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Comparative analysis of a temperate and a tropical seagrass bed fish assemblages in two estuarine systems: the Mira estuary (Portugal) and the Mussulo lagoon (Angola)

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Abstract: The fish assemblages of a temperate (Mira estuary, Portugal) and a tropical (Mussulo lagoon, Angola) seagrass beds were comparatively analysed based on the species composition, fish abundance and functional guilds. The species composition in the two assemblages was very different and the number of species recorded in the Mira site (47) was higher than that in the Mussulo site (18). The dominant fish families were the Syngnathidae, Gobiidae, Sparidae and Labridae in the Mira assemblage and the Haemulidae and Mugilidae in the Mussulo. Both assemblages were composed of a large proportion of species that use these estuarine systems as nursery areas. The percentage of resident species was higher in the Mira estuary. Considering the trophic guilds, for both areas, the benthophagous species were the dominant group. A comparative analysis of the abundance ranks of the fish families recorded in several seagrass bed assemblages worldwide reflected mainly biogeographical areas rather than seagrass habitat types.

Résumé : *Analyse comparée de deux ensembles de poissons d'herbiers tempérés et tropicaux dans l'estuaire du Mira (Portugal) et la lagune de Mussulo (Angola).* Les communautés de poissons des herbiers d'une région tempérée (estuaire du Mira, Portugal) et d'une région tropicale (lagune de Mussulo, Angola) ont fait l'objet d'une analyse comparée à partir de la composition en espèces, de leur abondance et des régimes alimentaires. La composition spécifique est très différente dans les deux communautés et le nombre d'espèces enregistrées à Mira (47) est plus important qu'à Mussulo (18). Les familles de poissons dominantes sont les Syngnathidae, les Gobiidae, les Sparidae et les Labridae pour le site de Mira, les Haemulidae et les Mugilidae pour le site de Mussulo. Les deux communautés sont composées en majorité d'espèces qui utilisent l'estuaire comme nourricerie. Dans l'estuaire du Mira il y a un pourcentage élevé d'espèces résidentes. Aux deux endroits, les réseaux trophiques sont dominés par les espèces benthophages. Une analyse comparée du rang d'abondance des familles de poissons au sein des peuplements d'herbiers du monde entier, reflète principalement les régions biogéographiques, plutôt que l'habitat des herbiers.

Keywords: Seagrass, fish assemblage, estuarine system, Mira, Mussulo, temperate, tropical

Introduction

Seagrass beds are common habitats in estuarine systems worldwide (Pollard 1984). These habitats have long been considered important as nursery and feeding areas for fish (Middleton et al., 1984, Gray et al., 1996, Hannan & Williams, 1998).

Studies on seagrass fish communities were mainly conducted in the Mediterranean, North-western Atlantic, Gulf of Mexico, Caribbean, North-western Pacific, Indian Ocean, Southern Ocean and South-western Pacific areas.

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Pollard (1984) analysed 30 fish assemblages occurring in a wide variety of habitats and suggested that community structure was rather determined by zoogeographical factors than by the seagrass habitat type. According to this author, Syngnathidae, Gobiidae, Monacanthidae, Sparidae, Labridae, Gerreidae, Scorpaenidae, Sciaenidae, Tetraodontidae and Blenniidae dominated the seagrass fish assemblages.

Despite these common patterns, several authors emphasized that the composition and structure of seagrass fish communities can be affected by the adjacent habitats (see Jenkins & Wheatley, 1998). Robblee & Zieman (1984), in a comparison of seagrass fish communities of different latitudes, found that in the tropics the presence of coral reefs near seagrass beds was the major cause of the differences observed between warm-temperate and tropical habitats. Baelde (1990), studied the structural differences between two seagrass fish assemblages, and recognized that the proximity of mangrove and coral reefs clearly influenced differences in the nearby seagrass fish assemblages.

Within estuarine environments, other highly productive habitats are common, namely saltmarshes in temperate systems, and mangroves in tropical areas. The aim of the present study was to compare the seagrass fish assemblages of a temperate South-European Atlantic estuary (Mira, Portugal) with a tropical Atlantic coastal lagoon (Mussulo, Angola). In contrast to the Indian and Pacific Oceans, little is known about the seagrass fish communities of the temperate and tropical Atlantic and quite nothing is known about the Angola lagoons. Both the trophic and ecological guild structures and the function of these two particular fish assemblages were compared. The community structures, in terms of fish families, are also compared with those presented in previous studies of various seagrass beds communities worldwide.

Material and methods

Study areas

The Mira river is located on the southwest coast of Portugal (08º45'N; 38º20'W) (Fig.1). The estuary is about 30 km long and 150 m wide in the lower part. A part of the estuary is bordered by saltmarshes that cover an area of about 285 ha. The tidal range is approximately 4 m. The climate in the region of the Mira is temperate with an annual temperature range of 8 ºC to 25 ºC.

Important seagrass beds of *Zostera marina* Linnaeus, 1753 and *Zostera noltii* Hornemann 1832 are situated near the mouth of the Mira river. The annual water temperature and salinity ranges determined for the eelgrass estuarine areas were 12.0 ºC to 22.5 ºC and 27 to 37, respectively, and were similar to those measured in the adjoining coastal areas (Almeida, 1988).

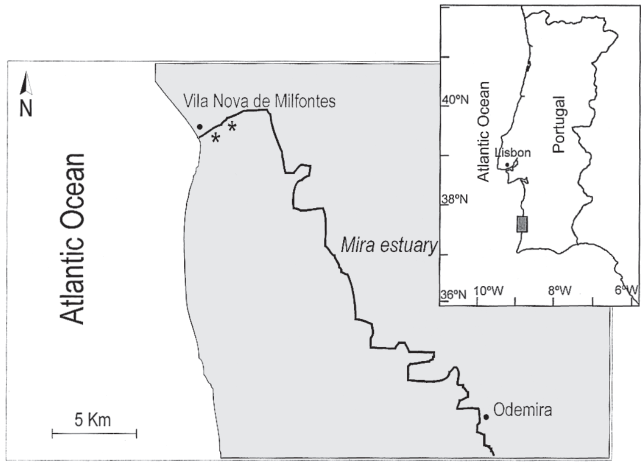

Figure 1. Location of the Mira estuary and sampling areas (*) within seagrass beds.

Figure 1. Localisation de l'estuaire du Mira et sites d'échantillonnage (*) dans les herbiers.

A differential distribution pattern of these two seagrass species was described for the Mira estuary. *Zostera noltii* occurred until 3 m depth, and was therefore exposed to low tide, while *Z. marina* was found in deeper areas, 6 m depth, and permanently submerged (Almeida, 1988).

The Mussulo lagoon is situated near Luanda, Angola (Fig. 2) and has an area of 157 km^2. This lagoon is a semi-enclosed bay with an inlet, open channels, sandy banks, mangroves and seagrass beds. The study area, in the south-east portion of the lagoon (08º59'S; 13º6'E), is bordered to the north by mangrove trees and is characterized by abundant seagrass beds, composed by *Halodule wrigthii* Ascherson, 1868, which have a patchy distribution throughout the lagoon, and are exposed during low tide. The tidal amplitude in the Mussulo lagoon is less than one metre.

The tropical climate in the Mussulo region has a seasonal pattern with a dry season (May to September) and a rainy season (November to April). In the Luanda region the rainfall is very low (340 mm year^{-1}) and high values of relative humidity are recorded all along the year (about 80%).

The mean values of water temperature and salinity in the Mussulo study area were, respectively, 24 ºC and 39 in the dry season, and 30 ºC and 35 in the rainy season. Anthropogenic pressures (industrial pollution and domestic sewage) on both the Mira and the Mussulo systems are low.

Fish sampling and data analysis

Data on species composition and abundance at Mira seagrass beds were obtained from Almeida (1988). Fish were captured monthly, at high tide, using a 1.5 m beam trawl with 10 mm stretched mesh size. Two areas of

Figure 2. Location of the Mussulo lagoon and sampling areas (*) within seagrass beds.

Figure 2. Localisation de la lagune de Mussulo et sites d'échantillonnage (*) dans les herbiers.

2500 m^2, at 1 km and 2 km from the estuary mouth, were sampled (Fig. 1).

In the Mussulo lagoon, sampling was performed in both the dry and rainy seasons, during day, at high tide, using a beach seine 80 m length, 2 m high and 10 mm of stretched mesh size. Two areas were analysed (Fig. 2); the first located in the north of the region, close to mangrove trees, and the second which is about 300 m south from the first one. During the sampling two replicates were made in both areas and the fishing operations lasted for 20 minutes each.

The comparison of species abundance was based on the numeric percent determined for each estuarine system. The classification of species into functional guilds was adapted from Elliott & Dewailly (1995). Each species was assigned to an ecological and a trophic guild.

The ecological guilds were established from habitat usage pattern: estuarine resident species (ER), marine accidental visitor species (MA), catadromous migrant species (C) and marine juvenile migrant species that use the estuary as a nursery (MJ).

The trophic guilds considered were: planktonivorous (P), benthophagous (B), piscivorous (Pc), herbivorous (H) and detritivorous (D). Membership of guilds was determined based on the stomach contents data of Almeida (1988) and Costa (unpublished data), for the Mira estuary, and of Santos (unpublished data) for the Mussulo lagoon.

In order to compare fish assemblages from different geographical areas a cluster analysis was performed on data from Kikuchi (1966), Briggs & O'Connor (1971), Carr & Adams (1973), Hutomo & Martosewojo (1977), Bell & Harmelin-Vivien (1982) and Middleton et al, (1984). The city-block distance and weighted pair-group average clustering methods (Hair et al, 1996) were used and obtained from *Statistica* software.

Data were standardized by assigning ranks of abundance to the fish families. The family taxonomic level was used instead of species since most of the species were unique of a particular geographical area. Although fishes of the same family may have different life history patterns, in most cases similarities in their ecological niche can be recognized. Similar analytical procedures were also used in previous studies comparing fish assemblages (see Pollard, 1984).

Results

A total of 47 species from 19 families were identified in the Mira seagrass beds (Table 1). The dominant families were the Syngnathidae, Gobiidae, Sparidae and Labridae. The most abundant species were *Symphodus bailloni*, *Gobius niger, Diplodus vulgaris* and *Symphodus melops*, which represented each from 17 to 10% of the total number of individuals caught (Table 1).

In the Mussulo lagoon, 18 species belonging to 14 families were found (Table 2). Only the Haemulidae and Mugilidae were represented by more than one species (respectively, three and two species). The fish assemblage was dominated in abundance by *Pomadasys rogerii* and *Mugil cephalus*, which represented respectively 38% and 23% of the total number of individuals caught (Table 2).

Regarding the ecological guilds, the estuarine resident species (ER) were the dominant group in the Mira estuary (Fig. 3). The marine juvenile migrant (MJ) and the marine accidental (MA) groups represented respectively, 34% and 21% of the species and only one catadromous (C) species was found (Fig. 3). In the Mussulo lagoon the contribution of the juveniles (MJ) group was higher, representing 67% of the total number of species (Fig. 3). Less important groups were those of estuarine resident (ER) and marine accidental (MA) species that presented an equable proportion of the total number of species (17% each). No catadromous (C) species was found in the Mussulo lagoon.

The community structure defined in terms of trophic guilds was similar in both estuarine systems. The benthophagous (B) species were dominant in both fish assemblages (64% and 65% in Mira and Mussulo, respectively) (Fig. 4). The proportions of herbivorous (H) and piscivorous (Pc) species were higher in the Mussulo, while the planktonivorous (P) group accounted for a high percentage in the Mira estuary (Fig. 4).

Table 1. Fish species found in the seagrass beds of Mira estuary. RA: Relative abundance = percentage of total individuals caught; EG: ecological guild, C - catadromous migrant species, ER - estuarine resident species, MA - marine accidental visitor species, MJ - marine juvenile migrant species; TG: trophic guild, B – benthophagous, H – herbivourous, P – planktonivorous, Pc – piscivorous.

Tableau 1. Données sur les espèces de poissons récoltées dans les herbiers de l'estuaire du Mira. RA: Abondance relative = pourcentage du total des individus récoltés ; EG : catégorie écologique, C - espèce migratice catadrome, ER - espèce résidant dans l'estuaire, MA - espèce marine accidentelle, MJ - juvénile d'espèce marine migratrice ; TG : régime alimentaire, B – benthophage, H – phytophage, P – planctonophage, Pc – piscivore).

Family	Species	RA	EG	TG
Clupeidae	*Sardina pilchardus* (Walbaum, 1792)	0.0	MA	P
Anguillidae	*Anguilla anguilla* (Linnaeus, 1758)	1.7	C	B
Congridae	*Conger conger* (Linnaeus, 1758)	0.4	MA	Pc
Syngnathidae	*Syngnathus acus* Linnaeus, 1758	1.6	ER	P
	Syngnathus abaster Risso, 1827	0.0	ER	P
	Syngnathus rostellatus Nilsson, 1855	0.1	ER	P
	Syngnathus typhle (Linnaeus, 1758)	7.7	ER	P
	Nerophis ophidion (Linnaeus, 1758)	1.4	ER	P
	Nerophis lumbriciformis (Jenyns, 1855)	0.1	ER	P
	Entelurus aequoreus (Linnaeus, 1758)	0.2	ER	P
	Hippocampus ramulosus Leach, 1814	0.5	ER	P
Gadidae	*Ciliata mustela* (Linnaeus, 1758)	0.0	MJ	Pc, B
Moronidae	*Dicentrarchus labrax* (Linnaeus, 1758)	0.0	MJ	Pc, B
Mullidae	*Mullus surmuletus* Linnaeus, 1758	0.1	MJ	B
Sparidae	*Boops boops* (Linnaeus, 1758)	1.6	MJ	H
	Diplodus annularis (Linnaeus, 1758)	0.4	MJ	B
	Diplodus sargus (Linnaeus, 1758)	1.5	MJ	B
	Diplodus vulgaris (Geoffroy St. Hilaire, 1817)	10.8	MJ	B
	Diplodus puntazzo (Cetti, 1777)	0.2	MJ	B
	Sarpa salpa (Linnnaeus,1758)	0.2	MJ	H
	Spondyliosoma cantharus (Linnnaeus,1758)	9.6	MJ	B
Labridae	*Labrus bergylta* Ascanius, 1767	0.6	MJ	B
	Ctenolabrus rupestris (Linnaeus, 1758)	0.3	MJ	B
	Symphodus bailloni (Valenciennes, 1839)	17.3	ER	B
	Symphodus cinereus (Bonnaterre, 1788)	1.1	MJ	B
	Symphodus melops (Linnaeus, 1758)	10.8	MJ	B
Gobiidae	*Gobius niger* Linnaeus, 1758	16.0	ER	B
	Gobius auratus Risso, 1810	6.8	ER	B
	Gobius cruentatus Gmelin, 1789	0.0	MA	B
	Gobius paganellus Linnaeus, 1758	4.7	ER	B
	Aphia minuta (Risso, 1810)	0.1	ER	B
	Gobiusculus flavescens (Fabricius, 1779)	0.9	ER	B
	Pomatoschistus microps (Køyer, 1838)	0.2	ER	B
	Pomatoschistus pictus (Malm, 1865)	0.2	ER	B
Callionymidae	*Callionymus lyra* Linnaeus, 1758	0.6	MJ	B
Blenniidae	*Blennius gattorugine* (Linnaeus, 1758)	0.1	ER	B
	Parablennius pilicornis (Cuvier, 1829)	0.1	ER	B
Atherinidae	*Atherina presbyter* Cuvier, 1829	0.9	ER	P, B
Scorpaenidae	*Scorpaena porcus* Linnaeus, 1758	0.0	MA	B
	Scorpaena notata Rafinesque, 1810	0.0	MA	B
Bothidae	*Arnoglossus thori* Kile, 1913	0.1	MA	B
Soleidae	*Solea senegalensis* Kaup, 1858	0.0	MJ	B
	Microchirus azevia (Capello, 1867)	0.0	MA	B
Tetraodontidae	*Sphoeroides marmoratus* Lowe, 1838	0.0	MA	B
Gobiesocidae	*Apletodon microcephalus* (Brook, 1890)	0.0	MA	B
	Lepadogaster candollei Risso, 1810	0.1	MA	B
Batrachoididae	*Halobatrachus didactylus* (Bloch & Schneider, 1801)	0.8	ER	Pc, B
Total number of individuals caught		9256		

A cluster analysis was performed to data of abundance ranks of fish families recorded in several seagrass bed assemblages worldwide (see Table 3). The dendrogram obtained mainly reflected biogeographical areas (Fig. 5). The Mira community was most closely related to the north-western Mediterranean assemblage. The Mussulo and the Gulf of Mexico communities were similar to each other and related to the north-western Atlantic system. The seagrass fish assemblages from the northwest Pacific and Indian Ocean are more closely related to each other than to the southwest Pacific system.

Discussion

A comparative analysis of fish assemblages, and the overall comparison between different geographical areas, present considerable constraints on data analysis. The collection of data over varying time periods, by different sampling methods using different strategies and effort constitute potential sources of data bias. So, a comparative analysis of the efficiency of sampling methods is of extreme importance in order to validate the results. Harmelin-Vivien & Francour (1992) compared the efficiency and bias of trawling and visual censuses methods in the estimation of abundance of seagrass beds fish populations, and found significant differences according to the method used. Although no comparative efficiency essays were conducted in the present work, the differences between the two techniques used are not so important as the ones reported when comparing trawling and visual censuses by Harmelin-Vivien & Francour (1992). Both beam trawl and beach seine are low selective gears that, in shallow areas, capture both benthic and pelagic species. In the sampling surveys conducted in the sites of Mira and Mussulo, the same mesh size was used and a similar sampling effort was considered.

The conversion of absolute values to percentage composition and the use of the functional guilds methodology reduce to some degree the variability resulting from methodological differences (see Elliot & Dewailly, 1995).

The species richness in the Mira estuary and the Mussulo lagoon were very different. Until now no general trend in species richness has been suggested for seagrass fish assemblages. Pollard (1984), in a review of 30 seagrass fish assemblages

Table 2. Fish species found in the seagrass beds of the Mussulo lagoon. RA: Relative abundance = percentage of the total individuals caught; EG: ecological guild; TG: trophic guild, D – detritivorous; see Table 1 for other guilds abbreviations.

Tableau 2. Données sur les espèces de poissons récoltées dans les herbiers de l'estuaire du Mussulo. RA : Abondance relative = pourcentage du total des individus récoltés ; EG : catégorie écologique ; TG : régime alimentaire ; D – détritivore ; voir Tableau 1 pour les autres abréviations.

Family	Species	RA	EG	TG
Rhinobatidae	*Rhinobatos rhinobatos* (Linnaeus,1758)	0.4	MJ	B
Dasyatidae	*Dasyatis margarita* (Günther, 1870)	1.3	MJ	B
Albulidae	*Albula vulpes* (Linnaeus, 1758)	0.0	MA	B
Clupeidae	*Ethmalosa fimbriata* (Bowdich, 1825)	0.7	MJ	P
Hemiramphidae	*Hemiramphus balao* Lesueur, 1821	1.0	MJ	H, B
Carangidae	*Caranx hippos* (Linneaeus, 1766)	0.2	MA	Pc
Lutjanidae	*Lutjanus agennes* Bleeker, 1863	5.0	MJ	Pc
Gerreidae	*Eucinostomus melanopterus* (Bleeker, 1863)	6.1	MJ	B
Haemulidae	*Pomadasys rogerii* (Cuvier,1830)	37.9	MJ	B
	Pomadasys jubelini (Cuvier, 1830)	2.6	MJ	B
	Pomadasys perotaei (Cuvier, 1830)	7.4	MJ	B
Polynemidae	*Polydactylus quadrifilis* (Cuvier, 1829)	0.1	MA	B
Mugilidae	*Mugil cephalus* Linnaeus, 1758	23.7	MJ	D
	Mugil curema Valenciennes, 1836	1.1	MJ	D
	Liza dumerili (Steindachner, 1870)	5.2	MJ	D
Cichlidae	*Tilapia* sp.	2.7	ER	D
Tetraodontidae	*Sphoeroides marmoratus* Lowe, 1838	4.5	ER	H, B
Gobiidae	*Thorogobius angolensis* (Norman, 1935)	0.0	ER	B
Total number of individuals caught		3532		

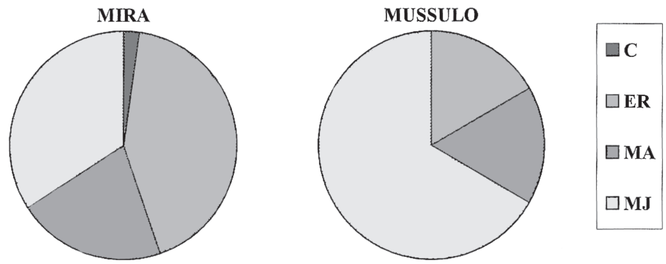

Figure 3. Proportion of fish species according to ecological guild in the Mira and Mussulo seagrass beds (C - catadromous; ER - estuarine resident species; MA - marine accidental visitors; MJ - marine juvenile migrants).

Figure 3. Proportion des espèces de poissons selon les catégories écologiques dans les herbiers de Mira et de Mussulo (C - catadrome ; ER - espèce résidente dans l'estuaire ; MA - espèce marine accidentelle ; MJ - juvénile d'espèce marine migratrice).

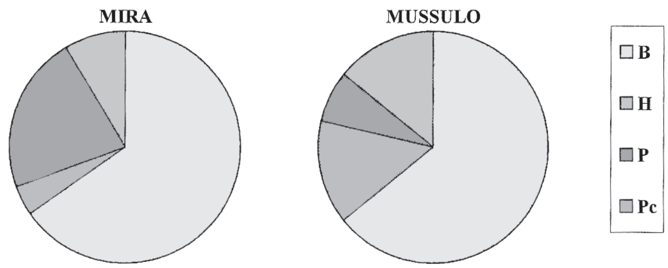

Figure 4. Proportion of fish species according to trophical guild in the Mira and Mussulo seagrass beds (B - benthophagous; H - herbivorous; P - planktonivorous; Pc – piscivorous).

Figure 4. Proportion des espèces de poissons selon les catégories trophiques dans les herbiers de Mira et de Mussulo (B - benthophage ; H – phytophage ; P - planctonophage ; Pc – piscivore).

throughout the world, obtained species numbers from 19 (South-western Australia) to 189 (Madagascar). According to this author, the total number of species reported for the various habitats reflected to a large extent both the sampling methods and the sampling intensity in the different studies. Nevertheless, the Afro-Atlantic zoogeographical area that extends from South Africa to Guinea has been reported as a low species richness region (Briggs, 1974).

Several authors (see Baelde, 1990, Jenkins et al., 1997) outlined that the habitat type and the heterogeneity of seagrass areas can be of major importance in determining species richness and community structure and function. The Mira estuary contains saltmarsh areas that are also important as nursery grounds for several fish species (Costa et al., 1994a). Although some of the species that occur in the Mira estuary are exclusively found within seagrass (25%) or saltmarsh (15%) areas, the large majorities have been recorded in both habitats (38%). This result emphasizes the importance of habitat heterogeneity in the structuring of fish assemblages and supports the concept of opportunistic habitat use patterns that have been suggested for estuarine associated fish communities (see Sogard et al., 1989, Szedlmayer & Able, 1996).

In the Mussulo lagoon, the mangrove areas are also important habitats for several species. Costa et al. (1994b) recorded 36 species in these mangrove areas, that is a high number of species compared with that found in the adjoining seagrass beds. The difference in species richness

Table 3. Fish families abundance ranks of several seagrass assemblages in different geographical areas (NW Med.: North-western Mediterranean; NW Atlant.: North-western Atlantic; Gulf Mex.: Gulf of Mexico; NW Pacific: North-western Pacific; Indian: Indian Ocean; SW Pacific: South-western Pacific).

Tableau 3. Niveau d'abondance des familles dans plusieurs communautés d'herbiers de différentes régions géographiques (NW Med. : nord-ouest de la Méditerranée ; NW Atlant : nord-ouest de l'Atlantique ; Gulf Mex. : Golfe du Mexique ; NW Pacific : nord-ouest du Pacifique ; Indian : Océan Indien ; SW Pacific : sud-ouest du Pacifique.

	Mira	Mussulo	NW Med. (1)	NW Atlant. (2)	Gulf Mex. (3)	NW Pacific (4)	Indian (5)	SW Pacific (6)
Syngnathidae	4		6	4		9	14	2
Gobiidae	2		4		14	1	13	1
Monacanthidae						2	4	3
Sparidae	3		3	22	1	30		9
Labridae	1		1	10		6	2	12
Gerreidae		3			6	3	6	17
Scorpaenidae	18		5			10		4
Sciaenidae				8	2			29
Tetraodontidae	16	5		5	13	12	28	14
Bleniidae	10				9	12	10	25
Clupeidae	18	9		12	8	19	15	6
Ambassidae								13
Apogonidae						11	1	21
Eugraulidae				17	5			
Bothidae			12	22		27		18
Mugilidae		2		11		35		5
Terapontidae								8
Cyprinodontidae				3				
Mullidae	11		8			15	11	21
Clinidae								18
Centracanthidae			2					
Scaridae							9	
Serranidae			10			16	26	29
Diodontidae								34
Gasterosteidae				1				
Lutjanidae		4		19		32	25	40
Odacidae								29
Kyphosidae						18	19	16
Eleotridae								
Congiopodidae						7		
Belonidae				6	11		15	
Batrachoididae	7			13				
Cottidae				22		5		
Atherinidae	6		15	2	7		5	40
Sillaginidae						17		7
Arripidae								
Aulorhynchidae						7		
Carangidae		11		19	4	28		15
Platycephalidae						14	28	10
Soleidae	14.5				15		28	20
Plotosidae						4		34
Anguillidae	5			9				
Gobiesocidae	14.5		17					
Hemiramphidae		8			10			40
Callionymidae	8		17			33	20	34
Lethrinidae						21	7	21
Pomacentridae			7				8	
Siganidae						21	3	34
Gadidae	18		9	14				
Scorpididae								21
Cynoglossidae								25

(cont.)

Table 3 (continued)
Tableau 3 (suite)

	Mira	Mussulo	NW Med. (1)	NW Atlant. (2)	Gulf Mex. (3)	NW Pacific (4)	Indian (5)	SW Pacific (6)
Pleuronectidae				7				29
Acanthuridae						35		
Muraenidae								
Chaetodontidae							26	
Aulostomidae								
Albulidae		13						
Bothidae	12.5							
Cichlidae		6						
Congridae	9							
Dasyatidae		7						
Lepadogasteridae	12.5							
Moronidae	20							
Polynemidae		12						
Haemulidae		1			3			
Rhinobatidae		10						

(1) Bell & Harmelin-Vivien (1982). (2) Briggs & O'Connor (1971). (3) Carr & Adams (1973). (4) Kikuchi (1966). (5) Hutomo & Martosewojo (1977). (6) Middleton et al., (1984)

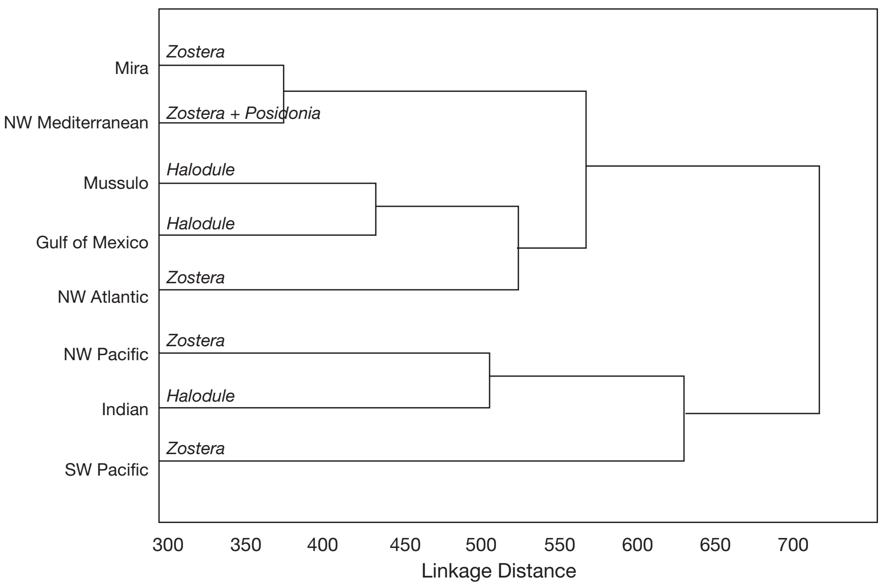

Figure 5. Dendrogram of the cluster analysis performed to abundance ranks of the fish families recorded in several seagrass bed assemblages (see Table 3).

Figure 5. Dendrogramme des groupements réalisés par rang d'abondance des familles de poissons enregistrées dans plusieurs peuplements d'herbiers (voir Tableau 3).

between these two habitats (seagrass and mangrove) could be due to the shallowness of seagrass areas that, during low tide, can reach depths as low as 10 cm. It could be expected that only a few species could tolerate such a depth variation range registered in the seagrass areas. Furthermore, only six species were common to both habitats, which may indicate the existence of habitat segregation. The avoidance of regularly emerged areas by some species has also been demonstrated for the Mira seagrass beds. Almeida (1988) found that only a few species can occur in the upper levels of the seagrass areas and even described a differential spatial pattern of *Zostera* according to species (*Z. marina* vs. *Z. noltii*).

Species composition in the Mira and Mussulo estuarine systems was different. Only three fish families (Gobiidae, Clupeidae and Tetraodontidae) were common to both environments. This agrees with Pollard (1984) who found, even within a small geographical scale, considerable differences in species composition and abundance of seagrass fish communities.

The higher number of juvenile fish found in Mira and Mussulo corroborates the importance of seagrass beds as nursery areas as demonstrated in many other studies (see Middleton et al., 1984, Hannan & Williams, 1998).

The percentage of resident species in seagrass beds found in several geographical areas, varied widely from 14% to more than 60% (see Bell & Harmelin-Vivien, 1982; Burchmore et al., 1984; Hannan and Williams, 1998). The low number of resident species found in the Mussulo seagrass areas may be due to the extreme depth variation. The adjacent mangrove areas are more favourable for resident species since depth in these habitats never attains such extreme low values.

Dietary preference guilds indicated that assemblages both in Mira and in Mussulo were dominated by benthophagous species and had only a few piscivorous species. The role as feeding ground played by seagrass beds is surely related to the high food availability, especially of benthic invertebrates, that has been reported in several seagrass beds compared to adjacent un-vegetated areas (see Virnstein et al., 1983; Lewis, 1984; Orth et al., 1984; Edgar, 1990). The predominance of species feeding on invertebrates has been reported for several estuarine systems (Elliott & Dewailly, 1995). Nonetheless, some authors noticed that the most abundant trophic group in some seagrass fish assemblages were omnivorous species (Kikuchi, 1966; Adams, 1976).

The use of seagrass beds habitats has also been related to refuge against predators. Several authors have suggested a potentially lower predation pressure on fish in intertidal grounds compared to subtidal estuarine areas (Rozas & Hackney, 1984; Kneib, 1997). This is obvious in the Mussulo lagoon where predators such as Sphyraenidae, with *Sphyraena sphyraena* (Linnaeus, 1758) and Carangidae, with *Caranx hippos* (Linnaeus, 1766) were common in subtidal areas along with other unusual predators including species of Carcharinidae.

Despite the differences found in species composition between the Mira and the Mussulo seagrass fish communities, the similarities in structure and function of fish assemblages in these areas emphasized the importance of these habitats for fish, particularly as nursery and feeding areas. This supports the growing worldwide literature demonstrating the importance of seagrass habitats for juvenile fish.

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