

CHARACTERIZATION OF THE DWARF FOREST OF “CERRO COPEY” (MARGARITA ISLAND, VENEZUELA)

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With 6 figures, 2 tables and 1 appendix

ABSTRACT. The dwarf forest of the east slope of “Cerro Copey” on Margarita Island, Venezuela, is highly conditioned by strong winds that whip the area and persistent clouds that cover it. Three well differentiated habitats with distinct floristic composition are present: dwarf forest itself, the intermediate zone between the dwarf forest and the humid forest and areas disturbed by the wind action and by man activities. This dwarf forest is thought to be of recent origin and related to the Trinitarian and Continental flora. The relationships between the “Cerro Copey” dwarf forest and similar forests in the Antilles are discussed. A total of 117 species were identified, belonging to 99 genera and 45 families of Angiosperms. Only four species are endemic: *Mikania johnstonii* (Asteraceae), *Inga macrantha* (Fabaceae), *Blakea monticola* (Melastomataceae) and *Epidendrum johnstonii* (Orchidaceae). In the most exposed areas, the landscape is dominated by the “copey” *Clusia alata* (Guttiferae) and by *Glomeropitcairnia erectiflora*, a bromeliad.

INTRODUCTION

The Margarita Island is located in the north east coast of Venezuela, 38 km from the mainland, between the 10°51'46” and 11°10'49” parallels, and between the 63°46'40” and 64°24'28” meridians. The “Cerro Copey” traces a northern-southern arc, in the east part of the island, and is the highest mountain formation on it (930 m a.s.l.). Several authors have contributed to study its flora during this century, emphasizing its floristic richness and diversity of vegetation types, which are uncommon for an insular zone with relatively low elevations (JOHNSTON, 1909; ORTEGA, 1982; HOYOS, 1985; SUDGEN, 1986).

The plant community studied, is located in the east slope of the “Cerro Copey” summit, between 750 and 930 m a.s.l., and differs from the traditional classification models

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because of exceptional features in its physiognomy and floristic composition, due to uncommon environmental factors. In fact, the “Cerro Copey” summit is almost daily covered by a dense layer of clouds, and is whipped by the Trade Winds, which can reach a speed of 80 km/h, flowing east-northeast during almost all the year. The mist pushed by the wind against any surface, transforms in water, which can drips toward the ground counteracting, in part, the scarcity of rain water (mean annual precipitation registered in “Cerro Copey”, at 350 m a.s.l., is of 950 mm). This type of plant community, which grows in certain tropical or subtropical zones of the world, under similar conditions (proper of islands: CAVELIER & GOLDSTEIN, 1989; GIODA et al., 1992), has gotten different names worldwide, like “elfin forest”, “elfin woodland”, and “dwarf forest”. The wind has been considered the main environmental factor involucrated in the “dwarfism” of these plant communities. It is characterized by the presence of woody species, which form an impenetrable plant weft, due to the horizontal expansion of their branches and roots, and with only one stratum. In northern South America there are only three known localities which have these conditions: the “Serranía de Macuira” in the Goajira peninsula of Colombia; the “Cerro Santa Ana” in the Paraguaná peninsula of Venezuela, and the community in question, in the summit of “Cerro Copey” (SUDGEN, 1986).

The aim of this work is the characterization of the “dwarf forest” of the “Cerro Copey”, mainly related to its situation, habitats, composition and floristic relationships with similar forest in the Antilles and in the American Continent.

MATERIALS AND METHODS

Eight fiel trips, of four days each one, were done to the study area, during the years 1989 (July and October), 1990 (January, June and November) and 1991 (March, May and October). A total of 117 Angiosperm species, representative of the community under study, were collected in reproductive stage. This number must be close the total number of species, because during the last year of study, it scarcely increased in 10 taxa.

The biological material was collected as herbarium specimens for identification. This was done with the help of appropriate floristic literature and collaboration of specialists. The reproductive material was preserved in ethanol 70%, to determine sexuality of each species.

RESULTS AND DISCUSSION

Study site

The “Cerro Copey National Park” (10°57’34”N 63°58’08”W), covers an area of 7130 Ha., Mostly mountain lands. The dwarf forest is situated in the summit of the highest mountain of the park (930 m a.s.l.), occupying an approximate area of 1200 Ha. (Fig. 1).

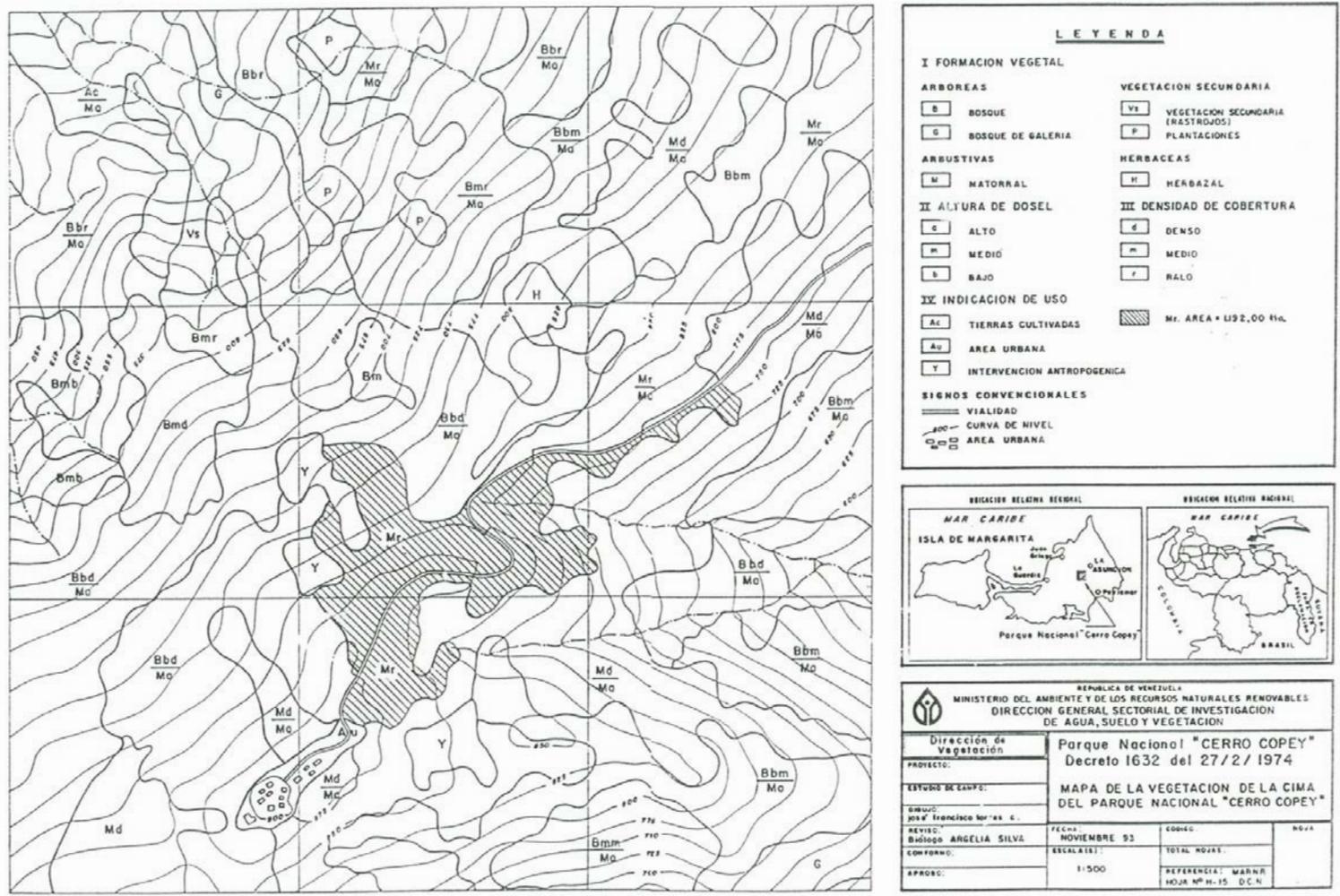


Fig. 1 - Map of the vegetation in the summit of "Cerro Copey" elaborated with aerial photographs, showing situation of the dwarf forest (striped area), indicated as "matorral ralo" (Mr).

There is a deciduous forest at the base of “Cerro Copey”, which is replaced at 350 m a.s.l., by a humid forest, due to the presence of insular orographical clouds, which increase dramatically the environmental humidity. Reduction of the vegetation size in the dwarf forest begins at 750 m a.s.l., in the eastern slope, where the wind effect begins to operate. Likewise, the floristic richness of the forest gradually decreases up to the summit. The dwarf forest location is pointed out in Fig. 1. The map, done with the assemblage of aerial photographs, shows the exact location of the dwarf forest (striped area), from the level line of the 750 m a.s.l. until the highest point, at 930 m a.s.l., always in the eastern slope. Otherwise, in the north slope, the humid forest stretches until the summit, producing a mixture of both vegetations in the line of separation of the slopes, introducing some elements of the humid forest in the dwarf forest. Likewise, an invading vegetation of special features penetrates the areas disturbed by wind action or man activities.

For this reason, three habitats should be recognized in this community: the dwarf forest in strict sense, the limit with the humid forest, and the disturbed areas. From these, the dwarf forest has different physiognomies due to different species composition.

Floristic characterization

At the summit of “Cerro Copey”, the landscape is dominated by two species *Clusia alata* Planch. & Triana, which grows in a dwarf form not exceeding 1-2 m high in the majority of the area, and a bromeliad, *Glomeropitcairnia erectiflora* Mex (Fig. 2). Two vegetation profiles, made with photographs, allow to describe the landscape aspect in both sides of the road, emphasizing the importance of these two species and their relation with other important shrubs in the zone (Fig. 3). The predominating species in each one of the three habitats are presented in Table 1.

According to the floristic analysis conducted, in the studied sample there were 45 families of Angiosperms, 39 of them Dicotyledonous (78 genera and 89 species), and 6 Monocotyledonous (22 genera and 28 species), totalizing 99 genera and 117 species (Appendix 1). This result shows that the great majority of the genera are monospecific in the study area. This fact could be related with the recent establishment of the forest. Indeed, all seems to indicate that the mountain vegetation of Margarita Island is of recent origin, probably less than 10000 years. (SUDGEN, 1986), after the last Pleistocene climatic events. Another reason that could be invoked to explain monospecificity of the genera observed in the zone, is the aleatory long distance colonization (ESCALA, 1994). According to this process, only species with features that enable them to survive in special climatic conditions (high wind speed) can establish themselves.

Among the families present in the zone, 8 can be shown as dominant based on the species number (with five or more species). In descending order, they are: Asteraceae (15; 12,8%), Fabaceae (10; 8,6%), Cyperaceae (9; 7,7%), Orchidaceae (8; 6,8%), Poaceae (7; 6,0%), Rubiaceae (6; 5,1%), Euphorbiaceae (5; 4,3%), and Solanaceae (5; 4,3%). These families included 55,6% of the species in the sample.



Fig. 2 - Appearance of the dwarf forest in one of the zones most whipped by the wind. The landscape is dominated by *Clusia alata* and the terrestrial bromeliad *Glomeropitcairnia erectiflora*.

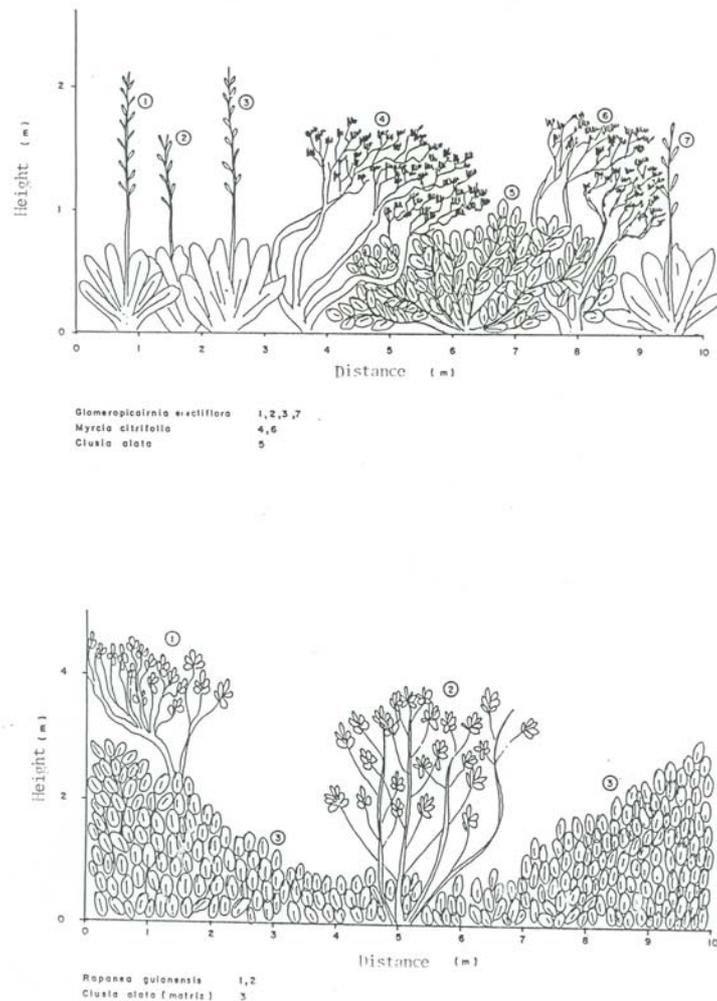


Fig. 3 - Vegetation profiles of the dwarf forest of "Cerro Copey", where the height of the individuals and the way they are intermixed can be estimated.

The dwarf forest, in a strict sense, has 37 species (31,6% of the sample), representing 33 genera and 22 families (Appendix 1). This confirms the relative floristic poverty of this type of forests, which are exposed to uncommon environmental conditions. If the woody species of the humid forest that are infiltrated in the limit zone are considered, the forest elements reach 56 species (50 genera and 36 families). On the other hand, in the disturbed areas a total of 60 species were recorded, representing 54 genera and 20 families (Fig. 4). It is interesting to be noted however, that a higher number of families are represented in the forest. This points out that the slight superiority of number of genera and species in the disturbed areas is due to the presence of some of the dominant families mentioned above (i.e. Asteraceae, Fabaceae, Poaceae), which are poorly represented or even absent in the forest.

TABLE 1 - Dominant species in each type of of the habitat in the dwarf forest of "Cerro Copey".

* Species that are present even in the most exposed zones to the action of wind.

+ Species that are present in very humid zones of the forest: border of small water courses, rocky walls, and tree trunksthat are continually humid.

Dwarf forest	Limit between dwarf forest and humid forest	Periodically disturbed areas by the action of wind	Disturbed areas by man activities
Shrubs: <i>Blakea monticola</i> <i>Blepharocalix eggersii</i> <i>Clidemia urceolata</i> <i>Clusia alata</i> * <i>Daphnopsis americana</i> <i>Erythroxylum densum</i> <i>Guapira pacurero</i> <i>Ilex sideroxyloides</i> * <i>Inga macrantha</i> <i>Myrcia citrifolia</i> * <i>Rapanea guianensis</i> <i>Roupala montana</i> <i>Senna fruticosa</i> <i>Symplocos suaveolens</i> <i>Wedelia fruticosa</i> Bromeliads: <i>Glomeropitcairnia erectiflora</i> * Epiphytes: <i>Caracasia tremadena</i> <i>Hillia parasitica</i> Herbs: <i>Eleocharis caribaea</i> + <i>Fimbristylis spathacea</i> + <i>Rhynchospora nervosa</i> + <i>R. pusilla</i> + <i>Utricularia alpina</i> + Orchids: <i>Epidendrum elongatum</i> <i>E. johnstonii</i> + Climbers: <i>Canavalia dictyota</i> <i>Ditassa subulata</i> <i>Machaonia ottonis</i> <i>Mikania johnstonii</i> <i>Passiflora cyanea</i> <i>P. tuberosa</i> <i>Vaccinium latifolium</i>	Araceous: <i>Anthurium hookeri</i> Shrubs or small trees: <i>Cestrum megalophyllum</i> <i>Clusia alata</i> <i>Licania membranosa</i> <i>Guettarda scabra</i> <i>Maytenus karstenii</i> <i>Ocotea leucoxyllum</i> <i>Persea cerulea</i> <i>Solanum arboreum</i> <i>Styrax pallidus</i> Bromeliads: <i>Aechmea fendleri</i> Orquids: <i>Epidendrum nocturnum</i> <i>Pleurothallis pluriracemosa</i> <i>Sacoila lanceolata</i> Palms: <i>Euterpe karsteniana</i> Climbers: <i>Heteropteris laurifolia</i>	Herbs or subshrubs: <i>Andropogon leucostachyus</i> <i>Axonopus affinis</i> <i>Borreria ocimoides</i> <i>Centropogon cornutus</i> <i>Coutoubea spicata</i> <i>Cuphea denticulata</i> <i>Cyperus surinamensis</i> <i>Emilia fendlery</i> <i>Enicostema verticillatum</i> <i>Fymbristylis complanata</i> <i>Ichnanthus nemorosos</i> <i>Justicia secunda</i> <i>Lasciasis divaricata</i> <i>Olyra latifolia</i> <i>Oxalis frutescens</i> <i>Paspalum conjugatum</i> <i>Rhynchospora rugosa</i> <i>Sauvagesia erecta</i> <i>Scleria bracteata</i> <i>S. latifolia</i> <i>Sporolobus indicus</i> <i>Wedelia fruticosa</i> <i>Wulffia baccata</i>	Herbs or subshrubs: <i>Baccharis trinervis</i> <i>Calea solidaginea</i> <i>Coniza bonarensis</i> <i>Cordia curassavica</i> <i>Croton hircinus</i> <i>Diodia apiculata</i> <i>Hippobroma longiflora</i> <i>Melochia caracasana</i> <i>Miconia minutiflora</i> <i>Mitracarpus hirtus</i> <i>Paspalum conjugatum</i> <i>Sida acuta</i> <i>Solanum asperum</i> <i>Stachytarpheta jamaicensis</i> <i>S. trinitensis</i> <i>Tournefortia volubilis</i> <i>Wedelia calycina</i>

Appendix 1 - List of species collected in the dwarf forest (750-930 m a.s.l.) of “Cerro Copey” (Margarita Island). Habitat in which these species can be found preferentially is indicated within parenthesis. DF = dwarf forest; L = limit between dwarf forest and humid forest; HF= humid forest; IZ = disturbed area of the forest: a. inside the forest; b. in the road border.

1. ACANTHACEAE

1. *Justicia secunda* Vahl - (IZ a)

2. AQUIFOLIACEAE

2. *Ilex sideroxyloides* (Sw.) Griseb - (DF)

3. ARACEAE

3. *Anthurium hookeri* Kunth. - (L)

4. ARECACEAE

4. *Euterpe karsteniana* Engel - (L)

5. ASCLEPIADACEAE

5. *Ditassa subulata* Johnston - (DF)

6. ASTERACEAE

6. *Ageratum conizoides* L. - (IZ b)
7. *Baccharis trinervis* (Lam.) Persoon - (IZ b)
8. *Bidens pilosa* L. - (IZ b)
9. *Calea solidaginea* H.B.K. - (IZ b)
10. *Conyza bonariensis* (L.) Cronq. - (IZ b)
11. *Eclipta alba* (L.) Hassk - (IZ b)
12. *Emilia fosbergii* DC. - (IZ a,b)
13. *Erechtites hieracifolia* (L.) Raf. ex DC. - (IZ b)
14. *Eupatorium ballotaefolium* H.B.K. - (IZ b)
15. *Mikania johnstonii* Robinson - (IZ a)
16. *Neurolaena lobata* (L.) R. Br. - (IZ b)
17. *Vernonia cinerea* (L.) Less. - (IZ b)
18. *Wedelia calycina* Rich - (IZ b)
19. *W. fruticosa* Jacq. - (DF; IZ a,b)
20. *Wulffia baccata* (L.) Kuntz. - (DF; IZ a,b)

7. BIGNONIACEAE

21. *Tabebuia chrysantha* (Jacq.) Nicholson - (L)

8. BORAGINACEAE

22. *Cordia curassavica* (Jacq.) Roem & Schult - (IZ b)
23. *C. polycephala* (Lam.) Johnston - (IZ b)
24. *Tournefortia volubilis* L. - (IZ b)

9. BROMELIACEAE

25. *Aechmea fendleri* André ex Mez - (L)
26. *Glomeropitcairnia erectiflora* Mez - (DF)

10. CAMPANULACEAE

27. *Centropogon cornutus* (L.) Druce - (IZ a)

28. *Hippobroma longiflora* (L.) Don - (IZ b)
11. CELASTRACEAE
29. *Maytenus karstenii* (Kl.) Reiss - (L)
12. CHRYSOBALANACEAE
30. *Lycania membranosa* Sagot ex Lasennan - (L)
13. CYPERACEAE
31. *Cyperus surinamensis* Rottb. - (IZ a)
32. *Eleocharis caribaea* (Rottb.) Blake - (DF)
33. *Fibristylis complanata* (Retz.) Link - (IZ a)
34. *F. spathacea* Roth. - (DF)
35. *Rhynchospora nervosa* (Vahl) Boeckeler - (DF)
36. *R. pusilla* Curtis - (DF)
37. *R. rugosa* (Vahl) Gale - (IZ a)
38. *Scleria bracteata* Cav. - (DF; L)
39. *S. latifolia* Sw. - (IZ a)
14. ERICACEAE
40. *Vaccinium latifolium* Benth. & Hooker - (DF; L)
15. ERYTROXYLACEAE
41. *Erytroxylum densum* Rusby - (DF)
16. EUPHORBIACEAE
42. *Chamaesyce thymifolia* (L.) Millsp. - (IZ b)
43. *C. lasiocarpa* (Kl.) Arthur - (IZ b)
44. *C. dioica* (H.B.K.) Millsp. - (IZ b)
45. *Croton hircinus* Vent. - (IZ b)
46. *Margaritaria nobilis* L. - (L)
17. FABACEAE
47. *Canavalia dictyota* Piper - (IZ a)
48. *Cassia chamaecrista* L. - (IZ b)
49. *Desmanthus virgatus* (L.) Willd. - (IZ b)
50. *Desmodium axilare* (Sw.) DC. var *acutifolium* (Kuntz.) Urban - (IZ b)
51. *Inga macrantha* Johnston - (DF; L)
52. *Mimosa pudica* L. - (IZ b)
53. *Rhynchosia minima* (L.) DC. - (IZ b)
54. *Senna fruticosa* Miller - (DF; L)
55. *Stylosanthes viscosa* (L.) Swartz - (IZ b)
56. *Zornia diphylla* (L.) Pers. - (IZ b)
18. GENTIANACEAE
57. *Coutoubea spicata* Aubl. (IZ a)
58. *Enicostema verticilatum* (L.) Engl. ex Gilg - (IZ a)
19. GUTTIFERAE
59. *Clusia alata* Planch. & Triana - (DF; L)

60. *C. minor* L. - (L)
20. LAURACEAE
61. *Ocotea leucoxylum* (Sw.) Lanessan - (L)
62. *Persea caerulea* (R. & P.) Mez - (L)
21. LENTIBULARIACEAE
63. *Utricularia alpina* Jacq. - (DF; L)
22. LYTHRACEAE
64. *Cuphea denticulata* H.B.K. - (IZ a)
23. MALPIGHIACEAE
65. *Heteropteris laurifolia* (L.) Juss. (IZ a)
24. MALVACEAE
66. *Sida acuta* Burm. - (IZ b)
25. MARCGRAVIACEAE
67. *Caracasia tremadena* (Ernst) Szysz. - (DF; L)
26. MELASTOMATAACEAE
68. *Blakea monticola* Johnston - (DF; L)
69. *Clidemia urceolata* DC. - (DF; L)
70. *Miconia minutiflora* (Bonpl.) DC. - (IZ b)
27. MYRSINACEAE
71. *Rapanea guianensis* Aubl. - (DF; L)
28. MYRTACEAE
72. *Blepharocalix eggersii* (Kiaersk) Landrum - (DF)
73. *Myrcia citrifolia* (Aubl.) Urb. - (DF; L)
29. NYCTAGINACEAE
74. *Guapira olfersioana* (L.K. & O.) Lundell - (L)
75. *G. pacurero* (H.B.K.) Little - (DF)
30. OCHNACEAE
76. *Sauvagesia erecta* L. - (IZ a)
31. ONAGRACEAE
77. *Ludwigia octovalvis* (Jacq.) Raven - (IZ b)
32. ORQUIDACEAE
78. *Epidendrum elongatum* Jacq. - (DF; L)
79. *E. johnstonii* Ames - (DF; L)
80. *E. nocturnum* Jacq. - (DF; L)
81. *Erythroides venezuelana* Garay et Dunsterv. - (DF; L)
82. *Habenaria monorrhiza* (Sw.) Rchbl. - (DF; IZ a)
83. *Maxillaria melina* Lindl. - (DF)
84. *Pleurothallis pluriracemosa* Garay. - (L)
85. *Sacoila lanceolata* (Aubl.) Garay. - (L)
33. OXALIDACEAE
86. *Oxalis frutescens* L. subsp. *frutescens* Lourt. - (IZ a,b)

34. PASSIFLORACEAE

87. *Passiflora cyanea* Masters - (DF; L)88. *P. suberosa* L. - (DF; L)

35. PLANTAGINACEAE

89. *Plantago major* L. - (DF)

36. POACEAE

90. *Andropogon leucostachyus* H.B.K. - (IZ a,b)91. *Axonopus affinis* Chase - (IZ a,b)92. *Ichnanthus nemorosus* (Sw.) Doell. - (IZ a,b)93. *Lasiacis divaricata* (L.) Hitchc. - (DF; L)94. *Olyra latifolia* L. - (IZ a,b)95. *Paspalum conjugatum* Bergius - (IZ a,b)96. *Sporolobus indicus* (L.) R. Br. - (IZ a,b)

37. POLYGALACEAE

97. *Polygala paniculata* L. - (IZ a,b)

38. PROTEACEAE

98. *Roupala montana* Aubl. - (DF; L)

39. RUBIACEAE

99. *Borreria ocimoides* (Burm.) DC. - (IZ a,b)100. *Diodia apiculata* (Willd. ex Roem. & Schult) Schum. - (IZ b)101. *Guettarda scabra* (L.) Lam. - (L)102. *Hillia parasitica* Jacq. - (DF; L)103. *Machaonia ottonis* (Schum.) Urban - (DF; L)104. *Mitracarpus hirtus* (L.) DC. - (IZ b)

40. SOLANACEAE

105. *Cestrum megalophyllum* Dun. - (L)106. *Solanum arboreum* H. B. K. - (L)107. *S. asperum* Rich. - (IZ b)108. *S. brachyacanthum* H. & B. ex Dun. - (L)109. *S. extensum* Bitter - (L)41. STERCULIACEAE110. *Melochia caracasana* Jacq. - (IZ b)111. *M. tomentosa* L. - (IZ b)42. STYRACACEAE112. *Styrax pallidus* DC. - (L)

43. SYMPLOCACEAE

113. *Symplocos suaveolens* Klotzsch ex Brand - (DF; L)44. THYMELACEAE114. *Daphnopsis americana* (Mill.) Johnston subsp. *caribaea* (Griseb.) Nevling. - (DF; L)45.

VERBENACEAE

115. *Lantana camara* var. *moritziana* (Otto & Dietr.) López-Palacios - (IZ b)116. *Stachytarpheta jamaicensis* (L.) Vahl - (IZ b)117. *S. trinitensis* Moldenke - (IZ b)

With respect to the species distribution according to life form, in the three habitats considered (Fig. 5) it stands out the notable dominance of the shrubby habit in the forest (42% in the dwarf forest in strict sense; 44% in the limit between forests); surpassing the tree like elements (15,4% in the dwarf forest in a strict sense; 33,3% in the limit between forests). This fact explains the “dwarf” physiognomy of the forest. As can be expected the herbaceous life form predominates in the disturbed area (77%).

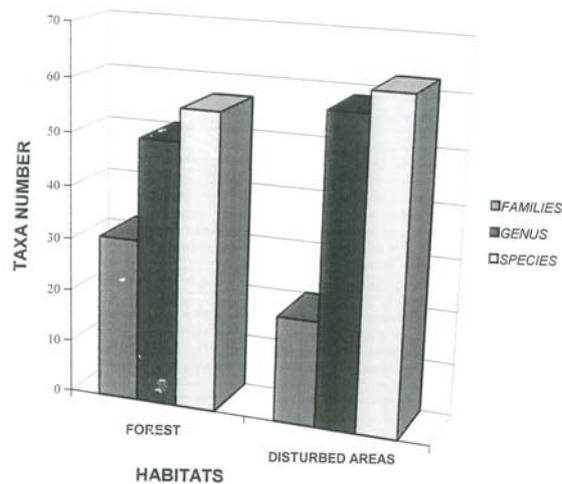


Fig. 4 - Comparison between number of families, genus and species present in the dwarf forest and in the disturbed areas.

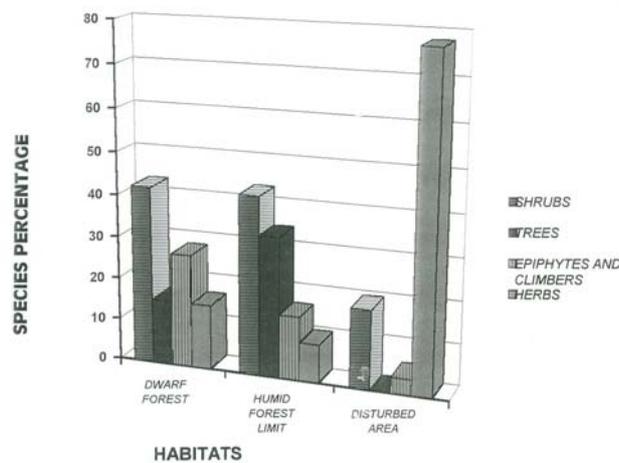


Fig. 5 - Distribution of species according to their life forms in the three habitats that conform the dwarf forest.

In relation with sexuality of the species in this community, 81,2% of them are hermaphrodite, 9,0% are dioecious, 5,3% are monoecious, 3,6% are gynomonoecious, and 0,9% are andromonoecious. If we compare these results between the two habitats: forest and disturbed areas (Fig. 6), besides the dominance of hermaphroditism in both, it stands out the importance of dioecy in the forest, and of monoecy and ginomonoecy in disturbed areas (mainly present in the species of Asteraceae). It must be noted that, between the woody elements of the dwarf forest, some dioecious species play a preponderant role in its physiognomy: *Clusia alata*, *Daphnopsis americana*, *Euterpe karsteniana*, *Guapira pacurero*, *Ilex sideroxyloides*, and *Ocotea leucoxilum*.

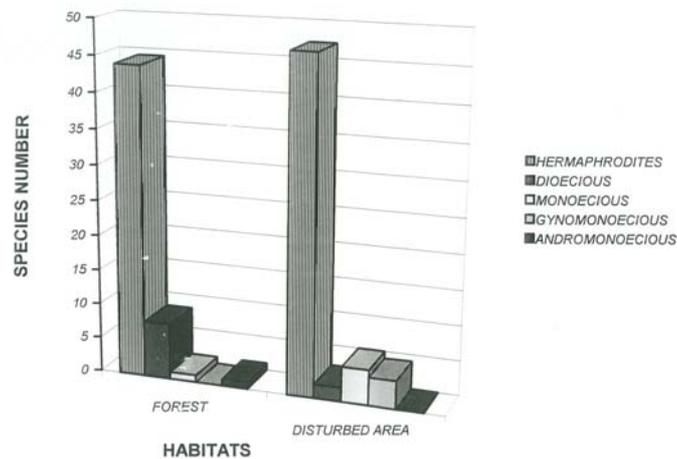


Fig. 6 - Distribution of species according to their sexuality in the dwarf forest and in the disturbed areas.

This result, the dioecy as the second sexual form in the community, and specially in woody species, is similar to the findings reported by other authors in tropical rain forests (BAWA et al., 1985; SOBREVILA & ARROYO, 1982). It is surprising, however, that in an isolated community, the dioecious woody species are very successful. SUDGEN (1983) reported a proportion of dioecious species between 15% and 29% in three floras studied, including dwarf and cloud forest (Macuira, Santa Ana and Copey). Specifically to "Cerro Copey" he reports 25% of dioecy, when considering all the vegetation. The presence of pollinators (XENA DE ENRECH & MADRIZ, 1994) and biotic dispersers (ESCALA, 1994) is guaranteed in this community, which may contribute to explain the situation. SUDGEN (1983) himself, recognizes that dioecy must be less disadvantageous in an island colonization if it is associated with efficient dispersal mechanisms and not specialized flowers visited by unspecific pollinators. It is tempting to postulate, however, that separation of sexes brings to certain woody species a better capacity of adaptation to special environmental conditions.

Endemism

The Margarita Island (only 23 km separated from continental land) finishes its elevation formation during the Pliocene, but during the Quaternary, reduction in the sea level, allowed Margarita island to form part of the continental land some times. During these connection periods, which also included the Trinidad island, floristic and faunistic exchanges between Margarita and the Continent could occur on one side, and with the Antilles islands, on the other side (ORTEGA, 1982).

These biotic interchanges between the island and mainland seem to be supported by the low endemism in the zone. Only four Angiosperm endemic species have been mentioned in the dwarf forest: the climbing asteraceous *Mikania johnstonii*, the leguminous *Inga macrantha*, the melastome *Blakea monticola*, and the orchidaceous *Epidendrum johnstonii* (HOYOS, 1985). Furthermore, it must be pointed out, that the two dominant species in the landscape of the dwarf forest, covey (*Clusia alata*) and the bromeliad (*Glomeropitcairnia erectiflora*) seem to have a restricted distribution. In Venezuela, *Clusia alata* does not exceed the “Cordillera de la Costa”, and *Glomeropitcairnia erectiflora* only has been reported in the “Cerro Copey”, Trinidad, and the Paria peninsula, at the northeast of Venezuela. Besides, ORTEGA (1982) does not find any endemic Pteridophyte in the Margarita Island.

Floristic Relationships

The dwarf forests have been frequently reported in the Antilles. BEARD (1944) points out that the difference between this vegetation type in the Antilles and in the Old World rests in the type of leaves, predominantly large in the former and small in the latter. Then, it is not surprising, that in almost all the dwarf forests reported in the Antilles, the dominant species is a *Clusia* with large leaves. Likewise, the author considers the strong winds, that regularly blow in these islands, as the main factor that determines the presence of a dwarf vegetation. BEARD reports this type of forest in: a) Trinidad (Monte El Aripo, approximately 900 m high) with *Clusia intertexta* as the dominant species (probably synonymous of *Clusia alata*), and a woody flora of only 11 species; b) in Granada, with *Ilex sideroxyloides* among the principal species; c) St. Vincent, where genera *Clusia* and *Ilex* stand out; and d) Sta. Lucía, Guadeloupe, and Martinique where again *Clusia* dominates.

In Dominica, HODGE (1954) considers the “elfin forest” as the most interesting area in the island, where the woody specimens form a continuum in which it is impossible to walk, with *Clusia* and *Ilex* standing out once more, as well as a climbing species from the genus *Mikania*. Other “elfin forests” have been described in Jamaica (SHREVE, 1914) and Cuba (SEIFRIZ, 1943), always with the same features of few woody species of low height and horizontal growth, with interlacing stems.

The most detailed study of a dwarf forest is the one done in “Montañas de El Luquillo”, east of Puerto Rico. GLEASON & COOK (1927) reported its existence, for the first time, pointing out the presence of genera like *Ilex*, *Ocotea* and *Tabebuia*. In the same study

area, DANSEREAU (1966) mentioned a broad-leaved forest, where *Clusia* and *Ocotea* stand out, a palm forest of the genus *Euterpe* and an "elfin forest" in where predominate genera like *Clusia*, *Ilex*, *Ocotea*, *Rapanea*, *Symplocos*, and *Tabebuia*. HOWARD (1968), in the "Pico del Oeste", points out that, in the slope exposed to the wind, the vegetation did not surpass 2-3 m high and also points out the presence of the woody genus *Clusia*, *Ilex*, and *Miconia*. The grasses *Andropogon* and *Ichnanthus*, and the sedge *Scleria* among others, grow in the open areas. *Eleocharis* rosettes grows in open humid sites. A comparison between the vegetation of "Pico del Oeste" and the dwarf forest in "Cerro Copey" is included in Table 2.

WILLIAMS (1928) reported for the Flora of Trinidad 33 genus and 23 species also mentioned in this study (Table 2).

Small vegetation spots in low elevations (200 m high) with an evergreen forest are presented in the "Archipiélago de Los Testigos". This group of small islands is near Margarita Island and Trinidad in the Caribbean Sea, and is highly influenced by the Trade Winds. FERNANDEZ & ORTEGA (1984) mention an interesting list of taxa that are common with the dwarf forest of "Cerro Copey" (23 genus, 9 species; Table 2).

The flora of continental mountains near Margarita, is that of the "Cerro Patao", in the Paria peninsula (STEYERMARK & AGOSTINI, 1966), and Turimiquire and adjacent regions, also at the northeast part of Venezuela (STEYERMARK, 1966). Comparison between the vegetation of the dwarf forest of "Cerro Copey" and of these close zones allows to formulate the following comments. In the summit of "Cerro Patao" (1020 m a.s.l.), according to its authors, there isn't a dwarf vegetation as the one described by BEARD (1944; 1946) in Trinidad; but exists a very humid forest, with the bromeliad *Glomeropitcairnia erectiflora* being the only species of the ones mentioned in the summit that is at the same time in the summit of "Cerro Copey". From the extensive floristic list that the authors reported in "Cerro Patao", there are only 11 genus and 6 species that coincide with our results (Table 2). Related to the mountain region of Turimiquire, the flora also has little relation with that present in the summit of the "Cerro Copey" (only 6 genera and 6 species; Table 2).

SUDGEN (1983) presents a comparison between the three regions in the north of South America, which includes in their vegetation dwarf forests: "Cerro Copey", "Cerro Santa Ana", and "Serranía de Macuira". The author points out the differences of isolation, geology, diversity, and habitat between the three regions. He presents a list of 98 tree and shrublike species. Of them, only 17 species are present in more than one region. From the comparison of this data with the data presented here, only six of these species are present in the three regions (Table 2). Of these six species, three are present in the dwarf forest of "Cerro Copey": *Croton hircinus*, *Persea caerulea* and *Rapanea guianensis*; two are common to the dwarf forest of "Cerro Copey" and to "Cerro Santa Ana", *Euterpe karsteniana* y *Daphnopsis americana*; and a simple species, *Margaritaria nobilis*, is present in Macuira as well as in the dwarf forest of "Cerro Copey". If we include the herbaceous elements present in the cloud forest of Macuira (cited by SUDGEN, 1982 a,b), *Utricularia alpina* scarcely appears in the dwarf forest of the "Cerro Copey".

TABLE 2 - Floristic relationships between the dwarf forest of “Cerro Copey” (Margarita Island, Venezuela) and other forests of the Antilles and north of South America. Common genera or species are mentioned according to the available references.

* Genus presence. ** Species presence.

“Cerro Copey” (Margarita Island, Venezuela)	A	B	C	D	E	F
<i>Aechmea</i> sp.	*	---	---	---	---	---
<i>Ageratum conyzoides</i> .	---	**	---	---	---	---
<i>Andropogon leucostachyus</i>	---	---	*	---	**	---
<i>Anthurium</i> sp.	---	*	*	---	---	---
<i>Baccharis trinervis</i>	---	**	---	---	---	---
<i>Bidens pilosa</i>	---	**	---	---	---	---
<i>Blepharocalix</i> sp.	*	---	---	---	---	---
<i>Borreria ocimoides</i>	**	**	---	---	---	---
<i>Calea solidaginea</i>	---	**	---	---	---	---
<i>Cestrum</i> sp.	*	---	---	---	---	---
<i>Clusia</i> sp.	---	*	*	*	---	---
<i>Cordia curassavica</i>	**	---	*	---	---	---
<i>Croton hircinus</i>	*	---	---	---	---	**
<i>Daphnopsis americana</i>	---	**	*	---	---	**
<i>Desmanthus virgatus</i>	**	---	---	---	---	---
<i>Diodia</i> sp.	---	*	---	---	---	---
<i>Eclipta alba</i>	---	**	---	---	---	---
<i>Eleocharis</i> sp.	---	---	*	---	---	---
<i>Emilia</i> sp.	---	*	---	---	---	---
<i>Epidendrum nocturnum</i>	*	**	**	---	**	---
<i>Erechthites hieracifolia</i>	---	**	---	---	---	---
<i>Erytroxylum</i> sp.	---	*	---	---	---	---
<i>Eupatorium ballotaefolium</i>	**	*	---	---	---	---
<i>Euterpe karsteniana</i>	---	---	*	---	---	**
<i>Fimbristylis</i> sp.	---	---	*	---	---	---
<i>Glomeropitcairnia erectiflora</i>	---	**	---	**	---	---
<i>Guapira</i> sp.	*	---	---	---	---	---
<i>Habenaria monorrhiza</i>	---	**	---	---	---	---
<i>Heteropteris</i> sp.	*	---	---	---	---	---
<i>Hillia parasitica</i> .	---	**	**	---	---	---
<i>Ichmanthus</i> sp.	---	---	*	*	---	---
<i>Ilex sideroxyloides</i> .	---	**	**	---	---	---
<i>Inga</i> sp.	---	---	---	*	---	---
<i>Justicia</i> sp.	---	---	*	---	---	---
<i>Margaritaria nobilis</i>	---	---	---	---	---	**
<i>Maxillaria</i> sp.	---	---	---	*	---	---
<i>Maytenus karstenii</i>	---	*	---	---	**	---
<i>Melochia tomentosa</i> .	**	**	---	---	---	---

TAB. 2 - (Cont.)

<i>Miconia sp.</i>	----	----	*	----	----	----
<i>Mikania sp.</i>	----	*	*	----	----	----
<i>Mitracarpus hirtus</i>	*	**	----	----	----	----
<i>Neurolaena lobata</i>	----	**	----	----	----	----
<i>Ocotea leucoxilum</i>	----	----	**	----	----	----
<i>Olyra sp.</i>	----	----	----	*	----	----
<i>Oxalis sp.</i>	----	*	----	----	----	----
<i>Passiflora suberosa</i>	**	----	----	----	----	----
<i>Persea caerulea</i>	----	----	----	----	----	**
<i>Pleurothallis sp.</i>	----	----	----	*	----	----
<i>Polygala sp.</i>	----	*	----	----	----	----
<i>Rapanea guianensis</i>	----	----	*	----	**	**
<i>Rhynchosia minima</i>	**	----	----	----	----	----
<i>Rhynchospora rugosa</i>	----	----	----	----	**	----
<i>Roupala montana</i>	----	**	----	----	----	----
<i>Sauvagesia erecta</i>	----	**	**	----	----	----
<i>Scleria hirtella</i>	----	----	*	----	**	----
<i>Senna sp.</i>	*	----	----	----	----	----
<i>Sida acuta</i>	*	**	----	----	----	----
<i>Solanum arboreum</i>	*	----	----	**	----	----
<i>Sporolobus sp.</i>	*	----	----	----	----	----
<i>Stylosanthes sp.</i>	*	----	----	----	----	----
<i>Symplocos sp.</i>	----	----	*	----	----	----
<i>Tabebuia sp.</i>	----	----	*	*	----	----
<i>Tournefortia volubilis</i>	**	----	----	**	----	----
<i>Utricularia alpina</i>	----	----	----	*	----	**
<i>Vaccinium latifolium</i>	----	**	----	----	----	----
<i>Vernonia cinerea</i>	----	**	----	----	----	----
<i>Wedelia fruticosa</i>	**	**	----	----	----	----
<i>Wulffia baccata</i>	----	**	----	----	----	----
<i>Zornia sp.</i>	*	----	----	----	----	----
Total number of common genera or species	23* 9**	33* 23**	21* 5**	11* 3**	6* 6**	7* 7**

A = Archipiélago “Los Testigos”, Venezuela (FERNÁNDEZ & ORTEGA, 1984)

B = Trinidad Island, including Monte “El Aripo” (WILLIAMS, 1928; BEARD, 1946)

C = Montañas de “El Luquillo”, “Pico Oeste”, Puerto Rico (HOWARD, 1968)

D = “Cerro Patao”, Península de Paria, Venezuela (STEYERMARK & AGOSTINI, 1966)

E = “Cerro Turumiquire”, northeast of Venezuela (STEYERMARK, 1966)

F = Other dwarf forest of the north of South América (SUDGEN, 1983)

All previous considerations, allow us to deduce that the floristic relationships of the species in the flora of “Cerro Copey” summit must be treated with caution. Without any

doubt, there is a relationship with the continent, as was mentioned previously by HOYOS (1985) and SUDGEN (1986), but it is not the only one. According to the available information, the higher affinity seems to be with the Trinidad Island (and even with the small “Archipiélago de Los Testigos”!) instead of the most near continental area (Paria peninsula). Probably, the direction of the Trade Winds is partially responsible for this situation. Moreover, there seems to be an affinity between Antillean dwarf forests. The remarkable correspondence of 21 genera between the dwarf forests of “Cerro Copey” and “Pico Oeste” in Puerto Rico, is a good example to consider the influence of colonization of this type of communities by species with special features. This lets them a long distance dispersal, followed by implantation and survival in zones strongly whipped by the wind. The study of the common features between these species must be the next step in the understanding of these fragile and scarce plant communities.

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REFERENCES

BAWA, K.S., D.R. PERRY & J.H. BEACH:

1985. Reproductive biology of tropical lowland Rain Forest Trees. I: Sexual systems and incompatibility mechanisms. *Amer. J. Bot.* 72: 331-345.

BEARD, J.S.:

1944. Forestry in the Windward Islands. Development and Welfare W. *Indies Bull.* 11. Trinidad. 183 pp.
1946. The Natural vegetation of Trinidad. Oxford Forestry Mem. 20. 152 pp. Clarendon Press, Oxford.

CAVELIER, J. & G. GOLDSTEIN:

1989. Mist and fog interception in elfin cloud forest in Colombia and Venezuela. *J. Tropical Ecology* 5: 309-322.

DANSEREAU, P.:

1966. Studies on the vegetation of Puerto Rico. I. Description and integration of the plant-communities. *Inst. Caribbean Sci. Spec. Publ.* 1: 1-45.

ESCALA, M.:

1994. Biología de Diseminación de un Bosque Húmedo Achaparrado (Cerro Copey, Isla Margarita). Tesis Doctoral, Facultad de Ciencias, U.C.V., Caracas.

FERNANDEZ DEL VALLE, A. & F. ORTEGA:

- La vegetación del Archipiélago de Los Testigos. *Mem. Soc. Ciencias Nat. La Salle* 122: 37-55.

GIODA, A., A. ACOSTA, P. FONTANEL, Z. HERNÁNDEZ & A. SANTOS:

1992. L'arbre fontaine. *La recherche* 249: 1400-1408.

GLEASON, H.A. & M.T. COOK:

1927. Plant Ecology of Porto Rico. *Sci. Surv. Porto Rico Virgin Is.* 7: 1-173.

HODGE, W.H.:

1954. Flora of Dominica. *Lloydia* 17: 1-238.

HOWARD, R.A.:

1968. The ecology of an elfin forest in Puerto Rico. I. Introduction and composition studies. *J. Arnold Arb.* 49(4): 381-418.

- HOYOS, J.F.:
1985. Flora de la Isla Margarita de Venezuela. Soc. y Fund. La Salle de Ciencias Nat., Monografía 34, Caracas. 927 pp..
- JOHNSTON, J.R.:
1909. Flora of the Islands of Margarita and Coche, Venezuela. *Contr.Gray Herb.* 37: 1-149.
- ORTEGA, F.J.:
1982. La Fitogeografía de las Pteridofitas de la Isla de Margarita. *Mem. Soc. Ciencias Nat. La Salle* 117: 135-150.
- SEIFRIZ, W.:
1943. The plant life of Cuba. *Ecol. Monogr.* 13: 375-426.
- SHREVE, F.:
1914. A montane Rain-forest. Carnegie Inst. Publ. Washington D.C. 110 pp.
- SOBREVILA, C. & T.K. ARROYO:
1982. Breeding systems in a montane tropical cloud forest in Venezuela. *Pl. Syst. Evol.* 140: 19-37.
- STEYERMARK, J.A.:
1966. El Cerro Turimiquire y la región adyacente. *Acta Bot. Venezuelica* 1(3,4): 104-168.
- STEYERMARK, J.A. & G. AGOSTINI:
Exploración botánica al Cerro Patao y zonas adyacentes a Puerto Hierro, en la Península de Paria, Edo. Sucre. *Acta Bot. Venezuelica* 2(2): 7-80.
- SUDGEN, A.M.:
1983. Determinants of species composition in some isolated neotropical cloud forest. In: S.L. SUTTON, T.C. WHITMORE & A.C. CHADWICK (Eds.), *Tropical rain forest: Ecology and Management*: 43-56. British Ecological Soc., Special Pub. 2, Blackwell Scientific Pub., Oxford.
1986. The montana vegetation and Flora of Margarita Island, Venezuela. *J. Arnold Arboretum* 67: 187-232.
- WILLIAMS, R.O.:
1928. Flora of Trinidad and Tobago. Department of Agriculture Trinidad and Tobago. 464 pp.
- XENA DE ENRECH, N. & R. MADRIZ:
1994. Aspectos de la Biología de Polinización en una comunidad vegetal ubicada en la cima del "Cerro Copey" (Isla Margarita). *Acta Bot. Venezuelica* 17: 35-68.