (*H'*) and Pileou's evenness index (*J'*) of the molluscan communities of Marina Hammamet Harbor

	SUMMER				AUTUMN				WINTER				SPRING				Total of individuals/ station
STATIONS	*S*	*A*	*H'*	*J'*	*S*	*A*	*H'*	*J'*	*S*	*A*	*H'*	*J'*	*S*	*A*	*H'*	*J'*	
A	8	535	0.75	0.27	7	335	0.68	0.24	3	701	0.23	0.09	6	227	0.36	0.15	1798
B	5	180	0.63	0.27	8	17	0.71	0.28	6	326	0.65	0.33	4	38	0.57	0.36	641
C	4	104	0.50	0.25	2	67	0.24	0.15	3	40	0.30	0.16	2	19	0.28	0.22	230

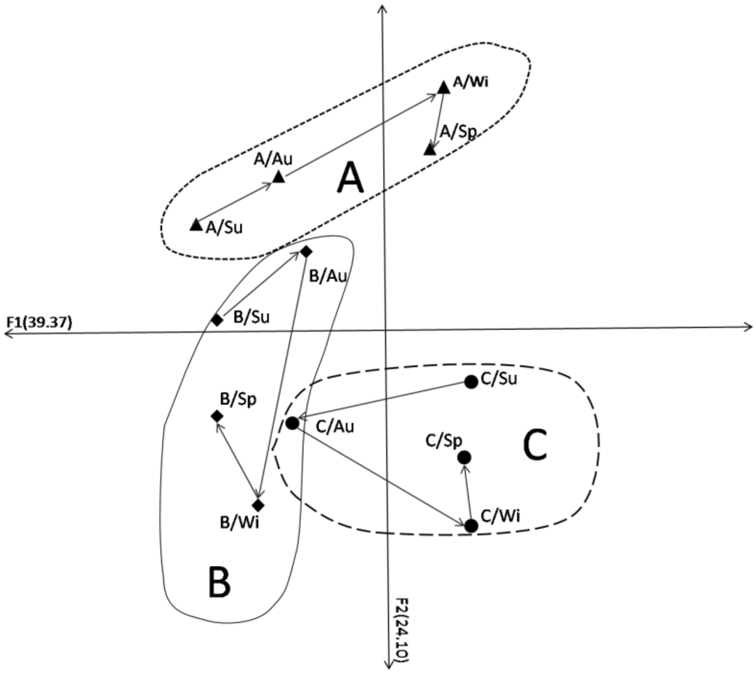

Figure 5. General schema of the correspondence factor analysis (FCA).A: station A; A/Au: station A/ Autumn; A/Wi: station A/ Winter; A/Su: station A/Summer; B: station B; B/Au: station B/ Autumn; B/Wi: station B/ Winter; B/Su: station B/Summer C: station C; C/Au: station C/ Autumn; C/Wi: station C/ Winter; C/Su: station C/Summer.

value near 63%. Axis 2 (24.10%) separates station B and station C of Station A (Figure 6). The taxonomic identification of the collected mollusks produced a list of 14 species, unequally distributed among sampling stations. Most of the sample taken at the station "A" is placed in the center. This station is characterized by the presence of bivalves such as *Ostrea stentina, Mytilus galloprovincilais* and *Pinctada imbricata radiata* with respective contributions of 38.2%; 12.7% and 21%. The mental test showed a significant relationship between station "A" and station "B" for spatial population structure of mollusks (r^2= 0.903; P= 0.013). Gastropods dominate at station "B" such as *Stramonita haemastoma*, *Cerithium vulgatum* contributing to the first factor respectively 10% and 12.9%. Station C is characterized by the presence of few species: *Ostrea stentina*, *Cerithium vulgatum* and *Patella caerulea*, which contribute significantly to the formation of the second factor with 49.9%. FCA analysis allowed separating station C from the rest of stations, most likely because of the lowest abundance of individuals recorded in this latter station (8.46%) compared to stations A (66.15%) and B (25.38%). Axis 1 (39.37%) isolates mostly the samples during winter and spring period from samples during others seasons. The samples at St A/winter and St A/spring, contribute significantly to the formation of the first factor, with respective values of 45.2%, and 23%. For against, the species collected at the station B and C during winter period have significantly higher contributions to the formation of the second factor with respectively, 24.5% and 46.9%.

Structural Analysis

The estimated ecological descriptors, total number of species (*S*), abundance of individuals (*A*), Pielou's evenness (*J'*) and Shannon Wiener diversity

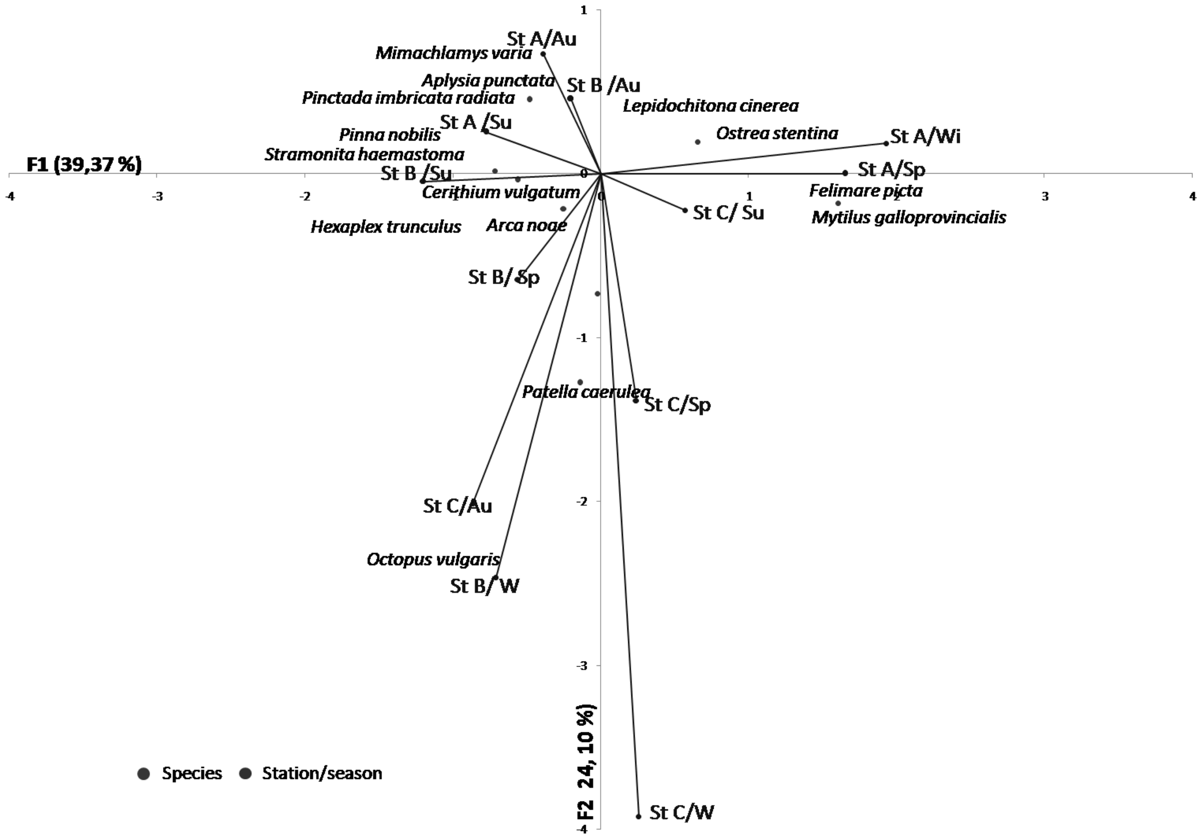

Figure 6. Plot of the two first components (axes 1 and 2) of a Factorial Correspondence Analysis (FCA) conducted based on the spatial and temporal population structure of mollusks abundances recorded in the three sampling stations of Hammamet Marina harbor. Station A; A/Au: station A/ Autumn; A/Wi: station A/ Winter; A/Su: station A/Summer; B: station B; B/Au: station B/ Autumn; B/Wi: station B/ Winter; B/Su: station B/Summer C: station C; C/Au: station C/ Autumn; C/Wi: station C/ Winter; C/Su: station C/Summer.

index (*H'*) showed also seasonal variations : *A* varied from 19 to 701 individuals m^{-2} and *S* from 2 to 8 species. As for *J'* and *H'*, these two indexes were found to range between 0.09 and 0.36 and between 0.23 and 0.71 respectively (Table 2). The observed number of mollusc individuals increased significantly from summer (810 individuals) to autumn (1067 individuals) (F=102.631, P<0.001), and thereafter it decreased in winter and spring. At the spatial scale, higher values of *H'* and *J'* were recorded in station B (2.56 and 1.24 respectively), located close to the sea inlet. In contrast, lower values were found in the innermost station C (*H'*: 1.32 and *J'*: 0.78), located at the proximity of the boats' berthing area.

Discussion

The present work highlighted that in spite of the small size and recent foundation (since 2001) of Marina Hammamet, this studied port was found to support a rather moderately rich, in terms of density, mollusc community. In fact, the mollusc assemblage described herein can be considered as rich and diversified when compared with the findings of other studies conducted in other Mediterranean areas at very larger study areas (Koutsoubas *et al*., 2000 [21 species; 19 individuals m^{-2}]; Zammouri-Langar *et al*., 2001 [32 species; 700 individuals m^{-2}]; Chaouti and Bayed, 2011 [37 species; 218.81 individuals m^{-2}]; Aloui-Bejaoui and Afli, 2012 [77 species; 96 individuals m^{-2}]). The results of the number and density of species and diversity indices revealed the same seasonal distribution pattern of the molluscan community, ranging from rich community in the summer to an poorer one in winter, apparently due to a "dystrophic crisis" episode occurring during summer. Similar seasonal patterns have also been observed in other studies (Amanieu *et al*., 1977; Gravina *et al*., 1989; Arias and Drake, 1994; Dounas and Koutsoubas, 1996; Lardicci *et al*., 1997). This study gives for the first time a list of mollusc species hosted by the peculiar habitat of Hammamet Marina, which can be considered as far from definitively complete. In the Marina Hammamet, the number of species is relatively low in comparison with even if the abundance of particular species may be extreme such as *P. imbricta radiata and O. stentina.* These species were reported for the first time as an element of the molluscan fauna of Marina Hammamet and they are distributed over the major part of the harbor throughout the year.

This work has also revealed that most of the mollusc species found in Marina Hammamet was also recorded in various substrate types and assemblages including assemblage of Gravels (AG), assemblage of coarse sand and fine gravels (SGCF), assemblage of Muddy Sands (MS), whose type most present is the assemblage of fine sands (AFS). Similar findings were also reported by other authors who argued in favor of a strong and direct functional relationship matching the substratum nature and the prevalence of certain trophic groups (Dauvin, 1988; Grall and Glémarec, 1997; Bazaïri *et al*., 2003). The mollusc species recently recorded in the Hammamet Marina fauna revealed the majority of the established species in the harbor were suspension feeders. In all, the mollusc community of Hammamet Marina ecosystem was dominated by suspension-feeder Mediterranean bivalve species in particular *O. sentina* and *P. imbricata radiata*. The high abundances of these latter suspensivores can be related to the high and strong activities of currents (McLusky and McIntyre, 1988), enhanced mainly by the aeration system of the Marina port. Station A appeared to be trophically more balanced since many trophic groups are represented in various proportions. In fact, it appeared that approaching the harbor, where the water is turbid, suspension feeders are increasingly disturbed and other trophic groups start to colonize bottom sediments. As for station B, it was found to be dominated by herbivores and carnivores. Only four species were found at this station with a total abundance of only 13 individuals m².

Based on the molluscan zonation and on the results of the BIO-ENV analysis, the innermost part of the Marina showed a different faunal composition in comparison with the areas close to the sea inlet. Additionally in station A, with the least contact with the sea, it was found had a higher abundance value due to the higher number of individuals mainly of the bivalve species *O. stentina, P. imbricata radiata and M. galloprovincialis* and the presence of some gastropod species such as *C. vulgatum, S. haemastoma* and *Patella caerulea* Linnaeus, 1758.

Station B is the closest to the sea inlet, located relatively far from the harbor area in proximity to the ship channel, and influenced mostly by the sea. This station showed high abundance of gastropods and a lower abundance of cephalopods and polyplacophores. Such an observation is probably due to the adaptative behavior of an euryhalin and eurytherm marine biocenosis where physico-chemical parameters may affect the exclusion of some species compared to others leading to the selection of one trophic group in one particular area (Afli *et al.*, 2008, 2009b).

Station C is localized close to the mooring boats. The seawater in station C is very turbid and in which significant sediment heavy metal pollution was previously reported (CITET, 2009). The low abundance of mollusc species in this station and the surrounding areas could be due to the large quantities of hydrocarbon discharged from the boats. Thus, re-suspension of accumulated pollutants may intensify the uptake of toxic material by mollusks (Cabanellas-Reboredo *et al.*, 2010). The species of molluscs were not abundant in the peripheral areas and the areas outside the harbor. Therefore, it could be concluded that the molluscan community in station C seemed to be affected by the higher anthropogenic pressure assessed compared to the other two stations, mainly oil pollution which was reported to have a negative impact on benthic communities (El Mgren *et al*., 1983).

Thus, biotic indices based on these groups (*H'* and *J'*) are not well adapted to study just the diversity of the structure of the mollusc communities but may be all the macrobenthic fauna. According to the results of the present study, the calibrated Shannon Wiener index *H'* appeared to be more informative than the other parameters, and better discriminated between the stations. Thus, these low diversity values can be correlated more to the type of communities examined rather than the sediment type and environmental parameters.

Conclusion

The use of several approaches in the harbor area of Hammamet Marina made it possible to obtain a preliminary assessment of the functional diversity of the molluscan fauna community. Indeed, each discipline makes a more or less great and necessary contribution in order to understand the functioning of the ecosystem. Ecological, taxonomic and trophic data analyzed together showed that Marina Hammamet harbor is moderately rich, in terms of density, mollusc community. Despite the pressures generated by human activities (touristic activities, pollution, and Boat waste (hydrocarbons) many macro-invertebrate communities (including Molluscan fauna) of the Hammamet Marina are still considerable. In order to protect these species, this area should be conserved and managed in the future so as to continue to provide significant habitats for organisms in the area.

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