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# THE STRUCTURE OF *BOSTRYCHIETUM* COMPLEX IN AN ALLUVIAL MANGROVE FOREST IN THE GULF OF MONTIJO, PACIFIC OF PANAMA

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## ABSTRACT

The present study provides information about the structure and temporal variations of the *Bostrichietum* complex in a *Rhizophora racemosa* and *pelliciera rhizophorae* dominated alluvial mangrove in the gulf of Montijo, western Panama. Twenty-one segments of one meter length of *Rhizophora racemosa* roots were randomly sampled below the high water mark and measured in terms of breadth (diameter) and surface area occupied by each species of the complex. In a second study, a year later, algal cover of thirty segments of roots were carefully removed and left to dry to a constant dry weight for a week after the collection date. Each species was weighted separately and biomass was expressed in mg/cm$^2$ of root. The *Bostrychietum* complex was composed by three species of red algae, *Bostrychia calliptera* (Montagne) Montagne (Rhodomelaceae), *Caloglossa leprieurii* (Montagne) G. Martens (Delesseriaceae) and *Catenella impudica* (Caulacanthaceae). *Bostrychia calliptera* showed the broadest range of cover with 1.61 ± 0.04 m$^2$ (81.8%) whereas *Caloglossa leprieurii* registered a cover of 0.35 ± 0.028 m$^2$ (17.7%) and *Catenella impudica* only 0.009 ± 0.005 m$^2$ (0.5%). In the second study epiphytic biomass was measured in terms of the dry weight and the density of algal mass surrounding roots determined in both dry and rainy season. A total of 88.1 mg of algae were collected, 90.7% corresponding to *Bostrychia calliptera* and 9.3% to *Caloglossa leprieurii*. *Catenella impudica* was not found. Biomass of *B. calliptera* was relatively constant between dry and rainy season with mean density of 37.8 y 42.1 mg/cm$^2$ while *C. leprieurii* registered low values of 8.2 mg/cm$^2$ in the dry season and less of 1 mg/cm$^2$ in the rainy season.

**KEYWORDS**
*Bostrychietum complex, Bostrychia*, mangrove algae structure, mangrove epiphytes.

**RESUMEN**
El presente trabajo provee información sobre la estructura y variación temporal del complejo *Bostrychietum* en un manglar aluvial del golfo de Montijo dominado por *Rhizophora racemosa* y *Pelliciera rhizophorae*. En un primer estudio se seleccionó veintiún segmentos de raíces de *Rhizophora racemosa* de un metro de largo y se determinó la composición del complejo *Bostrychietum* y el área superficial ocupada por cada elemento del complejo. En un segundo estudio, un año después, se determinó el peso seco de los componentes del complejo en treinta segmentos de raíces de *R. racemosa* seleccionados al azar. El complejo *Bostrychietum* estuvo integrado por algas rojas de las especies *Bostrychia calliptera* (Montagne) Montagne (Rhodomelaceae), *Caloglossa leprieurii* (Montagne) G. Martens (Delesseriaceae) and *Catenella impudica* (Caulacanthaceae). *Bostrychia calliptera* mostró la mayor cobertura con 1.61 ± 0.04 $m^2$ (81.8%) mientras que *Caloglossa leprieurii* registró 0.35 ± 0.028 $m^2$ (17.7%) y *Catenella impudica* 0.009 ± 0.005 m2 (0.5%). En el segundo estudio se recolectaron 88.1 mg of algas de los cuales 90.7% correspondió a *Bostrychia calliptera* y 9.3% a *Caloglossa leprieurii*. *Catenella impudica* no se encontró en esta ocasión. La biomasa de *B. calliptera* se mantuvo constante con valores de 37.8 mg/cm2 para la estación seca y 42 mg/$cm^2$ para la lluviosa mientras que *C. leprieurii* registró valores bajos de 8.2 mg/$cm^2$ en la estación seca y menos de 1 mg/$cm^2$ para la estación lluviosa.

**PALABRAS CLAVES**
Complejo *Bostrychietum*, *Bostrychia*, estructura de algas de manglar, epifitas de manglar

## INTRODUCTION

The *Bostrychietum complex* (Post 1936) is an association of specialized red algae that grows on roots of different species of mangroves in tropical and subtropical coastal areas. The complex is usually composed by species of the genus *Bostrychia and Stictosiphonia* (Rodomelaceae, Ceramiales), *Caloglossa* (Delesseriaceae, Ceramiales) and *Catenella*, (Caulacanthaceae, Gigartinales). Algae of the complex are frequently overlooked of mangrove flora studies because of the inconspicuous size and little it is known of their role in the mangrove ecosystems. *Bostrychia* species

are conspicuous components of the complex growing epiphytically on *Rhizophora* prop roots (Taylor, 1945, 1960) and pneumatophores of *Avicennia* (King & Puttock, 1989). Although food chains in mangrove habitats have long been supposed to be based on detritus derived from mangrove litter (Odum & Heald, 1972; Lugo & Snedaker, 1974) recent studies have revealed that epiphytic algae may also serve as an additional important source of carbon in the mangrove food web (Rodriguez & Stoner, 1990) and indicators of the health status of the mangrove. Peña -Salamanca (2008) studied the spatial and temporal dynamics of algal biomass associated with mangrove roots at Buenaventura bay, Colombia and found that tidal inundation and the vertical position along the roots seem to be the most important factors influencing the algal biomass. Quiel Rodríguez et al. (2010) developed an exploratory study of macroalgae associated with mangrove vegetation at Remedios, southeast of the province of Chiriquí (Panamá). They reported for the first time the presence of *Catenella impudica* (Montagne) J. Agardh and *Bostrychia montagnei* Harvey. García Furlan (2013) studied the Macrofauna associated with *Bostrychietum* community in different environments on the northern coast of São Paulo, Brazil. The weight of the sample (alga dry weight + sediment dry weight) was used to calculate the density of individuals. The algal composition varied through the sampled months as well as in relation to distance from the sea. The purpose of the present investigation was to provide information about the structure and temporal variations of the *Bostrichietum* complex in a *Rhizophora racemosa* - *phelliciera rhizophorae* dominated mangrove in the gulf of Montijo, western Panama.

## MATERIALS AND METHODS

### Area of study

The study was carried out at Puerto Limón mangrove, a small patch of alluvial mangrove located near Pilón, Montijo with UTM coordinates 0491173 East and 0877245 North (Fig. 1). The area is dominated by the tea mangrove *P. rhizophorae* (Planch and Triana), *Rhizophora racemosa* (G. Mey) and *Mora oleifera* (Triana Ducke), accompanied by the black mangrove *Avicennia germinans* (L.) in combination with the mangrove fern *Acrostichum aureum* (L.) (Cámara-Artiga *et al*., 2004).

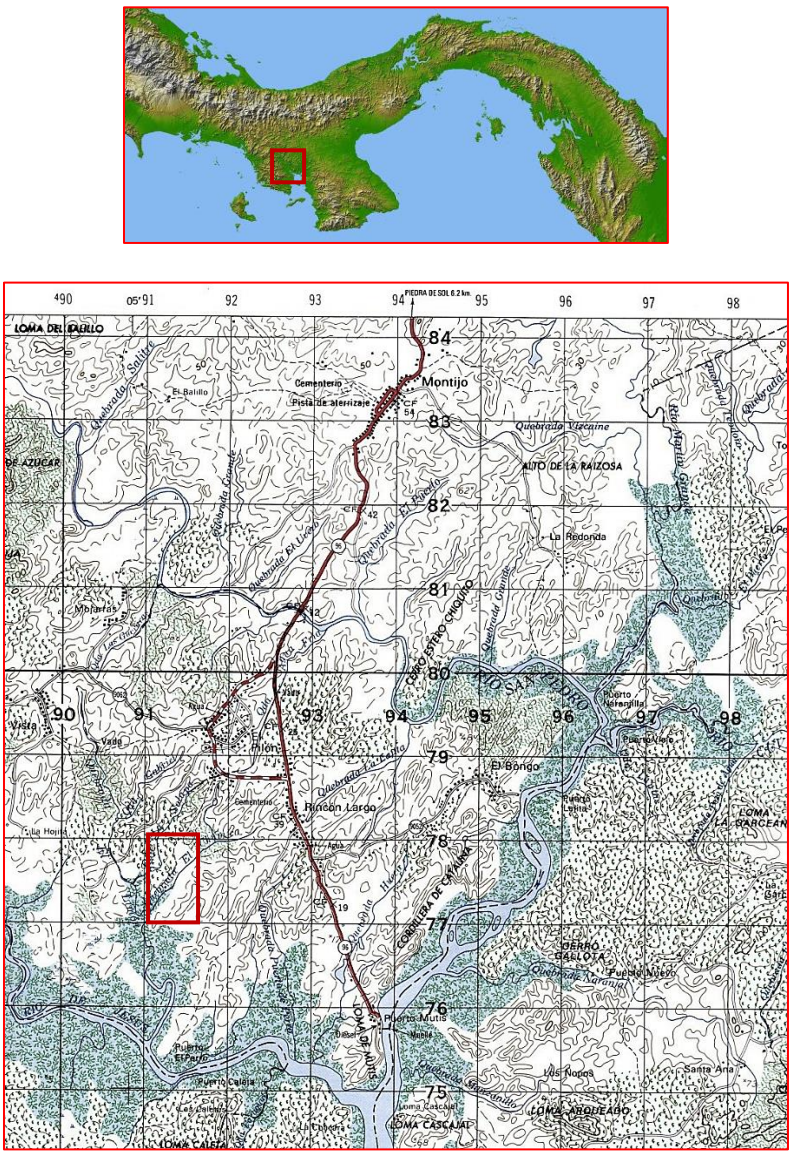



Fig.1. Location of the study area at Puerto Limón, an alluvial mangrove patch at El Pilón, Montijo.

## Sample Collection

A 25 m² quadrant was localized in a patch of *Rhizophora racemosa* where the algal epiphytes were abundant. The samplings were carried

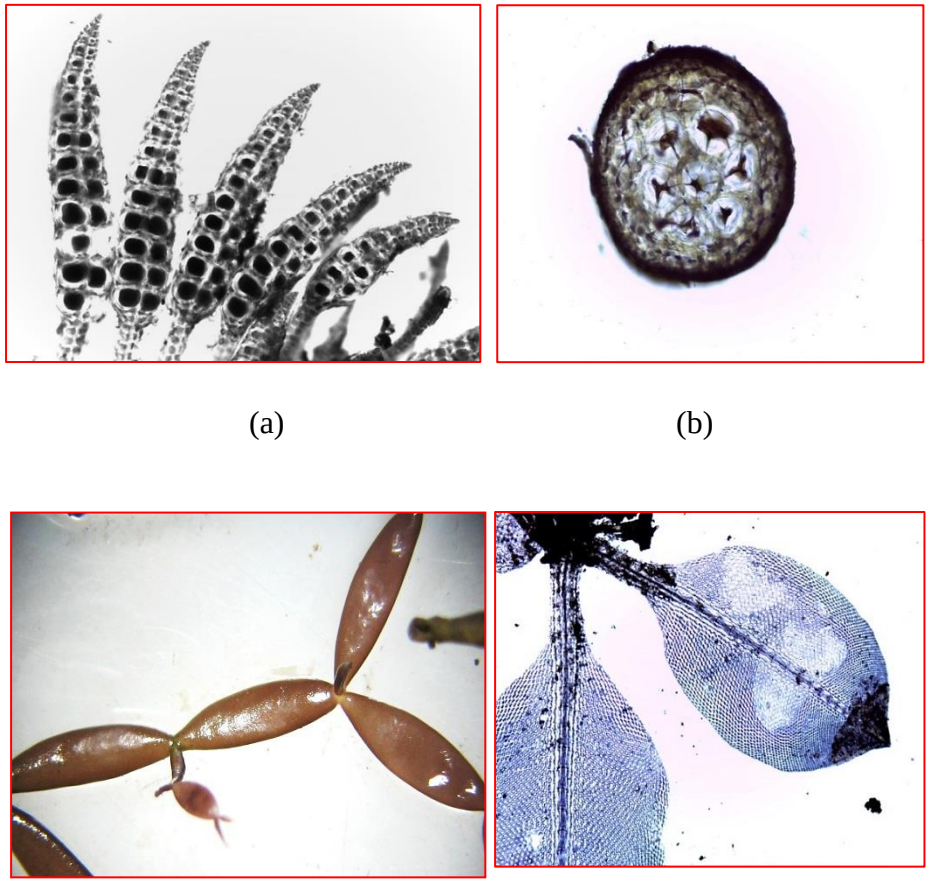
out in July and September 2010. Twenty one segments of one meter length were randomly sampled below the high water mark and measured in terms of breadth (diameter) and the surface area ($m^2$) occupied by each species of the complex using the formula $2\pi rh = \pi dh$ (Steinke & Naidoo, 1990). In a separated study carried out in the dry and rainy season of 2011, epiphytic algae of thirty segments of roots of 0.5 meter of length were carefully removed and repeatedly washed to get rid of the mud and detrital particles as much as possible. Algae were then placed in a wood oven and left to dry to a constant dry weight for a week after the collection. Each species was weighted separately in a precision balance and the biomass was expressed in $mg/cm^2$ of root.

## RESULTS

### Composition of the *Bostrychietum* complex

The epiphytic algal flora of *R. racemosa* roots was composed by three species of red algae, *Bostrychia calliptera* (Montagne) Montagne (Rhodomelaceae), *Caloglossa leprieurii* (Montagne) G. Martens (Delesseriaceae) and *Catenella impudica* (Caulacanthaceae). *Bostrychia calliptera* (*Figs 1a, 1b*) is characterized by being polysiphonous, decumbent, conspicuously pinnate with 6 pericentral cells in the main axes, stichidia stipitate, lanceolate blades, a little curved, with 2 rows of sporangia visible from the side.

*Catenella impúdica* (*Fig. 1c*) is dull violet plant, creeping, ditrichotomous, the younger segments slender and the older broader and flattened. Haptera formed from normal segments of the tallus. *Caloglossa leprieurii (Fig. 1d)* is spreading, mostly prostrate, purplish red to almost black and attached by rhizoids from the ventral surface at constrictions. Blades are linear to oval, constricted at forks or elsewhere and the branches are formed at nodes or midribs.



(a) (b)

(c) (d)

Fig.1. *Bostrychia calliptera* showing tetrasporangia tetrahedrally divided and in two rows within stalked stichidia (a) with 6 pericentral cells in a cross section of the main axes (b). Habit of *Catenella impudica* (c). Blades oval, constricted at forks in *Caloglossa leprieurii* (d).

**Cover area and epiphytic biomass on roots of *Rhizophora racemosa***

Table 1 shows the cover area ($m^2$) of *B. calliptera* and *C. leprieurii* on roots of *Rhizophora racemosa*. Cover areas were calculated separately for each specie. *Bostrychia calliptera* showed the highest average of cover with 1.61 ± 0.04 $m^2$ (81.8%) whereas *Caloglossa leprieurii* registered a cover of 0.35 ± 0.028 $m^2$ (17.7%) and *Catenella impúdica*

only 0.009 ± 0.005 $m^2$ (0.5%). The epiphytic algal cover was 97.0 ± 0.4 percent of available area on roots. In 2011 study epiphytic biomass was measured in terms of the dry weight and the density of algal mass surrounding roots determined in both dry and rainy season (Table 2). A total of 88.1 mg of plant material were collected, 90.7% corresponding to *Bostrychia calliptera* and 9.3% to *Caloglossa leprieurii*. *Catenella impudica* was not found. Biomass of *B. calliptera* was relatively constant between dry and rainy season with mean density of 37.8 y 42.1 mg/$cm^2$ while *C. leprieurii* registered low values of 8.2 mg/$cm^2$ in the dry season and less of 1 mg/$cm^2$ in the rainy season.

## DISCUSSION

The *Bostrychietum* complex is a specialized group of algae occurring as epiphytes on the stems and roots of mangrove trees or growing on other substrata within the mangrove ecosystem and usually is dominated by the genus *Bostrychia* in association with *Caloglossa*, *Catenella*, *Murrayella*, and *Stictosiphonia* (King and Puttock 1989, 1994a, King et al. 1988 and Kamiya *et al.*, 1997). The *Bostrychia-Caloglossa* association dominate the *Bostrychietum* of Puerto Limón and their presence is indicator of a mangrove forest in a not disturbed state (Pedroche et al, 1995). Peña-Salamanca (2008) studied the composition and the spatial and temporal variation of the complex growing on roots of *Rhizophora mangle* and pneumatophores of *Avicennia germinans* in Buenaventura bay, Colombia. Four species dominated the algal flora and collectively contributed with 90 % of the total algal biomass. *Bostrychia calliptera* was the most dominant with 32 % of the total biomass, followed by *Boodleopsis verticillata* (26 %), *Catenella impudica* (18 %), and *Caloglossa leprieurii* (12 %). Three of these four species are present in Puerto Limon, but the wide prevalence of *B. calliptera* is suggested of the changes in salinity and drying that occur from winter to summer (Yarish et al, 1979; Yarish and Edwards, 1982). Indeed, *Bostrychietum* is a microecosystem with many factors modulating the interactions between species, making further investigation on the existing relationships between species and the operating environmental factors necessary (Furlan, 2013). Densities of Puerto Limon, were lower than those recorded in

Buenaventura where reported values were 20.7 to 54.8 g/m$^2$ for *Bostrychia calliptera* and 8.1 to 11.2 g/m$^2$ for *Caloglossa leprieurii*.

Table 1. Cover area (m$^2$) of *B. calliptera*, *C. leprieurii* and *C. impudica* on roots of *Rhizophora racemosa* in July and September 2010.

*Bostrychiacalliptera*

| NUMBER OF ROOT | July | September |
|---|---|---|
| 1 | 0.1000 | 0.1000 |
| 2 | 0.0549 | 0.0549 |
| 3 | 0.1060 | 0.1060 |
| 4 | 0.0961 | 0.0833 |
| 5 | 0.0653 | 0.0669 |
| 6 | 0.1060 | 0.1060 |
| 7 | 0.0884 | 0.0844 |
| 8 | 0.0592 | 0.0546 |
| 9 | 0.0628 | 0.0596 |
| 10 | 0.0973 | 0.0973 |
| 11 | 0.0912 | 0.0756 |
| 12 | 0.0747 | 0.0730 |
| 13 | 0.0967 | 0.0835 |
| 14 | 0.0714 | 0.0824 |
| 15 | 0.0637 | 0.0546 |
| 16 | 0.0452 | 0.0452 |
| 17 | 0.0725 | 0.0725 |
| 18 | 0.0678 | 0.0644 |
| 19 | 0.0389 | 0.0389 |
| 20 | 0.0879 | 0.0879 |
| 21 | 0.0904 | 0.0904 |
| **TOTAL** | **1.6364** | **1.5814** |
| **MEAN** | **0.0779** | **0.0753** |

*Caloglossa leprieurii*

| NUMBER OF ROOT | July | September |
|---|---|---|
| 2 | 0.0078 | 0.0078 |
| 5 | 0.0082 | 0.0147 |
| 7 | 0.0120 | 0.016 |
| 8 | 0.0318 | 0.0364 |
| 9 | 0.0157 | 0.0188 |
| 11 | 0.0228 | 0.0279 |
| 12 | 0.0131 | 0.0149 |
| 13 | 0.0241 | 0.0263 |
| 15 | 0.0273 | 0.0364 |
| 17 | 0.0311 | 0.0311 |
| 18 | 0.0452 | 0.0486 |
| 19 | 0.0584 | 0.0584 |
| 21 | 0.0351 | 0.0351 |
| TOTAL | 0.3326 | 0.3724 |
| MEAN | 0.0255 | 0.0286 |

***Catenella impudica***

| NUMBER OF ROOT | July | September |
|---|---|---|
| # 4 | 0.0053 | 0.0128 |

Table 2. Dry weight mean (mg/cm$^2$) of algal epiphytic on roots of *Rhizophora racemosa* in the dry and rainy season of 2011.

| SPECIE | DRY SEASON | RAINY SEASON | MEAN |
|---|---|---|---|
| *Bostrychia calliptera* | 37.8 | 42.1 | 39.9 |
| *Caloglossa leprieurii* | 8.2 | 0.02 | 4.1 |

## CONCLUSSION

The wide dominance of *Bostrychia calliptera* in the *Bostrychietum* association of Puerto Limón is suggested of the importance of environmental factors in the spatial and temporal distribution of mangrove algae. The ability to withstand emersion and salinity variations seems to be the major determinants of the abundance of this specie. Predominance of *B. calliptera* on *Rhizophora* roots in both summer and rainy season reveal absence of competitive interactions for bare space during colonization and absence of well-defined zonation pattern.

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