First Community in Abandoned Pasture Lands or Crops in Eastern Cuba’s Rainforest over Metamorphic Rocks

Orlando Joel Reyes, Félix Acosta Cantillo, Luz Margarita Figueredo Cardona, Pedro Bergues Garrido

Abstract: Miconio prasinae–Cyatheion arboreae alliance is described. Although it has five associations, we address three in this work, corresponding to immediate, secondary and early successional communities in abandoned pasture lands or crops in submountains rainforest over metamorphic rocks. The objective of this work is to study the first communities in used and abandoned fields, because they are of a great importance in the understanding of the vegetation’s evolution and for management purposes. In the submontane forest on the metamorphic complex, the destruction of mature vegetation produces important losses in climatic biodiversity and transcendental changes in ecosystem composition. The change in soil use, especially the transformation to pastureland, has favored the development of herbaceous and shrubby plant communities. This study is not only of practical relevance in describing the associations of the pine forests the plant associations and the study of the ecological conditions in which they develop, but its results can be used as a working tool in the environmental management and silviculture for the restoration of degraded areas. The study of diverse Cuban vegetation types suggests that the methodology of Zurich Montpellier’s school is more effective as compared to other authors because its syntaxa is good to recognize and is able to transform in a forest typology. The main species are pioneers heliophilous with a type of “r” selection.

Keywords: Ecological Succession, Secondary Communities, Sierra del Purial, Eastern Cuba

1. Introduction

Although there are some works about succession in Cuban forest [8, 15, 16]; there was not enough those made on mountain areas [18].

In submountain rainforest over metamorphic complex [18] destruction of maturity vegetation produce important loses in climatic biodiversity and transcendental changes in ecosystemic composition. In a similar ecosystem Caluff [4] and Sanchez-Ruiz [22, 23] had quantify heavy losses of pteridological and spiders diversity with the change of use of soils, getting the maximum with pasturelands transformation. The objective of this work is to study the evolution of first communities in used and abandoned fields in the submountain rainforest ecotopes over metamorphic complex in rainiest areas of Cuban archipelago.

2. Methodology

Natural conditions of the studied area.

The area is inside the more rainy territory of Cuban archipelago, between 2 500 to 3 000 mm [13] regularity distributed. Geology is represented by Sierra del Purial Formation [7], composed by different kind of schist, intermediate tuffs between other rocks. Relief is very dissected with slopes between 35 and 45° rarely less. Soil is ferralitic red and leached red-brown colour [14], frequently little deep, over ferralitic weathering crust.

Sampling methodology

According to Braun Blanquet [3] methodology phytocoenological inventories (lists, stands, samples, relevés), with a minimum area of 625 m² [18] were made. In addition, observations of the ecotope (slope; exposition; altitude; general, nano and micro relief) were made in the
place of the samples and their surroundings.

For the characteristic combination of the associations, the species with degrees of presence IV and V [24] were used, and for the subassociations and variants the differential combinations.

Weber et al. [25] was followed for the categorization and the name of syntaxa. Completed scientific names (genus, species and author) are observed in Tables and Acevedo-Rodriguez & Strong [1], sometime ameded by Greuter & Rankin Rodriguez [10, 11], Borhidi et al. [2] and Sanchez [20, 21]. Collected specimens are in Herbarium BSC.

3. Results

In this work the subsequent phytosociological arrangement was made:

**Clase Clidemia - Cyatheetalia arborea Reyes clas. nov.**
Holotypus: Andropogono-Coccocypseletalia lanceolati Reyes ord. nov.

Herbaceous and secondary scrub, constituted by the immediate and early secondary communities that develop in abandoned fields and slopes that are produced in the construction of the roads in areas of the submountain and mountain rainforests (sometimes known as cloud forests in the Antilles), it is generally rich in ferns.

The climate is tropical, with rainfall between 1 200 and 3 500 mm. It was studied in rainforest ecotopes in Nipe Sagua Baracoa and Sierra Maestra, observed in the Central Mountain Range of the Dominican Republic and similar types of vegetation were described from the mountains of Puerto Rico.

Character species. Strongly associated: *Cyathea arborea*, *Gleichenella pectinata*, *Stichurus bifidus*, *Lycopodiella cernua*, *Nephrolepis brownii*, *Miconia prasina*, *Piper aduncum*, *Pluchea carolinensis*, *Tibouchina longifolia*, *Spermacoce laevis*, *Andropogon virginicus*, *A. bicornis*, *Blechnum occidentale*, *Urena lobata*, *Desmodium triflorum*, *D. canum*, *Spermacoce laevis*, *Elephantopus scaber*, *Andropogon virginicus*, *A. bicornis*, *Blechnum occidentale*, *Urena lobata*, *Desmodium triflorum*, *D. canum*, *Spermacoce laevis*, *Elephantopus scaber*.

In this work we only will study *Miconio prasinaceae-Cyatheion arboreae* alliance.

**Miconio prasinaceae-Cyatheion arboreae**

Holotypus: *Clidemio-Cyatheetum arboreae* Reyes ass. nov.

Secondary scrub- and grasslands, constitute by immediate and early secondary communities developed in abandoned fields and pasture lands, as in talus (roadbanks) as a result of road built in ecotopes of rainforest over metamorphic rocks, it is generally rich in ferns. Weather is warm, tropical, with rainfall levels for about 1 200 to 3 500 mm.

Composition - characteristics species. *Cyathea hordia*, *C. arborea*, *Stichurus bifidus*, *Lycopodiella cernua*, *Tibouchina longifolia*, *Pitirogramma calomelanus*, *N. prasina*, *Piper aduncum*, *P. arboenum*, *Clidemia hirta*, *Urena lobata*, *Desmodium triflorum*, *D. canum*, *Spermacoce laevis*, *Elephantopus scaber*.

From five associations in these alliance we only will study *Miconio prasinaceae-Cyatheion arboreae* alliance.

**Miconio prasinaceae-Cyatheion arboreae**

Holotypus: *Clidemio-Cyatheetum arboreae* ass. nov.

Secondary scrub- and grasslands, constitute by immediate and early secondary communities developed in abandoned fields and pasture lands, as in talus (roadbanks) as a result of road built in ecotopes of rainforest over metamorphic rocks, it is generally rich in ferns. Weather is warm, tropical, with rainfall levels for about 1 200 to 3 500 mm.

Composition – characteristics species. Strongly associated: *Cyathea arborea*, *Gleichenella pectinata*, *Stichurus bifidus*, *Lycopodiella cernua*, *Nephrolepis brownii*, *Miconia prasina*, *Piper aduncum*, *P. arboenum*, *Clidemia hirta*, *Urena lobata*, *Desmodium triflorum*, *D. canum*, *Spermacoce laevis*, *Elephantopus scaber*.

From five associations in these alliance we only will study three in this work.

Studied associations in this work:

1) *Neurolaeno lobatae-Lantanetum camarae* Reyes ass. nov. Table 1, holotypus inv. 1.

### Table 1. **Neurolaeno lobatae - Lantanetum camarae.** Presen=presence.

| N. order | 1 | 2 | Presence |
|----------|---|---|----------|
| Altitude (mosl) | 450 | 460 |
| Inclination (degrees) | 60 | 20 |
| Exposition | N | NW |
| E<sub>2</sub> Shrub layer (% covers) | 10 | 100 |
| E<sub>2</sub> Herbaceous layer (%) | 90 | 35 |
| N. species | 41 | 38 |
| Characteristics | 1.1 | 2.2 |
| E<sub>2</sub>- Lantan camara | 2(1-2) |
In this phytocoenose is observed a pioneering group of heliophilous (sun-loving) species, synanthropic much of them, that are absent in much of the advanced successional stages, heliophilous (sun-loving) species, synanthropic much of them, that reach eight meters. This pasture land has a dense shrublike-herbaceous layer with 100% cover, in the more developed areas there are some isolated specimens of *Miconia prasina*, sometime abundant are *Nephrolepis brownii*, *Elephantopus scaber* and *Spermacoce laevis*, the rest with less cover (Table 2). Was study 12.02.2004 (N20°17.2′, W74°43′).

| N. order | 1      | 2      | Presen |
|----------|--------|--------|--------|
| Clidemia umbellata (Mill.) L. O. Wms. | 1.1    | +.2    | 2(+1) |
| Calyptrona umbrosa (Sw.) H. E. Moore | +.1    | +.1    | 2(+)  |
| Erythrostemon lobata (L.) R. Br. ex Cass. | 3.2    | 3.2    | 2(3)  |
| Cyathea arborea (L.) J. Sm. | 1.2    | r.1    | 2(±1) |
| Chromolaena odorata (L.) R. Br. | 1.1    | +.1    | 2(±1) |
| Tibouchina longifolia (Vahl) Baillon | +.1    | +.1    | 2(±1) |
| Urena lobata L. | 1.1    | +.1    | 2(±1) |
| Casearia sylvestris Sw. var. sylvestris | +.1    | +.1    | 2(±1) |
| Clidemia hirta (L.) D. Don | 1.1    | +.1    | 2(±1) |
| Miconia prasina (Sw.) DC. | r.1    | +.1    | 2(±1) |
| Pluchea carolinensis (Jacq.) G. Don in Sweet. | +.1    | +.1    | 2(±1) |
| Psidium guajava L. | +.1    | r.1    | 2(±1) |
| Elephantopus scaber L. | +.1    | +.1    | 2(±1) |
| Cocculusinnymum herbaceum Auhl. | r.1    | 1.2    | 2(±1) |
| Phaia tankervillae (Banks) Blume | r.1    | r.1    | 2(r)  |
| Polygala leptocaulis T. & G. | +.1    | 2(±1) |
| Stachytarpheta cayennensis (L. C. Rich.) Vahl | +.1    | 2.2    | 2(±2) |
| Spermacoce laevis Lam. | 1.2    | 3.2    | 2(1-3) |
| Rhyynchospora colorata (L.) H. Pfeiff. | r.2    | 2.2    | 2(r-2) |
| Sida rhombifolia L. | +.1    | 3.2    | 2(±3) |
| Pitrophyllum calomelanos (L.) Link | r.2    | +.2    | 2(r+)  |
| Nephrolepis biserrata (Sw.) Schott | +.2    | +.2    | 2(+)  |
| Lygodium volubile Sw. | r.1    | r.1    | 2(r)  |
| Odontosoria aculeata (L.) J. Sm. | +.1    | +.1    | 2(±1) |

**Table 2. Urena lobatae-Miconietum prasinae.**

In addition. Inv. 1. Zanthoxylum martinicense (Lam.) DC. +.1, Guarea guidonia (L.) Sleumer +.1, Solanum nigrum L. +.1, Rhytidophyllum exsertum Griseb. +.1, Desmodium canum (J. F. Gmel.) Schinz & Thell. 1.1, D. triflorum (L.) P. DC. +.1, Miconia sp. r.1, Andropogon bicornis L. +.2, Scleria secans (L.) Britt. +.2, Lycopodiella cernua (L.) Pic. Serm. +.2, Ludwigia octovalvis (Jacq.) Raven r.1, Capania americana L. +.1, Alchornea latifolia Sw. +.1, Machaeocera cubensis (Kak.) T. Koyama r.2, Trema micranthum (L.) Blume r.1, Vernoninia sp. +.1; Inv. 2. Guettarda sp. +.1, Triunfetia semirioloba Jacq. +.1, Citharexylum fruticosum L. 1.1, Solanum torvum Sw. r.1, Piper peltata (L.) Miq. r.1, Puncum sp. 1.2, Emilia sonchifolia (L.) DC. r.1, Andropogon virginicus L. r.2, Bactris cabensis Burret (+.1), Adiantum pyramidal (L.) Wild. +.2.

N. order       1       2       3       4       5       Presen
Altitude (mold) 580 590 540 540 560
Inclination (degrees) 20 20 12 20 45
Exposition WSW  WSW  NW  W  SSW
E<sub>F</sub> Canopy layer (covers %) . . . 20 . 30
E<sub>F</sub> Shrub layer (%) 80 100 85 . 90
E<sub>F</sub> Herbaceous layer (%) 85 20 100 100 95
N. species 21 20 24 28 36 25.8
Characteristics E<sub>F</sub>-Miconia prasina (Sw.) DC. 4.4 5.5 5.5 4.3 5.5 5(4-5)
E<sub>F</sub>- Urena lobata L. 1.1 +.1 1.1 1.1 +.1 5(+1)
Clidemia hirta (L.) D. Don 1.1 r.1 r.1 1.1 +.1 5(r-1)
Spermacoce laevis Lam. r.1 r.1 1.1 3.2 +.1 5(r-3)
Elephantopus scaber L. r.1 +.1 1.1 3.2 1.1 5(r-3)
Nephrolepis biserrata (Desv.) Hovenk. & Miyam. 1.2 +.2 4.4 +.2 2 5(+4)
E<sub>F</sub>-Capania americana L. r.1 r.1 . . 2.1 4(r-2)
E<sub>F</sub>- Desmodium axillare (Sw.) P. DC. 1.2 . 1.2 +.1 +.1 4(+1)
Axonopus compressus (Sw.) Beauv. +.2 1.2 1.2 r.2 . 4(r-1)
Cyatheaem horrido arboreae Reyes ass. nov. Table 3, holotype inv. 1.
This phytocoenose represents an early community formed for the abandoning of a pasture land and a crop field respectively in northern expositions. Nowadays constitute a Homeostasis I and beginning of Fiera II also, in which mainly Cyathea arborea constitute a dominant layer between 7 and 10 m high.
It is developed over a yellow and leached ferralitic soil, loamed and with gravels, in which is observed a dense rootlets (rhizoids) of the tree fern before mentioned in the first 4 or 5 cm of the profile, at 10 cm deep this rhizoids are not found. The humus layers are absent, principally fronds of dominant fern are observed; is considered that more over of a fast decomposition, because of the big slope the formed

humus will be drag for the intensity of rainfalls.
In the inventory 2 is observed that trees break the Cyathea arborea layer and interact between them, beginning the stage known as Fiera II. The species here present are: Ficus membranacea, Cupania glabra, C. americana, Cecropia peltata L. +.1, Cyathea arborea (L.) J. Sm. +.1, Chusia rosea Jacq. 1.2, Spondias mombin L. +.1, Alchornea latifolia Sw. r.1, Rhizophyllum exsertum (Griseb. 1.1, Eugenia pinnator Benth. Urb. +.1, Phyllis tankervilliae (Banks) Blume r.1, Macrostelites tomatiensis (Gaudich.) Ching r2, Adiantum sp. +.2, Guazania monstachia (L.) Ruphy ex Mez +.2, Solanum antillarum O. E. Schulz. r.1, Vitis stilifolia H.& B. 1.1, Lygodium volubile Sw. r.1.

Table 3. Cyatheaem horrido arboreae.

| N. order | 1 | 2 | 3 | 4 | 5 | Presen |
|----------|---|---|---|---|---|--------|
| L- Mikania micrantha Kunth | +.1 | r.1 | r.1 | r.1 | . | 4(+r+) |
| Accompaniers | | | | | | |
| E.2 r. Psiudym guajava L. | r.1 | . | . | +.1 | 1.1 | 3(+r-1) |
| E.1 Guarea guidonia (L.) Sleumer | r.1 | . | r.1 | . | +.1 | 3(+r+) |
| Triunfetta semitriuloba Jacq. | r.1 | . | +.1 | . | +.1 | 3(+r+) |
| Thoeuchina longifolia (Vahl) Baillon | r.1 | . | . | +.1 | r.1 | 3(++r+) |
| Stachytarphae cayennensis (L. C. Rich.) Vahl | r.1 | r.1 | . | 1.1 | +.1 | 3(-r-) |
| Scleria secano (L.) Britit. | 1.2 | +.2 | 2.2 | . | . | 3(-r+) |
| Lycopodiella cernua (L.) Pte. Ser. | 1.2 | . | . | 1.1 | +.1 | 3(-r+) |
| Desmodium triflorum (L.) P. DC. | . | r.2 | . | +.2 | +.2 | 3(+r-) |
| Opismenmus setarius (Lam.) R. & S. | . | +.2 | 1.2 | . | 1.2 | 3(-r-) |
| Scleria lichosperma (L.) Sw. | . | r.2 | . | 2.2 | 3.2 | 3(-r-) |
| Spalthogolitis plicata Blume | . | r.2 | r.1 | . | +.1 | 3(+r+) |
| Blechnum occidentale L. | . | r.2 | 2.2 | . | 4.3 | 3(-r-) |
| E.2 r. Piper aduncum L. | . | . | . | 2.1 | r.1 | 2(r+) |
| E.1 Piper umbellatum L. | . | r.1 | . | r.1 | . | 2(r+) |
| Andropogon bicorsis L. | +.2 | . | . | 2.2 | . | 2(r-) |
| Hyptis verticillata Jacq. | . | . | . | r.1 | r.1 | 2(r+) |
| Desmodium canum (J. F. Gmel.) Schinz & Thell. | . | . | . | 1.2 | +.2 | 2(-r-) |
| Cyathea horrida L. | r.2 | r.2 | . | . | . | 2(r+) |
| L- Turbina corymbosa (L.) Hall. | r.1 | . | . | . | . | 2(r+) |

In addition. Inv. 1. Cococycophyllum herbaceum Aubl. +.2, Passiflora suberosa L. r.1; Inv. 2. Gleichenella pectinata (Wild.) Ching 2.2; Inv. 3. Bactris cubensis Burtt r.1, Scheffleria morototoni (Aubl.) Mag., Stey. & Frodin r.1, Calyptronoma occidentalis (Sw.) H. E. Moore +.1, Buchenavia tetrphylla (Aubl.) R. A. Howard (+.1), Telypteris reticulata (L.) Proctor r.2, Guazuma ulmifolia Lam. r.1, Zygygium jambos (L.) Alston r.1, Pisonia aculeata L. r.1; Inv. 4. Chromolaena odorata (L.) King & Robins. 1.1, Vernonia cinerea (Less.) r.1, Sida rhombifolia L. r.1, Canavalia sp. r.1, Clidemia umbellata (Mill.) L. O. Wims. r.1, Mimosa pudica L. +.1, Spiranthes lanceolata (Aubl.) León r.1; Inv. 5. Sapindus marmalensis Sw. +.1, Chrysophyllum oleifforme L. 1.1, Cecropia peltata L. +.1, Cyathea arborea (L.) J. Sm. +.1, Chusia rosea Jacq. 1.2, Spondias mombin L. +.1, Alchornea latifolia Sw. r.1, Rhizophyllum exsertum (Griseb. 1.1, Eugenia pinnator Benth. Urb. +.1, Phyllis tankervilliae (Banks) Blume r.1, Macrostelites tomatiensis (Gaudich.) Ching r2, Adiantum sp. +.2, Guazmania monstachia (L.) Ruphy ex Mez +.2, Solanum antillarum O. E. Schulz. r.1, Vitis stilifolia H.& B. 1.1, Lygodium volubile Sw. r.1.
In addition, Inv. 1. Panicum sp. 3.2, Scleria melaleuca Reichb. +.2, Coccocypselum herbaceum Aubl. r.1, Coccocypselum herbaceum Aubl. r.1, Neurolaena lobatae (L.) R. Br. r.1, Miconia sp. r. 1, Hemidictyum marginatum (L.) C. Presl r.1, Diplazium unilobum (Poir.) Hieron. r.2, Adiantum pyramidale (L.) Wild. +.2, Lygodium volubile Sw. +.1, Platygynia sp. +.1, Pentalinon luteum (L.) Hansen & Wunderlin r.1; Inv. 2. Ficus membranacea C. Wr. +.1, Cupania glabra Sw. 2.1, Guarea guandina (L.) Sleumer +.1, Cecropia peltata L.+.1, Zanthoxylum martinicense (Lam.) DC. +.1, Piper aduncum L. +.1, Psychotria grandis Sw. +.1, Xanthosoma sagittifolium (L.) Schott; R. Ruiz (com. pers.) said that arum cultivate in north exposure putrefy, while in south exposure has a normal develop.

It is important to emphasize how in the developed communities with tree ferns predominance its rhizoids conform a dense layer that protect the soil against the erosion, which is a coincidence that soft roots predominate in this first stages [5, 6]. This communities are very similar to the humid forest of México where Cyatheaceae are very distinguished elements [17].

It is outstanding that in the Fiera II beginning for be located in the surrounded of a mature forest the seeds rain function have a great efficiency to arboreal species enter. Is also considered that in this stages the majority of biomass found as stems and leaves, frequently is not woody [12].

### 4. Discussion

In the syntaxa evolution of submountain rainforest over metamorphic rocks [19], when a secondary stage (field or pasture land) is cut, burn and late abandoned it will conform a immediate secondary community like Neuroloena lobatae - Lantianetum camarae association.

Very interesting to observe how during these first stages of the serie the majority of species are of herbaceous type, frequently with ferns dominance. However with the succession advanced process (immediat, early and late stages), while those that evolutioned in south exposition putrefy, while in south exposition has a normal develop.

It is confirmed that in the studied area, due the great levels of precipitations and its relatively uniformity, in the Homeostasis I a differentiation of associations is produced as a function of exposure. The elements of the north exposure develop a dominant community of Cyathea arborea, while those that evolved in south exposure Miconia prasina is the predominant. This is also a coincidence with the importance of this exposition for the cultivation of arum (Xanthosoma sagittifolium Schott.); R. Ruiz (com. pers.) said that arum cultivate in north exposure putrefy, while in south exposure has a normal develop.

It is confirmed that in the studied area, due the great levels of precipitations and its relatively uniformity, in the Homeostasis I a differentiation of associations is produced as a function of exposure. The elements of the north exposure develop a dominant community of Cyathea arborea, while those that evolved in south exposure Miconia prasina is the predominant. This is also a coincidence with the importance of this exposition for the cultivation of arum (Xanthosoma sagittifolium Schott.); R. Ruiz (com. pers.) said that arum cultivate in north exposure putrefy, while in south exposure has a normal develop.

### 5. Conclusions

When a secondary succession developed, in the first stages, communities are represented mainly by herbaceous pioneers heliophilous with a type "r" selection that are also generalist species. We also observed that in the Homeostasis I, with a small arboreal layer, the exposition defines the dominant species in the canopy in these places with leached ferrallitic soil originating from metamorphic rocks with 2,500 to 3,000 mm annual rainfall. It is also considered that canopy species entry is produced in the surroundings of the forest as a result of seeds rain.

### References

[1] Acevedo-Rodriguez, P. & M. T. Strong. 2012. Catalogue of Seed Plants of the West Indies. Smithsonian Contributions to Botany 98. 1192 p.

[2] Borhidi, A., M. Fernández-Zequeira & R. Oviedo Prieto. 2017. Rubiáceas de Cuba. Budapest. Akadémiai Kiadó. 494 p.

[3] Braun Blanquet, J. 1951. Pflanzensoziologie; Grundzüge der Vegetationskunde. 2 Aufl. Wien.

[4] Calulf, M. G. 2015. Pérvida de biodiversidad pteridológica en diferentes formas de uso de la plusvisilva de baja altitud sobre complejo metamórfico. En Pluvisilvas cubanas: tesoro de biodiversidad. p. 149-156. La Habana.

[5] Carvalheiro, K. & D. C. Nepstat 1996. Deep soil heterogeneity and fine root distribution in forests and pastures of eastern Amazonia. Plant and Soil 182: 279-285.

[6] Cavelier, J., J. Estevez & B. Arjona. 1996. Fine root biomass in three successional stages of an Andean cloud forest in Colombia. Biotrópica 28: 728-736.

[7] Colectivo de Autores. 2013. Léxico estrictográfico de Cuba. Instituto de Geología y Paleontología (IGP) y Servicio Geológico de Cuba. Coordinador General Jorge de Huelves Alonso.

[8] Figueredo, L. M., F. Acosta, O. J. Reyes & E. Fornaris. 2012. Caracterización de la vegetación de las Terrazas Costeras de la Reserva de la Biosfera Baconao, Santiago de Cuba, Cuba. Brenses 78: 25-33.
[9] Gliessman, S. R. 2002. Agroecología: Procesos ecológicos en agricultura sostenible. CATIE, Turrialba.

[10] Greuter, W. & R. Rankin Rodríguez. 2016. The Spermatophyta of Cuba. A Preliminary Checklist. Part II: Checklist. Botanischer Garten & Botanisches Museum Berlin-Dahlem & Jardín Botánico Nacional, Universidad de La Habana. 398 p.

[11] Greuter, W. & R. Rankin Rodríguez. 2017. Vascular plants of Cuba. A preliminary checklist. Second, updated Edition of The Spermatophyte of Cuba, with Pteridophyte added. Botanischer Garten - Botanisches Museum Berlin-Dahlem & Jardín Botánico Nacional, Universidad de la Habana. 444 p.

[12] Guariguata, M. R. & R. Ostertag. 2002. Sucesión secundaria. En M. R. Guariguata & G. H. Kattan (eds). Ecología de bosques neotropicales. Editorial Tecnológica, Cartago, Costa Rica. 591-623 p.

[13] Guevara, V., Y. Rodriguez & A. Roque (Redactores Temáticos). 2019. Precipitación media hiperanual 1961-2000. En: Atlas Nacional de Cuba LX Aniversario. La Habana.

[14] Hernández A., J. M. Pérez Jiménez, D. Bosh & N. Castro Speck. 2015. Clasificación de los Suelos de Cuba 2015. Instituto Suelos e Instituto Nacional de Ciencias Agrícolas. La Habana.

[15] Pérez, E., N. Enríquez, N. Martínez González, L. Alfonso Ferrá & R. Rivero Vega. 2004. Reforestación sucesional en la Sierra de Cubitas, Estudio de Caso: Boca de Domínguez. Camagüey, Cuba. Biodiversidad de Cuba Oriental, Editorial Academia 7: 32-45.

[16] Pérez Carreras, E. & N. Enríquez Salgueiro. 2004. La sucesión vegetal como proceso natural para el mantenimiento de la diversidad biológica en los Matorrales xeromorfoespinosos de la llanura serpentínica de Maraguan, Camagüey. Biodiversidad de Cuba Oriental, Editorial Academia 7: 79-92.

[17] Pérez-Paredes, M. G., A. Sánchez-González & J. D. Tejero-Diez. 2014. Estructura poblacional y características del hábitat de dos especies de Cyatheaceae del estado de Hidalgo, México. Botanical Science 92 (2). versión On-line ISSN 2007-4476 versión impresa ISSN 2007-4298.

[18] Reyes, O. J. 2005. Estudio sinecológico de las pluvisilvas submontanas sobre rocas del complejo metamórfico. Foresta Veracruzana 7 (2): 15-22.

[19] Reyes, O. J. & F. Acosta Cantillo. 2007. La sucesión vegetal en la Pluvisilva submontana sobre rocas metamórficas en las Cuchillas y Mesas de Baracoa – Imías. Memorias II Simposio Internacional sobre Restauración Ecológica. Texto 56. ISBN 978-959-250-322-9. 11 p.

[20] Sánchez, C. 2017. Lista de los helechos y licófitos de Cuba. Brittonia, DOI 10.1007/s12228-017-9485-1. ISSN: 0007-196X (print) ISSN: 1938-436X (electronic, published online 23 June 2017). 24 p.

[21] Sánchez, C. 2021. Inventario de los licófitos y helechos de Cuba: sinonimia, distribución y estado de conservación. Revista del Jardín Botánico Nacional 42: 1-53.

[22] Sánchez-Ruiz, A. 2001. Efectos de los cambios de uso del suelo sobre la fauna de arañas (Arachnida: Araneae) en el macizo Sagua Baracoa, Cuba. AvaCient. 32: 3-12.

[23] Sanchez-Ruiz, A. 2015. Principales daños sobre las comunidades de arañas (Arachnida: Araneae) provocadas por la deforestación de los bosques en los macizos montañosos del oriente de Cuba. Pluvisilvas cubanas: tesoro de biodiversidad. p. 195-198. La Habana.

[24] Scamoni, A. 1960. Waldgesellschaften und Waldstandorte. Akademie-Verlag. Berlin. 326 p.

[25] Weber, H. E., J. Moravec, & J. P. Theurillat. 2000. Internacional Code of Phytosociological Nomenclature. 3rd Edition. Journal of Vegetation Science 11: 739-768.