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Diet of *Scorpaena porcus* and *Scorpaena notata* (Pisces: Scorpaenidae) in the western Mediterranean

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Abstract: Food preferences of 230 *Scorpaena porcus* and 576 *S. notata* were investigated from the stomach contents of fish caught in the Gulf of Valencia (Spain), between October 1991 and October 1994. Our aim was to study the effects of predator size and season on the feeding habits of both species, the existence of a possible dietary overlap between species, and to compare our results with those of other studies in the Mediterranean. Crustacea Decapoda constituted the preferential prey of both fish species, whereas Amphipoda were secondary prey. However, these two scorpaenids had different diets, shown by the prey species composition of the stomach contents. *Scorpaena notata* had a more diverse diet (67 different species) than *S. porcus* (44 different species). The vacuity index was low for both species, although it varied significantly over the year, with a maximum during the reproductive period. Little variation was found in the food composition of different *S. porcus* size groups: brachyura dominated in number and occurrence in the diet of all size classes. A variation was found in the food composition of different *S. notata* size groups: the frequency of occurrence of reptantia and brachyura increased with increasing *S. notata* size, whereas the frequency of amphipods, mysids, isopods, and copepods decreased. In both species, seasonal dietary changes were also recorded. There was a moderate dietary overlap between these two species.

Résumé: *Régime alimentaire de* Scorpaena porcus *et* Scorpaena notata (*Pisces: Scorpaenidae*) *en Méditerranée occidentale.* Les préférences alimentaires de 230 *Scorpaena porcus* et 576 *S. notata* capturés dans le Golfe de Valence (Espagne), entre octobre 1991 et octobre 1994, ont été étudiées d'après leurs contenus stomacaux. Notre but était d'étudier les variations dans l'alimentation des deux espèces selon les saisons et la taille des individus et de comparer ces résultats avec ceux d'autres études faites en Méditerranée. Les crustacés Décapodes constituent les proies préférentielles des deux espèces examinées, tandis que les Amphipodes sont des proies secondaires. Cependant, ces deux rascasses ont des régimes alimentaires différents, comme le montre la composition spécifique des contenus stomacaux. *S. notata* a un régime alimentaire plus diversifié (67 espèces de proies) que *S. porcus* (44 espèces de proies). L'indice de vacuité est faible pour les deux espèces, bien qu'il ait varié significativement durant l'année, atteignant un maximum pendant la période de reproduction. Peu de changements sont observés dans le régime alimentaire des différents groupes de taille de *S. porcus* et les Brachyoures dominent en nombre et en fréquence d'occurrence dans toutes les classes de taille. Une variation a été observée dans le régime alimentaire des différentes classes de taille de *S. notata* : la fréquence d'occurrence des Reptantia et des Brachyoures augmente avec l'augmentation de taille, tandis que la fréquence d'occurrence des Amphipodes, Mysidacés, Isopodes et Copépodes diminue. Chez les deux espèces on observe un changement de régime alimentaire avec la saison. Les deux espèces présentent un chevauchement alimentaire modéré.

Keywords: Scorpaenidae, *Scorpaena porcus*, *S. notata*, diet overlap, Mediterranean

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Introduction

Scorpaena porcus Linnaeus, 1758 and *S. notata* Rafinesque, 1810 are two common marine demersal fishes in Spanish Mediterranean waters. Both scorpaenids inhabit the same grounds (rocky areas and *Posidonia* beds), although *S. notata* has a wider bathymetric distribution (Harmelin-Vivien et al., 1989).

Diet analysis is necessary to demonstrate the trophic overlap among species within a community. This parameter is essential in determining the intensity of the interspecific interactions in marine fish communities (Macpherson, 1981). Although the feeding habits of scorpaenid fishes in the Mediterranean were studied during the last decades (Dieuzeide et al., 1955; Bell & Harmelin-Vivien, 1983; Harmelin-Vivien et al., 1989; Bradai & Bouain, 1990; Pallaoro & Jardas, 1991; Arculeo et al., 1993), no statistical significance of the diet variations is discussed in these studies. Furthermore, very little is known about the trophic relationships between these species, except in the work of Harmelin-Vivien et al. (1989) referring to the Gulf of Marseille.

The present work was conducted within the framework of a project on the study of trophic relationships in a demersal fish community in the Gulf of Valencia. The aim of this paper was to examine the diet and dietary overlap of two scorpaenid species in the western Mediterranean, taking into account the effect of predator size and season on the feeding habits of both species, and also to compare our results with those of other studies in the Mediterranean.

Materials and methods

A total of 230 *Scorpaena porcus* and 576 *S. notata* were taken at depths from 50 to 175 m, in the fishing grounds of the Gulf of Valencia (39º25' - 39º35' N; 0º17' - 0º15' W), between October 1991 and October 1994 (Table 1). Fish were caught from diurnal commercial trawl catches landed at the port of Valencia (Spain).

Monthly samples, stored in ice boxes, were quickly transferred to the laboratory. There, they were measured (total length), to the lower half centimetre, immediately dissected and the stomachs were removed and preserved in 6% formalin. Upon opening, stomach contents were stored in a 70% ethanol solution. Evidence of regurgitation was never observed in any fish.

The percentage of empty stomachs (vacuity index, V%) was also recorded. A χ^2 test was applied to test differences in the number of empty stomachs. In the laboratory, identification of prey was carried out at specific level whenever possible. We registered number and wet weight (nearest 0.1 mg) of the food items, after wiping of the surface water.

Table 1. Number of *Scorpaena porcus* and *S. notata* stomachs (total and empty) considered in this study, by year and season.

Tableau 1. Nombre total des estomacs et nombre des estomacs vides chez les deux espèces de *Scorpaena* considérées dans cette étude, par année et par saison.

year	winter total	winter empty	spring total	spring empty	summer total	summer empty	autumn total	autumn empty
Scorpaena porcus								
oct '91 - sep '92	24	2	14	6	21	10	13	4
oct '92 - sep '93	19	5	42	6	19	7	16	3
oct '93 - sep '94	21	2	12	2	17	7	12	0
Scorpaena notata								
oct '91 - sep '92	43	4	42	12	43	20	66	15
oct '92 - sep '93	25	5	77	15	47	21	70	24
oct '93 - sep '94	34	2	35	7	46	15	48	14

The contribution of each prey to the diets of both species was determined by the frequency of occurrence (F%), numerical composition (Cn%) and biomass composition (Cw%) (Hyslop, 1980). The Index of Relative Importance (IRI) (Pinkas et al., 1971), as modified by Hacunda (1981), was calculated for consumed prey items:

$$IRI=F(Cn+Cw)$$

To assess changes in the diet with size, fish were divided into three size classes according to age (Siblot-Boutéflika, 1976): Group I (<11 cm) maximum 2 years, Group II (11-15 cm) between 2 and 4 years old, and Group III (>15 cm) the oldest ones.

The interspecific dietary overlap between size classes and seasons was calculated at the level of species according to Schoener (1970):

$$a = 1\text{-}0.5 \left(\sum_{i=1}^{n} |p_{xi} - p_{yi}| \right)$$

where n is the number of food organisms, p_{xi} and p_{yi} are the numerical composition of index of prey (i) in the diets of species x and y, respectively. The index has a minimum value of zero, when no overlap occurs, and a maximum value of one, when all prey are shared in equal proportions by the two species. The convention established by Langton (1983) and Brodeur & Pearcy (1984) was invoked. Overlap index values of 0.00-0.29 were considered low, values of 0.30-0.60 were considered medium, and values >0.60 were considered high.

In order to compare both species' diets, prey items were partitioned into six categories: natantia, brachyura, reptantia, amphipods, other crustaceans (mysids, isopods, copepods and stomatopods), and "other groups" (polychaetes, molluscs, ascidians, teleosts and vegetal remains).

A cluster analysis based on squared Euclidean distance (Sokal & Rohlf, 1981) was carried out on biomass composition data of their preys, to evaluate the pattern of the diet of each scorpaenid species according to fish size in each season.

Statistical differences ($P<0.05$) in diet composition as a function of size and season were assessed by applying a χ^2-test (Sokal & Rohlf, 1981). This was applied over the number of stomachs in which a prey occurs (*n*).

The significance of variation of mean number of prey and weight per stomach was tested by analysis of variance (ANOVA). The normality of the data was verified using the Kolmogorov-Smirnov test and the homogeneity of variances using the Bartlett's test (P<0.05). When the data do not satisfy the assumptions of parametric tests, several transformations were applied (logarithmic, arcsine and square root transformations). If this condition remains, a nonparametric one-way ANOVA (Kruskal-Wallis test) was applied (Sokal & Rohlf, 1981).

Results

General feeding trends

Of the 230 stomachs of *Scopaena porcus* examined, 54 were found to be empty (23.5%). The vacuity index varied significantly over the year (χ^2=15.41, df=3, P<0.01), with a maximum in summer (42.1%) and a minimum in winter (14.1%) (Figure 1).

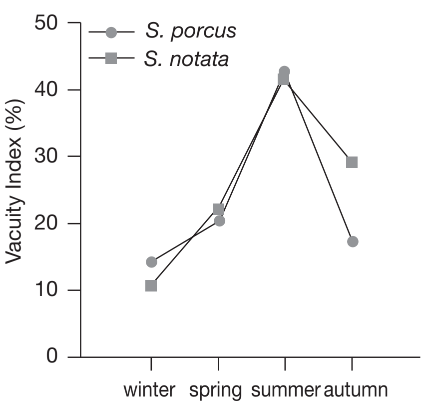

Figure 1. Seasonal variation of the vacuity index (V%)
Figure 1. Variation saisonnière de l'indice de vacuité (V %).

The stomachs of 26.7% *S. notata* were empty. Like in *S. porcus*, the vacuity index varied significantly over the year (χ^2=29.83, df=3, P<0.001), with a maximum in summer (41.2%) and a minimun in winter (10.8%).

The proportion of empty stomachs examined did not varied significantly among the size classes of *S. notata* (χ^2=3.17, df=2, P>0.05) and *S. porcus* (χ^2=5.47, df=2, P>0.05).

Data on the frequency of occurrence F (%), the numerical composition Cn (%), biomass composition Cw (%) and the Index of Relative Importance (IRI) of the main prey species consumed by this scorpaenids, in the study area, are given in Tables 2 and 3**.** Further details, of the prey items found in *S. porcus* and *S. notata* stomach contents, are given in appendix 1 and 2, respectively.

The stomach contents of *S. porcus* contained 44 different prey species, with a low average number of prey per stomach (mean 1.87). Crustaceans were the most numerous prey ingested, dominated by brachyura (*Pilumnus hirtellus*, *Liocarcinus corrugatus* and *Goneplax rhomboides*) and reptantia (*Pisidia longimana* and *Upogebia deltaura*). Less abundant crustaceans included natantia (*Processa mediterranea* and *Philocheras monacanthus*) and amphipods. Less important taxa found in the stomach contents were molluscs, copepods, isopods, mysids, stomatopods, polychaetes and teleosts. According to the IRI, the most important prey was *Pilumnus hirtellus*, followed by *Pisidia longimana* and *Liocarcinus corrugatus*.

The number of prey species recorded for *S. notata* was 67, with an average number of 2.11 preys per stomach, comprising almost exclusively crustaceans. Among these crustaceans, natantia (*Processa mediterranea*, *Alpheus glaber* and *Thoralus cranchii*), reptantia (*Pisidia longimana*) and brachyura (*Pilumnus hirtellus*) made up the greatest number and also occurred most frequently in stomachs. Polychaetes and amphipods were secondary preys, whereas isopods, copepods, mysids, stomatopods, molluscs and teleosts were infrequent. For the IRI, *Pisidia longimana* was by far the most important prey, followed by *Pilumnus hirtellus* and *Processa mediterranea*.

Variation in stomach contents relative to fish length

In both species, there were no significant differences in the average number of prey per stomach in the different size classes (Figure 2). The average prey weight per stomach changed with the different *Scorpaena notata* size groups (F=3.369, df=573, P<0.05), although in *Scorpaena porcus* no significant changes were found (F=0.94, df=227, P>0.05). The vacuity coefficient had no significant differences in the various size groups of both species.

Little variation was found in the food composition of different *S. porcus* size groups (Table 4). Brachyura dominated in number and occurrence in the diet of all size classes (χ^2=2.43, df=2, P>0.05). Predation on natantia did not vary significantly with the size of *S. porcus* (χ^2=3.78, df=2, P>0.05), but there was a trend for reptantia to be less consumed by large specimens (χ^2=6.62, df=2, P<0.05). Amphipods were consumed primarily by small specimens (χ^2=6.11, df=2, P<0.05), whereas "other groups" were present primarily in large specimens. No significant values were found for other crustaceans (χ^2=3.45, df=2, P>0.05).

Table 2. Main prey registered in stomachs of *Scorpaena porcus*. n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F (%), frequency of occurrence; Cn (%), numerical composition; Cw (%), biomass composition; IRI, Index of Relative Importance; only appears those species for which IRI> 25.

Tableau 2. Proies préférentielles observées dans les estomacs de *Scorpaena porcus*. n, nombre d'estomacs où apparaissent les proies ; p, nombre d'individus d'un type de proie ; F (%), indice de fréquence d'occurrence ; Cn (%), pourcentage numérique ; Cw (%), pourcentage en poids ; IRI, Indice d'Importance Relative ; apparaissent uniquement les espèces pour lesquelles IRI> 25.

Food items	n	p	F(%)	Cn(%)	Cw(%)	IRI
Bathynectes longipes	5	6	2.841	1.395	11.502	36.641
Goneplax rhomboides	14	14	7.955	3.256	5.152	66.883
Ilia nucleus	8	9	4.545	2.093	3.514	25.489
Liocarcinus corrugatus	17	19	9.659	4.419	6.082	101.431
Liocarcinus depurator	10	13	5.682	3.023	4.162	40.824
Pilumnus hirtellus	26	33	14.773	7.674	16.713	360.272
Pisidia longimana	33	45	18.750	10.465	2.086	235.338
Processa mediterranea	13	15	7.386	3.488	1.227	34.833

Table 3. Main prey registered in the stomachs of *Scorpaena notata*. n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F (%), frequency of occurrence; Cn (%), numerical composition; Cw (%), biomass composition; IRI, Index of Relative Importance; only appears those species for which IRI> 25.

Tableau 3. Proies préférentielles observées dans les estomacs de *Scorpaena notata*. n, nombre d'estomacs où apparaissent les proies ; p, nombre d'individus d'un type de proie ; F (%), indice de fréquence d'occurrence ; Cn (%), pourcentage numérique ; Cw (%), pourcentage en poids ; IRI, Indice d'Importance Relative ; apparaissent uniquement les espèces pour lesquelles IRI> 25.

Food items	n	p	F(%)	Cn(%)	Cw(%)	IRI
Polychaeta	24	28	5.687	2.293	11.361	77.655
Alpheus glaber	36	37	8.531	3.030	2.162	44.296
Macropodia rostrata	23	35	5.450	2.867	2.274	28.017
Pilumnus hirtellus	43	53	10.190	4.341	14.156	188.472
Pisidia longimana	91	217	21.564	17.772	6.014	512.920
Processa mediterranea	34	97	8.057	7.944	5.277	106.525
Thoralus cranchii	37	61	8.768	4.996	0.148	45.098

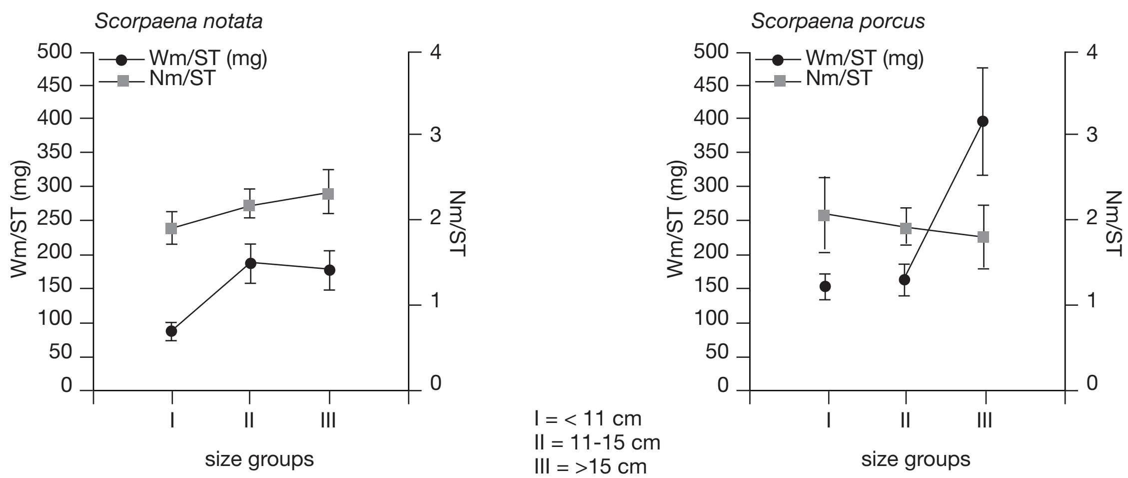

Figure 2. Average number of prey per stomach (Nm/ST) and average prey weight per stomach (Wm/ST) for the size groups. Nm= Number of prey; Wm= Weight of prey; ST= Number of stomachs.

Figure 2. Nombre moyen de proies par estomac (Nm/ST) et poids moyen des proies par estomac (Wm/ST) pour chaque groupe de taille. Nm = Nombre de proies ; Wm = Poids des proies ; ST = Nombre d'estomacs.

Table 4. Diet of each size group of *Scorpaena porcus*, with regard to the frequency of occurrence F (%), numerical composition Cn (%), biomass composition Cw (%) and Index of Relative Importance (IRI). Group I <11 cm; Group II = 11-15 cm; Group III >15 cm.

Tableau 4. Alimentation de chaque classe de taille de *Scorpaena porcus*, selon l'indice de fréquence d'occurrence F (%), le pourcentage numérique Cn (%), le pourcentage en poids Cw (%) et l'Indice d'Importance Relative (IRI). Groupe I <11 cm ; Groupe II = 11-15 cm ; Groupe III >15 cm.

	Natantia	Reptantia	Brachyura	Amphipods	Other groups	Other crustaceans
Group I						
F (%)	22.22	17.79	82.22	17.78	2.22	2.22
Cn (%)	29.13	7.77	50.48	9.71	0.97	1.94
Cw (%)	4.96	2.23	87.94	0.13	4.69	0.04
IRI	757.51	177.73	11381.83	174.98	12.58	4.40
Group II						
F (%)	38.57	8.57	74.29	11.43	11.43	11.43
Cn (%)	28.57	3.43	53.14	5.14	4.57	5.14
Cw (%)	7.99	11.88	61.55	0.06	17.95	0.56
IRI	1410.32	131.23	8519.99	59.48	257.39	65.23
Group III						
F (%)	27.87	3.28	68.85	3.28	26.23	11.47
Cn (%)	18.42	1.32	42.10	1.97	10.53	25.66
Cw (%)	6.72	11.78	151.61	0.17	36.75	16.44
IRI	700.80	42.92	13337.64	7.03	1240.07	483.14

Table 5. Diet of each size group of *Scorpaena notata*, with regard to the frequency of occurrence F (%), numerical composition Cn (%), biomass composition Cw (%) and Index of Relative Importance (IRI). Group I <11 cm; Group II = 11-15 cm; Group III >15 cm.

Tableau 5. Alimentation de chaque classe de taille de *Scorpaena notata,* selon l'indice de fréquence d'occurrence F (%), le pourcentage numérique Cn (%), le pourcentage en poids Cw (%) et l'Indice d'Importance Relative (IRI). Groupe I <11 cm ; Groupe II = 11-15 cm ; Groupe III >15 cm.

	Natantia	Reptantia	Brachyura	Amphipods	Other groups	Other crustaceans
Group I						
F (%)	50.00	15.79	32.89	23.03	10.53	25.66
Cn (%)	37.08	11.49	18.02	12.53	4.96	15.93
Cw (%)	28.54	5.58	32.79	0.26	30.47	2.37
IRI	3280.63	269.51	1671.12	294.46	373.00	469.36
Group II						
F (%)	55.25	24.31	52.49	18.23	18.23	12.15
Cn (%)	40.79	12.41	26.13	8.08	6.95	5.64
Cw (%)	18.63	5.15	36.58	0.10	28.47	11.08
IRI	3282.95	426.80	3291.09	149.10	645.89	203.16
Group III						
F (%)	52.81	37.08	57.30	14.61	24.72	3.37
Cn (%)	21.57	39.22	24.51	5.88	7.84	0.98
Cw (%)	9.79	12.42	51.01	0.08	26.64	0.07
IRI	1656.10	1914.43	4327.53	87.08	852.29	3.53

Appreciable variation was found in the food composition of different *S. notata* size groups (Table 5). An increase in length was also followed by defined changes in feeding habits: the frequency of occurrence of reptantia (χ^2=13.99, df=2, P<0.001), brachyura (χ^2=18.09, df=2, P<0.001) and other groups (χ^2=8.52, df=2, P<0.05) increased with increasing *S. notata* size whereas the frequency of amphipods (χ^2=2.75, df=2, P>0.05) and other crustaceans (χ^2=23.90, df=2, P<0.001) decreased. Natantia were important in all size classes (χ^2=0.91, df=2, P>0.05). The numerical composition index indicates that natantia were the most numerous prey ingested in the small and medium size classes, whereas reptantia were important in the large size class.

Seasonal variations in stomach contents

In *Scorpaena porcus*, the average number of prey (F=26.86, df=226, P>0.05) and their weight (F=0.95, df=226, P>0.05) per stomach changes throughout the year (Figure 3). In this case, a minimum of 0.91 prey items per stomach was recorded in summer whereas the average prey weight was maximum in this season. On the other hand, for *S. notata*, the average number of prey (F=52.76, df=572, P<0.01) and weight per stomach (F=9.90, df=572, P<0.01) in winter and spring were higher than in summer and autumn.

The relative importance of the prey groups of *S. porcus* changed seasonally (Figure 4). Brachyura were the most important prey in all seasons, although occuring less frequently in summer (χ^2=10.23, df=3, P<0.05). Natantia (χ^2=19.63, df=3, P<0.001), reptantia (χ^2=22.24, df=3, P<0.001) and amphipods (χ^2=9.13, df=3, P<0.05) were present primarily during spring. No significant differences were found for other crustaceans and other groups.

Brachyura were important in the stomach contents of *S. notata* throughout the year (χ^2=6.87, df=3, P>0.05), whereas natantia were present primarily during spring and summer (χ^2=11.62, df=3, P<0.01) (Figure 4). Reptantia occurred less frequently in the diet during summer and autumn (χ^2=57.63, df=3, P<0.01). Amphipods (χ^2=19.17, df=3, P<0.001) appeared most frequently during winter and spring. No significant differences were found for other groups (χ^2=3.40, df=3, P>0.05) and other crustaceans (χ^2=1.27, df=3, P>0.05). According

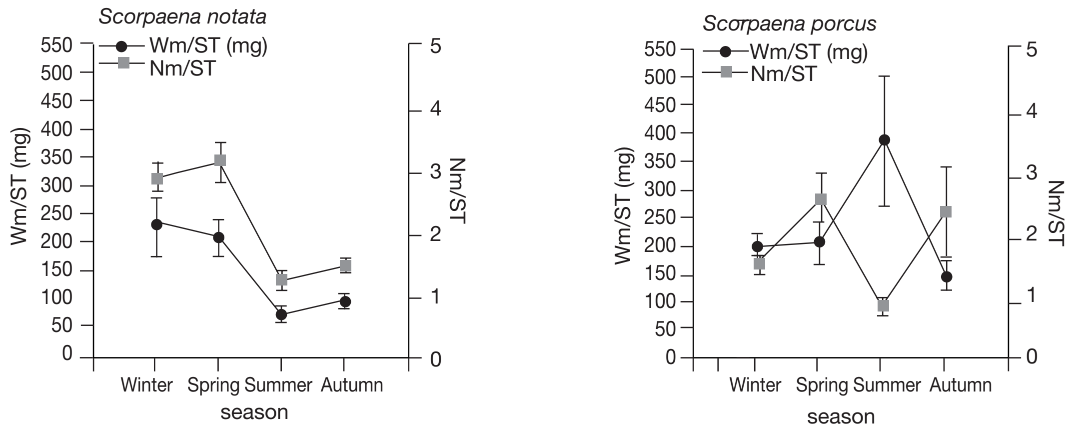

Figure 3. Average number of prey per stomach (Nm/ST) and average prey weight per stomach (Wm/ST) throughout the year. Nm = Number of prey; Wm = Weight of prey; ST = Number of stomachs.

Figure 3. Nombre moyen de proies par estomac (Nm/ST) et poids moyen des proies par estomac (Wm/ST) tout au long de l'année. Nm = Nombre de proies ; Wm = Poids des proies ; ST = Nombre d'estomacs.

to the IRI, reptantia were the most important prey group in winter, natantia showed the higher values in spring and summer, whereas brachyura constituted the main prey items in autumn.

Diet overlap

Of the 79 different species found in the stomachs, 31 occurred in the diet of both scorpaenid. The extent of interspecific dietary similarity was quantified by comparing dietary overlaps among all possible pairs of group size within each season (Table 6).

In winter, the dietary overlap between Group III of *S. porcus* and Group II of *S. notata* was 0.63. It reflects here a predilection of these predators for the same decapod (*Pisidia longimana, Pilumnus hirtellus*, *Thoralus cranchii* and *Processa mediterranea*) and amphipod species (*Dexamine spiniventris*). Medium dietary overlap was also evidenced among Group II of *S. porcus* and Group I and Group III of *S. notata*, owing to the fact that they prey heavily on *Pisidia longimana*.

In spring, Schoener's index between Group II of both species showed a high dietary overlap. Similar results were found when we compared the diet of Group II of *S. porcus* and Group III of *S. notata*. In both cases they mainly overlaped for brachyura (*Pilumnus hirtellus*, *Macropodia rostrata*), Reptantia (*Pisidia longimana*) and Natantia (*Philocheras monacanthus*, *Processa mediterranea*, *Hippolyte longirostris*).

During summer months, interspecific diet overlap of the different size classes was not important, because both species have a very varied diet. In this season, the Group I of *S. porcus* did not ingested any food and so no comparison was done with this class.

In autumn, the dietary overlap between Group II of *Scorpaena porcus* and Group I of *S. notata* was high (0.62), owing to the fairly similar proportions of brachyuran species such as *Pilumnus hirtellus*, *Inachus thoracicus* and *Achaeus gracilis.* An interspecific diet overlap among Group II of *S. porcus* and Groups II and III of *S. notata* was also important, due to a predilection for the same decapod species (*Pisidia longimana* and *Achaeus gracilis*). No *S. porcus* smaller or equal to 10.5 cm were obtained in this study, for this reason their feeding could not be compared with the size classes of *S. notata*.

A cluster analysis of dietary data (Figure 5) produced, below the value of 70%, two major fish groups. The first (group A) includes mainly large *Scorpaena porcus* specimens and shows the highest similarity value which each other; their specimens are linked because their diet is dominated by *Pilumnus hirtellus* and *Pisidia longimana*. The second group (B) contains mainly *Scorpaena notata* specimens and can be further divided into two subgroups, 1 and 2. The cluster analysis did not clearly distinguish diet categories according to size and/or season neither in the subgroup 1, nor in the subgroup 2 although this one was composed, with others, of the autumn *S. notata* specimens.

Discussion

Crustacean decapods are the main dietary components of *Scorpaena porcus* and *S. notata*. These are typical scorpaenids prey items, irrespective of species, biotope or geographic zone considered (Harmelin-Vivien et al., 1989). In Spanish Mediterranean waters, as in the Tyrrhenian Sea (Arculeo et al., 1993), *S. porcus* appears to feed mainly on

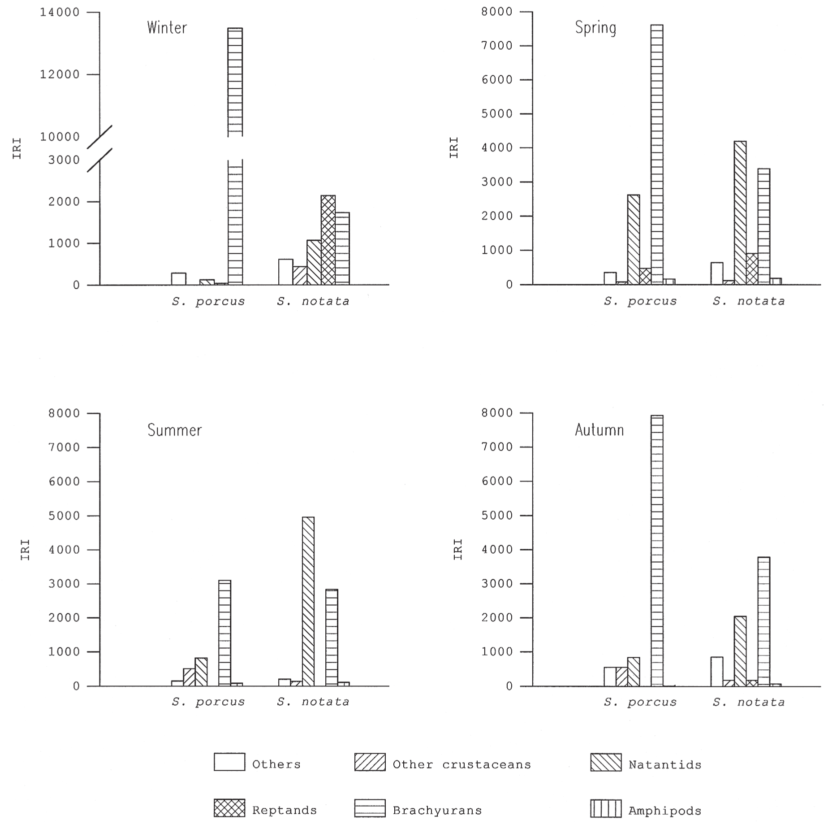

Figure 4. Seasonal changes in the Relative Importance Index (IRI) of the main prey categories for *Scorpaena porcus* and *S. notata*.

Figure 4. Changements saisonniers de l'Indice d'Importance Relative (IRI) des principales catégories de proies chez *Scorpaena porcus* et *S. notata*.

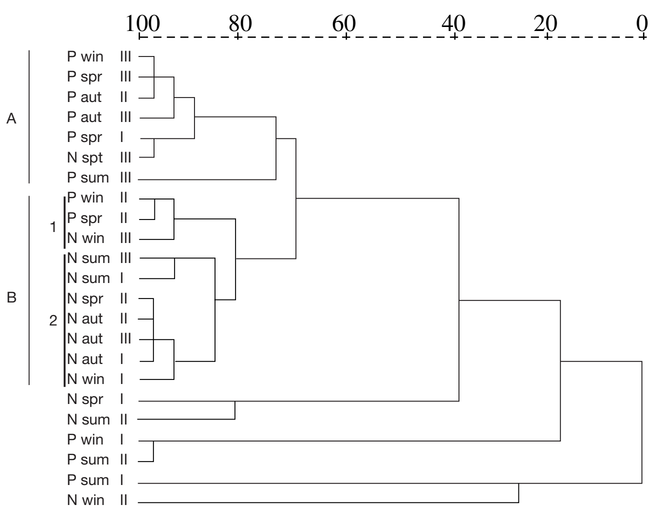

Figure 5. Dendrogram of the cluster analysis of trophic similarity of *Scorpaena porcus* and *Scorpaena notata* based on size and season. P (*Scorpaena porcus*), N (*S. notata*), win (winter), spr (spring), sum (summer), aut (autumn), I (Group I <11 cm), II (Group II 11-15 cm), III (Group III >15 cm).

Figure 5. Dendrogramme de l'analyse des similarités trophiques de *Scorpaena porcus* et *S. notata* en fonction de la taille et de la saison. P (*Scorpaena porcus*), N (*S. notata*), win (hiver), spr (printemps), sum (été), aut (automne), I (Groupe I <11 cm), II (Groupe II 11-15 cm), III (Groupe III >15 cm).

←

decapods. Similar results have been reported for other Mediterranean areas. But teleosts were frequent in the stomach contents of fish from French and Tunisian Mediterranean waters (Bell & Harmelin-Vivien, 1983; Harmelin-Vivien et al., 1989; Bradai & Bouain, 1990) and Adriatic coast (Pallaoro & Jardas, 1991). The dominant part played by crustaceans in the diet of *S. notata* is also noted by Harmelin-Vivien et al. (1989). Nevertheless, these authors found some different natantia (*Hippolyte inermis*), brachyura (*Macropipus arcuatus*, *Maia squinado*, *Pisa armata* and *Xantho incisus*) and amphipoda species (*Dexamine spinosa*, *Maera knudseni* and *Apherusa bispinosa*) due to the fact that they sampled fish at depths from 16 to 20 m in *Posidonia oceanica* seagrass beds. Furthermore, the lower frequency of amphipods in our study compared with that of Harmelin-

Table 6. Interspecific food overlap of the different size classes as a function of season. Index calculated according to Schoener (1970) (see Material and methods).

Tableau 6. Chevauchement dans l'alimentation des deux espèces, pour les différentes classes de taille et selon les saisons. Valeurs calculées d'après Schoener (1970) (voir Matériel et méthodes).

Winter			
S. porcus	Group I	Group II	Group III
S. notata			
Group I	0.14	0.61	0.53
Group II	0.08	0.57	0.63
Group III	0.07	0.61	0.50

Spring			
S. porcus	Group I	Group II	Group III
S. notata			
Group I	0.42	0.52	0.50
Group II	0.47	0.62	0.54
Group III	0.37	0.64	0.54

Summer			
S. porcus	Group I	Group II	Group III
S. notata			
Group I	------	0.46	0.32
Group II	------	0.33	0.29
Group III	------	0.21	0.30

Autum			
S. porcus	Group I	Group II	Group III
S. notata			
Group I	------	0.62	0.53
Group II	------	0.58	0.41
Group III	------	0.42	0.37

Vivien et al. (1989) was probably due to the absence of specimens smaller than 8 cm in our samples. In fact, these authors observed a rather abrupt decrease in the percentage of amphipods in the stomachs of specimens with an average length of more than 6 cm.

In both species, the percentage of empty stomachs was lower than the values found by previous investigators for other areas (Harmelin-Vivien et al., 1989; Bradai & Bouain, 1990; Pallaoro & Jardas, 1991). However, these percentages were not constant throughout the year. Several investigators pointed out in different fish species that a maximum of empty stomachs was recorded during the reproductive period in relation to a significant decrease in food intake during reproduction (Macpherson, 1978; Sanz, 1985; Redón et al., 1994; Morte et al., 1999). Spawning for both scorpaenids occurs in summer (Siblot-Boutéflika, 1976), which corresponds to the maximum vacuity-index values recorded in the present study.

No changes were observed in the vacuity index of different scorpaenid size classes, while opposite results have been presented for *S. porcus* in the Adriatic coast (Pallaoro & Jardas, 1991).

In the present study, *S. porcus* showed little variation in the food composition of different size groups. However, a relative increase of fish and brachyuran ingestion, and a decrease of natantia, have been observed in relation to growth increase in other areas (Harmelin-Vivien et al., 1989; Bradai & Bouain, 1990; Pallaoro & Jardas, 1991). However comparison between areas is often difficult due to the small size of the samples and to variations in length of the sampled specimens. Fish diets also change according to the abundance of different prey in the environment, provided that these prey are within the selected size range and have similar ecological characteristics (Macpherson, 1978; Froglia, 1988; Redón et al., 1994). Furthermore, the importance of different food items may change as the predator grows.

It was observed that the diet of *S. notata* also changed with size classes. This change was due to the decrease of the frequency of occurence of amphipods and other crustaceans with increasing predator size whereas the frequency of occurence of reptantia, brachyura and other groups increased. Harmelin-Vivien et al. (1989) reported similar results, but they found a higher occurrence of teleosts in the stomachs of larger specimens.

Cannibalism was rarely observed, and only in *S. porcus*, in our study. In contrast, Harmelin-Vivien et al. (1989) reported frequent cannibalism in both scorpaenid species.

In both species feeding habits changed seasonally and these changes, besides variations of diet according to fish size, could be due to depth of sampling sites. This is difficult to control when samples are caught by professional fisherman. However, in our study fish were collected over a relatively narrow depth range (50 to 175 m) where the structure of bottom communities are probably similar.

Although the high taxonomic groups of the major prey of *S. porcus* and *S. notata* were very similar, both *Scorpaena* species preyed on different species or genera of the same family, so that food overlap and probably competition is low. Overlap values calculated may be helpful in comparing how close the feeding habits of these two species are, but they may be of limited use when examined from an ecological point of view. High overlap values did not provide sufficient evidence of competition unless resources are in short supply (Pianka, 1976) and no data is available to assess whether food supply is scarce or abundant. Nevertheless, studies along the eastern coast of Spain, showed that the main prey identified in both scorpaenid diet are common in the benthos (Zariquiey-Alvarez, 1968; Fusté, 1982, 1989; Abelló, 1986; García-Raso, 1987; Abelló et al., 1988). Several studies into demersal fish communities have revealed an increase of food overlap due to the opportunistic utilization of superabundant food resources by fishes (Macpherson, 1981; Targett, 1981; Delbeck & Williams, 1987; Morte et al., 1997, 1999). On the other hand, a cluster analysis in the present study shows a certain segregation between the two scorpaenid species.

In conclusion, the two species examined in this study appear to have approximately similar diets (mainly reptantia and brachyurans), but there is a more diverse diet in one of the species, so that only a moderate dietary overlap occurs.

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Appendix 1. Prey registered in the stomach of *Scorpaena porcus*. n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F (%), frequency of occurrence; Cn (%), numerical composition; Cw (%), biomass composition; IRI, Index of Relative Importance; * = values < 0.01.

Annexe 1. Proies observées dans les estomacs de *Scorpaena porcus*. n, nombre d'estomacs où apparaissent les proies ; p, nombre d'individus d'un type de proie ; F (%), indice de fréquence d'occurrence ; Cn (%), pourcentage numérique ; Cw (%), pourcentage en poids ; IRI, Indice d'Importance Relative ; * = valeurs < 0.01.

Food items	n	p	F(%)	Cn(%)	Cw(%)	IRI
Polychaeta	6	6	3.409	1.395	3.773	17.618
Mollusca						
Bivalvia	2	2	1.136	0.465	0.037	0.571
Gastropoda	2	2	1.136	0.465	0.037	0.571
Cephalopoda	1	1	0.568	0.233	1.823	1.168
Sepiola sp.	2	2	1.136	0.465	3.564	4.578
Crustacea						
Copepoda	1	20	0.568	4.651	*	2.643
Isopoda						
Cirolana cranchii Leach (Hansen, 1905)	1	1	0.568	0.233	0.024	0.146
Cymodoce truncata	2	2	1.136	0.465	0.124	0.669
Eurydice affinis Hansen, 1905	1	1	0.568	0.233	0.075	0.175
Sphaeroma sp.	2	2	1.136	0.465	0.010	0.540
Amphipoda	1	1	0.568	0.233	*	0.133
Gammaridea	11	12	6.250	2.791	0.022	17.577
Ampelisca sp.	1	3	0.568	0.698	*	0.399
Dexamine spiniventris (A. Costa, 1853)	5	6	2.841	1.395	0.011	3.995
Mysidacea	1	1	0.568	0.233	*	0.134
Siriella sp.	1	2	0.568	0.465	*	0.268
Anchialina agilis (G.O. Sars), 1877	4	16	2.273	3.721	0.040	8.547
Leptomysis mediterranea G.O. Sars, 1877	1	2	0.568	0.465	*	0.267
Stomatopoda						
Pseudoesquillopsis ceresii (Roux, 1828)	1	1	0.568	0.233	8.766	5.113
Rissoides desmaresti (Risso, 1816)	2	2	1.136	0.465	0.691	1.313
Decapoda						
Natantia	2	2	1.136	0.465	0.228	0.788
Alpheus dentipes Guérin, 1832	8	11	4.545	2.558	0.976	16.064
Alpheus glaber (Olivi, 1792)	1	1	0.568	0.233	0.382	0.349
Athanas nitescens (Leach, 1814)	5	7	2.841	1.628	0.242	5.311
Hippolyte sp.	2	2	1.136	0.465	0.011	0.541
Hippolyte longirostris (Czerniavsky, 1868)	4	6	2.273	1.395	0.045	3.274
Processa sp.	2	3	1.136	0.698	0.245	1.072
Processa canaliculata Leach, 1815	6	8	3.409	1.860	0.710	8.764
Processa mediterranea (Parisi, 1915)	13	15	7.386	3.488	1.227	34.833
Sicyonia carinata (Brünnich, 1768)	7	8	3.977	1.860	2.394	16.923
Thoralus cranchii (Leach, 1817)	3	13	1.705	3.023	0.107	5.335
Thoralus sollaudi (Zariquiey Cenarro, 1935)	3	12	1.705	2.791	0.123	4.966
Crangonidae	2	2	1.136	0.465	0.013	0.544
Philocheras monacanthus (Holthuis, 1961)	8	18	4.545	4.186	0.118	19.564
Reptantia	2	2	1.136	0.465	0.622	1.236
Calcinus ornatus (Roux, 1828)	1	1	0.568	0.233	0.167	0.227
Pisidia sp.	2	2	1.136	0.465	0.419	1.004
Pisidia longimana (Risso, 1816)	33	45	18.750	10.465	2.086	235.338
Scyllarus sp.	1	1	0.568	0.233	1.642	1.065
Upogebia sp.	1	1	0.568	0.233	0.037	0.153
Upogebia deltaura (Leach, 1815)	10	10	5.682	2.326	0.992	18.849
Paguridea	1	1	0.568	0.233	0.166	0.226
Brachyura	1	1	0.568	0.233	0.320	0.314
Achaeus gracilis (O. Costa, 1839)	2	3	1.136	0.698	0.648	1.530
Bathinectes longipes (Risso, 1816)	5	6	2.841	1.395	11.502	36.641
Ethusa mascarone (Herbst, 1785)	3	3	1.705	0.698	0.762	2.489
Eurynome aspera (Pennant, 1777)	2	2	1.136	0.465	0.132	0.679
Goneplax rhomboides (Linnaeus, 1758)	14	14	7.955	3.256	5.152	66.883
Ilia nucleus (Linnaeus, 1758)	8	9	4.545	2.093	3.514	25.489
Inachus dorhynchus Miranda & Rivera, 1940	9	9	5.114	2.093	0.731	14.440
Inachus phalangium (Fabricius, 1775)	2	2	1.136	0.465	0.175	0.727
Inachus thoracicus Roux, 1830	1	1	0.568	0.233	0.018	0.143
Liocarcinus sp.	2	3	1.136	0.698	0.960	1.884
Liocarcinus corrugatus (Pennant, 1777)	17	19	9.659	4.419	6.082	101.431

Food items	n	p	F(%)	Cn(%)	Cw(%)	IRI
Liocarcinus depurator (Linnaeus, 1758)	10	13	5.682	3.023	4.162	40.824
Liocarcinus pusillus (Leach, 1815)	2	2	1.136	0.465	2.317	3.161
Majidae	2	2	1.136	0.465	0.640	1.256
Macropodia sp.	5	6	2.841	1.395	0.538	5.493
Macropodia deflexa Forest, 1978	2	2	1.136	0.465	0.149	0.698
Macropodia linaresi Forest & Zariquiey Alvarez, 1964	1	1	0.568	0.233	0.074	0.174
Macropodia rostrata (Linnaeus, 1761)	10	11	5.682	2.558	0.750	18.799
Pachygrapsus sp.	1	1	0.568	0.233	0.171	0.229
Pachygrapsus marmoratus (Fabricius, 1787)	8	8	4.545	1.860	1.368	14.676
Parthenope massena (Roux, 1830)	3	3	1.705	0.698	0.281	1.668
Pilumnus sp.	2	2	1.136	0.465	0.898	1.549
Pilumnus hirtellus (Linnaeus, 1761)	26	33	14.773	7.674	16.713	360.272
Pilumnus spinifer H. Milne Edwards, 1834	3	3	1.705	0.698	1.818	4.289
Xantho pilipes A. Milne Edwards, 1867	2	2	1.136	0.465	0.444	1.033
Xantho poressa (Olivi, 1792)	1	1	0.568	0.233	0.184	0.237
Teleostei	3	3	1.705	0.698	2.224	4.979
Scorpaena notata Rafinesque, 1810	1	1	0.568	0.233	0.705	0.533
Pleuronectiformes	1	1	0.568	0.233	0.461	0.394
Lesueurigobius friesii (Malm, 1874)	6	6	3.409	1.395	4.093	18.711
Vegetal remains	1	1	0.568	0.233	0.038	0.153

Appendix 2. Prey registered in the stomach of *Scorpaena notata*. n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F (%), frequency of occurrence; Cn (%), numerical composition; Cw (%), biomass composition; IRI, Index of Relative Importance; * = values < 0.01.

Annexe 2. Proies observées dans les estomacs de *S. notata*. n, nombre d'estomacs où apparaissent les proies ; p, nombre d'individus d'un type de proie ; F (%), indice de fréquence d'occurrence ; Cn (%), pourcentage numérique ; Cw (%), pourcentage en poids ; IRI, Indice d'Importance Relative ; * = valeurs < 0.01.

Food items	n	p	F(%)	Cn(%)	Cw(%)	IRI
Polychaeta	24	28	5.687	2.293	11.361	77.655
Mollusca						
Bivalvia	5	5	1.185	0.410	0.060	0.556
Gastropoda	8	8	1.896	0.655	0.096	1.423
Turritella communis Risso, 1826	6	6	1.422	0.491	0.116	0.864
Cephalopoda	5	5	1.185	0.410	5.881	7.453
Rossia sp.	1	1	0.237	0.082	0.698	0.185
Sepioidea	1	1	0.237	0.082	1.150	0.292
Sepiola sp.	4	5	0.948	0.410	5.014	5.141
Crustacea						
Copepoda	3	12	0.711	0.983	*	0.699
Isopoda	2	2	0.474	0.164	0.010	0.082
Cirolanidae	2	2	0.474	0.164	0.031	0.092
Cirolana cranchii	3	3	0.711	0.246	0.036	0.200
Cymodoce truncata (Leach, 1814)	14	14	3.318	1.147	0.318	4.859
Idotea chelipes (Pallas, 1766)	1	1	0.237	0.082	*	0.021
Sphaeromatidae	1	1	0.237	0.082	*	0.020
Sphaeroma sp.	1	1	0.237	0.082	*	0.020
Amphipoda	14	15	3.318	1.229	0.017	4.133
Gammaridea	18	24	4.265	1.966	0.028	8.503
Ampelisca sp.	7	9	1.659	0.737	0.010	1.240
Dexamine sp.	1	1	0.237	0.082	*	0.020
Dexamine spiniventris	21	26	4.976	2.129	0.030	10.747
Iphimedia vicina Ruffo & Schiecke, 1979	2	3	0.474	0.246	*	0.118
Lembos sp.	2	2	0.474	0.164	*	0.079
Leucothoe sp.	9	9	2.133	0.737	0.012	1.598
Caprellidae						
Phtysica marina Slabber, 1769	4	4	0.948	0.328	*	0.311
Mysidacea	5	6	1.185	0.491	*	0.586
Anchialina agilis	5	5	1.185	0.410	*	0.488
Gastrosaccus normani	13	16	3.081	1.310	*	4.062
Leptomysis gracilis (G.O. Sars), 1864	6	9	1.422	0.737	0.012	1.065
Leptomysis lingvura (G.O. Sars), 1866	1	1	0.237	0.082	*	0.020
Leptomysis mediterranea	7	10	1.659	0.819	0.014	1.381
Parapseudomma calloplura (Holt & Tattersall, 1905)	1	1	0.237	0.082	*	0.020
Siriella sp.	5	6	1.185	0.491	0.012	0.596
Siriella clausii G.O. Sars, 1876	1	2	0.237	0.164	*	0.040
Stomatopoda						
Pseudosquillopsis ceresii	2	2	0.474	0.164	5.876	2.863
Decapoda						
Natantia	8	8	1.896	0.655	0.326	1.861
Alpheus dentipes	10	11	2.370	0.901	0.661	3.700
Alpheus glaber	36	37	8.531	3.030	2.162	44.296
Alpheus macrocheles (Hailstone, 1835)	2	2	0.474	0.164	0.120	0.135
Athanas nitescens	18	19	4.265	1.556	0.207	7.519
Chlorotocus crassicornis (Costa, 1871)	3	3	0.711	0.246	0.844	0.774
Hippolyte sp.	7	10	1.659	0.819	0.032	1.412
Pandalina brevirostris (Rathke, 1843)	1	1	0.237	0.082	0.013	0.022
Processa sp.	22	28	5.213	2.293	1.403	19.267
Processa canaliculata	18	24	4.265	1.966	1.267	13.790

Food items	n	p	F(%)	Cn(%)	Cw(%)	IRI
Processa edulis (Risso, 1816)	10	12	2.370	0.983	0.582	3.709
Processa mediterranea	34	97	8.057	7.944	5.277	106.525
Processa parva Holthuis, 1951	20	34	4.739	2.785	1.737	21.428
Sicyonia carinata	20	21	4.739	1.720	1.154	13.620
Thoralus cranchii	37	61	8.768	4.996	0.148	45.098
Thoralus sollaudi	7	13	1.659	1.065	0.082	1.903
Crangonidae	1	1	0.237	0.082	*	0.020
Philocheras bispinosus (Hailstone, 1835)	3	3	0.711	0.246	0.013	0.184
Philocheras monacanthus	15	29	3.555	2.375	0.123	8.880
Pontocaris cataphracta (Olivi, 1792)	2	2	0.474	0.164	0.105	0.128
Pontocaris lacazei (Gourret, 1887)	7	9	1.659	0.737	2.000	4.540
Reptantia	1	1	0.237	0.082	0.201	0.067
Dardanus arrosor (Herbst, 1796)	1	1	0.237	0.082	0.098	0.043
Galathea intermedia Lilljeborg, 1851	4	4	0.948	0.328	0.110	0.415
Pisidia longimana	91	217	21.564	17.772	6.014	512.920
Scyllarus pygmaeus (Bate, 1888)	2	2	0.474	0.164	0.388	0.261
Upogebia deltaura	4	4	0.948	0.328	0.266	0.562
Upogebia littoralis (Risso, 1816)	1	1	0.237	0.082	0.120	0.048
Brachyura	7	7	1.659	0.573	1.446	3.350
Acanthonyx lunulatus (Risso, 1816)	2	2	0.474	0.164	0.136	0.142
Achaeus cranchii Leach, 1817	3	6	0.711	0.491	0.033	0.373
Achaeus gracilis	19	22	4.502	1.802	0.129	8.694
Atelecyclus rotundatus (Olivi, 1792)	2	2	0.474	0.164	0.121	0.135
Ebalia sp.	5	5	1.185	0.410	0.203	0.725
Eurynome aspera	7	11	1.659	0.901	0.013	1.516
Eurynome spinosa Hailstone, 1835	5	5	1.185	0.410	0.375	0.743
Ethusa mascarone	5	6	1.185	0.491	0.348	0.994
Goneplax rhomboides	10	10	2.370	0.819	2.215	7.189
Ilia nucleus	19	19	4.502	1.556	3.585	23.146
Inachus communissimus Rizza, 1839	4	5	0.948	0.410	0.273	0.647
Inachus dorsettensis (Pennant, 1777)	4	5	0.948	0.410	0.282	0.656
Inachus phalangium	8	10	1.896	0.819	0.780	3.032
Inachus thoracicus	2	3	0.474	0.246	0.169	0.197
Liocarcinus sp.	5	7	1.185	0.573	1.301	2.221
Liocarcinus arcuatus (Leach, 1814)	3	5	0.711	0.410	0.801	0.861
Liocarcinus corrugatus	2	2	0.474	0.164	0.413	0.273
Liocarcinus depurator	12	16	2.844	1.310	3.070	12.456
Liocarcinus zariquieyi (Gordon, 1968)	3	3	0.711	0.246	0.527	0.549
Macropodia deflexa	1	1	0.237	0.082	*	0.021
Macropodia longipes (A. Milne Edwards & Bouvier, 1899)	9	10	2.133	0.819	0.487	2.786
Macropodia longirostris (Fabricius, 1775)	3	4	0.711	0.328	0.232	0.398
Macropodia rostrata	23	35	5.450	2.867	2.274	28.017
Parthenope massena	11	11	2.607	0.901	0.837	4.529
Pirimela denticulata (Montagu, 1808)	4	4	0.948	0.328	0.634	0.911
Xanthidae						
Pilumnus sp.	3	3	0.711	0.246	1.169	1.005
Pilumnus hirtellus	43	53	10.190	4.341	14.156	188.472
Pilumnus spinifer	15	15	3.555	1.229	1.496	9.683
Xantho pilipes	5	5	1.185	0.410	1.584	2.362
Xantho poressa	2	2	0.474	0.164	0.618	0.370
Ascidacea						
Styelidae	1	1	0.237	0.082	1.037	0.265
Teleostei	13	13	3.081	1.065	1.081	6.609
Gobiidae	2	2	0.474	0.164	1.221	0.657
Gobius niger Linnaeus, 1758	1	1	0.237	0.082	0.571	0.155
Vegetal remains	4	4	0.948	0.328	0.097	0.402