



Biota Neotropica

ISSN: 1676-0611

cjoly@unicamp.br

Instituto Virtual da Biodiversidade
Brasil

Moreira Rocha, Rosana; Guerra-Castro, Edlin; Lira, Carlos; Marquez Pauls, Sheila; Hernández, Ivan; Pérez, Adriana; Sardi, Adriana; Pérez, Jeannette; Herrera, César; Carbonini, Ana Karinna; Caraballo, Virginia; Salazar, Dioceline; Diaz, Maria Cristina; Cruz-Motta, Juan José
Inventory of ascidians (Tunicata, Ascidiacea) from the National Park La Restinga, Isla Margarita, Venezuela

Biota Neotropica, vol. 10, núm. 1, 2010, pp. 209-218

Instituto Virtual da Biodiversidade

Campinas, Brasil

Available in: <http://www.redalyc.org/articulo.oa?id=199115789021>

- How to cite
- Complete issue
- More information about this article
- Journal's homepage in redalyc.org

redalyc.org

Scientific Information System

Network of Scientific Journals from Latin America, the Caribbean, Spain and Portugal

Non-profit academic project, developed under the open access initiative

Inventory of ascidians (Tunicata, Ascidiacea) from the National Park La Restinga, Isla Margarita, Venezuela

Rosana Moreira Rocha^{1,11}, Edlín Guerra-Castro², Carlos Lira³, Sheila Marquez Pauls⁴, Ivan Hernández⁵,
Adriana Pérez³, Adriana Sardi⁶, Jeannette Pérez⁶, César Herrera⁶, Ana Karinna Carbonini⁷,
Virginia Caraballo³, Dioceline Salazar⁸, Maria Cristina Diaz⁹ & Juan José Cruz-Motta^{6,10}

¹Departamento de Zoología, Universidade Federal do Paraná – UFPR,
CP 19020, CEP 82531-980 Curitiba, PR, Brasil

²Centro de Ecología, Instituto Venezolano de Investigaciones Científicas,
CP 21827, Caracas 1020-A, Venezuela, e-mail: eguerra@ivic.ve

³Laboratorio de Zoología, Universidad de Oriente, Núcleo de Nueva Esparta,
Escuela de Ciencias Aplicadas del Mar,

CP 658, Porlamar 6301, Isla Margarita, Venezuela, e-mail: c_lira_g@hotmail.com,
adripeva@gmail.com, amanonvi@gmail.com

⁴Instituto de Zoología Tropical, Escuela de Biología, Universidad Central de Venezuela,
CP 47058, Caracas 1041, Venezuela, e-mail: s.m.pauls@gmail.com

⁵Departamento de Ciencias, Universidad de Oriente, Núcleo de Nueva Esparta,
Guatamara, Isla de Margarita, Venezuela, e-mail: ivanhernavila@yahoo.com

⁶Laboratorio de Ecología Experimental, Universidad Simón Bolívar,
CP 89000, Sartenejas, Caracas 1080, Venezuela,

e-mail: adrianasardi@gmail.com, jeannetteperezbenitez@yahoo.es, herrera.ce@gmail.com

⁷Laboratorio de Biología Marina, Universidad Simón Bolívar,
CP 89000, Sartenejas, Caracas 1080, Venezuela, e-mail: carbonini@usb.ve

⁸Departamento de Biología, Escuela de Ciencias, Universidad de Oriente, Núcleo de Sucre,
CP 245, CEP 6101, Cumaná, Venezuela, e-mail: disalma21@gmail.com

⁹Museo Marino de Margarita, Bulevar El Paseo,
Boca del Río, Margarita, Edo. Nueva Esparta, Venezuela, e-mail: taxochica@gmail.com

¹⁰Departamento de Estudios Ambientales, Universidad Simón Bolívar,
CP 89000, Sartenejas, Caracas 1080, Venezuela, e-mail: juancruz@usb.ve

¹¹Corresponding author: Rosana Moreira Rocha, e-mail: rmrocha@ufpr.br

ROCHA, R.M., GUERRA-CASTRO, E., LIRA, C., PAUL, S.M., HERNÁNDEZ, I., PÉREZ, A., SARDI, A., PÉREZ, J., HERRERA, C., CARBONINI, A.K., CARABALLO, V., SALAZAR, D., DIAZ, M.C. & CRUZ-MOTTA, J.J. **Inventory of ascidians (Tunicata, Ascidiacea) from the National Park La Restinga, Isla Margarita, Venezuela.** *Biota Neotrop.* 10(1): <http://www.biotaneotropica.org.br/v10n1/en/abstract?inventory+bn00510012010>.

Abstract: Although ascidians form a conspicuous part of sessile assemblages in the Caribbean, no specialized inventories have been developed in Venezuela, except for a list of 15 species reported from Margarita Island (1984). Here we present the results of a taxonomic workshop held in the Universidad de Oriente, Boca del Río, Margarita Island during April 20-25 of 2009, sponsored by the NaGISA-Caribbean Sea program. La Restinga National park was surveyed and we found 29 species belonging to 19 genera and 10 families. The most abundant colonial species were *Clavelina oblonga*, *Aplidium accarensense*, *Polyclinum constellatum*, *Distaplia bermudensis*, *Symplegma rubra*, *S. brakenhielmi*, *Botrylloides nigrum* and *Ecteinascidia turbinata*. Among the solitary ascidians *Phallusia nigra*, *Ascidia curvata*, *Microcosmus exasperatus*, *Styela canopus*, *Styela* sp.1 and *Styela* sp. 2 were the most abundant. The ascidian diversity in this lagoon is one of the highest for similar habitats in the Caribbean and seven species are new registers for Venezuela (*Ascidia curvata*, *Ecteinascidia styeloides*, *Aplidium accarensense*, *Distaplia stylifera*, *Trididemnum orbiculatum*, *Symplegma rubra*, and *S. brakenhielmi*). One point of concern for the conservation of la Restinga National Park is the presence of possible introduced species, and some management procedures are suggested.

Keywords: *Urochordata*, taxonomy, South Caribbean, mangrove, coastal lagoon, conservation, bioinvasion.

ROCHA, R.M., GUERRA-CASTRO, E., LIRA, C., PAUL, S.M., HERNÁNDEZ, I., PÉREZ, A., SARDI, A., PÉREZ, J., HERRERA, C., CARBONINI, A.K., CARABALLO, V., SALAZAR, D., DIAZ, M.C. & CRUZ-MOTTA, J.J. **Inventário de ascídias (Tunicata, Ascidiacea) do Parque Nacional La Restinga, Isla Margarita, Venezuela.** *Biota Neotrop.* 10(1): <http://www.biotaneotropica.org.br/v10n1/pt/abstract?inventory+bn00510012010>.

Resumo: Apesar das ascídias formarem uma parte conspícua das comunidades incrustantes no Caribe, nenhum inventário especializado foi realizado na Venezuela, com exceção de uma lista de 15 espécies registradas na Ilha Margarita (1984). Aqui apresentamos os resultados de um workshop de taxonomia realizado na Universidad de Oriente, Boca del Rio, Margarita Island em 20-25 de abril de 2009, como parte do programa NaGISA-Caribbean Sea program. O Parque Nacional La Restinga foi estudado e encontradas 29 espécies pertencendo a 19 gêneros e 10 famílias. As espécies coloniais mais abundantes foram *Clavelina oblonga*, *Aplidium accarensense*, *Polyclinum constellatum*, *Distaplia bermudensis*, *Symplegma rubra*, *S. brakenhielmi*, *Botrylloides nigrum* e *Ecteinascidia turbinata*. Entre as espécies solitárias, *Phallusia nigra*, *Ascidia curvata*, *Microcosmus exasperatus*, *Styela canopus*, *Styela* sp.1 e *Styela* sp. 2 foram as mais abundantes. A diversidade de ascídias nesta laguna é uma das maiores neste tipo de habitat no Caribe e sete espécies representam novos registros para a Venezuela (*Ascidia curvata*, *Ecteinascidia styeloides*, *Aplidium accarensense*, *Distaplia styliifera*, *Trididemnum orbiculatum*, *Symplegma rubra*, e *S. brakenhielmi*). Uma questão de preocupação para a conservação do Parque Nacional La Restinga é a presença de possíveis espécies exóticas, portanto algumas medidas de manejo são sugeridas.

Palavras-chave: *Urochordata, taxonomia, Caribe Sul, manguezal, laguna costeira, conservação, bioinvasão.*

Introduction

Ascidians are one of the most conspicuous invertebrate groups in coastal benthic assemblages. In the Caribbean, inventories of ascidian species have been done at Netherlands Antilles (Millar 1962, Goodbody 1984a), Guadeloupe (Monniot, C. 1983a, b, c & Monniot, F. 1983a, b, c), Jamaica (Goodbody 1993, 2003), Cuba (Zanui 1990), Belize (Goodbody 2000, 2004) and Panama (Rocha et al. 2005). In Venezuela, however, no specialized inventories have been developed except for the list of 15 species presented by Goodbody (1984b) for Margarita Island. In general, reports of ascidians from the Venezuelan Coast come mainly from ecological studies such as Sutherland (1980), Montes (1985), Álvarez (1989) and Orihuela et al. (1991) and the status of endemic, regional or even invasive ascidians in Venezuela is completely unknown (Zoppi de Roa 2003). This situation has prevented detailed descriptions of macrobenthic assemblages such as those growing on mangrove roots, coral reefs, rocky shores and *Thalassia* beds (Conde & Carmona-Suárez 2003, Miloslavich et al. 2005).

The survey reported here was done in the National Park La Restinga where diverse and abundant assemblages of tunicates grow on the mangrove roots (Cervigon & Gomez 1986, Orihuela et al. 1991, Díaz et al. 1992). La Restinga has been preserved as a national park since 1974 because of its highly diverse habitat contrasting with the arid vegetation of the terrestrial environment surrounding it (Presidential Ordinance n° 1591). This important system attracted the interest of many scientists whose studies included ecological aspects of primary production and planktonic biomass (Gómez 1983), polychaetes (Díaz & Liñero 2009), mollusks (González 1976, Nirchio et al. 1991, Bigatti et al. 2005, Miloslavich et al. 2007, Buitrago et al. 2009), crustaceans (Scelzo 1972, López Greco et al. 2001, Bolaños et al. 2004), fishes (Gómez 1981, Fuentes et al. 2003, Marín et al. 2003), and mangrove root fouling (Orihuela et al. 1991). However, a few studies described the ascidian fauna and only 15 species have been reported (Goodbody 1984b, Orihuela et al. 1991), representing a very small diversity for a Caribbean lagoon bordered by mangrove habitat. Although a few lagoons have been studied in the Caribbean, those better known usually contain between 25-40 species of ascidians (Toffart 1983, Goodbody 2004). Our survey increased the registers of ascidians in the mangrove complex La Restinga to at least 29 species.

Material and Methods

1. Study site

La Restinga is a coastal hypersaline lagoon located in the central part of Margarita Island, Venezuela. The lagoon has an area of 30 km²,

maximum depth of 6 m and is formed by a complex system of channels and ponds bordered by mangrove habitats. Detailed description of the environmental characteristics of the lagoon is provided by Cabrera & Penoth (1988), Gómez (1991), Orihuela et al. (1991), Ramírez (1996) and Salazar et al. (2003).

In general, the ascidians attach to the mangrove prop roots of *Rhizophora mangle*, usually in large biomass, and represent an important portion of the fouling community (Sutherland 1980, Álvarez 1989, Díaz et al. 1992, Farnsworth & Ellison 1996, Goodbody 2000).

This survey was performed in four sites inside La Restinga: Entrance, Mánamo, La Tortuga and La Isleta (Figure 1). The Entrance (10° 58' 50" N and 64° 9' 55" W), Mánamo (10° 58' 49" N and 64° 9' 22" W) and La Isleta (10° 59' 13" N and 64° 09' 17" W) have a stable salinity around 36-38% and strong tidal currents (Gómez 1991). La Tortuga (11° 00' 07" N and 64° 09' 47" W) is a hypersaline area, presenting salinity up to 45% (Gómez 1991). The movement of fishing

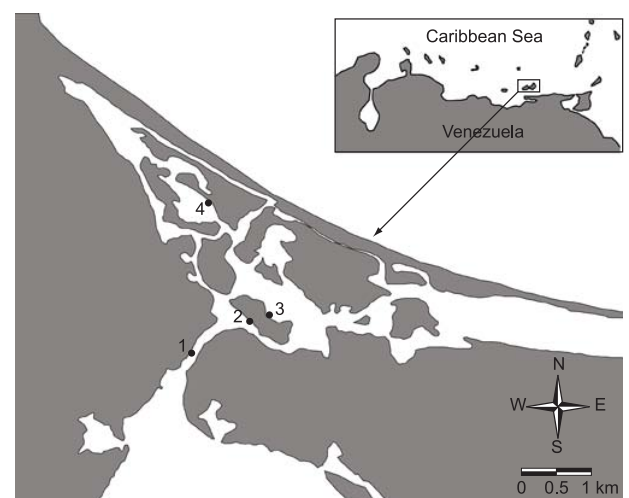


Figure 1. Map of la laguna of La Restinga National Park, Margarita Island, Venezuela. 1 - Entrance, 2 - Mánamo, 3 - La Isleta, 4 - La Tortuga. Insert showing location of Margarita Island.

and leisure boats is intense, increasing both the water hydrodynamics and the potential for species transport.

2. Field and laboratory work

The survey was performed on 20th and 21st of April 2009, with an effort of 1 hour snorkeling in each site by 14 divers. Specimens were photographed before collection for color and shape assessment of living animals. Samples were relaxed for 2 hours in a menthol-saturated sea-water solution and fixed in 5% seawater formalin.

Dissection followed routine methods (Monniot, C & Monniot, F 1972) and the literature for Caribbean ascidians and adjacent regions was consulted for identification (Berrill 1932, Van Name 1945, Millar 1962, 1978, Van der Sloot 1969, Monniot, C. 1972a, b, 1983a, b, c, Monniot,

F. 1972, 1983a, b, c, Millar & Goodbody 1974, Monniot, C & Monniot, F 1984, Goodbody 1984a, 1984b, 1993, 1994, 2000, 2003, 2004, Goodbody & Cole 1987, 2006, Zanui 1990, Rocha et al. 2005).

Voucher specimens of all sampled species are deposited in the reference collections of the Museo Marino de Margarita, Isla Margarita and Museo Oceanológico “Benigno Roman” de la Estación de Investigaciones Marinas de Margarita (EDIMAR) - Fundación La Salle de Ciencias Naturales.

Results

We found 29 species belonging to 19 genera and 10 families (Table 1). Colonial species were abundant, usually covering soli-

Table 1. List of the species found at La Restinga National Park, Boca del Río, Isla Margarita, Venezuela. The number of Xs correspond to the relative visual abundance of the species comparing the four sites.

| | Mánamo | La Tortuga | Entrance | La Isleta |
|--|--------|------------|----------|-----------|
| Corellidae | | | | |
| <i>Rhodosoma turcicum</i> (Savigny, 1816) | - | - | XX | - |
| Asciidiidae | | | | |
| <i>Phallusia nigra</i> Savigny, 1816 | XXX | X | XXX | XX |
| <i>Ascidia curvata</i> (Traustedt, 1882) | XX | - | XX | X |
| <i>Ascidia</i> sp. | X | X | X | X |
| Perophoridae | | | | |
| <i>Ecteinascidia styeloides</i> (Traustedt, 1882) | - | - | X | X |
| <i>Ecteinascidia turbinata</i> Herdman, 1880 | XXX | X | XXX | XX |
| <i>Perophora viridis</i> Verrill, 1871 | - | - | X | - |
| Clavelinidae | | | | |
| <i>Clavelina oblonga</i> Herdman, 1880 | XXX | X | XXX | XXX |
| Polyclinidae | | | | |
| <i>Aplidium accareense</i> (Millar, 1953) | XXX | X | XXX | XX |
| <i>Polyclinum constellatum</i> Savigny, 1816 | X | XXX | X | X |
| Holozoidae | | | | |
| <i>Distaplia bermudensis</i> Van Name, 1902 | XX | - | XXX | X |
| <i>Distaplia stylifera</i> (Kowalevsky, 1874) | - | - | XX | X |
| Didemnidae | | | | |
| <i>Diplosoma listerianum</i> (Milne-Edwards, 1841) | X | XX | X | X |
| <i>Lissoclinum fragile</i> (Van Name, 1902) | XX | - | X | X |
| <i>Lissoclinum</i> sp. | X | - | X | X |
| <i>Didemnum cineraceum</i> (Sluiter, 1898) | - | - | X | - |
| <i>Didemnum duplicatum</i> Monniot, 1983 | X | - | - | - |
| <i>Didemnum perlucidum</i> Monniot, 1983 | - | - | XX | X |
| <i>Trididemnum orbiculatum</i> (Van Name, 1902) | X | - | X | - |
| Styelidae | | | | |
| <i>Symplegma brakenhielmi</i> (Michaelsen, 1904) | XXX | X | XXX | XXX |
| <i>Symplegma rubra</i> Monniot, 1972 | XXX | - | XXX | X |
| <i>Botrylloides nigrum</i> (Herdman, 1886) | XXX | XX | XXX | XXX |
| <i>Botrylloides</i> sp. | XXX | X | X | X |
| <i>Styela canopus</i> Savigny, 1816 | X | X | XXX | XX |
| <i>Styela</i> sp. 1 | XXX | XX | XXX | XXX |
| <i>Styela</i> sp. 2 | XX | X | X | XX |
| Pyuridae | | | | |
| <i>Microcosmus exasperatus</i> Heller, 1878 | XXX | XX | XXX | XXX |
| <i>Herdmania pallida</i> (Heller, 1878) | - | - | X | - |
| Molgulidae | | | | |
| <i>Molgula occidentalis</i> Traustedt, 1883 | X | - | X | - |
| TOTAL | 22 | 14 | 28 | 22 |



Figure 2. a) *Rhodosoma turcicum* (Savigny, 1816); b) *Phallusia nigra* Savigny, 1816; c) *Ascidia curvata* (Traustedt, 1882) covered by *Symplegma brakenhielmi*; d) *Ecteinascidia turbinata* Herdman, 1880; e) *Ecteinascidia styeloides* (Traustedt, 1882); f) *Perophora viridis* Verrill, 1871; g) *Clavelina oblonga* Herdman, 1880; h) *Aplidium accarense* (Millar, 1953); i) *Polyclinum constellatum* Savigny, 1816. Photos credits: a, e, f, g) RMR; b) AKC; c,d) CH; h) SMP; i) EGC.



Figure 3. a, b, c) *Polyclinum constellatum* Savigny, 1816; d, e) *Distaplia bermudensis* Van Name, 1902; f, g) *Distaplia stylifera* (Kowalevsky, 1874); h) *Diplosoma listerianum* (Milne-Edwards, 1841); i) *Didemnum cineraceum* (Sluiter, 1898). Photos credits: a, d) EGC; b) SMP; c) RMR; e, f) AP; g) JP; h) MCD; i) AKC.

Rocha, R.M. et al.



Figure 4. a) *Didemnum perlucidum* Monniot, 1983; b) *Trididemnum orbiculatum* (Van Name, 1902); c,d) *Symplegma brakenhielmi* (Michaelsen, 1904); e) *Symplegma rubra* Monniot, 1972; f, g) *Botrylloides nigrum* (Herdman, 1886); h) *Botrylloides* sp.; i) *Styela canopus* Savigny, 1816. Photos credits: a, b, i) RMR; c) SMP; d, e, h) EGC; f) CH.

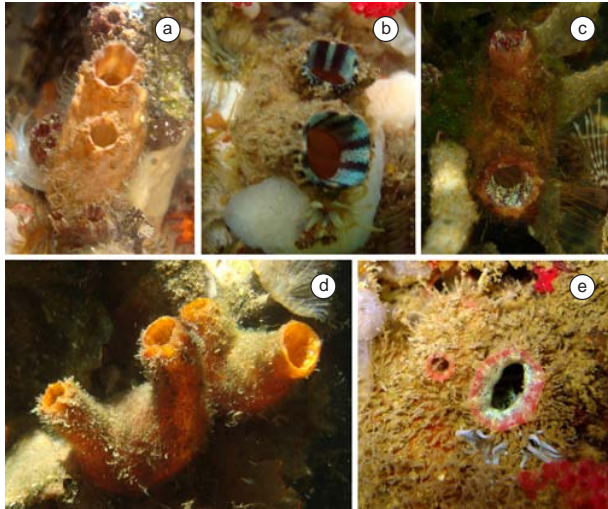


Figure 5. a) *Styela* sp. 2; b) *Styela* sp. 1; c) *Herdmania pallida* (Heller, 1878); d) *Microcosmus exasperatus* Heller, 1878; e) *Molgula occidentalis* Traustedt, 1883. Photos credits: a, b, c) RMR; d) EGC; e) AP.

tary animals. The most abundant species were *Clavelina oblonga*, *Aplidium accarense*, *Polyclinum constellatum*, *Distaplia bermudensis*, *Symplegma rubra*, *S. brakenhielmi*, *Botrylloides nigrum* and *Ecteinascidia turbinata*. Among the solitary ascidians *Phallusia nigra*, *Ascidia curvata*, *Microcosmus exasperatus*, *Styela canopus*, *Styela* sp. 1 and *Styela* sp. 2 were the most abundant.

Five species were not identified either because of the lack of enough taxonomic characters or because they did not match with any Atlantic species: *Ascidia* sp., *Lissoclinum* sp., *Botrylloides* sp., *Styela* sp. 1 and *Styela* sp. 2. *Ascidia* sp. is very similar to *Ascidia curvata* but with red or orange vessels in the tunic, easily seen around the siphons. *Lissoclinum* sp. is white in the field but turns brown or orange in formalin. The colony contains a thin layer of more or less dense spicules (sometimes almost none) on the surface and the preserved zooids are very opaque with brown pigment and orange stigmata. The tunic is soft and extensively adheres to the zooids, at least in freshly fixed animals, which made it very difficult to pull out zooids in good condition for identification. Reproductive structures were not available for examination. Larvae present three adhesive papillae and four pairs of finger-like ampullae. *Botrylloides* sp. (Figure 4h) presents a uniform orange colony with long linear systems. Neither gonads or larvae were available for identification. *Styela* sp. 1 and *Styela* sp. 2 present very similar internal structure but are considered separate species because of the different appearance of living animals. *Styela* sp. 1 has a white tunic and wide oral siphons; both siphons have wide radial blue bands inside (Figure 5b). In *Styela* sp. 2 the tunic is a light brown or rose, without the blue bands on the siphons but with many irregular tunic projections around both siphons (Figure 5a). In both species the body is elongate with a variable number of gonads in each side: *Styela* sp. 1 has 3-8 (right side) and 2-5 (left side); *Styela* sp. 2 has 5-7 (right side) (one specimen had no gonads on the right side), and 4-6 (left side). The structure of the gonads is also very similar with long tubular ovaries surrounded by orange elongate male follicles, not very dense or ramified, positioned vertically with only the proximal end attached to the body wall. The follicles of *Styela* sp. 1 were usually shorter than the ones in *Styela* sp. 2.

The Entrance was the most diverse site with 28 species, and La Tortuga was the least rich with 14 species (Table 1). The list of sampled species with a visual estimate of abundance is presented in Table 1 and photos of the species in the field are presented in Figures 2-5.

Discussion

Although the survey presented here was short and covered only four sites in the lagoon, we sampled 29 species of ascidians, a relatively high richness when compared to other Caribbean lagoons with mangrove habitats: 25 in Guadeloupe (Toffart 1983), 30 in Puerto Rico (Toffart 1983), 11 in Trinidad (Toffart 1983), 7 in Florida (Toffart 1983), 23 in Piscadera Baai, Curaçao (Goodbody 1984b), 15 in Lac, Bonaire (Goodbody 1984b), 55 in Pelican Cays, Belize (Goodbody 2000), 40 in Twin Cays, Belize (Goodbody 2004), 39 in Port Royal, Jamaica (Goodbody 2003), 29 in Almirante Bay, Bocas del Toro, Panama (Rocha et al. 2005).

Two previous studies reported 15 species for La Restinga (Goodbody 1984b, Orihuela et al. 1991) (Table 2). Among the species reported by Goodbody (1984b) and Orihuela et al. (1991), we did not encounter *Ascidia interrupta*, *Didemnum conchyliatum*, *Symplegma viride* and *Styela plicata*. The first two are common Caribbean species and new surveys can reveal their presence in the area. *Symplegma viride* could be easily confounded with *S. brakenhielmi* since differences between these species are subtle (see Monniot 1972b, 1983b for descriptions). *Styela plicata* is an introduced species in the Atlantic (Barros et al. 2009) found usually in high densities in harbors and marinas. Since we surveyed the same site mentioned by Goodbody (1984b) – “Puente de la Restinga” (= Entrance) and did not find any individuals, either the species has disappeared from the area or it was misidentified and perhaps was our *Styela* sp. 1 or *Styela* sp. 2.

Considering the list of known species for Venezuela, 30 species have been previously reported (Table 2). *Ascidia curvata*, *Ecteinascidia styeloides*, *Aplidium accarense*, *Distaplia styliifera*, *Trididemnum orbiculatum*, *Symplegma rubra*, and *S. brakenhielmi* are new records for this country but all species are widespread in the Caribbean. *Aplidium accarense*, though, was first described for Ghana, Africa (Millar 1953) and is also known from south Brazil where it is suspected to be introduced (Rocha et al. 2009). Molecular data would be helpful to better understand the genetic structure between the populations of *A. accarense* in the American and African Coasts. *Distaplia styliifera* is considered by Van Name (1945) as a synonymy of *D. bursata*. Both are very similar indeed because the description of *D. bursata* fits in the wide range of character variation reported for *D. styliifera*, for which the majority of records of are in the Indo-Pacific. In the Caribbean it was reported from the west coast of Florida, Jamaica and Colombia (Van Name 1945), but recent studies did not list the species in Jamaica (Goodbody 1993, 2003), Guadeloupe (Monniot, F 1983c) or Belize (Goodbody 2000, 2004). In Bocas del Toro, Panama, it occurs in the marina of the city, but only on artificial substrata (RMR, unpublished data). All this evidence also suggests that *D. styliifera* is not native in the Caribbean.

The Entrance was the richest site in species. Among the sampled species, only *Didemnum duplicatum* was not registered in The Entrance, but many white didemnids were observed but not collected because this was the last site visited and we were trying to not re-collect similar organisms. White didemnids, though, can not be certainly identified by pictures and it is possible that we will find not only *D. duplicatum* but other species in this site. Tidal currents in The Entrance may prevent sedimentation on the sessile community, usually a negative factor that causes mortality to recruits and juveniles (Young & Chia 1984) and disturbs water filtration by the adults (Peterson 2007). At La Tortuga the high salinity seems to be strongly selecting against the survival of some species and only half of the species encountered during this study was registered at La Tortuga. *Polyclinum constellatum* was especially abundant at this site as ball-shaped colonies filled with a gelatinous tunic with the

Table 2. List of known species for Venezuela.

| | La Tortuga ¹ | Margarita island ¹ | Los Testigos ¹ | Cubagua Island ² | Aves Island ³ | Chacopata Bay, Sucre ³ | Mochima Bay, Sucre ⁴ | Buche Bay ⁵ | La Restinga, Margarita Isl. ⁶ | La Restinga, Margarita Isl. ^{7,8} | Margarita Island ⁷ |
|--|-------------------------|-------------------------------|---------------------------|-----------------------------|--------------------------|-----------------------------------|---------------------------------|------------------------|--|--|-------------------------------|
| Diazoniidae | | | | | | | | | | | |
| <i>Rhopalaea abdominalis</i> (Sluiter, 1898) | X | - | - | - | - | - | - | - | - | - | - |
| Corellidae | | | | | | | | | | | |
| <i>Rhodossoma turcicum</i> (Savigny, 1816) | - | - | - | - | - | - | X | - | - | - | - |
| Asciidiidae | | | | | | | | | | | |
| <i>Ascidia interrupta</i> Heller, 1878 | - | - | - | - | - | - | - | - | - | X | - |
| <i>Phallusia nigra</i> Savigny, 1816 | - | - | - | - | - | - | X | - | X | X | - |
| Perophoridae | | | | | | | | | | | |
| <i>Ecteinascidia conklini</i> Berrill, 1932 | - | - | - | - | - | - | - | X | - | - | - |
| <i>Ecteinascidia turbinata</i> Herdman, 1880 | - | - | - | - | - | - | - | - | - | X | - |
| <i>Perophora bermudensis</i> Berrill, 1932 | - | - | - | - | X | - | - | - | - | - | - |
| Clavelinidae | | | | | | | | | | | |
| <i>Clavelina oblonga</i> Herdman, 1880 | - | - | - | - | - | - | - | - | - | X | - |
| Polyclinidae | | | | | | | | | | | |
| <i>Aplidium bermudae</i> (Van Name, 1902) | - | - | - | X | - | - | - | - | - | - | - |
| <i>Aplidium funginum</i> (Sluiter, 1898) | X | - | - | - | - | - | - | - | - | - | - |
| <i>Polyclinum constellatum</i> Savigny, 1816 | - | - | - | - | - | - | - | X | - | X | X |
| Polycitoridae | | | | | | | | | | | |
| <i>Eudistoma hepaticum</i> (Van Name, 1921) | - | - | - | - | - | - | - | - | - | - | X |
| <i>Eudistoma olivaceum</i> (Van Name, 1902) | - | - | - | - | - | - | - | - | - | - | X |
| Holozoidae | | | | | | | | | | | |
| <i>Distaplia bermudensis</i> Van Name, 1902 | - | - | - | - | - | - | - | - | - | X | - |
| Didemnidae | | | | | | | | | | | |
| <i>Didemnum conchyliatum</i> (Sluiter, 1898) | - | - | - | - | - | - | - | - | - | X | - |
| <i>Didemnum duplicatum</i> Monniot, 1983 | - | - | - | - | - | - | - | - | - | X | - |
| <i>Didemnum vanderhorsti</i> Van Name, 1924 | - | - | - | - | - | - | - | - | - | - | X |
| <i>Diplosoma listerianum</i> (Milne-Edwards, 1841) | - | - | - | - | - | - | - | - | X | X | X |
| Styelidae | | | | | | | | | | | |
| <i>Botrylloides nigrum</i> (Herdman, 1886) | - | X | - | - | - | - | - | X | X | X | - |
| <i>Symplegma viride</i> Herdman, 1886 | - | - | - | - | - | - | - | X | X | X | - |
| <i>Styela canopus</i> Savigny, 1816 | - | - | - | - | - | - | - | X | - | X | - |
| <i>Styela plicata</i> (Lesueur, 1823) | - | - | - | - | - | - | X | - | X | X | - |
| <i>Polycarpa appropinquata</i> (Sluiter, 1898): | X | - | - | - | - | - | - | - | - | - | - |
| <i>Polycarpa aurita</i> (Sluiter, 1890) | X | - | - | - | - | - | - | - | - | - | - |
| <i>Polycarpa nivosa</i> (Sluiter, 1898) | - | - | ? | - | - | - | - | - | - | - | - |
| <i>Polycarpa spongiabilis</i> (Traustedt, 1883) | X | - | - | - | - | - | X | - | - | - | - |
| Pyuridae | | | | | | | | | | | |
| <i>Microcosmus exasperatus</i> Heller, 1878 | - | - | - | - | - | - | - | X | - | X | - |
| <i>Herdmania pallida</i> (Heller, 1878) | - | - | - | - | - | - | X | - | - | X | - |
| <i>Pyura vittata</i> (Stimpson, 1852) | - | - | - | - | - | - | X | - | X | - | - |
| Molgulidae | | | | | | | | | | | |
| <i>Molgula occidentalis</i> Traustedt, 1883 | - | - | - | - | - | X | - | - | - | - | - |

¹Sluiter 1898, ²Van Name 1945, ³Millar 1962, ⁴Bermúdez & Jimenez 1975, ⁵Sutherland 1980, ⁶Ramirez, 1996 (based in Galan 1976), ⁷Goodbody 1984b, ⁸Orihuela et al. 1991.

zooids located only around the outer edge like the ones observed in Port Royal, Jamaica (Goodbody 2003).

One point of concern for the conservation of la Restinga National Park is the presence of possible introduced species, since it is a protected area (Presidential Ordinance n°1591). Other studies identified the presence of introduced species in Venezuela (Montes & Prieto 2005, Perez et al. 2007) but the lack of comprehensive surveys allowed the recognition of only one introduced tunicate, *Styela clava* (Herdman, 1881). Given the fact that it is a cold water species, its identification is doubtful. Ascidians have been recognized as frequent invaders of new areas in recent years (Lambert 2005, 2007) causing major fouling problems for the bivalve aquaculture industry (Carver et al. 2003, LeBlanc et al. 2007). In natural environments they have the potential to displace native species causing reduction of biodiversity. In La Restinga we detected some species that are already widespread in the Caribbean and probably represent historical introductions such as *Microcosmus exasperatus* and *Styela canopus*. The presence of *Ascidia sydneiensis* was only guessed by photos and should be confirmed as well as *Styela plicata*. If present, these species are still not abundant and manual eradication could be tried. If *Aplidium accarensense* and *Distaplia stylifera* prove to be introduced they represent a real threat to the diversity of the region, since they grow in large, massive colonies that could smother and displace other species.

The movement of recreational and fishing boats has already been shown to be an important vector for intraregional spread of invaders both in freshwater and marine environments (Johnson et al. 2001, Wasson et al. 2001, Darbyson et al. 2009). Frequent cleaning of the hulls and anchors, and control of water discharge, oyster shells and other shellfish refuse, are important management procedures toward the prevention of species dispersal. Furthermore, artificial substrates are also known as important habitats used by introduced species for first establishment (Glasby et al. 2007). The avoidance of construction of piers or other structures inside the lagoon which would add artificial substrate for colonization of sessile animals and frequent (less than two months) cleaning of existing structures are other prevention measures that should be followed. Managers should also promote periodic monitoring to increase the chances of early detection and possible eradication of introduced species.

Old photos of mangrove roots by CL and AP (2007-2008) showed the presence of a few species not collected in this survey, including *Clavelina picta*, *Ascidia sydneiensis* and a colony with round systems which resembles *Distaplia corolla*. Other cryptic species such as *Corella minuta*, *Perophora* spp. and *Ecteinascidia minuta* frequently found in Caribbean mangrove habitats are also expected in further collections in the area. It is also important to consider that the only two studied Caribbean lagoons that presented a richer community of ascidians than "La Restinga" are those in Belize that were studied for years and include temporary and rare species (Goodbody 2000, 2004). Thus the list here presented is far from complete and we expect to have 35-38 ascidian species in La Restinga lagoon, which would make this mangrove system among the ones with the highest biodiversity in the Caribbean.

Acknowledgements

This workshop was mainly sponsored by NaGISA-Caribbean Sea program. Special thanks to Prof. Juan Bolaños, Prof. Monzerrat Esteves and Prof. Jesús Rosas, all from Escuela de Ciencias Aplicadas del Mar, Universidad de Oriente, for logistic facilities in Boca del Rio. Special thanks to Prof. Jesús Eloy Conde from Center for Ecology, IVIC, for supporting this workshop with minor costs and lab material. We also extend our gratitude to Lic. Oscar Hernández

from Instituto Nacional de Parques (INPARQUES). RMR received a research grant from CNPq and thanks the Bocas Research Marine Station - STRI for lab space while preparing this paper.

References

- ÁLVAREZ, A. 1989. Establecimiento, desarrollo y mantenimiento de una comunidad epibentónica tropical. Tese de Doutorado, Universidad Central de Venezuela, Caracas.
- BARROS, R., ROCHA, R.M. & PIE, M. 2009. Human-mediated global dispersion of *Styela plicata* (Tunicata, Ascidiacea). *Aquat. Invas.* 4(1):45-57.
- BERMUDEZ, I.R. & JIMENEZ, G. 1975. Estudio comparativo de cuatro especies de ascidias de la Bahía de Mochima, Estado Sucre. *Lagena* (35-36):31-49.
- BERRILL, N.J. 1932. Ascidians of the Bermudas. *Biol. Bull.* 62(1):77-88.
- BIGATTI, G., MILOSLAVICH, P. & PENCHASZADEH, P. 2005. Sexual differentiation and size at first maturity of the invasive mussel *Perna viridis* (Linnaeus, 1758) (Mollusca: Mytilidae) at La Restinga Lagoon (Margarita Island, Venezuela). *Am. Malac. Bull.* 20(1):65-69.
- BUITRAGO, E., BUITRAGO, J., FREITES, L. & LODEIROS, C. 2009. Identificación de factores que afectan el crecimiento y la supervivencia de la ostra de mangle, *Crassostrea rhizophorae* (Guilding, 1828), bajo condiciones de cultivo suspendido en la laguna de La Restinga, Isla de Margarita, Venezuela. *Zoot. Trop.* 27(1):79-90.
- BOLAÑOS, J., CUESTA, J., HERNÁNDEZ, G., HERNÁNDEZ, J. & FELDER, D. 2004. Abbreviated larval development of *Tunicotheres moseri* (Rathbun, 1918) (Decapoda: Pinnotheridae), a rare case of parental care among brachyuran crabs. *Sci. Mar.* 63(3):373-384.
- CABRERA, T. & PENOTH, E. 1988. Estudio de las condiciones físico-químicas de la Laguna de La Restinga, Isla de Margarita, Venezuela. *Saber* 1(2):23-37.
- CARVER, C.E., CHISHOLM, A. & MALLETT, A.L. 2003. Strategies to mitigate the impact of *Ciona intestinalis* (L.) biofouling on shellfish production. *J. Shellf. Res.* 22(3):621-631.
- CERVIGON, F. & GOMEZ, A. 1986. Las lagunas litorales de la Isla de Margarita, sus recursos y conservación. Fundación Científica Los Roques, Caracas.
- CONDE, J.E. & CARMONA-SUÁREZ, C. 2003. Ecosistemas marino-costeros. In Biodiversidad en Venezuela (M. Aguilera, A. Azocar & E. González Jiménez, eds). Fundación Polar, Caracas, p. 863-883. (v. II)
- DARBYSON, E., LOCKE, A., HANSON, J.M. & WILLISON, J.H.M. 2009. Marine boating habits and the potential for spread of invasive species in the Gulf of St. Lawrence. *Aquat. Invas.* 4(1):87-94.
- DÍAZ, H., CONDE, J.E. & ORIHUELA, B. 1992. Estimating the species number and cover of a mangrove-root community: a comparison of methods. *Aust. J. Mar. Freshw. Res.* 43(4):707-714.
- DÍAZ, O. & LIÑERO, M. 2009. Porcentaje del grado de infestación de *Polypora* cf. *websteri* Hartman, 1943 (Polychaeta: Spionidae) por clase de talla de *Crassostrea rhizophorae* (Guilding, 1828) de la laguna La Restinga (Isla de Margarita, Venezuela). *Rev. Cient.* 19(2):113-118.
- FARNSWORTH, E.J. & ELLISSON, A.M. 1996. Scale-dependent spatial and temporal variability in biogeography of mangrove root epibiont communities. *Ecol. Monogr.* 66(1):45-66.
- FUENTES, L., SILVA, C. & REYES, Y. 2003. Parásitos en juveniles de *Lutjanus griseus* (Pisces: Lutjanidae) de la Laguna de la Restinga Isla de Margarita, Venezuela. *Interciencia* 28(3):463-468.
- GALÁN, A. 1976. Contribución al estudio de las incrustaciones biológicas en la laguna de La Restinga, Isla de Margarita, Venezuela. *Bol. Inst. Oceanogr. Venez.* 15(2):153-168.
- GLASBY, T.M., CONNELL, S.D., HOLLOWAY, M.G. & HEWITT, C.L. 2007. Nonindigenous biota on artificial structures: could habitat creation facilitate biological invasions? *Mar. Biol.* 151(3):887-895.
- GÓMEZ, A. 1981. Estudio de la comunidad de peces de dos localidades de la Laguna de La Restinga. *Bol. Inst. Oceanogr. Venez.* 20(1-2):91-112.
- GÓMEZ, A. 1983. Pigmentos clorofílicos, producción primaria y abundancia planctónica en el canal de entrada de la Laguna de La Restinga. *Bol. Inst. Oceanogr. Venez.* 22(1-2):91-112.
- GÓMEZ, A. 1991. Interacción entre un estuario negativo (Laguna de La Restinga, Isla de Margarita) y el mar Caribe adyacente. *Bol. Inst. Oceanogr. Venez.* 30(1-2):47-55.
- GONZÁLEZ, A. 1976. Observaciones sobre la fijación larvaria de la ostra (*Crassostrea rhizophorae*) en la laguna de La Restinga, Isla de Margarita (Venezuela). *Lagena* (37-38):13-14.

- GOODBODY, I. 1984a. The ascidian fauna of two contrasting lagoons in the Netherlands Antilles: Piscadera Baai, Curacao, and the Lac of Bonaire. *Stud. Fauna Curaçao Caribb. Isl.* 67(202):21-61.
- GOODBODY, I. 1984b. Ascidians from Caribbean shallow water localities. *Stud. Fauna Curaçao Caribb. Isl.* 67(203):62-76.
- GOODBODY, I. 1993. The ascidian fauna of a Jamaican lagoon: thirty years of change. *Rev. Biol. Trop.* 41(10):35-38.
- GOODBODY, I. 1994. The tropical Western Atlantic Perophoridae (Ascidacea): I. The genus *Perophora*. *Bull. Mar. Sci.* 55(1):176-92.
- GOODBODY, I. 2000. Diversity and distribution of ascidians (Tunicata) in the Pelican Cays, Belize. *Atoll Res. Bull.* 480:302-326.
- GOODBODY, I. 2003. The ascidian fauna of Port Royal, Jamaica. I. Harbor and mangrove dwelling species. *Bull. Mar. Sci.* 73(2):457-476.
- GOODBODY, I. 2004. Diversity and distribution of ascidians (Tunicata) at Twin Cays, Belize. *Atoll Res. Bull.* 524:1-20.
- GOODBODY, I. & COLE, L. 1987. A new species of *Perophora* (Ascidacea) from the Western Atlantic, including observations on muscle action in related species. *Bull. Mar. Sci.* 40(2):246-254.
- GOODBODY, I. & COLE, L. 2006. The tropical western Atlantic Perophoridae (Ascidacea) ii. The genus *Ecteinascidia*. *Bull. Mar. Sci.* 79(1):49-70.
- JOHNSON, L.E., RICCIARDI, A. & CARLTON, J.T. 2001. Overland dispersal of aquatic invasive species: a risk assessment of transient recreational boating. *Ecol. Applic.* 11(6):1789-1799.
- LAMBERT, G. 2005. Ecology and natural history of the protochordates. *Can. J. Zool.* 83(1):34-50.
- LAMBERT, G. 2007. Invasive sea squirts: a growing global problem. *J. Exp. Mar. Biol. Ecol.* 342(1):3-4.
- LEBLANC, N., DAVIDSON, J., TREMBLAY, R., MCNIVEN, M. & LANDRY, T. 2007. The effect of anti-fouling treatments for the clubbed tunicate on the blue mussel, *Mytilus edulis*. *Aquaculture* 264(1-4):205-213.
- LÓPEZ GRECO, L.S., BOLAÑOS, J., RODRÍGUEZ, E.M. & HERNÁNDEZ, G. 2001. Survival and molting of the pea crab larvae *Tunicotheres moseri* Rathbun 1918 (Brachyura: Pinnotheridae) exposed to copper. *Arch. Envir. Con. Tox.* 40(4):505-510.
- MARÍN, B., QUINTERO, A., BRUSSIÈRE & DODSON, J. 2003. Reproduction and recruitment of white mullet (*Mugil curema*) to a tropical lagoon (Margarita Island, Venezuela) as revealed by oolith microstructure. *Fish. Bull.* 101(4):809-821.
- MILLAR, R.H. 1953. On a collection of ascidians from the Gold Coast. *Proc. Zool. Soc. London* 123(2):277-325.
- MILLAR, R.H. 1962. Some Ascidians from the Caribbean. *Stud. Fauna Curaçao Caribb. Isl.* 13(59):61-77.
- MILLAR, R.H. 1978. Ascidians from the Guyana shelf. *Neth. J. Sea Res.* 12(1):99-106.
- MILLAR, R.H. & GOODBODY, I. 1974. New species of ascidians from the West Indies. *Stud. Fauna Curaçao Caribb. Isl.* 45(148):142-161.
- MILOSLAVICH, P., PENSHASZADEH, P. & BIGATTI, G. 2007. Imposex in gastropods from Venezuela. *Cienc. Mar.* 33(3):319-324.
- MILOSLAVICH, P., KLEIN, E., MARTIN, A., BASTIDAS, C., MARIN, B. & SPINIELLO, P. 2005. Marine biodiversity reviews: Venezuela. In *Caribbean marine biodiversity: the known and the unknown* (P. Miloslavich & E. Klein, eds). Destech Publications, Lancaster.
- MONNIOT, C. 1972a. Ascidies Stolidobranches des Bermudes. *Bull. Mus. Natn. Hist. Nat.* 43(57):617-643.
- MONNIOT, C. 1972b. Ascidies Phlebobranches des Bermudes. *Bull. Mus. Natn. Hist. Nat.* 61(82):938-948.
- MONNIOT, C. 1983a. Ascidies littorales de Guadeloupe II. Phlebobranches. *Bull. Mus. Natn. Hist. Nat.* 5(1):51-71.
- MONNIOT, C. 1983b. Ascidies littorales de Guadeloupe. IV. Styelidae. *Bull. Mus. Natn. Hist. Nat.* 5(2):423-456.
- MONNIOT, C. 1983c. Ascidies littorales de Guadeloupe VI. Pyuridae et Molgulidae. *Bull. Mus. Natn. Hist. Nat.* 5(4):1021-1044.
- MONNIOT, C. & MONNIOT, F. 1972. Clé mondial des genres d'ascidies. *Arch. Zool. Exp. Gen.* 113(3):311-367.
- MONNIOT, C. & MONNIOT, F. 1984. Ascidies littorales de Guadeloupe. VII. Espèces nouvelles et complémentaires à l'inventaire. *Bull. Mus. Natn. Hist. Nat.* 6(3):567-582.
- MONNIOT, F. 1972. Ascidies aplousobranches des Bermudes. Polyclinidae et Polycitoridae. *Bull. Mus. Hist. Nat.* 61(82):949-962.
- MONNIOT, F. 1983a. Ascidies littorales de Guadeloupe. I. Didemnidae. *Bull. Mus. Hist. Nat.* 5(1):5-49.
- MONNIOT, F. 1983b. Ascidies littorales de Guadeloupe. III. Polyclinidae. *Bull. Mus. Hist. Nat.* 5(2):413-422.
- MONNIOT, F. 1983c. Ascidies littorales de Guadeloupe V. Polycitoridae. *Bull. Mus. Natn. Hist. Nat.* 5(4):999-1019.
- MONNIOT, F. 1984. Ascidies littorales de Guadeloupe VIII. Questions de systematique evolutive posées par les Didemnidae. *Bull. Mus. Natn. Hist. Nat.* 6(4):885-905.
- MONTES, A.A. 1985. Aspectos bioecológicos de las poblaciones de ascidias solitarias en la Bahía de Mochima y costa sur del Golfo de Cariaco. *Dissertação de Mestrado, Universidad de Oriente, Venezuela.*
- MONTES, A.A. & PRIETO, A. 2005. Primer registro para Venezuela y aspectos morfológicos de la ascidia solitaria *Styela barnharti* Ritter & Forsyth, 1917 (Tunicata: Stolidobranchia). *Saber* 17(1):81-83.
- NIRCHIO, M., PÉREZ, J.E. & CEQUEA, H. 1991. Allozyme variation of *Lap Loci* in *Crassostrea rhizophorae* in relation to temperature and/or salinity. *Sci. Mar.* 55(4):563-567.
- ORIHUELA, B., DIAZ, H. & CONDE, J.E. 1991. Mass mortality in a mangrove roots fouling community in a hypersaline tropical lagoon. *Biotropica* 23(4b):592-601.
- PÉREZ, J.E., ALFONSO, C., SALAZAR, S.C., MACSOTAY, O., BARRIOS, J. & MARTINEZ ESCARBASSIERE, R. 2007. Especies marinas exóticas y criptogénicas en las costas de Venezuela. *Bol. Inst. Oceanogr. Venez.* 46(1):79-96.
- PETERSEN, J.K. 2007. Ascidian suspension feeding. *J. Exp. Mar. Biol. Ecol.* 342(1):127-137.
- RAMÍREZ, P. 1996. *Lagunas Costeras Venezolanas*. Benavente & Martínez, Porlamar.
- ROCHA, R.M., FARIA, S.B. & MORENO, T.R. 2005. Ascidians from Bocas del Toro, Panamá. I. Biodiversity. *Caribb. J. Sci.* 41(4):600-612.
- ROCHA, R.M., KREMER, L.P., BAPTISTA, M.S. & METRI, R. 2009. Bivalve cultures provide habitat for exotic tunicates in southern Brazil. *Aquat. Invas.* 4(1):195-205.
- SALAZAR, J.C., ROSAS C., J.A., RODRÍGUEZ R., J.C. 2003. Condiciones sedimentológicas de la laguna La Restinga, Isla de Margarita, Venezuela. *Interiencia* 28(1):44-50.
- SCELZO, M. 1972. Crecimiento y migración del camarón *Penaeus brasiliensis* Latreille (Decapoda. Penaeidae) en la Laguna de manglar de La Restinga, Isla de Margarita, Venezuela. *Atlántica* 5(2):107-108.
- SLUITER, C.P. 1898. Tuniciers recueilli en 1896, par la Chazalie, dans la mer des Antilles. *Mem. Soc. Zool. France* 11:5-34.
- SUTHERLAND, J.P. 1980. Dynamics of the epibenthic community on roots of the mangrove *Rhizophora mangle*, at Bahia de Buche, Venezuela. *Mar. Biol.* 58(1):75-84.
- TOFFART, J.L. 1983. Les peuplements des racines de palétuviers en Guadeloupe (Antilles Françaises). I. Analyse floristique et faunistique; méthodologie et premier résultats. *Bull. Ecol.* 14(4):227-239.
- Van der SLOOT, C.J. 1969. Ascidians of the family Styelidae from the Caribbean. *Stud. Fauna Curaçao Caribb. Isl.* 30(110):1-57.
- Van NAME, W.G. 1945. The North and South American ascidians. *Bull. Am. Mus. Nat. Hist.* 84:1-476.
- WASSON, K., ZABINC, C.J., BEDINGER, L., DIAZ, M.C. & PEARSE, J.S. 2001. Biological invasions of estuaries without international shipping: the importance of intraregional transport. *Biol. Conserv.* 102(2):143-153.
- YOUNG, C.M. & CHIA, F.S. 1984. Microhabitat-associated variability in survival and growth of subtidal solitary ascidians during the first 21 days after settlement. *Mar. Biol.* 81(1):61-68.
- ZANUI, A.H. 1990. Lista de ascidias cubanas. *Poeyana* 388:1-7.
- ZOPPI DE ROA, E. 2003. Biodiversidad de Venezuela. In *Biodiversidad en Venezuela* (M. Aguilera, A. Azocar & E. González Jiménez, eds). Fundación Polar, Caracas, p. 522-532.

Received 25/06/09

Revised 19/12/09

Accepted 01/01/10