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Feeding Habit of *Semicossyphus maculatus* (Labridae) in Coastal Waters of Iquique in Northern Chile

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Abstract The dietary composition of *Semicossyphus maculatus* in the littoral zone of three localities in northern Chile, Huayquique, Playa Blanca, and Los Verdes, was studied. The diet of this species did not vary by localities, and no significant differences in food were observed between two size groups and between sexes. The guts of specimens captured at depths from 1 m to 15 m usually contained mobile and sessile benthic organisms, principally Bivalvia, Gastropoda, Decapoda (Crustacea), and Cirripedia. Based on the present evidence the feeding pattern of this species is discussed.

Little attention has been given to the feeding habits of the littoral fishes in northern Chile. With the exception of studies on *Hippoglossina macrops* Steindachner (Bahamonde, 1954; Tomicic, 1973; Yani et al., 1977), *Trachurus murphy* Nichols (Rosario, 1970), *Graus nigra* Philippi (Moreno, 1972), *Sicyases sanguineus* Müller et Troschel (Paine and Palmer, 1978), *Semicossyphus maculatus* (Pérez) examined preliminarily by Fuentes (in press) and Gallardo (1979), and some information on the diet of some fish species mentioned by Mann (1954), we have no information on the feeding habits of coastal species of the northern Chilean waters. The present study was undertaken in order to provide further information on *S. maculatus*.

Semicossyphus maculatus is one of the most important fishes for both commercial and sport fisheries in northern Chile. This species could be threatened of extinction because professional and sport spear fishermen obtain this species easily and in a great amount. Nevertheless, antecedents such as population densities, growth and reproduction, and ecological relationships are completely unknown. An appropriate study on the diet and its local variations could permit a better comprehension of feeding pattern and trophic relationships among species. At the same time ecological principles such as prey-predator relations in the littoral community of fishes could be known.

Material and methods

The analysis of food content in the gut of *Semicossyphus maculatus* was based on an examination of 81 specimens sampled mainly in three localities near Iquique, Chile (Fig. 1), where this species is abundant and the substrata are rather similar; one sample obtained from Huayquique (Lat. 20°17′S) in July 1977, one sample from Playa Blanca (Lat. 20°20′S) in July 1976, and one sample from Los Verdes (Lat. 20°26′S) in March 1977. Other 17 specimens collected in July 1977 in different places between Huayquique and Los Verdes were used for comparing the diets of two body sizes and sexes. Material data are shown in Table 1. All fish were caught with a spear gun in depths from 1 m to 15 m, and between 1000 hrs and 1700 hrs. Total length of the specimens was determined to the nearest 0.5 cm, and sex by macroscopical observation of the gonads. The complete digestive tubes were taken out, and preserved in 10% formalin for the examination of their contents. For molluscs identification Marincovic (1973) was followed and for crustacean identification Haig (1955, 1960) was followed. Most food items could be identified to species level.

For the gut contents both the numerical method and the frequency of occurrence method were used. In the numerical method the number of individuals of each food type in each gut was counted. The quotient is the percentage of representation, by number, of

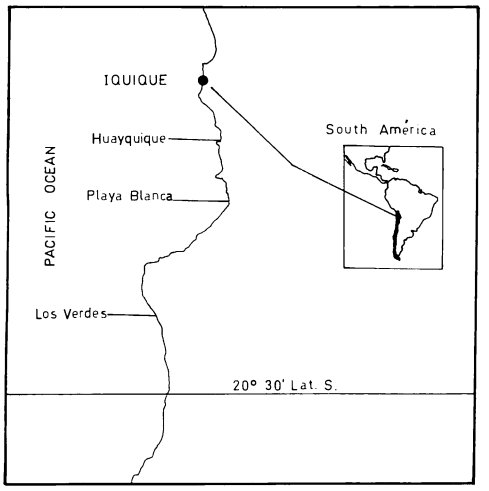

Fig. 1. Location of sampling localities near Iquique in northern Chile.

each type of food (Windell, 1968). In the occurrence method the number of guts in which each item occurs was recorded, then summed to give a total. The occurrence of each type of food is expressed as a percentage of these total.

The results obtained by the numerical and occurrence methods were compared using nonparametric coefficients following Moreno and Osorio (1977); Kendall's concordance coefficient (W) was calculated for establishing in which degree of similarity the diets among three localities could be considered to agree (Siegel, 1956). The significance of W was tested by determining the probability associated with the occurrence under null hypothesis that the true values of $W=0$. The values of W can range between zero which means no agreement and one, perfect agreement.

Siegel (1956) pointed out that when three or more rank sets are correlated the associations or differences between certain subsets could be obscured. For that reason the author established an independent comparison plan among the three localities sampled. The degree of similarity between samples was measured using the nonparametric Kendall rank correlation coefficient τ (tau), which was computed according to Siegel (1956). To standardize all comparisons, the same 20 food categories were used in all computation of the coefficient. The choice of categories was based on the most common items, determined by both numerical and occurrence methods, found in the digestive tube of all fish examined. The categories chosen were: 1. *Aulacomya ater*; 2. *Semimytilus algosus*; 3. *Brachidontes granulata*; 4. *Protothaca thaca*; 5. *Entodesma cuneata*; 6. *Scurria scurra*; 7. *Tegula* sp.; 8. *Prisogaster niger*; 9. *Crassilabrum crassilabrum*; 10. *Mitrella unifasciata*; 11. *Nassarius gayi*; 12. *Chiton cumigsii*; 13. *Balanus* sp.; 14. *Allopetrolisthes spinifrons*; 15. *Allopetrolisthes punctatus*; 16. *Pagurus* sp.; 17. *Cancer* sp.; 18. *Taliepus marginatus*; 19. *Tetrapygus niger*; 20. *Ophiactis kröyeri*.

The significace of τ was tested by using a normal approximation to test null hypothesis that the true value of $\tau=0$ (Siegel, 1956). The significance of z was determined referring to a table of areas of the normal curve. Probability values lower than 0.05 were considered to indicate significant similarity in the diets, between 0.01 and 0.001 highly significant similarity, and lower than 0.001 very highly significant similarity (Elliot, 1971).

Results

The total amount of *Semicossyphus maculatus* sampled was 81 specimens composed of 17 males and 64 females, and the total length ranged from 34.0 cm to 72.0 cm. All the specimens had some food items in their guts, indicating that they were collected while they were in feeding activity, and we could hope

Table 1. Sample composition of *Semicossyphus maculatus* from the coastal zone of Iquique, Chile.

Total length (cm)	Huayquique (n=30)		Playa Blanca (n=17)		Los Verdes (n=17)		Others (n=17)	
	Male	Female	Male	Female	Male	Female	Male	Female
34.0~50.0	4	20	0	9	0	11	0	12
50.1~72.0	4	2	3	5	4	2	2	3

Table 2. Diets of *Semicossyphus maculatus* in three localities of Iquique, Chile, assessed by both numerical (N) and frequency of occurrence (Oc) methods.

Prey species	Huayquique (n=30)				Playa Blanca (n=17)				Los Verdes (n=17)			
	N	%N	Oc	%Oc	N	%N	Oc	%Oc	N	%N	Oc	%Oc
Mollusca												
Bivalvia												
Aulacomya ater	31	4.55	18	11.11	30	1.16	10	7.04	9	1.25	3	4.00
Semimytilus algosus	31	4.55	17	10.49	122	4.73	10	7.04	179	24.89	13	17.33
Brachidontes granulata	10	1.47	7	4.32	19	0.73	4	2.82	5	0.69	2	2.66
Protothaca thaca	17	2.50	12	7.40	8	0.31	3	2.11	6	0.83	2	2.66
Entodesma cuneata	3	0.44	3	1.85					2	0.27	1	1.33
Gastropoda												
Collisella sp.					1	0.03	1	0.70				
Scurria scurra	3	0.44	1	0.61	1	0.03	1	0.70				
Tegula atra	23	3.38	10	6.17					5	0.69	2	2.66
Tegula tridentata					56	2.17	9	6.34				
Tegula sp.					4	0.15	2	1.41				
Prisogaster niger	1	0.14	1	0.61	27	1.04	2	1.41	4	0.55	1	1.33
Rissoina inca					52	2.01	1	0.70				
Turritella cingulata	5	0.73	3	1.85	51	1.97	5	3.52				
Crepipatella dilatata					7	0.27	5	3.52	2	0.27	1	1.33
Crassilabrum crassilabrum	104	15.29	18	11.11	38	1.47	8	5.63	17	2.36	6	8.00
Mitrella unifasciata	261	38.88	22	13.58	10	0.38	5	3.52	191	25.56	13	17.33
Nassarius gayi	100	14.70	12	7.40	73	2.83	14	9.86	17	2.36	10	13.33
Nassarius dentifer									3	0.41	2	2.66
Concholepas concholepas	2	0.29	1	0.61								
Indeterminatae					8	0.31	2	1.41				
Polyplacophora												
Chiton cumingsii	7	1.02	5	3.08	5	0.19	3	2.11	2	0.27	1	1.33
Chiton sp.					1	0.03	1	0.70				
Crustacea												
Cirripedia												
Chthamalus sp.	4	0.58	1	0.61								
Balanus psitacus									23	3.19	2	2.66
Balanus sp.	31	4.55	9	5.55	777	30.15	12	8.45	75	10.43	11	14.66
Amphipoda									1	0.14	1	1.33
Decapoda												
Alpheus chilensis									1	0.14	1	1.33
Pandalidae					2	0.07	2	1.41				
Liopetrolisthes mitra					1	0.03	1	0.70				
Allopetrolisthes spinifrons	3	0.44	2	1.23	1	0.03	1	0.70				
Allopetrolisthes angulosus					2	0.07	2	1.41				
Allopetrolisthes punctatus	5	0.73	4	2.46	8	0.31	2	1.41	1	0.14	1	1.33
Pachycheles grossimanus	1	0.14	1	0.61								
Percellanidae					13	0.50	6	4.22				
Megalobrachium peruvianus					5	0.19	3	2.11				
Paraxantus barbiger	3	0.44	1	0.61								
Pagurus edwarsii	5	0.73	2	1.23	27	1.04	8	5.63				
Pagurus sp.					3	0.11	2	1.41				
Pinaxodes chilensis					1	0.03	1	0.70				
Cancer polyodon	2	0.29	2	1.23								
Cancer sp.	3	0.44	2	1.23	1	0.03	1	0.70				
Leptograpsus variegatus					2	0.07	1	0.70				

Table 2. Continued

Prey species	Huayquique (n=30)				Playa Blanca (n=17)				Los Verdes (n=17)			
	N	%N	Oc	%Oc	N	%N	Oc	%Oc	N	%N	Oc	%Oc
Taliepus dentatus	1	0.14	1	0.61								
Taliepus marginatus					1	0.03	1	0.70	1	0.14	1	1.33
Echinodermata												
Echinoidea												
Tetrapygus niger	4	0.58	4	2.46	5	0.19	5	3.49				
Loxoechinus albus					1	0.03	1	0.70				
Asteroidea												
Patiria chilensis					2	0.07	2	1.41				
Ophiuroidea												
Ophiactis kröyeri	20	2.94	3	1.85	1	0.03	1	0.70				
Chordata												
Fish eggs					1211	46.99	4	2.82	175	24.00	1	1.33
Total of number of preys	680				2577				717			
Total occurrence of preys			162				142				75	

a good representativity of natural composition of the diet.

The results of both numerical and occurrence method analyses of three localities are shown in Table 2, where all prey-items found are detailed. Mollusca, Bivalvia and Gastropoda, particularly *Aulacomya ater*, *Semimytilus algosus*, *Brachidontes granulata*, *Protothaca thaca*, *Crassilabrum crassilabrum*, *Mitrella unifasciata* and *Nassarius gayi*, were the most important food types in the three localities. The cirripedian *Balanus* sp. was also important. In the particular case of Playa Blanca and Los Verdes, fish eggs were found in a great number but with low occurrence. This item could be considered, according to Nikolski

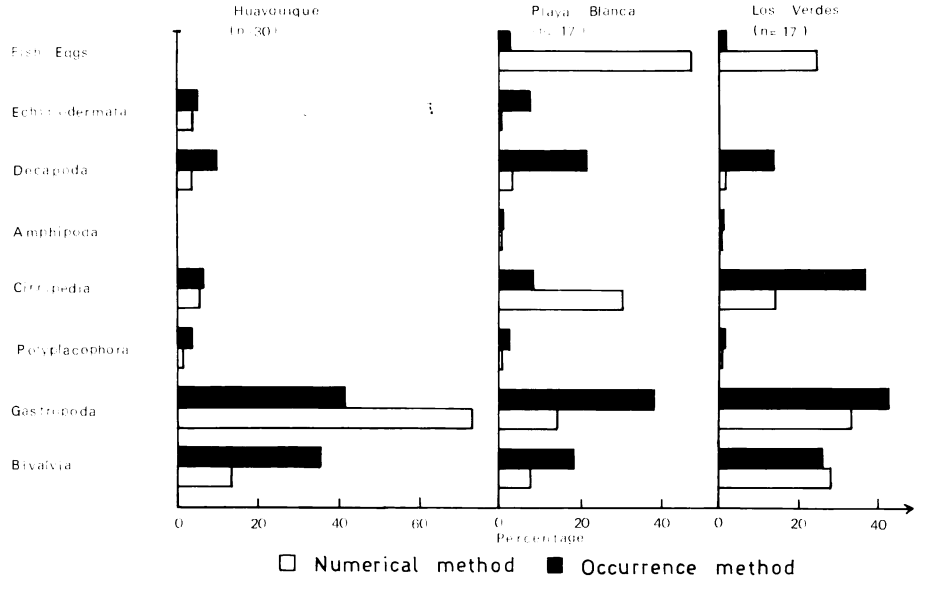

Fig. 2. Taxonomical groups of preys present in the diet of *Semicossyphus maculatus* in three localities of Iquique, Chile.

(1963), to be incidental food, and coincident with the spawning season of some other demersal fish species (Fuentes, in press).

To assess the relative importance of each taxonomical group present in the natural diet of *S. maculatus*, preys were grouped into eight taxonomical groups (Fig. 2, fish eggs were included in the Chordata), and individual percentage of preys belonging to a respective group was summed. Important groups both in number and in frequency were Bivalvia, Gastropoda, Cirripedia, and Decapoda. Polyplacophora, Echinodermata, and Amphipoda groups were less important food items in the diet.

The multivariate nonparametric analysis of the diet, based on 20 food items, showed a high concordance degree among the three localities, both in the numerical method ($W=0.825$; $P<0.001$) and the occurrence method ($W=0.783$; $P<0.001$). Both W values were much closer to one than to zero, indicating high agreement. In the independent comparison plan established among the three localities, the results obtained (Table 3) show that the diets in the three localities present a notorious association. The diets can be considered to be very highly similar ($P<0.001$) in the three localities in the numerical method results; very similar ($P<0.01$) between Huayquique and Playa Blanca and between Playa Blanca and Los Verdes localities, and very highly similar ($P<0.001$) between Huayquique and Los Verdes localities in the occurrence method results.

The diets of fish were compared between two groups of body sizes and between sexes, also by the Kendall rank correlation coefficient. The same 20 food items were used. The results in Tables 4 and 5 suggest that the diets are very highly similar ($P<0.001$) between the two size groups of the fish and between males and females.

Table 3. Kendall's rank correlation for comparisons of the diet of *Semicossyphus maculatus* in three different places of Iquique, Chile. Figures in parentheses are values of z for testing the significance of tau. The bottom left portion of the table contains the results of comparisons based on numerical method, the top right portion of the table contains the results of comparisons based on the frequency of occurrence method.

	Huayquique	Playa Blanca	Los Verdes
Huayquique	—	0.458 (2.821)**	0.532 (3.280)***
Playa Blanca	0.517 (3.186)***	—	0.376 (2.321)**
Los Verdes	0.516 (3.178)***	0.561 (3.458)***	—

* $P<0.05$; ** $0.01>P>0.001$; *** $P<0.001$

Table 4. Kendall's rank correlation coefficients for comparisons of the diet of *Semicossyphus maculatus* in two different body size groups. I Group, rank 34.0 cm to 50.0 cm TL (n=56) and II Group, rank 50.1 cm to 72.0 cm TL (n=25). The bottom left portion of the table contains the results of the numerical method, the top right portion contains the results of the frequency of occurrence method. In parentheses are values of z for testing the signicance of tau.

	I Group	II Group
I Group	—	0.624 (3.848)***
II Group	0.624 (3.845)***	—

*** $P<0.001$

Table 5. Kendall's rank correlation coefficients for comparisons of the diet of *Semicossyphus maculatus* by sex (males, n=17; females, n=64). The bottom left portion of the table contains the results of the numerical method, the top right portion contains the results of the frequency of occurrence method. In parentheses are values of z for testing the significance of tau.

	Males	Females
Males	—	0.664 (4.091)***
Females	0.582 (3.589)***	—

*** $P<0.001$

Discussion

Semicossyphus maculatus (pejeperro in Spanish common name) can be considered to be an essentially carnivorous fish, occupying the third place in the trophic chain of the sublittoral community. As the study was made on the fish captured on the superior sublittoral zone (1 m to 15 m), we can assert that this species is also a generalist in terms of the breadth of its diets (Paine and Palmer, 1978). The basic foods in the Nikolski's (1963) sense could be composed of Bivalvia, Gastropoda, and Decapoda; secondary foods could be Cirripedia, Echinodermata and Polyplacophora, and incidental foods could be Amphipoda and fish eggs. The feeding activity must take place during daylight because all specimens collected had the digestive tubes with large contents, and the author observed them actively feeding during the sampling time. Individuals collected early in the morning already had as much gut contents as those collected in the afternoon, indicating that *S. maculatus* may actively feed at night, too.

The analysis of the gastric content of specimens collected along a latitudinal gradient did not show significant differences in the specific dietary composition in the three localities and no tendency to change benthophagous feeding pattern. With the exception of Amphipoda and fish eggs in the sample from Huayquique, the same principal groups of prey were present in the three localities (Fig. 2). The insignificant differences observed in Huayquique-Playa Blanca pair and Huayquique-Los Verdes pair of comparison in the occurrence method (Table 3) could be caused by small differences in the occurrence of the same preys. Therefore the author followed the criterion of Mann and Orr (1969) in order to give little importance to such differences. In some specimens the author observed a little loss of the gut content due to the sampling method which took out some content and partially destroyed the digestive tube. Regarding the practical absence of differences among localities, two possibilities could be considered: all specimens collected could have belonged to the same or very close population, or the range of the latitudinal gradient could have been very small. In field observations no differences in the type of substratum and faunistic composition were observed. Meristic characters, external morphology and the range of body sizes in the sample were similar, too, then the first consideration could be true. In the second assertion, a large latitudinal gradient can reveal differences in the dietary composition depending if the geographical distribution of *S. maculatus* is determined by the type of habitats or by another ecological factors.

Although mouth size imposes a limit on the size of food eaten (Thomas, 1962), no change in the diet with increase in size ranging from 34.0 cm to 72.0 cm was observed in the dietary analysis of *S. maculatus*. Possibly a type of size-prey segregation can exist not only by body sizes but also between sexes, and then predators of different sizes could consume different sizes of individuals of the same taxa (Menge, 1972; Dodson, 1970). Moreover, adult males and females are different in external morphology and show different coloration patterns. The habitat compared with juvenile could be different because the adults swim freely near the bottom sometimes inside macroalgal forests. That could be determining for changes in the trophic preferences.

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チリ北部・イキケの沿岸水域における *Semicossyphus maculatus*（ベラ科）の食性

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チリ北部の沿岸帯において，*Semicossyphus maculatus* の食物組成を研究した．ウアイキケ，プラヤブランカおよびロスヴェルデスの3地域で，本種の食性は変化なく，大小2群間および雌雄間での食性にも大きな差違は観察されなかった．水深1mより15mまでの範囲で採集した標本の消化管には，移動性および固着性の底生生物，主に腹足類，斧足類，十脚類，甲殻類，蔓脚類が一般に含まれていた．これらの知見に基づいて，本種の摂餌様式を討論した．

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