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INTERTIDAL FISH ASSEMBLAGES OF THE CENTRAL CHILEAN COAST: DIVERSITY, ABUNDANCE AND TROPHIC PATTERNS.

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ABSTRACT. Intertidal fish assemblages of the central Chilean coast: diversity, abundance and trophic patterns.

Diversity and abundance patterns as well as trophic structure were investigated for rocky tidepool fishes of the central Chilean coast. Six mid-intertidal rock-pools were sampled from January to October 1989 using rotenone and handnets. Eleven species of fish representing eight families totalling 597 individuals were captured during the 10-month sampling period. Six of these species belonging to Tripterygiidae, Blenniidae and Clinidae were year-round residents of rock-pools. Five other species occupied these pools temporarily. The girellids **Graus nigra** and **Girella laevifrons** were predominant species in the tidepools investigated, although their presence was markedly seasonal (found mainly during summer and fall) and were represented almost exclusively by juvenile individuals. A similar phenomenon was observed with most of the transient species, which indicates that tidepools are important nursery areas for these species. The intertidal fish assemblage studied was primarily composed by carnivorous species (73%) which preyed mainly upon benthic crustacean prey typical of these habitats. No strictly herbivorous fish were found, although two species (G. **laevifrons** and **Scartichthys viridis**) included an important proportion of algal material in their diets. Niche overlap among these species was relatively low (less than 50%) in most species-pairs suggesting that some degree of resource partitioning has occurred in this fish assemblage.

Key words: Tidepool fishes, diversity, feeding niches, Eastern South Pacific.

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RESUMEN. Ensambles de peces intermareales de la costa de Chile central: patrones de diversidad, abundancia y estructura trófica.

Se estudiaron los patrones de diversidad y abundancia, y estructura trófica de peces que habitan pozas del intermareal rocoso de la costa de Chile central. Seis pozas del intermareal rocoso medio fueron muestreadas entre enero y octubre de 1989 mediante el uso de rotenona y redes de mano. Un total de 597 especímenes representantes de 11 especies y 8 familias fueron capturadas durante este estudio. Seis de estas especies, pertenecientes a las familias Triperygiidae, Blenniidae y Clinidae, resultaron ser residentes estables de estas pozas. Las restantes cinco especies fueron registradas sólo en forma temporal. Las especies dominantes en las pozas investigadas fueron los girelidos **Graus nigra** y **Girella laevifrons.** La presencia de estas especies, sin embargo, fue marcadamente estacional (principalmente durante verano y otoño) y sus representantes exclusivamente individuos juveniles. Una situación similar fue observada para la casi mayoría del resto de las especies transitorias o temporales, lo cual indica que estas pozas intermareales representan importantes áreas de reclutamiento para estas especies. El emsamble de peces estudiado se compone principalmente de especies carnívoras (73%) las cuales depredan mayoritariamente sobre crustáceos bentónicos, típicos de estos ambientes. Ninguna especie estrictamente herbívora fue encontrada en estas pozas, aun cuando dos especies (**G. laevifrons** y **Scartichthys viridis**) incluyen una proporción importante de algas en su dieta. La sobreposición trófica entre estas especies fue relativamente baja (menos de un 50%) lo cual sugiere la existencia de mecanismos de repartición de recursos alimenticios en estos ensambles de peces.

Palabras claves: Peces intermareales, nichos tróficos, diversidad, Pacífico Sudoriental.

INTRODUCTION

Fishes are important components of most temperate rocky shore communities (Choat 1982). Surprisingly, nearshore fishes and particularly those inhabiting rocky intertidal pools have been poorly studied along the extensive Chilean coastline. Although Moreno et al. (1979) studied several ecological aspects of littoral Chilean fishes, they did not include the intertidal

ichthyofauna in their analysis. These tidepool fishes have received considerable attention in recent years at several temperate localities (Gibson 1982, Horn 1989). Taxonomic characterizations of these fish assemblages, for example, have been well documented for Californian and South African waters (Moring 1976, Yoshiyama 1981, Beckley 1985a). Temporal and spatial patterns of abundance have also been described for these intertidal fishes (Grossman 1982, 1986, Beckley 1985b, Moring 1986). Most of these studies have shown that intertidal ichthyofaunas of rock-pools are composed by residents species (i.e., found year-round) and temporary or transient species (i.e., found on a seasonal basis or just as juveniles) (see Gibson 1982). Studies on the population structure of these fish species have pointed out the importance of tidepools as nursery habitats for outstanding littoral fish species (Williams 1957, Beckley 1985b).

Although several recent studies have documented that intertidal fishes play an important role in determining community structure in the tropics (see Horn 1989), there is yet not clear idea of the particular roles that these species may play in temperate waters. The aims of the present study are: (1) to provide the first qualitative and quantitative characterization of fish assemblages occurring in rocky intertidal pools of the central coastline of Chile, including diversity and abundance patterns, and (2) to elucidate their trophic structure. The ecological patterns described in this study are important because they provide a baseline for future research and the required ecological background for understanding the ecological organization and the dynamic processes operating in this type of intertidal communities.

MATERIAL AND METHODS

Fishes were collected at three semi-protected sites of the central Chilean coastline: Quintay, El Tabo, and Las Cruces (between 33° 11' and 33° 30' S; 71° 33' W). A total of six mid-intertidal rock-pools ranging in size from 1.5 to 17 m^3 were investigated. One of these pools was sampled every six weeks from January to October 1989 during low tides when the pool was completely isolated from the sea. The other five were sampled once between January and March 1989. All pools studied were characterized by rock-walls with similar algal cover, and a mixed rock-sand bottom. The pools were poisoned with rotenone (75-100 ml/m^3) and the fish collected with handnets for about 2-3 hours or until no fish was seen. All captured fish were fixed in a 5-10% solution of formalin-seawater mixture, placed in labeled plastic bags, and transported to the laboratory for further analysis. Preserved fish were identified, counted, measured (total length = TL) to the nearest 1.0 mm, and wet-weighed to the nearest 1.0 g on a digital balance. Stomachs and intestines of all specimens collected were cut open and the contents were flushed

into Petri dish. Gut contents flooded with distilled water were examined under a dissecting microscope. Contents were sorted out and identified to the finest possible taxonomic resolution. Prey items were damp-dried on paper towel, and the number of individuals and total weight (to the nearest 0.1g) of each prey category were recorded. Representative samples of all species were deposited at the Sala de Sistemática of the Pontificia Universidad Católica de Chile, Ichthyological collection (SSUC PI # 0002-0016). Diversity of food resources used by fishes was measured using Shannon's diversity index (H) (Pielou 1972). Niche overlap was calculated using the formula proposed by Pianka (1973).

RESULTS

A total of 597 individual fish representing 11 species in eight families were collected in the six rocky intertidal pools studied off the central Chilean coast (Table 1). The most abundant species were the girellids **Graus nigra** (Philippi 1987) and **Girella laevifrons** (Tschudi 1844), comprising more than 80% of the total number of fishes captured (Table 1). Most of the girellids, however, were small immature individuals averaging about 90 mm in TL (Table 1) which occurred mainly during summer and early fall although present throughout the study period. The marine catfish ("bagre") **Aphos porosus** (Valenciennes, 1837) was the third most important species in order of abundance (Table 1). They were found between January and March; few were reproductive adults with large numbers of eggs and most were recently hatched individuals. Substantial masses of these eggs were commonly observed in the pools between cracks and crevices during January and February. Eight other species were relatively less common in the samples (representing less than 3% of the total number of fish collected): **Tripterygion chilensis** Cancino (in: De Buen 1960), **Tripterygion cunninghami** Smitt, 1898, **Scartichthys viridis** (Valenciennes, 1836), **Hypsoblennius sordidus** Bennett, 1828, **Bovichthys chilensis** Reagan, 1914, **Chelodactylus variegatus** Valenciennes, 1833, **Gobiesox marmoratus** Jenyns, 1842 and **Auchenionchus microcirrhis** Valenciennes, 1836 (Table 1). With the exception of the latter two species which were only found in late summer (March), the remainder of these nine species were collected throughout the time span of this study.

Analysis of the body size of the species collected (Table 1) shows that most temporary species in tidepools were juvenile individuals (e.g., **G. nigra**, **G. laevifrons**, **C. variegatus** and **G. marmoratus**). Large individuals of these species are common components of rocky subittoral habitats along this coastline (Moreno et al. 1979). Resident species in these habitats, however, are represented by both juvenile and adult individuals, primarily the latter.

Trophic composition of the intertidal fishes captured is composed of eight primarily carnivorous species (72.7%). No strictly herbivorous species were found, although the species classified as omnivorous (**S. viridis** and **G. laevifrons**; 18.2%) have been found to have a primarily herbivorous diet in subtidal habitats (F.P. Ojeda, personal observations). **Aphos porosus**, being a strict carnivorous species (Mann 1954), was classified as fasted (9.1%) because all gut contents analyzed were empty. The dietary composition of the fish species analyzed, expressed as percentage frequency of total food weight is presented in Table 2. The most important group in the diet of these predators was benthic crustacean prey, particularly amphipods, decapods and isopods (Table 2). Gastropod and bivalve molluscs were important prey items for some of these fish species (e.g. for **C. variegatus**) (Table 2). Only **G. laevifrons** and **S. viridis** were found to consume filamentous macroalgal species (particularly green algae) in large proportions (Table 2). Other groups such as polychaets and insects made up a small proportion of the diet of these fishes (Table 2).

The specific dietary composition of the five most abundant fish species collected is summarized in Table 3. The most generalist benthic predator was **G. nigra**, which preyed upon a total of 16 invertebrate taxa. Crustaceans, particularly amphipods (several species) and decapods such as **Petrolisthes violaceus**, were the most important prey item for **G. nigra**, as well as for **T. chilensis** and **C. variegatus** (Table 3). The bivalve, **Semimytilus algosus**, was also an important prey of **C. variegatus**. Several filamentous algal species such as **Enteromorpha**, **Ulva** and **Gelidium** were the most important item in the gut contents of **G. laevifrons** and **S. viridis** (Table 3). Small individuals of **S. algosus**, common inhabitants of algal mats, were also found in large quantities in the gastric contents of these species (Table 3).

The intertidal fishes studied showed similar niche breaths, ranging from 2.9 to 3.9 (Shannon-Wiener diversity index). Three species pairs showed extensive niche overlaps (**T. chilensis** - **G. nigra**: 0.76, **G. laevifrons** - **S. viridis**: 0.72 and **C. variegatus** - **T. chilensis**: 0.80). The remainder pairs had overlap values smaller than 0.50 as consequence of their differential utilization of benthic prey (see Table 3).

DISCUSSION

The number of fish species encountered in this study is comparable to that observed in similar rocky intertidal habitats of other temperate coastlines. Mistry et al. (1989) found 15 species in a central Californian intertidal zone, which is in accordance with what Grossman (1982) and Matson et al. (1986) documented for similar intertidal pools in protected areas.

TABLE 1. List, number (N), body size (total length and weight) and resindence status (RS) of 11 intertidal fish species collected in central Chile. T = Temporary R = Resident Species. $\bar{x}$ = Average.

SPECIES	N	(%)	Total Lergth Range (mm)	$\bar{x}$	Weight Range (g)	$\bar{x}$	RS
Kyphosidae							
Graus nigra	261	(43.7)	24 - 203	93.6	0.2 - 121.4	14.5	T
Girella laevifrons	227	(38.0)	39 - 153	89.5	0.9 - 64.5	15.2	T
Tripterygiidae							
Tripterygion chilensis	18	(3.0)	32 - 83	52.0	0.3 - 5.2	2.0	R
Tripterygion cunninghami	2	(0.3)	72 - 77	74.5	2.6 - 4.2	3.4	R
Blenniidae							
Scartichthys viridis	12	(2.0)	54 - 224	132.5	1.3 - 134.6	40.0	R
Hypsoblennius sordidus	4	(0.7)	47 - 84	62.0	1.4 - 8.0	3.8	R
Batrachoididae							
Aphos porosus	50	(8.4)	21 - 228	30.3	0.1 - 93.3	14.1	T
Cheilodactylidae							
Cheilodactylus variegatus	9	(1.5)	55 - 114	93.5	1.3 - 17.0	10.7	T
Bovichthyidae							
Bovichthys chilensis	1	(0.2)	149		31.08		R
Gobiesocidae							
Gobiesox marmoratus	12	(2.0)	14 - 63	60.6	0.4 - 4.4	2.1	T
Clinidae							
Auchenionchus microcirrhis	1	(0.2)	103		10.7		R
TOTALS	597						

TABLE 2. Gut contents expressed as percentage frequency of total food weight of 10 tidepool fish species collected in central Chile. Other = Sediments and highly digested items.
(*) = Number of stomachs analized.

		% Wet Weight of Stomach Contents										
SPECIES	(*)	AMPHIPODS	DECAPODS	ISOPODS	CUMACEANS	CIRRIP	GASTROPODS	BIVALVES	POLYCHAETES	INSECTS	ALGAE	OTHER
G. nigra	(72)	24.0	56.0	2.0	0.5	0.1	6.0	5.0	5.0	1.0	---	0.6
G.laevifrons	(81)	5.0	6.0	6.0	1.1	0.1	2.0	12.0	2.0	9.0	56.0	0.8
T. chilensis	(17)	37.0	21.0	4.5	---	2.0	14.0	15.3	---	1.0	---	5.2
T. cunninghami	(2)	48.2	39.0	---	---	---	---	2.9	1.9	---	---	8.2
S. viridis	(11)	0.9	---	0.1	0.4	0.1	0.4	21.0	---	---	31.8	45.3
H. sordidus	(4)	3.6	---	0.2	---	0.2	---	---	---	---	---	96.0
C. variegatus	(9)	27.7	---	24.8	0.8	---	0.7	21.5	2.1	2.8	---	19.6
B. chilensis	(1)	1.8	68.2	---	---	---	---	---	---	---	---	30.0
G. marmoratus	(2)	4.3	---	1.3	---	0.3	14.7	---	14.5	---	---	64.9
A. microcirrhis	(1)	---	60.0	---	---	---	---	---	---	---	---	40.0

TABLE 3. Gut contents of the five most abundant fish species captured in 6 tidepools of central Chile. N = Number of individuals % W = Percentage of total food weight Ns = Number of stomachs analized.

PREY	G. nigra		T. chilensis		C. variegatus		G. laevifrons		S. viridis	
	N	% W	N	% W	N	% W	N	% W	N	% W
CRUSTACEANS										
Amphipods	1186	24,0	207	48,2	417	27,7	553	5.0	136	0.9
Decapods										
Petrolisthes violaceus	13	25,7	2	19,0	-	-	3	3,9	-	-
Cyclograpsus cinereus	5	16,3	-	-	-	-	-	-	-	-
megalope larvae	6	6,0	-	-	-	-	-	-	-	-
unidentified	-	8,0	-	20,0	-	-	-	2,1	-	-
Isopods										
Excirolana hirsuticauda	14	0,7	-	-	7	15,3	66	2,8	-	-
Cirolana robusta	17	1,0	-	-	3	9,5	80	3,2	3	0,1
Isocladus sp.	7	0,3	-	-	-	-	-	-	-	-
Cumaceans	24	0,5	-	-	22	0,8	36	1,1	47	0,4
Barnacles (cirri)	-	0,1	-	-	-	-	-	0,1	-	0,1
MOLLUSCS										
Gastropods										
Collisella araucana	9	2,9	-	-	1	0,7	15	1,1	8	0,2
Collisella cecilliana	4	1,0	-	-	-	-	10	0,7	4	0,1
Collisella orbignyi	6	1,3	-	-	-	-	-	-	-	-
Littorina araucana	3	0,5	-	-	-	-	6	0,2	2	0,1
Littorina peruviana	2	0,3	-	-	-	-	-	-	-	-
Bivalves										
Semimytilus algosus	53	5,0	18	2,9	74	21,5	257	12,0	673	21,0
Polychaetes										
Nereididae	21	5,0	2	1,9	3	2,1	13	1,5	-	-
Pisionidae	-	-	-	-	-	-	6	0,5	-	-
INSECTS	3	1,0	-	-	10	2,8	80	0,9	-	-
ALGAE		-		-		-		56,0		31,8
OTHER		0,6		8,2		19,6		0,8		45,3
Ns		72		17		9		81		11

Beckley (1985a) and Collette (1986) found similar numbers of fish species in intertidal habitats off the coast of South Africa and New England, respectively. Further, the number of families represented is also in agreement to that reported for other intertidal zones worldwide (see Gibson 1982).

Graus nigra and G. **laevifrons** were by far the most abundant fishes in this study. These species also showed the highest recolonization rates after repeated removal. This may be owing to the fact that these girellids do not present clear homing behaviors as suggested by Grossman (1982) for other temperate fishes. Visual censuses of fish done by the authors in the shallow subtidal zone at these same localities show that juvenile individuals of G. **laevifrons**, but not of G. **nigra**, are common and abundant components of these environments. Repopulation of tidepools by these girellids, therefore, must have occurred by local migration from adjacent intetidal pools (for G. **nigra**) and from the shallow subtidal zone (for G. **laevifrons**).

As it has been documented for other temperate rocky coasts (Gibson 1982, Beckley 1985b), the intertidal fish assemblage studied can be classified into two components: resident species and temporary species. Dominant resident species belonged to the families Tripterygiidae, Blenniidae and Clinidae (Table 1), which have been reported as typical members of rocky intertidal pools (Gibson 1982). Year-round residency of Clinids and Blenioids in tidal pools has been explained with reference to several reproductive adaptations in these fishes that reduce the pelagic phase of their life cycles (Gibson 1969). Most temporary or transient species in this study were juvenile of the families Kyphosidae (Girellinae), Chellodactylidae and adults of Batrachoididae (Table 1). The seasonal occurrence of young recruits of G. **nigra** and G. **laevifrons** as well as of juvenile of C. **variegatus** indicates that intertidal rock-pools of Central Chile are important nursery areas for these species. Further, the absence of juveniles of these species noted in other coastal habitats (e.g., subtidal) also suggests that they could use rock-pools as main nursery areas. Similar results have been reported by Beckley (1985b) and Bennett (1989) for intertidal fishes along the coastline of South Africa.

The intertidal fish assemblage studied was composed mainly by carnivorous species (Table 2). Predation pressure effected by these fishes is heavily concentrated upon benthic invertebrate prey such as amphipods and decapods, which have been shown to represent energy-rich prey (Ojeda & Dearborn, in press). Primarily herbivorous fish, on the other hand, were poorly represented in this assemblage, although two species (G. **laevifrons** and S. **viridis**) included large proportions of macroalgae in their diets (Table 2). Comparable results have also been documented by Grosmann (1982), Matson **et al.** (1986) and Yoshiyama **et al.** (1986) in Californian waters. The scarcity of herbivorous fishes in temperate latitudes has been traditionally explained as a consequence of biogeographic patterns exhibited by Percoids (which include the majority of the known herbivorous fish families), and

to existing physiological contraints for utilization of algal material in cold waters (Mead 1970, Wheeler 1980). Recent studies and ongoing research by one of the authors (F.P. Ojeda), however, point out that herbivory may well represent a real (i.e. functional) and common phenomenon among temperate fishes (see Horn 1989).

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