Coenoses 8(2):85-95, 1993

THE USE OF FEEDING INDICES FOR THE STUDY OF FOOD WEBS: AN APPLICATION TO A *POSIDONIA OCEANICA* ECOSYSTEM

V. Zupo

Stazione Zoologica di Napoli, Laboratorio di Ecologia del Benthos, Punta S. Pietro. I-80077, Ischia, Italy

Keywords: Food preferences, Gut contents, Multivariate analysis, Trophic groups.

Abstract. I propose the use of new feeding indices, to classify species in homogeneous trophic groups. To illustrate the approach I examined macrozoobenthic species sampled in *Posidonia oceanica* meadows off the Island of Ischia (Mediterranean Sea, Gulf of Naples).

Introduction

The study of the food web of a complex system, such as a *Posidonia oceanica* bed, involves many aspects. A crucial point is to understand the role of each species in the web (Ledoyer 1962); this is done by means of direct methods: analysis of gut contents, food preference studies, etc., or indirect methods: trophic groups' analysis (Gambi *et al.,* in press; Russo 1989, Fauchauld and Jumars 1979, Purchon 1977).

Size and type (plant or animal) of preys are two important aspects for the interpretation of diet pattern (Fauchald and Jumars 1979). When multivariate analysis is applied to "gut content-species" matrices, the ordination of species in the space of the first significant axes reflects mainly the size and type (plant or animal) of preys (Chessa *et al.* 1983; Zupo and Fresi 1984).

I propose trophic data be treated via a mathematical approach to study trophic data not only on the basis of multivariate methods, but also by means of two new indices that characterize species according to their feeding behaviour as defined by gut contents.

Materials and methods

a) Study area and data collection

The community data derived from samples collected on *Posidonia oceanica* beds around the Island of Ischia (Figure 1), where the meadows form a continuous belt from depths of 1 to about 33 m (Colantoni *et al.* 1982). Twelve samples were collected by means of a bottom trawl with a 4 cm mesh, in 12 random points of the meadow. Six samples (1 to 6) were collected in winter, the others (7 to 12) in summer (see Figure 1). All specimens of each sample were deep frozen to prevent digestion of the ingested preys, then fixed in 70 % alcohol, identified at species level (Table 1a) and dissected for the analysis of the gut content. Species were only considered if more than 5 individuals were sampled.

Gut contents were classified in 25 categories ("food items") and the average gut content of each species was computed according to abundance, on the basis of an arbitrary code, ranging from 0 to 3. This produced a matrix of 77 species (consumers) and 25 food items (Table 1b).

b) Statistical analysis

The data matrix was analyzed by means of correspondence analysis (Legendre and Legendre 1984, Chessa *et al.* 1983), and by clustering techniques. Average linkage (Orlóci 1978) was applied to the correlation matrix between food items, to obtain food items' groups, while the sum of squares was applied to the distance matrix between consumers, to obtain trophic groups of species (Feoli and Feoli-Chiapella 1979). The analysis of redundancy and specific variance (Orlóci 1973) was done for food items in order to weigh their importance in the data structure. This should also reflect their importance in the food web: if a food item has high redundancy it means that it is common in the diet of the considered species; if a food item has high specific variance it is independent from other preys.

The indices proposed, to order the species on the basis of prey-type and prey-size, respectively, are obtained from the following formulae:

Prey type index:

$$T_i = (\sum V_i - \sum C_i) / \sum M_{ij}$$

Prey size index:

$$S_i = \ln (\sum (PS_j \times M_{ij}) / \sum M_{ij})$$

where:

V_i = abundance (or frequency) of vegetal items;

C_i = abundance (or frequency) of animal items;

Table 1a. Species analysed.

N.	Species	N.	Species
	POLYCHAETA		DECAPODA
1)	Ditrupa arietina	34)	Anapagurus sp.
2)	Eunice pennata	35)	Clibanarius erythropus
3)	Hermonia hystrix	36)	Dorippe lanata
4)	Hyalinoecia tubicola	37)	Ethusa mascarone
5)	Lumbrinereis latreilli	38)	Eurynome aspera
6)	Notomastus sp.	39)	Inachus communissimus
7)	Pomatoceros triqueter	40)	Inachus dorsettensis
8)	Sabella fabrici	41)	Inachus phalangium
9)	Serpula vermicularis	42)	Inachus toracichus
10)	Spirographis spallanzani	43)	Palaemon xiphias
	MOLLUSCA	44)	Macropodia rostrata
11)	Aequipecten opercularis	45)	Maya verrucosa
12)	Anomia ephippium	46)	Paguristes oculatus
13)	Tellina balaustina	47)	Pagurus alatus
14)	Calliostoma granulatum	48)	Pagurus prideauxi
15)	Calyptrea chinensis	49)	Parthenope massena
16)	Glans trapetia	50)	Processa macrophtalma
17)	Chlamys varia		ECHINODERMATA
18)	Corbula gibba	51)	Amphiura chiaiei
19)	Cymatium corrugatum	52)	Antedon mediterranea
20)	Dentalium dentalis	53)	Astropecten irregularis
21)	Fusinus syracusanus	54)	Echinaster sepositus
22)	Gibbula ardens	55)	Echinocardium mortenseni
23)	Jujubinus exasperatus	56)	Hacelia attenuata
24)	Jujubinus striatus	57)	Holothuria tubulosa
25)	Bolinus brandaris	58)	Luidia ciliaris
26)	Plagiocardium papillosum	59)	Ophioderma longicaudum
27)	Rissoa violacea	60)	Ophiomixa pentagona
28)	Tricholia pullus	61)	Ophiotrix fragilis
29)	Tricholia speciosa	62)	Ophiotrix quinquemaculata
30)	Phyllonotus trunculus	63)	Ophiura texturata
31)	Venericardia antiquata	64)	Paracentrotus lividus
	ISOPODA - AMPHIPODA	65)	Psammechinus microtuberc.
32)	Cymodoce truncata	66)	Sphaerechinus granularis
33)	Ichnopus taurus		TUNICATA
		67)	Alocynthia papillosa
			PISCES
		68)	Arnoglussus imperialis
		69)	Hippocampus ippocampus
		70)	Hippocampus guttulatus
		71)	Labrus bimaculatus
		72)	Lepadogaster candollei
		73)	Scorpaena porcus
		74)	Scorpaena scrofa
		75)	Serranellus hepatus
		76)	Symphodus rostratus

Table 1b. Food items identified in the gut contents.

N.	ITEM
1)	Green Posidonia tissues
2)	Brown Posidonia tissues
3)	Macrophytes
4)	Diatoms
5)	Dinoflagellates
6)	Radiolarians
7)	Coccolithophorids
8)	Foraminiferids
9)	Organic detritus
10)	Bryozoans
11)	Spongias
12)	Nematodes
13)	Sedentarian polychaetes
14)	Errantia polychaetes
15)	Bivalves
16)	Gastropods
17)	Halacarids
18)	Copepods
19)	Isopods
20)	Amphipods
21)	Reptantia decapods
22)	Natantia decapods
23)	Other crustaceans
24)	Holothuroids
25)	Other echinoderms

M_{ij} = abundance (or frequency) of each considered item;
PS_j = mean prey size (measured in mm or mg);

The first index (T) defines prey type (plant or animal) and varies between -1 and 1: negative values identify carnivorous species, values close to 0 are typical of omnivores and positive values indicate plant feeding species. The second index (S) depends on prey size and has no limits; it is 0 when the mean prey size equals 1 mm, representing the limit between micro- and macrobenthos (McIntyre *et al.* 1984). Natural logarithm is used to discriminate microphages from others: since their preys are, on an average, smaller than 1 mm, the S index is negative.

As shown in Figure 2, in plots representing the ordination of species based on the two indices, it can be predicted that "omnivorous-detritus feeders" species,

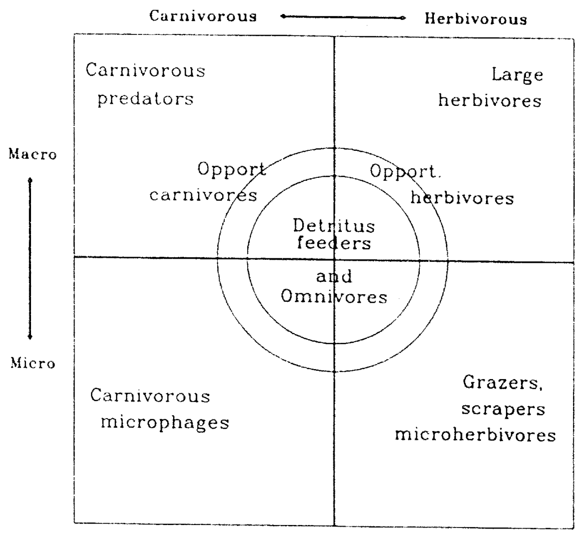

Figure 2. Predictive model of trophic groups in the plane described by T and S indices. Detritus feeder species that use both animal and vegetal preys of different size, will be ordered in the center; large herbivores will be in the first quadrant (large plant materials); carnivorous predators in the second (large animal preys); micro-carnivores in the third (small animal preys); micro-herbivores (as grazers) will be confined to the fourth quadrant (small plant materials).

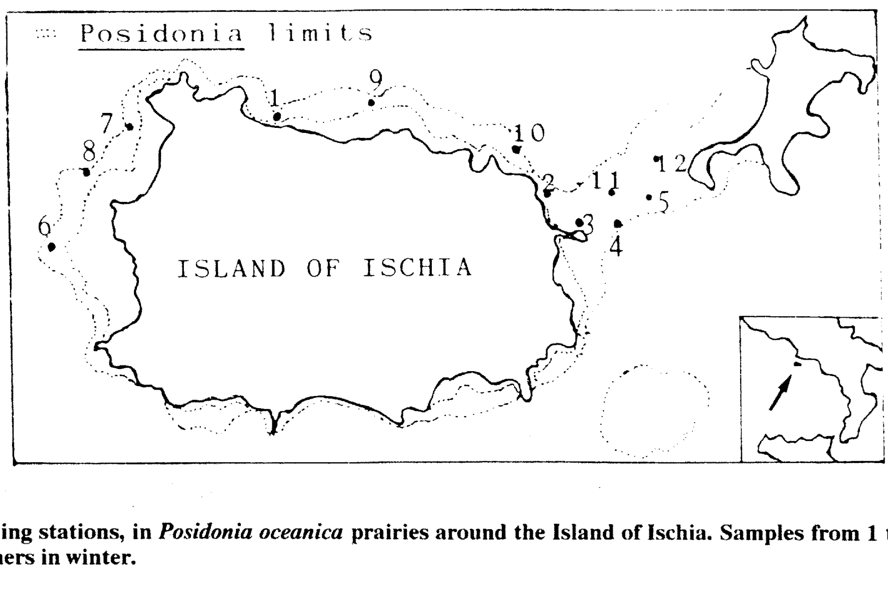

Figure 1. Sampling stations, in *Posidonia oceanica* prairies around the Island of Ischia. Samples from 1 to 6 were taken in summer, the others in winter.

that use both animal and vegetal preys of various sizes, will occupy a central position, while carnivorous predators (large animal preys) will be confined to the second quadrant, carnivorous microphagous (small animal preys) to the third, grazers, scrapers etc. (small plant foods) in the fourth, and large herbivores (large plant foods) in the first.

Differences in the indices obtained for a species, examined in space or time scale, can show adaptations to environmental conditions.

Ellipses of equal concentration (Lagonegro and Feoli 1985) based on the trophic groups revealed by the cluster analysis, were superimposed both on the ordination given by the two T and S indices and on that obtained by correspondence analysis.

Canonical correlation analysis was applied to correlate the first two axes obtained by correspondence analysis to the T and S indices, to verify the correlation of the two variable sets. Concentration analysis was applied to the "species-food items" matrix, after restructuration on the basis of the cluster analysis (applied to the food items and to the T and S indices), to define homogeneous trophic groups by means of the new indices. Trophic groups obtained by means of T and S indices were then used to analyze the food web of the *P. oceanica* prairies under study and to obtain a seasonal model.

Results

a) Ecological observations

A total of 841 specimens belonging to 76 species were collected (Table 1a). The population is dominated by echinoderms (39 %), decapod crustaceans (27 %) and molluscs (22 %). Other taxa (polychaetes, amphipods, tunicates and fishes) accounted only for 12 % of the total number of individuals. Species of both the foliar stratum and rhizome layer were found in all samples.

Gut contents were grouped in 25 food items, as shown in Table 1b. All the considered food items have a shared variance higher than 0.1; plant items show the highest specific variance and redundancy. The highest values of redundancy and specific variance are shown by *Posidonia* detritus, micro- and macro-Epiphytes (Dia, Mac) and Crustaceans, which can be considered the main pathways of energy transfer in the system (Figure 3).

As shown in Figure 4, cluster analysis, applied to the gut contents, distinguished two main groups of food items: the first consisting of plants and associated epibiontic community (green and brown *Posidonia* tissues, macroalgae, diatoms, sponges, radiolarians, foraminiferids, etc.), and the second represented principally by secondary producers (polychaetes, crustaceans, echinoderms, fishes). Within the first cluster, plants by epiphytes are broken down further.

Cluster analysis applied to consumer species (Figure 5) defines three main trophic groups: the first contains herbivore species, the second mainly fishes and other macro-carnivores, the third mainly detritus feeders and omnivores.

The results of correspondence analysis applied to the "species-food items" matrix are shown in Figure 6. Three clusters were identified, and they corresponded to the main trophic groups derived by the cluster

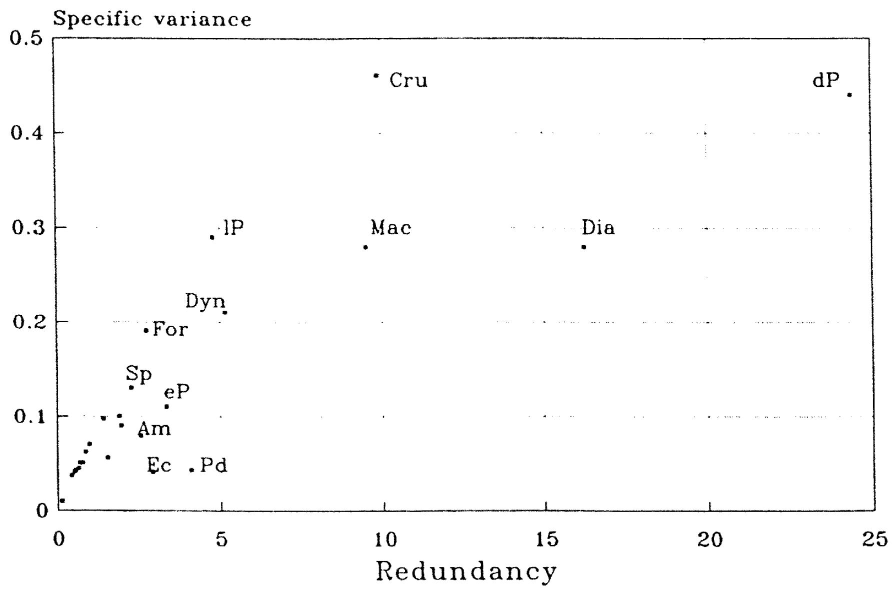

Figure 3. Main food items found in the gut contents, ordered by means of Redundancy and Specific variance. dP = brown *Posidonia;* Dia = Diatoms; Cru = Crustaceans; Mac = Macrophytes; 1P = green *Posidonia*; Dyn = Dynophlagellates; For = Foraminifera; Sp = Sponges; eP = errantia Polychaetes; Am = Amphypods; Ec = Echinoderms; Pd = *Posidonia* detritus.

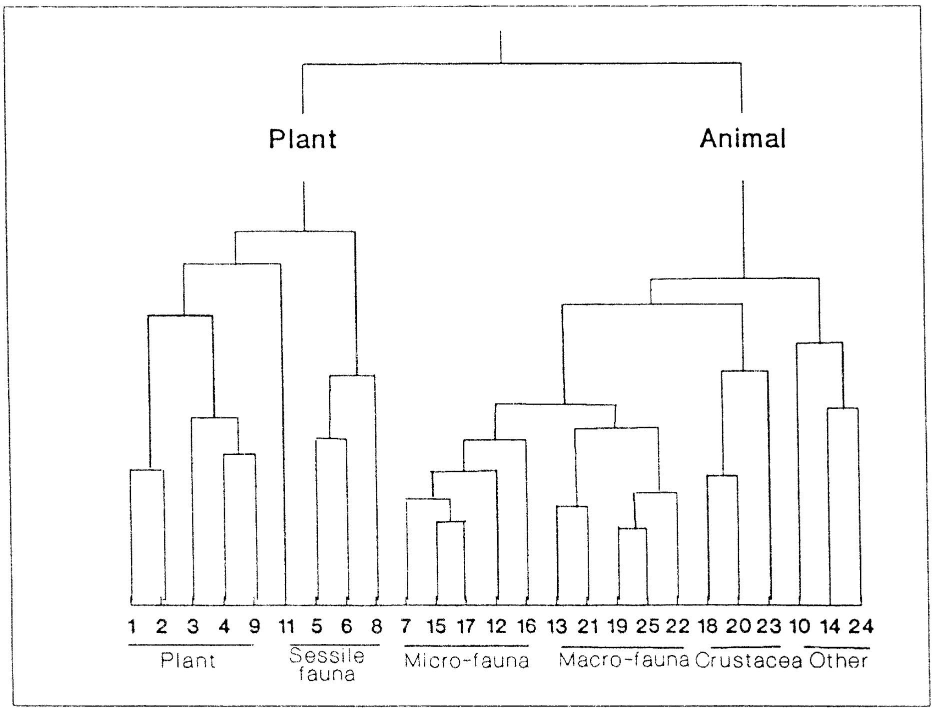

Figure 4. Dendrogram of food items obtained by hierarchical classification of food items, by average linkage clustering applied to the correlation matrix. See Table 1b for identification of food items number.

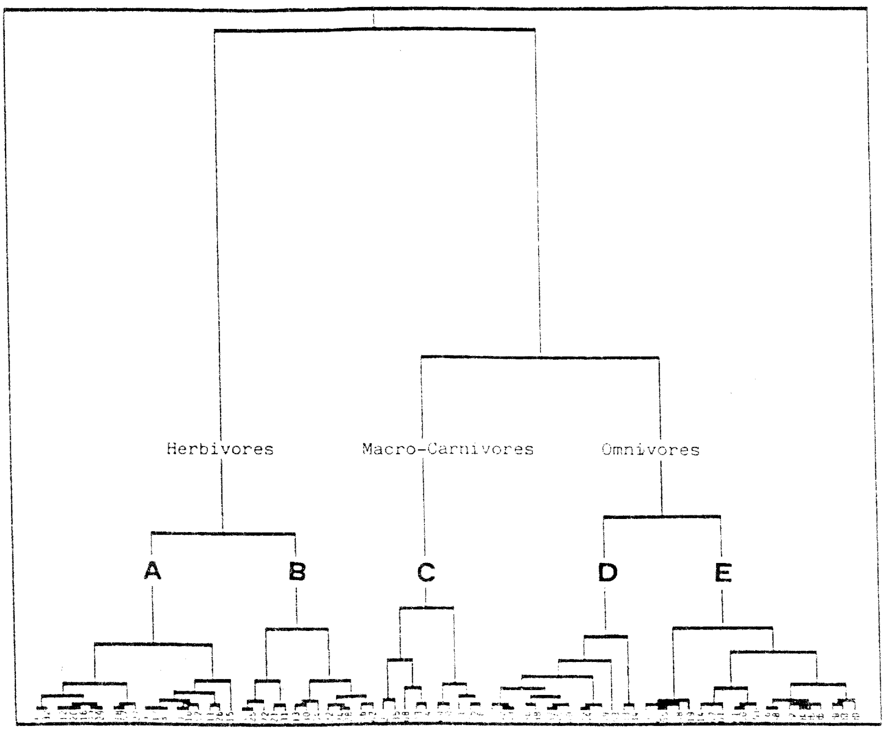

Figure 5. Dendrogram of the species grouped by the sum of squars clustering based on geodesic distance. Numbers refer to species indicated in Table 1a. A = herbivores; B = microherbivores; C = omnivores and detritus feeders; D = Carnivores; E = opportunistic herbivores.

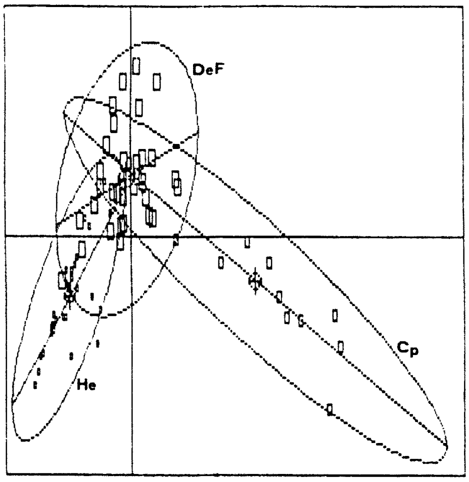

Figure 6. Ordination of the species obtained by the correspondence analysis performed on the "species-food items" matrix. Ellipses of equal concentration are superimposed. He = herbivores; Cp = carnivores; DeF = detritus feeders and omnivores.

analysis. Moreover, ellipses of equal concentration were superimposed on these groups. Data were mainly ordered, on the first axis, on the basis of the prey type (plant or animal) and, on the second, on the basis of prey size.

b) Indices

T and S indices were calculated for each species (see Table 2). The ordination given by the S and T indices (represented, respectively, on the axes 1 and 2) is shown in Figure 7. Ellipses of equal concentration based on the three main trophic groups were superimposed also in this case. The distance between the centroids of ellipses is significant with both procedures, although some groups seem to overlap. Cluster "He" contains most of the micro-herbivores species sampled, while cluster "Cp" contains large predators and "DeF" the detritivorous species, according to the predictive model reported in Figure 2. Also the pattern of clusters is similar in the representations obtained with the correspondence analysis and with the feeding indices, with the cluster "DeF" partially overlapping "He" and "Cp".

Canonical correlation analysis showed that 84.78% of variance is common between the two first axes obtained by the correspondence analysis and the T and S axes. According to the Bartlett (1974) test, the H_o hypothesis (independence between the two types of representation) can be rejected at p=.01.

The concentration analysis applied to the "trophic groups-food items" matrix (Figure 8) shows the correspondence between food items and the trophic groups identified by the T and S indices: carnivores are segregated in the cluster containing large vagile organisms and Crustaceans; omnivores and opportunistic herbivores are related to small vagile organisms, plant materials and other animal preys; mesograzers and microherbivores are found in the second and third quadrant, in relation to plant matter and epiphytes.

The numerical limits of the T and S indices that define the trophic groups obtained by this analysis can then be used to define trophic groups in the T, S plane. When we plot the areas defined by these limits on a cartesian system (Figure 9) we can verify the corresponedence with the previsional model shown in Figure 2. We therefore suggest that the limits reported in Figure 10 can be used to define trophic groups of species on the basis of the proposed feeding indices (Table 2).

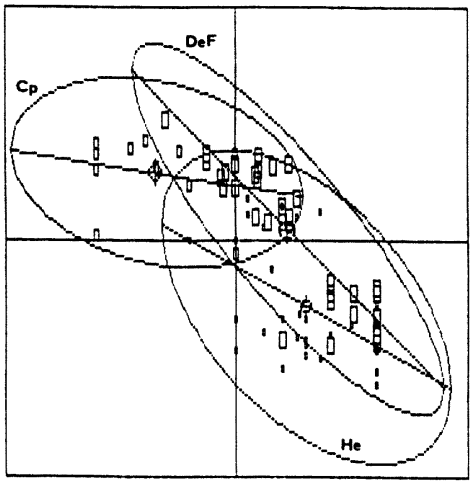

Figure 7. Ordination of the species in the T (type) and S (size) plane. Ellipses of equal concentration are superimposed. He = herbivore; Cp = carnivores; DeF = detritus feeders and omnivores.

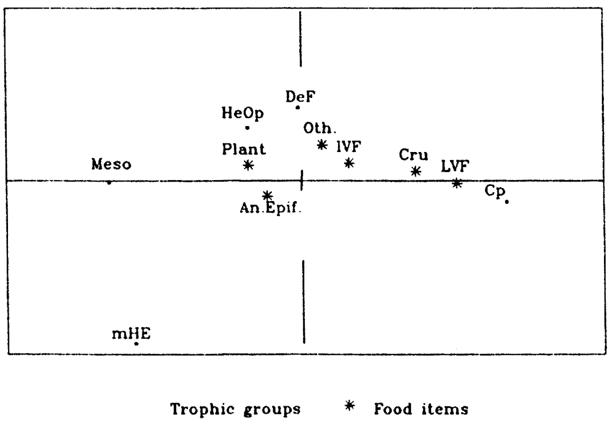

Figure 8. Concentration analysis of the "trophic groups-food items" matrix. mHe = micro-herbivores; Meso = mesograzers; HeOp = opportunistic herbivores; DeF = detritus feeders and omnivores; Cp = carnivores; Plant = plant materials; 1VF = small vagile fauna; LVF = large vagile fauna; Cru = crustaceans; AnEpif = animal epiphytes; Oth = other animals (holothuroids, bryozoans, etc.).

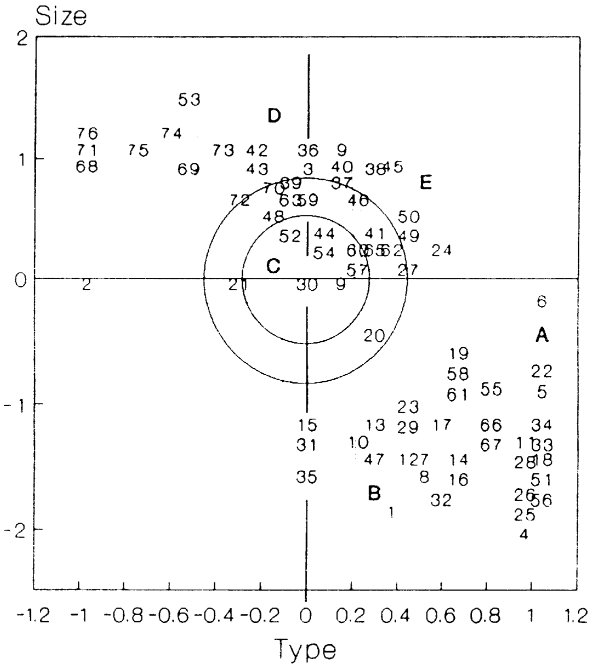

Figure 9. Ordination of species by the T and S indices. The boxed areas represent the groups defined by cluster analysis (A = herbivore; B = micro-herbivores; C = omnivores; D = carnivores; E = opportunistic herbivores). circles represent the limits proposed to define trophic groups.

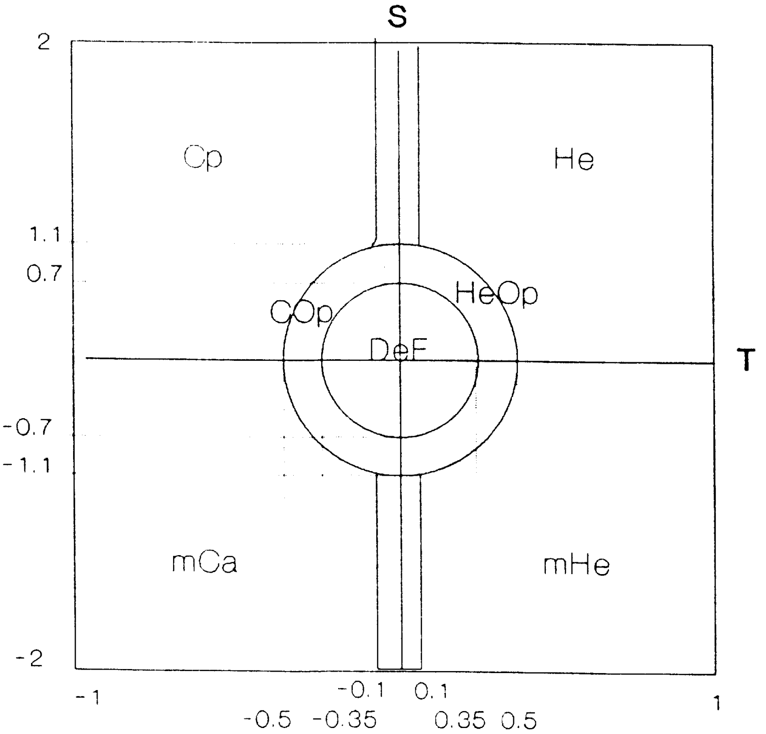

Figure 10. Proposed limits for the T and S indices characterizing each trophic group (abbreviations as in Table 2).

Table 2. Species ordered in trophic groups by means of T (type) and S (size) indices. COp = opportunistic carnivores; CP = macrophage carnivores; DeF = omnivores and detritus feeders; HeOp = opportunistic herbivores; mHe = micro-herbivores.

n.	SPECIES	T	S	Group	n.	SPECIES	T	S	Group
36)	Dorippe lanata	0	1,08	COp	50)	Processa macrophtalma	0,43	0,58	HeOp
48)	Pagurus prideauxi	-0,1	0,88	Cop	15)	Caliptrea chinensis	0	-1,1	HeOp
43)	Palaemon xiphias	-0,2	1,1	COp	49)	Parthenope massena	0,43	0,58	HeOp
63)	Ophiura texturata	-0,08	0,72	Cop	46)	Paguristes oculatus	0,16	0,83	HeOp
39)	Inachus communissimus	-0,07	0,96	COp	35)	Clibanarius erythropus	0	-0,16	HeOp
72)	Lepadogaster candollei	-0,33	0,78	COp	47)	Pagurus alatus	0,33	-1,36	mHe
70)	Hippocampus guttulatus	-0,11	0,92	COp	55)	Echinocardium mortenseni	0,83	-0,71	mHe
69)	Hippocampus hippocampus	-0,56	1,03	CP	51)	Amphiura chiaiei	1	-1,3	mHe
73)	Scorpaena porcus	-0,4	1,26	CP	4)	Hyalinoecia tubicola	1	-2	mHe
74)	Scorpaena scrofa	-0,64	1,39	CP	18)	Corbula gibba	1	-1,15	mHe
71)	Labrus bimaculatus	-1	1,37	CP	17)	Chlamys varia	0,5	-1,36	mHe
2)	Eunice pennata	-1	0,08	CP	13)	Tellina balaustina	0,33	-1,08	mHe
68)	Arnoglossus imperialis	-1	1	CP	10)	Spirographis spallanzani	0,2	-1,27	mHe
42)	Inachus toracichus	-0,2	1,2	CP	11)	Aequipecten opercularis	1	-1,12	mHe
75)	Serranellus hepatus	-0,75	1,29	CP	67)	Alocynthia papillosa	0,82	-1,16	mHe
76)	Symphodus rostratus	-1	1,2	CP	26)	Plagiocardium papillosum	1	-1,82	mHe
53)	Astropecten irregularis	-0,5	1,67	CP	58)	Luidia ciliaris	0,67	-0,71	mHe
3)	Hermonia hystrix	0	1,2	CP	24)	Jujubinus striatus	0,6	-0,41	mHe
65)	Psammechinus microtuberc.	0,38	0,35	DeF	28)	Tricholia pullus	1	-1,12	mHe
30)	Phyllonotus trunculus	0	0	DeF	66)	Sphaerechinus granularis	0,83	-1,01	mHe
21)	Fusinus syracusanus	-0,33	0,01	DeF	34)	Anapagurus sp.	1	-1,06	mHe
62)	Ophiotrix quinquemaculata	0,33	0,48	DeF	7)	Pomatoceros triqueter	0,5	-1,44	mHe
44)	Macropodia rostrata	0,14	0,9	DeF	23)	Jujubinus exasperatus	0,45	-1	mHe
60)	Ophiomixa pentagona	0,14	0,33	DeF	19)	Cymatium corrugatum	0,67	-0,57	mHe
59)	Ophioderma longicaudum	0	0,75	DeF	5)	Lumbrinereis latreilli	1	-0,64	mHe
52)	Antedon mediterranea	-0,09	0,58	DeF	56)	Hacelia attenuata	1	-1,52	mHe
57)	Holothuria tubulosa	0,23	0,28	DeF	8)	Sabella fabrici	0,33	-1,78	mHe
41)	Inachus phalangium	0,33	0,48	DeF	25)	Bolinus brandaris	1	-2	mHe
9)	Serpula vermicularis	0,2	0,19	DeF	6)	Notomastus sp.	1	-0,72	mHe
54)	Echinaster sepositus	0,09	0,38	DeF	61)	Ophiotrix fragilis	0,67	-0,83	mHe
64)	Paracentrotus lividus	0,33	0,37	DeF	12)	Anomia ephippium	0,43	-1,33	mHe
20)	Dentalium dentalis	0,25	-0,38	DeF	29)	Tricholia speciosa	0,5	-1,1	mHe
40)	Inachus dorsettensis	0,17	1,16	HeOp	16)	Glans trapetia	0,67	-1,3	mHe
37)	Ethusa mascarone	0,17	1	HeOp	32)	Cymodoce truncata	0,6	-1,62	mHe
38)	Eurynome aspera	0,27	1,04	HeOp	33)	Ichnopus taurus	1	-1,4	mHe
31)	Venericardia antiquata	0	-1,52	HeOp	22)	Gibbula ardens	1	-0,87	mHe
45)	Maya verrucosa	0,38	1,08	HeOp	14)	Calliostoma granulatum	0,67	-1,46	mHe
27)	Rissoa violacea	0,43	0,34	HeOp	1)	Ditrupa arietina	0,5	-1,6	mHe

c) Analysis of the Posidonia ecosystem

Figure 11 (A and B) shows the results of a trophic analysis of the system (by P. C. A.) performed on the trophic groups defined as described above on the "stations vs trophic groups" matrix. We observe (Figure 11A) that micro-herbivore species (mHe) are well defined, due to their numerical abundance, while carnivorous predators (CP) are close to such "euryphagous" species as opportunistic (COp, HeOp) and detritus feeder (DeF) organisms. The ordination of the station points (Figure 11B) clearly separates the stations around "Punta Caruso" from those around "Punta Castello" along F2, while stations 1, 2 and 3 are clearly separated from the others along F1. The food web of the "Castello" area is based mainly on detritus feeders, while that of "Punta Caruso" is characterized by a higher abundance of micro-herbivores. The stations at the lower limit are characterized by a high number of individuals. The composition of the feeding groups pf each station is variable, being related to such environmental conditions as depth and structural characteristics of the meadow, although summer samples are characterized by a high abundance of micro-herbivore species (Figure 12), and detritus feeders are more abundant in winter samples. Herbivore-opportunistic species are abundant throughout the year, while carnivore-opportunistic species are more abundant in winter months.

Discussion

Cluster analysis (Figure 4) clearly shows the main criteria of food selection: the main clusters indicate that species choose their foods principally on the basis of type ("plant related" or "animal"), while sub-clusters give a size discrimination. This analysis also shows a link between of *Posidonia* epiphytes and the plant tissues. This is probably because most part of the macrozoobenthic species considered in this study can eat brown *Posidonia* tissues, but they do not select plant materials from the associated epiphytic community. There is clearly an absence of herbivore utilizing plant tissues directly: large amounts of *Posidonia* biomass flow in the food web through the detritus chain, consisting of several "opportunistic-detritus feeder" species (Figure 9). The high specific variance and redundancy of plant items (Figure 3) confirm the importance of primary production (mainly *Posidonia* detritus and plant epiphytes) in the food web and shows that detritus chain and grazing activity are the main pathways of energy transfer to the secondary production.

The three groups identified in Figure 7 are well defined. Carnivore predators, including many fishes,

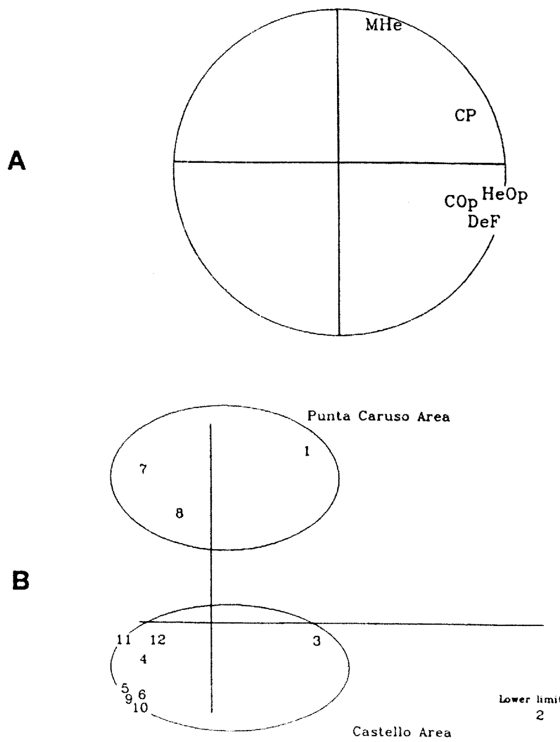

Figure 11. Principal component ordination of the "stations-trophic groups" matrix, after the definition of groups by means of the T and S indices. A: Trophic groups ordination (MHe = micro-herbivores; CP = carnivores; COP = opportunistic carnivores; HeOp = opportunistic herbivores; DeF = detritus feeders and omnivores); B: station ordination.

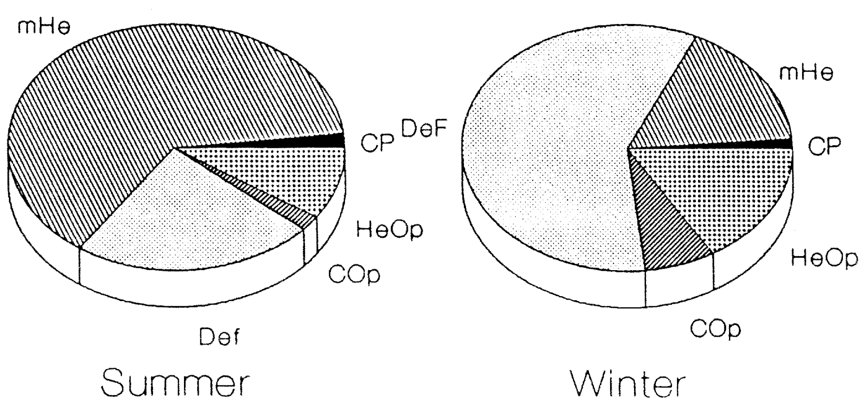

Figure 12. Trophic composition in summer and winter by summing data from all the stations. Abbreviations as in Table 2.

are present in the second quadrant; grazers, such as many species of molluscs, are in the fourth quadrant, close to some filter feeders and other micro-herbivore species; such detritus feeders as *Holothuria tubulosa* occupy a central position, as expected by the previsional model of Figure 2. Macro-herbivores and micro-carnivores are absent: according to the previsional model of Figure 2, these would be ordered, respectively, in the distal portions of the first and third quadrant.

By using the ellipses of equal concentration we also observe a high correspondence between the clusters obtained by correspondence analysis (Fig, 6) and those deriving from the scatterplot of the two indices (Figure 7), so that the two representations provide a single model of the meadow, in which the importance of grazers and detritus feeders is assessed (Figure 9). Also Canonical Correlation analysis shows high correlation between the two different representations.

In the PCA. of the "stations-groups" matrix, the split along F2 (Figure 11b) can be due to the less developed leaf canopy that characterizes the meadows around Punta Caruso (in the eastern region of the island). In this area the meadows grow on rocky bottoms interrupted by patches of *Cymodocea nodosa*, rocks, and sandy sediments. This meadow is less extended and more exposed to external influences. Meadows in the second group (in the western region of the island) are larger, continuous, and characterized by a higher leaf canopy and density (Colantoni *et al.,* 1982; Giraud *et al.,* 1979).

Probably because of these differences, the stations of "Punta Caruso" are characterized by a higher number of microherbivore and a lower number of detritus feeders with respect to those of "Castello" area. In fact, in a less dense prairie, the litter accumulation can be at a lower scale, due to the continuous export of detritus by the currents. The separation of stations 1, 2 and 3 from the other stations, along F1, is probably due to the fact that samples were collected along the internal limit of the prairie.

The comparison of summer and winter samples, to study the seasonal trophic dynamics of the system, shows adaptations of the animal community to the different environmental conditions (Figure 12). In particular, the higher abundance of micro-herbivore (mHe) species in summer samples can be related to the plant growth and to the development of the epiphytic community, while the abundance of detritus feeders (DeF) in winter can be due to a higher litter biomass.

Conclusions

The main factors governing many trophic systems are prey type (plant or animal) and size. Utilizing two feeding indices it is possible to define each species on the basis of feeding behaviour, and to classify species in trophic groups, which can be utilized for further analysis.

The trophic indices described in the present study can be used to compare data resulting from different investigations and to define differences observed in the feeding behaviour of a species studied under temporal or spatial scales.

By means of homogeneous trophic groups based on T and S indices, it was shown that the food web of *Posidonia oceanica* is highly influenced by the presence of micro-herbivores and detritus feeder species, and plant materials seem to flow into the web mainly through these channels, due to the relative absence of pure macro-herbivores.

The abundance of litter can modify the structure of food webs of meadows that are differently exposed, thereby influencing the abundance and composition of the important "detritus chain" (Velimirov *et al.,* 1981; Ott and Maurer 1977). The trophic groups assemblage varies according to the structural characters of the meadows, such as exposure, density of the beds, etc. This phenomenon is even more obvious when different areas of the same bed are considered. In fact, the internal limit zones are characterized by a higher density of "detritus feeders" and of "opportunistic carnivores".

The number of microherbivores is higher in summer, while in winter there is an increase of detritus feeders. This result can be attributed to a higher amount of litter in winter months and to a more developed epiphytic layer in summer months.

The data reported here are preliminary and further studies are needed to understand better the results described. However, the findings confirm that the proposed indices can be useful to standardize feeding groups; in addition they can be utilized for statistical analysis, they allow comparisons of results by different authors, and contribute to our understanding of the complex systems food webs.

Acknowledgements. I am grateful to L. Mazzella, M. B. Scipione, M. C. Gambi, G. F. Russo and M. Lorenti of the Benthos Laboratory of Stazione Zoologica "A. Dohrn" for help in the classification of species, and fragments in the gut contents. I am indebted to Prof. E. Feoli, of Trieste University, for the accurate, critical revision of the manuscript, and the data analysis suggestions, although I am responsible for the use made of statistical procedures. Data were analyzed by means of a computer program package by Lagonegro and Feoli (1985b).

This work is supported by an E. E. C. fellowship, Environmental Programme (ref. EV-4V-0139-B) and by STEP-0063-C contract.

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Manuscript received: April 1993