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Longshore Distribution of *Mesodesma donacium* (Bivalvia: Mesodesmatidae) on a Sandy Beach of the South of Chile

by

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Abstract. Monthly samples were taken from February 1989 to January 1990 to evalute the longshore distribution and density of the bivalve *Mesodesma donacium* in a dissipative beach in southern Chile. The results showed that its distribution was patchy. Adult clams were confined to the surf zone, while the vast majority of juveniles occurred in the swash zone. The highest densities of adults were found in summer and autumn (up to 159 individuals per 0.25 m^2 in February 1989), while the minimum occurred during winter. Juveniles had similar densities all year round (up to 16–20 individuals per 0.25 m^2). Most clams collected in the surf zone had similar shell lengths (70–75 mm); those collected in the swash zone were smaller than 25 mm. No relationships were found between distribution and abundances of clams and variability in textural characteristics of the surf or swash zone. Due to the limited longshore variability in grain size and sorting of sands, it is suggested that the variabilities in distribution and abundances of clams may be related to large-scale habitat characteristics rather than to small-scale textural variability.

INTRODUCTION

Macroinfaunal species living on exposed sandy beaches often show aggregated patterns of distribution. Such is the case of haustoriid amphipods (Dexter, 1971), isopods (Bally, 1983; Glynn et al., 1975), anomuran decapods such as *Emerita* (Efford, 1965; Cubit, 1969; Dillery & Knapp, 1970; Perry, 1980; Bally, 1983; Bowman & Dolan, 1985), and bivalves such as *Donax* (Loesch, 1957; Bally, 1983; McLachlan & Hesp, 1984; Sastre, 1985), *Donacilla* (McLachlan & Hesp, 1984), and *Mesodesma* (Tarifeño, 1980; Defeo et al., 1986). While some authors have suggested that biological factors (e.g., reproductive behavior) have an important role in explaining these aggregated patterns (e.g., Efford, 1965), most have stressed the role of beach morphodynamics and/or physical characteristics in general as primary causes of patchiness in these habitats. For example, Cubit (1969) and Bowman & Dolan (1985), found that aggregations of *Emerita* are associated with beach morphology such as cusps and troughs. A similar situation was recorded by McLachlan & Hesp (1984), who found that in an Australian reflective beach, *Donacilla angusta* and *Donax parva* occurred with the highest abundances in the cusp bays.

Mesodesma donacium (Lamarck, 1818) is a typical inhabitant of the surf and subtidal zones of exposed sandy beaches of the Chilean coast (Tarifeño, 1980). This bivalve supports a fishery of high commercial value; figures from

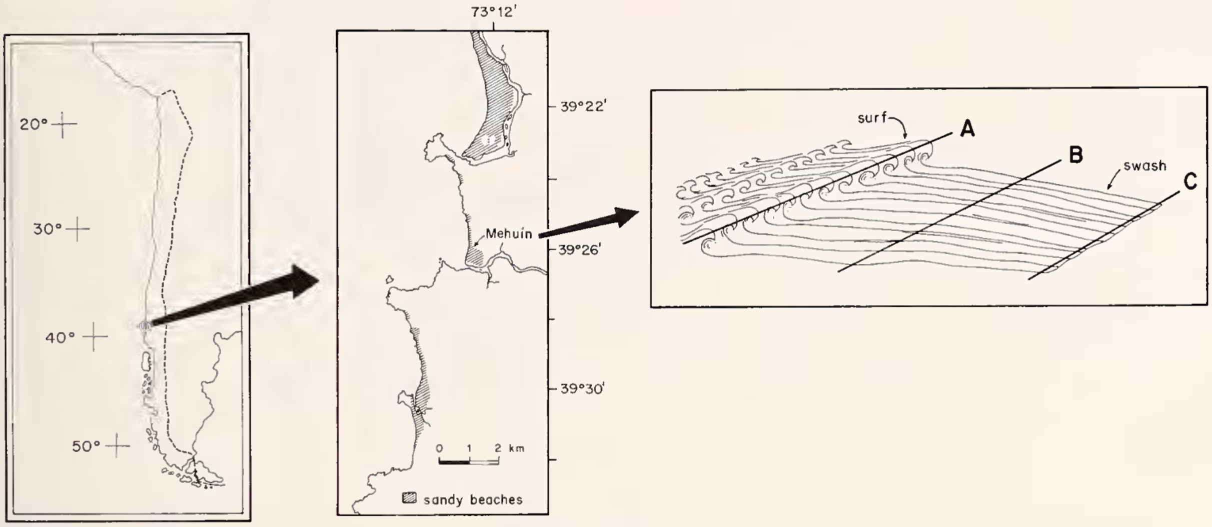

Figure 1

Location of the beach at Mehuín, southern Chile, and positions of transects A (surf zone), B, and C (upper limit of the swash run-up).

SERNAP (Servicio Nacional de Pesca) show that in the years 1988–1991, the landing of *M. donacium* in the Chilean coast has varied between 17,122 tons in 1989 and 9397 tons in 1990. In the same period, beaches located in the X Region of the country (about 40–42°S) have produced 25–58% of the annual catch (SERNAP, 1988–1991). The findings of Tarifeño (1980) for sandy beaches of Valparaíso, Chile (ca. 32°S) confirm that *M. donacium* is not evenly distributed along the coast and that its distribution might be related to longshore differences in sand-grain size. Moreover, unpublished observations have suggested that the temporal distribution of *M. donacium* in sandy beaches of the south of Chile follows a dynamic pattern.

The present study evaluates the spatial and temporal variability in the longshore distribution of *Mesodesma donacium* in southern Chile. Relationships between this variability and sand-grain size distribution are also examined.

MATERIALS AND METHODS

The sandy beach at Mehuín, Chile (39°26′S, 73°13′W) is a dissipative beach 1800 m long and fully exposed to breaking waves of the Pacific Ocean (Figure 1). Preliminary sampling of the swash zone and the near-shore edge of the breakers showed that most adult *Mesodesma donacium* (>55 mm) occurred near or just at that edge; for example, 75–90% of the adults collected during these samples (January and February 1989) came from between the breaker line and the swash zone on the beach face. Definitive collections (February 1989–January 1990) for adult clams were therefore carried out in the surf zone, which was about 1.2–1.5 m deep. One quadrat of 0.25/m^2 (ca. 35 cm deep) was sampled at 100-m intervals along a longshore transect covering most of the length of the beach (transect A, Figure 1). Clams were collected in a way similar to how fishermen collect *M. donacium* in the sandy beaches of south-central Chile—by twisting the feet in an area enclosed for the sampling quadrat and using the body weight to excavate the sand until clams emerged at the sediment water interface to be picked up by hand. To ensure all the clams were collected, the sediments of the sampling areas were carefully examined by hand.

Preliminary observations suggested that most juvenile *Mesodesma donacium* inhabit the mid- to high levels of the swash zone. Metallic cylinders (20 cm in diameter, 35 cm long) were used to collect sediment samples in the mid swash zone (i.e., the mid distance between the near-shore edge of the breaker zone and the upper limit of the swash run-up; transect B, Figure 1) and at the upper limit of the swash run-up (transect C, Figure 1) (one sample every other 100 m). These collections were made at the same intervals established for the surf zone (transect A). The near-shore edge of the breaker zone was also examined for juvenile clams. However, due to difficulties in using 20-cm-diameter metallic cylinders, we used PVC cylinders of 10-cm diameter (20 cm long) to collect sediment samples in the latter zone. Sediment samples collected from stations located at transects A, B, and C, and aimed to assess the distribution and abundance of juveniles, were sieved through a 1-mm-mesh sieve, the residue being carefully examined under a binocular microscope. Density data of adult and juvenile clams were expressed as the number of individuals per 0.25 m^2. Morisita's index of dispersion was used to measure the spatial pattern of clams. Shell-size analyses were based on anteroposterior shell lengths obtained with vernier calipers (±0.1 mm).

A 1.7-cm-diameter plastic cylinder was used to collect sediment samples from areas close to each sampling station

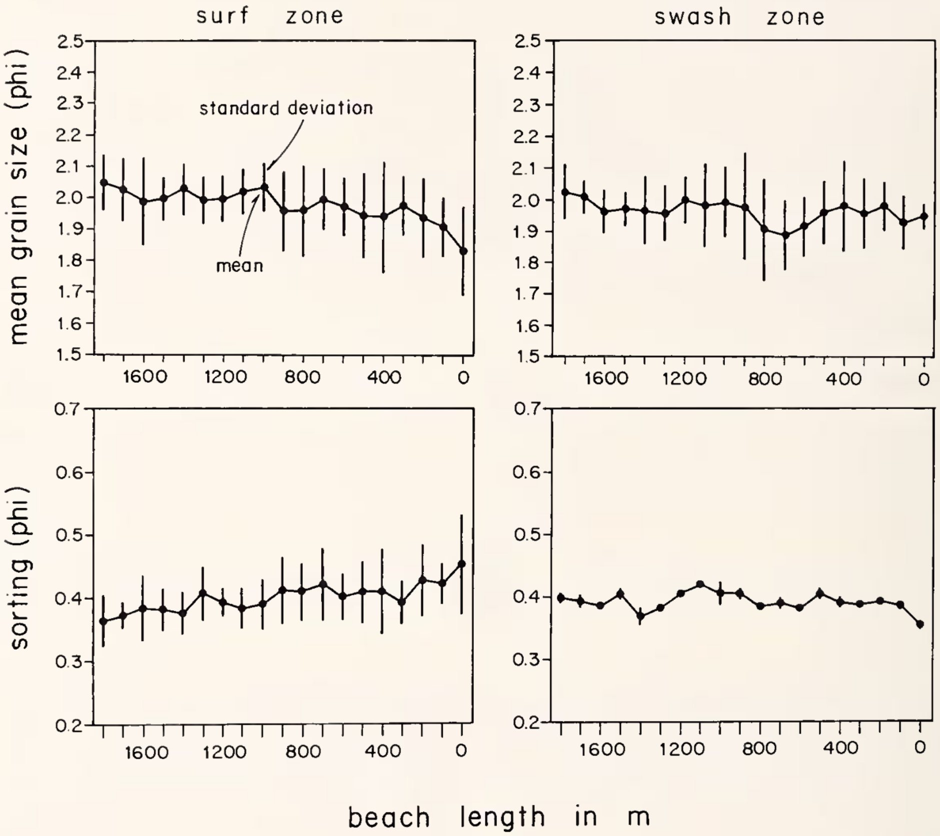

Figure 2

Spatial variability in mean sand-grain size and sorting along the surf and swash zone of the beach at Mehuín. The values are means based upon monthly measurements (n = 12).

to analyze relationships between clam distribution and density and textural characteristics of the sediments. Sand samples were washed with tap water to remove salts and analyzed with an Emery settling tube (Emery, 1938). Mean grain size and sorting were calculated with a moments computational method (Seward-Thompson & Hails, 1973) using a program written by Pino (1982) for a Hewlett-Packard 41 CV.

RESULTS

The sands of the surf and swash zones at the beach of Mehuín were similar in mean grain size and sorting (Figure 2). Most of the sediments can be classified as medium (1–2 phi), well-sorted sands (Folk, 1980). Mean grain size and sorting showed no longshore spatial or seasonal trend; thus, the results are presented as means for the whole period (Figure 2).

Mesodesma donacium had a discontinuous longshore distribution along the beach; that is, several clam beds were clearly distinguished during each sampling period (Figure 3). These beds were usually separated, either by areas with very low densities or by vacant areas whose lengths ranged from 200 to 800 m. The most extensive beds were observed in February 1989, when the length of the largest bed was close to 500 m. The location of the surf areas that had the maximum densities of clams shifted throughout the study period. For example, during February 1989 the greatest densities of *M. donacium* were observed 500 m and 1500 m from the starting point (0 m) of transect A, while during May, density peaks were observed at 0 m and 600 m (Figure 3). The density of clams in the surf-zone beds were highest in February 1989, when a maximum of 159 individuals per 0.25 m^2 was collected at the 1500-m sampling station. High densities were also observed during May; thereafter, the population declined continuously until the following November, when the maximum density of adults was only 53 individuals per 0.25 m^2. Spring recovery was apparent, since low densities of clams were again observed during December and January (Figure 3).

The majority of clams collected in the surf zone (transect A) were adults. Mean shell lengths along the studied surf beds were quite similar (Figures 3, 4). The most representative size classes were 70–75 mm in shell length (Figure 3). During some months, smaller shell lengths occurred

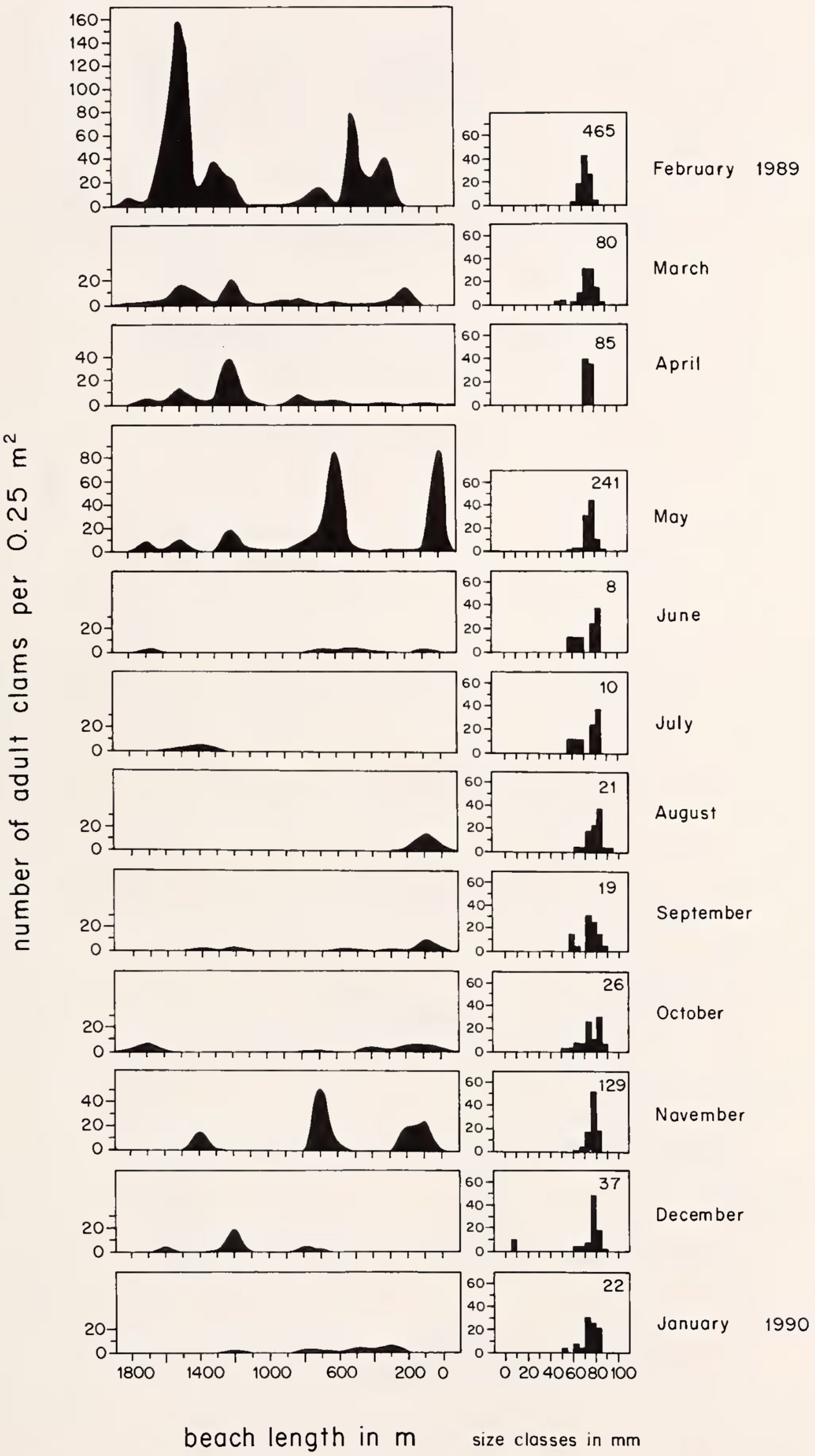

Figure 3

Spatial variability in the density of *Mesodesma donacium* along the surf zone of the beach of Mehuín. The monthly histograms show the size-class distribution (frequency in percentage) of the total number of clams collected each month.

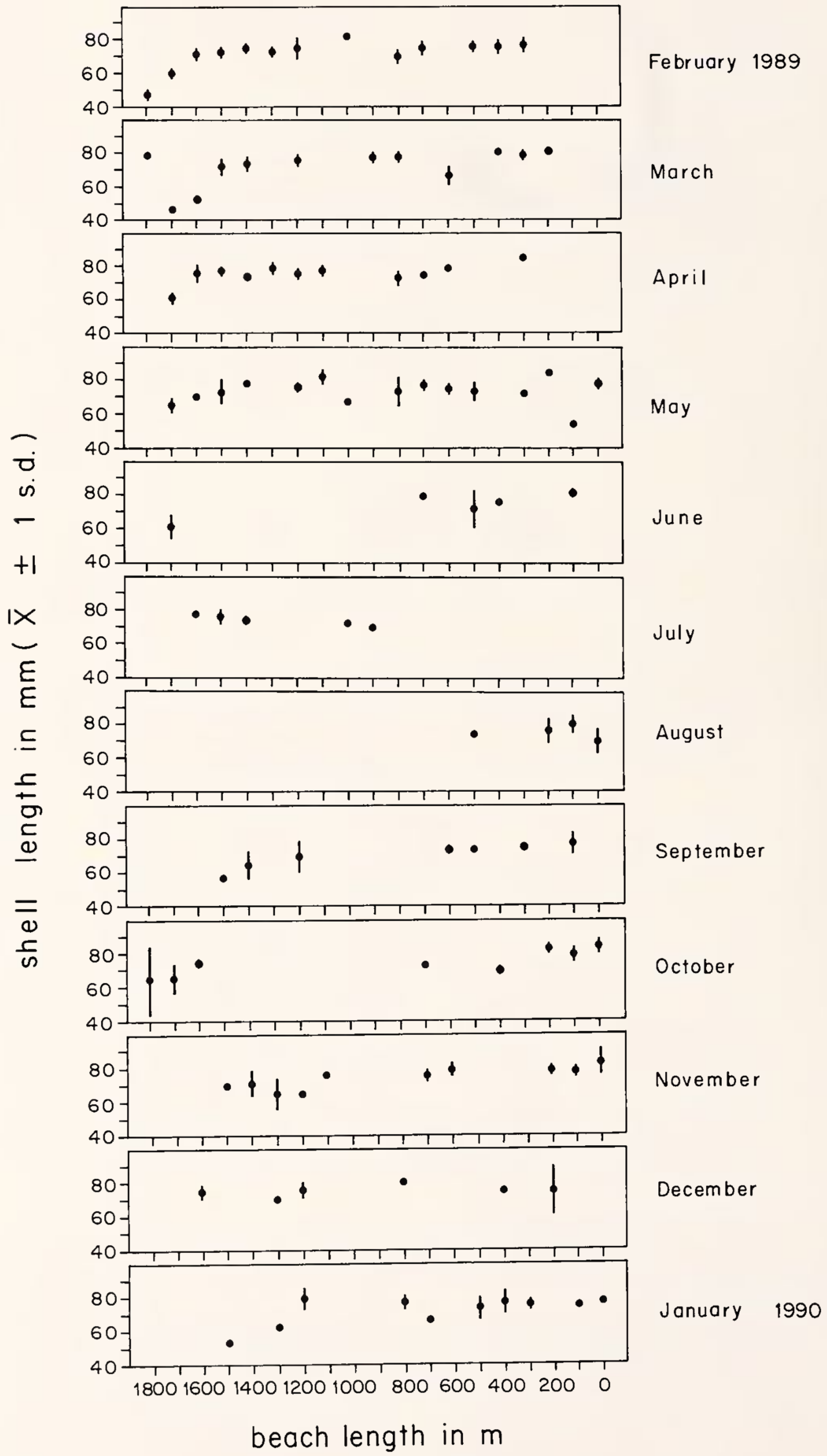

Figure 4

Spatial variability in the mean shell length of *Mesodesma donacium* along the surf zone of the beach at Mehuín.

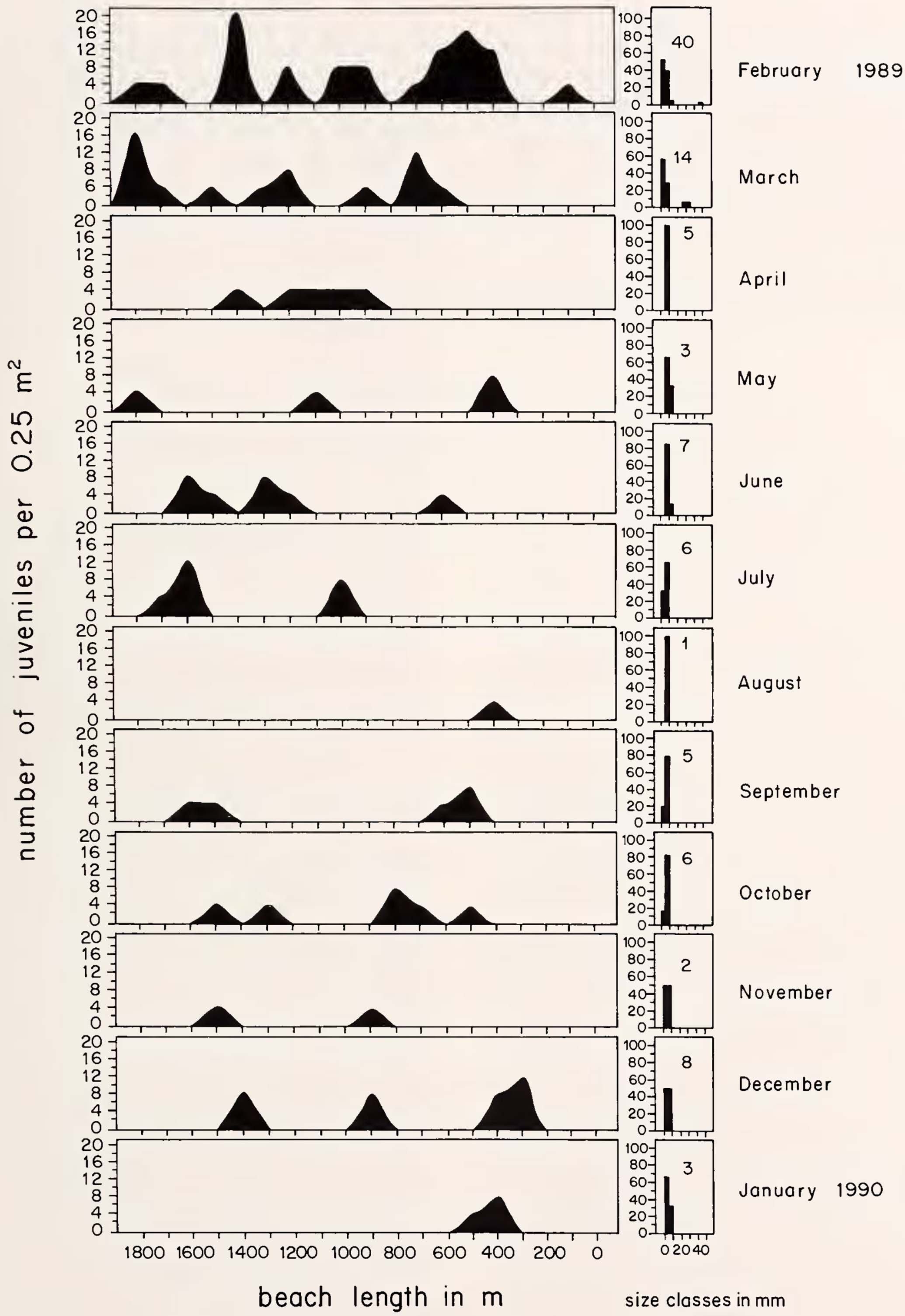

Figure 5

Spatial variability in the density of *Mesodesma donacium* along the swash zone of the beach at Mehuín. The monthly histograms show the size-class distribution (frequency in percentage) of the total number of clams collected each month.

at the final portion of transect A, about 1700–1800 m from the starting point. For example, clams as small as 45–48 mm were collected along the final portion of the transect during February and March (Figure 4). Clams collected in the swash zone (transects B and C) were represented by specimens smaller than 25 mm and also had a discontinuous distribution along the beach (Figure 5). The highest densities of these juvenile specimens (up to 16–20 individuals per 0.25 m^2) occurred during February and March.

Monthly values of Morisita's index of dispersion for adult and juvenile clams were significantly greater than 1, indicating an aggregated pattern of distribution (Table 1).

Table 1

Values of Morisita's index of dispersion for clams collected in the surf and swash zone of the beach of Mehuín. Values <1 = regular distribution, 1 = random, >1 = aggregated.

Month	Surf zone	Swash zone
February 1989	3.41	2.12
March	2.98	3.01
April	4.69	3.04
May	4.67	6.00
June	1.93	3.53
July	4.40	6.53
August	7.85	17.00
September	4.32	4.37
October	2.61	3.59
November	4.43	7.78
December	4.95	4.06
January 1990	1.91	8.75

DISCUSSION

The results of this study show that the spatial distribution of *Mesodesma donacium* was patchy. Similar findings were obtained by Tarifeño (1980) for sandy beaches of central Chile and by Defeo et al. (1986) and Olivier et al. (1971) for *M. mactroides* in comparable habitats of Uruguay and Argentina, respectively. *Donax,* another bivalve genus typically inhabiting sandy beaches, also shows an aggregated pattern of distribution, either in warm (Sastre, 1985; Neuberger-Cywiak et al., 1990) or temperate waters (Ansell, 1983; Donn, 1987). The development of a patchy distribution might be related to a high substrate selectivity, as has been shown for *D. denticulatus* (Wade, 1967; Ansell & Trevallion, 1969; Trueman, 1971).

The maintenance of clams in substrates with particular swash or surf characteristics might be related to their burrowing abilities, which in turn are related to grain sizes. For example, Brito & de Mahieu (1981) (not seen but cited in Neuberger-Cywiak et al., 1990) found that the burrowing speed of *Donax denticulatus* was higher in sands with finer grains. Thus, it is quite reasonable to conclude that grain-size characteristics are of primary importance in the distribution of sandy beach clams. However, Sastre (1985) and Neuberger-Cywiak et al. (1990) found that *D. denticulatus* in Puerto Rico and *D. trunculus* in Israel showed aggregated patterns of distribution, in spite of sand-grain sizes being homogeneous along the shore. This agrees with our findings for *Mesodesma donacium* in the beach at Mehuín: thus, causes other than sand-grain size must lead to the patchy distribution of these clams.

Biological interactions have been postulated to produce aggregated distributions in sandy beach organisms. For example, Leber (1982) suggested that the patchy distribution of *Donax* in sandy beaches of North Carolina was related to competition with *Emerita*; however, no strong evidence has been provided to support this suggestion. Predation by birds and fishes has also been invoked as a cause for patchy distribution of sandy beach bivalves (e.g., Loesch, 1957; Wade, 1967; Leber, 1982; Ansell, 1983). Vertebrate predation is not strong enough to affect clam distribution, even when gulls (*Larus dominicanus*) prey on medium-size specimens of *Mesodesma donacium* inhabiting the low levels of the swash zone. Instead, it is suggested that the temporal variability in the distribution and abundance of *M. donacium* is related to continuous changes in large-scale habitat characteristics.

Short-term changes in beach topography have been documented for the intertidal zone of the beach of Mehuín (Jaramillo, 1987). Similar variability has also been observed for the surf and subtidal zones of this beach; thus, changes in the position of bars, troughs, rip currents and, also, massive transport of sands along the shore occurs over short periods of time (i.e., days and weeks), a situation that may affect the distribution of clams, either by concentrating them in some areas or by causing high mortalities in these populations. This massive transport of sand may also cause emigration to deeper waters, resulting in complete absence or limited abundance of clams in the surf zone during certain months, especially during the winter period. Defeo et al. (1986) mentioned that clam beds of *Mesodesma mactroides* in sandy beaches of Uruguay varied in length day by day as a result of sudden changes in environmental conditions. Neuberger-Cywiak et al. (1990) reported that *Donax trunculus* was more abundant in some shallow underwater rises and suggested that this pattern was produced by active migration and currents. Penchazadeh & Olivier (1975) reported that, in Argentinean sandy beaches, *Donax hanleyanus* had higher abundance in similar rises, while McLachlan & Hesp (1984) found that, in an Australian reflective beach, *Donacilla angusta* and *Donax parva* occurred with the highest abundances in cusp bays, which should provide maximum feeding time. These observations were similar to those of Donn et al. (1986), who found higher abundances of *Donax serra* where beach face slopes were flattest in an intermediate beach in South Africa. This suggests that this bivalve might be able to detect spatial variability in beach slope.

This study has shown a clear size-based separation in the vertical zonation of *Mesodesma donacium,* with the adult clams restricted to the surf zone and the juveniles primarily in the swash zone. Tarifeño (1980) reported similar findings for sandy beaches in Valparaíso, Chile, trends opposite to those suggested by Arntz et al. (1987) for shallow waters of the Peruvian coast, where many juveniles of *M. donacium* recruit in deeper waters and grow while they migrate toward the shore. The present results are also similar to those for *Donax serra* inhabiting a comparable habitat on the west coast of South Africa, where smaller individuals occur higher in the shore and larger ones farther down (De Villiers, 1975; Donn, 1990). But, in contrast to the findings from the beach at Mehuín, Jaramillo et al. (unpublished data) found that juveniles (in low numbers) coexisted with adults in the surf zone in an intermediate beach near the outlet of the Queule River estuary, 5 km north of Mehuín. Differences in wave disturbance might well account for the local variability in the distribution of juveniles. The more developed breaker zone at the beach of Mehuín could preclude the maintenance of a stable population of juveniles in the surf zone. However, it is also possible that the almost complete absence of juveniles recorded in the surf zone at Mehuín could have been related to the small coring device used in the present study.

Mean shell lengths of adult clams along the surf zone at the beach of Mehuín were similar to those observed in other beaches of Chile (Tarifeño, 1980). Thus, most of these clams probably belonged to the same age class. However, during certain months smaller clams occurred toward the southern section of the longshore sampling transect, close to the outlet of Lingue River estuary. Similar results were reported by Donn (1987), who found that juveniles of *Donax serra* were more abundant toward river mouths in two bays in South Africa. He suggested that spat of *D. serra* were able to select these sheltered areas (Donn, 1987). High abundances of juveniles of *Mesodesma donacium* have also been found in the sand flats located at the mouths of estuaries close to the beach at Mehuín (E. Jaramillo, unpublished data). However, there is insufficient evidence to conclude that this is a similar situation to that suggested by Donn (1987). Extensive sampling in the sublittoral zone of the beach at Mehuín could reveal a similar pattern to that suggested by Arntz et al. (1987) for shallow waters of Peru; that is, considerable recruitment of juveniles.

The present study has shown that the patchy distribution of *Mesodesma donacium* cannot be directly related to changes in sand-grain size characteristics. However, some relationships still may exist, but were not detected because of the span of the sampling schedule. Sudden changes in surf and swash zone morphodynamics should confer changes in textural characteristics of sediments and, if the distribution and abundance of *M. donacium* is related to such large-scale habitat changes, it should also be related to changes in sand-grain size. Clearly, more detailed studies including short-term monitoring of textural and large-scale habitat characteristics are needed to understand the dynamics of surf clam populations in the south of Chile.

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