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Temporal variability of the sand beach macroinfauna in south-central Chile

Variabilidad temporal de la macroinfauna de playas arenosas en el centro-sur de Chile

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ABSTRACT

Two sandy beaches were studied in south - central Chile (*ca.*, 39° S), during 17 months to analyze the seasonal variability in population abundances and zonation of the most common species of the intertidal macroinfauna. The beaches displayed differences in mean grain size, Dean's parameter (a composite index of wave and sediment characteristics) and beach face slope. The peracarids *Orchestoidea tuberculata* Nicolet (Amphipoda, Talitridae), *Excirolana braziliensis* Richardson and *Excirolana hirsuticauda* Menzies (Isopoda, Cirolanidae), and the anomuran crab *Emerita analoga* (Stimpson) (Hippidae) were the most common organisms at both beaches, being *E. analoga* and *E. hirsuticauda* the top contributors to abundance. *O. tuberculata* tended to occur in higher abundance, either during autumn - early winter or late summer - early autumn; *E. braziliensis* was more abundant during summer - early autumn, while the abundances of *E. hirsuticauda* and *E. analoga* were quite erratic throughout seasons. In general, the temporal patterns of abundance did not show significant correlations with the beach physical factors considered. The species showed a clear pattern of zonation: *O. tuberculata* occurred in the upper beach levels (around the drift line); *E. braziliensis* occurrred in the mid - upper levels of the retention zone; *E. hirsuticauda* occurred throughout all the retention zone and also in the upper and middle levels of the resurgence zone, while *E. analoga* was mostly found in the swash zone and lower levels of the resurgence zone. Although, seasonal changes in the intertidal distribution was observed, it can be seen that each physical zone of the beaches is biologically distinct through seasons.

Key words: sandy beaches, macroinfauna, temporal variability, south - central Chile.

RESUMEN

Se estudiaron dos playas arenosas en el centro sur de Chile (ca., 39° S), con el objetivo de analizar la variabilidad estacional en las abundancias poblacionales y zonación de las especies más comunes de la macroinfauna intermareal. Estas playas mostraron diferencias en tamaño de partícula, parámetro de Dean (índice compuesto de características del oleaje y el sedimento) e inclinación. Los peracáridos *Orchestoidea tuberculata* Nicolet (Amphipoda, Talitridae), *Excirolana braziliensis* Richardson y *Excirolana hirsuticauda* Menzies (Isopoda, Cirolanidae), y el anomuro *Emerita analoga* (Stimpson) (Hippidae) fueron los organismos más comunes en ambas playas, siendo *E. analoga* y *E. hirsuticauda* los mayores contribuyentes a la abundancia. *O. tuberculata* tendió a ocurrir en mayor abundancia, ya sea durante otoño - inicio del invierno o desde fines del verano a inicios del otoño; *E. braziliensis* fue más abundante durante verano - inicios del otoño, mientras que las abundancias de *E. hirsuticauda* y *E. analoga* fueron bastante erráticas a través de las estaciones del año. En general, los patrones temporales de abundancia no mostraron correlaciones significativas con los factores físicos considerados. Las especies mostraron un patrón claro de zonación: *O. tuberculata* ocurrió en los niveles superiores de la playa; *E. braziliensis* ocurrió en los niveles medios y superiores de la zona de retención; *E. hirsuticauda* ocurrió a través de toda la zona de retención y también en los niveles superiores y medios de la zona de resurgencia, mientras que *E. analoga* fue mayoritariamente recolectada en la zona de resaca y niveles inferiores de la zona de resurgencia. Aun cuando se observaron cambios estacionales en la distribución de la macroinfauna, se puede concluir que cada zona física de la playa es biológicamente distinta a través de las estaciones del año.

Palabras clave: Playas arenosas, macroinfauna, variabilidad temporal, centro sur de Chile.

INTRODUCTION

Variation in time and space is a characteristic of ecological systems (Wiens 1986). As stated by Chesson (1986), the common occurrence of this variation and that related to species populations raises important questions such as How related is the structure of a community to environmental variation? Studies carried out in different habitats have shown that indeed, species and communities are affected by such a variation

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(Brewer 1979, Diamond & Case 1986). For example, a decline in biomass of ground finches and seeds was found at an island of the Galápagos during an extended dry period (Grant 1986). Similarly, mean annual precipitation affects seed resources and thus population abundance of desert granivores (Brown et al. 1979). In coastal habitats, it has been found that annual changes in environmental temperature affect the soft bottom macrofauna inhabiting coastal North Sea areas (Beukema 1990). Thus, in the soft bottom bivalves *Cerastoderma*, *Mya* and *Macoma* recruitment on tidal flats of the Wadden Sea is generally poor after mild winters and high after cold winters (Jensen & Jensen 1985, Beukema 1982, 1992). The bivalve *Scrobicularia plana* shows latitudinal variation in reproduction pattern along a coastal gradient extended from the German and Dutch Wadden Sea to France; in this case temperature variation and sediment instability are involved in that population variation (Essink et al. 1991).

Sandy beaches are amongst the most dynamic aquatic habitats (Swart 1983, Brown & McLachlan 1990). Spatial and temporal variations in wave climates (e.g, Aubrey 1983) and seaward gradients in physical conditions (Fleischack & Freitas, 1989, Jaramillo 1987a, McLachlan et al., 1984) confer tho these habitats its dynamic characteristics. Thus, it is reasonable to think that in such a dynamic habitat, macrofaunal communities should be influenced by such physical variations. For example, seasonal changes of beach macroinfauna have been related to seasonal changes in beach morphology (e.g., Ansell et al. 1972, McLusky et al. 1975). On the other hand, seasonal variation in macrofauna have been also related to seasonal variation in temperature. For example, Salvat (1966) and Fish (1970) found that in sandy beaches of France and Wales, the abundance of the isopod *Excirolana pulchra* Leach decreased at the upper levels of its distribution during summer. Jones (1970) observed that in sandy beaches of the south of Wales, the cirolanid isopods *Eurydice pulchra* Leach and *Eurydice affinis* Hansen, escaped from extreme winter temperatures by moving from intertidal to subtidal levels. Seasonal variation in temperature appears to affect decapod movements, and consequently seasonal variation in community structure in a sandy beach of North Carolina (Leber 1982).

Studies concerning the Chilean sandy beach macroinfauna have been mainly devoted to describe zonation patterns of the intertidal macroinfauna. The first one was that of Dahl (1952) who described the across shore distribution of crustaceans at Montemar, Puerto Montt and Punta Arenas (central, south central and southern extreme of Chile, respectively). Afterwards, the sandy beach macroinfauna of central Chile was studied by Osorio et al. (1967) and Nuñez et al. (1974), that of the north by Jaramillo (1987b) and Clarke & Peña (1988), that of the north central Chile by Sanchez et al. (1982) and Jaramillo (1987 b), and that of south central Chile by Jaramillo (1978, 1982, 1987 a, b, 1994), Jaramillo & González (1991), Jaramillo & McLachlan (1993), and Jaramillo et al. (1993). The vast majority of these studies are the result of short - term surveys. Even though, two general conclusions can be drawn from these studies: i) the numerically dominant organisms along the Chilean coast are crustaceans (mostly Peracarida and Anomura), and ii) peracarid species typically dominate upper and middle beach levels, while anomurans dominate at the lower beach levels.

Jaramillo & McLachlan (1993), Jaramillo et al. (1993) and Jaramillo (1994) have shown that community parameters (species richness, abundance and biomass) and zonation of the sandy beach macroinfauna of south central Chile, are closely related to the morphodynamic type of the beach measured by Dean´s parameter (Short & Wright 1983). However, the studies reported so far for this coast have not addressed the effect of time (e.g, seasonal changes) on beach morphodynamics, and consequently upon community parameters and zonation of the macroinfauna.

Sandy beaches of south central Chile are characterized by seasonal changes in beach topography and grain size (Jaramillo 1987 a). Winter throughout spring is typically an erosion period, while summer an autumn are characterized by accretion of sands which becames finer than during the former period

(Jaramillo 1987a). Given the temporal pattern of sand variability we hypothesized that macroinfaunal temporal changes at two sandy beaches located in south central Chile (Mehuín, ca. 39° S) follow beach physical changes.

MATERIAL AND METHODS

The two beaches studied were located at Mehuín, in the south central area of the Chilean coast (approximately 39 - 40° S, Fig. 1). These beaches are separated by a rocky shore promontory; Playa Grande is a beach 2000 m in length, while the other one (Playa Universitaria) is a beach approximately 300 m long (Fig. 1). We choosed two closely located beaches to avoid eventual effects of regional variability on the conclusions of the study.

The morphodynamic type of both beaches correspond to the high-energy intermediate to dissipative category of Short & Wright (1983). They are fully exposed to the breaking waves of the Pacific Ocean. The tides are semidiurnal with a maximum range of approximately 1.5 m.

Study sites were sampled monthly during spring low tides from April 1992 to August 1993. On each site, samples (0.03 m^2, 30 cm deep) were collected with plastic cores at ten equally spaced levels along three replicated transects (1 m apart each other) extending from above the drift line to the swash zone; i.e., the uppermost station was located above

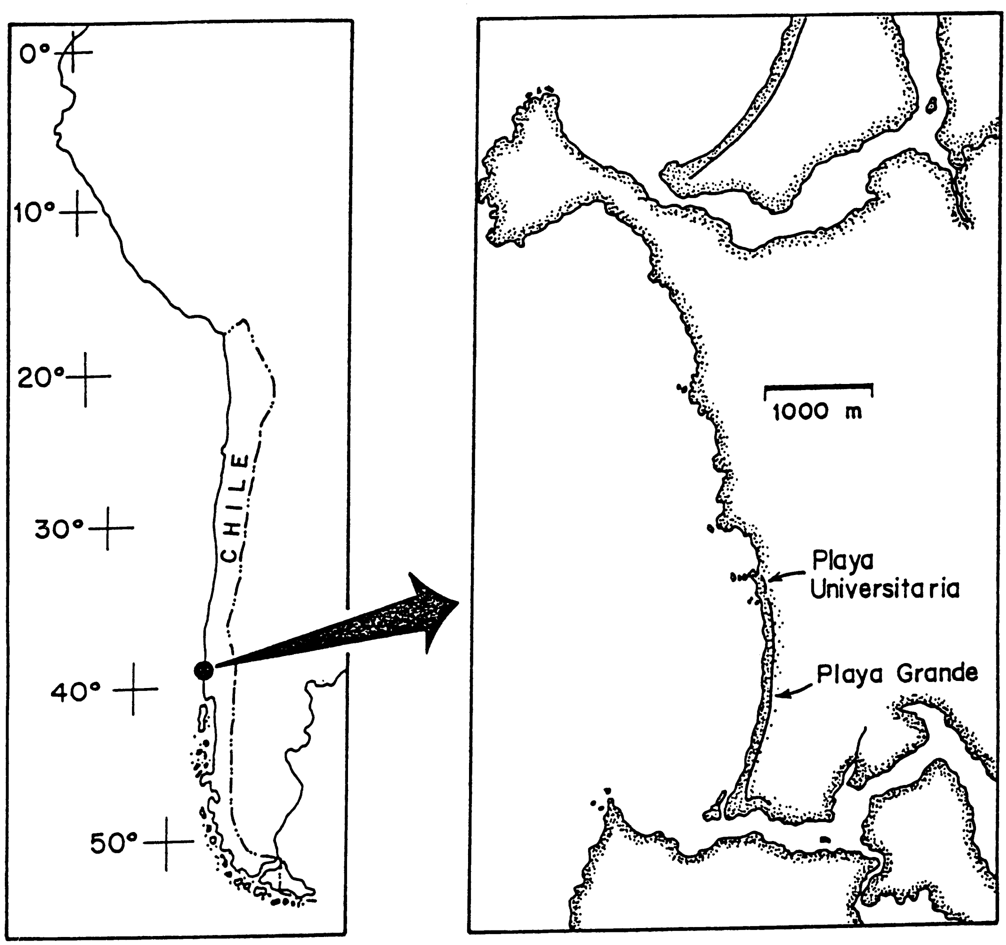

Fig. 1: Location of the sandy beaches studied at Mehuín, south - central Chile: Playa Universitaria (PU) and Playa Grande (PG).

Localización de las playas arenosas estudiadas en Mehuín, centro-sur de Chile: Playa Universitaria (PU) y Playa Grande (PG).

the drift line, the second on the drift line and the last at the lowest limit of the swash zone (indicated by bore collapse). The sediment was sieved through 1 mm mesh and the macroinfauna was stored in 5% formalin until sorting. Abundance values per running meter of beach were obtained by linear interpolation between sampling stations, after obtaining mean abundances per m^2 at each station. The temporal variation in the zonation of the macroinfauna was analyzed by visual examination of kite diagrams and temporal variation of distribution modes (i.e. location of the population mode).

Wave height was estimated on every visit by measuring the height of breaking waves (n = 10) with graduated poles against the horizon, and adding the result to the height difference between the location of the observer and the lowest point where the backwash met the next incoming swash bore. The wave period (measured with a stop watch, n = 10) was measured as the time interval between breakers. Triplicate sediment samples (1 m apart each other) were taken from the upper, middle and lower beach (stations 2, 5 and 10, respectively), for grain size analysis; which was carried out using a settling tube (Emery 1938). Mean grain size was calculated according to the moments computational method (Seward - Thompson & Hails 1973) and used to estimate sand fall velocity according to the method described by Gibbs et al. (1971). From estimated mean wave height, wave period and sand fall velocity, Dean´s dimensionless parameter (Ω) (Short & Wright 1983) was calculated for each sampling day: Ω = wave height (cm) / sand fall velocity (cm s^{-1}) x wave period (s). The morphology (i.e., beach face slope at the site of the transect) of each site was determined by Emery´s profiling technique (Emery 1961).

Sediment samples were collected at each station for water content analyses by using a 3.5 cm diameter plastic core (3 cm of depth). Samples were wrapped in aluminium foil and weighed inmediately after collection. Water content of the sand was estimated as the loss in weight of wet sediments after drying (120° C for 96 hours). The penetrability of the sediments was measured by dropping a 33.6 g metal rod down a 1 m tube. The depth to which the rod penetrated into the sediment was measured 4 times at each station.

Visual observations of the variability in moisture across the intertidal were used to analyze variability in zonation of the most common species. The visual observations were carried out to observe the limits of the dry, retention, resurgence, and swash (= saturation) zones, as defined by Salvat (1964, 1966). In this categorization the dry zone corresponds to that located at the top of the shore (usually above the drift line) where the sand is normally wetted only by spray; the retention zone is that area of the intertidal which is reached by all tides and where some moisture always remains in the interstitial space; the resurgence zone is the zone marked by movement of water on the outgoing tide, and the saturation zone is that permanently saturated with water (McLachlan 1990, Salvat 1964, 1966)

RESULTS

The beaches

Figure 2 and Table 1 show the variability in physical factors at the two beaches. Wave tended to be higher during autumn and winter and lower during summer. No significant differences between beaches were found when the averages based on 17 monthly data of wave height were compared (Table 1). The same was found for wave periods (Table 1). In general, the coarsest sands were found at Playa Universitaria (Fig. 2); indeed, the average for this parameter (274.1µm) at this beach was significantly higher (Table 1).

The temporal pattern of Dean's parameter (Ω) at both beaches showed similar trends. During some months, both beaches had Ω values lower than 6 which is indicative of intermediate beach types (sensu Short & Wright 1983); on the other hand, during other months, Ω values were higher (> 8) which is typical of beaches displaying dissipative characteristics (*sensu* Short & Wright 1983). Generally, the highest Dean´s values were estimated when wave heights were higher. Taking into account the average based on 17 monthly data it was found that the Dean´s parameter was significantly

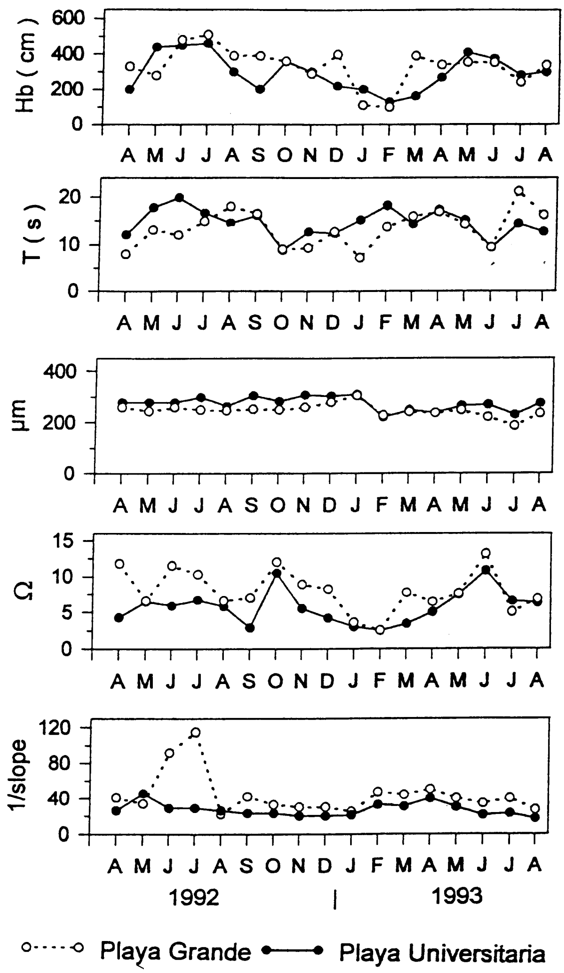

Fig. 2: Temporal variability in wave (breaker) height (Hb), wave period (T), mean particle size (µm), Dean´s parameter (Ω) and beach face slope (1/slope).

Variabilidad temporal de altura de las olas en zona de rompiente (Hb), período de la ola (T), tamaño medio de la partícula (µm), parámetro de Dean (Ω) y pendiente de la cara de la playa (1/slope).

higher at Playa Grande (i.e., a more dissipative condition) (Table 1). This beach also had flater slopes, especially during June - July 1992 (Fig. 2).

Abundance of the macroinfauna

As found in other studies (Jaramillo & McLachlan 1993, Jaramillo et al. 1993, Jaramillo 1994), the peracarids *Orchestoidea tuberculata* Nicolet (Amphipoda, Talitridae), *Excirolana braziliensis* Richardson and *Excirolana hirsuticauda* Menzies (Isopoda, Cirolanidae), and the anomuran crab *Emerita analoga* (Stimpson) (Hippidae) were the most common organisms at both beaches, being *Emerita analoga* and *Excirolana hirsuticauda* the most abundant (Fig. 3).

The temporal variability in population abundances of these species is shown in Figure 3. *Orchestoidea tuberculata* tended to occur in higher abundance, during autumn - early winter and late summer - early autumn; this pattern is more evident at Playa Universitaria where the highest abundance occurred during April - July 1992 and March - May 1993. *Excirolana braziliensis* was more abundant during summer - early autumn (February - April); while the abundance of *Excirolana hirsuticauda* and *Emerita analoga* were the most erratic, with many peaks being observed throughout the study period (Fig. 3).

The temporal variability in the abundance of *Excirolana braziliensis* was positively correlated with Dean's parameter (i.e., the highest abundances of this isopod occured when Dean's were lower; a more intermediate beach condition) and negatively correlated with beach face slopes. By contrast, other species did not show any significant correlations (Table 2).

The abundance of *Orchestoidea tuberculata* was significantly higher at Playa Universitaria during the first four months of the study period, but there were not differences in the rest of the period. In general, the other species did not show differences between the two beaches (Fig. 3).

Zonation of the macroinfauna

The monthly intertidal distribution of *Orchestoidea tuberculata*, *Excirolana braziliensis*, *Excirolana hirsuticauda* and *Emerita analoga* is shown in Figs. 4-7. Figure 8 shows the monthly variation in the location of the distribution mode of these species.

The amphipod *Orchestoidea tuberculata* occurred higher up on the beach (Fig. 4). The general trend was to show its maximum abundance above the drift line (dry zone) during late autumn throughout early spring (May - October), and below it (i.e., at the upper levels of the retention zone) during the summer months (December - March; Fig. 4). The analysis of the monthly variability of the

TABLE I

Physical characteristics at each beach and results of one way analysis of variance. Averages based on monthly data (n = 17 months). See values of p in the results of variance analyses

Características físicas de cada playa y resultados de los análisis de varianza de una vía. Promedios basados en datos mensuales (n = 17 meses). Ver valores de p en los resultados de los análisis de varianza

Variables	Beaches	Average	ANALYSIS OF VARIANCE Source of variation	ss	df	ms	f ratio	p
wave height (cm)	Playa Universitaria	297.6	between groups	10658.9	1	10658.9	0.947	0.3480
	Playa Grande	333.0	within groups	360022.1	32	11250.7		
			total	370681.1	33			
wave period (sec.)	Playa Universitaria	14.6	between groups	11.1	1	11.1	0.915	0.3561
	Playa Grande	13.4	within groups	387.1	32	12.1		
			total	398.2	33			
mean grain size (μm)	Playa Universitaria	274.1	between groups	6062.2	1	6062.2	8.864	0.0055
	Playa Grande	247.4	within groups	21884.8	32	683.9		
			total	27947.1	33			
Ω	Playa Universitaria	5.7	between groups	43.1	1	43.1	5.926	0.0207
	Playa Grande	8.0	within groups	233.0	32	7.3		
			total	276.1	33			
1/slope	Playa Universitaria	26.9	between groups	2439.5	1	2439.5	7.653	0.0093
	Playa Grande	43.9	within groups	10200.7	32	318.8		
			total	12640.2	33			

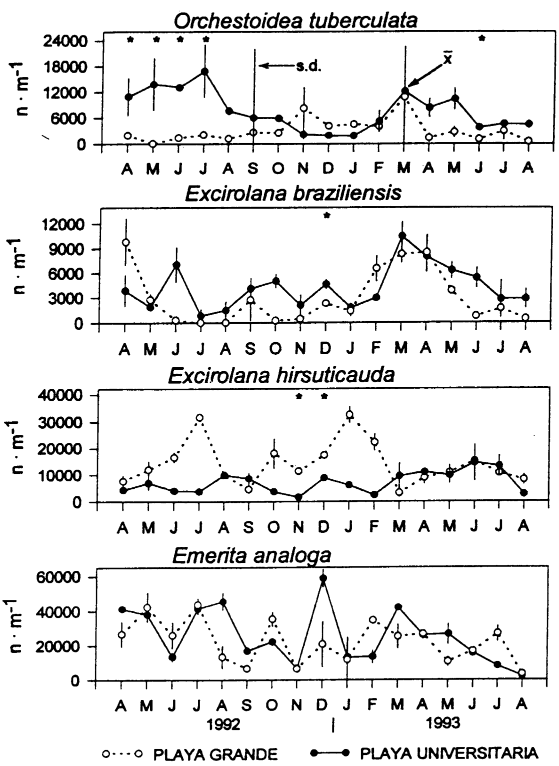

Fig. 3: Temporal variability in macroinfaunal abundances.

Variabilidad temporal en la abundancia de la macroinfauna.

distribution mode shows that at Playa Universitaria, *Orchestoidea tuberculata* moved up to beach levels located above the drift line during autumn and winter months and to lower beach levels (close to the drift line) during the warmer months (Fig. 8). A similar pattern of seasonal movements was not observed at Playa Grande where the distribution mode was always near by to the drift line (Fig. 8).

The isopod *Excirolana braziliensis* occurrred in the mid and upper levels of the retention zone (right below the drift line) without showing much seasonal variability in its zonation (Fig. 5). *Excirolana hirsuticauda* occurred throughout the entire retention zone; during some months, this isopod was also found in the upper and middle levels of the resurgence zone (Fig. 6). The distribution modes of both isopods was quite shifting at both beaches; it were usually found below the drift line (Fig. 8).

The anomuran crab *Emerita analoga* was mostly found in the swash zone and lower levels of the resurgence zone (Fig. 7). At both beaches, and during winter and spring, the distribution mode of *Emerita analoga* shifted towards lower beach levels than

TABLE 2

Results of regression analyses for the abundances of the species versus Ω and beach face slope from each site

Resultados de los análisis de regresión para las abundancias de las especies versus Ω y pendiente de cada sitio

Beaches	Species	Ω a	Ω b	Ω r	Ω p	1/slope a	1/slope b	1/slope r	1/slope p
Playa Universitaria	*Orchestoidea tuberculata*	7018.35	112.80	0.05	0.82	−2844.66	390.06	0.65	0.01
	Excirolana braziliensis	6761.26	−664.19	−0.48	0.05	−2844.09	202.36	0.47	0.05
	Excirolana hirsuticauda	5043.70	354.28	0.22	0.40	5905.23	43.29	0.08	0.74
	Emerita analoga	30324.90	−847.96	−0.12	0.64	8082.48	645.45	0.30	0.24
Playa Grande	*Orchestoidea tuberculata*	4265.03	−141.21	−0.15	0.56	3722.65	−13.49	−0.12	0.66
	Excirolana braziliensis	2545.88	211.01	0.24	0.35	3907.97	7.32	0.07	0.80
	Excirolana hirsuticauda	15914.40	−224.13	0.08	0.76	8314.31	132.45	0.38	0.13
	Emerita analoga	18175.90	513.43	0.12	0.63	10558.80	266.91	0.52	0.03

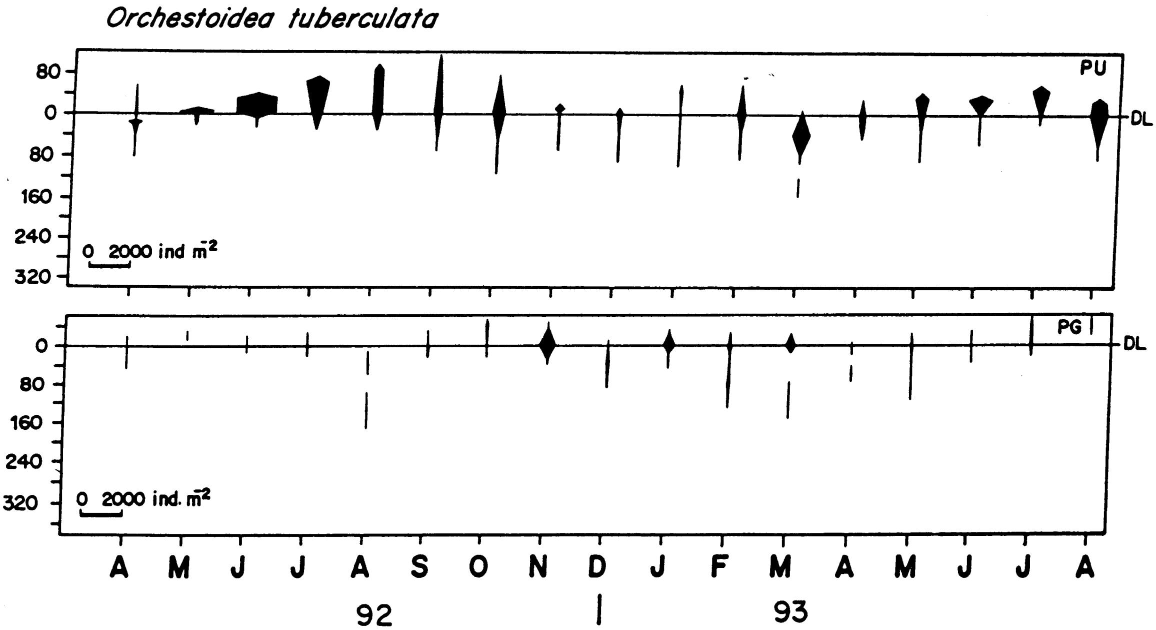

Fig. 4: Intertidal distribution of the amphipod *Orchestoidea tuberculata* relative to the drift line (DL). Numbers in the y axis refer to cm above and below drift line.

Distribución intermareal del anfipodo *Orchestoidea tuberculata* en relación a la línea de resaca. Los números en el eje y se refieren a cm sobre y bajo la línea de resaca.

those occupied during some warmer months (Fig. 8).

Orchestoidea tuberculata and *Excirolana braziliensis* occurred in sediments which rendered similar ranges in water content at both beaches (ca. 1 - 21%) (Fig. 9, Table 3). However, the most frequent occurrences for the former species were in sands with higher water contents (see the mode for both species at both beaches in Table 3). *Excirolana hirsuticauda* was collected from sediments with water contents between approximately 4 and 23% (Fig. 9); most frequently it occurred in sediments having 16 - 19% of water content (see the modes in Table 3). *Emerita analoga* was primarily collected from sediments having 20 - 21 % of water content (Table 3); its range was 8 - 34% (Fig. 9).

The results presented in Fig. 10 and Table 3 show that the sediments occupied by *Orchestoidea tuberculata* and *Excirolana braziliensis* were the softer ones (i.e., more penetrable during the low tide samplings), while those in wich *Excirolana hirsuticauda*

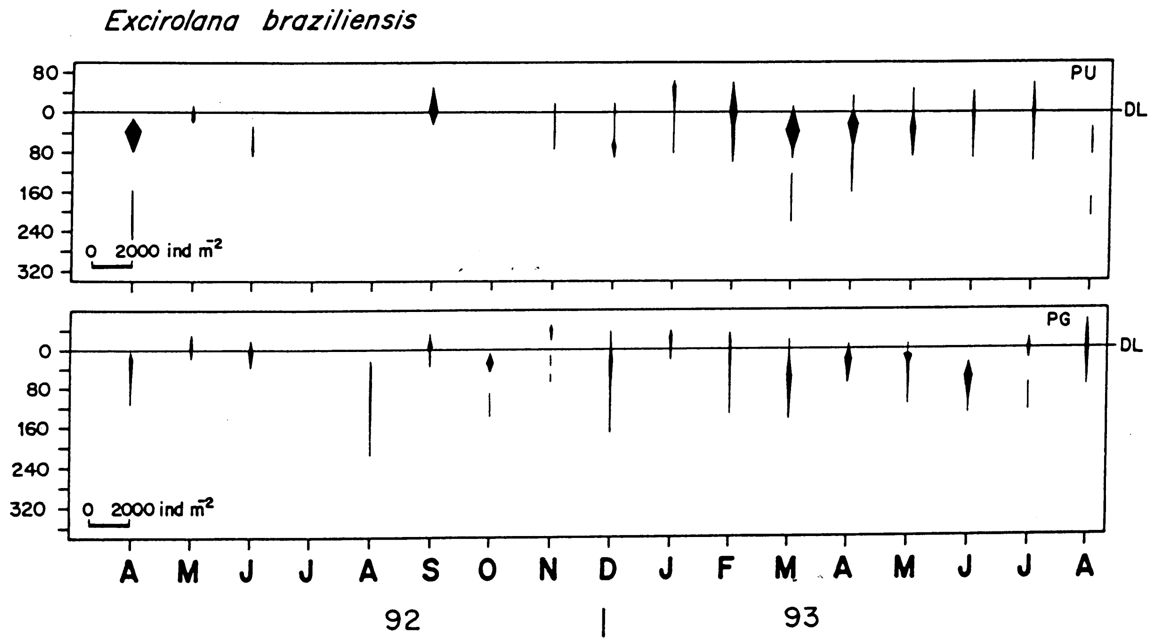

Fig. 5: Intertidal distribution of the isopod *Excirolana braziliensis* relative to the drift line (DL). Numbers in the y axis refer to cm above and below drift line.

Distribución intermareal del isópodo *Excirolana braziliensis* en relación a la línea de resaca. Los números en el eje y se refieren a cm sobre y bajo la línea de resaca.

TABLE 3

Water content and penetrability values of sediments from which the species were collected, in the beaches Playa Universitaria and Playa Grande

Contenidos de agua y valores de penetrabilidad en los sedimentos desde donde se recolectaron las especies en Playa Universitaria y Playa Grande

Beaches	Species	Water content (%) Average	(s.d.)	Mode	Range	Penetrability (cm) Average	(s.d.)	Mode	Range
Playa Universitaria	*Orchestoidea tuberculata*	6.8	(4.7)	5.1	1.3-20.1	2.7	(1.1)	2.1	0.9-6.0
	Excirolana braziliensis	7.3	(5.4)	4.7	1.3-19.2	2.6	(1.2)	2.1	1.0-6.0
	Excirolana hirsuticauda	18.0	(3.8)	16.0	3.9-23.0	1.2	(0.1)	1.0	0.6-2.7
	Emerita analoga	21.5	(3.1)	21.0	8.4-33.3	1.6	(0.5)	1.2	0.8-3.1
Playa Grande	*Orchestoidea tuberculata*	11.9	(5.4)	5.5	1.3-21.2	2.0	(0.9)	1.8	0.4-4.8
	Excirolana braziliensis	12.5	(6.0)	4.3	1.3-21.3	1.9	(0.9)	1.6	0.7-4.8
	Excirolana hirsuticauda	17.4	(3.9)	19.3	3.8-22.7	1.1	(0.4)	0.9	0.6-3.8
	Emerita analoga	21.9	(3.0)	20.2	13.3-33.8	1.3	(0.4)	1.2	0.6-2.5

and *Emerita analoga* were collected were the harder ones (i.e., lower penetrability values).

DISCUSSION

This study has shown that the physical characteristics of the beaches studied are quite dynamics. Consequently, it was expected that changes in beach morpho-dynamics might well affect the macroinfauna. However, habitat variation and macroinfaunal variations were not closely associated, at least on the scale of month to month changes. This suggests that apart from the beach physical factors studied, another ones should be involved in such a temporal variation of the macroinfauna. It is also possible that the macroinfauna of the sandy beaches studied indeed changes rapidly to

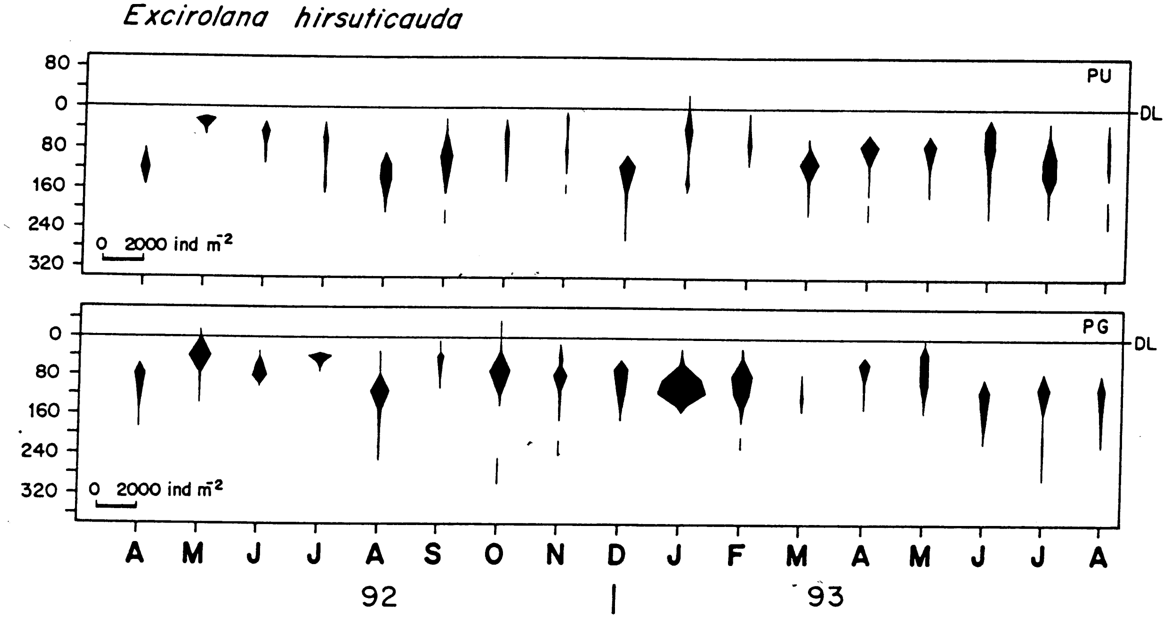

Fig. 6: Intertidal distribution of the isopod *Excirolana hirsuticauda* relative to the drift line (DL). Numbers in the y axis refer to cm above and below drift line.

Distribución intermareal del isópodo *Excirolana hirsuticauda* en relación a la línea de resaca. Los números en el eje y se refieren a cm sobre y bajo la línea de resaca.

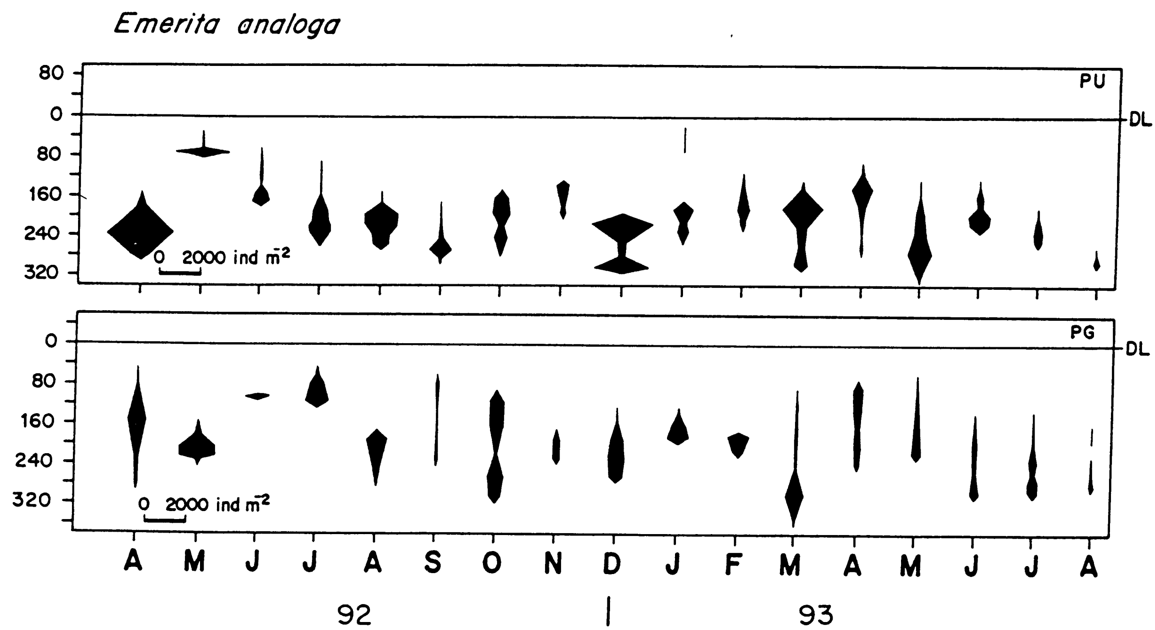

Fig. 7: Intertidal distribution of the anomuran *Emerita analoga* relative to the drift line (DL). Numbers in the y axis refer to cm above and below drift line.

Distribución intermareal del anomuro *Emerita analoga* en relación a la línea de resaca. Los números en el eje y se refieren a cm sobre y bajo la línea de resaca.

track environmental variations, but those changes occur in a time interval to which our sampling program was not the adequate to find relationships. It shoud be also pointed out that the beach state index (Dean's parameter) is strongly affected by wave height, a physical parameter which was estimated during a single observation period

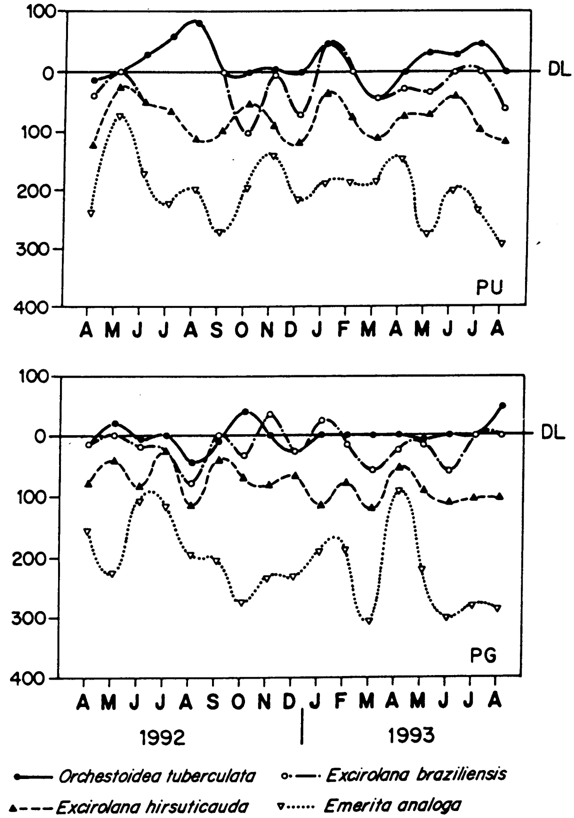

Fig. 8: Temporal variation of the distribution modes of the crustaceans relative to the drift line (DL) at Playa Universitaria (PU) and Playa Grande (PG). Numbers in the y axis refer to cm above and below drift line.

Variabilidad temporal en las modas distribucionales de los crustáceos en relación a la línea de resaca. Los números en el eje y se refieren a cm sobre y bajo la línea de resaca.

at each site. Thus it is possible that this highly temporally variable parameter may have had a strong influence on monthly values calculated for this index, thus rendering misleading results.

The absence of relationships between habitat and faunal variations at the beaches studied means that the relationship found by several authors between beach type and community structure of the macroinfauna (McLachlan 1990, McLachlan et al. 1993, Jaramillo & McLachlan 1993, Jaramillo et al. 1993 and Jaramillo 1994) does not hold when time scales longer than sanpshot samplings are considered. However, there are some studies wich suggest that there are close relationships between physical and macroinfaunal variation. For example, Croker et al. (1975) and Leber (1982) reported seasonal changes in the community structure of sandy beaches of northern New England and North Carolina, respectively; changes probably related to seasonal changes in environmental temperature. Brazeiro & Defeo (1996) reached similar conclusions after studying a sandy beach of Uruguay for a period of one year. For seasonal differences in abundances and zonation of the macroinfauna inhabiting a sandy beach of north central Chile, Sánchez et al. (1982) suggested variation in grain size and beach face slope.

The findings of this study show that the zonation patterns described earlier for the macroinfauna of this area (Jaramillo &

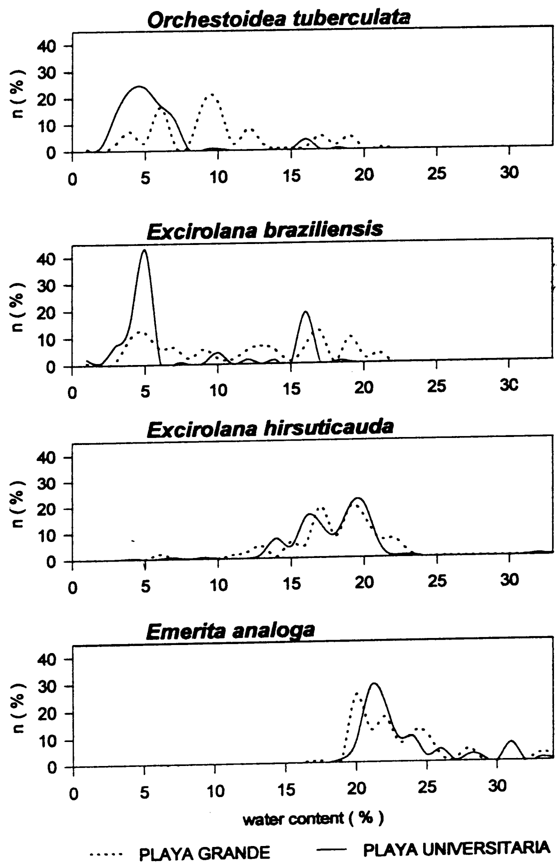

Fig. 9: Frequency of water contents of sediments from which *Orchestoidea tuberculata*, *Excirolana braziliensis*, *Excirolana hirsuticauda* and *Emerita analoga* were collected.

Frecuencias de contenidos de agua en los sedimentos de los cuales se recolectaron *Orchestoidea tuberculata*, *Excirolana braziliensis*, *Excirolana hirsuticauda* y *Emerita analoga*.

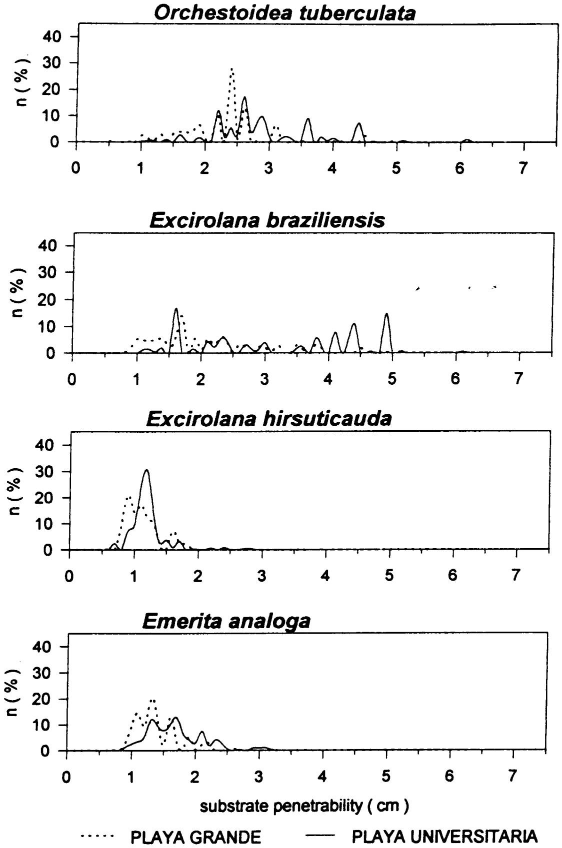

Fig. 10: Frequency of penetrabilities of sediments from which *Orchestoidea tuberculata*, *Excirolana braziliensis*, *Excirolana hirsuticauda* and *Emerita analoga* were collected.

Frecuencias de penetrabilidades en los sedimentos de los cuales se recolectaron *Orchestoidea tuberculata*, *Excirolana braziliensis*, *Excirolana hirsuticauda* y *Emerita analoga*.

McLachlan 1993, Jaramillo et al. 1993, Jaramillo 1994), and which resulted from snapshot samplings hold quite well. Thus, even when species shift seasonally in their across shore distribution, they were distributed in a well defined zonation pattern with talitrid amphipods and cirolanid isopods in the upper beach levels, cirolanid isopods in the middle ones and anomuran crabs in the lower beach levels. It is worthwhile mentioning that this zonation pattern represent the day low tide zonation when most of the animals are buried below the sand surface. This accentuates the physical differences of sand types occupied by the different species and exemplified by the specific differences in water content and penetrability of sands.

The former results are also reminiscent of those reported in the supra regional study of Dahl (1952), the paradigmatic study to which most zonation schemes are compared; the amphipod as a characteristic species of the supratidal zone and the isopods as typical from the midlittoral zone. Dahl (1952) also found anomuran crabs (*Emerita analoga*) in the lower beach levels of a sandy beach located in central Chile (Montemar); however, he did not use this organism to characterize the infralittoral zone of temperate, but of tropical and subtropical beaches.

The results of this study show that the suggested zonation scheme of Salvat (1964, 1966), which is based upon relative humiditiy of sands, and thus independent of zoogeographical limitations and presence of characteristics organisms, can be superimposed to that of Dahl (1952). *Orchestoidea tuberculata* and *Excirolana braziliensis* occurred highest on the beach, with a trend for the former species to shift a bit higher during some months, thus characterizing the dry upper beach zone with the driest and softest sands. The latter species characterized the upper levels of the retention zone. *Excirolana hirsuticauda* occupied the mid beach levels, primarily the lower levels of the retention zone, while *Emerita analoga* was a typical organism of the lower shore, characterizing the resurgence - swash zone.

But even when both, Dahl's (1952) and Salvat's (1964) schemes can be superimposed themselves for the case of the studied beaches, some exceptions are still found; e.g, in some months the distribution of the isopod *Excirolana braziliensis* extended up to the dry zone - supralittoral zone.

In conclusion, our results show that despite the dynamic nature of the beaches studied, the population abundances of their crustaceans tend to be independent of beach stage. They also tend to have temporal changes, but no always seasonal repeteable distributional patterns. The species studied here, were always present at both study sites. Both, a cirolanid isopod (*Excirolana hirsuticauda*) and an anomuran crab (*Emerita analoga*) are the most abundant species, a conclusion which seems to stands for all the south central Chile, providing that similar types of beaches are compared (cf. Jaramillo *et al.*, 1993).

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