

Biomass and density of *Thalassia testudinum* beds in Mochima Bay, Venezuela.

Biomasa y densidad de praderas de *Thalassia testudinum* en la bahía de Mochima, Venezuela

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RESUMEN

Un estudio acerca de las variaciones de la biomasa y densidad de *Thalassia testudinum* fue realizado en cuatro localidades de la Bahía de Mochima, en la costa nororiental de Venezuela. Entre enero y diciembre de 2002, se tomaron ocho réplicas mensuales de sedimento, empleando un perforador de PVC de 15 cm de diámetro, las mismas fueron tamizadas en una malla de 0,5 mm de apertura. El promedio de la temperatura y salinidad fue $\bar{X} = 27,82 \pm 1,26$ y $= 37,09 \pm 0,86$ respectivamente. La densidad mensual de *Thalassia* estuvo comprendida entre 45 ind.m⁻² (septiembre) y 507 ind. m⁻² (enero) ($\bar{X} = 160,64 \pm 136,38$ ind.m⁻²). El ANOVA mostró diferencias significativas en la variación de la abundancia mensual de la fanerógama ($F = 9,643$, $p < 0,001$) y entre las localidades ($F = 9,532$, $p < 0,001$). Los mayores valores de densidad y biomasa fueron observados en Mangle Quemao y Ensenada de Reyes y las menores en Toporo. En esta última localidad la baja densidad y biomasa podrían estar relacionadas con la presencia de gran cantidad de epífitas sobre las hojas de la fanerógama.

Palabras clave: Biomasa, Densidad, Mochima, Praderas, *Thalassia testudinum*, Venezuela

ABSTRACT

A spatial study about the variations of biomass and density of *Thalassia testudinum* was made in four localities of Mochima Bay, northeastern coast of Venezuela. Between January and December 2002 eight replicate samples were taken monthly, with a core 15 cm in diameter, and the sediment was sieved through a 0.5 mm opening mesh. Temperature and salinity average were $\bar{X} = 27.82 \pm 1.26$ and $= 37.09 \pm 0.86$ respectively. The monthly density of *Thalassia* shoots ranged from 45 ind.m⁻² (September) to 507 ind.m⁻² (January) ($\bar{X} = 160.64 \pm 136.38$ ind.m⁻²). ANOVA showed significant variations of abundance within the months ($F = 9.643$, $p < 0.001$) and localities ($F = 9.532$, $p < 0.001$). Highest values of density and biomass were obtained in Mangle Quemao and Ensenada de Reyes and the lowest in Toporo. In this last one, the low density and biomass could be attributed to greater abundance of epiphytes on their leaves.

Key words: Biomass, Density, Mochima, Seagrass, *Thalassia testudinum*, Venezuela

INTRODUCTION

Beds of *Thalassia testudinum* Bank ex König are often cited as some of the most productive ecosystems on earth, rivaling cultivated crops in annual net primary production (Fourqurean *et al.* 2001). Seagrass beds are an important source of foods and contribute to the stabilization of sediments (Gutiérrez-Aguirre *et al.* 2000). Some organisms feed exclusively on the leaves or epiphytes (Ogden *et al.* 1973; Noriega *et al.* 2002), mainly green turtles, Scaridae and Acanthuridae fishes, and echinoids. These communities play an important structural and trophic role in coastal environments, but their community structure and biomass can vary seasonally due to changes related to environmental variables (Poumian-Tapia & Ibarra- Obando 1999), such as temperature, sediment resuspension, seasons, pollution and grazing. In the Caribbean Sea, *T. testudinum* is probably the most important benthic primary producer (Greenway 1976; Duarte & Chiscano 1999). In Venezuela it is the most abundant and widely distributed phanerogam.

Numerous studies have been made in Mochima Bay about the biological resources, and hydrological and geological characteristics, but few on the *T. testudinum* resource. This study showed the spatial variations of the density and biomass of *T. testudinum* in four localities of Mochima Bay, between September and August 2002.

MATERIALS AND METHODS

The study was carried out in January-December 2002, in four localities from Mochima Bay ([Fig. 1](#)): Varadero (10°21'05" Lat. N, 64°20'19" Long. W) and Toporo (10°22'00" Lat. N, 64°20'10" Long. W) whose coasts are populated with *Rhizophora mangle*, both located in protected areas and with low energy; Mangle Quemao (10°22'28" Lat. N, 64°20'53" Long. W) and Ensenada de Reyes (10°20'06" Lat. N, 64°21'57" Long. W) both located in exposed areas to wave actions with sandy coast and few mangroves.

Table 1. Summary of ANOVA test to monthly density, biomass and dry-weight of each *Thalassia* component in the localities studied (n = 96 for each locality).

	Localities			
	Mangle Quemao	Ensenada de Reyes	Varadero	Toporo
Density (shoots.m ⁻²)	5.741 ²	9.553 ²	1.305 ³	4.031 ²
Biomass leaves (gr. m ⁻²)	8.195 ²	8.613 ²	2.725 ¹	2.831 ¹
Biomass wet rhizomes (gr. m ⁻²)	10.036 ²	3.492 ²	5.233 ²	2.955 ¹
Biomass wet roots (gr. m ⁻²)	6.240 ²	1.652 ³	4.241 ²	2.420 ³
Biomass wet dead leaves (gr. m ⁻²) ²	3.840 ²	4.931 ²	1.636 ³	3.596 ²
Dry-weight green leaves (gr. m ⁻²)	9.664 ²	4.537 ²	3.252 ²	1.723 ³
Dry-weight rhizomes (gr. m ⁻²)	20.746 ²	6.246 ²	3.407 ²	3.480 ²
Dry-weight roots (gr. m ⁻²)	10.076 ²	1.647 ³	3.670 ²	2.752 ¹
Dry-weight dead leaves (gr. m ⁻²)	4.761 ²	4.761 ²	0.639 ³	1.723 ³
Biomass wet total (gr. m ⁻²)	10.548 ²	2.902 ¹	4.225 ²	3.393 ²
Dry-weight total (gr. m ⁻²)	20.517 ²	5.053 ²	3.637 ²	3.682 ²

Significant level: ¹ p < 0,01; ² p < 0,001; ³ not significant.

Fig. 1. Location of the study sites on Mochima Bay.

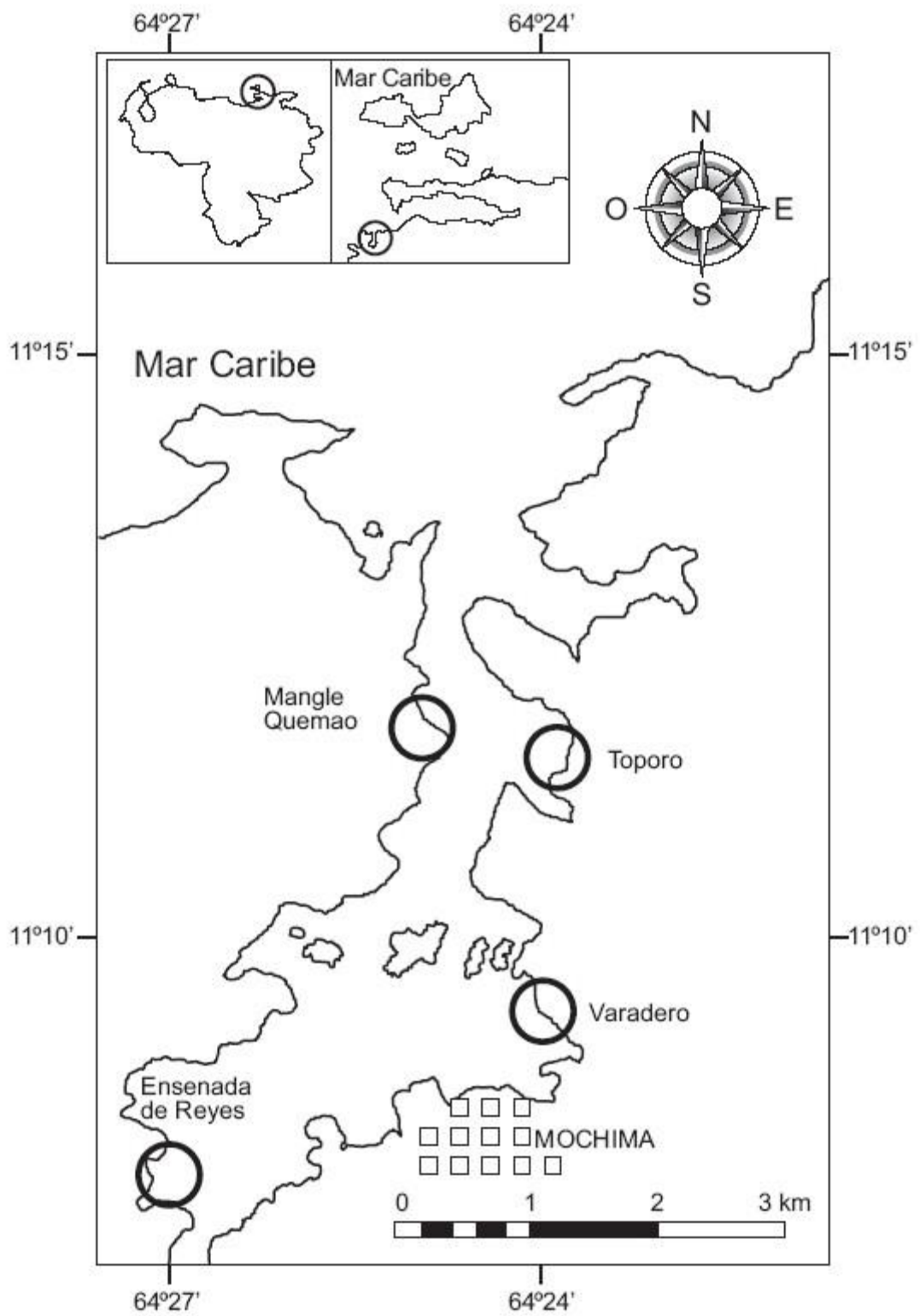
Eight replicate samples were taken in each locality using the methodology described by Liñero-Arana & Díaz-Díaz (2006). *Thalassia* shoots were placed in plastic bags with seawater and transferred in containers with ice and water to the laboratory, and separated in four portions: green leaves, rhizomes, roots and dead leaves. Wet and dry weights of each component of the plant were determined. In order to determine dry weight each component was dried at 80°C for 24 h to constant weight. Sediment samples, for granulometric analysis (Gray 1981), were taken monthly, using a PVC corer of 15 cm in internal diameter, buried to 35 cm. Organic content in sediment was determined using the methodology described by López-Jamar & Cal (1990). Salinity and temperature measurements were done monthly, using a SCT system (Jenway model 2000).

RESULTS

Temperature values ranged between 24.7°C in December and 30.2°C in March ($\bar{X} = 27.82 \pm 1.26$), while salinity varies between 35.6‰ in September and 38.9‰ in January ($\bar{X} = 37.09 \pm 0.86$), respectively.

The monthly density average of *Thalassia* shoots was $\bar{X} = 160.64 \pm 136.38$ shoots.m⁻². Mangle Quemao and Ensenada de Reyes showed the greater shoot densities and Toporo the lowest (Fig. 2). Table 1 summarizes ANOVA's test results to the density and biomass of each component of *Thalassia* within the months, showing the differences found between density and biomass within localities and months. Significant positive Pearson's correlation was found between sediment organic content and biomass of roots ($r = 0.56$; $p < 0.01$) and dry weight of roots ($r = 0.5$; $p < 0.01$). A significant negative Pearson's correlation was observed

between *T. testudinum* shoot abundances and organic content ($r = -0.789$, $p < 0.01$). [Fig. 3](#) show the monthly variation of the four components of *Thalassia*. The sediment from Mangle Quemao and Varadero showed a predominance of fine size particles (44.90% and 39.50%, respectively), while in Ensenada de Reyes and Toporo medium size particles (57.69% and 41.74%) were found. Posteriori-test Student-Newman-Keuls (SNK) for the density and biomass of *T. testudinum* by localities showed significant differences between Toporo and other localities (SNK, $p < 0.001$), and for dry weight between localities (SNK, $p < 0.001$), and January and other months. Significant differences of organic content within the localities ($F = 15.587$, $p < 0.001$) were found. Greatest values of organic content were found in Varadero ($\bar{X} = 9.81 \pm 3.45$), followed by Mangle Quemao ($\bar{X} = 4.65 \pm 1.21$), Ensenada de Reyes ($\bar{X} = 3.42 \pm 1.13$), and Toporo ($\bar{X} = 3.02 \pm 1.55$).



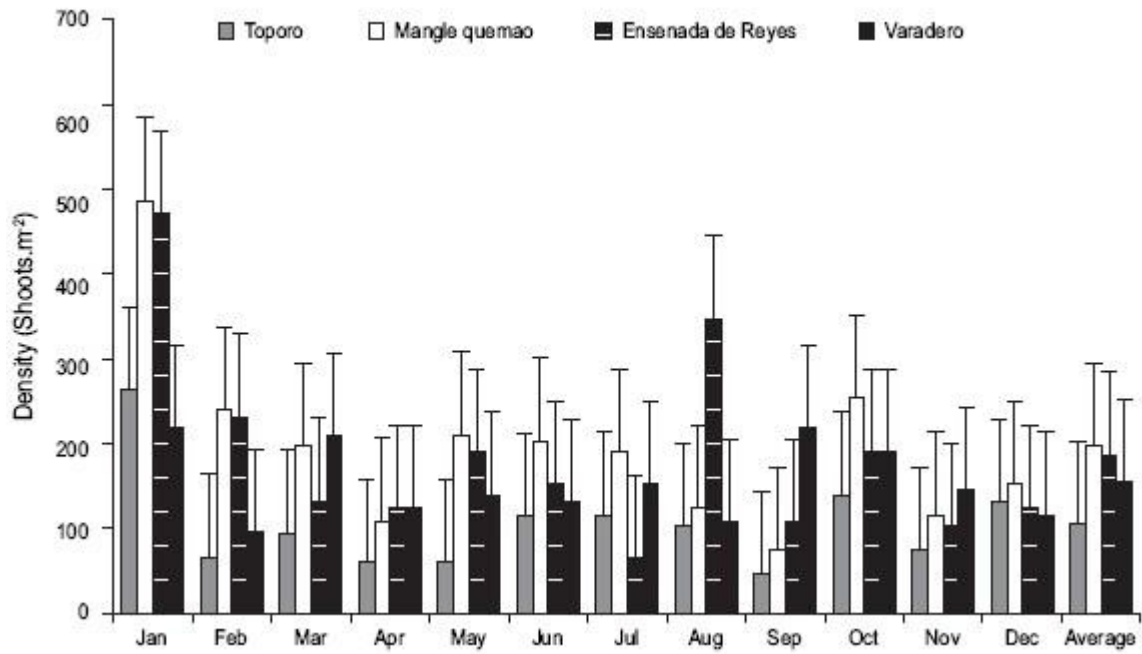


Fig. 2. Monthly variation of density shoots of *T. testudinum* in the studied localities (the error bars represent the standard deviation of the mean).

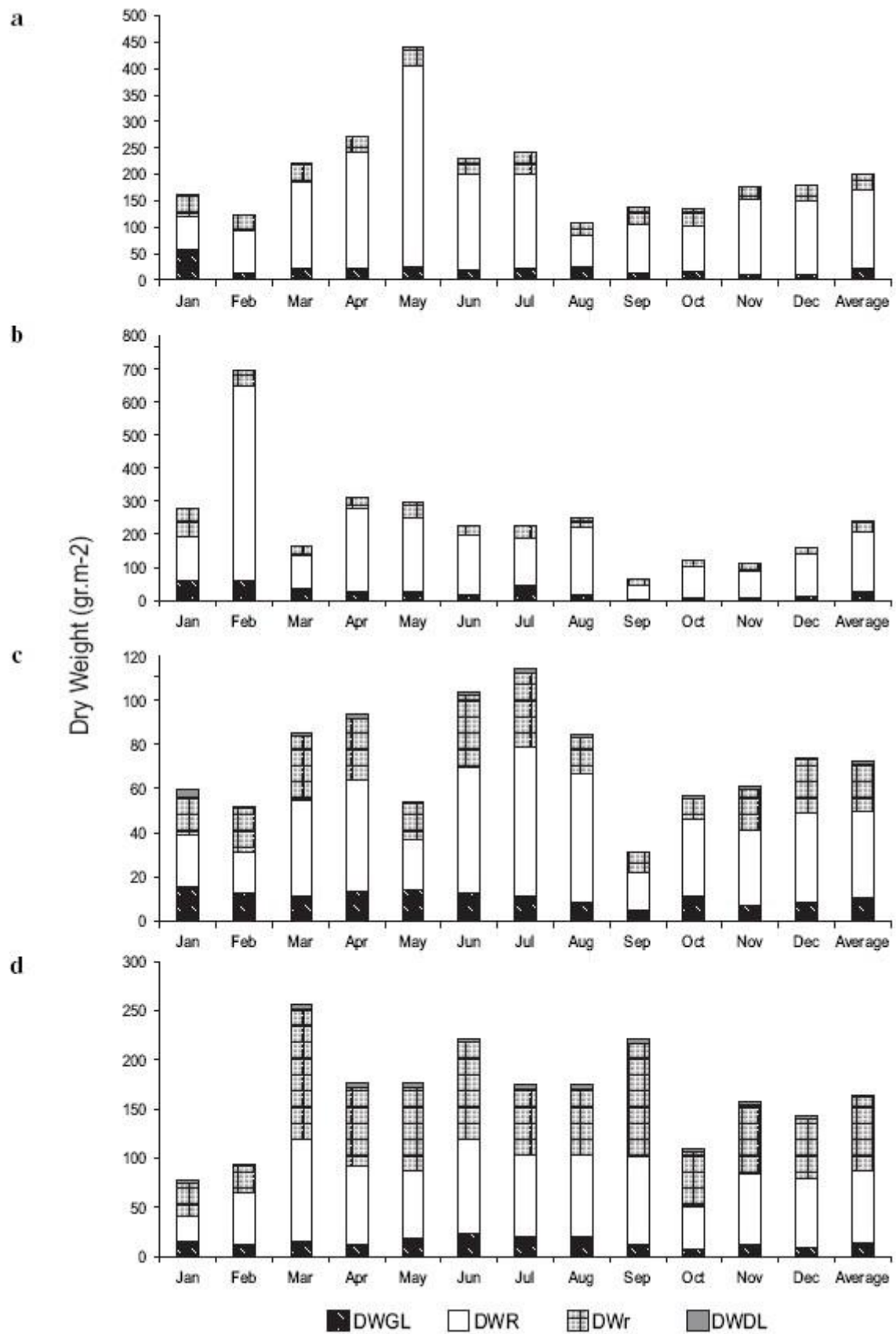


Fig. 3. Monthly variation of four components of *Thalassia* in localities studied: **a.** Mangle Quemao. **b.** Ensenada de Reyes. **c.** Varadero. **d.** Toporo (DWGL:

dry weight of green leaves; DWR: dry weight of rhizomes; DWr: dry weight of roots; DWDL: dry weight of dead leaves)

DISCUSSION

Den Hartog (1970) and Phillips (1960, cited by Stoner 1980) mentioned that the optimum salinity for *T. testudinum* growth vary approximately, between 24.5 and 38.5, being the maximum and minimum values reported 48.0‰ in Florida Bay, and 10.0‰ in Crystal Bay (on the west coast of Florida). Turtle grass is probably intolerant of salinities over 45‰ for extended periods of time (Moore 1979). Duarte (1991), Dixon (2000) and Koch (2001) reported that temperature probably limits the distribution of *Thalassia*, thus, in the northern of Florida and in the Gulf of Mexico, is apparently capable of supporting a warm temperate climate; however, along Florida's east coast temperatures reached values between 35.0 and 40.0°C, which will kill the leaves of *Thalassia*. The temperatures optimal ranged between 10.5°C and 30.0°C (Den Hartog 1970; Zieman 1975). In this study the values ranged between these ranks, except in January when the salinity (38.9‰) was lightly superior and the temperature was inferior.

The density and the biomass showed significant variations between the months and the localities. In this study, the density of *Thalassia* shoots was lower than that recorded by Ibañez-Aguirre & Solís-Weiss (1986) in Terminos Lagoon, Mexico (609 shoots.m⁻²), Lewis & Stoner (1983) in Apalache Bay, Florida (184 shoots.m⁻²), Liñero-Arana & Díaz-Díaz (2006) in Chacopata Beach, northeastern coast of Venezuela (284 shoots.m⁻²).

The monthly variation of green leaf and roots biomass in Mochima Bay showed a pattern associated to climatology. In September a decrease of these components was observed as a consequence of increase of turbidity, due to the run-offs produced in rains, and decrement of the light incidence on the seagrass bed (Phillips *et al.* 1995; Zieman *et al.* 1999). But the decrease in February could be associated to decrease of temperature, due to upwelling, that in Venezuela occurs between December and February (Bonells *et al.* 1990), which has also been observed by Pérez & Galindo (2000) in Morrocoy National Park.

Most of the biomass of the seagrass is submerged into the sediments, the radical systems constitute between 77 and 85% of total biomass, and green leaves between 13 and 20% (Dawes 1986; Den Hartog 1970; Zieman 1987). These ranges agree with the results obtained in this study, where around the 12 to 20% of the biomass of *Thalassia* belongs to the green leaves. The percent of weight of the rhizomes increases directly with the sediment size. Zieman & Zieman (1989) indicated that the ratio biomass of leaves: rhizome is affected by the type of sediment where the seagrass grows. Den Hartog (1970) pointed out that on fine mud the weight roots: rhizomes: leaves ratio was 1:3:1, on muddy sand was 4:7:1, and on coarse sand was 7:3:1. However, in this study the root: rhizomes: leaves ratio was 1.4:2.5:1, in Toporo characterized by medium size particles, and 1:4.5:1, in Mangle Quemao with fine particles.

Absence of significant correlations between abundance and biomass of shoots with granulometric characteristics is supported by Virnstein & Howard (1987) those who indicated that the biomass of *T. testudinum* is independent of the grain size and of the hydrodynamic effects of the habitat. Noriega *et al.* (2002) indicates that *Thalassia* beds located in more exposed zones show a less vegetal biomass, and that those located in protected areas show a greater density and biomass. Patriquin (1973) and Gutierrez-Aguirre *et al.* (2000) consider that the presence of mangroves contributes to elevate the biomass and the productivity of *Thalassia*, but

Tomasko & Lapointe (1991), point out that proximity to mangroves and mangrove detritus could be the organic enrichment of the water column that increased the epiphytes on the leaf and reduced the rate of growth of rhizome due, possibly, to decreased available energy as a result of the shade produced by epiphyte communities. The considerations above indicated would serve to explain the results obtained in Toporo and Varadero. These are located in a protected zone with weak circulation and their coasts are populated with *Rhizophora mangle* mangroves. In both it was found the lowest values of density and biomass, attributing this to the greater presence of epiphytes on their leaves. It is known that these can have deleterious effects on the biomass (Patriquin 1973; Tomasko & Lapointe 1991; Barrios & Díaz-Díaz 2005), getting to produce the early death of the leaf (Den Hartog 1967).

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