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POPULATION STRUCTURES OF FISH IN THE INTERTIDAL RANGES OF THE PORTUGUESE COASTS

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INTERTIDAL RANGE
FISH COMMUNITY
EVENNESS

ABSTRACT – In this paper the diversity of fish in the intertidal ranges of the Portuguese coasts was studied. For this purpose ninety samples of intertidal fish from five rocky shores were studied. At these places diversified suitable habitats for fish were found. Results showed : (a) *Lipophrys pholis* (Pisces, Blenniidae) was the dominant species in all places and (b) these fish communities were typified by low diversity and evenness.

ZONE INTERTIDALE
COMMUNAUTÉ ICHTYOLOGIQUE
EQUITABILITÉ

RÉSUMÉ – Dans ce travail est étudiée la diversité des espèces de Poissons de la zone intertidale. Dans ce but 90 échantillons de Poissons de cinq zones rocheuses, correspondant à des habitats diversifiés ont été étudiés. Les résultats ont montré que : (a) *Lipophrys pholis* est partout l'espèce dominante; (b) une typologie de ces communautés de Poissons a été établie d'après la diversité et l'équitabilité.

INTRODUCTION

Studies of intertidal fish on the Portuguese coast have been reported by several authors (Almada *et al.* 1983, 1987; Gomes & Almeida, 1979).

However, little attention has been given to the structure of their communities as well as to the vertical distribution as revealed in relation to tidal level. This paper examines and compares the species richness and the pattern of diversity and evenness of five communities in different points along the Portuguese coast.

DESCRIPTION OF THE SAMPLING POINTS

Five rocky shores were selected to cover a range of conditions of substratum type, degree of wave exposure, sea water temperature and salinity, and tidal amplitude.

The points were in Porto (below the Zoological Marine Station), Praia da Consolação, Praia do Magoito, and Sesimbra (below the Forte do Cavalo) on the western coast and Praia do Vau on the southern coast (Fig. 1).

The shore studied in Porto is a sandy area with protruding granitic boulders. It is exposed to direct wave action and thus is under harsh conditions. The rocky zonation is not very clear. However, the midshore region is mainly made up of *Mytilus galloprovincialis* (Lamarck) (Mollusca, Bivalvia) and *Chthamalus stellatus* (Poli) (Arthropoda, Cirripedia) which are good indications that the shore is exposed.

Praia da Consolação is a calcareous shore in a small bay facing south-west and is subject to weak wave action only. Its upper part is a deposit of boulders fallen from the cliff on a succession of banks (lying east/west) and sloping south. Some of these boulders have rolled on to the bank surfaces down to water level offering all manner of fissures, crevices and pools. Boulders in the upper shore are almost completely covered by *C. stellatus* where a strip of *Lichina pygmaea* Agardh (Lichen) may be found. This strip is a good suggestion of sheltered conditions. Lower down the shore, the rocky zonation is very clear.

Praia do Magoito is also a calcareous shore sloping steeply downshore. Exposed to the main direction of the waves it weathers harshly. The rocky surfaces erode into some larger among many smaller pools. The midshore region is mainly made up of *M. galloprovincialis* and *C. stellatus*.

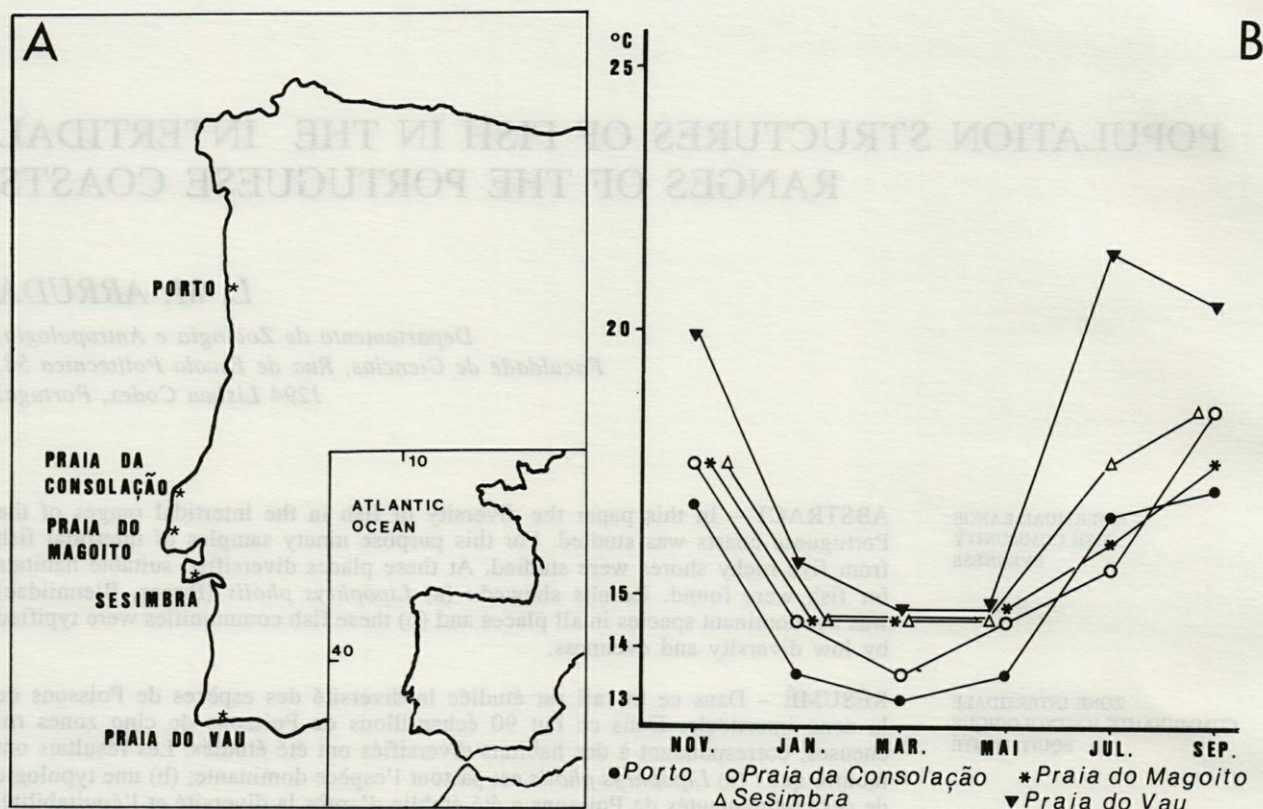


Fig. 1. - A, Sampling points. B, Temperature variations in the five study points.

At Sesimbra the shore is a nearly vertical calcareous cliff. Facing south it is subject to weak wave actions only, showing well-marked subzones of plants and animals. Some pools are found at different levels. The upper shore is almost completely covered with *C. stellatus* in which some plaques of *L. pygmaea* are scattered.

At Praia do Vau the study point is a calcareous platform with a gentle slope and is bordered by a sandy beach. Facing southward, it is not exposed to wave action like some of the shores on the western coast. The upper shore, is almost completely covered with *C. stellatus*. A particular zone of *L. pygmaea* at the top of the tide range is noted. Boulders and sand are in the bottom of the pools and slits.

Figure 1 B shows the mean bi-monthly temperatures of the surface sea water at each of the five study points. The temperatures followed a seasonal cycle ranging between 13 C and 18.5 C on the western coast, and between 14.5 C and 21.5 C on the southern coast.

Salinity was almost constant ranging from 35.3 ‰ to 36.5 ‰ and between 36.3 ‰ and 36.6 ‰ on the western and southern coasts, respectively (Fig. 2).

The annual mean value (± 1 sd) of the maximal amplitude of the tide was $3.3. \pm 0.26$ m in Porto

and 3.2 ± 0.17 m at Praia to Vau, gradually decreasing from north to south.

Therefore, the five study points may be considered as offering diversified habitat suitable for fish : (a) the shores in Porto, Praia da Consolação and Praia do Vau are formed by both rocky pools and interstices among the boulders, whereas at Praia do Magoito and Sesimbra are formed only by rocky pools; (b) in Porto and Praia do Magoito the shores are exposed, whereas at Praia da Consolação, Sesimbra and Praia do Vau there are sheltered conditions; and (c) in Porto and at Praia do Vau the study points are bordered by sandy beaches, whereas at Praia da Consolação, Magoito and Sesimbra are rocky shores.

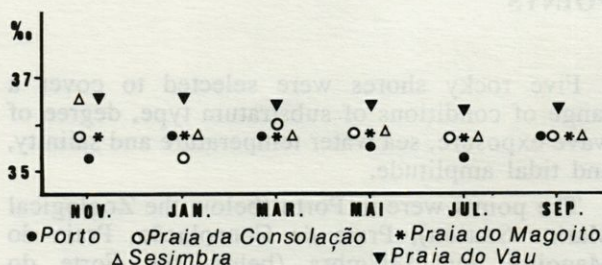


Fig. 2. - Salinity variations in the five study points.

MATERIAL AND METHODS

Material

Ninety samples were taken between November 1982 and July 1986, one from each intertidal flat, to obtain six collections every two months. The individuals caught were sorted into species and weighed before being preserved.

Sampling

During low water conditions fish were caught from pools as well as from boulder areas, after sulphuric ether have been diluted in the sea water. Samples were taken at three tidal levels : high tide, mid tide and low tide. In the case of the boulders sampling was effected by removing fish gently in

a topographically delimited area taking care to prevent the fish from escaping. A uniformity of the fishing effort was achieved because the same pools and boulder areas were used throughout the study. Additional collections from other pools and boulder areas were also made to assess the census results in the selected pools and boulders.

Treatment of data

The mathematical treatment was applied to the chronological sequences of the samples collected and the data on the structure of the communities. The following parameters were recorded :

(a) Species richness, *s*, the number of species sampled at each sampling point.

Table I. - Checklist of species of fish caught from the intertidal range in each sampling area (H : high tide; M : mid tide; L : low tide; A : accidental).

	Porto	Praia da Consolação	Praia do Magoito	Sesimbra	Praia do Vau
<i>Anguillidae</i>					
<i>Anguilla anguilla</i> (Linnaeus)	A				
<i>Blennidae</i>					
<i>Coryphoblennius galerita</i> (Linnaeus)	H/M	H/M	H/M	H/M	H/M
<i>Lipophrys pholis</i> Linnaeus	M/L	M/L	M/L	M/L	M/L
<i>Parablennius incognitus</i> (Bath)					L
<i>Parablennius gattorugine</i> Brunnich	L	L	L	L	L
<i>Paralipophrys trigloides</i> Valenciennes	M/L	M/L	M/L	M/L	M/L
<i>Cottidae</i>					
<i>Taurulus bubalis</i> (Euphrasen)	L				
<i>Clinidae</i>					
<i>Clinitrachus argentatus</i> (Risso)					L
<i>Gadidae</i>					
<i>Ciliata mustela</i> (Linnaeus)	L	L	L		L
<i>Gobiidae</i>					
<i>Gobius paganellus</i> (Linnaeus)	M/L	M/L		M/L	M/L
<i>Gobiesocidae</i>					
<i>Apletodon dentatus</i> (Facciola)	L	L			
<i>Lepadogaster candolei</i> Risso	L	L			
<i>Lepadogaster lepadogaster</i> (Bonnaterre)	L	L		L	
<i>Labridae</i>					
<i>Symphodus melops</i> (Linnaeus)					L
<i>Liparidae</i>					
<i>Liparis montagui</i> (Donovan)	L	L			
<i>Syngnathidae</i>					
<i>Nerophis lumbriciformes</i> (Jenyns)	L	L			L

(b) Diversity index, H, where

$$H = \sum_{i=1}^s p_i \log_2 p_i, p_i \text{ being the proportion of individuals in the } i^{\text{th}} \text{ species (Shannon, 1948), and evenness, E, where } E = H/\log_2 s \text{ (Pielou, 1967, 1977). The evenness, varying between 0 and 1, indicates the degree of equitability of the species distribution in the community; comparison of E between samples with different species number is not valid, but some underlying pattern may be seen for each sample.}$$

(c) a complete description of the community would include an analysis of the niches of all species. While this was not possible to achieve, a brief discussion of the vertical distribution of the most abundant species is useful in understanding the structure of the community.

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RESULTS

Species richness

A total of 16 species of fish were caught and their occurrences in relation to tide are shown in Table I. The greater number of species (12) occurred in Porto and all species captured in Praia da Consolação, Praia do Magoito and Sesimbra were also caught in Porto. However, the species *Clinitrachus argentatus* (Clinidae), *Parablennius incognitus* (Blenniidae) and *Symphodus melops*

Table II. – A, Number of species (N) and biomass (B) (gr) for each sampling area and for each sampling period. B, Diversity index (Shannon, 1948) (H) and evenness (E) in number of individuals for the different collections of samples.

A		Nov.	Jan.	Mar.	May	Jul.	Sep.	Total
Porto	N	9	8	4	5	6	8	12
	B	245	371	260	635	330	463	2303
Praia da Consolação	N	8	9	7	9	8	10	11
	B	564	516	1060	319	331	657	3447
Praia do Magoito	N	3	3	3	3	4	4	5
	B	117	101	98	198	158	160	832
Sesimbra	N	5	3	3	3	5	5	6
	B	45	3	9	19	66	41	183
Praia do Vau	N	10	8	6	6	7	10	10
	B	266	223	208	233	257	308	1495

B		Nov.	Jan.	Mar.	May	Jul.	Sep.
Porto	H	1.91	1.46	0.68	1.41	1.85	1.40
	E	0.58	0.49	0.43	0.61	0.72	0.47
Praia da Consolação	H	1.41	2.29	2.21	1.85	2.64	2.22
	E	0.71	0.72	0.79	0.58	0.88	0.64
Praia do Magoito	H	0.8	0.8	1.03	0.72	1.55	1.46
	E	0.5	0.51	0.65	0.46	0.78	0.63
Sesimbra	H	1.61	0.56	0.52	1.14	1.1	1.7
	E	0.69	0.30	0.26	0.52	0.47	0.63
Praia do Vau	H	2.66	2.12	1.91	1.81	2.19	2.19
	E	0.8	0.71	0.69	0.56	0.76	0.62

(Labridae) were only captured at Praia do Vau. Moreover, in most of the samples the number of species and biomass were greater in Praia da Consolação than in the other study points (Table II A).

Table III lists the three most abundant species in each sample, together with the percentages they occupied in the total weight of the sample. *Lipophrys pholis* (Blenniidae) was the dominant species in all points.

Table III. – Percentages by weight of the three most abundant species in each sample.

Porto			
Nov.	<i>L. pholis</i> (88)	<i>C. mustela</i> (5)	<i>C. galerita</i> (3)
Jan.	<i>L. pholis</i> (77)	<i>C. mustela</i> (15)	<i>P. trigloides</i> (3)
Mar.	<i>L. pholis</i> (96)	<i>P. gattouguine</i> (3)	<i>C. galerita</i> (1)
May	<i>L. pholis</i> (90)	<i>C. galerita</i> (6)	<i>C. mustela</i> (3)
Jul.	<i>L. pholis</i> (82)	<i>G. mediterraneus</i> (10)	<i>N. lumbiciformes</i> (4)
Sep.	<i>L. pholis</i> (82)	<i>P. gattouguine</i> (7)	<i>C. mustela</i> (6)
Praia da Consolação			
Nov.	<i>L. pholis</i> (63)	<i>P. trigloides</i> (10)	<i>P. gattouguine</i> (10)
Jan.	<i>L. pholis</i> (54)	<i>P. gattouguine</i> (24)	<i>L. lepadogaster</i> (12)
Mar.	<i>L. pholis</i> (81)	<i>P. trigloides</i> (13)	<i>P. gattouguine</i> (3)
May	<i>L. pholis</i> (62)	<i>P. gattouguine</i> (17)	<i>P. trigloides</i> (8)
Jul.	<i>L. pholis</i> (46)	<i>P. gattouguine</i> (17)	<i>L. lepadogaster</i> (15)
Sep.	<i>L. pholis</i> (46)	<i>G. mediterraneus</i> (15)	<i>P. gattouguine</i> (12)
Praia do Magoito			
Nov.	<i>L. pholis</i> (88)	<i>C. galerita</i> (10)	<i>P. trigloides</i> (2)
Jan.	<i>L. pholis</i> (87)	<i>P. gattouguine</i> (11)	<i>C. galerita</i> (2)
Mar.	<i>L. pholis</i> (88)	<i>C. galerita</i> (11)	<i>P. trigloides</i> (1)
May	<i>L. pholis</i> (88)	<i>C. galerita</i> (11)	<i>P. trigloides</i> (1)
Jul.	<i>L. pholis</i> (70)	<i>C. galerita</i> (24)	<i>C. mustela</i> (4)
Sep.	<i>L. pholis</i> (71)	<i>C. galerita</i> (18)	<i>C. mustela</i> (6)
Sesimbra			
Nov.	<i>L. pholis</i> (64)	<i>C. galerita</i> (18)	<i>P. gattouguine</i> (9)
Jan.	<i>L. pholis</i> (57)	<i>C. galerita</i> (32)	<i>P. trigloides</i> (11)
Mar.	<i>L. pholis</i> (56)	<i>C. galerita</i> (33)	<i>P. trigloides</i> (11)
May	<i>L. pholis</i> (43)	<i>C. galerita</i> (37)	<i>P. trigloides</i> (20)
Jul.	<i>L. pholis</i> (56)	<i>C. galerita</i> (27)	<i>G. paganelus</i> (12)
Sep.	<i>L. pholis</i> (66)	<i>C. galerita</i> (17)	<i>P. trigloides</i> (12)
Praia do Vau			
Nov.	<i>L. pholis</i> (30)	<i>S. melops</i> (21)	<i>P. trigloides</i> (16)
Jan.	<i>L. pholis</i> (44)	<i>G. paganelus</i> (25)	<i>P. gattouguine</i> (7)
Mar.	<i>L. pholis</i> (52)	<i>G. paganelus</i> (31)	<i>P. trigloides</i> (19)
May	<i>L. pholis</i> (49)	<i>P. gattouguine</i> (28)	<i>G. paganelus</i> (15)
Jul.	<i>L. pholis</i> (47)	<i>P. gattouguine</i> (18)	<i>C. galerita</i> (16)
Sep.	<i>L. pholis</i> (32)	<i>S. melops</i> (25)	<i>P. gattouguine</i> (12)

Diversity and evenness

The range of diversity was different among the five points. The values of both diversity and evenness were greater in Praia da Consolação than on the other study points for each sampling period except in the first sampling period (November) where they were greater at Praia do Vau (Table II B).

The vertical distribution as revealed in relation to tidal level (Table I) showed that the blenniids *Coryphoblennius galerita* (Blenniidae) and *L. pholis* were strictly intertidal species, but differences could be detected in tidal zonation. *C. galerita* showed concentration in the upper tidal zone while *L. pholis* was found predominantly at mid tidal level. Both species were caught on rocky and sandy shores in pools and among boulders, respectively. The other species attained greatest densities in the lower tidal zone except *Gobius paganelus* (Gobiidae) that occurred frequently in the

mid tidal level. Moreover, *Paralipophrys tri-gloides*, *Parablennius gattorugine* and *P. incognitus* (Blenniidae) were found both in pools and among boulders on the rocky shore. *Lepadogaster lepadogaster* (Gobiesocidae) was common among small boulders but not in pools. *Nerophis lumbri-ciformes* (Syngnathidae) remained hidden amongst the lower branches of seaweeds or under stones. *Ciliata mustela* (Gadidae) was a shore-dwelling species found in rocky pools and under algae. *Symphodus melops* (Labridae) and *C. argentatus* were found in pools among dense algal growth.

DISCUSSION

Additional census from other pools and boulder areas were similar to those of the census pools and boulder areas in species composition, ranked abundance, and species diversity. Although pools and boulder areas provided a very similar picture of the composition of the local ichthyofauna, both number and biomass of species were greater in Porto, Praia da Consolação and Praia do Vau than in Praia do Magoito and Sesimbra in general.

The ichthyofaunas of the study points were typified by low diversity and evenness. The fall in evenness is due to the dominance of one species in the communities. In fact, in these communities *L. pholis* was represented by large number of individuals and biomass, but the other species were represented by a small number of individuals and biomass. This was exaggerated in Porto where *L. pholis* occupied 77-96 % of the total weight of each sample. In addition, most of the values obtained for evenness are below 0.8, which suggests that the communities of fish in the lagoon are not in evenness. Values greater or equal to 0.8 are usually considered as indicators of evenness in the communities (Daget, 1976).

As referred to before the study points appeared as five diversified habitat suitable for fish. Those points formed by both rocky pools and interstices among the boulders (Porto, Praia da Consolação and Praia do Vau) were characterized by high number of species and low population density, whereas those formed only by rocky pools (Magoito and Sesimbra) were characterized by low number of species and high population density. The habitat formed by both rocky pools and interstices among boulders would enhance niche diversification, while at the same time the increase patchiness of its environmental mosaic would reduce population density.

Moreover, the number of species present is not related with the degree of exposure to wave action (e. g. Praia do Magoito and Sesimbra both have low species diversity and are exposed to different degrees of wave action).

The seasonal values for water temperatures, salinity and tidal amplitude were not significantly different at the five study points. Certainly they influence species composition but not the patterns of diversity of the communities.

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