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Director: DrC. Marta Bonilla Vichot
Email: mbon@upr.edu.cu

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Original article

Characterization of the vegetation of the El Retiro Natural Reserve, Santiago de Cuba, Cuba

Caracterización de la vegetación de la Reserva Natural El Retiro, Santiago de Cuba, Cuba

Caracterização da vegetação da Reserva Natural El Retiro, Santiago de Cuba, Cuba

Rosa María Brooks Laverdeza[1*] http://orcid.org/0000-0002-7719-2501

Alberto de las Mercedes Beyris Mazar[1] https://orcid.org/0000-0003-1753-8299

Jainer Costa Acosta[1] https://orcid.org/0000-0003-2914-7340

Josefina Blanco Ojeda[1] https://orcid.org/0000-0002-3497-7173

[1]Centro Oriental de Ecosistemas y Biodiversidad. Cuba.

[*]Corresponding author: syedhassanraxa@gmail.com

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ABSTRACT

The studies of flora and vegetation that have been carried out in El Retiro Natural Reserve have been limited to some of its sectors, so there is still no information about the structure of its vegetation formations and the relationship between them. Therefore, the objective of this research was to characterize the vegetation of this protected area. The following aspects were analyzed: dominant species, stratification and distribution in all vegetation types. A more detailed map of the distribution of vegetation formations in the area was obtained. Seven vegetation types were identified, of which secondary shrubland in semi-deciduous microphyllous forest ecotypes and secondary shrubland in coastal and pre-coastal shrubland ecotypes were new vegetation records for the reserve.

The coastal and pre-coastal scrub and the semi-deciduous microphyllous forest were the richest vegetation formations in terms of number of species and endemics. In the analysis of biological similarity, they were the most similar.

Keywords: Protected area; Vegetation type; Coastal zone.

RESUMEN

Los estudios de flora y vegetación que se han realizado en la Reserva Natural El Retiro, se han limitado a algunos de sus sectores, por lo que no se cuenta aún con información referente a la estructura de sus formaciones vegetales y la relación entre ellas. Por ello el objetivo de esta investigación fue caracterizar la vegetación de esta área protegida. Fueron analizados los siguientes aspectos: especies dominantes, estratificación y distribución en todos los tipos de vegetación. Se obtuvo un mapa con mayor nivel de detalle de distribución de las formaciones vegetales en el área. Se identificaron siete tipos de vegetación, de los cuales el matorral secundario en ecótopos de bosque semideciduo micrófilo y el matorral secundario en ecótopos matorral costero y precostero resultaron nuevos registros de vegetación para la reserva. El matorral costero y precostero y el bosque semideciduo micrófilo fueron las formaciones vegetales más ricas en número de especies y endémicos. En el análisis de similitud biológica las mismas resultaron ser las de mayor afinidad.

Palabras clave: Área protegida; Tipo de vegetación; Zona costera.

RESUMO

Os estudos de flora e vegetação que foram realizados na Reserva Natural El Retiro, foram limitados a alguns de seus setores, de modo que ainda não há informações sobre a estrutura de suas formações vegetais e a relação entre elas. Portanto, o objetivo desta pesquisa foi o de caracterizar a vegetação desta área protegida. Foram analisados os seguintes aspectos: espécies dominantes, estratificação e distribuição em todos os tipos de vegetação. Foi obtido um mapa mais detalhado da distribuição das formações vegetais na área. Sete tipos de vegetação foram identificados, dos quais o arbusto secundário em ecotopos de floresta semi decídua e o arbusto secundário em ecotopos de arbustos costeiros e pré-costeiros foram novos registros de vegetação para a reserva. Os matos costeiros e pré-costeiros e as florestas microfílicas semi decíduas foram as formações vegetais mais ricas em termos de número de espécies e endêmicos. Na análise da similaridade biológica, verificou-se que estes eram aqueles com maior afinidade.

Palavras-chave: Área protegida; Tipo de vegetação; Zona costeira.

INTRODUCTION

The transformation of Cuban vegetation is extraordinary, only some relatively little altered relicts remain in places of very difficult use by agriculture which is one of the causes that lead to the loss of biodiversity (González-Torres *et al*., 2016). One of the reference works for the study of plant formations in Cuba and the phytocenoses present in them is that of Borhidi (1996).

Reyes and Martínez (2005) emphasize the importance of Cuba's coastal communities, since, as an archipelago, a large part of its surface is directly or indirectly affected by the sea. Reyes (2012) proposes a detailed classification of the vegetation formations present in the eastern region of Cuba, coastal and pre-coastal scrub among the characteristic vegetation types of its southern coast.

The most extensive vegetation formations in the coastal zone of the Baconao Biosphere Reserve are the coastal and pre-coastal scrub and the semi-deciduous microphyllous forest, with a high richness of endemic species (Menéndez *et al.*, 1986). In a study carried out by Capote *et al.*, (1987) between Daiquirí and Verraco, these vegetation types are characterized and three plant associations are identified, and they also describe the vegetation of the sandy and rocky coast, uveral, mangrove and secondary savannah vegetation.

However, no vegetation survey has yet been published for the area, nor a vegetation cover map showing its different types. Therefore, the objective of the study is to characterize the vegetation of El Retiro Natural Reserve in terms of vertical stratification, strata coverage, ecotype, distribution and surface area occupied in the study area, species richness and similarities between each type of vegetation, which contributes to updating the management plan for this protected area.

MATERIALS AND METHODS

Study area

El Retiro Natural Reserve is located on the southern slope of the Gran Piedra Mountain Range 30 km from the city of Santiago de Cuba in the province of the same name (Figure 1). It is located at coordinates 19°55'31.30" N, 75°37'47.69" W and 19°52'47.22" N, 75°34'22.73" W. The protected area is located in a zone of emerged terraces, arranged parallel to the coastline with a predominance of dogtooth (Figueredo *et al.*, 2012).

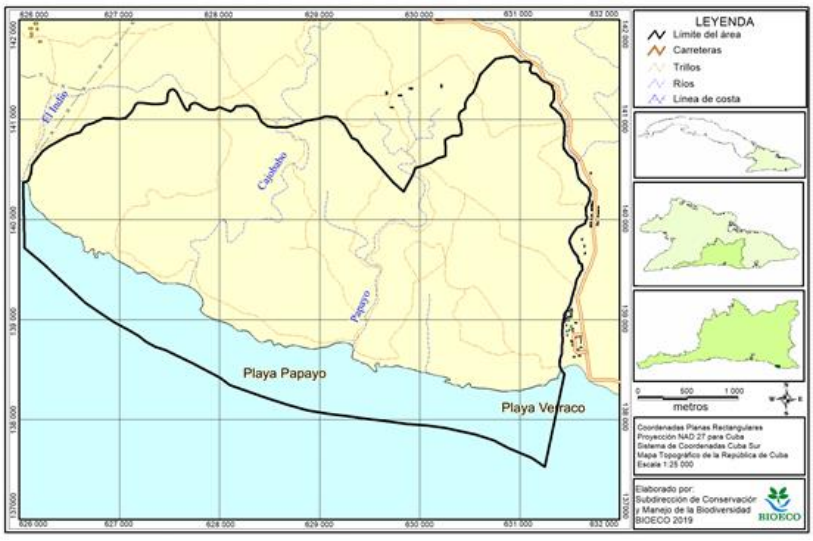

Figure 1. - Map of El Retiro nature reserve

According to Reyes and Martínez (2005), the soils in the study area are of two types: brown and red rendzinas. The brown soils found in the hills are rich in carbonates and very shallow, but not in the depressions where they accumulate and become more developed. The red rendzinas occur in the areas closest to the sea, in the hollows of the dogtooth and in the diaclasas; they are also rich in calcium and very shallow.

The average annual temperature is between 24°C and 26°C (Montenegro 1991a) and the average annual relative humidity is between 70 % and 80 % (Montenegro 1991b). Rainfall does not exceed 800 mm and averages approximately 650 mm per year (Montenegro 1991b).

Methodology

To characterize the vegetation, 13 field expeditions were conducted between 2018 and 2019. The classification of the vegetation of eastern Cuba (Reyes, 2012) was taken into account and the description of the vegetation formations for the coastal zone of the Baconao Biosphere Reserve (Figueredo *et al*., 2012) was reviewed. In each one, the main plant species that form them, their spatial structure, stratum coverage, the ecotype where they develop, and their distribution in the study area were studied.

For the characterization of the vegetation, plots were established as sampling units in the forest and shrubland formations. The size of the plots in the natural vegetation formations was estimated by forming the Area-Species Curve; in the case of the secondary vegetation formations, the size of the plots of the original formation was assumed, and for the secondary forest in mangrove ecotones, the criteria of Mancina *et al*., (2017) were consulted.

The size of the plots for the semi-deciduous microphyll forest and secondary scrub in semi-deciduous microphyll forest ecotones was 20 x 20 m and for the secondary forest in mangrove ecotones, coastal and pre-coastal scrub, secondary scrub in coastal and pre-coastal scrub ecotones was 10 x 10 m.

In the vegetation complexes, transects were placed perpendicular to the coastline, 3 m wide and of variable length (from 6 to 15 m), according to the limit of each of these complexes towards the interior.

In each sample, the species and the number of individuals per species were determined. Species identification was carried out in the field and doubtful material was collected for later determination in the BSC herbarium. The list of plant species present in the plots was recorded together with an estimation of their abundance-cover values according to the Braun-Blanquet scale.

The strata studied were arboreal, shrub and herbaceous, as well as lianas and epiphytes. For their height, the criteria of Reyes (2012) and Figueredo *et al*., (2012) were taken into account, considering the herbaceous stratum (with herbs and postures of trees and shrubs), which did not exceed two meters in height), the shrub stratum (comprised shrubs and saplings between 2 and 5 m in height) and arboreal stratum (trees greater than 5 m in height). In each of them, the cover and species abundance-dominance according to Braun-Blanquet (1950) were estimated.

To determine the distribution of the vegetation formations in the area and the preparation of maps, routes were plotted according to the geographic coordinates obtained with GPS (Garmin, model Etrex 20, Handheld). Lansat 8 images with spatial resolution of 30 m and temporal resolution of 16 days, from the United States Geological Survey (LC08_L1TP_011046_20161213_20170316_01_T1) were used, freely downloaded from the site www.earthexplorer.org. The obtained image was corrected by the process of conversion to radiance in the Roof of the Atmosphere (TOA) (Codazzi, 2013) using the semi-automatic classification tool 6.4.2 incorporated in the open source Geographic Information System QGIS 2.18.

The Normalized Difference Vegetation Index (NDVI) was applied (Cobos *et al*., 2016). As a result of the application of this index, a raster image was obtained with values ranging between -1 and 1, the first one being considered the one with the lowest plant biomass according to (Cobos *et al*., 2016). According to the surface of the study area they were locally verified and reclassified in the laboratory according to the differences of the observed formations and the vegetation map was obtained. For soil classification, the criteria of Hernández-Jiménez *et al*., (2015) were followed.

To complement the species richness data by vegetation type, transects 200 m long and 2 m wide were conducted, with the exception of vegetation complexes. For the comparison of species richness among the vegetation formations, the Sorensen's Index of Biological Similarity was applied (Sorensen, 1948).

RESULTS

Vegetation types

A vegetation map was obtained showing seven 1:2500 vegetation types (Figure 2): semi-deciduous microphyll forest, secondary forest in mangrove ecotones, coastal and pre-coastal scrub, secondary scrub in semi-deciduous microphyll forest ecotones, secondary scrub in coastal and pre-coastal scrub ecotones, rocky coast vegetation complex and sandy coast vegetation complex. Coastal and pre-coastal scrub predominates in extension, which can be differentiated into coastal scrub and pre-coastal scrub, followed in extension by semi-deciduous microphilous forest.

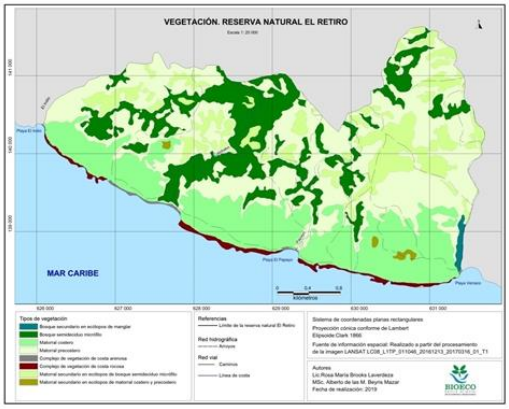

Figure 2. - Vegetation in El Retiro Natural Reserve

Semideciduous microphyllous forest. It is found in slightly undulating areas of El Retiro, in the localities of El Indio, Cajobabo, Papayo, Camino de la Virgen, Alto de los Guayacanes, La Presita and Verraco. It occupies an area of 209.9 ha, which represents 19 % of the study area. It is established on soils from rocks of the El Cobre Group.

The forests located between 175 and 350 meters above sea level grow on variable slopes (between 35 and 40 degrees) and steeper slopes in certain areas. The soils are mainly brown, shallow and, in some places, stony or with few rocky outcrops.

It presents a tree stratum of 9 m in height on average; the emergent can reach between 12 and 15 m. The vegetation cover of this stratum is approximately 60 %. Among the species with the highest number of individuals are *Amyris elemifera, Bursera simaruba, Colubrina elliptica, Eugenia monticola, Phyllostylon rhamnoides* and *Thouinia trifoliata.*

The shrub stratum has coverage of approximately 60 %. The species with the highest number of individuals are *Adelia ricinella, Amyris elemifera, Eugenia monticola, Gymnanthes lucida, Maytenus buxifolia subsp. cochlearifolia, Phyllostylon rhamnoides* and *Varronia bullata subsp. globosa.*

The herbaceous stratum has coverage of approximately 15 %. It is composed of species that mostly belong to the upper strata. Those with the greatest number of individuals are *Sida ulmifolia, Spermacoce laevis, Argythamnia candicans* and *Heliotropium curassavicum.*

The lianas predominate in the understory. Among them are present *Galactia parvifolia, Jacquemontia havanensis, Stigmaphyllon sagranum* and *Mascagnia lucida*. The epiphyte sinusia is mainly represented by *Tillandsia* species.

Secondary forest in mangrove ecotones: It is established in sites near the mouth of rivers and streams, as well as in some beach areas with brown, muddy soils with poor drainage. It covers an area of 1.5 ha and represents 0.4 % of the study area. The arboreal stratum covers between 30 and 40 % and can reach up to 8 m in height, mainly *Coccoloba uvifera* and *Conocarpus erectus*.

The shrub stratum covers up to 70 % and is characterized by the *abundance* of *Cordia collococca, Prosopis juliflora, Thespesia populnea* and *Vachellia macracantha*. The shrubs *Annona reticulata, Ricinus communis,* and *Pluchea carolinensis* are also abundant. The herbaceous stratum is scattered (15 % cover), dominated by *Heliotropium curassavicum*, *Typha domingensis* and isolated seedlings of *Prosopis juliflora*.

Among the lianas, *Angadenia berteroi, Cryptostegia grandiflora* and *Stigmaphyllon sagranum* were common. No epiphytes were recorded in this vegetation type.

Coastal and pre-coastal scrub: This is the most extensive vegetation formation in the study site (53 %) occupying 744.6 ha. The vegetation is discontinuous and is closely related to the irregularities of the area (slope angle, exposure, soil type). It generally presents two strata, although with an irregular structure, with local differences in the dominance of species. Two types of scrubland can be differentiated by their physiognomy.

Coastal scrub is found on the southern slopes of the hills of the El Retiro nature reserve, along the coast, in the localities of El Indio, Cajobabo, Papayo, and Verraco. It develops on the Río Maya geological formation, in very scarce, shallow soil. They are red rendzinas that are presented in small hollows of the dog's tooth limestone formation.

There is a sparse and dispersed shrub-arboreal stratum, but the shrub stratum predominates, which is denser. The coverage of the shrub stratum is approximately 75-80 %. Its predominant height varies between 1 and 3 m, although emergent individuals can be found between 7 and 8 m high. *Bursera simaruba, Buxus glomerata, Colubrina elliptica, Exostema caribaeum, Gymnanthes lucida, Caesalpinia vesicaria* and *Maytenus buxifolia subsp. cochlearifolia.*

The herbaceous stratum, with a vegetation cover of approximately 35 %, is composed mainly of seedlings and juveniles of species that inhabit the upper strata. There are numerous individuals of *Agave underwoodii* and some species of *Cactaceae.*

Epiphytes are represented mainly in the shrub stratum, with a predominance of several species of *Tillandsia*. Among the lianas, *Cissus trifoliata, Jacquemontia havanensis, Stigmaphyllon sagranum* and *Mascagnia lucida prevail.*

The pre-coastal scrub develops in the northern part of the reserve, on brown, shallow, percolating soils from rocks of the El Cobre Group (monzonites), in the localities of El Indio, Cajobabo, Papayo, Camino de la Virgen, Alto de los Guayacanes, La Presita and Verraco. It has an arboreal stratum with a height of 5 to 8 m, with emergents that can reach 10 m where the soil is more developed, while the shrubs, very dense (80 % coverage), The predominant species are *Agave underwoodii, Pilosocereus polygonus, Plumeria filifolia, Exostema velutinum, Croton sagranus, Adelia ricinella, Gymnanthes lucida, Brya ebenus, Cordia gerascanthus, Ateleia cubensis* and *Simarouba glauca var*. latifolia, among others.

The herbaceous stratum up to 35 % cover, with the presence of *Scleria lithosperma, Oplonia polyece, Spermacoce laevis, Helicteres semitriloba, Heliotropium indicum, Erythroxylum havanense* and *Croton sagranus*. There were also some individuals of dominant species in the upper strata such as *Brya ebenus, Agave underwoodii, Croton sagranus* and *Gymnanthes lucida.*

Among the epiphytes, *T. schiedeana, T. usneoides and T. fasciculata predominated. Lianas included Serjania diversifolia, Passiflora foetida, Stigmaphyllon sagranum, Platygyna hexandra, Cissus microcarpa* and *Abrus precatorius*.

Secondary scrub in semi-deciduous microphilous forest ecotones: It was located in El Indio, Papayo, Camino de la Virgen, Alto de los Guayacanes and La Presita. It develops on shallow yellowish-brown soils, occupying an area of 150.5 ha, which *represents 13 % of the total area of the study area.*

It is composed of two strata, a shrub stratum that covers between 70 and 80 % with a height between 4 and 6 meters. This stratum is dominated by *Bourreria virgata, Caesalpinia vesicaria, Colubrina elliptica, Dichrostachys cinerea, Exostema caribaeum, Henoonia myrtifolia, Maytenus buxifolia subsp. buxifolia, Prosopis juliflora, Randia aculeata* and *Zanthoxylum pistaciifolium.* Isolated individuals of tree species can also be found between 7 and 8 m, such as *Andira inermis, Bursera simaruba, Cordia*

leucosebestena, Guapira obtusata subsp. obtusata, Jacaranda caerulea, Plumeria obtusa subsp. obtusa.

The herbaceous stratum was scattered (10 % cover), with an abundance of *Hibiscus clypeatus* subsp. *cryptocarpos, Lantana camara, Paspalum distortum, Pavonia fruticosa* and *P. spinifex. Occasionally patches of Evolvulus arbuscula var. arbuscula* and *Turnera diffusa were observed.*

Among the lianas and epiphytes, *Abrus precatorius, Centrosema virginianum, Galactia parvifolia, Smilax havanensis, Stigmaphyllon sagranum* and *Tillandsia usneoides* predominate. These species were found mainly in the shrub understory.

Secondary shrubland in coastal and pre-coastal shrubland ecotones: It develops in heavily disturbed sites in the localities of Camino de la Virgen and Verraco. In the latter, east of the reserve, there are patches originated mainly by fires that occurred between 2007 and 2008. It is composed of two strata (shrub and herbaceous). The shrub stratum covers between 50 and 60 % with a height between 4 and 6 meters. *Vachellia macracantha, Agave underwoodii, Calliandra colletioides, Caesalpinia vesicaria, Henoonia myrtifolia, Maytenus buxifolia subsp. cochlearifolia,* and some isolated individuals of *Dichrostachys cinerea* that form small monospecific patches predominate. The herbaceous stratum is very scarce (5 % cover), with the presence of *Waltheria indica*, *Chloris barbata, Melochia tomentosa* and juveniles of *Agave underwoodii*.

The most common lianas are *Cissus trifoliata, Galactia parvifolia, Passiflora foetida, P. suberosa* and *Stigmaphyllon sagranum*. Among the epiphytes, *Tillandsia schiedeana* was very abundant.

Rocky coastal vegetation complex: It is observed immediately along the high coastline, in the localities of El Indio, Papayo, and Verraco. It is strongly influenced by wave spray and covers an area of 18.2 ha, which represents 1.6 % of the total surface of the study area.

The vegetation is stunted, not exceeding 1 m in height due to the influence of the winds. The vegetation cover is open and scattered, arpoximately 25 %. The species present are *Sesuvium portulacastrum, S. maritimum, Borrichia arborescens, Conocarpus erectus, Chamaesyce mesembryanthemifolia, Strumpfia maritima*, and some cactus. Some endemic species are also found in this formation, like *Agave underwoodii, Melocactus harlowii, Plumeria filifolia* and *Rhytidophyllum acunae.*

Sandy coast vegetation complex. This vegetation formation is disturbed because of its proximity to the beaches of El Indio, Cajobabo, Papayo and Verraco. It represents 0.3 % of the total area, with an extension of 3.3 ha. The dominant stratum is herbaceous with a height of up to 45 cm and 50 % coverage. It is creeping vegetation with the presence of *Canavalia rosea, Chamaesyce mesembryanthemifolia, Herissantia crispa, Indigofera suffruticosa, Ipomoea pes-caprae* subsp. *brasiliensis, I. tiliacea* and *Stigmaphyllon sagranum*.

Species by vegetation type and biological similarity

Coastal scrub and semi-deciduous microphyllous forest were the natural vegetation formations with the greatest surface area, and also the richest in number of species and endemics (Table 1). The rest of the vegetation types present were less diverse and with

low percentages of endemism; coinciding with those of smaller surface extension; of these, the ones with the least extension and number of species were: secondary forest in mangrove ecotones and the vegetation complexes of sandy and rocky coast.

Table 1. - Species and endemisms by vegetation type in the El Retiro nature reserve

Type of vegetation	Extension (ha)	No. of species	Endemisms
Bsm	216,8	342	75
Bs-M	5,1	48	2
Mxc	744,6	519	107
Ms-Bsm	150,5	302	36
Ms-Mxc	6,5	88	9
Ccr	18,2	36	5
Cca	3,3	43	1

Bsm: Semi-deciduous microphyllous forest, **Bs-M**: Secondary forest in mangrove ecotones, **Mxc**: Coastal and pre-coastal scrub, **Ms-Bsm**: Secondary scrub in semi-deciduous microphyllous forest ecotones, **Ms-Mxc**: Secondary scrub in coastal and pre-coastal scrub ecotones, **Ccr**: Rocky coast vegetation complex, **Cca**: Sandy coast vegetation complex.

The species *Stigmaphyllon sagranum* was observed in all the studied vegetation formations. *Abutilon abutiloides* and *Bothriochloa pertusa* were present in six; *Agave underwoodii, Hibiscus clypeatus subsp. cryptocarpos, Henoonia myrtifolia, Hylocereus undatus, Scleria lithosperma, Strumpfia maritima* among others were found in five. Among the epiphytes, *Tillandsia schiedeana and T. usneoides were present*in four of the plant formations. Others such as *Encyclia phoenicea, T. fasciculata* and *T. turquinensis* were present in three of the plant formations.

Regarding the Biological Similarity Index between plant formations, the highest affinity was observed between the semi-deciduous microphyllous forest and the coastal and pre-coastal scrub (Table 2). In contrast, the lowest similarities were established between the secondary forest in mangrove ecotones and the rocky coastal vegetation complex.

Table 2. - Biological similarity between vegetation types in El Retiro Nature Reserve

Vegetation types	Ms-Bsm	Bs-M	Cca	Ccr	Mxc	Ms-Mxc
Bsm	53,97	11,79	8,31	7,94	**64,71**	29,30
Ms-Bsm		13,69	15,11	11,73	61,42	39,36
Bs-M			19,78	**7,14**	11,11	23,53
Cca				30,38	11,22	18,32
Ccr					10,59	8,06
Mxc						25,62

Bsm: semi-deciduous microphyll forest, **Ms-Bsm**: secondary shrubland in semi-deciduous microphyll forest ecotones, **Bs-M**: secondary forest in mangrove ecotones, **Cca**: sandy coastal vegetation complex, **Ccr**: rocky coastal vegetation complex, **Mxc**: coastal and pre-coastal scrubland, **Ms-Mxc**: secondary shrubland in coastal and pre-coastal scrubland ecotones.

DISCUSSION

The plant formations recorded coincide with those reported by Capote *et al.,* (1987) in the coastal zone between Daiquirí and Verraco, except for the secondary shrubs in semi-deciduous microphyll forest ecotones and in coastal and pre-coastal scrub ecotones, which constitute new records of plant formations for the area. In addition, the secondary scrub in semi-deciduous microphilous forest ecotones constitutes a new vegetation type record in the coastal zone of the Baconao Biosphere Reserve.)

The vegetation map obtained reflects at a more detailed scale the distribution of vegetation formations in the study area. As a background, there was a larger scale vegetation map made by Figueredo *et al*., (2012) for the coastal terraces of the Baconao Biosphere Reserve, which includes the El Retiro natural reserve as one of its core zones. The most extensive formations coincide with those of the vegetation map of Figueredo *et al.*, (2012). Reyes (2012) for eastern Cuba also referred to the dominance in terms of extension of coastal and pre-coastal scrub and semi-deciduous microphyllous forest.

In the study area, the uveral was not observed, only isolated individuals of *Coccoloba uvifera* and *Conocarpus erectus* were found in the coastal strip from Cajobabo to Verraco. However, Capote *et al.,* (1987) described this plant formation for the localities of Daiquirí and Verraco and by Figueredo *et al.*, (2012) for the coastal terraces of Baconao.

Regarding the secondary forest in mangrove ecotones, the four floristic elements that typify Cuban mangroves (Reyes, 2012, Mancina *et al*., 2017), *Rhizophora mangle, Avicennia germinans, Conocarpus erectus* and *Laguncularia racemosa*, were found. The latter is considered a pioneer species and colonizer of disturbed sites (Brooks *et al*., 2016).

Figueredo *et al.*, (2016) characterized the mangrove forest patches in the Baconao Biosphere Reserve; of these, those of Cajobabo and Verraco are mentioned in the El Retiro nature reserve. Currently, there are no mangroves in the area that conserve their original floristic composition and structure, but rather a secondary forest in mangrove ecotones.

In the coastal and pre-coastal scrubland, the greatest numbers of local endemisms were found according to Borhidi (1996). In general, there is an abundance of xerophytes adapted to arid conditions, with morphological and physiological modifications that allow them to survive the scarcity of water in the soil.

According to Reyes and Acosta (2005), these are plants with a very well-developed absorption mechanism, with a greatly reduced leaf surface, thick cuticle and other modifications that allow them to reduce transpiration. Reyes (2012) reports it south of the Sierra Maestra, very close to the sea and generally under the influence of sea winds loaded with salts (saltspray).

Secondary scrub in semi-deciduous microphyllous forest ecotones occurs in territories that were used for extensive grazing and have been exploited by the Gran Piedra-Baconao Integral Forestry Company. It is found near the reserve's access roads, with 86 % of the exotic species registered in the study area. Some of the species found in this thicket coincide with those reported by Figueredo *et al*., (2012) who mentioned this vegetation formation in the Río Cajobabo area of the El Retiro nature reserve.

The natural vegetation formations of greater extension and richer in number of species and endemics coincide with those recorded by Figueredo *et al*., (2012) for the characterization of the vegetation in the coastal terraces of the Baconao Biosphere Reserve. Secondary vegetation in semi-deciduous microphyllous forest ecotones also stood out in this regard.

Species richness in secondary vegetation in semi-deciduous microphyllous forest ecotones was given by the coexistence of species typical of the original plant formation and other plants that have become established when the ecosystem has been disturbed. Brooks *et al.*, (2016) obtained similar results in terms of species richness in secondary plant formations for the synanthropism analysis.

Vegetation complexes had the lowest species richness. This is mainly due to the fact that they occur in sites under the influence of prevailing coastal factors such as nutrient poverty, rapid water infiltration, strong and drying action of winds on the vegetation, high incidence of saline aerosol contained in the air and high degree of insolation.

The low number of species in the rocky coast vegetation complex may also be conditioned by the almost total absence of soil due to its development on rocky cliff coasts, as well as the high salinity resulting from the splashing of the waves when they hit the cliffs and the evaporation of seawater contained in the hollows. In the case of the sandy coast vegetation complex, it is also based on the washing of the sandy substrate, produced mostly by the action of the waves, which causes a lack of nutrients in the substrate.

The most frequent species among plant formations were found from natural to completely destroyed habitats due to their ecological plasticity. Their ability to adapt to sites with strong natural or anthropogenic expansive impact has been confirmed (Figueredo *et al.,* 2012 and Brooks *et al*., 2016).

Most of the epiphytes were recorded in natural plant formations which coincided with Brooks *et al*., (2016) regarding the decrease in epiphyte diversity in disturbed ecosystems of the Siboney-Juticí Ecological Reserve. This characteristic has allowed them to be used as indicators of structural changes in the ecosystem, as well as to evaluate successional processes or increased degradation in ecosystems (Figueredo *et al*., 2011).

The greatest biological similarities were found between the semi-deciduous microphyllous forest and the coastal and pre-coastal scrub. The high floristic affinity between these plant formations was mainly due to the fact that they develop in poor, poorly evolved soils and environmental conditions of high temperatures and low precipitation (Reyes and Fornaris, 2011).

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