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## **Liverworts (Hepaticae) from the Leeward Islands of the Netherlands Antilles**

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### **ABSTRACT**

In this first paper on the liverworts of the leeward islands of the Netherlands Antilles, a total of 16 species are being reported: 15 from Curaçao (mainly Christoffelberg area) and 2 from Bonaire. All species are drought-tolerant and widespread in the neotropical lowlands. A key to the species and references to descriptions of each species are given as well as short notes on distribution and ecology.

### **INTRODUCTION**

The leeward group of the Netherlands Antilles comprises the islands of Aruba, Bonaire and Curaçao. Botanical investigations in the Netherlands Antilles, which also include the windward group consisting of Saba, St. Eustatius and the southern part of St. Maarten, started already in the 18th century, but it was not until the beginning of this century that a Flora was published (Boldinh, 1913). A Flora of the leeward group was subsequently published by Arnoldo (1954) and an elaborate study of the vegetation of all six islands by Stoffers (1956).

A new comprehensive Flora is currently being published by Stoffers (1962-). All these botanical studies focussed only on Pteridophyta and Spermatophyta. The first paper on the Bryophyta of the Netherlands Antilles was that by Florschütz (1967), which provided a list of 32 species of mosses (Musci) based on recent collections and a list of collectors.

Nothing has been published so far on the liverworts (Hepaticae), hornworts (Anthocerotae) and the lichens of the islands.

The present study treats the Hepaticae of the leeward islands, especially the Christoffelberg area on Curaçao and the Brandaris complex on Bonaire. The collections on which this study is based were made by the author in December 1976 and January 1977 in connection with vegetation studies in the area in collaboration with Prof. A. L. Stoffers and Mr. R. Stronkhorst. The specimens (cited as "Stoffers et al.") are deposited in the herbarium of the University of Utrecht (U). A few additional, unidentified specimens from U, collected by Florschütz on Curaçao in 1965, have also been taken into account.

The leeward islands of the Netherlands Antilles are very low Caribbean islands. The highest is Curaçao, reaching to 375 m on the Christoffelberg. Consequently, the climate of the islands is relatively dry. The annual rainfall on Curaçao is 516 mm and on Bonaire 525 mm. October-Januari is the wetter period: about 300–350 mm of rainfall (Stoffers 1956). The wind blows steadily throughout the year, mainly from NE and SE directions, and has a desiccant influence on the vegetation. The dry climatic conditions lay their restrictions upon the development of a bryophyte vegetation on the leeward islands. A total of 16 species of liverworts was collected by the author on Curaçao and Bonaire. No liverworts are as yet known from Aruba. The same holds for mosses (Florschütz 1967), which is probably due to the lower elevation (up to 188 m) and an annual rainfall of only 359 mm on Aruba (Stoffers l.c.). The richest area for mosses and liverworts in the leeward group is the Christoffelberg on Curaçao. All species of liverworts recorded are drought-tolerant to some degree and occur in mesophytic to xerophytic woodlands, mostly terrestrial and sometimes epiphytic on trees, e.g. on *Coccoloba swartzii* and *Capparis linearis*. When terrestrial, they grow in shaded places, e.g. in rock shelters and fissures, in gaps, under low bushes, and sometimes in cushions of *Octoblepharum albidum* associated with other species. As to their distribution, most species are rather widespread in the neotropics. No endemic liverworts are known from the Netherlands Antilles.

## LOCALITIES

### CURAÇAO:

#### 1. Tafelberg of St. Hyronimus.

One species of *Riccia* (*R. violacea*) was found in the dry, evergreen summit woodland on limestone.

#### 2. Christoffelberg area

This area comprises the following localities:

- a. The N-NE slope of the mountain (the so-called "Savonet-side").
- b. Around the "Groote Steen" or Piedra Mulina, between Christoffelberg and Ceru Gracia.

- c. Slopes of Ceru Gracia.
- d. The "Rooi", S-SE of Ceru Gracia and Piedra Mulina.
- e. Knip plantation and Rooi Kajoeda, NW of Christoffelberg.

In locations "a-d" a deciduous seasonal forest is found, which is the most luxuriant forest type found on Curaçao and Bonaire. Its relatively humid condition accounts for the occurrence of 15 species of liverworts. Most of them are terrestrial, but two of them occur both terrestrial and epiphytic (*Frullania kunzei* and *Cylindrocolea rhizantha*) and one of them is exclusively epiphytic (*Cololejeunea minutissima* ssp. *myriocarpa*). In locality "e" a dry, thorny woodland is present, which can be considered as a degradation phase of the deciduous seasonal forest. In this dry habitat only *Brachiolejeunea corticalis* is found.

#### BONAIRE:

##### 1. Slopes of the Brandaris

Here an evergreen bushland is found, which can be considered as a degradation phase of the dry evergreen woodland.

##### 2. Along road from Slagbaai to Labra

Here a *Croton* facies of a *Croton-Lantana-Cordia* thicket is found, a vegetation derived from the thorny woodland.

Only species of the very drought-tolerant genus *Riccia* were found on both locations. This might be due to the absence of a deciduous seasonal forest. More intensive collecting might reveal more species of liverworts on Bonaire.

#### KEY TO THE SPECIES

1. Plants thallose; rhizoids colourless . . . . .	2
2. Thallus with thick midrib and broad, thin, "wing-like" margins; sporophyte globose, sessile on upper surface; spore surface reticulate, areas of the surface network $15-36 \mu\text{m} \times 9-21 \mu\text{m}$ . . . . .	<i>Cronisia paradoxa</i>
2. Thallus $\pm$ uniformly thickened; surface crystalline green, grooved longitudinally, sharply incised at apex; sporophyte globose, sunk into thallus . . . . .	<i>Riccia</i>
3. Thallus with purple-black sides, without wings; spore-surface reticulate, each area $6-9 \mu\text{m}$ in diam. . . . .	<i>R. violacea</i>
3. Thallus-sides green, with narrow wings; spore-surface reticulate, each area $9-21 \mu\text{m}$ in diam. . . . .	<i>R. wainionis</i>
1. Plants appearing thallose at first sight (especially when dry), but with stem and irregularly undulate leaves; rhizoids purple . . . . .	<i>Fossumbronia spec.</i>
1. Plants distinctly foliose; rhizoids colourless . . . . .	4
4. Leaves not distinctly divided into lobe and lobule . . . . .	5
5. Leaves uniformly bilobed; (mostly) terrestrial . . . . .	<i>Cylindrocolea rhizantha</i>

5. Leaves  $\pm$  unlobed or with vague indication of a smaller lobule in the same plane as the lobe, connected to the lobe with an obscure keel; epiphytic . . . . . *Cololejeunea minutissima* ssp. *myriocarpa*
4. Leaves divided into lobe and lobule . . . . . 6
6. Lobule resembling an inverted cup, very narrowly attached to the leaf-lobe and  $\pm$  parallel to the stem . . . . . *Jubulaceae*
7. Shoots 0,8–1,5 mm wide; lobule as long as wide, if explanate then up to 2,5 times as long as wide; underleaves 2,5–4 times as wide as stem; leaves squarrose; perianth 3-keeled . . . . . *Frullania ericoides*
7. Shoots 0,5–0,7 mm wide; lobule bullet-shaped, 1,5–2 times as long as wide; underleaves less than 1,5 times as wide as stem; leaves not squarrose; perianth 3-keeled . . . . . *F. kunzei*
7. Shoots 1,2–2,1 mm wide; lobule explanate, 1,5 times as long as wide; underleaves up to 1,5 times as wide as stem; leaves not squarrose; perianth 5-keeled . . . . . *F. cf. inflata*
6. Lobule a fold along the ventral side of the leaf-lobe, forming a distinct keel with the leaf-lobe . . . . . *Lejeuneaceae*
8. Underleaves absent; lobule folded loosely under lobe, obscurely marked with an 2-celled apical tooth . . . . . *Cololejeunea minutissima* ssp. *myriocarpa*
8. Underleaves present . . . . . 9
9. Underleaves large and undivided, densely overlapping; lobules up to two-third of the length of the ventral leaf-margin, with 3–9 teeth . . . . . 10
10. Plants olive-green when dry, with flagelliform shoots producing caducous leaves; leaves distinctly squarrose when moist; stems fragile . . . . . *Acrolejeunea torulosa*
10. Plants blackish when dry, without flagelliform shoots; leaves weakly squarrose when moist; stems more rigid . . . . . *Brachiolejeunea corticalis*
9. Underleaves bifid and often inconspicuous, not overlapping; lobules up to one-half of the length of the ventral margin or reduced, with 1 tooth . . . . . 11
11. Leaf-cells with large, concave-sided trigones and frequent, large intermediate wall-thickenings . . . . . *Cheilolejeunea rigidula*
11. Leaf-cells with small trigones and occasional, small intermediate wall-thickenings . . . . . 12
12. Lobules (mostly) well developed, inflated, broadly ovate, about 0,1 mm long . . . . . 13
13. Shoots 0,5–0,8 mm wide; leaves broadly ovate; asexual reproduction by caducous leaf-lobes . . . . . *Rectolejeunea maxonii*
13. Shoots 0,2–0,5 mm wide; leaves obliquely ovate-triangular, somewhat narrowed to the obtuse to narrowly rounded apex; asexual reproduction not seen . . . . . *Lejeunea laetevirens*
12. Lobules uniformly reduced to a small, few-celled, basal fold . . . . . 14
14. Apical tooth on lobule 2–5 cells long, erect . . . . . *L. pililoba*
14. Apical tooth on lobule a single projecting cell . . . . . *L. minutiloba*

## MARCHANTIALES

### CORSINIACEAE

*Cronisia paradoxa* (Wils. & Hook.) Berk.

Descr. et illustr.: Jovet-Ast (1964).

*Cronisia paradoxa* occurs in the northern part of South America. It can be found mainly in Brazil but also in Colombia. Plants of this species live on exposed soils. We have only one collection from Curaçao: from the Christoffelberg on the so called "Savonet-side". Here a deciduous seasonal forest is present on a diabase soil. The species was collected below an exposed rock in a patch of (mainly) *Hyophila* and *Fissidens*.

CURAÇAO: Stoffers et al. 8319, Christoffelberg on Savonet-side, terrestrie.

### RICCIACEAE

*Riccia* L.

Two species were recognised among the Antilles collections, which were kindly identified by Dr. S. Jovet-Ast (Paris) as *R. wainionis* Steph. and *R. violacea* Howe. *R. wainionis* is a species of Brazil and the West Indies whereas *R. violacea* occurs in the West Indies and southern U.S.A. They are apparently the most common West Indian representatives of the genus.

*Riccia violacea* Howe

Descr.: Jovet-Ast (1957).

On Curaçao *Riccia violacea* was found on the tafelberg of St. Hyronimus in the dry, evergreen summit woodland on limestone, and on the Savonet-side of the Christoffelberg in deciduous seasonal forest. On Bonaire it was found along the road from Slagbaai to Labra in a *Croton* facies of a *Croton-Lantana-Cordia* thicket, a vegetation derived from the thorny woodland. It was also found on the slope of the Brandaris where an evergreen bush is found, a degradation phase of the dry evergreen woodland. All collections were terrestrie.

CURAÇAO: Florschütz 3456, Christoffelberg, on soil; Stoffers et al. 8022, St. Hyronimus, on soil; Stoffers et al. 8121 & 8122, slope Christoffelberg on Savonet-side, on soil; Stoffers et al. 8171, Ceru di Palomba, on soil.

BONAIRE: Stoffers et al. 8346, road Slagbaai-Labra, on soil; Stoffers et al. 8365, slope Brandaris, on soil.

*Riccia wainionis* Steph.

Descr. et illustr.: Jovet-Ast (1957).

On Curaçao *Riccia wainionis* was found on the Savonet-side of the Christoffelberg where a deciduous seasonal forest is found. On Bonaire it was found along the road from Slagbaai to Labra in a *Croton* facies of the *Croton-Lantana-Cordia* thicket, a vegetation derived from the thorny woodland. All collections were terrestrie.

CURAÇAO: Stoffers et al. 8124, 8125, 8148, 8306 & 8319, Christoffelberg on Savonet-side, on soil.

BONAIRE: Stoffers et al. 8338, 8339, 8340, 8341, 8343, 8343 & 8345, road Slagbaai-Labra, on soil.

## METZGERIALES

### FOSSOMBRONIACEAE

#### *Fossombronia spec.*

Species of this genus can be found on calcareous or non-calcareous, loamy and sandy soils, and occur throughout the tropical and temperate parts of the world. We made only one collection of this genus: on the slope of the Christoffelberg near the Piedra Mulina, terrestrial in deciduous seasonal forest. Species determination in *Fossombronia* is almost entirely based on spore-ornamentation and spore-size. Since our material was sterile species determination was not possible.

CURAÇAO: Stoffers et al. 8135, near Piedra Mulina, on soil.

## JUNGERMANNIALES

### CEPHALOZIELLACEAE

#### *Cylindrocolea rhizantha* (Mont.) Schust.

(*Cephaloziella rhizantha* (Mont.) Steph.)

Descr. et illustr.: Fulford (1976); Schuster (1956).

*Cylindrocolea rhizantha* has been reported so far from scattered localities in tropical America: Brazil, Venezuela, Mexico, Cuba and Florida. According to Schuster (l.c.) it is a rather xerophytic species. On Curaçao *Cylindrocolea rhizantha* is found in shaded locations, mostly terrestrial, for instance in tufts of *Octoblepharum albidum*. In the Curaçao material I found a considerable variation in size and form of the underleaves: while Fulford describes them as being "1–3 cells long, 1–2 cells wide, or absent", in my specimens they were 3–4(–8) cells long and 1–2(–4) cells wide, or absent (Plate 1: 1). In addition, the density of the foliation also varies considerably.

CURAÇAO: Stoffers et al. 8133 & 8402, Piedra Mulina, on soil; Stoffers et al. 8398 & 8405, Piedra Mulina, on *Coccoloba swartzii*; Stoffers et al. 8311 & 8313, Christoffelberg, on soil.

## JUBULACEAE

### *Frullania ericoides* (Nees) Nees

(*Frullania squarrosa* (Reinw., Blume & Nees) Nees)

Descr. et illustr.: Breil (1970); Vanden Berghe (1972).

*Frullania ericoides* is a very common, pantropical species. According

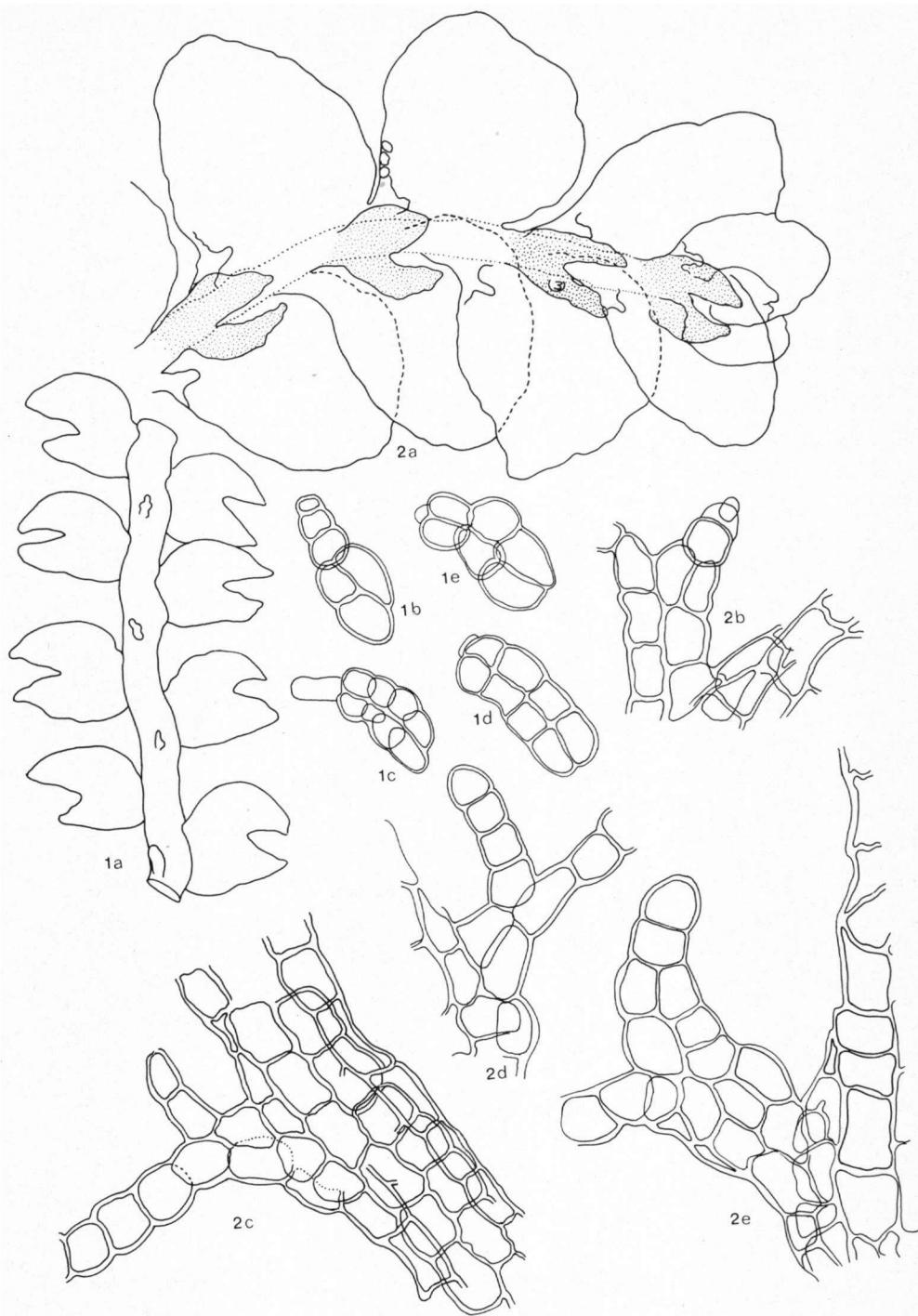


PLATE 1. Hepaticae from Netherlands Antilles. 1. *Cylindrocolea rhizantha* (Mont.) Schust. 1a. Stem, ventral view ( $130\times$ ). 1b-e. Underleaves ( $720\times$ ). 2. *Lejeunea pililoba* Spruce. 2a. Stem, ventral view ( $130\times$ ). 2b-e. Lobules ( $530\times$ ).

to Breil (l.c.) it can be found in many dry forest associations, occurring in reddish-brown to brownish-green mats, sometimes mixed with other bryophytes. On Curaçao *Frullania ericoides* occurs terrestrial or epiphytic in rather dry locations.

CURAÇAO: Florschütz 3456, Christoffelberg, on soil; Stoffers et al. 8091, Ceru Gracia, on soil; Stoffers et al. 8151 & 8321, Christoffelberg, on soil; Stoffers et al. 8168, 8294 & 8295, Christoffelberg, epiphytic; Stoffers et al. 8228 & 8232, between Ceru Gracia and Piedra Mulina, on soil; Stoffers et al. 8259 & 8288, between Ceru Gracia and Piedra Mulina, on *Capparis linearis*.

*Frullania kunzei* (Lehm. & Lindenb.) Lehm. & Lindenb.

Descr. et illustr.: Breil (1970); Evans (1897).

*Frullania kunzei* is known from the northern part of South America, from the West Indies and from the southern part of the United States.

According to Breil (l.c.) it is a species with a wide moisture tolerance and grows in pure reddish-brown to green patches, sometimes mixed with other bryophytes. In Curaçao it has the same ecology as *F. ericoides*. Both species were sometimes found growing over foliose lichens on more or less exposed rocks.

CURAÇAO: Stoffers et al. 8128 & 8404, Piedra Mulina, on soil; Stoffers et al. 8132, 8133 & 8135, near Piedra Mulina, epiphytic; Stoffers et al. 8182, Ceru di Palomba, on rock; Stoffers et al. 8398 & 8405, near Piedra Mulina on *Coccoloba swartzii*.

*Frullania cf. inflata* Gott.

Resembles *Frullania inflata* but differs in the more flattened perianth. Moreover, *F. inflata* is a species that occurs in North America, reaching southward to Mexico (Breil 1970). We have only one collection from Curaçao: from the Savonet-side of the Christoffelberg. The material was not sufficient to draw a definite conclusion.

CURAÇAO: Stoffers et al. 8321, slope Christoffelberg on Savonet-side, on soil.

## LEJEUNEACEAE

*Acrolejeunea torulosa* (Lehm. & Lindenb.) Schiffn.

(*Ptychocoleus torulosus* (Lehm. & Lindenb.) Trevis.)

Descr. et illustr.: Gradstein (1975).

*A. torulosa* is a common species of northern South America and occurs mostly epiphytic in rather open meso- to xerophytic woodlands and along roadsides in lowland areas. All collection-sites on Curaçao are in a meso- to xerophytic vegetation: deciduous seasonal forest or derivative thorny woodland.

CURAÇAO: Florschütz 3457a, Christoffelberg, on tree; Stoffers et al. 8153, Christoffelberg; Stoffers et al. 8134, near Piedra Mulina, on soil; Stoffers et al. 8222 & 8225, between Ceru Gracia and Piedra Mulina, on soil.

*Brachiolejeunea corticalis* (Lehm. & Lindenb.) Schiffn.

Descr. et illustr.: Evans (1902).

*B. corticalis* is widely distributed in tropical America. In Florida it grows in appressed, greenish to blackish mats (Evans l.c.). On Curaçao, the species is restricted to the relatively humid deciduous seasonal forest of the Christoffelberg area, where we found it often on rock and soil but never on trees.

CURAÇAO: Florschütz 3456, Christoffelberg, on soil; Stoffers et al. 8086, near Pos Kajoeda, on soil; Stoffers et al. 8129, 8130, 8133, 8401 & 8404, near Piedra Mulina; Stoffers et al. 8169, Ceru di Palomba, on rock.

*Cololejeunea minutissima* ssp. *myriocarpa* (Nees & Mont.) Schust.

Descr. et illustr.: Evans (1911); Schuster (1955).

According to Schuster (l.c.), this subspecies is largely restricted in the neotropics to the West Indies, but also found in Mexico and southern Florida. Generally it grows on bark of living trees and occasionally also on exposed roots and on dead wood. All collections from Curaçao are from trees in the Christoffelberg area.

CURAÇAO: Stoffers et al. 8322, Christoffelberg, on tree; Stoffers et al. 8398 & 8405, near Piedra Mulina, on *Coccloba swartzii*.

*Cheilolejeunea rigidula* (Nees & Mont.) Schust.

(*Euosmolejeunea duriuscula* (Nees) Evans).

Descr. et illustr.: Breil (1970); Evans (1902).

*C. rigidula* occurs throughout tropical America. It apparently has a wide tolerance for moisture conditions and may occur in xerophytic woodlands (Breil l.c.). We have only one collection from Curaçao: on soil on a slope of the Ceru Gracia in deciduous seasonal forest.

CURAÇAO: Stoffers et al. 8091, Ceru Gracia, on soil.

*Rectolejeunea maxonii* Evans

Descr. et illustr.: Breil (1970); Evans (1912).

*R. maxonii* has been reported from the West Indies, Mexico and the southeastern part of the United States. In Florida it apparently grows in rather moist locations: floodplains, swamps etc. (Breil l.c.). On Curaçao, the species was found in a relatively humid location: on soil in deciduous seasonal forest among other bryophytes, e.g. *Brachiolejeunea corticalis*, *Fissidens kegelianus* and *Calymperes richardii*.

CURAÇAO: Stoffers 8401, near Piedra Mulina, on soil.

*Lejeunea laetevirens* Nees & Mont.

(*Microlejeunea laetevirens* (Nees & Mont.) Evans)

Descr. et illustr.: Schuster (1962).

This species occurs throughout the lowland areas of the Neotropics, from northern South America to the SE part of the United States. It has a wide environmental tolerance, according to Schuster (l.c.), and may occur on trees, on soil and on limestone rocks. On Curaçao it was found exclusively on soil in the Christoffelbergarea in the mesophytic deciduous seasonal forest.

CURAÇAO: Stoffers et al. 8311 & 8314, Christoffelberg, on soil; Stoffers et al. 8400, 8401 & 8403, Piedra Mulina, on soil.

*Lejeunea pililoba* Spruce

(*Stylolejeunea pililoba* (Spruce) Evans)

Descr. et illustr.: Schuster (1962).

*L. pililoba* is restricted to northern South America, the West Indies and the South of Florida. According to Schuster (l.c.) this species is almost exclusively epiphytic in the West Indies and rarely grows on rock. On Curaçao, however, the species is usually terrestrial and rarely epiphytic. All collections are from the Christoffelberg area. The apical tooth on the lobule (Plate 1: 2) in our material is only 2–5 cells long whereas Schuster describes it as being (2–3)4–12 cells long.

CURAÇAO: Florschütz 3456, Christoffelberg, on soil; Stoffers et al. 8322, Christoffelberg, on soil and epiphytic; Stoffers et al. 8091, Ceru Gracia, on soil; Stoffers et al. 8232, between Ceru Gracia and Piedra Mulina, on soil; Stoffers et al. 8401, Piedra Mulina, on soil.

*Lejeunea minutiloba* Evans

Descr. et illustr.: Evans (1917).

*L. minutiloba* is probably common in the West Indies and is also to be found in Mexico and Florida. It is reported to grow at low altitudes on rocks and epiphytic. On Curaçao it was found epiphytic and terrestrial in deciduous seasonal forest, only near Piedra Mulina.

CURAÇAO: Stoffers et al. 8398, Piedra Mulina, on *Coccoloba swartzii*; Stoffers et al. 8400 & 8403, Piedra Mulina, on soil.

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