

THE BRYOPHYTES (HORNWORTS, LIVERWORTS AND MOSSES) OF THE BAHIA HONDA REGION (VERAGUAS, PANAMA)

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I. Introduction

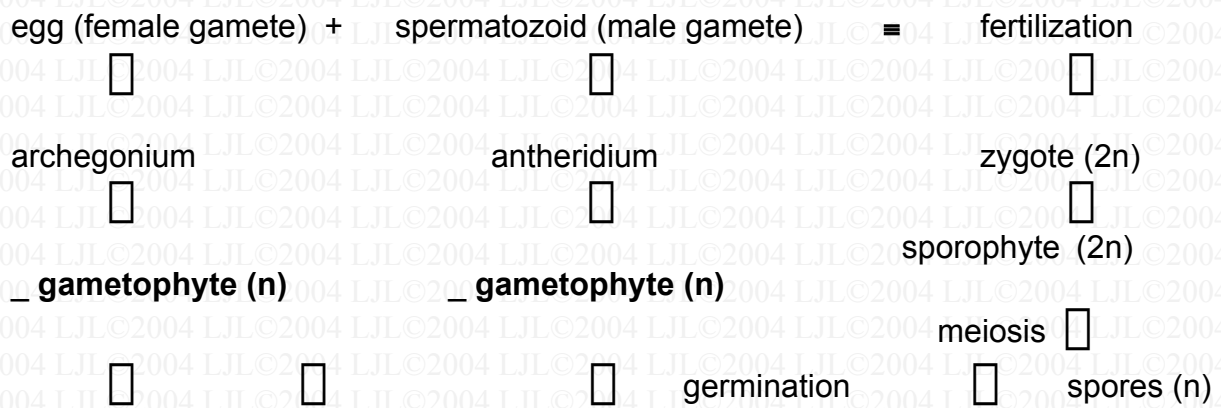
Mosses, liverworts and hornworts (Figs. 1-4), collectively known as **bryophytes** (gr. *bryon* = musci + *phyton* = plants) are small (few centimeters in height) green plants of humid places. They are **poikilohydric** organisms, that is, their humidity depends on that of the environment and they can react directly to water supply. Only one species *Cryptothallus hirsutus* H. A. Crum is subterranean having associations with fungi and nearly devoid of chlorophyll. Bryophytes are important component of the tropical and temperate forests and are one of the few plant groups found in the harsh environment of the Arctic and the Antarctic. Their greatest diversity is found in the Tropics. Bryophytes form extensive growths in cloud forests serving as biological sponges to retain rain and dust (Fig. 5). In retaining a great amount of rainfall in these growths, bryophytes play an important role in preventing soil erosion and provide a reservoir of water and nutrients for the germination of seeds and spores, and for plants and animals (nematods, rotifers, tardigrads) associated with them. Nevertheless, in lowland tropical rain forests,

<i>Octoblepharum albidum</i>	*	*	*	*	*	*	*	*	*	*	
<i>O. erectifolium</i>		*	*	*	*						
<i>O. pulvinatum</i>		*	*	*	*						
Macromitriaceae											
<i>Macromitrium guatemaliense</i>		*	*	*	*						
Neckeraceae											
<i>Neckeropsis undulata</i>	*	*	*	*	*	*					
Pilotrichaceae											
<i>Callicostella colombica</i>		*	*	*	*						
<i>Callicostella pallida</i>	*	*	*	*	*						
<i>Lepidopilum scabrisetum</i>		*	*	*	*						
Phylloprepaniaceae											
<i>Phylloprepanium falcifolium</i>		*	*	*	*						
Pottiaceae											
<i>Hyophila involuta</i>	*	*	*	*	*	*	*	*	*	*	*
Pterobryaceae											
<i>Jaegerina scariosa</i>		*	*	*	*	*	*				
<i>Orthostichopsis tetragona</i>		*	*	*	*						
<i>Pirella pohlii</i>	*	*	*	*	*	*	*				
Racopilaceae											
<i>Racopilum tomentosum</i>	*	*	*	*	*	*	*				
Sematophyllaceae											
<i>Acroporium longirostre</i>		*	*	*	*						
<i>Sematophyllum galipense</i>		*	*	*	*		*				
<i>S. subpinnatum</i>	*	*	*	*	*	*	*	*	*	*	
<i>S. subsimplex</i>		*	*	*	*		*				
<i>Taxithelium planum</i>	*	*	*	*	*		*	*	*		
<i>Trichosteleum fluviale</i>		*	*	*	*						
<i>T. sentosum</i>		*	*	*	*						
<i>T. subdemissum</i>		*	*	*	*		*				
<i>Trichostelium vincentinum</i>		*	*	*	*						

Stereophyllaceae												
<i>Eulacophyllum cultelliforme</i>		*	*	*	*							
Thuidiaceae												
<i>Cyrto-hypnum involvens</i>	*	*	*	*	*		*					
<i>C. schistocalyx</i>	*	*	*	*	*		*					
TOTAL	23	63	59	61	59	20	26	15	8	8	2	

particularly in seasonally dry forests, the epiphytic bryophyte vegetation is very poor. Measurements of photosynthesis (the process by which plants convert energy of light, CO₂ and water into chemical compounds) under field and laboratory conditions of lowland and mountain bryophytes revealed that high nocturnal temperatures which causes CO₂ losses might be the main reason for the differences in the abundance of bryophytes and lichens in the various altitudinal belts in the tropics. The strongly elevated loss of CO₂ at higher temperatures would hamper a positive carbon balance in the lowlands (Frahm 1987, 1990a, 1994a; Proctor 1982; Richards 1984; Zotz *et al.* 1997, 1999).

Bryophytes differ from vascular plants in their lack of roots for anchorage and absorption of water and nutrients and the lack of an internal conductive system (except mosses in the order Polytrichales). Thus, translocation of water and dissolved minerals is mostly **ectohydric** (gr. *ek* = out of + *hydro* = water). Unlike vascular plants, the dominant and long persistent stage of the life cycle is the **gametophyte or the sexual phase**. The sporophyte of bryophytes is an ephemeral phase, dependent on the gametophyte. The gametophyte bears the sex organs: **archegonia** (female, Fig. 6) and **antheridia** (male, Fig. 7). Archegonia produce eggs and antheridia, apically biflagellated sperms. Bryophytes, like their algal ancestors, need water for fertilization. Sperms swim in a pellicle of water to reach the egg that is contained in the base (the **venter**) of the archegonium. The fertilized egg (zygote) is the first cell of the sporophyte. The sporophyte in mosses and liverworts have three parts: the **foot** that attaches the sporophyte to the gametophyte and serves also to absorb substances from it, the **seta**, a pedicel that elevates the **capsule** above the gametophyte. The capsule contains the spores. Sporophytes of hornworts lack a seta. Thus, the life cycle of bryophytes is an alternation of gametophytic (the dominant, generally haploid phase) and sporophytic (diploid phase) generations.



Schematic life cycle of a bryophyte

Unlike most algae, bryophytes are land plants, the sex organs have a cover of sterile cells that protect the reproductive cells, they have an embryonic phase (like vascular plants) and the gametophytes may have leaves and stems. The first fossil record of these plants dates back to the Devonian, ca. 400 million years ago.

It is estimated that there are ca. 15,000 bryophytes species in 120 genera worldwide (Gradstein & *al.* 2001). Three groups (**taxa**) of bryophytes are recognized: liverworts, mosses and hornworts. They are placed in three distinct Phylum or Divisions: Marchantiophyta or Hepaticophyta, Bryophyta and Anthocerotophyta (Table 1). The oldest fossil known is of a liverwort and its morphology is similar to extant taxa (Metzgeriales) in various characters. Most phylogenetic evidence place hornworts as the sister group of the other bryophytes (mosses and liverworts) and vascular plants. Liverworts and mosses appear to be more closely related to vascular plants. Nevertheless, molecular and morphological studies are continuing to clarify the relationships of bryophytes to the algae and vascular plants.

Bryophytes have two types of vegetative body: foliose and thallose. Hornworts are thallose (Fig. 1), liverworts have both types of vegetative body (Figs. 2-3) and mosses are foliose (Fig. 4). Thallose bryophytes are green, ribbon-like and dorsiventrally flattened, while foliose forms have stems and leaves. Foliose bryophytes may grow erect, pendent or prostrate (close to the substrate) and the gametophyte can be differentiated into main stem and lateral branches. Both types of gametophytes are attached to the substrate by fine thread-like structures, the **rhizoids**. These are unicellular (composed of a single cell) in liverworts and

hornworts and multicellular (composed of many cells) in mosses. Gametophytes of foliose bryophytes can display various life forms that may be altered by environmental conditions (adapted from Mägdefrau 1982, Churchill 1994):

1. **Turfs:** Unbranched or little branched shoots that grow upright in dense or loose groupings (*Calymperes*, *Syrrhopodon*, *Octoblepharum*) (Fig. 8).
2. **Cushions:** Stems more or less erect, tightly clustered and radiating at the edges (*Leucobryum*, *Ochrobryum*) (Fig. 9).
3. **Mats:** Gametophytes are trailing or creeping, the main and lateral shoots lie close to the substrate (most Lejeuneaceae, *Sematophyllum*, *Isopterygium*) (Fig. 10).
4. **Fans:** The main stem is creeping on vertical surfaces of bark or rock, secondary branches project horizontally to obliquely downward. They usually have flattened leaves (*Neckeropsis*) (Fig. 11).
5. **Pendants:** The main shoot hangs down from the trunks or branches of trees on which they grow (*Orthostichopsis*). They form luxurious ribbons in cloud forests (Fig. 12).
6. **Dendroids:** Gametophytes with a stolon-like stem from which many erect (but not dorsiventral) branches are produced (*Bryopteris*, *Pireella*) (Fig. 13).

Many bryophytes have a broad geographical range while others are restricted to specific microhabitats (caves, bromeliads) and geographical areas (e.g., Neotropics, Paleotropics). Experimental data have indicated that spores of some bryophytes can be transported in the upper layers of the atmosphere to sites far away from their origins, like different continents, where they can germinate if a substrate and environmental conditions are suitable. They are good biodiversity indicators and have been used successfully in developing an altitudinal zonation of tropical rain forests (Frahm 1990b, 1991, 1994b). Like lichens, bryophytes are also good indicators of quality of the environment. They can accumulate pollutants in their bodies. The effects of these can be detected by abnormalities in growth or disappearance of sensitive species.

II. Methodology

About 750 collections were made during the month of January 2002 in all trails and all substrates in Island Canales de Tierra and the coastal area of Bahía

Honda. Of these, 20% have been identified to species, particularly mosses. The *Ceratolejeunea* were identified by Dr. G. Dauphin and the hornworts by Lic. J. C. Villarreal. Unlike vascular plants, bryophytes grow in mixed communities, thus every collection has on average, three to five species, one or two of mosses and the rest liverworts. Some of the liverworts are minute and grow epiphyllous on leaves of mosses or other hepatics. For this report the major components of the communities have been identified. Those species that are found in very small amount will be revised afterwards. Most collections were gathered from living trees. Samples collected were placed in paper bags and numbered. Locality, type of forest, details of the site and microhabitat, substrate and, for corticolous bryophytes, the height above the ground at which the sample was taken was recorded. Samples were dried in an electric dryer (Sigg dörrex).

Nomenclature for mosses follows TROPICOS, Churchill & Salazar Allen (2001) and Buck (1998). For liverworts and hornworts various monographs and other taxonomic works were also consulted (Gradstein 1989, 1994, 2001; Schuster 1980, 1992, 2000; Bischler 1962 among some). Geographical distribution was obtained from LATMOSS and TROPICOS (for mosses) from the web site of the Missouri Botanical Garden and the revision of monographs and floristic reports that have appeared in various scientific journals particularly Tropical Bryology. Geographical areas were slightly modified from that of Index Muscorum (van der Wijk *et al.* 1959-1969). All collections are deposited at PMA herbarium. Abbreviation for collector N. Salazar Allen and others is NSA *et al.* Photos, unless otherwise stated were taken by N. Salazar Allen. Many photographs are from specimens of other localities that have been used to illustrate relevant aspects of bryophytes. The magnification at which some photos were taken under the microscope is indicated by a number followed by an x, e.g., 100x, 400x.

III. The Bryoflora

Sixty three bryophytes have been identified to species and 12 to genus. Some of those identified to genus may include more than one species, e.g., *Frullania*, *Lejeunea* and *Plagiochila*. Of the samples identified, 55 are mosses in 17 families and 30 genera; 18 are liverworts distributed in 7 families and 15 genera and one is a hornwort (Tables 1, 4).

Island Canales de Tierra and its adjacent peninsulas (Bahía Honda) have a bryophyte flora characteristic of tropical lowland rainforests. Their growth is not as luxurious as in cloud forests and they are mainly corticolous (growing on the bark of trees) epiphytes (gr. *epi* = upon, on + *phyton* = plant). Short turfs (Fig. 8) and mats (Fig. 10) are the dominant life forms found on bark of trees with also some dendroids (Fig. 13) (Table 2). Fans and pendent forms are found in very moist to wet areas, near creeks particularly in Bahía Honda.

To determine the most frequent families of bryophytes in the area a table of frequency was elaborated. The frequency was estimated as a percentage of the total number of sites collected (modified after Rudas & Aguirre 1990). Thus, the number of sites where the families appear was divided by the total number of sites collected and multiplied by 100. The highest percentage obtained was 57.7% represented by the moss family Calymperaceae followed by the Sematophyllaceae (30.3%), Leucobryaceae (15.9%), Fissidentaceae (9.4%), Hypnaceae (7.46%), Pterobryaceae (3.98%) and Pilotrichaceae (3.48%). The most frequent family among the liverworts was the Lejeuneaceae (31.8%), the other families are represented by one or two species with restricted distribution. Even though all the liverworts have not been identified to species, a survey of collections indicates that members of the Lejeuneaceae are the most important component of the liverwort flora of the island and adjacent peninsulas.

The most diverse families in number of species among the liverworts is the Lejeuneaceae (7 spp.) and of mosses, the Calymperaceae (13 spp.), Sematophyllaceae (9 spp.), Leucobryaceae (5 spp.), Fissidentaceae (5 spp.), Hypnaceae (4 spp.), Pilotrichaceae (3-4 spp.) and Pterobryaceae (3 spp.). All other families of liverworts and mosses are represented by one or two species (Table 1). It is interesting to note that even though the Hypnaceae and Pilotrichaceae have nearly the same number of species the first one is much more frequent to find in collections than the Pilotrichaceae. The Pilotrichaceae is the least frequent among the main families of the area. Members of the Pilotrichaceae generally grow in moist to wet substrates, their low frequency may reflect their habitat preference.

Bryophytes of Canales de Tierra Island and Bahía Honda are found mainly on bark of trees, decomposing logs and rocks. This substrate distribution is very characteristic of bryophytes in most lowland rainforests. Terrestrial mosses are particularly rare in areas where great amount of litter accumulates during the dry season, e.g., lowland seasonally dry forests. Various corticolous epiphytes occur also on rock. The sharp distinction found in temperate areas between corticolous and rupicolous (growing on rocks) species is not apparent in the tropics (Pócs 1982).

The most speciose and frequently found bryophyte families, Lejeuneaceae, Calymperaceae and Sematophyllaceae are the ones found in nearly all substrates, except leaves (Table 3). Of these families, the Lejeuneaceae normally has species that grow on leaves. Epiphyllous liverworts have not being identified to species but an overview of them indicates that they belong in the Lejeuneaceae.

The bryoflora of Island Canales de Tierra is relatively poor in species when compared to Bahía Honda. Only 31 (49.2%) of the 63 species identified occur in the island while 54 (85.7%) are in Bahía Honda (bryophytes identified to genus have not being counted in this respect) (Table 4). Turfs life forms are rather short with gametophytes in loose arrangements instead of compact turfs as observed in cloud forests and mats are generally loose with slender stems and abundant rhizoids. Pendent forms (e.g., *Phyllogonium*, *Squamidium*), indicators of mesic habitats, are absent as well as mesic thalloid (e.g. *Monoclea*, *Symphyogyna*) and foliose (e.g., *Bryopteris filicina*) liverworts. The seasonally dry climatic conditions, the high temperatures prevalent in the island, coupled with the low elevation and the high degree of anthropogenic disturbance may be responsible for the low abundance and diversity of bryophytes. The species that grow in the island must be adapted to these environmental conditions. Comparatively, bryophytes in forested areas in the more protected adjacent peninsulas grow more abundantly but those on trees near the coast exhibit similar life forms as bryophytes in the island.

A. Hornworts

All hornworts are thallose plants growing in moist areas; they cannot withstand desiccation. They can be distinguished from thalloid hepatics by the presence in their cells of single chloroplasts with a pyrenoid (an area where the

enzyme ribulose diphosphate carboxylase is located. This enzyme is important in fixing CO₂ during photosynthesis) (Fig. 14). Pyrenoids are found in many groups of algae but are absent in other land plants. The hornworts unlike liverworts lack oil bodies in their cells and the sporophyte is lanceolate (Fig. 1), producing spores for longer time due to an active cell producing tissue (**meristem**) on its basal area. Mosses can be distinguished from hornworts by their foliose habit.

Of the three groups of bryophytes, the least represented in the area is the hornworts with only one species *Notothylas dissecta* Steph. found on rock, in a moist site near Los Chombos beach. This is the second report of this species for Panama. The first record, identified by Dr. G. Hässel, is from El Valle de Antón (Province of Coclé) at 560 m of elevation (Salazar *et al.* 16079a, PMA).

Notothylas is a pantropical genus with at least 5 species (among these *N. dissecta*) at low elevations in the neotropics. It grows on periodically moist soils in warm lowland areas. It can be found also in soil of gardens, plantations, along disturbed old ditches often in disturbed open places or among loose grass in backyards. The species here reported is known also from Guatemala and India (Gradstein 2001, Asthana & Srivastava 1991). It is most certainly that the species grows throughout the Neotropics but the lack of studies on *Notothylas* restricts an evaluation of its geographical distribution. The nearly absence of anthocerotes in the area is similar to what was found in Coiba Island (SalazarAllen & Chung 1997). It is possible that collecting during the rainy season may reveal the presence of other anthocerotes; many of them grow annually and disappear during the dry season.

B. Liverworts (hepatics)

Liverworts can be foliose or thallose (Figs. 2-3). Most liverworts found in Canales de Tierra Island and Bahía Honda are foliose and trailing, growing close to the substrate. Liverworts are distinguished from other bryophytes by the presence of oil bodies in their cells (Fig. 15), unicellular rhizoids, trigones (thickenings on their cell walls (Figs. 18B, 19B) and a delicate sporophyte growing within specialized structures (e.g., perianth, involucre) and projecting out of them when it is ready to shed the spores (Figs. 3C, 17C, 18C). Also, their leaves unlike moss leaves (except *Takakia*) can be dissected (Fig. 16). The sporophyte of liverworts has a delicate,

hyaline pedicel called the **seta** that supports the capsule where the spores and **elaters** are produced. Elaters are hygroscopic, unicellular, elongated structures with one or more helicoidal wall thickenings (Fig. 17D). They twist and untwist with changes in humidity contributing to the dispersal of spores. Some liverworts emit volatile terpenoids or simple aromatic compounds that give them a characteristic odor (turpentine, mushroomy, sweet-woody, carrot-like or lemon among some). Most of these compounds are contained in their oil bodies. Many functions has been assigned to these substances, among them protection against herbivory and desiccation. Some of these compounds have physiological activities like antimicrobial, antifungal, antiseptic, diuretic and antipyretic; some may also produce dermatitis when frequently exposed to them while others have shown antitumor activity against certain types of carcinomas (Asakawa 1990).

The hepatic flora of Canales de Tierra Island and adjacent peninsulas is not exceedingly rich in species when compared with other areas in the Neotropics, probably due to the low altitude of the island and peninsulas and the prolonged dry season. The single most important family of leafy liverworts is the Lejeuneaceae (Table 1). Other studies in Panama (Gradstein & Salazar Allen 1992, Salazar Allen & Chung 1997) and the Neotropics (Cornelissen & Ter Steege 1989, Salazar Allen & Gradstein 1996, among some) also revealed that the Lejeuneaceae is very diverse in lowland tropical rainforests perhaps the most diverse family of liverworts.

Families of Leafy Liverworts

THE LEJEUNEACEAE

The Lejeuneaceae is one of the largest families of leafy liverworts in the Tropics with hundreds of species. Seventy genera have been described for Tropical America and it is estimated that there are about 90 worldwide (Gradstein 2001). It is considered the most advanced and most highly specialized family among the leafy liverworts (Mitzutani 1961 in Dauphin 2000). Members of this family grow on bark of trees, branches, twigs and on leaves (**epiphyllous**). Leaves in plants of this family consist of three parts: the main lamina called the **lobe**, a small lobe on the ventral side called the **lobule** and a hyaline **papilla** inserted on the inner surface of the lobule (Figs. 2B, 17A-B). The lobule is interpreted as an adaptation of these plants to the

epiphytic growth (Gradstein 1994). Its size is influenced by humidity in the environment. Studies in *Stictolejeunea squamata* (Gradstein 1995) and *Symbiezidium barbiflorum* (Cornelissen & Ter Steege 1989) showed that plants growing in humid rain forests had smaller lobules than those growing in more exposed drier habitats.

In the Lejeuneaceae the leaves are arranged in three rows like most liverworts. There are two lateral rows, the “**leaves**”, and one ventral, the **underleaves** or **amphigastria** (though these may be absent in some genera) (Fig. 2B, 21A-B). Leaf insertion which is oblique in most liverworts is a very important character to distinguish among taxa. In the Lejeuneaceae the uppermost margins (oriented towards the shoot apex) of the lateral leaves are attached to the dorsal side of the stem (when viewed from above). Thus, each leaf overlaps the one above. This is called **incubous insertion** (Figs. 20A, 21A). The Lejeuneaceae can be distinguished by the incubous leaves with a large dorsal lobe and a small ventral lobule, the usual presence of underleaves and a single archegonium (rarely two). Rhizoids grow in tufts from the base of underleaves (Gradstein 2001).

The species of Lejeuneaceae with underleaves like those that occur in Canales de Tierra Island and Bahía Honda can be divided into two groups: (1) those with entire underleaves (the “holostipous lejeuneaceae”) (Fig. 18A) and (2) those with bifid underleaves (the “schizostipous lejeuneaceae”) (Fig. 21B). These are not natural groups but the distinction is very useful taxonomically. Of the seven species of Lejeuneaceae identified, 4 are holostipous (*Bryopteris filicina*, *Caudalejeunea lehmanniana*, *Stictolejeunea squamata* and *Symbiezidium transversale*; *Archilejeunea* and *Lopholejeunea* are also holostipous. Three are schizostipous: *Ceratolejeunea cornuta*, *Cheilolejeunea rigidula*, *Lejeunea glaucescens* and also *Harpalejeunea*.

Almost all epiphyllous liverworts of the tropical rain forests are Lejeuneaceae. Some are xerotolerant epiphytes (tolerant to some degree of dessication) growing on the canopy or in gaps, in open degraded habitats, along open trails, e.g., *Caudalejeunea lehmanniana* (Fig. 18) and *Cheilolejeunea rigidula*, while others grow on shaded, moist habitats, e.g., *Bryopteris filicina* (Fig. 19), *Stictolejeunea squamata* (Fig. 20), various species of *Ceratolejeunea* (Gradstein 2001). As stated

above, liverworts have oil bodies in their cells these could be found among the chloroplasts or solitary in a single cell. In the latter case, these cells are called **ocelli**. *Stictolejeunea squamata* and various species of *Leptolejeunea* and *Ceratolejeunea* have ocelli (Figs. 20, 21A). Species of these genera are usually found in lowland tropical rainforests but they can also grow in cloud forests at higher elevations. The presence of a *Lejeunea*, a mostly corticolous and sometimes epiphyllous liverwort (Gradstein 2001), in soil at base of a tree with *Fissidens pellucidus* and *Calypogeia* is perhaps an extension of its corticolous growth. *Lejeunea glaucescens* is a mesophytic species. It grows in areas where humidity is high and also under relatively exposed conditions (Schuster 1980). It was found corticolous on a shrub at 1.5 m from the ground on the trail to the water tanks in Canales de Tierra Island. Its presence in this area indicates microenvironmental conditions of high moisture.

Plants of *Bryopteris filicina* can be recognized in the field by its dendroid growth. In very long plants, the leafy stems become pendent. Also, the aspect of the plant varies in wet and dry conditions (Fig. 19). When wet, the plants are robust and fan-shaped, when dry the leaves wrap tightly around the stem giving the plant a filiform, thread-like appearance. The single specimen of this species was collected in Bahía Honda on trunk of an *Inga* tree (about 2 m from ground level) growing near a cascade of Limón river. This species is a good indicator of shaded, humid environmental conditions.

Plants of *Ceratolejeunea* can be distinguished by their glossy dark brown color, the very large lobules (**utriculi**) at base of branches (Fig. 21C), the horn-like projections of the perianth (Fig. 21E) and the frequent occurrence of ocelli at base of leaves or in the lower part of the leaves (Fig. 21A). The world region with the highest diversity of *Ceratolejeunea* is the Neotropics. The major center of endemism and species diversity for the genus is the Caribbean (Dauphin 2000). *Ceratolejeunea cornuta* is found mainly in primary and secondary lowland and montane forests from sea level to 2500 m. It grows usually in well illuminated places, in the canopy, light-gaps and areas of old secondary growth (Dauphin 2000).

Symbiezidium transversale has a yellow-brown to olive green color and a worm- to ribbon-like, horizontal growth closely adnate to the cortex of trees and

shrubs (Fig. 22). The plants are usually robust. It was found on the lower part of a tree in the trail to Leren and on a cut tree, 1 m above the base in Quebrada Manglarito, both sites in Bahía Honda. Like *Bryopteris*, species of *Symbiezidium* are understory plants of moist sites.

THE CALYPOGEIACEAE AND THE LEPIDOZIACEAE

These families are represented by *Calypogeia miquelii* and *Zoopsidella antillana* respectively. They both grow in soil at bases of trees. *Calypogeia* is a worldwide genus with 15 species in tropical America (Gradstein 2001) among these *C. miquelii*. The species of *Zoopsidella*, except *Z. caledonica* (Steph.) Schust., are all neotropical ranging north to the Antilles (Schuster 2000). Species of *Zoopsidella* are commonly found in undisturbed forests and also on smaller earth banks and gullies (Pócs 1982). *Zoopsidella antillana* was found in Canales de Tierra Island (Sendero Punta and Trail to Ensenada Guabo) and Bahia Honda (Near Manglarito Beach close to a cascade) both in rather moist areas. It is interesting to note here that Sendero Punta is an area with tall trees and good coberture, which favors a moister environment.

Calypogeia can be distinguish from *Zoopsidella* by its distantly arranged, incubous leaves, the apex of leaves divided into two, usually triangular, pointed lobes separated by a V-shaped sinus, lack of trigones and small underleaves divided into two divergent lobes with a wide, rounded sinus between them (Bischler 1962). The whitish or pale green *Zoopsidella* has flat spreading leaves attached to the side of the stem in two rows. Each leaf has 2 large, sausage-shaped papillae on the upper margins, the underleaves are reduced to a few small basal cells and two ephemeral papillae (Fig. 23) (Gradstein 2001, Schuster 2000).

THE PLAGIOCHILACEAE

This is a family of 8 genera four of them in the Neotropics. The most important genus is *Plagiochila*. It is the largest genus of liverworts with about 100 species in tropical America (Gradstein 2001). Plants of this family unlike the those of the Lejeuneaceae have a **succubous leaf insertion** (the anterior margin of the lobe is inserted on the ventral side of stem when viewed from above) (Fig. 24), mostly

dentate leaves with long decurrent bases, the near absence of underleaves, rigid thick-walled cortex and a laterally compressed perianth among some distinguishing characters (Gradstein 2001).

Thallose liverworts

THE ANEURACEAE

It is interesting to note the growth of the thallose *Riccardia* at the base of a tree on the trail to Ensenada Guabo on the N side of Canales de Tierra Island. This thallose liverwort grows on very humid environment like moist or wet soil, highly decomposed wood or bark and boggy grounds (Gradstein 2001). Plants of *Riccardia* consist of green, narrow thalli, pinnately or palmately branched. The thalli grow more or less erect or prostrate (Fig. 25). Neotropical species of *Riccardia* are in need of a taxonomic revision (Gradstein 2001).

Thus, most species of liverworts in the area are corticolous. The presence of genera and species of corticolous liverworts on decomposing trunks indicate early stages of decomposition where communities on erect trunks are still growing. Of the ten hepatics identified to species, seven are Neotropical elements (Table 5) some of them (e.g., *Lejeunea glaucescens*) extending into subtropical areas of North America. *Cheilolejeunea rigidula* is pantropical and *Caudalejeunea lehmanniana* is disjunct in tropical America and Africa.

C. Mosses

Mosses unlike hepatics lack oil bodies, the leaves are arranged in various ranks around the stem, some leaves have one or sometimes two **midribs** or **costae** (Fig. 26) and they have complex sporophytes that project from the gametophyte early in development, protected by the **calyptra** (remnants of the female sex organ, the archegonium) (Fig. 27). Unlike liverworts and hornworts, sex organs in mosses are surrounded by filamentous, hair-like structures called **paraphyses** that are thought to serve in maintaining a moist surface around the organs (Fig. 28).

In mosses perichaetia (archegonia with their protecting leaves) and sporophytes that developed once archegonia are fertilized are found in one of three positions: 1) terminal on the main stem, 2) terminal on lateral branches and 3) lateral along the primary stem or on very short terminal or lateral branches that appear sessile. These three conditions are technically called **acrocarpy**, **cladocarp** and **pleurocarpy** respectively. Individual species are characterized by one type of perichaetial position. Cladocarp is interpreted as functional pleurocarpy that have evolved in various independent moss lineages (LaFarge-England 1996). Acrocarpy is considered to have evolved first (Vitt 1984). The development of pleurocarpy is thought to have had an adaptive significance providing mosses growing in stable mesic environments a mechanism for mat formation by continuous growth under favorable environmental conditions. The evolution of pleurocarpy from the acrocarpous condition is basically an amplification of the branching system and bud formation with the separation of growth from sex organ production. It is considered that the epiphytic habitat would be more readily exploitable for mosses that have separated vegetative growth from sex organs production (Vitt 1984).

Sporophytes of mosses are the most complex amongst the bryophytes. The capsule is composed of an **urn** in which spores are produced and a hat-like structure that covers the mouth of the capsule, the **operculum** (Fig. 29). At the mouth of the capsule there is usually one or two rows of delicate teeth-like structures called the **peristome** (Fig. 29B). The peristome contributes to the dispersal of spores. There are two types of peristomes according to the rows of teeth that compose them: 1) simple peristomes have a single row of teeth and 2) double peristomes have two rows of teeth. Double peristomes have an inner layer of teeth called the **endostome** and an outer layer called the **exostome**. These two layers may lie opposite each other (the less derived condition) or alternate (more derived, advanced, condition). It is thought that double peristomes with opposite rows of teeth preceded the alternate form (Vitt 1984). Most recent moss taxa, particularly in tropical rain forests have double peristomes with alternate teeth.

The moss flora of the island and adjacent peninsulas (Bahía Honda) is composed of 52 species, 17 families and 30 genera. Collections of three genera, *Bryum*, *Dicranella* and one *Callicostella* are awaiting specific determination. Most mosses are members of two families (Table 1): Calymperaceae (13 spp.) and

Sematophyllaceae (9 spp.). Other families represented are Fissidentaceae (5 spp.), Leucobryaceae (5 spp.), Hypnaceae (4 spp.), Pilotrichaceae (3-4 spp.) and Pterobryaceae (3 spp.). The rest of the families are represented by one or two species. Of the 55 mosses identified 25 occur in Canales de Tierra Island and 48 in the adjacent peninsulas (Bahía Honda) (Table 4). The paucity and absence in the island of members of the Pilotrichaceae (3-4 species) and Meteoriaceae respectively, two families of very moist to wet habitats indicate comparatively much drier conditions in this island than in the adjacent Peninsulas (Bahía Honda), Coiba Island or Barro Colorado Island (in the Canal Zone) where plants of these families have been found.

Moss Families

CALYMPERACEAE

Plants of the Calymperaceae are characterized by their erect turf-forming habit, acrocarpy, leaves with a usually clasping basal area composed largely of porate, hyaline dead cells (the **cancellinae**), presence of an intramarginal region of elongated cells in some species (the **teniola**, e.g., *Calymperes*) and frequent production of leaf gemmae (Figs. 30-34). The cancellinae is thought to serve for short-term water storage allowing plants to extend their metabolic activities after wetting. The teniola is presumably functioning for support and perhaps, water transports (Reese 1993). Most collections show the presence of gemmae. These are structures produced by proliferation of leaf cells (usually at the leaf apex) that serve to propagate the plants. It is a way of cloning since these gemmae have the same genome as their parents.

The Calymperaceae is a pantropical family. Its geographical range extends from Asia, the islands of the Pacific, Africa, Australia and America (Reese 1993). Some species extend their ranges to subtropical and temperate zones. There are two genera of Calymperaceae in tropical America: *Calymperes* and *Syrrhopodon*. Thirty-nine species of *Syrrhopodon* and sixteen of *Calymperes* are known for the Neotropics. The center of distribution of these two genera (the area from which they radiated to other areas) in the Americas is considered to be northeastern South America (Reese 1993). A world wide analysis of the distribution of these genera indicates that, even though a group of species have a pantropical distribution, the

majority of the other species are distributed in the Neotropics or the Palaeotropics. Moreover, different types of morphology and species complexes have developed independently in each of the floristic regions indicating a long history of geographical isolation following the evolutionary origin of the precursors of the family (Reese, 1993). Most plants of the Calymperaceae are found in lowland, humid, warm habitats of tropical and subtropical forests. Nevertheless, in comparing the altitudinal distribution of the two Neotropical genera, *Syrrhopodon* unlike *Calymperes* can grow at elevations over 2000 meters. In Canales de Tierra Island and adjacent areas, 5 species of *Calymperes* and 8 of *Syrrhopodon* have been identified (Table 1). Although species of both genera are mainly corticolous, the species of *Calymperes* have a wider range of substrate in which they occur (Table 2). Species of *Syrrhopodon* occur mostly corticolous. The presence of both genera on decomposing logs as well as species of other families that are mainly corticolous indicate that the trunks are in their first stages of decomposition with bark communities that grow in upright trunks.

Of the five species of *Calymperes* in Canales de Tierra Island and adjacent peninsulas, four are pantropical and one, *C. nicaraguense*, is neotropical. Species of *Syrrhopodon* on the contrary have a more restricted distribution with 4 neotropical species, three disjunct in America and Africa (*S. africanus*, *S. incompletus* var. *incompletus* and *S. lycopodioides*) and only one pantropical (Table 5). *Syrrhopodon incompletus* is particularly weedy throughout its range (Reese & Orbán 1986). According to Reese (1987a), the greater altitudinal and latitudinal range, the broad ecological amplitude and the lack of derived characters suggest that *Syrrhopodon* is ancestral to other genera in the Calymperaceae, among these *Calymperes*. It is thought that both genera (*Calymperes* and *Syrrhopodon*) evolved at a similar rate, the ancestral taxon may have more neotropical species due to its long evolutionary history when compare to the most recent one (*Calymperes*). It is difficult to explain satisfactorily how the pantropical taxa of *Syrrhopodon* achieved their wide ranges, especially since none of them seems to have special adaptations for long distance dispersal (Reese 1987a, b). In contrast, species of *Calymperes* have developed abundant gemmae and a wide range of structures related to them (Figs. 30B-C, 31B-C, 32B-D, 33B).

Unlike *Calymperes*, many taxa of neotropical *Syrrhopodon* have large ranges, particularly altitudinally, more or less equivalent to those ranges exhibit by species restricted to the paleotropics. This phenomenon reflects the broader ecological amplitude of *Syrrhopodon*, with a wider altitudinal distribution, whereas *Calymperes* is restricted to tropical lowland areas (Reese 1987b).

SEMATOPHYLLACEAE

The Sematophyllaceae is primarily a tropical pleurocarpous family with two main centers of species diversity: the Paleotropics and the Neotropics (Tan & Buck 1989). It is a large and heterogeneous family. According to Buck and Tan (1989) the numerous genera and species in the family as well as its predominance in lowland tropical habitats in the Neotropics and the Paleotropics make it easy to speculate that the diversification of the family took place in recent times. Plants of this family are recognizable by their golden green color, the inflated, sometimes colored alar cells at base of the leaves and the costa short and double or absent (Fig. 28C, 36A). The four genera of Sematophyllaceae found: *Acroporium*, *Sematophyllum*, *Taxithelium* and *Trichosteium*, are more diverse in the Old World. According to the ornamentation of their leaf cells two morphotypes can be distinguished among genera of Sematophyllaceae found in the area: a) plants with smooth cells and b) those with papillose cells. *Acroporium* and *Sematophyllum* have smooth cells; *Taxithelium* and *Trichosteium* have papillose cells. Both types are of wide distribution in the Neotropics. *Taxithelium* differs from *Trichosteium* in that their leaf cells have seriate papillae in their lumen while leaf cells in *Trichosteium* are unipapillose (Figs. 35, 36B). Though variations in size of papillae have been observed particularly in *Trichosteium* making it difficult sometimes to determine their presence (Buck & Tan 1989), most specimens found in Canales de Tierra Island and Bahía Honda have clearly distinguished papillae. *Taxithelium planum* is one of the most common mosses (“a weed”) in the lowland forests of tropical America and the most common species of the six known for the genus (Buck 1985, Churchill & Salazar Allen 2001).

LEUCOBRYACEAE

The Leucobryaceae has eight genera and some 150 species (Churchill & Salazar Allen 2001). It is primarily pantropical in distribution though it extends into temperate regions of northern and southern hemispheres. Plants of this family are distinguished by the whitish-green appearance of their erect, acrocarpous gametophyte with fleshy, multistratose leaves. These leaves are composed of a layer of green cells (**chlorocysts**) surrounded by one or more layers of dead, porous, hyaline cells (**hyalocysts**) (Fig. 37B, 38C). The cushion-forming *Leucobryum* and *Ochrobryum* can be readily distinguished from the turf-forming *Octoblepharum* by their concave, tubular, lanceolate leaves (Fig. 37). The latter genus has ligulate, distally plane leaves. The species of *Leucobryum* and *Ochrobryum* found in this study are neotropical.

Octoblepharum is a very common genus in lowland rain forests (Fig. 38). There are two types of sexual condition among species of *Octoblepharum*: 1) **dioicous** (plants with one type of sex organ) and 2) **monoicous** (producing both female and male sex organs in the same plant). The dioicous condition is considered to be ancestral. *Octoblepharum erectifolium* and *O. pulvinatum* are dioicous while *O. albidum* is monoicous. Female and male plants must be in close proximity for dioicous bryophytes to produce sporophytes. Also, bryophytes need water for the male gamete to reach the egg. The male gamete is fragile and does not survive for long periods and the distance it can travel is usually small (e.g., 5 cm though in occasions it could be as long as 50 cm or 1.5-2.0 m in the large mosses, e.g., *Dawsonia*) (Richardson 1981). Thus, monoicous species usually produce more sporophytes than dioicous ones. This is the case for *O. albidum* when compared to *O. pulvinatum* and *O. erectifolium*. Also, it has been observed that chlorocysts from the apex of the leaves in *O. albidum* can develop into rhizoids or protonema (the filamentous phase of the gametophyte) from which gemmae or new plants are produced (Fig. 38D). This is a mean of asexual reproduction. Leaves of *O. erectifolium*, *O. pulvinatum* and also of some *O. albidum* are usually fragile and can be broken easily. This may represent a mechanism for dispersal since almost any part of the bryophyte gametophyte can reproduce a new plant. In a study of genetic variation in populations of *Octoblepharum*, it was found that in most cases, for *O. albidum*, each population consisting of one genet (clone) has apparently being founded sometimes asexually or sexually by a single colonizer that has formed an isolated, clonally propagating "minipopulation". Genetically independent

minipopulations inhabiting the same area appear to form a loosely organized "metapopulation" (Korpelainen & Salazar Allen 1999). Species of *Octoblepharum* can also be grouped by peristomial type. Two types of simple peristome are known: 1) those with 8 teeth and 2) those with 16 teeth. *Octoblepharum pulvinatum* have 16 teeth while *O. albidum* and *O. erectifolium* have eight. The ancestral condition is considered to be that of 16 teeth. Thus, *O. albidum* appears to be the most derived of the species with a monoicous condition and a reduced peristome, *O. erectifolium* is intermediate and *O. pulvinatum* is considered to have retained most ancestral characters.

Octoblepharum albidum has a pantropical distribution. It is particularly common in moist or wet lowland forests but extend its altitudinal range to montane forests above 2000 m (Churchill & Salazar Allen 2001). *Octoblepharum erectifolium* and *O. pulvinatum* are neotropical and grow in lowland as well as in montane forests to 2400 m (*O. erectifolium*). It is most probable that the monoicous condition of *O. albidum*, the abundant production of sporophytes coupled with its ability to reproduce vegetatively have given this species an advantage for dispersal and colonization over a wide geographical range.

The Calymperaceae and the Leucobryaceae are both acrocarpous families. They also have simple peristomes though these differ in their morphology and ornamentation as well as in other important characters suggesting different genealogical lineages.

FISSIDENTACEAE

The Fissidentaceae is a family that consists of one genus *Fissidens* and more than 500 species worldwide and 100 in tropical America (Pursell 1994). Of the species here reported, *F. zollingeri* and *Fissidens pellucidus* are of worldwide distribution, the other three species are neotropical. In the area, plants of *Fissidens* are small in size and the gametophytes are sparsely distributed among liverworts and mosses. *Fissidens* is one of the easiest mosses to recognize in the field; its small size, erect growth, costate leaves arranged in two rows along the stem and the basal, sheath-like, vaginant lamina are distinguishing features (Fig. 39). Most *Fissidens* in the lowlands rain forests of Panama are small plants of few millimeters

tall, nevertheless, some species like *F. polypodioides*, the largest species of the genus in Central America (Pursell 1994) can attain heights of 8 cm. This species grows in cloud forests at moderately high elevations in the mountains of Panama.

HYPNACEAE

The Hypnaceae is a family with members in the temperate and tropical zones. It contains some 30-40 genera and nearly 1000 species are attributed to the family. In the Neotropics there are 21 genera and approximately 70 species (Churchill & Salazar Allen 2001). Plants of this family have their leaves usually pointing to the same side and curved like the blade of a sickle, the costa is double and short and alar cells are usually differentiated at base of leaf. Of the four species in the area, two are pantropical (*Chryso-hypnum diminutivum*, *Isopterygium tenerum*) (Fig. 40); *Rhacopilopsis trinitensis* is disjunct in America (Central America to Brazil) and Africa. *Vesicularia vesicularis* is widely distributed in tropical America with some varieties extending into southern Florida in the United States (Buck 1998).

PTEROBRYACEAE

The Pterobryaceae unlike the Hypnaceae is an entirely tropical family with 27 genera and less than 160 species world wide (Buck & Vitt 1986; Magill 1982). There are 10 genera and about 35 species in the Neotropics (Churchill & Salazar Allen 2001). The family is probably quite old and many genera occur in more than one tropical continent (Buck 1991). The family is almost exclusively epiphytic and the gametophytes show a wide range of life forms, e.g., pendent, dendroid. The primary stem is creeping (often called **stolon**) and the leaves usually differentiate from branch leaves, being scale like or smaller. Secondary stems are erect, pendent or dendroid. In those dendroid forms like *Pirella* the secondary stem projects from the substrate branching abundantly above the basal area or **stipe**. Thus the plants look like miniature trees (Fig. 41). Of the species found in the area, *Orthostichopsis* has a pendent life form, *Pirella* is dendroid and *Jaegerina* has a fan type of life form with leaves helically arranged around the secondary usually unbranched stems. Species of Pterobryaceae and Neckeraceae are indicators of very shady, wet habitats. *Sematophyllum* and *Taxithelium* are also common in this type of community (Pócs 1982). These are mostly understory shade epiphytes. The

occurrence of *Orthostichopsis tetragona* on leaf must be the result of a fallen piece of moss from upper branches getting stuck to a leaf. This species is mainly pendent and corticolous.

PILOTRICHACEAE

The Pilotrichaceae is a family of some 23 genera with mostly pantropical distribution. There are 21 genera and about 200 species in the Neotropics. The Neotropics is particularly rich in the number of unique genera (Churchill & Salazar Allen 2001). Plants of this family can be distinguished by their pleurocarpous habit, the presence of a usually well developed double costa in the leaves and double peristome with alternate teeth (Fig. 26B). Members of this family are usually found in moist to wet habitats. Of the two genera found in the area, *Lepidopilum* is primarily Neotropical with two or three species found in West Africa and *Callicostella* is pantropical (Churchill & Salazar Allen 2001). All species reported for Canales de Tierra Island and Bahía Honda are neotropical elements. *Callicostella* differs from *Lepidopilum* in its leaves often more or less incurved or crisped when dry (as opposed to flattened in *Lepidopilum*), strong double costa usually projecting and toothed at back and the laminal cells isodiametric and usually unipapillose.

Geographic affinities of the mosses of Canales de Tierra Island and adjacent peninsulas are mainly with tropical America with some disjunct elements particularly with Africa. There is also 11 pantropical taxa (among these, *Calymperes afzellii*, *C. erosum*, *Taxithelium planum*) and 3 cosmopolitan species (*Hyophila involuta*, *Octoblepharum albidum* e *Isopterygium tenerum*) (Table 5).

There is a slight predominance of species (26/23) and families (10/7) of pleurocarpous (including one cladocarpous) mosses in the moss flora of Canales de Tierra Island and adjacent peninsulas (Table 2). The predominance of pleurocarpous forms in neotropical lowland forests has been observed for continental areas (Churchill 1994; Salazar Allen & Gradstein 1996) as well as natural (Montoya 1990; Rudas & Aguirre 1990) and man-made islands (Salazar Allen *et al.* 1991).

For Canales de Tierra Island and Bahía Honda, those families with double peristome (Bartramiaceae, Bryaceae, Hypnaceae, Neckeraceae, Phyllo drepaniaceae, Pilotrichaceae, Pterobryaceae, Racopilaceae, Sematophyllaceae, Stereophyllaceae and Thuidiaceae) have the most derived type of peristome: double alternate. This fact and the high number of pleurocarpous in the moss flora of the area are related to the recent geological history of the Isthmus.

Geographic affinities

The bryoflora of Canales de Tierra Island and Bahía Honda is mainly composed of neotropical elements with some disjunct and pantropical species (Fig. 42). Eight of the ten species of hepatics are Neotropical, one is disjunct with Africa (*Caudalejeunea lehmanniana*) and one is pantropical (*Cheilolejeunea rigidula*). For mosses, 25 of the 52 species are Neotropical, 13 are disjunct between America and Africa, 11 are pantropical and 3 are cosmopolitan (Table 5). Most neotropical species of bryophytes are Mesoamerican-Caribbean elements.

Comparing the flora of the area with that of other natural (Coiba, Cocos and Gorgona) or man-made islands (Barro Colorado) (Table 6), for liverworts, one species (neotropical) is shared with Coiba, six with Barro Colorado (four of these neotropical species and two with wider distribution), five species are shared with Cocos (4 of them neotropical and one pantropical) and two with Gorgona (both neotropical) (Tables 5, 6). Of the 52 moss species reported for the area, 25 are shared with the nearby Coiba Island, 32 with Barro Colorado Island in the Canal Zone (created with the construction of the Panama Canal), 18 with Cocos Island in Costa Rica and 17 with Gorgona in Colombia (Table 6). It is most probable that when all collections are identified to species more affinities may be found between these islands and Canales de Tierra. Nevertheless its comparatively small size, seasonally dry climate and anthropogenic disturbance suggest that its bryoflora will be less diverse. Since most species are neotropical elements that are distributed in mainland it is not surprising that these species occur in Canales de Tierra Island and Bahía Honda as well as in the other islands mentioned above. The composition of the bryoflora of Canales de Tierra and the recent geologic history of the island suggests that the bryophytes were acquired from mainland areas.

IV. Final Remarks

The absence of endemics, the predominance of derived families of hepatics and mosses reflects the recent geological history of the Isthmus of Panama and the historic development of its bryophyte flora from adjacent landmasses.

Bryophytes are important components of tropical rain forests. There is an urgent need for taxonomic and ecophysiological research on these interesting plants particularly when one considers the fast rate of deforestation in the tropical world. Bryophytes are one of the oldest organisms on earth and one of the first terrestrial plants. The mechanisms developed for survival and adaptation to different environments throughout the geological history of the planet and to particular ecosystems and habitats today is worth examining; among these, the close relationships of bryophytes with other organisms, some of them like the fungi; perhaps as old as or older than bryophytes. Understanding the ecological requirements and physiological mechanisms that are critical for their growth in tropical lowland and montane environments will allow an evaluation of the potential for survival and maintenance of tropical bryodiversity in lieu of global climatic changes. Particularly in third world countries, the funding of research stations in different ecosystems and habitats and the training of personnel is critical for development of short and long term research. The scientific information obtained will be fundamental for the reinforcement and expansion of conservation efforts and sustainable use of tropical forest resources.

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LIVERWORTS AND HORNWORTS

ANEURACEAE

Riccardia sp.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero camino a
Ensenada Guabo. NSA *et al.* 19965.

Región de Bahía Honda. Bosque de tierras
bajas. Río Limón. NSA *et al.* 20484.

ANTHOCEROTACEAE

Notothyas dissecta Steph.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Playa Los
Chombos. NSA *et al.* 20222.

CALYPOGEIACEAE

Calypogeia miquelii Mont.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero Punta.
NSA *et al.* 20143.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero de Manglarito hacia Playa
Limón. NSA *et al.* 20336, 20421.

CEPHALOZIACEAE

Cephalozia sp.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Cerca de Sendero
Punta. NSA *et al.* 19998.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero del
laboratorio a la oficina. NSA *et al.* 20178.

JUBULACEAE

Frullania subgén. *Frullania*

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero camino a
Ensenada Guabo. NSA *et al.* 20117.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero de Manglarito hacia Playa
Limón. NSA *et al.* 20394.

LEJEUNEACEAE

Archilejeunea sp.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero El Edén. NSA *et al.* 20473.

Bryopteris filicina (Sw.) Nees

Región de Bahía Honda. Bosque de tierras
bajas. Río Limón cerca de la cascada. NSA
et al. 20500.

Caudalejeunea lehmanniana (Gott.) Evans
Región de Bahía Honda. Bosque alterado
de tierras bajas. Playa Bejucosa-Limón.
NSA *et al.* 20258.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia Playa El Edén. NSA *et
al.* 20472, 20475.

Ceratolejeunea cornuta (Lindb.) Schiffn.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero detrás del
laboratorio hacia Playa Los Chombos. NSA
et al. 19926.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero camino a
Ensenada Guabo. NSA *et al.* 19960, 20061,
20110, 20113.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero Punta.
NSA *et al.* 20126.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero de la vía
del tren hacia el laboratorio. NSA *et al.*
20190.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero de Manglarito hacia Playa
Limón. NSA *et al.* 20395.

Región de Bahía Honda. Bosque de tierras
bajas. Península de Punta Gorda. E. B.
Wong 608.

Región de Bahía Honda. Bosque de tierras
bajas., "Quebrada Seca", Salmonete. E. B.
Wong 619.

Cheilelejeunea rigidula (Nees ex Mont.)

Schust.
Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero de los
tanques de reserva de agua. NSA *et al.*
19761.

Cheilelejeunea sp.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero detrás del
laboratorio hacia Playa Los Chombos. NSA
et al. 19932.

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20338.

***Harpalejeunea* sp.**

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero Punta. NSA *et al.* 20141.

***Lejeunea glaucescens* Gott.**

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero de los tanques de reserva de agua. NSA *et al.* 19743.

***Lejeunea* spp.**

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero de los tanques de reserva de agua. NSA *et al.* 19750.

Región de Bahía Honda. Bosque alterado de tierras bajas. Playa Bejucosa-Limón. NSA *et al.* 20265.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa Limón. NSA *et al.* 20445.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa El Edén. NSA *et al.* 20492.

***Lopholejeunea* sp.**

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa El Edén. NSA *et al.* 20472.

***Stictolejeunea squamata* (Wild. ex Weber) Schiffn.**

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero Punta. NSA *et al.* 20134.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero de la estación del tren hacia Playa Clinton. NSA *et al.* 20242.

Región de Bahía Honda. Bosque de tierras bajas. Quebrada que desemboca en Playa Los García. NSA *et al.* 20430.

***Symbiezidium transversale* (Sw.) Trevis.**

Región de Bahía Honda. Bosque de tierras bajas. Quebrada Manglarito. NSA *et al.* 20312.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia El Edén. NSA *et al.* 20521.

LEPIDOZIACEAE

***Zoopsidella antillana* (Steph.) Schust.**

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero camino a Ensenada Guabo. NSA *et al.* 19990.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero Punta. NSA *et al.* 20066.

Región de Bahía Honda. Bosque de tierras bajas. Cerca de Playa Manglarito. NSA *et al.* 20421.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa Limón. NSA *et al.* 20501.

PLAGIOCHILACEAE

***Plagiochila dichotoma* (Web.) Dum.**

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero de los tanques de reserva de agua. NSA *et al.* 19750.

***Plagiochila* spp.**

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia El Edén. NSA *et al.* 20521.

Región de Bahía Honda. Bosque de tierras bajas. "Quebrada Seca", Salmonete, E. B. Wong 615.

MOSSES

BARTRAMIACEAE

***Philonotis uncinata* (Schwaegr.) Brid.**

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero detrás del laboratorio. NSA *et al.* 19924.

Región de Bahía Honda. Bosque de tierras bajas. Cerca de la casa de los biólogos. NSA *et al.* 20535.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa El Edén. NSA *et al.* 20490.

Región de Bahía Honda. Bosque de tierras bajas. Río Limón. NSA *et al.* 20486, 20528.

BRYACEAE

Bryum sp.

Región de Bahía Honda. Bosque de tierras bajas. De Río Limón a Sendero El Edén. NSA *et al.* 20488.

CALYMPERACEAE

Calymperes afzelii Sw.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero de los tanques de reserva de agua. NSA *et al.* 19749, 19750, 19756.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero detrás del laboratorio hacia Playa Los Chombos. NSA *et al.* 19804, 19810, 19911, 20218.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Lado sur de la isla. NSA *et al.* 19853.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Camino hacia la parte más alta de la isla, al lado del monorriel. NSA *et al.* 19969, 20025.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero Punta. NSA *et al.* 20064, 20067, 20108, 20145.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero del laboratorio a la oficina. NSA *et al.* 20180.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero hacia Playa Clinton. NSA *et al.* 20212, 20213, 20239.

Región de Bahía Honda. Bosque alterado de tierras bajas. Playa Bejucosa-Limón. NSA *et al.* 20296.

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20323, 20386, 20458, 20513, 20514.

Calymperes erosum Müll. Hal.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero de los tanques de reserva de agua. NSA *et al.* 19743, 19744, 19752, 19761, 19768.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero detrás del laboratorio. NSA *et al.* 19768, 19829, 19830, 19837, 19914.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero detrás del laboratorio hacia Playa Los Chombos. NSA *et al.* 19802, 19803, 19807, 19809, 19816, 19842, 19891, 19903.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero Punta. NSA *et al.* 20069, 20071, 20074, 20107, 20122, 20124.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Lado sur de la isla. NSA *et al.* 19874, 19919, 19930.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero camino a Ensenada Guabo. NSA *et al.* 19956, 19962, 1964, 19965, 19985, 20006, 20010, 20045, 20105.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero hacia Playa Clinton. NSA *et al.* 20206, 20211, 20217, 20237, 20245.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Camino hacia la parte más alta de la isla, al lado del monorriel. NSA *et al.* 20021, 20235.

Región de Bahía Honda. Bosque alterado de tierras bajas. Playa Bejucosa-Limón. NSA *et al.* 20265.

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20317, 20324, 20338, 20376, 20394, 20464, 20502, 20510.

Calymperes levyanum Besch.

Región de Bahía Honda. Bosque de tierras bajas. Quebrada Manglarito. NSA *et al.* 20312.

Calymperes nicaraguense Ren. & Card.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero Punta.
NSA *et al.* 20065, 20140.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia Playa Limón. NSA *et
al.* 20380, 20387.

Calymperes palisotii Schwaegr.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero detrás del
laboratorio. NSA *et al.* 19818, 19902, 19914.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero camino a
la oficina. NSA *et al.* 20030.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero camino a
Ensenada Guabo. NSA *et al.* 20045.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero Punta.
NSA *et al.* 20074.

Región de Bahía Honda. Bosque de tierras
bajas. Playa Limón. NSA *et al.* 20469.

Syrrhopodon africanus (Mitt.) Paris
Región de Bahía Honda. Bosque de tierras
bajas. Alrededor del área en tierra firme que
bordea a la Isla Canales de Tierra. NSA *et
al.* 20474.

Syrrhopodon circinatus (Brid.) Mitt.
Región de Bahía Honda. Bosque de tierras
bajas. Península de Punta Gorda. E. B.
Wong 605.

Syrrhopodon gardnerii (Hook.) Schwaegr.
Región de Bahía Honda. Bosque de tierras
bajas. Sendero de Manglarito hacia Playa
Limón. NSA *et al.* 20333.

Syrrhopodon hornschurchii Mart.
Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia Playa Limón. NSA *et
al.* 20386.

Syrrhopodon incompletus Schwaegr.
Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero Punta.
NSA *et al.* 20019.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia Playa Limón. NSA *et
al.* 20454, 20456.

Syrrhopodon ligulatus Mont.
Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero del
laboratorio a la oficina. NSA *et al.* 20189.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia Playa Limón. NSA *et
al.* 20453.

Syrrhopodon lycopodioides (Brid.) Müll.
Hal.
Región de Bahía Honda. Bosque alterado
de tierras bajas. Sendero hacia Playa El
Edén. NSA *et al.* 20471.

Syrrhopodon rigidus Hook. & Grev.
Región de Bahía Honda. Bosque de tierras
bajas. Cerca a la casa de los biólogos. NSA
et al. 20535.

DICRANACEAE

Dicranella sp.
Región de Bahía Honda. Bosque de tierras
bajas. Sendero de Manglarito hacia Playa
Limón. NSA *et al.* 20324.

Leucoloma tortellum (Mitt.) A. Jaeg.
Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero Punta.
NSA *et al.* 20081, 20082.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero hacia
Playa Clinton. NSA *et al.* 20217.

FISSIDENTACEAE

Fissidens dissitifolius Sull.
Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero de los
tanques de reserva de agua. NSA *et al.*
19760.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia El Edén desde Playa
Limón. NSA *et al.* 20488.

Fissidens mollis Mitt.
Región de Bahía Honda. Bosque alterado
de tierras bajas. Sendero Bejucosa-Limón.
NSA *et al.* 20264.

Región de Bahía Honda. Bosque de tierras bajas. Río Limón. NSA *et al.* 20483, 20484, 20527, 20542.

Fissidens pellucidus Hornsch.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero camino a Ensenada Guabo. NSA *et al.* 19957, 19990.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero Punta. NSA *et al.* 19998, 20066, 20143.

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20336.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero del laboratorio a la oficina. NSA *et al.* 20178.

Región de Bahía Honda. Bosque de tierras bajas. Playa El Edén. NSA *et al.* 20492.

Fissidens weirii Mitt.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero Punta. NSA *et al.* 20067.

Fissidens zollingeri Mont.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Quebrada Clinton. NSA *et al.* 20291.

HYPNACEAE

Chryso-hypnum diminutivum (Hampe) Buck.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero de los tanques de reserva de agua. NSA *et al.* 19758.

Región de Bahía Honda. Bosque alterado de tierras bajas. Sendero Bejucosa-Limón. NSA *et al.* 20301.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia El Edén desde Playa Limón. NSA *et al.* 20476.

Isopterygium tenerum (Sw.) Mitt.

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20333.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa Limón. NSA *et al.* 20455.

Región de Bahía Honda. Bosque de tierras bajas. Alrededor del área en tierra firme que bordea a la Isla Canales de Tierra. NSA *et al.* 20474.

Rhacopilopsis trinitensis (Müll. Hal.) Britt. *et. Dix.*

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20333.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa Limón. NSA *et al.* 20373, 20454, 20456, 20463.

Vesicularia vesicularis (Schwaegr.) Broth.

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20313, 20412.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa Limón. NSA *et al.* 20455.

LEUCOBRYACEAE

Leucobryum affn. subobtusifolium (Broth.) Allen

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa Limón. NSA *et al.* 20459, 20460, 20463.

Ochrobryum cf. sessile Allen

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero Punta. NSA *et al.* 20181.

Octoblepharum albidum Hedw.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero detrás del laboratorio hacia Playa Los Chombos. NSA *et al.* 19803, 19804, 19807, 19830, 19914.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero hacia los acantilados. NSA *et al.* 19843.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero camino a Ensenada Guabo. NSA *et al.* 20006.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero Punta.
NSA *et al.* 20019, 20051, 20090.

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero de la
oficina a la estación del tren. NSA *et al.*
20099, 20235, 20236.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero de Manglarito hacia Playa
Limón. NSA *et al.* 20321, 20322, 20326.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia Playa Limón. NSA *et al.*
20453, 20459, 20460, 20468.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia El Edén desde Playa
Limón. NSA *et al.* 20471.

***Octoblepharum erectifolium* Mitt.**

Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia Playa Limón. NSA *et al.*
20454.

***Octoblepharum pulvinatum* (Dozy & Molk.)
Mitt.**

Región de Bahía Honda. Bosque de tierras
bajas. Sendero de Manglarito hacia Playa
Limón. NSA *et al.* 20333.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia Playa Limón. NSA *et al.*
20455.

MACROMITRIACEAE

***Macromitrium guatemaliense* Müll. Hal.**

Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia El Edén desde Playa
Limón. NSA *et al.* 20530.

NECKERACEAE

***Neckeropsis undulata* (Hedw.) Reichd't.**

Región de Bahía Honda. Bosque de tierras
bajas. "Quebrada Seca", Salmonete. E. B.
Wong 615.

PHYLLODREPANACEAE

***Phyllodrepanium falcifolium* (Schwaegr.)
Crosby**

Región de Bahía Honda. Bosque de tierras
bajas. Península de Punta Gorda. E. B.
Wong 605.

PILOTRICHACEAE

***Callicostella colombica* Williams**

Región de Bahía Honda. Bosque de tierras
bajas. Río Limón. NSA *et al.* 20482.

***Callicostella pallida* (Hornsch.) Aongstr.**

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Lado sur de la isla.
NSA *et al.* 19823.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero de Manglarito hacia Playa
Limón. NSA *et al.* 20412.

***Callicostella* sp.**

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque remanente de Tierras bajas.
Desviación del sendero hacia la quebrada.
NSA *et al.* 19969.

Región de Bahía Honda. Bosque de tierras
bajas. Sendero de Manglarito hacia Playa
Limón. NSA *et al.* 20400, 20401, 20402.

***Hypnella pallescens* (Hook.) A. Jaeg.**

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero de la
oficina a la estación del tren. NSA *et al.*
20096.

***Lepidopilum cf. scabrisetum* (Schwaegr.)
Steere**

Región de Bahía Honda. Bosque de tierras
bajas. Quebrada Manglarito. NSA *et al.*
20312.

POTTIACEAE

***Hyophila involuta* (Hook.) A. Jaeg.**

Región de Bahía Honda. Bosque de tierras
bajas. Sendero hacia El Edén. NSA *et al.*
20490.

Región de Bahía Honda. Bosque de tierras
bajas. Cascada del Río Limón. NSA *et al.*
20528.

PTEROBRYACEAE

***Jaegerina scariosa* (Lor.) Arz.**

Isla Canales de Tierra. 7°45'N, 81°35'W.
Bosque de tierras bajas. Sendero de la
oficina a la estación del tren. NSA *et al.*
20180.

***Orthostichopsis tetragona* (Hedw.) Broth.**

Región de Bahía Honda. Bosque de tierras
bajas. Río Limón. NSA *et al.* 20522, 20526

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia El Edén. NSA *et al.* 20478, 20479, 20530.

Pirella pohlii (Schwaegr.) Card.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero de la oficina a la estación del tren. NSA *et al.* 20180.

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20372.

RACOPIACEAE

Racopilum tomentosum (Hedw.) Brid.

Región de Bahía Honda. Bosque de tierras bajas. Sendero Manglarito. NSA *et al.* 20411.

SEMATOPHYLLACEAE

Acroporium longirostre (Brid.) Buck

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20376.

Sematophyllum galipense (Müll. Hal.) Mitt.

Región de Bahía Honda. Bosque alterado de tierras bajas. Playa Bejucosa-Limón. NSA *et al.* 20259.

Región de Bahía Honda. Bosque de tierras bajas. Sendero Manglarito. NSA *et al.* 20410, 20411.

Región de Bahía Honda. Bosque alterado de tierras bajas. Río Limón. NSA *et al.* 20529.

Región de Bahía Honda. Bosque de tierras bajas. Sendero Playa Los García-Playa Limón. NSA *et al.* 20443.

Sematophyllum subpinnatum (Brid.) Britt.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa Limón. NSA *et al.* 20364, 20445.

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20426.

Sematophyllum subsimplex (Hedw.) Mitt.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero Punta. NSA *et al.* 20082.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa Limón. NSA *et al.* 20361, 20459, 20462.

Taxithelium planum (Brid.) Mitt.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero de los tanques de reserva de agua. NSA *et al.* 19746, 19747, 19758, 19760.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Sendero detrás del laboratorio hacia Playa Los Chombos. NSA *et al.* 19803, 19804, 19806.

Isla Canales de Tierra. 7°45'N, 81°35'W. Bosque de tierras bajas. Lado sur de la isla. NSA *et al.* 19822, 19866, 19918.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero hacia los acantilados. NSA *et al.* 19945, 19946.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero camino a Ensenada Guabo. NSA *et al.* 19965, 19981, 20105.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero Punta. NSA *et al.* 20107.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero hacia Playa Clinton. NSA *et al.* 2013.

Región de Bahía Honda. Bosque alterado de tierras bajas. Playa Bejucosa-Limón. NSA *et al.* 20231, 20232, 20233, 20254, 20256, 20259, 20301.

Región de Bahía Honda. Bosque de tierras bajas. Sendero Playa Los García-Playa Limón. NSA *et al.* 20422.

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20444, 20445.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia El Edén desde Playa Limón. NSA *et al.* 20473, 20474, 20476, 20509, 20518.

Región de Bahía Honda. Bosque de tierras bajas. Playa Sol. NSA *et al.* 20538.

Trichosteleum fluviale (Mitt.) A. Jaeg.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero cerca del laboratorio. NSA *et al.* 19860.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Lado sur de la isla. NSA *et al.* 19919.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Cerca de los acantilados. NSA *et al.* 19946.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero camino a Ensenada Guabo. NSA *et al.* 19956, 19964, 19965, 19966.

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20323.

Región de Bahía Honda. Bosque de tierras bajas. Sendero Playa Los García-Playa Limón. NSA *et al.* 20441.

Región de Bahía Honda. Bosque de tierras bajas. Sendero Playa Limón. NSA *et al.* 20510.

Trichosteleum sentosum (Sull.) A. Jaeg.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero detrás del laboratorio. NSA *et al.* 19837.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Playa Los Chombos. NSA *et al.* 19842.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero Punta. NSA *et al.* 20013.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero camino a Ensenada Guabo. NSA *et al.* 20045.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero hacia Playa Clinton. NSA *et al.* 20206.

Región de Bahía Honda. Bosque alterado de tierras bajas. Playa Bejucosa-Limón. NSA *et al.* 20265.

Trichosteleum subdemissum (Besch.) A.

Jaeg.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Lado sur de la isla. NSA *et al.* 19950.

Región de Bahía Honda. Bosque de tierras bajas. Sendero hacia Playa Limón. NSA *et al.* 20464.

Trichosteleum vincentinum (Mitt.) A. Jaeg.

Isla Canales de Tierra. 7°45'N, 81°35'W.

Bosque de tierras bajas. Sendero del laboratorio a la oficina. NSA *et al.* 20189.

Región de Bahía Honda. Bosque de tierras bajas. Sendero de Manglarito hacia Playa Limón. NSA *et al.* 20324.

STEREOPHYLLACEAE

Eulacophyllum cultelliforme (Sull.) Buck & Irel.

Región de Bahía Honda. Bosque alterado de tierras bajas. Playa Bejucosa-Limón. NSA *et al.* 20231.

THUIDIACEAE

Cyrto-hypnum involvens (Hedw.) Buck & Crum

Región de Bahía Honda. Bosque alterado de tierras bajas. Playa Bejucosa-Limón. NSA *et al.* 20233.

Cyrto-hypnum schistocalix (Müll. Hal.)

Buck & Crum

Región de Bahía Honda. Bosque alterado de tierras bajas. Sendero Bejucosa-Playa Limón. NSA *et al.* 20231.

Table No. 1. Bryophytes of Canales de Tierra Island and Adjacent Peninsulas
(Bahía Honda)

FAMILY

SPECIES

ANTHOCEROTOPHYTA (HORNWORTS)

Anthocerotaceae *Notothylas dissecta* Steph.

MARCHANTIOPHYTA (LIVERWORTS OR HEPATICS)

Aneuraceae *Riccardia* sp.

Calypogeiaceae *Calypogeia miquelii* Mont.

Cephaloziaceae *Cephalozia* sp.

Jubulaceae *Frullania* subsp. *Frullania*

Lejeuneaceae *Archilejeunea* sp.
Bryopteris filicina (Sw.) Nees
Caudalejeunea lehmanniana (Gott.) Evans
Ceratolejeunea cornuta (Lindenb.) Steph.
Cheilolejeunea rigidula (Nees ex Mont.) Schust.
Cheilolejeunea sp.
Harpalejeunea sp.
Lejeunea spp.
Lejeunea cf. *glaucescens* Gott.
Lopholejeunea sp.
Stictolejeunea squamata (Willd. ex Web.) Schiffn.
Symbiezidium transversale (Sw.) Trevis

Lepidoziaceae *Zoopsidella antillana* (Steph.) Schust.

Plagiochilaceae *Plagiochila dichotoma* (Web.) Dum.
Plagiochila spp.

BRYOPHYTA (MOSSES)

Bartramiaceae *Philonotis uncinata* (Schwaegr.) Brid.

Bryaceae *Bryum* sp.

Calymperaceae *Calymperes afzelii* Sw.
Calymperes erosum Müll. Hal.
Calymperes levyanum Besch.
Calymperes nicaraguense Ren. & Card.
Calymperes palisotii Schwaegr.
Syrrhopodon africanus (Mitt.) Par.
Syrrhopodon circinatus (Brid.) Mitt.

Syrrhopodon hornschuchii Mart.
Syrrhopodon incompletus Schwaegr.
Syrrhopodon ligulatus Mont.
Syrrhopodon lycopodioides (Sw. ex Brid.) Müll. Hal.
Syrrhopodon prolifer Schwaegr.
Syrrhopodon rigidus Hook. & Grev.

Dicranaceae

Dicranella sp.
Leucoloma tortellum (Mitt.) A. Jaeg.

Fissidentaceae

Fissidens dissitifolius Sull.
Fissidens mollis Mitt.
Fissidens pellucidus Hornsch.
Fissidens weirii Mitt.
Fissidens zollingeri Mont.

Hypnaceae

Chryso-hypnum diminutivum (Hampe) W. R. Buck
Isopterygium tenerum (Sw.) Mitt.
Rhacopilopsis trinitensis (Müll. Hal.) E. Britton & Dixon
Vesicularia vesicularis (Schwaegr.) Broth.

Leucobryaceae

Leucobryum affn. subobtusifolium (Broth.) B. H. Allen
Ochrobryum cf. sessile B. H. Allen
Octoblepharum albidum Hedw.
Octoblepharum erectifolium Mitt.
Octoblepharum pulvinatum (Dozy & Molk.) Mitt.

Macromitriaceae

Macromitrium guatemaliense Müll. Hal.

Neckeraceae

Neckeropsis undulata (Hedw.) Reichdt.

Phyllo drepaniaceae

Phyllo drepanium falcifolium (Schwaegr.) Crosby

Pilotrichaceae

Callicostella colombica R. S. Williams
Callicostella pallida (Hornsch.) _ngstr.
Callicostella sp.
Lepidopilum scabrisetum (Schwaegr.) Steere

Pottiaceae

Hyophila involuta (Hook.) A. Jaeg.

Pterobryaceae

Jaegerina scariosa (Lor.) Arzeni
Orthostichopsis tetragona (Sw. ex Hedw.) Broth.
Pirella pohlii (Schwaegr.) Card.

Racopilaceae

Racopilum tomentosum (Hedw.) Brid.

Sematophyllaceae

Acroporium longirostre (Brid.) W. R. Buck
Sematophyllum galipense (Müll. Hal.) Mitt.
Sematophyllum subpinnatum (Brid.) E. Britton
Sematophyllum subsimplex (Hedw.) Mitt.
Taxithelium planum (Brid.) Mitt.
Trichosteleum fluviale (Mitt.) A. Jaeg.
Trichosteleum sentosum (Sull.) A. Jaeg.
Trichosteleum subdemissum (Schimp. ex Besch.) A. Jaeg.

Trichosteleum vincentinum (Mitt.) A. Jaeg.

Stereophyllaceae

Eulacophyllum cultelliforme (Sull.) W. R. Buck & Ireland

Thuidiaceae

Cyrt-hypnum involvens (Hedw.) W. R. Buck & H. A. Crum

Cyrt-hypnum schistocalyx (Müll. Hal.) W. R. Buck & H. A. Crum

Table No. 2. Position of perichaetia, life-forms and distribution by substrate of mosses of Canales de Tierra Island and Bahía Honda (substrate: **tr** = tree trunk, **sh** = shrub, **dl** = decomposing log, **so** = soil, **ro** = rock, **lf** = leaf, **li** = liana, **ct** = cut trunk).

Family	Species	Position of perichaetia			Life-forms						Substrate						
		Acro	Pleuro	Clado	Cushion	Turf	Mat	Fan	Pendent	Dendroid	tr	sh	dl	so	ro	lf	li
Bartramiaceae	Philonotis uncinata	*				*					*			*			
Bryaceae	Bryum sp.	*												*			
Calymperaceae	Calymperes afzelii	*				*					*	*	*	*		*	
	C. erosum	*				*					*	*	*	*			
	C. levyanum	*				*											
	C. nicaraguense	*				*					*						
	C. palisotii	*				*					*		*				
	Syrrhopodon africanus	*				*					*						
	S. circinatus	*				*					*						
	S. hornschuchii	*				*					*						
	S. incompletus	*				*					*						
	S. ligulatus	*				*					*	*	*				
	S. lycopodioides	*				*					*						
	S. prolifer	*				*					*		*				
	S. rigidus	*				*					*						
Dicranaceae	Dicranella sp.	*				*					*	*					

	<i>Leucoloma tortellum</i>	*			*							*				
Fissidentaceae	<i>Fissidens dissitifolius</i>			*	*							*	*			
	<i>F. mollis</i>			*	*							*	*	*		
	<i>F. pellucidus</i>			*	*					*		*	*			
	<i>F. weirii</i>			*	*					*						
	<i>F. zollingeri</i>			*	*											
Hypnaceae	<i>Chrysohypnum diminutivum</i>		*			*				*	*		*			
	<i>Isopterygium tenerum</i>		*			*				*						
	<i>Racopilopsis trinitensis</i>		*			*				*						
	<i>Vesicularia vesicularis</i>		*			*				*		*	*			
Leucobryaceae	<i>Leucobryum subobtusifolium</i>	*			*					*		*	*			
	<i>Ochrobryum sessile</i>	*			*							*	*			
	<i>Octoblepharum albidum</i>	*			*					*	*	*	*			
	<i>O. erectifolium</i>	*			*					*		*	*			
	<i>O. pulvinatum</i>	*			*					*		*	*			
Macromitriaceae	<i>Macromitrium guatemaliense</i>			*		*					*	*				
Neckeraceae	<i>Neckeropsis undulata</i>		*			*		*			*	*				
Phylloprepaniaceae	<i>Phylloprepanium falcifolium</i>		*			*				*						
Pilotrichaceae	<i>Callicostella colombica</i>		*			*							*			
	<i>C. pallida</i>		*			*							*	*		

	<i>Callicostella</i> sp.		*				*					*						
	<i>Lepidopilum scabrisetum</i>		*				*											
Pottiaceae	<i>Hyophila involuta</i>	*				*								*				
Pterobryaceae	<i>Jaegerina scariosa</i>		*				*					*						
	<i>Orthostichopsis tetragona</i>		*					*			*		*		*			
	<i>Pirella pohlii</i>		*						*		*							
Racopilaceae	<i>Racopilum tomentosum</i>		*				*							*				
Sematophyllaceae	<i>Acroporium longirostre</i>		*				*					*						
	<i>Sematophyllum galipense</i>		*				*				*							
	<i>S. subpinnatum</i>		*				*				*		*	*				
	<i>S. subsimplex</i>		*				*				*		*			*		
	<i>Taxithelium planum</i>		*				*				*	*	*	*	*	*	*	
	<i>Trichosteleum fluviale</i>		*				*				*	*	*	*	*	*	*	
	<i>T. sentosum</i>		*				*				*	*	*	*				
	<i>T. subdemissum</i>		*				*					*						
	<i>T. vincentinum</i>		*				*				*	*						
Stereophyllaceae	<i>Eulacophyllum cultelliforme</i>		*				*							*				
Thuidiaceae	<i>Cyrto-hypnum involvens</i>		*				*					*						
	<i>C. schistocalyx</i>		*				*					*						
Totals		26	23	1	2	25	23	2	1	1	34	11	21	8	14	1	4	6

Table No. 3. Distribution of bryophyte families by substrate (**tr** = tree trunk, **sh** = shrub, **dl** = decomposing log, **so** = soil, **ro** = rock, **lf** = leaf, **li** = liana, **ct** = cut trunk).

Family	tr	sh	dl	so	ro	lf	li	ct	total
Horworts and Liverworts									
Anthocerotaceae					*				1
Aneuraceae		*			*				2
Calypogeiaceae				*					1
Cephaloziaceae				*					1
Jubulaceae	*								1
Lejeuneaceae	*	*	*	*	*			*	6
Lepidoziaceae	*			*					2
Plagiochilaceae	*		*					*	3
Mosses									
Bartramiaceae	*				*				2
Bryaceae					*				1
Calymperaceae	*	*	*	*	*		*	*	7
Dicranaceae		*	*						2
Fissidentaceae	*		*	*	*				4
Hypnaceae	*	*		*	*				4
Leucobryaceae	*	*	*					*	4
Macromitriaceae			*						1
Neckeraceae			*						1
Pilotrichaceae	*	*			*			*	4
Pottiaceae					*				1
Pterobryaceae	*		*			*			3
Racopilaceae					*				1
Sematophyllaceae	*	*	*	*	*		*	*	7
Stereophyllaceae					*				1
Thuidiaceae			*						1

Table No. 4. Distribution of bryophyte genera and species in Canales de Tierra Island and Bahía Honda.

Family	Genus/Species	Canales de Tierra	Bahía Honda
HORNWORTS AND LIVERWORTS			
Anthocerotaceae	<i>Notothylas dissecta</i>	*	*
Aneuraceae	<i>Riccardia</i> sp.	*	*
Calypogeiaceae	<i>Calypogeia miquelii</i>	*	*
Cephaloziaceae	<i>Cephalozia</i> sp.	*	*
Jubulaceae	<i>Frullania</i> subgen. <i>Frullania</i>		*
Lejeuneaceae	<i>Archilejeunea</i> sp.		*
	<i>Bryopteris filicina</i>		*
	<i>Caudalejeunea lehmanniana</i>		*
	<i>Ceratolejeunea cornuta</i>	*	*
	<i>Cheilolejeunea rigidula</i>	*	*
	<i>Cheilolejeunea</i> sp.	*	*
	<i>Harpalejeunea</i> sp.	*	*
	<i>Lejeunea</i> cf. <i>glaucescens</i>	*	*
	<i>Lejeunea</i> spp.	*	*
	<i>Lopholejeunea</i> sp.		*
	<i>Stictolejeunea squamata</i>	*	*
	<i>Symbiezidium transversale</i>		*
Lepidoziaceae	<i>Zoopsidella antillana</i>	*	*
Plagiochilaceae	<i>Plagiochila dichotoma</i>	*	*
	<i>Plagiochila</i> spp.		*
MOSSES			
Bartramiaceae	<i>Philonotis uncinata</i>	*	*
Bryaceae	<i>Bryum</i> sp.		*
Calymperaceae	<i>Calymperes afzelii</i>	*	*
	<i>Calymperes erosum</i>	*	*
	<i>Calymperes levyanum</i>		*
	<i>Calymperes nicaraguense</i>	*	*
	<i>Calymperes palisotii</i>	*	*
	<i>Syrrhopodon africanus</i>		*
	<i>Syrrhopodon circinatus</i>		*
	<i>Syrrhopodon hornschuchii</i>		*
	<i>Syrrhopodon incompletus</i>	*	*
	<i>Syrrhopodon ligulatus</i>	*	*
	<i>Syrrhopodon lycopodioides</i>		*
	<i>Syrrhopodon prolifer</i>		*
	<i>Syrrhopodon rigidus</i>		*
Dicranaceae	<i>Dicranella</i> sp.		*
	<i>Leucoloma tortellum</i>	*	*
Fissidentaceae	<i>Fissidens dissitifolius</i>	*	*
	<i>Fissidens mollis</i>		*
	<i>Fissidens pellucidus</i>	*	*
	<i>Fissidens weirii</i>	*	*
	<i>Fissidens zollingeri</i>	*	*
Hypnaceae	<i>Chryso-hypnum diminutivum</i>	*	*

	<i>Isopterygium tenerum</i>	*
	<i>Rhacopilopsis trinitensis</i>	*
	<i>Vesicularia vesicularis</i>	*
Leucobryaceae	<i>Leucobryum aff. subobtusifolium</i>	*
	<i>Ochrobryum cf. sessile</i>	*
	<i>Octoblepharum albidum</i>	*
	<i>Octoblepharum erectifolium</i>	*
	<i>Octoblepharum pulvinatum</i>	*
Macromitriaceae	<i>Macromitrium guatemaliense</i>	*
Neckeraceae	<i>Neckeropsis undulata</i>	*
Phyllo drepaniaceae	<i>Phyllo drepanium falcifolium</i>	*
Pilotrichaceae	<i>Callicostella colombica</i>	*
	<i>Callicostella pallida</i>	*
	<i>Callicostella sp.</i>	*
	<i>Lepidopilum scabrisetum</i>	*
Pottiaceae	<i>Hyophila involuta</i>	*
Pterobryaceae	<i>Jaegerina scariosa</i>	*
	<i>Orthostichopsis tetragona</i>	*
	<i>Pirella pohlii</i>	*
Racopilaceae	<i>Racopilum tomentosum</i>	*
Sematophyllaceae	<i>Acroporium longirostre</i>	*
	<i>Sematophyllum galipense</i>	*
	<i>Sematophyllum subpinnatum</i>	*
	<i>Sematophyllum subsimplex</i>	*
	<i>Taxithelium planum</i>	*
	<i>Trichosteleum fluviale</i>	*
	<i>Trichosteleum sentosum</i>	*
	<i>Trichosteleum subdemissum</i>	*
	<i>Trichosteleum vincentinum</i>	*
Stereophyllaceae	<i>Eulacophyllum cultelliforme</i>	*
Thuidiaceae	<i>Cyrto-hypnum involvens</i>	*
	<i>Cyrto-hypnum schistocalyx</i>	*
	Total	38 (32 + 6 sp.)
	Hornworts and liverworts	13 (8 + 5 sp.)
	Mosses	25 (24 + 1 sp.)
		62 (54 + 8 sp.)

Table No. 6. Geographic relationships of the bryoflora of Canales de Tierra Island and Bahía Honda with that of Coiba (Panama), Barro Colorado (Zona del Canal) Cocos (Costa Rica) and Gorgona (Colombia) Islands (¹Salazar & Chung 1997, ²Arrocha 1981, ²Gradstein & Salazar Allen unpublished, ²Salazar *et al.* 1991, ²Stotler *et al.* 1998, ³Montoya 1990, ³Dauphin 1995, ⁴Rudas & Aguirre 1990).

Family/Species	Coiba ¹	Barro Colorado ²	Cocos ³	Gorgona ⁴
HORNWORTS & LIVERWORTS				
Anthocerotaceae <i>Notothydas dissecta</i>				
Calypogeiaceae <i>Calypogeia miquelii</i>		*		
Lejeuneaceae <i>Bryopteris filicina</i>		*		
<i>Caudalejeunea lehmanniana</i>		*		
<i>Cheilolejeunea rigidula</i>		*	*	
<i>Ceratolejeunea cornuta</i>		*	*	
<i>Lejeunea cf. glaucescens</i>			*	
<i>Stictolejeunea squamata</i>	*	*	*	*
<i>Symbiezidium transversale</i>		*	*	*
Lepidoziaceae <i>Zoopzidella antillana</i>			*	
Plagiochilaceae <i>Plagiochila dichotoma</i>				
Total	1	7	6	2
MOSSES				
Bartramiaceae <i>Philonotis uncinata</i>	*	*	*	*
Calymperaceae <i>Calymperes afzelii</i>		*	*	
<i>C. erosum</i>	*	*	*	*
<i>C. levyanum</i>	*	*		
<i>C. nicaraguense</i>	*	*		
<i>C. palisotii</i>		*		*
<i>Syrrhopodon africanus</i>				
<i>S. circinatus</i>			*	
<i>S. hornschuchii</i>	*			
<i>S. incompletus</i>	*	*	*	*
<i>S. ligulatus</i>	*			
<i>S. lycopodioides</i>			*	*
<i>S. prolifer</i>	*		*	*
<i>S. rigidus</i>			*	*
Dicranaceae <i>Leucoloma tortellum</i>				
Fissidentaceae <i>F. dissitifolius</i>				
<i>F. mollis</i>		*		
<i>F. pellucidus</i>		*	*	
<i>F. weirii</i>	*			
<i>F. zollingerii</i>	*	*		*

Hypnaceae				
<i>Chryso-hypnum diminutivum</i>	*	*		
<i>Isopterygium tenerum</i>	*	*	*	*
<i>Rhacopilopsis trinitensis</i>		*		
<i>Vesicularia vesicularis</i>		*	*	
Leucobryaceae				
<i>Leucobryum aff. subobtusifolium</i>				
<i>Ochrobryum cf. sessile</i>				
<i>Octoblepharum albidum</i>	*	*	*	*
<i>O. erectifolium</i>	*			
<i>O. pulvinatum</i>	*	*	*	*
Macromitriaceae				
<i>Macromitrium guatemaliense</i>				
Neckeraceae				
<i>Neckeropsis undulata</i>	*	*	*	
Pilotrichaceae				
<i>Callicostella colombica</i>		*		*
<i>C. pallida</i>	*	*		*
<i>Lepidopilum scabrisetum</i>		*		
Phylloprepaniaceae				
<i>Phylloprepanium falcifolium</i>				
Pottiaceae				*
<i>Hyophila involuta</i>				
Pterobryaceae				
<i>Jaegerina scariosa</i>	*	*		
<i>Orthostichopsis tetragona</i>	*	*		*
<i>Pirella pohlii</i>	*	*		
Racopilaceae				
<i>Racopilum tomentosum</i>		*		
Sematophyllaceae				
<i>Acroporium longirostre</i>	*			
<i>Sematophyllum galipense</i>			*	
<i>S. subpinnatum</i>				
<i>S. subsimplex</i>	*	*		*
<i>Taxithelium planum</i>	*	*	*	*
<i>Trichosteleum cf. fluviale</i>		*	*	
<i>T. sentosum</i>	*	*		
<i>T. subdemissum</i>		*		
<i>T. vincentinum</i>				
Stereophyllaceae				
<i>Eulacophyllum cultelliforme</i>				
Thuidiaceae				
<i>Cyrto-hypnum involvens</i>	*	*	*	
<i>C. schistocalyx</i>		*		
Total	25	32	18	17

LIST OF FIGURES (BRYOPHYTES)

Fig. 1. Anthocerototes (Hornworts). **Ga** = thallose gametophyte, **Es** = sporophyte, **In** = involucre (gametophytic tissue covering base of sporophyte). Involucre ca. 1 cm tall.

Fig. 2. Foliose liverworts. **A.** *Taxilejeunea sulphurea* (Lehm. & Lindenb.) Schiffn., on bark of tree. Width of plants including leaves varies from 1-2 mm. **B.** *Frullania* sp. Habit of plant, ventral view showing lateral leaves (**Llf**), ventral leaves or amphigastria (**Ulf**), and sac-like lobule (**Lob**) parallel to the stem. Altos de Campana National Park (Panama). 100x.

Fig. 3. Thallose liverworts. **A.** *Pallavicinia lyelii* (Hook) Carruth., two female plants (left and middle) and one male plant (lower right). Altos de Campana National Park (Panama). Thallus is ca. 5 mm wide. **B.** *Cyathodium spruceanum* Prosk., growing in soil. **C.** *Cyathodium spruceanum*, close up of female plants. **Es** = sporophytes, arrows point to the opening of the sac-like structure (involucre) where sporophytes are contained. Each vertical green line on the scale is separated by 2.5 cm. B-C, El Valle de Antón (Coclé).

Fig. 4. Mosses. *Groutiella* sp., corticolous. **Es** = sporophyte, **Ca** = calyptra. Altos de Campana National Park (Panama).

Fig. 5. Cushion growth of liverworts in the cloud forest of Cerro Tute (Veraguas).

Fig. 6. *Cyathodium cavernarum* Kunze. **A.** Mature archegonium with egg (female gamete) at base of venter. 250x. **B.** Fertilized archegonium, note swollen venter and neck above it. Neck of archegonia is 105 μ m long. 250x. Sendero El Charco, Soberanía National Park (Panama), *Salazar Allen 15214* (PMA).

Fig. 7. Sematophyllaceae. **A.** Young antheridia (male gametangia) surrounded by protecting (perigonial) leaves. 200x. **B.** Old dehiscent antheridia showing pedicel at base; perigonial leaf on the background. Canales de Tierra Island, *Salazar Allen et al. 20144* (PMA). 200x.

Fig. 8. Turf. Calymperaceae. Bahía Honda. Foto Niko López.

Fig. 9. Cushion. *Leucobryum martianum* (Hornsch.) Hampe, on decomposing log. Cerro Jefe (Panama). Ruler is 15 cm long.

Fig. 10. Mat. **A.** *Zelometeorium* sp. with sporophyte. **Ca** = calyptra, **Es** = sporophyte. Pakitza (Peru). **B.** Lejeuneaceae. Bahía Honda. Foto Niko López.

Fig. 11. Fan. *Neckeropsis undulata* on fallen trunk. Barro Colorado Island (Canal Zone), on Harvard trail, *Salazar Allen 6582* (PMA).

Fig. 12. Pendent. *Brymela tutezona* Crosby & Allen. Cloud forest of Cerro Tute (Veraguas).

Fig. 13. Dendroid. *Pireella* sp. Altos de Campana National Park (Panama). Plants are ca. 4 cm tall.

Fig. 14. *Notothylas* sp. **A.** Habit. In soil, lowland areas of Portobelo (Colón), **Sp** = shoot-like sporophyte within green involucre. Sporophytes are ca. 2-3 mm long. **B.** Border cells with single chloroplast. Each chloroplast has a central pyrenoid (**Pyr**).

Fig. 15. Oil bodies of liverworts. **A.** *Caudalejeunea lehmanniana*, cells at midleaf. 400x. Ipetí (Panama). **B.** *Radula* sp., cells at midleaf. Average diameter of cells ca. 18 μ m. 100x. **C.** *Taxilejeunea* sp. Basal part of the leaf. 400x. B-C, Altos de Campana National Park (Panama).

Fig. 16. *Trichocolea* sp. Leafy liverwort with dissected leaves. **A.** Habit of the plant. Photo by J.-P. Frahm. **B.** Magnified view of leaves, note short basal lamina dissected in its upper part into filiform lobes. **C.** Magnified view of leaf showing cells with papillose (warty) cuticle. A-B, Altos de Campana National Park (Panama).

Fig. 17. Lejeuneaceae. **A.** Ventral lobule with tooth (**Toh**) and hyaline papillae (**Pap**). 523.8x. *Salazar Allen et al.* 20381 (PMA). **B.** *Frullania* sp., ventral view, note sac-like lobules parallel to the stem. **C.** *Ceratolejeunea cornuta*, perianth with four horn-like projections. B-C, Altos de Campana National Park (Panama). **D.** *Aneura* sp. (thalloid hepatic), spores and elaters.

Fig. 18. *Caudalejeunea lehmanniana*. **A.** Ventral leaves (amphigastria), basal amphigastrium 470 μ m. 100x. Bahía Honda, *Salazar Allen et al.* 20472 (PMA). **B.** Cells at midleaf, note cordate (heart-shaped) trigones and intermediate thickenings between trigones. Diameter of cells ca. 41-45 μ m. 400x. **C.** Perianth. Size = 0.62 μ m long. 40x.

Fig. 19. *Bryopteris filicina*. **A.** Moist plant. **B.** Leaf cells at middle with oil bodies and trigones in their cell walls. Cells ca. 22.5 μ m long. 400x. Cerro Azul, El Cantar Nature Trail. (Panama).

Fig. 20. *Stictolejeunea squamata*. **A.** Plant on leaf (epiphylls) in its natural habitat. 250x. **B.** Dorsal view of plant, dots are ocelli. Perianth at center base with two enlarged ear-like apical lobes (like Mickey mouse hats). Lobes = 364 μ m long. 40x. **C.** Magnified view of leaf cells with ocelli. Average size of ocelli = 1.5 μ m. 400x. Altos de Campana National Park (Panama).

Fig. 21. *Ceratolejeunea* sp. **A.** Dorsal view of plant. Note incubous insertion of leaves. Enlarged cells on leaf at branching site are ocelli (**Oc**). 100x. **B.** Ventral view of plant at apex, note lobules and bifid underleaves (**Llf** = lateral leaf, **Lob** = lobule, **Ulf** = underleaf). 100x. **C.** Utricle. **D.** Cells at midleaf with chloroplasts and remnants of oil bodies (hyaline globules). 1000x. Bahía Honda, *Salazar Allen et al.* 20381 (PMA).

Fig. 22. *Symbiezidium* sp. On bark of *Hura crepitans* L. Barro Colorado Island (Canal Zone, *Salazar Allen s.n.*)

Fig. 23. *Zoopsideella* sp., monoicous species. **A.** Plant with perianth (dark branch). **B.** Magnified view of upper portion of vegetative apex, note two large sausage-like papillae on upper margins of leaves. 100x. On fallen palm leaf, decomposing, P-8, San Juan de Turbe, Area of La Conga. Panama Canal watershed, *Salazar Allen et al.* 17270 (PMA).

Fig. 24. *Plagiochila* sp. Habit. Bahía Honda. Foto Niko López.

Fig. 25. *Riccardia* sp., in its natural habitat on a wooden picnic table. White threads are hyaline seta of sporophytes. Altos de Campana National Park (Panama).

Fig. 26. Mosses. **A.** *Calymperes palisotii*. Gametophyte, leaves with single costa (midrib). Size of plant = 3 mm tall. Bahía Honda. *Salazar Allen et al.* 19902 (PMA). **B.** *Cyclodiction* sp. Leaf with double costa. 100x. Santa Fé (Veraguas). *Villarreal* 4 (PMA). **C.** Ecostate leaf (without costa) of Sematophyllaceae. Leaf = 600 μ m long. 200x. Bahía Honda. *Salazar Allen et al.* 20329 (PMA).

Fig. 27. Types of calyptra. **A.** Mitrate or campanulate. *Groutiella* sp. 25x. Veraguas, *Salazar Allen* 4. **B.** Cucullate. *Octoblepharum pulvinatum*. Type (L). **Urn** = urn of capsule, **Ope** = operculum, **Cal** = calyptra.

Fig. 28. Paraphyses. *Syrrophodon incompletus*, antheridia with paraphyses. 100x. Barro Colorado Island, *Salazar Allen* 6595 (PMA).

Fig. 29. *Octoblepharum albidum*. **A.** Old, dehisced sporophytes with seta, urn and calyptra on the far right. Operculum has fallen. Peru. *Ule* 2562 (H-BR). **B.** *Taxithelium planum*, double peristome, opening. Parque Natural Metropolitano (Panama).

Fig. 30. *Calymperes afzelii*. **A.** Base of leaf showing cancellinae of hyaline cells and teniola (intramarginal area of elongated cells). **B.** Adaxial view of upper portion of leaf modified into gemmae producing area. Width of apex = 45 μ m. 200x. **C.** Abaxial view of apex with lamina bent inside, apical area is almost all costa nearly devoid of lamina. 200x. Canales de Tierra Island, *Salazar Allen et al.* 19962 (PMA).

Fig. 31. *Calymperes erosum*. **A.** Upper portion of plant, gemmiferous leaf at middle, vegetative leaf on lower right of it. 50x. **B.** Close view of apex of gemmiferous leaf. Note cancellinae of hyaline cells on the right hand side of upper leaf. 100x. **C.** Magnified view of gemmiferous head, diameter of head = 170 μ m. 200x. Canales de Tierra Island, *Salazar Allen et al.* 20144 (PMA).

Fig. 32. *Calymperes palisotii*. **A.** Habit. 32x. Canales de Tierra Island, *Salazar Allen et al.* 19902 (PMA). **B.** Gemmiferous leaves. 32x. **C.** Magnified view of apex forming a receptacle where gemmae will be produced. 50x. **D.** Detached gemmae. Small gemmae = 251.32 μ m long. 400x. Canales de Tierra Island, *Salazar Allen et al.* 20144 (PMA).

Fig. 33. *Syrrhopodon parasiticus*. **A.** Cells near costa, abaxial view of leaf; average size of cells ca. 20 μ m. 400x. **B.** Gemmiferous leaf. 100x. Bahía Honda, Salazar Allen et al. 20487 (PMA).

Fig. 34. *Syrrhopodon incompletus*. Cross section of leaf above cancelinae showing costa at middle with central guide cells (large ones) surrounded by stereids (supporting cells). Note flaring margin of leaf, it bears double teeth.

Fig. 35. *Taxithelium planum*. **A.** Seriate papillae on lumen of cells. 400x. Parque Natural Metropolitano, Salazar Allen s.n.

Fig. 36. *Trichosteleum sentosum*. **A.** Inflated thick-walled alar cells at base of leaf. Middle alar cell = 34.2 μ m long. **B.** Apex of leaf showing cells with single papillae. 200x. Canales de Tierra Island, Salazar Allen et al. 19837 (PMA).

Fig. 37. *Leucobryum* sp. **A.** Upper portion of leaves. 100x. **B.** Lower portion of leaf showing abaxial hyalocysts (hyaline cells). 100x. **C.** Cross section of leaf at middle. Note central layer of chlorocysts (green cells, **ChI**) surrounded by hyaline cells (hyalocysts, **Hyl**). Width of midleaf = 118.8 μ m. Bahía Honda, Salazar Allen et al. 20460 (PMA).

Fig. 38. *Octoblepharum albidum*. **A.** Habit. Bahía Honda. Photo Niko López. **B.** Magnified view of plants, **Ca** = calyptra, **Es** = sporophyte. **C.** Cross section at midleaf. Note pores (**Por**) of hyalocysts (**Hyl**) and central layer of chlorocysts (**ChI**). 400x. **D.** Gemmae growing from rhizoids produced at apex of leaf. Green gemmae = 141.5 μ m long. 400x. C-D from Bahía Honda, Salazar Allen et al. 20333 (PMA) **E.** Peristome, dorsal view, midtooth = 92.7 μ m long. E-F from Bahía Honda, Salazar Allen et al. 20321 (PMA).

Fig. 39. *Fissidens guianensis*. **A.** Habit, **Ga** = gametophyte, **Es** = sporophyte. **B.** Magnified view of single gametophyte, **Al** = apical or ventral lamina, **VI** = vaginant lamina, **DI** = dorsal lamina. Altos de Campana National Park (Panama), Salazar Allen s.n. **C.** *Fissidens weiri* var. *weiri*. Portion of leaf showing margin (**Ma**) with elongated cells (limbidium), costa (**Co**) and vaginant lamina (**VI**). 200x. **D.** *Fissidens mollis*. Propagulae on axils of leaves, longest propagulum = 120 μ m. **E.** Cross section of leaf, note midrib (**Co**) with thickened border cells (stereids), dorsal (**DI**) and vaginant (**VI**) laminae. Width of costa = 44.5 μ m. 200x. Bahía Honda, Salazar Allen et al. 20525 (PMA).

Fig. 40. *Chryso-hypnum diminutivum*. Portion of branch with papillose leaf cells by projecting ends. Fourth leaf from bottom left = 0.5 mm long. 100x. Canales de Tierra Island, Salazar Allen et al. 19758 (PMA).

Fig. 41. *Pirella*. **A.** On bark of tree, 1.6 m above ground level. **B.** Magnified view of branch. Altos de Campana National Park (Panama).