Lichens of the Golfo Dulce Region, Costa Rica

Corcovado National Park
Piedras Blancas National Park
‚Regenwald der Österreicher'

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Lichens: ‚an introduction

As far as we know, the term 'lichen' was coined by the Greek philosopher Theophrastus around 300 B.C. He noticed unidentified outgrowths of different shapes on the bark of olive trees, and assumed they were mosses. Unlike mosses, however, which are true plants, lichens are a combination of two completely different organisms: a fungus, and an algal or cyanobacterial partner.

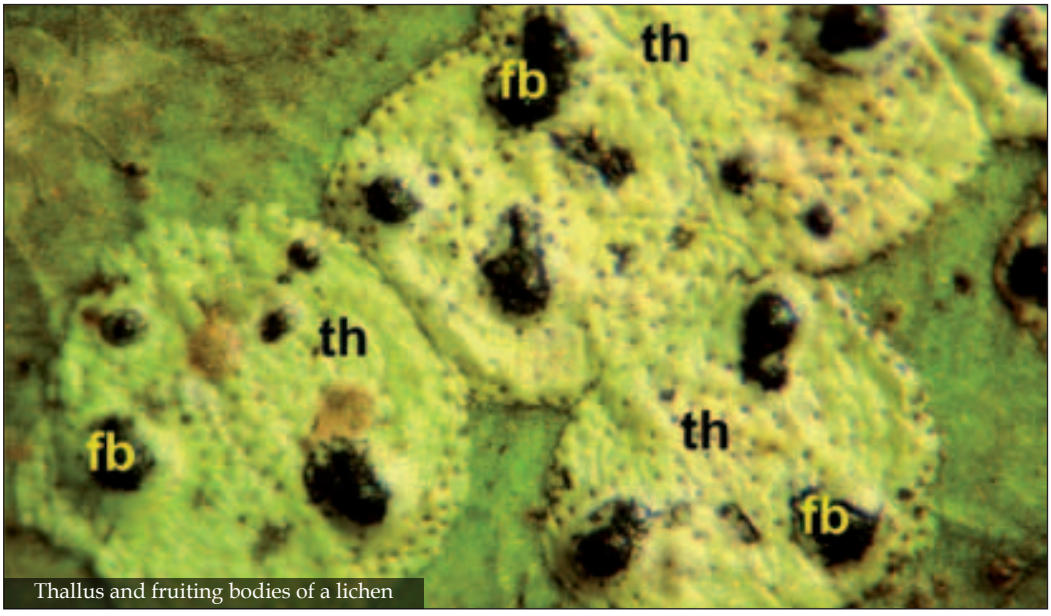
Over the centuries, the scientific term 'lichenology' has been used to cover all aspects of lichen research, including anatomy, physiology and systematics, and it has become a subject of topical interest. The question of whether to classify lichens within the plants has been discussed intensively, but biologists now generally agree in classifying the lichens within the fungi. Lichens are properly characterized as a community of green algae or cyanobacteria (photobiont, i.e. the photosynthetically active partner), and associated fungi (mycobiont).

The evolutionary development of fungi has resulted in a symbiosis that is capable of taking hold in nearly all different biotopes, including the most extreme. The biological partnership within lichens allows them to survive in exceptional living conditions that would be impossible for any other creature, including extremes of temperature or aridity. Lichens can even grow on synthetic materials produced by humans (anthropogenic substances), such as concrete or plastic or metal surfaces on cars. As a consequence, lichen genera thrive all over the world. Although this is true for lichens as a whole, certain groups may be very sensitive to particular ecological factors (e.g. humidity, light exposure or air quality). A large number of lichens, such as foliicolous species, require special light and humidity conditions in rainforests.

It is well known that chemical emissions influence the lichen symbiosis, and the effects of air pollution can be easily seen in lichen. In many countries, the sulphur dioxide in emissions used to be an important problem for lichens. Currently, nitrogen and ammonia emissions are probably causing more damage. Many lichen species react to air pollution by losing vitality, drying, and changing color. Once tolerable values of pollution are exceeded, lichens die and leave behind a 'lichen desert'.

Structure of lichens

The morphology of lichens is characterized by two significant features: the **thallus** (th) and the **fruiting bodies** (fb).



Thallus and fruiting bodies of a lichen

The thallus, which forms the vegetative body of the organism, is built up by the thin and filamentous structures (hyphae) of the mycobiont (fungus). This can show an incredible diversity of shapes, which can be used to identify lichen orders and families. Several morphological groups can be identified this way, including the crustose, foliose, squamulose, shrubby and pendent lichens. Within a group, however, finer aspects of anatomy need to be considered to determine the species.

Algal cells are embedded within the fungal tissue. Special hyphae surrounding these algal cells connect them to the fungal tissue, thus forming the symbiosis. This results in the c. 28,000 species that exist around the world today.

The thallus is divided into several layers, including the upper and lower cortex, the algal layer, a medulla (a layer consisting of hyphae) and rhizines (attachment organs of foliose lichens). The layers differ in cell structure, shape and arrangement according to the lichen species. For example, crustose species do not need a lower cortex because they are in direct contact with their substratum (rocks, wood or leaves).

Usnea sp., shrubby thallus

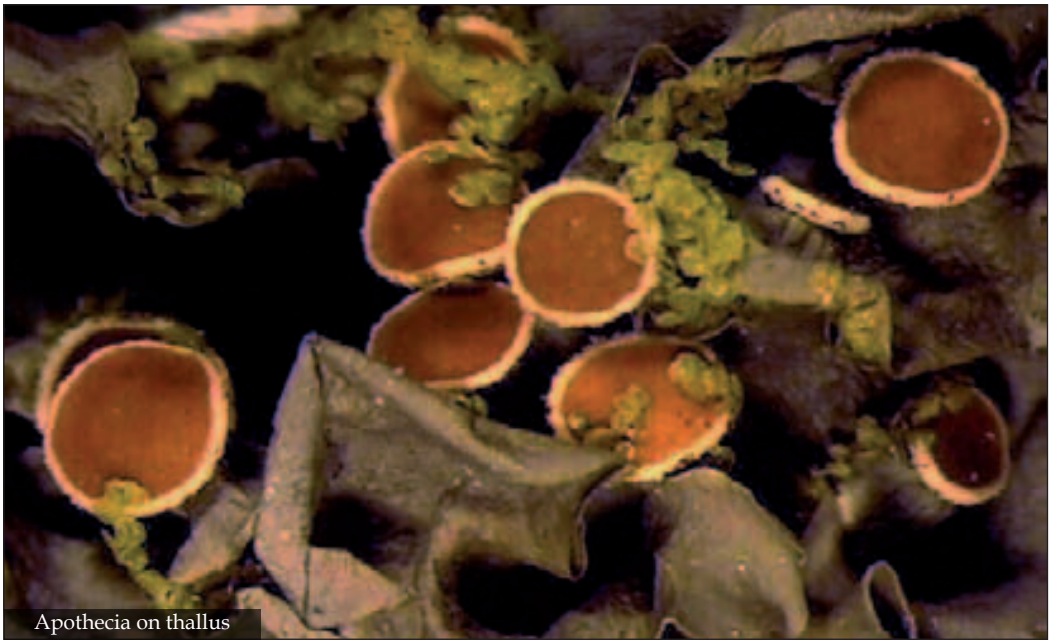
Reproduction

The second characteristic used to identify lichens is the shape and structure of the fruiting bodies found on the upper surface of the thalli (and occasionally on the lower surface). The fruiting bodies of the great majority of lichens are called ascomata, because the ascospores (reproductive units) are formed in special organs (asci) within the fruiting bodies. It is easy to distinguish three basic types of ascomata:

Apothecia: These are cup-shaped (convex or concave) structures similar to fungal fruiting bodies, with different colored disks sometimes covered by a mealy deposit (pruinose) and often surrounded by a special margin. Apothecia can be divided into different segments:

Excipulum: This is the tissue formed around and often underneath the hymenium. It sometimes appears blackened or carbonized (resembling coal) apically, laterally or completely.

Hymenium: This is a layer that develops in the central part of the ascoma, and produces spores. It consists of paraphyses (sterile hyphae) and spore-producing asci, both important features in identification. The hymenium can ap-

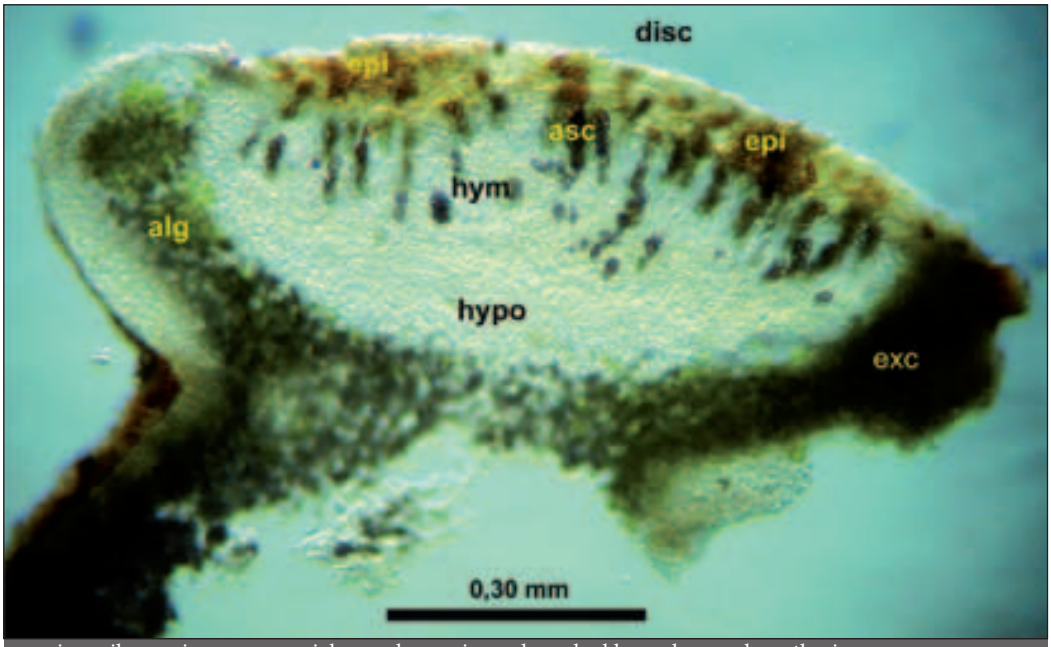


Apothecia on thallus

pear clear or interspersed with oil droplets, and changes its color in chemical reactions with iodine solution.

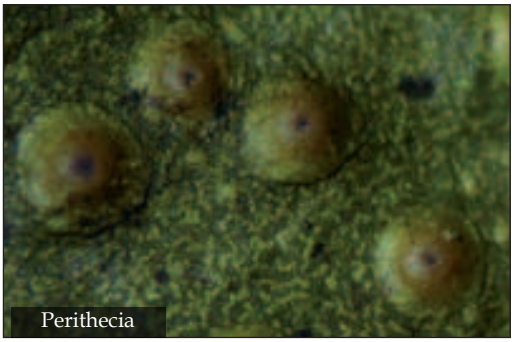
Asci: These are the club-shaped chambers which produce ascospores for reproduction.

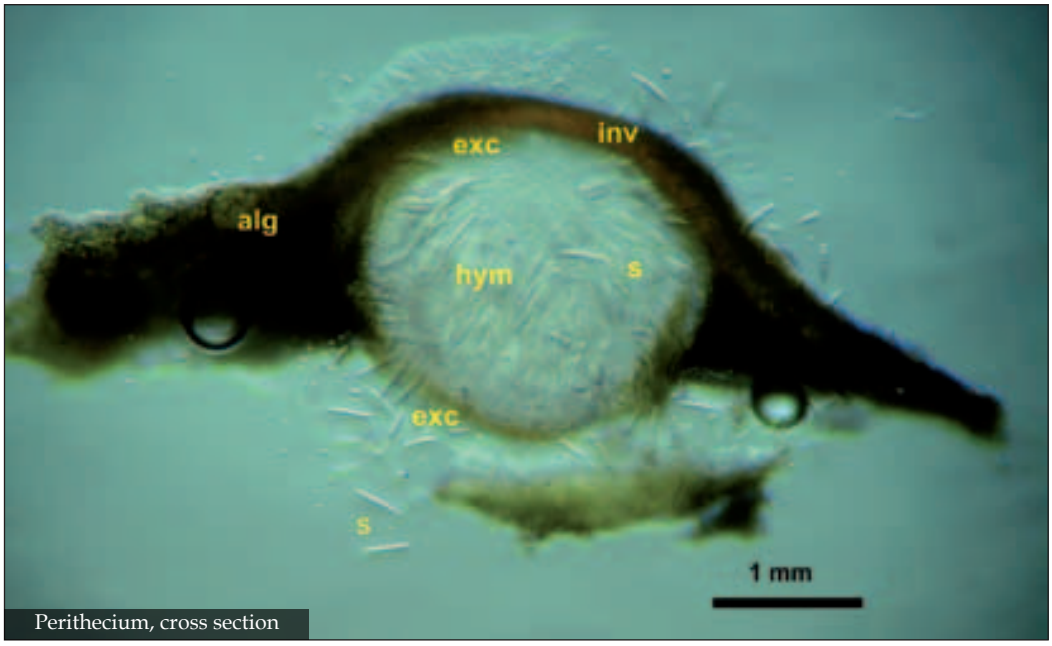
Ascospores (spores): These are reproductive units that develop within the asci. The number of spores depends on the species, but is often eight per ascus. The spores may be simple, variously septate, or muriform. Shape, color and dimension are further diagnostic features. See page 17 for details.



epi = epihymenium, asc = asci, hym = hymenium, alg = algal layer, hypo = hypothecium, exc = excipulum

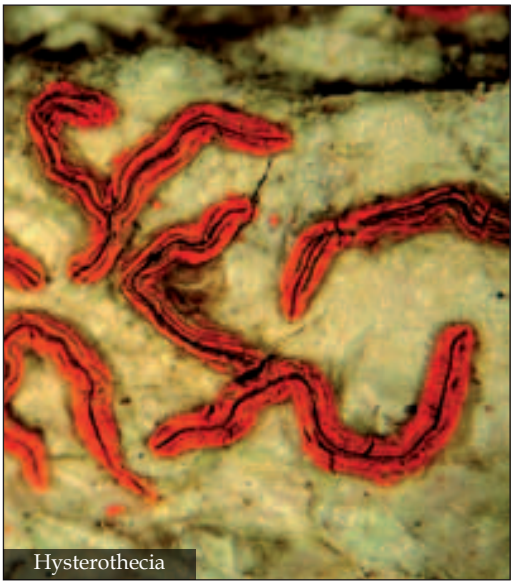
Perithecia: Unlike apothecia, these ascomata are pear-shaped or globose, and characterized by having just one small pore that enables the spores to be discharged. The different parts of perithecia and their functions correspond to those of the apothecia, but differ in stratification.

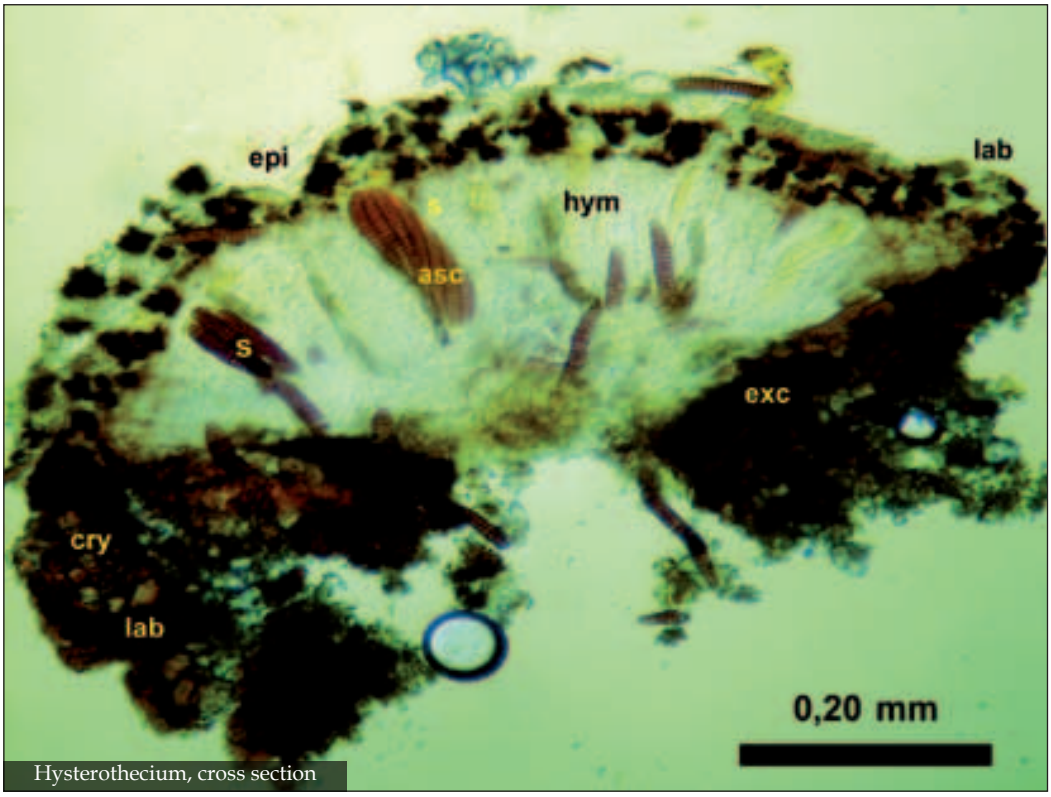

Perithecia



Perithecium, cross section

Hysterothecia: Hysterothecia may derive from apothecia or perithecia and appear as elongate, branched or curved fruiting bodies in a large variety of sizes. They are usually called lirellae, and their lateral parts (surrounding hymenium) are termed labia. These structures can appear closed (convergent) or open (divergent), the disk being visible or concealed, and pruinose or not pruinose. The upper parts of labia appear entire or striate. This form of ascomata is typical for the Graphidaceae family.


Hysterothecia



Hysterothecium, cross section

Ascospores (spores)

As well as the morphology of the thallus and ascomata, the spores are an important character used to describe lichens. These reproductive components grow in several phases of development in the asci of the mycobiont (see above). Spores are formed as a result of meiosis in special cell organs of the fungal partner in a lichen (asci), and differ in characteristic features according to lichen family, genus and species.

The length and width of spores must be measured because these are essential in identifying the species. Spore measurements can be made using special microscope oculars on cross sections of the ascomata mounted in water. The unit of measurement is 1µm = 0.001 mm.

Another important character in species identification is spore septation. Many lichen species have transversely septate ascospores with various numbers of septa. The shape of the cell lumina (angular or rounded) between septa, their color, and whether/how they change in a chemical reaction can help to identify the species. Some spores change their color to blue or red in contact with iodine solution. Other lichen spores that have transverse and longitudinal septa appear muriform (i.e. they resemble brick walls).

Lastly, the number of spores per ascus may be used in identifying species. Unfortunately, some spores may develop poorly and are found in a degenerate condition. Such lichen specimens are thus impossible to identify. The figures on the next page show examples of transversly septate and muriform ascospores at a magnification of × 400.

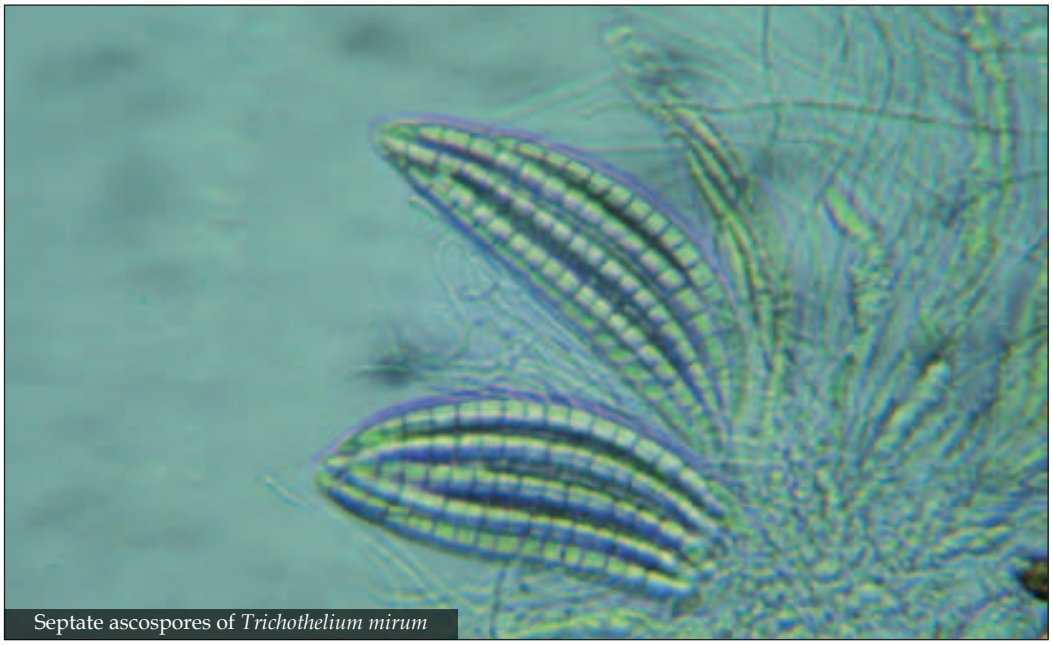
Vegetative reproductive structures

These are specialized thallus fragments for joint dispersal of myco- and photobionts. These allow reproduction by re-establishing a lichen thallus elsewhere under favorable conditions.

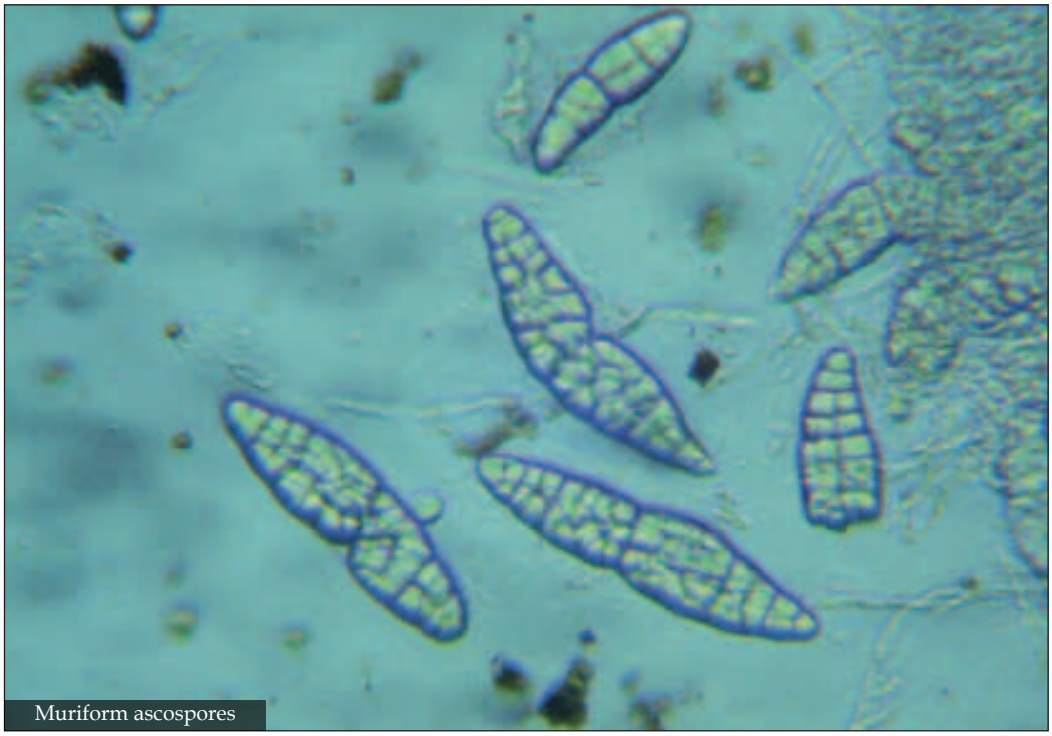
There are two main types:

Soralia: These are discrete thallus areas where the cortex breaks open to release tiny balls of hyphae, which envelop a number of photobiont cells. Soralia appear widely across species in various forms. They may, for example, appear as little powdery spots on the thallus surface or along its margins.

Isidia: These are corticated outgrowths of the thallus, and may appear in different forms. They are easily torn off the thallus and dispersed. (Unlike soralia, isidia might be classified as miniature lichens). Cylindrical, flattened, scale-like, simple or branched forms can all be distinguished. They may have a predetermined breaking point at their base (a noticeable thinning), or they may be very fragile overall in dry conditions. This allows them to be broken off and distributed.

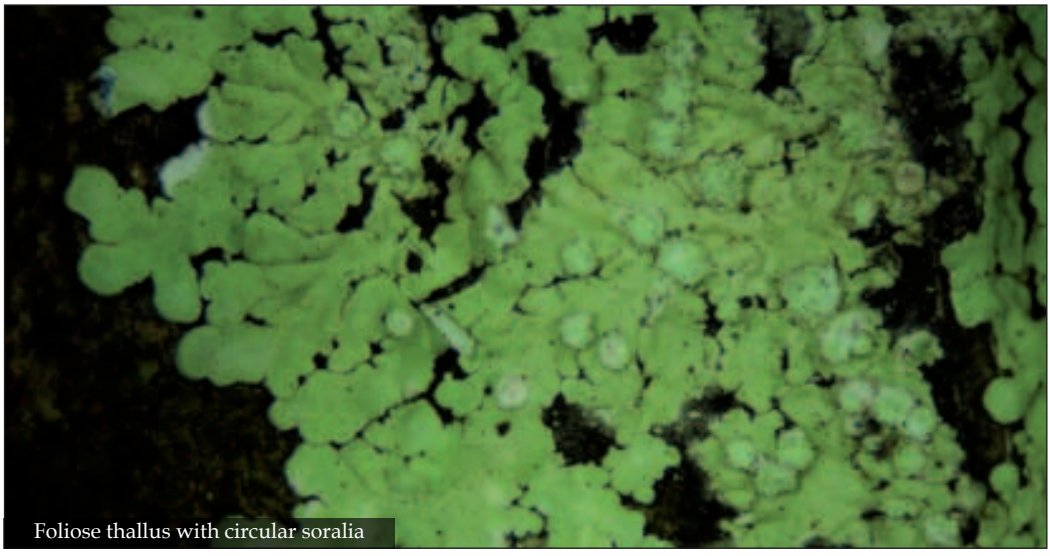


Septate ascospores of *Trichothelium mirum*



Muriform ascospores

Isidia on foliose thallus



Foliose thallus with circular soralia

Newly-described lichen species from the Esquinas forest

Porina pilifera

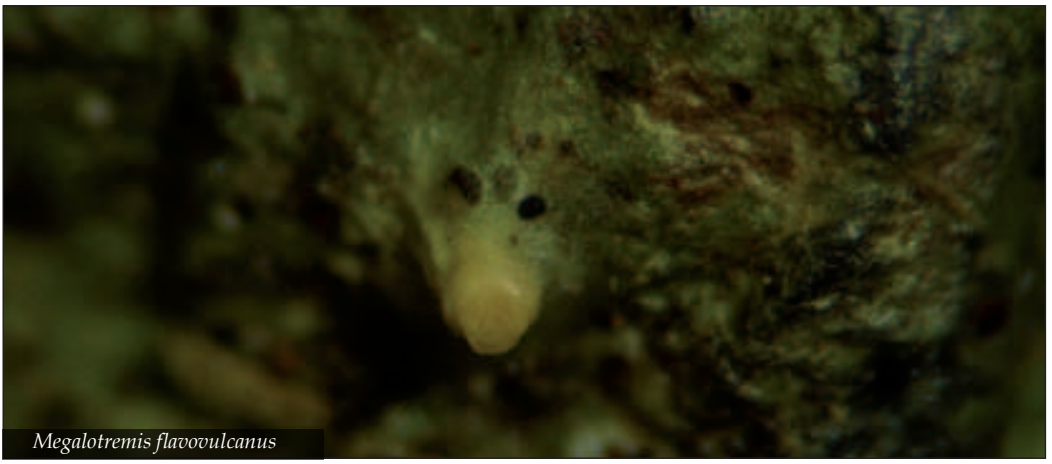
The genus *Porina* is known to contain the highest diversity of foliicolous lichens in Costa Rica. The species *P. pilifera* was described as new to science in 2006 by G. Neuwirth. The small, subglobose or hemispherical perithecia (0.2–0.4 mm) are hidden in a dense covering (tomentum) of fine hairs formed by individual hyphae of the mycobiont. The spores are 7-septate. After exact morphological and anatomical investigation, the lichen was identified as a new species. The type locality is in the Esquinas rainforest, along a trail to the Rio Bonito valley. The species has only been found a few times on different sites in the Esquinas rainforest, and may represent an endemic. It has been collected from leaves of palms that form parts of the understory vegetation and seems to prefer palm trees in tropical, perhumid lowland forest.

Byssolecania pluriseptata

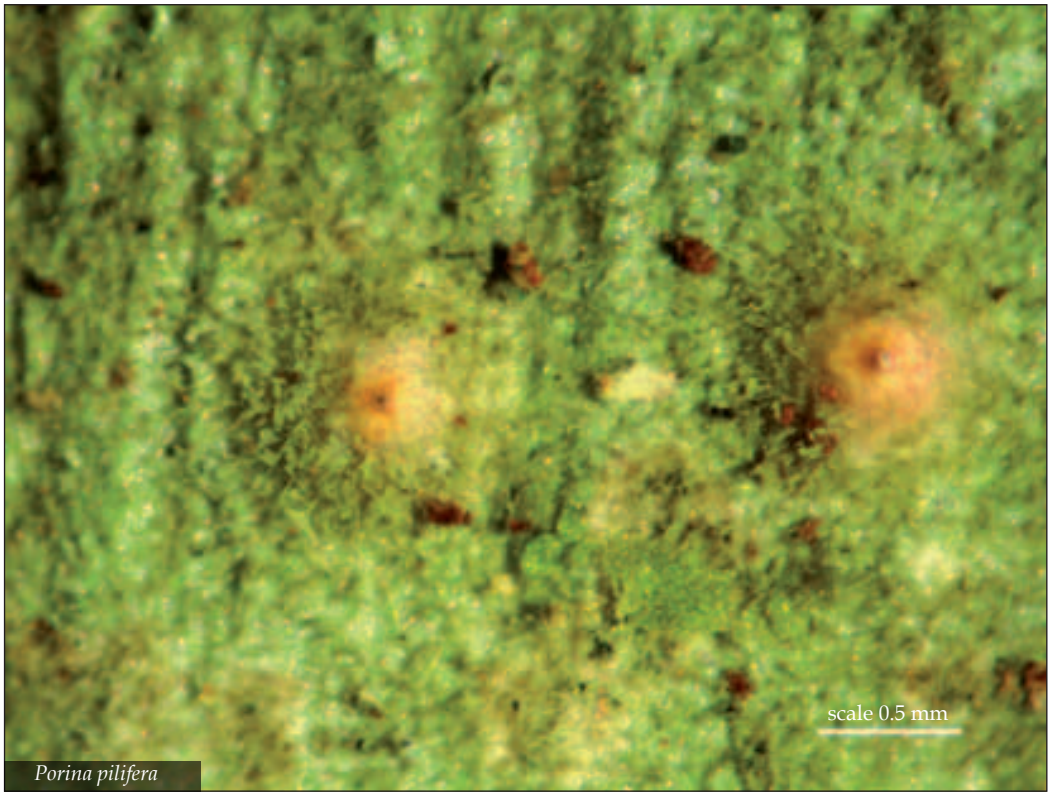
This is another new foliicolous species, recently described by O. Breuss. It appears to be common in the Golfo Dulce region. The genus *Byssolecania* has very flat, rounded apothecia almost level with the thallus surface, often with a paler and somewhat cotton-like marginal zone. The disks are yellowish brown to dark brown, or gray to blackish, up to one millimeter in diameter and easily detachable from the leaf surface as can be seen in the photograph. *B. pluriseptata* differs from other species of the genus in having longer spores with numerous (7–10) septa. The scientific name is based on the large number of spore septa.

Megalotremis flavovulcanus

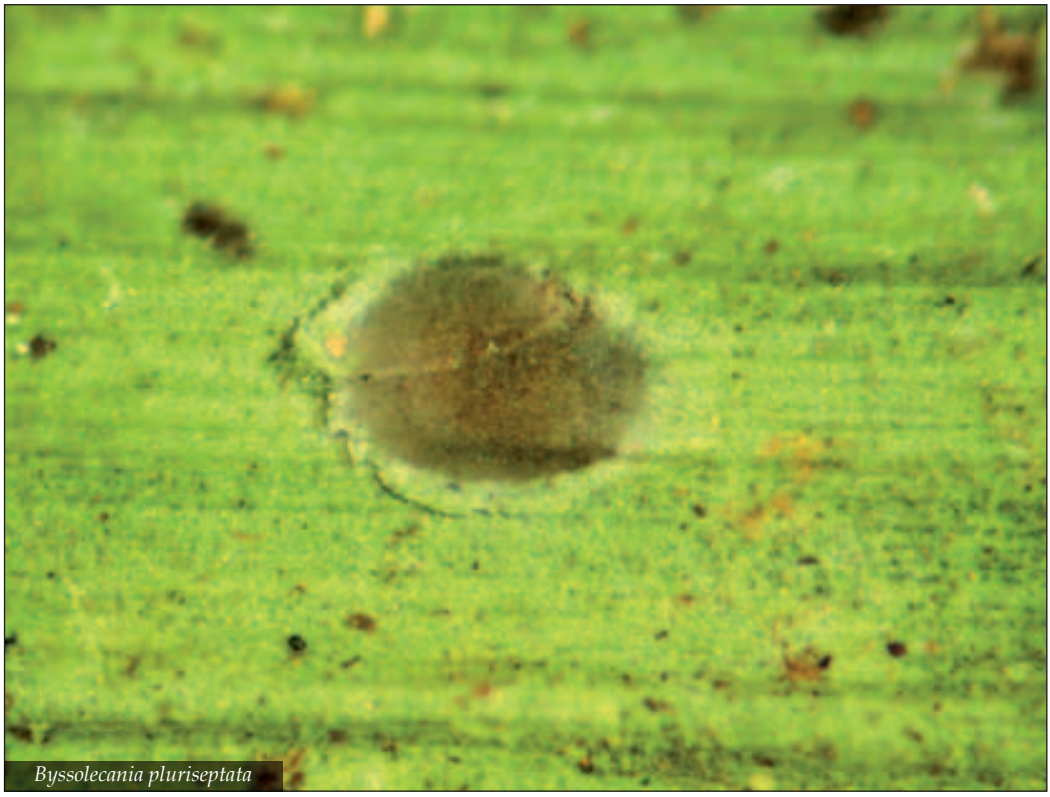
This species was described in 2005 by H. Komposch. It was found in the Golfo Dulce region (Osa peninsula and Bosque Esquinas), and is so far only known from the Caribbean and the Pacific lowland rainforests of Costa Rica, where it appears to be frequent on tree bark in the shady understory. The smooth, greenish thalli are large (reaching 10 centimeters or more in diameter). They are mostly found without fruiting bodies, but easily recognized by their distinctive pycnidia. These are fairly large (c. 1 mm tall) conical or tube-like structures that release a yellow droplet-shaped mass of conidia at the apex. It is likely that this species is endemic to Costa Rica, since it has not been reported from elsewhere, despite being conspicuous.



Megalotremis flavovulcanus



Porina pilifera



Byssolecania pluriseptata

Foliicolous lichens: leaf-inhabiting species

Porina radiata

Porina is a large genus, comprising over 360 species worldwide, the majority of which occur in the tropics. The fruiting bodies are perithecia, which are immersed in the thallus or sessile, and applanately lens-shaped to almost globose. They show great variation in their wall anatomy, since they may be naked or covered with a variety of layers. These may include a layer of algal cells, a crystal-encrusted layer, and a layer of different colors. The spores are mostly fusiform and transversely septate, with or without a gelatinous sheath, and some species have muriform spores. Forty *Porina* species are known to occur in the Golfo Dulce region; most of them are foliicolous. Among the foliicolous species, *P. radiata* can be easily identified by its radiate thallus ridges.

Porina epiphylla

This is a member of a group of externally similar species. The perithecia are covered by a thin thalline layer encrusted with crystals. The spores are narrow and lack a gelatinous sheath. *P. epiphylla* is pantropical and very common. It probably represents the most abundant leaf-inhabiting species of the genus.

Porina lucida

This is similar to the above species, with which it often grows on the same leaf. It is distinguished by its broader, lens-shaped (not hemispherical) perithecia, and larger spores.

Spores of *Porina lucida*

Porina lucida