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Cyanolichens of the Galapagos Islands – The genera *Collema* and *Leptogium*

Blaualgenflechten auf den Galapagos Inseln – Die Gattungen *Collema* und *Leptogium*

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Schlagwörter: Flechten, Inselbiogeographie, Collemataceae, *Leptogium, Collema,* Galapagos, Blaualgenflechten.

Summary: As part of a recent species inventory of lichens of the Galapagos Archipelago, 14 islands were visited, new specimens were collected, and recent and historic herbarium material was revised. Results of this study are presented here for the Collemataceae. In the family, only two genera are known from the islands: *Collema,* and *Leptogium*. The low, semi-arid islands support very few species. *Collema* is generally poorly represented, but *Leptogium* is relatively common in the humid highlands on islands with altitudes above 80-100 m. In total ten species are reported with detailed descriptions and a key, three species of *Collema,* seven species of *Leptogium.* The following are new to Galapagos: *Collema leptaleum, C. texanum, Leptogium azureum, L. javanicum* and *L. phyllocarpum.* A previous report of *L. isidiosellum* is based on an erroneous identification of *L. milligranum.*

Zusammenfassung: Im Rahmen eines Gesamtarteninventars der Flechten von Galapagos wurden bisher 14 Inseln des Archipels besucht, Herbarproben gesammelt, und historische Aufsammlungen revidiert. Resultate dieser Untersuchungen werden hier für die Familie Collemataceae zusammengefasst. Aus der Familie sind bisher die Gattungen *Collema* und *Leptogium* nachgewiesen. Auf den flachen, trockenen Inseln kommen generell nur wenige Arten vor. Die Gattung *Collema* ist mit nur drei Arten vertreten, hingegen ist *Leptogium* mit sieben Arten zumindest in den kühl-feuchten Hochlagen der Inseln (über 80-100 m) recht häufig. Insgesamt zehn Arten werden hier mit detaillierten Beschreibungen aufgeführt; davon sind die folgenden Arten neu für Galapagos:

Collema leptaleum, C. texanum, Leptogium azureum, L. javanicum und *L. phyllocarpum*. Ein früherer Nachweis von *L. isidiosellum* basiert auf Fehlbestimmungen von *L. milligranum*. Für alle Arten ist ein Bestimmungsschlüssel beigefügt.

Resumen: Como parte de un inventario general de las especies de líquenes de Galápagos, 14 islas del archipiélago fueron visitadas. En estas islas se han colectado muestras para el herbario, adicionalmente se han revisado colecciones históricas. Aquí se presenta resultados del inventario para la familia Collemataceae de la cual en Galápagos están conocidos los dos géneros *Collema* y *Leptogium*. En general, las islas bajas y áridas del archipiélago solamente soporten pocas especies. El genero *Collema* está presente solamente por tres especies, pero el genero *Leptogium* es mas común con siete especies, la mayoría típicamente prefiere las partes altas y húmedas de las islas (más que 80-100 m). En total diez especies son conocidas de las islas, de ellas las siguientes son nuevas para Galápagos: *Collema leptaleum, C. texanum, Leptogium azureum, L. javanicum y L. phyllocarpum*. Previos reportes de *L. isidiosellum* están basados en erróneas identificaciones de *L. milligranum*. Para todas estas especies se han incluido claves de identificación y descripciones detalladas.

Introduction

The Galapagos need little introduction. They are world famous. A brief, five-week visit in 1835 changed Charles Darwin's personal perception of the living world. His theory of natural selection revolutionized biological thinking and laid the groundwork for modern biology based on his coherent theory of evolution, and the first dynamic and thus truly scientific species concept.

For more than 150 years the islands subsequently inspired countless scientists. Today the archipelago is still referred to as a living laboratory of evolution. Despite this general interest, many inconspicuous organisms, which are less iconic than Darwin's Finches, Marine Iguanas, or Giant Tortoises have received little or almost no scientific attention. The last inventory of lichens by William A. WEBER dates back to the 1960s (WEBER 1966, WEBER & GRADSTEIN 1984, WEBER et al. 1977). It culminated in the publication of a preliminary checklist (WEBER 1986), and a brief update (WEBER 1993). Both lists are included without additional field work or a major revision of specimens in the Catalogue of the Lichens of the Smaller Pacific Islands (ELIX & MCCARTHY 1998).

The Galapagos are not only outstanding because of their importance in the history of biological sciences. They also remain one of the last tropical island ecosystems where the original biodiversity still remains almost entirely intact (SNELL et al. 2002, TYE et al. 2002). Until recently the islands have largely been spared a fate that is sadly characteristic for most other tropical archipelagos: massive waves of extinction of native and endemic species caused by the introduction of alien, invasive species from human settlers. Their relatively late discovery by the Bishop of Berlanga in 1535, their hostile and dry environment, and the strong isolation (1000 km off the coast of mainland Ecuador) are among the first reasons that Galapagos still remains unique. The foundation of the Galapa-

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gos National Park in 1964 and the inclusion of 97% of the land mass also were fundamental.

Today a vivid island tourism industry threatens this fragile balance and only recently the Galapagos, the first Natural World Heritage Site, were included by the UNESCO in the list of endangered World Heritage Sites.

Within this context, understanding the natural biodiversity, the ecological requirements of all species, not just a few iconic selected ones, remains fundamental. The vascular plant flora has been studied extensively (McMullen 1999, Wiggins & Porter 1971). In 2006, the Charles Darwin Research Station now started a first comprehensive inventory of non-vascular plants and plant-like organisms. Since then 14 different islands have been visited and almost 8,000 specimens have been collected and deposited at the herbarium of the Charles Darwin Research Station (CDS). With the beginning of this field work it became obvious that at least twice as many lichen species occur throughout the archipelago as are included in the most recent update of Weber's original list (Elix & McCarthy 1998).

This publication presents a brief review of the Galapagos Collemataceae: Ten species are reported in total, of these five species are new records, one previous record is based on an erroneous identification; detailed species descriptions and a key to all Galapagos species are also provided.

Methods

All specimens of *Collema* and *Leptogium* from Weber's original collections (COLO) were revised. In addition new specimens were collected during visits to the following island. In 2006 the author and consultant André Aptroot visited Isabela (Volcán Alcedo), Plaza Norte, Plaza Sur, Pinzón, Rocca Gordon, San Cristóbal, Santa Cruz, and Santiago. During 2006-2007 the author visited Bartolomé, Pinta, Rábida, San Cristóbal, and Santiago. On the following islands specimens were collected by CDRS staff Anne Guézou and Walter Simbaña: Floreana, and Española. Reports of specimens from Fernandina are based on Weber (1986).

Generally all different habitats were visited during these collection trips. Many islands are low and dry, and only few vegetation zones can be distinguished. Only few species of the Collemataceae occur in these semi-arid areas, and therefore little or no material was collected here. The higher islands however are characterized by humid zones, and the inhabited islands (Floreana, Santa Cruz, Isabela and San Cristóbal) also have extensive farmland areas. The following vegetation zones can generally be distinguished (sensu Tye et al. 2002, modified from Wiggins & Porter 1971):

(1) a Coastal Zone characterized by rocky lava shores, mangroves and occasional beaches (2) a Dry Zone with extensive bare lava flows, scrubland or

open forest dominated by *Bursera graveolens* (3) a Transition Zone, often characterized by the endemic guava tree *Psidium galapageium*, and typically draped in curtains of *Ramalina usnea* (4) a Humid Zone that differs from island to island and can be further subdivided into different vegetation types like the *Zanthoxylum fagara*-forest that is typically densely covered in carpets of *Frullania* spp., the *Scalesia* forests that are dominated by endemic *Scalesia*-trees, and the extensive scrubland dominated by endemic *Miconia robinsoniana*, ferns or *Tournéfortia* spp.; and finally (5) a High-altitude Dry Zone, which is only present above the cloud level and restricted two only two Islands, Isabela and Fernandina.

Specimens were studied at the facilities of the Charles Darwin Research station (CDRS), databased, deposited into the herbarium (CDS), and identified using BRODO (2001), JØRGENSEN & NASH (2004), SCHULTZ et al. (2004), and SWINSCOW & KROG (1988).

The Species

Collema furfuraceum DU RIETZ, Ark. Bot. **22**A: 3 (1929).

Thallus black to brownish black when dry, deep black when wet, foliose, adnate, moderately thick; outline orbicular; lobes distinct, broad; surface with conspicuous, broad pustules and lengthwise folds (ridges); isidia numerous, abundant, on ridges and pustules, rarely marginal, initially globular but soon becoming cylindrical, mostly simple, but occasionally branched with age, concolorous or darker than the thallus; apothecia not seen (Galapagos specimens).

Substrate & Ecology: A very common element of the dry lowlands, on a variety of trees or shrubs like *Bursera graveolens, Accacia rorudiana*, or *Opuntia* ssp., occasionally also found in the transition zone, on *Zanthoxylum fagara, Psidium galapageium, Pisonia floribunda*, etc.; not found in the moist uplands.

Distribution: Currently known from Isabela Island (Volcán Alcedo), San Cristóbal, Santa Cruz, and Santiago.

Notes: *Collema furfuraceum* is easily recognized by its deep black to brownish black color and the pustulate, ridged, densely isidiate surface.

Selected specimens: **Isabela Island:** Volcán Alcedo, along the trail going up the E-slope, at the NW-side of the trail, 0° 24′ 5″ S, 91° 2′ 36″ W, 420, dry zone; open *Bursera graveolens* stand with an occasional *Pisonia floribunda* and *Zanthoxylum fagara* and shrubs of *Macraea laricifolia* and *Waltheria ovata*, on bark, trunk of *Bursera graveolens* (ca. 25 cm in diam.), SE-exposed, 3 Sep 2006, BUNGARTZ 4362, CDS no. 28446. **San Cristóbal Island**: road leading out of Wreck Bay, on *Bursera*, 20 May 1976, J. LANIER s.n., L-63707, COLO no. 298472. **Santa Cruz Island**: Puerto Ayora, near begin of road to Baltra, 0° 44′ 34″ S, 90° 13′ 27″ W, 25 m, on bark of *Bursera*, 26 May 2005, APTROOT 63076, CDS no. 29804; along the trail from Puerto Ayora to Bahía Tortuga, 0° 44′ 48″ S, 90° 19′ 14″ W, 28 m, decidous forest in dry zone; with *Bursea graveolens, Acacia rorudiana*, and *Opuntia echios*;

over basalt, on bark, trunk of *Bursera graveolens*, sunny, wind- and rain-exposed, SW-exposed, 1 May 2006, BUNGARTZ 3331, CDS no. 26998; vicinity of Academy Bay, vicinity of seismic station, on *Bursera graveolens*, WEBER 20 (L-40207), COLO no. 189288. **Santiago Island:** E of salt lake at Santiago Bay, 91° 49′ 40″ W, 0° 14′ 25″ S, 70 m, open *Bursera* forest on pahoehoe lava flow, on *Bursera*, 30 Mar 1971, Pike 15-9 (L-55428), COLO no. 255997; Santiago Bay, on cactus, Dawson s.n. (L-41032), COLO no. 192952.

Collema leptaleum TUCK., Proc. Am. Acad. Arts. Sci. **6**: 263 (1864).

Thallus olive green to blackish grey when dry, darker when wet, foliose, adnate to ± loose, moderately thick; outline irregular; lobes indistinct, broad; surface smooth, dull, irregularly nodulose, but not broadly pustulate, occasionally fenestrate; lacking true isidia, but often broadly lobulate with conch-like ascending lobes; apothecia sessile, laminal, expanded; disk deep reddish brown, flattened to becoming slightly convex; margin lecanorine, concolorous with thallus, with a broad, loosely prosoplectenchymatous outer thalline exciple, and a distinct inner paraplectenchymatous proper exciple; ascospores vermiform, with rounded ends, ± coiled inside the ascus, typically 3-5 septate, 35-40 x 3-5 µm.

Substrate & Ecology: Rare, known only from three collections, on bark of *Bursera*, *Clerodendrum*, and *Tournefortia*; all in the transition zone (see below).

Distribution: New to the Galapagos; currently known only from Santiago and Isabela (Volcán Alcedo).

Notes: The species can easily be recognized by the strongly nodulose thallus with abundant, slightly convex apothecia and vermiform spores that are often ± coiled inside the ascus.

Specimen examined: **Isabela Island**: Volcán Alcedo, outer SE-exposed slope, ca. 500 m below the crater rim, 0° 27′ 13″ S, 91° 5′ 46″ W, 1035 m, humid zone; *Paspalum conjugatum* with scattered shrubs of *Tournefortia rufo-sericea*, on bark of *Tournefortia*, 3 Jun 2006, APTROOT 64844, CDS no. 31420. **Santiago Island**: along the trail from Bucanero to Jaboncillos, ca. 200 m below the summit, Cerro Gavilan, 0° 12′ 9″ S, 90° 47′ 3″ W, 796 m, upper transition zone; open *Psidium galapageium* forest with *Zanthoxylum fagara*, dense understory of *Clerodendrum molle*, *Tournefortia pubescens* and others, on bark of *Clerodendrum molle*; sunny, wind- and rain-exposed, 23 Mar 2006, BUNGARTZ 4738, CDS no. 28849; along the trail from Bucanero to Jaboncillos, ca. 5 km SE of Bucanero, 0° 11′ 19″ S, 90° 47′ 48″ W, 562 m, transition zone; open woodland of large *Bursera graveolens* and smaller *Psidium galapageium* trees with *Blainvillea dichotoma*, *Mentzelia aspera* and *Senna obtusifolia*, on bark of *Bursera graveolens*, W-exposed; semi-shaded, wind- and rain-sheltered, 22 Mar 2006, BUNGARTZ 4655, CDS, no. 28742.

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Collema texanum TUCK., Proc. Amer. Acad. Arts & Sci. 5: 385 (1862).

Thallus olive green, usually not black (even when wet), foliose, adnate to ± loose, moderately thick; outline irregular; lobes distinct, elongated, convex, canaliculate below, repeatedly furcate with down-turned and apically broadened ends; surface smooth, dull; isidia absent, sparse or common, globular, swollen, or inflated, with age rarely ± flattened; apothecia occasional to common, sessile to barely stalked, laminal, expanded; disk deep reddish brown, flattened to slightly concave or convex; margin lecanorine, concolorous with thallus, with a broad, densely prosoplectenchymatous outer thalline exciple, and a distinct inner prosoplectenchymatous proper exciple; ascospores ellipsoid to subfusiform, with acute to blunt ends 1(-3) septate, 12-22 x 4-7 µm.

Substrate & Ecology: In the Galapagos this is currently the only *Collema* species known from rock (basalt lava); moderately common; typically found in the transition zone, but some specimens also from the dry and humid vegetation zones.

Distribution: New to the Galapagos; currently known from Santa Cruz, Isabela, and Santiago.

Notes: The species can typically be recognized by the convex, narrow, repeatedly branched lobes that are canaliculate below.

Selected specimens: **Santa Cruz Island**: Puerto Ayora, near begin of road to Baltra, 0° 44′ 34″ S, 90° 13′ 27″ W, 25 m, on rock (lava), 26 May 2005, APTROOT 63102. **Santiago Island**: along the trail from Bucanero to Jaboncillos, ca. 3 km SE of Bucanero, 0° 10′ 52″ S, 90° 48′ 33″ W, 362 m, transition zone; open woodland of large *Bursera graveolens* and smaller *Psidium galapageium* trees, grassland and basalt boulders, on rock (basalt lava), 22 Mar 2006, APTROOT 65411. **Isabela Island:** Volcán Alcedo, along the trail going up the E-slope, basalt rubble field to the SE-side of the trail and the barranco, 0° 24′ 3″ S, 91° 2′ 35″ W, 434 m, dry lowlands; basalt rubble field with scattered vegetation *(Bursera graveolens, Zanthoxylum fagara, Pisonia floribunda, Senna pistaciifolia)*, on rock (basalt lava), 9 Mar 2006, APTROOT 64990, CDS no. 31570.

Leptogium azureum (SW. ex ACH.) MONT., in Webb & Berthold, Hist. nat. Iles Canar. **3**(2): 129 (1840).

Thallus slate gray to grayish black when dry, olive when wet, foliose, adnate, papery thin; outline ± orbicular; lobes distinct, elongate, ± broadened and flattened, regularly spreading (fan-shaped); surface smooth to barely striate, but not distinctly wrinkled, dull; lacking isidia; apothecia common, sessile to shortly stalked, laminal, expanded; disk pale to deep reddish brown, initially concave, flattened with age; margin lecanorine, concolorous with thallus or slightly pallid, with a broad paraplectenchymatous outer thalline exciple and an inner, indistinct, thin, prosoplectenchymatous proper exciple; ascospores ellipsoid to

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subfusiform, submuriform, 3-5 transversely, and (0)-1 longitudinally septate, 15-28 x 7-10 µm.

Substrate & Ecology: A common species throughout the humid vegetation of islands with higher elevations, most typical in the *Scalesia*-forest; typically on bark, rarely also on leaves or soil (humus), occasionally on rock.

Distribution: New to Galapagos, currently known from Floreana, Isabela, Santa Cruz, and Santiago.

Notes: A broad lobed species with sessile apothecia and no isidia, at first glance similar in appearance to *L. cyanescens*, which roughly has the same size, but is typically densely isidiate and rarely develops apothecia. Easily confused with *L. punctulatum*, another species that is very similar in size and overall appearance lacks isidia and is typically fertile. *Leptogium punctulatum*, however, has a two-layered thallus with numerous pits that correspond to attachment points where the two layers adhere to one another.

Leptogium azureum was originally confused with *L. cochleatum*, but all Galapagos specimens lack a distinctly paraplectenchymatous inner exciple and broad paraplectenchymatous hypothecium. Instead the proper exciple and hypothecium of all specimens is thin and prosoplectenchymatous.

Specimens examined: **Floreana Island**: 560 m, on *Psidium*, Itow 9 (L-40713), COLO no. 192200. **Isabela Island**: Volcán Alcedo, outer SE-exposed slope and crater rim, 0° 27′ 29″ S, 91° 7′ 19″ W, 1089 m, moist upland; disturbed by former grazing of goats therefore scattered trees *(Tournefortia rufo-sericea, Zanthoxylum fagara)*, on bark of *Tournefortia rufo-sericea*. **Santa Cruz Island**: ca. 1 km SE of Puntudo, 0° 39′ 12″ S, 90° 19′ 58° W, 673 m, humid zone with dominant *Pteridium arachnoideum*, *Polypodium* spp., *Thelypteris oligocarpa*, on dead leaves of *Pteridium arachnoideum* on the ground, 1 Feb 2006, ZIEMMECK 547, CDS no. 27105; Tras del Puntudo, ex finca de Don Benito, 0° 38′ 23″ S, 90° 19′ 57″ W, 732 m, Zona húmeda, sobre corteza de *Scalesia penduculata*, altura al pecho, 3 Feb 2007, NUGRA 383, CDS no. 35138. **Santiago Island**: outer S-exposed slope of Cero Gavilan, 0° 12′ 22″ S, 90° 47′ 6″ W, 815 m, fern-sedge zone; non-wooded summit pampa with *Portulaca oleraceum*, *Ageratum conyzoides*, *Cyperus virens*, *Digitaria ciliaris*, basalt boulders and outcrops, on bark of *Croton*, 23 Mar 2006, APTROOT 65537, CDS no. 32126.

Leptogium cyanescens (PERS.) KÖRB., Syst. Lich. Germ.: 420 (1855).

Thallus slate gray to grayish black when dry, olive when wet, foliose, adnate, papery thin; outline ± orbicular; lobes distinct, elongate, ± broadened and flattened, regularly spreading (fan-shaped); surface smooth to barely striate, dull, but not distinctly wrinkled; isidia numerous, quite variable in shape and size, either cylindrical and typically becoming branched, or becoming flattened, scale-like or lobules (phyllidiate), abundant across the thallus surface, but occasionally also along the thallus margin; apothecia rare, sessile to shortly stalked,

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laminal, expanded; disk pale to deep reddish brown, initially concave, flattened or indistinctly convex with age; margin lecanorine, typically pale, cream colored, rarely concolorous with the thallus, entire or isidiate, with a broad paraplectenchymatous outer thalline exciple and an inner, indistinct, thin, prosoplectenchymatous proper exciple; ascospores ellipsoid to fusiform, typically transversely 3-septate, rarely becoming submuriform with the formation of an additional longitudinal septum, 19-24 x 6-12 µm.

Substrate & Ecology: A very common epiphyte, occasionally epiphyllic (fern fronds, large leaves), less common on plant debris, rarely on soil (humus), occasionally also on rock; throughout the humid vegetation zones of islands with higher elevations, most typical in the *Scalesia*-forests, but also in *Zanthoxylon*- and *Miconia*-forests zone and throughout the agricultural areas of inhabited islands.

Distribution: One of the most common species of *Leptogium* in the Galapagos; currently known from Santa Cruz, Isabela, Santiago, Pinta, and San Cristóbal Island.

Notes: Easily recognized as a broad lobed species with abundant isidia, rarely also with apothecia. Similar in size and overall appearance to the non-isidiate *L. azureum*. Swinscow & Krog (1988) suggested that the two taxa form a classical species pair.

Selected specimens: **Isabela Island**: Volcán Alcedo, outer SE-exposed slope, ca. 500 m below the crater rim, 0° 27′ 13″ S, 91° 5′ 46″ W, 1035 m, humid zone; *Paspalum conjugatum* with scattered shrubs of *Tournefortia rufo-sericea*, on bark of *Tournefortia*, 6 Mar 2006, APTROOT 64845, CDS no. 31421; on crater rim SE of hut, 0° 27′ 35″ S, 91° 6′ 43″ W, 1080 m, humid zone; tortoise pasture with scattered trees *(Tournefortia rufo-sericea, Zanthoxylum fagara)*, on bone, carapace of living tortoise shell, 5 Mar 2006, APTROOT, 64823, CDS no. 31398. **Pinta Island**: along the trail up to the summit from the S-coast, 0° 34′ 39″ N, 90° 45′ 7″ W, 436 m; dense forest of *Zanthoxylum fagara*, few *Pisonia floribunda*, and the vine *Cissampelos pareira*; *Justicia galapagana* in understory, on bark, twigs of *Pisonia floribunda* (ca. 2 cm in diam.); shaded, wind- and rain-sheltered, 26 Feb 2007, BUNGARTZ 5802, CDS, 33475. **San Cristóbal Island**: along trail between entrance to Cerro Pelado and Cerro Partido, trail to Ripioso, 0° 51′ 40″ S, 89° 27′ 38″ W, 383 m, transition zone; dense forest on abandoned farmland with old trees of *Hippomane mancinella* and introduced species such as *Psidium guajava*, *Passiflora* sp. and an understory of *Chiococca alba* and *Rubus niveus*, on rock, E-exposed slope of small basalt rock; shaded, wind- and rain-sheltered, 28 April 2007, BUNGARTZ 6687, CDS no. 34923. **Santa Cruz Island**: along the road from Bellavista to Los Gemelos, 0° 37′ 55″ S, 90° 23′ 33″ W, 579 m; open *Scalesia pedunculata* forest with *Rubus niveus*, *Psychotria rufipes*, *Zanthoxylum fagara*, and scattered lava boulders, on bark, fallen trunk of *Scalesia* (ca. 15 cm in diam.); semi-shaded, wind- and rain-sheltered, 12 Feb 2006, BUNGARTZ 3484, CDS no. 27240; Tras del

Puntudo, ex finca de Don Benito, 0° 38′ 23″ S, 90° 19′ 57″ W, 732 m, Zona húmeda, sobre corteza, *Scalesia penduculata*, altura al pecho, 8 Feb 2007, NUGRA 388, CDS no. 35143; vicinity of Academy Bay, trail to La Copa, moist zone, tree trunks, WEBER 83 (L-40275), COLO no. 190021. **Santiago Island**: along the trail from Cerro Gavilan to La Central, 0° 13′ 2″ S, 90° 46′ 33″ W, 890 m, moist upland; artificial grassland caused by former grazing with *Setaria parviflora, Cyperus virens, Paspalum galapageium, Pityrograma calomelanos* var. *calomelanos, Rhynchospora nervosa, Doryopteris palmata, Hyptis rhomboidea* and open soil, on soil between pasture grasses, on NW-exposed and ca. 10° inclined slope; sunny, wind- and rain-exposed, 24 Mar 2006, BUNGARTZ 4835, CDS no. 29009; along the trail from the caseta in La Central to La Bomba (at the coast), ca. 2.5 km NE of the caseta, 0° 13′ 41″ S, 90° 44′ 9″ W, 528 m, transition zone; open woodland of *Psidium galapageium, Zanthoxylum fagara, Bursera graveolens, Trema micrantha* and *Opuntia galapageia* with shrubs of *Clerodendrum molle*, on bark, branches of *Pisonia floribunda*; semi-shaded, wind- and rain-sheltered, 25 Mar 2006, BUNGARTZ 4881, CDS no. 29085.

Leptogium javanicum MONT., Syll. Gen. Sp. Crypt.: 379 (1856).

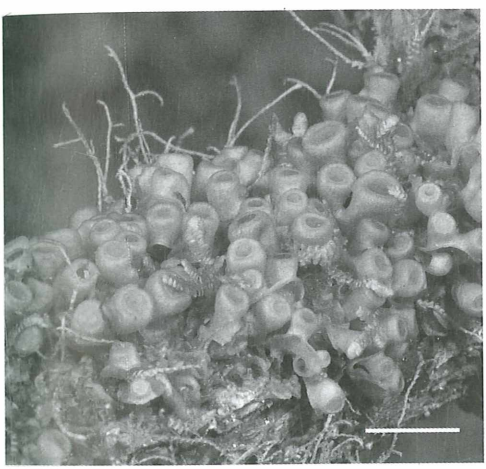

Fig. 1: *Leptogium javanicum;* wet, swollen thallus (bar = 0.5 cm).

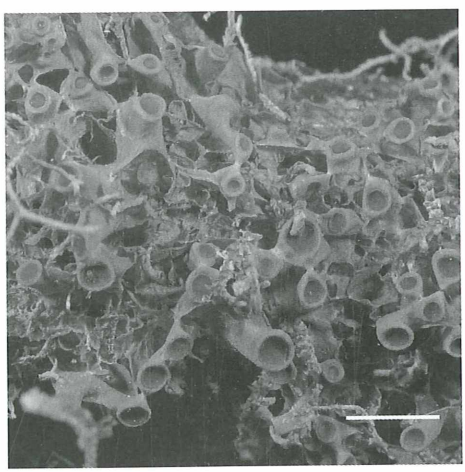

Fig. 2: *Leptogium javanicum;* dry, shrivelled thallus (bar = 0.5cm).

Thallus pale to dark gray when dry, olive green when wet, foliose, loosely attached, thin; outline irregular; lobes folded and contorted when dry, inflated and dome-shaped when wet; surface smooth when wet, indistinctly striate or wrinkled when dry, dull to ± shiny; lacking isidia; apothecia abundant, immersed at the apex of the dome-shaped thallus lobes; disk pale to deep reddish brown, initially concave, soon flattened; margin lecanorine; thalline exciple con-

colorous and confluent with the thallus, of several thick, paraplectenchymatous cell layers; proper exciple indistinct, in section thin and prosoplectenchymatous; ascospores ellipsoid to broadly ellipsoid, with blunt or ± tapered ends, muriform, 4-5 transversely and 1-2 longitudinally septate, 22-30 x 10-15 µm.

Substrate & Ecology: Rare; currently known only from the *Scalesia*-forest, from twigs and branches of the endemic tree *Scalesia pedunculata* and the native shrub *Chiococca alba*.

Distribution: New to the Galapagos; only known from Santa Cruz Island.

Notes: The thalli with inflated dome-shaped lobes and apically immersed apothecia can hardly be confused with any other *Leptogium* species of the Galapagos. Dry specimens may be mistaken for the plicate thalli of *L. phyllocarpum*, a species that, however, has a much thicker, strongly rugose thallus and more commonly grows in the dry rather than the humid zones of the islands.

Selected specimens: **Santa Cruz Island**: along the road to Baltra, S of Los Gemelos, 0° 38′ 43″ S, 90° 20′ 4″ W, 741 m, *Scalesia*-forest; *Scalesia pedunculata* forest with undergrowth of scattered *Chiococca alba* and abundant ground cover (*Valeriana chaerophylloides*, *Diodia radula* and ferns), on bark of trunk of *Scalesia pedunculata* (ca. 15 cm in diam.), E-exposed; shaded, wind- and rain-sheltered, 30 Sep 2006, BUNGARTZ 5526, CDS no. 32867; Cerca la vía sector los Gemelos, 0° 38′ 54″ S, 90° 40′ 6″ W, 661 m, Zona húmeda, sobre corteza, *Scalesia penduculata*, altura al pecho, 4 Jan 2007, NUGRA 283, CDS no. 33199.

Leptogium marginellum (SW.) GRAY, Nat. Arr. Brit. Pl. **1**: 401 (1821).

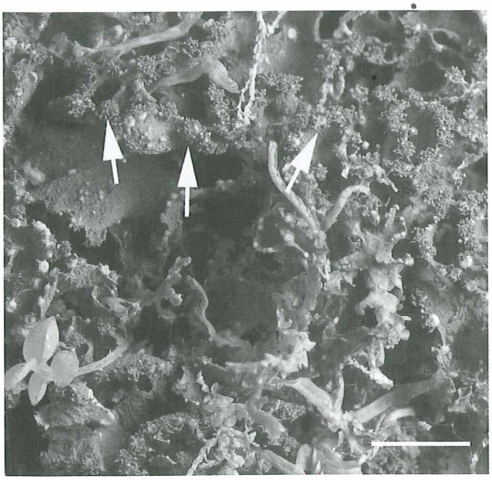

Fig. 3: *Leptogium marginellum;* arrows indicate coronate phyllidiate apothecia (bar = 0.5 cm).

Thallus dark gray to brownish gray when dry, olive brown when wet, foliose, loosely attached, moderately thin; outline irregular; lobes distinct, undulate, ± spreading; surface densely folded (plicate), dull; isidia numerous, granular to elongate phyllidiate, typically coronate-phyllidiate along the apothecial margin, rarely also in granular-coralloid clusters on the thallus surface; apothecia numerous, laminal, abundant across the thallus, sessile to distinctly stalked, globose; disk pale to deep reddish brown, urceolate, becoming concave to flattened; margin lecanorine, initially pale whitish or skin-colored, densely covered with blackish gray isidia (i.e., with a corona of several

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rows of granular to elongate phyllidiate isidia), with a broad paraplectenchymatous thalline exciple, a thin prosoplectenchymatous proper exciple, and a considerably thickened hymenium of mostly sterile paraphyses and few abortive asci; ascospores rarely developed, not seen (in Galapagos material).

Substrate & Ecology: A very common epiphyte, also often on wood, plant debris, and occasionally even on soil (humus); throughout the moist uplands, in all vegetation zones from the upper transition zone to the humid highlands.

Distribution: One of the most common species of *Leptogium* in the Galapagos; currently known from Floreana, Isabela, Santiago, Pinta, and Santa Cruz Island.

Notes: With its coronate granular-phyllidiate apothecia it cannot be easily confused with any other Galapagos species.

Specimens examined: **Floreana Island**: highlands above Cruz Farm, on bark, on *Croton*, 25 Apr 1976, WEBER s.n. (QCA). **Isabela Island**: Cerca las fumarolas, Volcán Alcedo, 0° 27′ 33.3″ S, 91° 6′ 43.2″ W, 1034 m, Zona de pampa, bosque húmedo dominante gramíneas y árboles de *Scalesia microcephala*, on bark, Sobre *Scalesia microcephala*, 29 Sep 2006, NUGRA 165, CDS no. 32819; Volcán Alcedo, outer SE-exposed slope, ca. 500 m below the crater rim, 0° 27′ 13″ S, 91° 5′ 46″ W, 1035 m, moist upland; disturbed by former grazing of goats; with *Dennstaedtia cicutaria*, *Paspalum conjugatum* and with scattered shrubs of *Tournefortia rufo-sericea*, on bark, twigs of *Tournefortia rufo-sericea*; semi-shaded, wind- and rain-sheltered, 6 Mar 2006, BUNGARTZ 4121, CDS no. 28104. **Pinta Island**: along the trail up to the summit from the S-coast, 0° 34′ 39″ N, 90° 45′ 7″ W, 436 m; dense forest of *Zanthoxylum fagara*, few *Pisonia floribunda*, and the vine *Cissampelos pareira*; *Justicia galapagana* in understory, on bark, base of *Zanthoxylum fagara* (ca. 10 cm in diam.), SE-exposed; sunny, wind- and rain-sheltered, 26 Feb 2007, BUNGARTZ 5783, CDS no. 33456. **Santa Cruz Island**: abandoned farm along the northern part of the loop road from Bellavista to Garrapatero, 0° 40′ 58″ S, 90° 18′ 31″ W, 255 m, humid zone; overgrown farm area with introduced trees like *Cedrela odorata*, *Persea americana*, *Syzygium malaccense*, *Cestrum auriculatum* and others; small open clearing, on trunk of *Cedrela odorata* (ca. 40 cm. in diam.), S-exposed; shaded, win- and rain-sheltered, 19 Feb 2006, BUNGARTZ 3683, CDS no. 27501; at base of barranco on old trail to Bella Vista, on *Bursera*, 11 Apr 1976, WEBER s.n. CDS no. 10813; farm along the northern part of the loop road from Bellavista to Garrapatero, 0° 40′ 56″ S, 90° 18′ 40″ W, 259 m, agricultural zone; living fence of thin *Erythrina* spp. (ø ca. 5 cm) around a farm, W-exposed, on bark, *Erythrina velutina*; sunny, wind- and rain exposed, 19 Feb 2006, BUNGARTZ 3707, CDS no. 27565; Tras del Puntudo, ex finca de Don Benito, 0° 38′ 23″ S, 90° 19′ 57″ W, 732 m, Zona húmeda, on bark, *Scalesia penduculata*, altura al pecho, 28 Dec 2006, NUGRA 247, CDS no. 33163; vicinity of Academy Bay, between first barranca and Bella Vista, transition zone, on trees, WEBER 182 (L-40287), COLO

no. 192394. **Santiago Island:** Cerro Gavilan, directly below the summit at the NE-exposed slope, 0° 12′ 19″ S, 90° 47′ 6″ W, 828 m, moist upland; formerly with scrub or forest, disturbed by former grazing therefore shrubs and trees missing; artificial pampa with *Solanum americanum*, *Portulaca oleraceum*, *Senna occidentalis*, *Borreria laevis*, and grasses, basalt boulders and outcrops, on rock, top of small basalt rock; sunny, wind- and rain-exposed, 22 Mar 2006, BUNGARTZ 4713, CDS no. 28811.

Leptogium milligranum SIERK, Bryologist **67**: 290 (1964).

Thallus black to brownish black when dry, deep olive or brownish black when wet, ± adnate, thick, swelling considerably when wet; outline orbicular; lobes indistinct and broadly merging; surface wrinkled, dull, longitudinally folded and thus strongly ridged; isidia numerous, granular, rarely ± subcylindrical; usually abundant all across thallus, especially on the thallus ridges, occasionally also marginal; apothecia not seen in Galapagos specimens.

Substrate & Ecology: On bark or wood, rarely also on rock (basalt lava), moderately common from the transition zone to the lower humid zone, rarely also at higher elevations.

Distribution: Known from Fernandina, Santiago, Santa Cruz, Isabela, and San Cristóbal.

Note: At first glance this species looks more like a *Collema*, but it cannot be easily confused with the three other *Collema* species currently known from Galapagos. Reports of WEBER of *L. isidiosellum* are erroneous; all Galapagos material previously identified as *Leptogium isidiosellum* (Riddle) Sierk has fusing lobes and coarsely granular isidia and thus belongs to *L. milligranum*. The species is often incorrectly reported as *L. millegranum*, the correct spelling being milligranum.

Specimens examined: **Fernandina Island**: W-side 30 m, WEBER 314 (L-40470), COLO no. 193190. **Isabela Island**: Volcán Alcedo, outer E-exposed slope just below the crater rim, 0° 25′ 17″ S, 91° 5′ 8″ W, 1077 m, humid zone; basalt outcrops, SE-exposed slope with scattered shrubs of *Tournefortia rufo-sericea*, *Opuntia insularis*, *Lantana peduncularis* and occasional trees of *Zanthoxylum fagara* among basalt rubble, on bark of *Croton*, 8 Mar 2006, APTROOT 65136, CDS no. 31719; Volcán Cerro Azul, S slope above Iguana Cove, 350 m, on *Scalesia*, 25 Jun 1976, H. SIPMAN 71 (L-63546), COLO no. 297890. **San Cristóbal Island**: plain between Cerro Pelado and Cerro Partido, S of Ripioso, 0° 51′ 31″ S, 89° 27′ 34″ W, 372 m, transition zone; dense shrubland with *Croton scouleri*, *Clerodendrum molle* and *Macraea laricifolia*, on bark, base of *Zanthoxylum fagara*; shaded, wind- and rain-sheltered, 28 Apr 2007, BUNGARTZ 6669, CDS no. 34905. **Santa Cruz Island**: at the North side of the island, along the dirt road to the ash quarry Mina Granilla Roja, 0° 36′ 56″ S, 90° 22′ 3″ W, 570 m, lower transition zone; dry, semi-deciduous forest with *Bursera graveolens* and *Zanthoxylum fagara*, on dead wood

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on the ground, 23 Feb 2006, BUNGARTZ 3894, CDS no. 27776; barranco behind Darwin Station, on *Bursera*, 21 Jun 1971, WEBER s.n. (L-54821), COLO no. 255249. **Santiago Island**: Santiago Bay, Dawson s.n. (L-41036), COLO no. 192948.

Leptogium phyllocarpum (PERS.) MONT., Annls Sci. Nat., Bot., sér. 3, 10: 134 (1848).

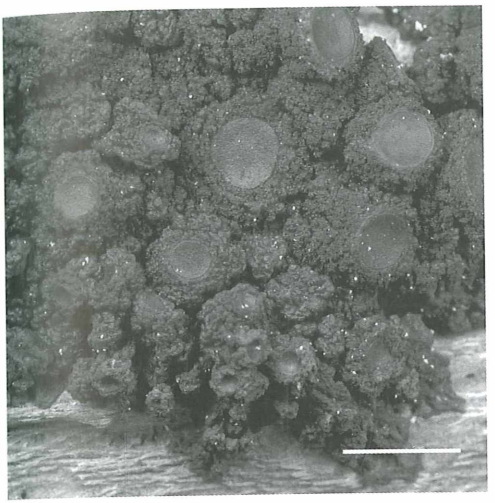

Fig. 4: *Leptogium phyllocarpum* (bar = 0.5 cm).

Thallus gray to dark black when dry, blackish when wet, foliose, adnate, thick, swelling considerably when wet; outline irregular; lobes distinct, narrow and elongated, frequently anastomosing; surface rugose, irregularly contorted and folded (plicate); lacking isidia, but sometimes lobulate along the thallus lobes and apothecial margin; apothecia common, distinctly stalked, submarginal, expanded; disk pale to deep reddish brown, initially concave but soon flattened; margin lecanorine, strongly folded (lamellate), occasionally lobulate, concolorous with the thallus, with a broad paraplectenchymatous outer thalline exciple and an inner, indistinct, thin, prosoplectenchymatous proper exciple; ascospores ellipsoid, muriform, 3-5 transversely septate, 1 longitudinally septate, 22-33 x 10-14 µm.

Substrate & Ecology: On bark or wood, rarely on rock, typically in dry habitats; common throughout the dry and lower transition zone, less frequent at higher altitudes and there typically in relatively dry, exposed habitats.

Distribution: New to Galapagos; known from Santa Cruz, San Cristóbal, Pinta, Santiago, Isabela, and Pinzón Island.

Specimens examined: **Isabela Island**: Volcán Alcedo, along the trail going up the E-slope, basalt rubble field to the SE-side of the trail and the barranco, 0° 24′ 3″ S, 91° 2′ 35″ W, 434 m, dry lowlands; basalt rubble field with scattered vegetation *(Bursera graveolens, Zanthoxylum fagara, Pisonia floribunda, Senna pistaciifolia)*, on bark of *Bursera*, 9 Mar 2006, APTROOT 64962, CDS no. 31541; upper NNW-exposed slope inside the crater, 0° 27′ 27″ S, 91° 7′ 23″ W, 1055 m, humid zone; open vegetation with *Adianthus concinnum*, and scattered shrubs of *Tournefortia rufo-sericea* among basalt rocks, on bark of *Scalesia*, 5 Mar 2006, APTROOT 64875, CDS no. 31452. **Pinta Island**: along the trail up to the summit from the S-coast, 0° 34′ 22″ N, 90° 45′ 3″ W, 329 m, transition zone; open woodland of

Zanthoxylum fagara, *Pisonia floribunda*, and few *Trema micrantha*; grasses and *Justicia galapagana* in the understory, on branch of dead *Trema micrantha*; sunny, wind- and rain-exposed, 27 Feb 2007, BUNGARTZ 5863, CDS 33539; along the trail up to the summit, ca. 3 km inland from the S-coast, 0° 33′ 42″ N, 90° 44′ 45″ W, 161 m, lower transition zone; dense vegetation of *Bursera graveolens*, *Croton scouleri*, *Scalesia baurii*, and few *Chiococca alba*, on bark, trunk of *Bursera graveolens* (ca. 15 cm in diam.), SW-exposed; semi-shaded, ± wind- and rain-exposed, 25 Feb 2007, BUNGARTZ 5679, CDS no. 33314. **Pinzón Island**: along the trail going up from Playa Escondida, N- to W-facing cliff above a crater, 0° 36′ 29″ S, 90° 40′ 14″ W, 318 m, dry transition zone with *Cordia lutea*, *Croton scouleri*, and at the bottom of the cliff also *Scalesia baurii* ssp. *baurii*, on bark, twigs, 16 Feb 2006, APTROOT 64053, CDS no. 30614. **San Cristóbal Island**: plain between Cerro Pelado and Cerro Partido, S of Ripioso, 0° 51′ 31″ S, 89° 27′ 34″ W, 372 m, transition zone; dense shrubland with *Croton scouleri*, *Clerodendrum molle* and *Macraea laricifolia*, on bark, branches of *Croton scouleri*; semi-shaded, wind- and rain-sheltered, 28 Apr 2007, BUNGARTZ 6662, CDS no. 34898. **Santa Cruz Island**: along road from Bella Vista to El Garrapatero, 0° 40′ 24″ S, 90° 14′ 19″ W, 142 m, lower transition zone; open forest of *Bursera graveolens* and few *Pisonia floribunda* at base of lava flow, on bark, E-exposed trunk of *Pisonia floribunda* (ca. 10 cm in diam.); semi-shaded, wind- and rain-sheltered, 15 Oct 2006, BUNGARTZ 5482, CDS no. 29699; at the North side of the island, along the dirt road to the ash quarry Mina Granilla Roja, 0° 36′ 56″ S, 90° 22′ 3″ W, 570 m, lower transition zone; dry semi-deciduous forest with *Bursera graveolens* and *Zanthoxylum fagara*, on rock, NE-exposed slope of basalt outcrop; sunny, wind- and rain-exposed, 23 Feb 2006, BUNGARTZ 3889, CDS no. 27771. **Santiago Island**: ca. 7 km inland from the E-coast, ± at the same latitude as Bahía Sullivan, 0° 17′ 4″ S, 90° 38′ 18″ W, 192 m, dry zone; shrubland of *Castela galapageia* and *Macraea laricifolia* with occasional trees, mostly *Bursera graveolens* and few *Pisonia floribunda*, on bark of *Bursera graveolens*, SE-exposed; semi-shaded, wind- and rain-sheltered, 17 July 2006, BUNGARTZ 5190, CDS no. 29403.

Leptogium punctulatum NYL., in Fournier, Mexic. Pl. **1**: 1 (1872).

Thallus slate gray to grayish black, olive when wet, foliose, adnate to ± loose, papery thin; outline ± orbicular; lobes distinct, elongate, ± broadened and flattened, regularly spreading (fan-shaped), composed of two layers owing to the adherence of thin lobes folded upon one another; surface smooth to barely striate, typically spotted with small pits where the two layers of thallus lobes are riveted to one another; lacking isidia; apothecia common, sessile to shortly stalked, laminal; disk pale to deep reddish brown, initially barely concave, soon flattened; margin lecanorine, often pale brownish, rarely concolorous with thallus, with a broad paraplectenchymatous thalline exciple and an indistinct, thin, prosoplectenchymatous proper exciple; ascospores ellipsoid to subfusiform,

ends often pointed, muriform, 4-5 transversely, and 1-2(-3) longitudinally septate, 25-39 x 10-14 µm.

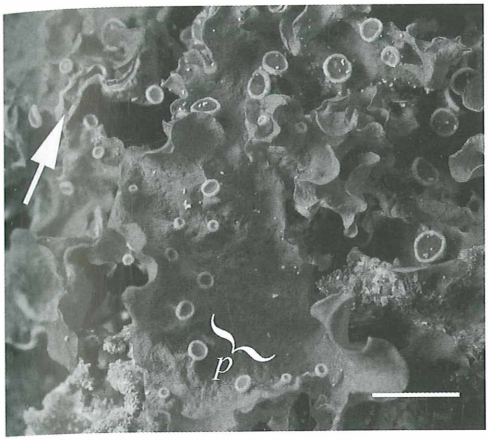

Fig. 5: *Leptogium punctulatum;* arrow indicates the folded double-layered thallus lobes, p pitted thallus surface (bar = 0.5 cm).

Substrate & Ecology: Relatively rare, but possibly overlooked because of its similarity with *L. azureum;* throughout the moist uplands of islands with higher elevations, occasionally also at lower elevations in the transition zone, but not found in the dry zone.

Distribution: Known from Floreana, Isabela, Santa Cruz, and San Cristóbal Island.

Notes: The two layered lobes with attachment pits are characteristic, but can easily be overlooked.

Specimens examined: **Floreana Island**: 560 m, on *Psidium*, Itow 9 (L-40732), COLO no. 192855. **Isabela Island**: Volcán Alcedo, on top of the crater rim, 0° 27′ 33″ S, 91° 6′ 49″ W, 1051 m, moist upland; disturbed by former grazing of goats therefore scattered trees *(Zanthoxylum fagara, Scalesia microcephala, Tournefortia rufo-sericea),* on bark, underside of small inclined *Scalesia* stem (ca. 6 cm in diam.); semi-shaded, wind- and rain-sheltered, 5 Mar 2006, BUNGARTZ 4099, CDS no. 28067. **Pinta Island**: E-slope of the highest crater, 525 m, in open mossy *Zanthoxylum* forest, on horizontal branch of *Pisonia* in shade, 11 Jul 1976, SIPMAN 136 (L-63612), COLO no. 297824. **San Cristóbal Island**: along trail between entrance to Cerro Pelado and Cerro Partido, trail to Ripioso, 0° 51′ 40″ S, 89° 27′ 38″ W, 383 m, transition zone; dense forest on abandoned farmland with old trees of *Hippomane mancinella* and introduced species such as *Psidium guajava, Passiflora* sp. and an understory of *Chiococca alba* and *Rubus niveus,* on bark, trunk of *Psidium guajava* (ca. 5 cm in diam.), N-exposed; semi-shaded, wind- and rain-sheltered, 28 Apr 2007, BUNGARTZ 6675, CDS no. 34911. **Santa Cruz Island**: below and N of Mount Crocker, 650 m, *Scalesia pedunculata* forest, near the margins of the stands where there is more light and less competition with hepatics, on horizontal branches of *Scalesia,* 16 Apr 1976, WEBER Lich. Exs. 505 (L-63680), COLO no. 297756; below Puntudo, 720 m, on bark, tops of horizontal branches of *Scalesia,* 18 Apr 1976, WEBER s.n. (QCA); Santa Cruz, Camote, Finca of René Valle, close to boundary of the National Park of Galápagos, 0° 38′ 21″ S, 90° 17′ 53″ W, 473 m, humid zone; young and dense forest of *Scalesia pedunculata* with

undergrowth of *Chiococca alba*, on bark, trunk of *Scalesia pedunculata* (ca. 10 cm in diam.); shaded, wind- and rain-sheltered, 12 Dec 2006, BUNGARTZ 5555, CDS no. 32996; on tops of horizontal branches of *Scalesia*; below Puntudo, 720 m, 18 Apr 1976, WEBER s.n., CDS no. 10839.

Key to the Species

1 Thallus without a cortex *(Collema)* 2
Thallus with a single-celled cortex *(Leptogium)* 4

2(1) Thallus distinctly pustulate; lobes ridged; with globose isidia becoming cylindrical; often lacking apothecia (not observed in Galapagos specimens) ..... ***Collema furfuraceum***
Thallus not pustulate; lobes often lengthwise folded or narrow, but not distinctly ridged; with or without isidia; usually with apothecia 3

3(2) Ascospores ± ellipsoid, not coiled in ascus, short, typically less than 22 µm long, 2(-4) celled; thallus lobes narrow, convex, canaliculate below, repeatedly furcate, rarely lobulate-isidiate, not fenestrate, on rock ..... ***C. texanum***
Ascospores vermiform, spirally coiled in ascus, 24-40 µm long, 4(-6) celled; thallus lobes ± broadened, ± flattened, not canaliculate below, irregularly spreading, lobulate or ± nodulose, but Galapagos material typically not isidiate, often fenestrate, on bark ..... ***C. leptaleum***

4(1) Thallus lacking isidia, typically with apothecia 5
Thallus isidiate 8

5(4) Thallus papery thin, composed of two layers folded upon one another, surface typically spotted with small pits where the lobes are riveted to one another ..... ***Leptogium punctulatum***
Thallus thin to thick, of one single layer, not distinctly pitted or riveted ... 6

6(5) Thallus thick; lobes rugose-plicate to lamellate; typically densely covered by stipitate apothecia with a strongly undulating, lamellate (folded) margin ..... ***L. phyllocarpum***
Thallus thin to moderately thickened; lobes smooth to rarely striate, not rugose or lamellate; apothecia not stipitate, apothecial margin smooth, not undulating, not lamellate 7

7(6) Thallus lobes flattened, broadened; apothecia laminal, sessile... ***L. azureum***
Thallus lobes strongly inflated, cylindrical, dome-shaped in the humid state, or folded (plicate) when dried-out; apothecia apical, immersed, at tip of the inflated, dome-shaped lobes ..... ***L. javanicum***

8(4) Isidia abundant along the apothecial margin; apothecia thus coronate; clusters of isidia rarely also forming on thallus surface..... ***L. marginellum***

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Isidia abundant on thallus lobes, not along the apothecial margin; apothecia typically with a thin, smooth margin, not coronate 9

9(8) Thallus lobes papery thin, discrete, smooth to faintly striate, not pustulate; isidia fine, cylindrical, occasionally ± flattened, becoming phyllidiate .... ***L. cyanescens***

Thallus lobes thick, fusing, with irregular ridges and pustules; isidia coarsely granular, swollen, not becoming phyllidiate ..... ***L. milligranum***

Discussion

Strongly isolated islands like the Galapagos are characterized by a relatively low species diversity and high numbers of endemic species. With only ten species the Collemataceae are relatively poorly represented in the Galapagos, but none of these species are endemic. On the contrary, all have a fairly wide tropical, or subtropical distribution, some even extend into temperate regions (*L. azureum*, *C. furfuraceum*, etc.). Other groups, like the section *Mallotium* (with a white tomentum on the lower surface), are not present throughout the Archipelago.

It is often argued that the microscopically small propagules of lichens explain why these organisms are widely distributed and why generally very few endemic species can be found among them. WEBER (1986) reported few endemic species for the Galapagos, all from coastal rock or the dry lowlands. This supports the general hypothesis that lichens are widely distributed, even across isolated islands. However, it does not explain the absence of whole species groups or the relatively low diversity of Galapagos Collemataceae.

In the Galapagos most species of the Collemataceae are confined to the moist uplands, where especially *Leptogium* is relatively common and often abundant. Only two species are found regularly in the dry Galapagos lowlands: *Collema furfuraceum*, a very common species, and *Leptogium phyllocarpum*, which is moderately common. Generally most Galapagos species prefer bark or wood as a substrate, *L. marginellum* is often found on decaying wood or on plant debris, a few species are occasionally growing on large leaves of fern fronds, only one species, *Collema texanum*, grows almost exclusively on rock. Differences in distribution between the islands can either be ascribed to relatively incomplete sampling – many areas still remain unvisited – or a general preference for humid habitats with most species absent from the lower, dry islands.

These preferences for humid habitats may also explain the low diversity and low endemism. In vascular plants endemism in the Glapagos is significantly more common among species of dry lowlands; relatively few endemic species occur in the humid highlands. The climate of the islands was generally much drier in the past; therefore it is often argued that plants which are adapted to dry conditions had more time to evolve and differentiate from their ancestors.

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If this hypothesis is correct, it may explain the relatively low species diversity and the absence of endemism of *Leptogium* and *Collema* in the Galapagos. Only few common species that are characteristic for moist habitats may have reached the archipelago at a relatively late time.

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