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Spatial and temporal variations in recruitment of *Donax serra* Röding (Bivalvia: Donacidae) on an exposed sandy beach of South Africa

Variación espacial y temporal del reclutamiento de *Donax serra* Röding (Bivalvia: Donacidae) en una playa expuesta del litoral sudafricano

MARIANO LASTRA[1] and ANTON McLACHLAN[2]

[1]Departamento de Recursos Naturales y Medio Ambiente, Area de Ecología, Universidad de Vigo, España
[2]Zoology Department, University of Port Elizabeth, Port Elizabeth 6000, South Africa

ABSTRACT

Included in a large project on the population dynamics of *Donax serra* along the eastern coast of South Africa, a study was developed to analize spatial and temporal variations in the recruitment. Samples were taken monthly in the surf zone of a 24 km exposed sandy beach (Maitlands beach) from April 1993 to March 1994, by sampling 17 stations at approximately 1 m depth in the surf which were equally spaced every 1.5 km. At each of these, 1 m^2 quadrats were excavated with a spade to an approximate depth of 8 cm. The sediment was sieved through a mesh of 1 mm. Samples were also collected for grain size analysis. Analysis of length-frequency histograms shows that the maximum abundance of recruits (individuals < 8 mm) occurred during the warmest months of the year, but recruitment was scattered in space, and apparently enhanced near the proximity of a river mouth. Regression analyses showed a significant correlation between abundance of recruits and percentage of fine sand, with the significance decreasing with increase in the size of recruits. These results suggest that grain size characteristics (*i.e.*, % in fine sands) are important in explaining the spatial distribution of recruitment in *D. serra*.

Key words: Sandy beach, size distribution, recruitment, correlation, *Donax*.

RESUMEN

Se llevó a cabo un estudio cuantitativo del reclutamiento de *Donax serra*, dentro de un proyecto relacionado con la variación espacial y temporal del reclutamiento de esta especie en la costa oriental de Sudáfrica. Con este objetivo se llevó a cabo una campaña de muestreos mensuales en la zona de surf de una playa expuesta, recogiéndose muestras a lo largo de 24 km de playa desde abril de 1993 hasta marzo de 1994, sobre un total de 17 estaciones de muestreo situadas aproximadamente a 1 m de profundidad y separadas 1,5 km. En cada lugar de muestreo se recogió un cuadrante con superficie de 1 m^2, penetrando 8 cm en el sedimento. Las muestras se tamizaron con malla de 1 mm y se recogió sedimento para el análisis granulométrico. El análisis de los histogramas talla-frecuencia mostró que las máximas abundancias de reclutas (individuos menores de 8 mm) se registraron durante los meses más cálidos del año, a pesar de lo cual, el reclutamiento de *D. serra* es disperso en términos espaciales y se incrementa en las proximidades de la desembocadura del río. Los análisis de regresión mostraron una correlación significativa entre la abundancia de reclutas y el porcentaje de arenas finas. Esta correlación disminuye a medida que se incrementa la talla de los reclutas. Los resultados sugieren que la granulometría del sedimento (*i.e.* las arenas finas) es un factor importante en la distribución espacial del reclutamiento de *D. serra*.

Palabras clave: Playas arenosas, distribución de tallas, reclutamiento, sedimentología, correlación, *Donax*.

INTRODUCTION

Donax serra is the largest size species in the genus, and its distribution extends from the north coast of Namibia to Transkei, on the eastern coast of South Africa. It is most abundant on exposed beaches where the sand is not too coarse and phytoplankton production is high. In general, more exposed beaches harbour larger populations of *D. serra,* and the species subsists mainly on phytoplankton blooms and organic froth resulting from heavy wave action (McLachlan & Hanekom 1979).

D. serra spats settle in the subtidal zone, and move upshore as they grow. The growth

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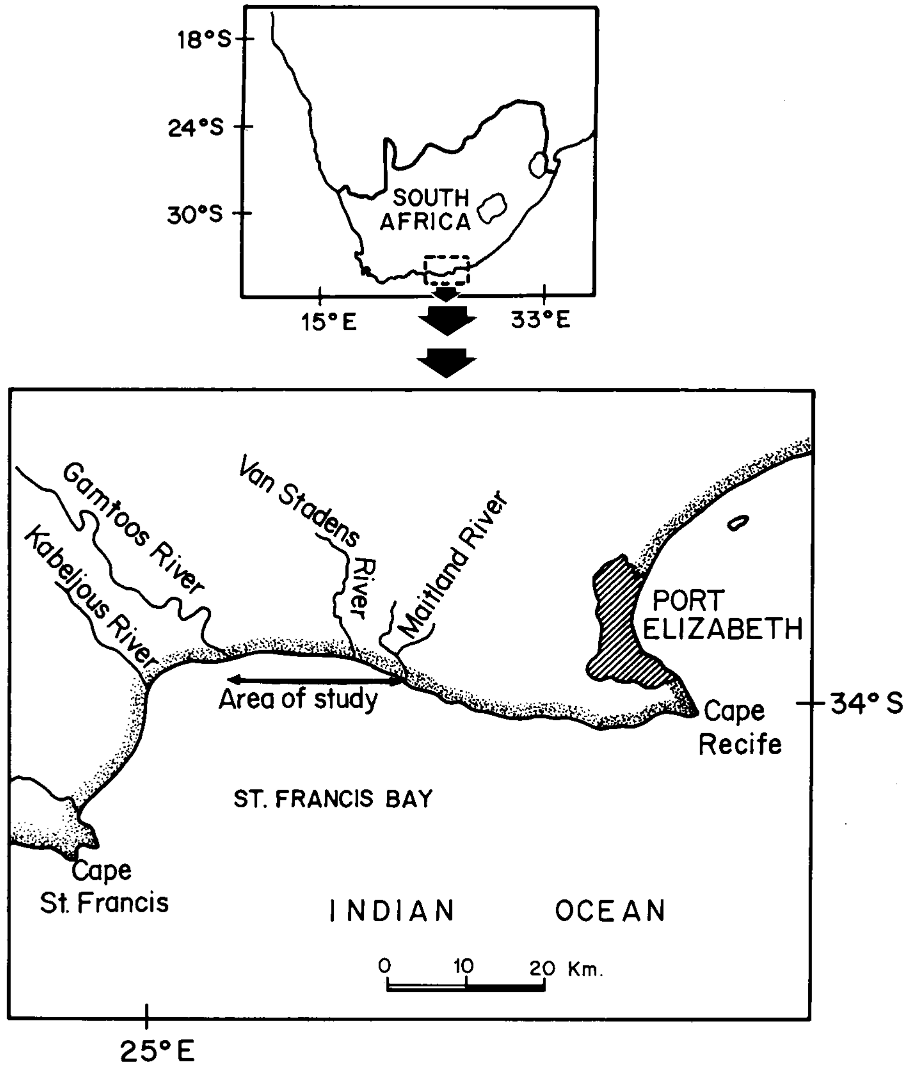

Fig. 1: Area of study east coast of South Africa.

Area de estudio en la costa este de Sudáfrica.

of this species is initially rapid, reaching 32 mm in the first year and 48 mm in the second year (McLachlan & Hanekom 1979). Thereafter, growth slows and mortality rates are low; most of the adult production goes into reproduction. Reproductive studies have showed that there are two spawning periods during January-April and during July-August and sexual maturity is attained between 38 mm and 49 mm on the west coast of South Africa (Hanekom 1975), and approximately at 45 mm on the east coast (McLachlan & Hanekom 1979). Some aspects of the ecology of *D. serra* differ considerably between east and west coasts, especially in relation to its distribution across the beach. On the east coast, adults occupy the mid to upper intertidal zone, and individuals < 15 mm length are most abundant in the subtidal (Donn et al. 1986). On the west coast, this intraspecific size zonation is reversed, with the smallest individuals occuring highest on the shore and the adults being most abundant in the subtidal (De Villiers 1975, Bally 1983).

Most of the published literature deals with biology and ecology of adults populations of *D. serra*. In contrast, very limited information is available concerning spatio-temporal variability in recruitment. The objetive of this study is quantifying the recruitment of this species and assesing spatial variability in this process in relation with the sedimentological parameters.

METHODS

The study was undertaken at Maitlands Beach, an exposed beach/dune system located 40 km west of Port Elizabeth, in the Indian Ocean. In this beach *D. serra* presents areas of high densities and there is only slight pressure by human activity which consist of limited collection for bait or food, always in small quantities.

Attempted to estimate when, where and in which conditions the recruitment of *D. serra* occurs, the sampling was undertaken in 17 stations at 1.5 km intervals along a 24 km shoreline located between two river mouths (Maitland River and Gamtoos River) (Fig. 1). All stations were sampled monthly between April 1993 and March 1994. Sampling was done during spring tides between the hour before and the hour after spring low tide.

Since this species recruits in the subtidal zone, our sampling was undertaken in this part of the beach, approximately at 1 m depth. At each station, an area of 1 m^2 was excavated to a depth of 8 cm, and the sediment sieved through a 1 mm mesh.

Samples were collected with an spade enclosed with 1 mm mesh, and covering 0.042 m^2; 24 samples provided a total area of 1 m2 at each station. Sediment samples were obtained using a small corer to a depth of 10 cm, taking three replicates at each station in the same points where the fauna was collected. The three sediment samples were mixed and analyzed for grain characteristics using a settling tube (Emery 1938). Mean grain size, sorting, skewness, percentages of very fine sand, fine sand, medium sand, coarse sand and very coarse sand (Pettijohn 1963) were calculated.

This study was concerned with recruitment of *D. serra* in the surf zone of an exposed sandy beach, and it is focused on specimens of 1-8 mm. This was based on the observation that 8 mm seems to be the mean size at which this species migrates into the intertidal (McLachlan & Hanekom, 1979).

RESULTS

Individuals of 1-8 mm length were present all along the beach throughout the year (Fig. 2), but in the first 12 km the densities were below 20 ind • m^{-2} from April to October, while along the rest of the beach they were almost always above this value. The density of the recruits of *D. serra* clearly increased from November to March all along the beach. The total number of recruits collected increased from 444 in October to almost 1911 ind • m^{-2} in March (Fig. 3). In all the points with high densities, individuals of 2.5 - 3.0 mm length were the modal class. High densities of recruits occurred only in some isolated points along the beach. These concentrations were quite unstable, since they did not remain in the same area from one month to another, indicating the irregularity of the recruitment processes in the surf zone.

The length-frequency histograms of all individuals $\leq$ 8 mm (Fig. 3) showed a clear reduction in numbers during the winter period, with a strong recruitment in December, February and March. The samples of April 1994 (not included in this study) revealed a clear reduction in number of recruits, confirming that March is the peak of the recruitment period.

A key question in the population study of *D. serra* has been the location and timing of settlement during the recruitment period. This can be elucidated by analysis the patterns of high densities of very small individuals. The pattern of high densities of individuals $\leq$ 3 mm revealed that settlement of *D. serra* occurs scattered in time and in space (Fig. 4): near ten isolated points of high recruitment occurred along the beach from November to March, and it was never possible to detect this process in two sucessive months at the same point. In the western part of the beach, settlement was detected from November to March at 7 points, while in the first 10 km from the eastern part of the beach, settlement was detected in February and only at two places. Settlement was more intense in the western part of the beach, especially in the last 3 km, near of the mouth of Gamtoos River. This concentration of recruitment was detected in the first and in the

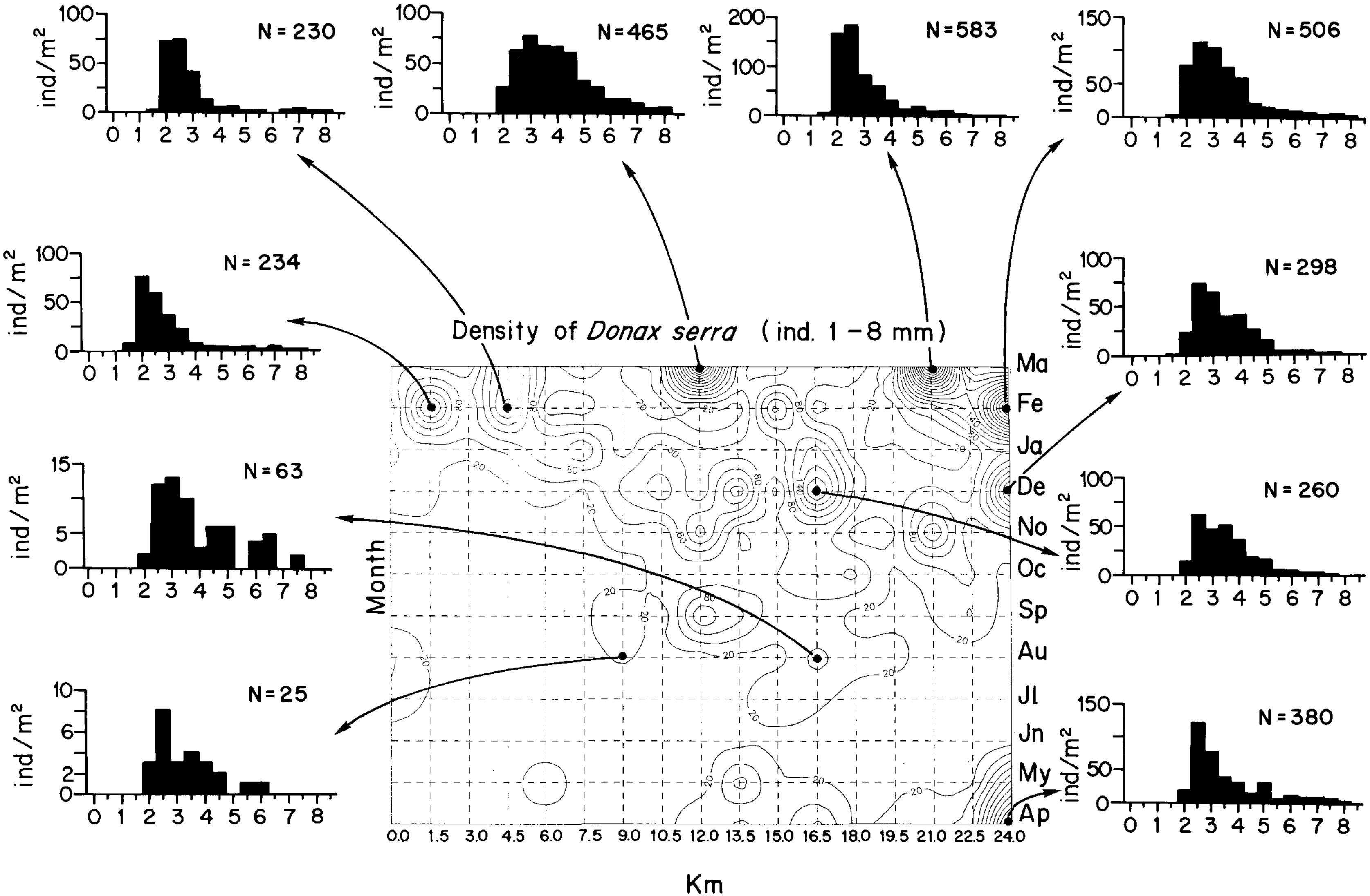

Fig. 2: Density (ind • m^{-2}) of *D. serra* recruits (1-8 mm in shell length) along the beach and length-frecuency histograms of stations with high and low

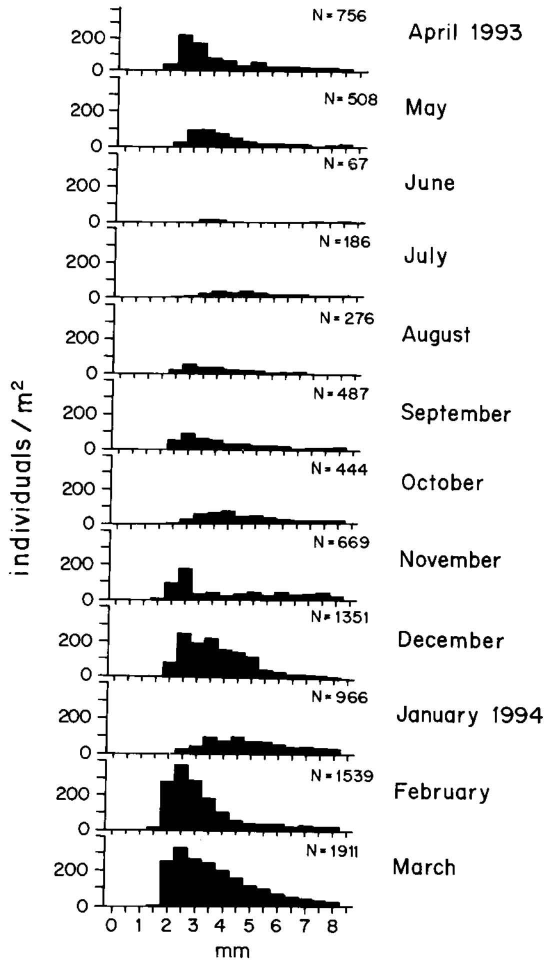

Fig. 3: Length-frecuency histograms of recruits collected each month.

Histogramas de frecuencia de longitudes de reclutas recolectados mensualmente.

last months of sampling, thus indicating the constancy and the importance of this area as a natural nursery for *D. serra* in the beach (Fig. 4).

Simple regression analysis between sedimentological parameters (% of fine sands, sorting coefficient, mean grain size, skewness) and the recruits density were performed, using the months in which those data were available (from August 1993 to March 1994). The results showed a significant positive correlation (μ = 0.168, $p < 0.05$; μ = 0.220, $p < 0.01$) between densities of the recruits and the percentage of fine sands (50 - 200 microns) and partially between densities and mean grain size. The rest of sedimentological parameters did not show significant correlations with the densities of the recruits.

A diagram of the distribution of the fine sands along the beach during the period August-March (Fig. 5a), indicates that fine sand is more prevalent in the western half of the beach, especially in the last 3 km, where the percentage was almost always above 25%. Something similar occured with the distribution of recruits over the same period (Fig. 5b): the densities were higher in the western part of the beach, with clear increases in the last 3 km, in the proximity of the Gamtoos River mouth.

Correlation analysis for the different sizes of recruits (Fig. 6) revealed that the smaller is the size of recruits, the better are the correlations between their densities and the percentage of fine sands or mean grain size. The correlation coefficient decreased with the increase in the size-range of the recruits, i.e. for the smallest sizes (i.e. 1-3 mm), the correlation was statistically significant at 99%, and this was reduced to 95% for 1-8 mm recruits.

Examining the months with large recruitment (February and March), the length-frequency histograms for the stations with above average contents of fine sands differ from the stations below the average; The stations with higher content of fine fraction have a higher presence of very small clams (Fig. 7); This was not so evident during the months without recruitment.

DISCUSSION

The variable distribution of the different size classes of *Donax* genus across the beach, from the mean intertidal zone to the surf zone, seems to be a common phenomenon as a response to biological and environmental pressures (De Villiers 1975, Bally 1983, Donn et al 1986, Bonsdorff & Nelson 1992). The contrasting zonation/distribution of the different stages may be related to intraspecific competition (Guillou & le Moal 1978, Ansell & Lagardere 1980), the granulometry of the beach (Maze & Laborda 1988), the temperature regimes as this affects burrowing times (Donn 1990, Donn & Els 1990), or the high temperature of the sand (Bayed & Guillou 1985).

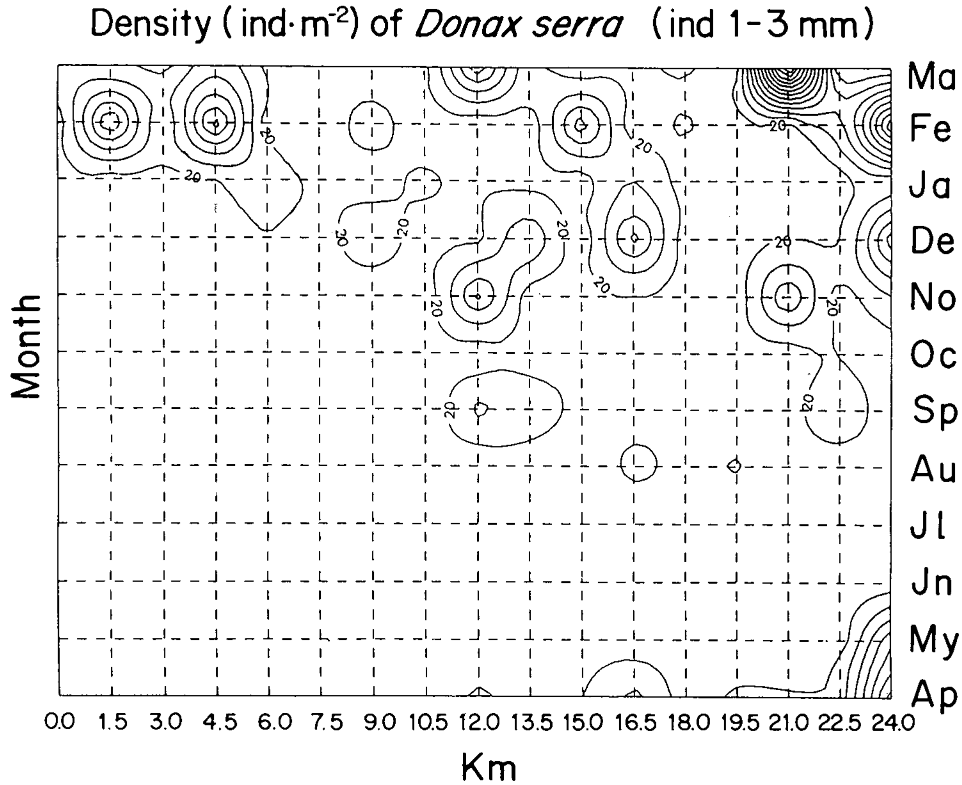

Fig. 4: Density (ind • m^{-2}) of recruits (1-3 mm in shell length) along the beach.

Densidad (ind • m^{-2}) de reclutas (1-3 mm en longitud de concha) a lo largo de la playa.

Spatial variability of *Donax* recruitment along the exposed sandy beaches is mainly influenced by the considerable hydrodynamism of these environments (Defeo et al. 1986, McLachlan 1990; McArdle & McLachlan 1992), but this is not the only factor that could affects this process. In some cases, the presence of a river mouth seems to promote the recruitment (Donn 1987); However, in other cases, the presence of freshwater inputs is responsible for lower abundances of the clams (Schoeman unplublished results). Moueza & Chessel (1976) concluded that the patchiness of recruitment is conditioned to tide currents, and appears to be strongly skewed towards a river mouth.

Limited data are available on spatial distribution of *Donax serra* recruitment on exposed sandy beaches. Our results suggest that, at least in one case, the presence of the river mouth promoted the presence of recruits, but in another two cases did not. Further, recruitment is related to variability in textural characteristics of the sediment in the surf zone (*i.e.* the presence of fine sands), a factor that also has importance in the distribution of adults in some populations of other species of beach clams (Maze & Laborda 1988, Jaramillo et al. 1994). The correlation between small size of the clams and fine sands indicates that the larvae in some way select the texture of the sediment where they settle, but this selectivity decreases with the time. Recruits of *D. serra* are specially sensitive to the granulometry of the sediment during the first stages and early growth, but this sensitivity/selectivity decreases as the size increase, suggesting that this selectivity is strongest during the settlement process. Naturally, granulometry is not the only parameter that induces the settlement of recruits and, for instance, heavy settlement in the proximity of the river mouth may also be a response to the high food concentration in this area. Another genus with similar ecological roles in the surf zone, *Mesodesma*, exhibits the same important time space variability and patchy

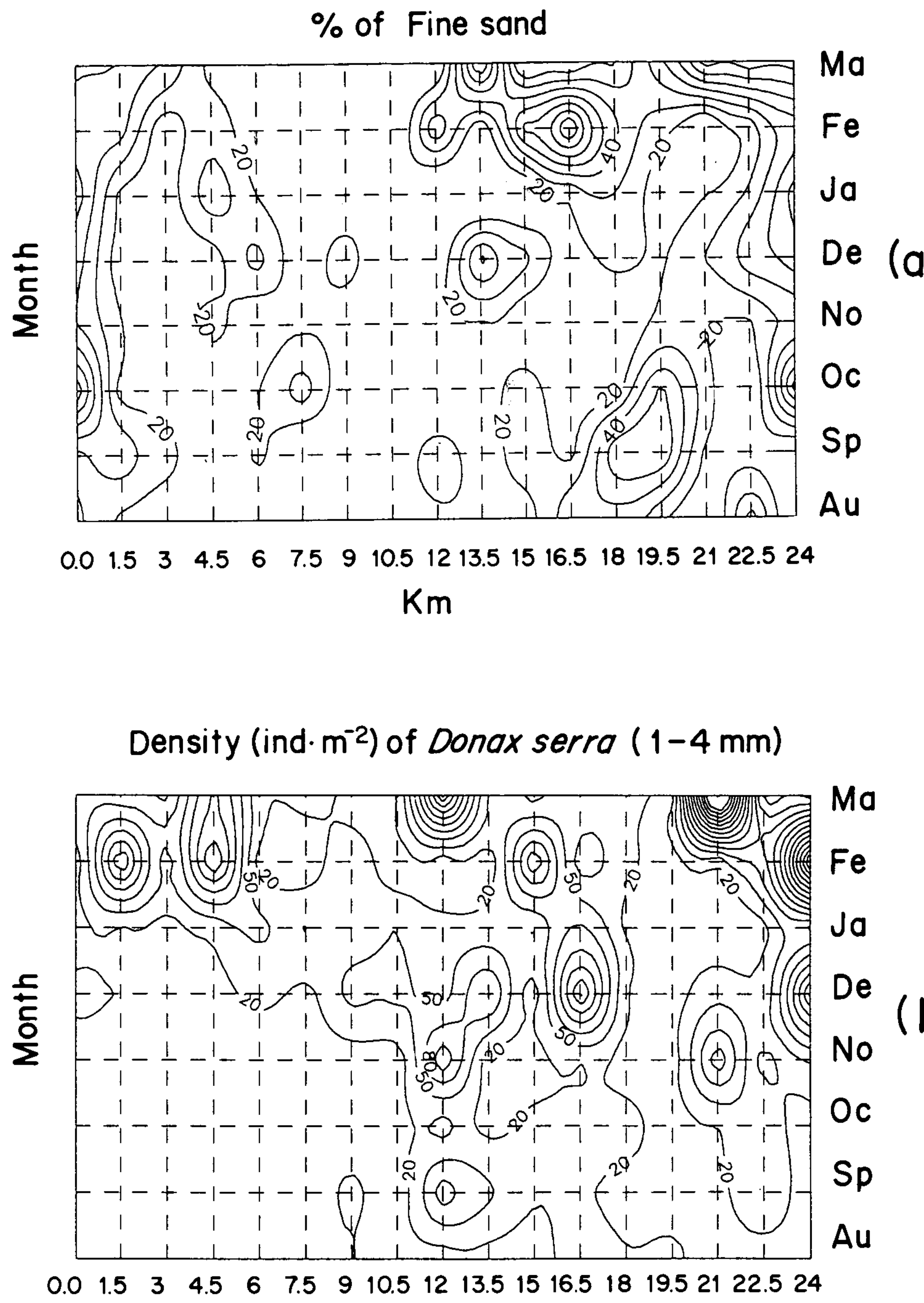

Fig. 5: (a) Percentage of fine sand in the sediment along the beach from August 1993 to March 1994. (b) density (ind • m^{-2}) of recruits (1-4 mm in shell length) for the same period.

(a) Porcentaje de arena fina en el sedimento a lo largo de la playa, desde agosto de 1993 a marzo de 1994. (b) densidad (ind • m^{-2}) de reclutas (1.4 mm de longitud de concha) para el mismo período.

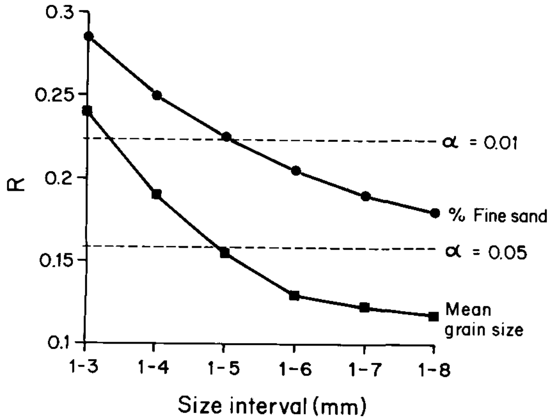

Fig. 6: Variation of the correlation coefficients (R) resulting from the relationship between abundance of different size intervals of *D. serra* recruits and the percentage of fine sands and mean grain size. Critical values of R (α) at the 0.01 and 0.05 probability levels are indicated.

Variación del coeficiente de correlación (R) resultante de la relación entre la abundancia de diferentes intervalos de tamaño de los reclutas de *D. serra* y el porcentaje de arenas finas y tamaño medio del grano. Se indican los valores críticos de R (α) a una probabilidad de 0.01y 0.05.

distribution (Jaramillo et al. 1994, Defeo et al. 1986) in relation to the high hydrodynamism and variability of these environments.

The time scale study has indicated that recruits of *D. serra* are present in large numbers over an extended period during summer, and in lower and variable numbers at other times of the year. In this respect, De Villiers (1979) conclude that this may be because of the non-synchronous nature of the breeding cycle, in relation to water temperature.

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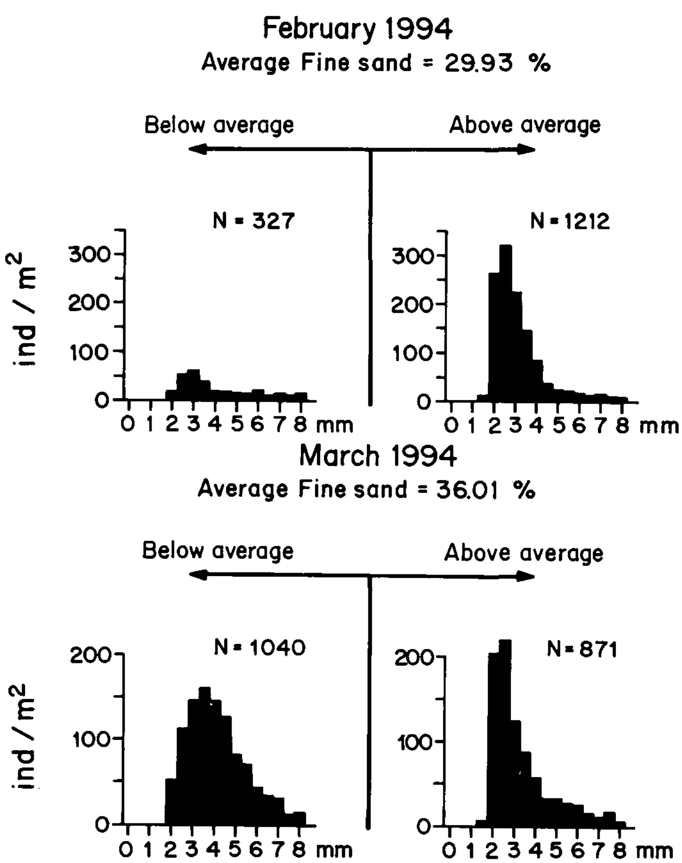

Fig. 7: Lenght frequency histograms for the stations with above and below average contents of fine sand during the months with highest density of recruits (February and March 1994).

Histogramas de frecuencia de longitudes de especímenes recolectados en estaciones con contenidos de arena fina bajo y sobre la media, durante los meses con mayor densidad de reclutas (febrero y marzo 1994).

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