

Lichens from Mount Kinabalu

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Abstract: 286 species of lichenized fungi on Mount Kinabalu are recorded by field survey and investigation of literature records and herbarium material. An annotated catalogue is presented, together with habitat notes, and a list of collectors. The summit area has a saxicolous lichen flora of boreal affinities, while the lower zones are more closely related to other SE Asian mountains. Eleven species appear to be restricted to the mountain, and four new species are described: *Phaeographis kinabalensis*, *Stereocaulon granulans*, *Pertusaria epitheciifera* and *Thelotrema subweberi*.

1. Introduction

Mount Kinabalu is in many respects a remarkable site for plant life. It rises up to more than 4000 meters from large stretches of lowland and low mountains, so that its higher parts are very strongly isolated from areas with a similar climate. Geologically it is a very young and fast-rising mountain, and its plant life seems to have had little time to adapt to high altitude conditions. Also its bedrock sets it apart. Its central part is composed of granite, surrounded by a ring of ultrabasic rock, both rock types being absent from surrounding areas. All this makes it a very interesting object for a study of the diversity of its biota, and it has already attracted much attention from biologists. Information about its plant life is found in numerous papers (e.g. Gibbs 1914, Luping et al. 1978, van Steenis

1965, 1967, Beaman & Beaman 1993). Among the cryptogams, bryophytes have received considerable attention (Menzel 1988 and successive papers of this series, 1988a). Lichens have been collected from the beginning of the exploration on, but mostly in an incidental and unrepresentative way. An important exception is Mason E. Hale, who visited the mountain in August of 1968 and collected over one thousand specimens, especially Parmeliaceae and Graphidales. About 40 lichen taxa were reported in the literature until 1993.

The biological importance of the mountain is fortunately appreciated by the local authorities, who created a National Park to protect it, Kinabalu Park. This includes all higher parts and much of the foothills. It is situated in Malaysia, State of Sabah, on the boundary of the

districts Kota Belud and Ranau. Its elevation ranges between c. 700 and 4100 m, and its coordinates are c. 06° 05' N, 116° 35' E. Maps of the mountain showing the geographical indications used below were published by Menzel (1988: 283, 295).

The natural vegetation of the mountain can be divided very roughly into four zones. On the lower slopes of the mountain, below c. 1500 m, the original vegetation is probably high forest. Most of this has long since disappeared and is replaced by cultivated fields and secondary vegetation (cf. Gibbs 1914). At c. 1500-2500 m montane forest occurs, which becomes increasingly rich in bryophytes with increase in altitude. Both zones are also present on surrounding mountains, so that their flora is not isolated, in contrast with the following zones. From c. 2500-3000 m the subsoil consists mainly of ultrabasic rock, which bears a stunted forest. The lower half of this zone has extensive moss growth, upwards lichens become more abundant. At c. 3000-4000 m, where the bedrock is granite, the vegetation consists of stunted forest on gravelly soil and low shrubs in rock fissures. The summit plateau, above 4000 m, is almost bare. Here only a few dwarfed vascular plants occur in fissures, and also only a few cryptogams. The scarcity of plant life is probably due to the extreme climatic conditions and to strong erosion. Cf. Gibbs (1914), who noted "no lichens or mosses on the rain- and wind-swept rock, the smooth surface of which prevents the formation of crannies or ledges, and opposes the consequent accumulation of detritus" and "...where erosion is too rapid for the establishment of any permanent botanical factors".

Van Steenis (1965) discussed the phytogeographical relations of Mount Kinabalu. He concluded that the lowland flora is similar to the surroundings. The montane flora shows strong similarities with Celebes and with other areas with similar mountains, such as Malaya, the Philippines and New Guinea. The subtemperate taxa, found in the highest parts, form a unique feature of the mountain. They show relations to the mountains on the Asian mainland, and to the Austral zone, but concern often endemic, derived taxa. The presence of endemic taxa on such a young mountain, where evolution seems to have

had little time to develop new taxa, is explained by assuming that they were received from ancient nearby mountains which have since been eroded away (van Steenis 1967).

The purpose of the present study is to offer a preliminary survey of the lichen flora of the mountain, its altitudinal zonation, geographical relations and other peculiarities.

2. Material and methods

This study is largely based on specimens collected during a one-week visit by the author in May 1989 together with Dr. B. C. Tan (Cambridge, USA). A full set is deposited in the herbarium of the headquarters of Kinabalu Park, P.O. Box 10626, 88806 Kota Kinabalu, Sabah, Malaysia [SNP], and an almost complete set in Berlin [B]. A preliminary report of this trip was given in the *Flora Malesiana Bulletin* (Sipman & Tan 1990).

Another important source is the material collected by Mason E. Hale in August 1968 and kept in Washington [US]. It was examined by the author during a visit in December 1991. Not all material collected by Hale was available at that time, many genera being on loan.

I have added all information found in the literature, and a few specimens that were encountered incidentally in herbaria, mainly in B and BM.

The specimens cited below were all examined by the author unless otherwise stated, excepting the Parmeliaceae and Thelotremaaceae in US, which were identified by Hale. For the examination the usual microscopic techniques were used, including staining of asci or spores with lugol solution. Part of the material was examined chemically, by spot tests or TLC, as described in White & James (1985). For TLC usually only solvent system A was used. Consequently no reliable distinction between protocetraric and fumarprotocetraric acid was made and the substance has been reported below as (fumar)protocetraric acid.

The available collections are not representative for the lichen flora of Mount Kinabalu, because they all originate from the southside of the mountain, along the available trails, especially

along the only trail leading to the summit, the "Summit Trail" or "Tourist Trail", leading from the Park Headquarters to Low's Peak. More remote slopes are very difficult of access and cannot be reached during a short stay. No lichens are at present known from there. Moreover, a considerable part of the available materials could not be identified with certainty because of poor taxonomical knowledge and was omitted. This amounts to about one third of the author's collections, especially members of the following groups: Graphidaceae, Lecideaceae s.l., Pannariaceae, pyrenocarps, and the genera *Dimerella*, *Menegazzia*, *Sticta* and *Usnea*. Because of these restrictions the species list is certainly very incomplete, and includes probably less than 50% of the extant lichen taxa of Mount Kinabalu.

3. Catalogue of the lichen species known from Mount Kinabalu

A. Annotated enumeration

An alphabetical list is presented of 286 lichen species known with certainty from Mt. Kinabalu. For all taxa the following details are given: 1) the name; 2) a short indication of the observed habitat; 3) the altitudinal range; 4) the collections and literature on which the record is based; and 5) notes on the chemistry and other remarks. The most frequent collectors are abbreviated: H = M. E. Hale, collections in US; S = H. Sipman & B. Tan, collections in B and SNP, unless otherwise stated. The collection numbers of these collectors are followed by locality numbers in brackets. Explanations for these numbers are presented in section B below. Where TLC has been used to check the chemistry, this is indicated by "TLC!", or the results are given in detail.

Anzia gregoriana Müll. Arg. - In tree crowns in the mossy forest along Tourist trail, c. 2000 m. S 30936 (2). TLC!

Anzia hypoleuca Müll. Arg. - In tree crowns in the mossy forest, common and widespread, along Tourist Trail and on the "Eastern Shoulder", 2500-3100 m. S 31064 [SNP] (8); S 31270, 31274, 31276

(16); S 31321 [SNP] (18); Chew, Corner & Stainton 2086 [BM] (det. Yoshimura, Aug. 1980); Chew, Corner & Stainton 2006 [BM] (det. Yoshimura, Aug. 1980). TLC: (S 31064) trace atranorin, lobaric acid; (S 31270, 31274) trace atranorin, lobaric acid, unkn. spot; (S 31276) trace atranorin, lobaric, fumarprotocetraric acids; (S 31321) trace atranorin, lobaric, fumarprotocetraric acids, unkn. spot.

Anzia semiteres (Mont. & v. d. Bosch) Stiz. - Epiphyte in tree crowns in mossy forest along Tourist trail, 2300 m. S 30942 (3); Low [BM], Kina-Balu. (det. Yoshimura, Aug. 1980). TLC: (S 30942) trace atranorin, norlobaridone, trace fumarprotocetraric acid; (Low s.n.) norlobaridone, loxodin, caperatic acid, fumarprotocetraric acid, atranorin, det. Yoshimura, Aug. 1980.

Arctoparmelia separata (Th. Fr.) Hale - On granite rock in the summit area, 4050 m. S 31143 (10). TLC! The specimen is tiny, with small lobes.

Arthonia calamicola (Sydow) R. Sant. - On leaves in undergrowth of lowland forest near Poring and montane forest near Park HQ, 700-1650 m. S 29427 (23); S 9505 (27).

Arthonia cyanea Müll. Arg. - On leaves in undergrowth of montane forest near Park HQ, 1650 m. S 29428 (23).

Arthonia lividofusca Müll. Arg. - On leaves in undergrowth of montane forest near Park HQ, 1650 m. S 29429 (23).

Arthonia lividula Vain. - On leaves in undergrowth of lowland forest near Poring, 700 m. S 29506 (27).

Arthonia ramosii (Räs.) R. Sant. - On leaves in undergrowth of montane forest near Park HQ, 1650-1900 m. S 30900 (1); S 29430 (23).

Arthonia trilocularis Müll. Arg. - On leaves in undergrowth of montane forest near Park HQ, 1700 m. S 29484 (24).

Arthrorhaphis citrinella (Ach.) Poelt - On shallow soil in depressions in granite rockflats in the summit area, 4050 m. S 31133, 31135 (10).

Aspidothelium fugiens (Müll. Arg.) R. Sant. -

- On leaves in undergrowth of montane forest near Park HQ, 1650-1700 m. S 29431, 29432 (23); S 29485 (24). The collections S 29432 and 29485 have perithecia with squamules rather than a disc, while S 29431, with disc, lacks spores.
- Aulaxina opegraphina** Fée - On leaves in undergrowth of montane forest near Park HQ, 1650 m. S 29433 (23).
- Bacidia palmularis** (Müll. Arg.) A. Zahlbr. - On leaves in undergrowth of lowland forest near Poring, 700-750 m. S 29507, 29508 [SNP] (27); S 29542 (28). The apothecia in 29508 and 29542 are hypophyllous-marginal.
- Badimia pallidula** (Kremp.) Vezda - On leaves in undergrowth of montane forest near Park HQ, 1650 m. S 29435 (23).
- Baeomyces crenulatus** Hepp - On mossy road bank in mossy oak forest along Tourist Trail, 1900 m. S 30931 (1).
- Baeomyces placophyllus** (Lam.) Ach. - On road bank in cloud forest and stunted forest along Tourist Trail, 2500-3800 m. S 31021 (7); S 31155 (11); S 31325 (18).
- Brigantiaea leucoxantha** (Spreng.) R. Sant. & Hafellner - In tree crowns of montane forest, probably widespread, 1400-1650 m. H 29015, 29133 (30); S 31439 (26).
- Bryoria dahlii** (P.M. Jørg.) Brodo & D. Hawksw. - In tree crowns of cloud forest and in stunted forest, shrubs and dwarfshrubs along Tourist Trail, "Gurulau Spur", 2300-4050 m. S 30948 [SNP] (3); S 31129 (10); S 31166 (11); Meijer B 10377 [L] (Jørgensen 1972, p. 192, as *Alectoria dahlii* P.M. Jørg.); Clemens [H] (Jørgensen 1972, p. 192, as *Alectoria dahlii*); Clemens 51399 [US] (det. D.L. Hawksworth, 1973, as *Alectoria dahlii*).
- Bryoria indonesica** (P.M. Jørg.) Brodo & D. Hawksw. - In tree crown of mossy oak forest and cloud forest, and in shrubs higher up, widespread, 1600-3500 m. H 28475 (36); H 28472 (38); H 29083, 29245 (41); H 28901 (46); H 28626 (48); H 28047 (50); H 28670 (51); H 28088, 28304 (52); S 31111 [SNP] (9); S 31206, 31207 (13); S 31271 [SNP] (16); W. Meijer B 10302 [L] (Jørgensen 1972, p. 195, as *Alectoria indonesica* P.M. Jørg.); J. & M.S. Clemens s.n., 8. Dec. 1933. Note: All Hale collections were identified by P.M. Jørgensen in 1973 (as *Alectoria*).
- Buellia coccinea** (Fée) Aptroot - In mossy forest and stunted cloudforest along Tourist Trail, 1900-3200 m. H 28334 (45); S 31254 (13).
- Bulbothrix subinflata** (Hale) Hale - In tree crown of montane forest, near Park HQ and along Mesilau trail, 1600-1650 m. H 28199, 28563 [SAN, US] (34); S 31442 (26). Hale 1965: 202, as *Parmelia subinflata* Hale. TLC!
- Byssolecania deplanata** (Müll. Arg.) R. Sant. - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29436 (23).
- Byssoloma leucoblepharum** (Nyl.) Vain. - On leaves of undergrowth in lowland- and montane forest, probably widespread, 750-1700 m. S 29437 (23); S 29486, 29509 (24); S 29543 (28).
- Byssoloma subdiscordans** (Nyl.) P. James - On monocot leaf in stunted, open, *Leptospermum*-dominated forest along Tourist Trail, 3200 m. S 31208 (13).
- Byssoloma vanderijstii** Sér. - On leaves of undergrowth in lowland forest near Poring, 700 m. S 29510 (27) (Sipman 1991: 257).
- Byssoloma vezdanum** Sér. - On leaves of undergrowth in lowland- and montane forest, near Poring and Park HQ, 750-1900 m. S 30905 (1); S 29544 (28).
- Calenia conspersa** (Stirt.) R. Sant. - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29440 (23).
- Calenia depressa** Müll. Arg. - On leaves of undergrowth in lowland- and montane forest, near Poring and Park HQ, 750-1650 m. S 29441 (23); S 29545 (28).
- Calenia monospora** Vezda - On leaves of undergrowth in tall forest near Poring, c. 750 m. S 29576a (28).
- Calenia phyllogena** (Müll. Arg.) Vezda - On leaves of undergrowth in lowland forest near Poring, 750 m. S 29547 (28).
- Calenia thelotremella** Vain. - On leaves in montane forest, "Tenompok divide", c.

- 1500 m. Clemens (on n. 29551 *Medinilla* [K]) (Santesson 1952: 351).
- Calicium tricolor** F. Wilson - On naked wood of treestump, sheltered at base, in clearing near Layang Layang, 2500 m. S 31318 (17).
- Calopadia fusca** (Müll. Arg.) Vezda - On leaves of undergrowth in lowland forest near Poring, 700-750 m. S 29511 (27); S 29548 (28).
- Candelariella vitellina** (Ehrh.) Müll. Arg. - On granite rock in the summit area, 4050 m. S 31142 (10).
- Catolechia wahlenbergii** (Ach.) Flot. - On thin soil in depression in granite rockflats in the summit area, 4050 m. S 31132 (10).
- Cetrelia braunsiana** (Müll. Arg.) W.L. Culb. & C.F. Culb. - Epiphyte along Mesilau Trail, c. 1800 m. H 28383 (42).
- Cetrelia chicitae** (Culb.) W.L. Culb. & C.F. Culb. - Epiphyte in montane forest along Mesilau Trail, 1700 m. H 28431 (39); Culberson & Culberson 1968: 505. TLC: atranorin, alectoronic, a-collatolic acids; soredia coarser than usual (Culberson & Culberson, l.c.).
- Cetrelia japonica** (A. Zahlbr.) W.L. Culb. & C.F. Culb. - Epiphyte in mossy or stunted forest along Mesilau Trail and Tourist Trail, 1600-3800 m. H 29269 (34) (see also Culberson & Culberson 1968: 513); S 31164 (11). TLC!
- Chaenotheca brunneola** (Ach.) Müll. Arg. - On naked wood of treestump, sheltered at base, in clearing near Layang Layang, 2500 m. S 31319 (17).
- Chroodiscus mirificus** (Kremp.) R. Sant. - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29444 (23).
- Cladia aggregata** (Sw.) Nyl. - On mossy road banks in cloudforest or above, along Tourist Trail, 2700-3500 m. H 28302 (52), teste P.M. Jørgensen 1973; S 30991 (6); S 31273 (16).
- Cladonia borbonica** Nyl. - on mossy road bank along Tourist Trail, c. 3100 m. S 31103 (9).
- Cladonia coccifera** (L.) Willd. agg. - On soil on road banks or open places in the cloud forest zone and above, along Tourist Trail, 2500-3600 m. S 31019 (7); S 31101 (9); S 31185 (12); S 31317 (17). TLC: usnic acid, zeorin. The material includes two morphotypes, at present under study by T. Ahti (Helsinki).
- Cladonia corniculata** Ahti & Kashiw. - On soil of road bank in *Leptospermum*-forest along Tourist Trail, 3200 m. S 31203 (13).
- Cladonia corymbescens** Nyl. ex Leight. - On mossy road banks in cloud forest, along Tourist Trail and Mesilau Trail, 1800-2900 m. H 28394, 28406 (42); H 28675 (129); S 30897 (1); S 30984 [SNP] (5).
- Cladonia didyma** (Fée) Vain. var. **vulcanica** (Zoll. & Moritzi) Vain. - On mossy road bank in stunted cloud forest along Tourist Trail and Mesilau Trail, 1800-2700 m. H 29080 (41); H 29057 (48); S 30978 (5); S 31010 (6). Thallus K+ yellow.
- Cladonia fenestralis** Nuno - On thin earth cover on porphyric rockflat in stunted forest below Villosa Shelter, 2900 m. S 31018 (7); Togashi 66925 [TNS, holotype] (Nuno 1975: 291-292). Kurok. Lich. rar. crit. exs. 212; Kurok. & Kashiw. Lich. rar. crit. exs. 306. Huovinen et al. 1990: 217 (erroneously cited as nr. 206).
- Cladonia fruticulosa** Kremp. - On mossy road banks in mossy oak forest and cloud forest along Tourist Trail, 1900-2700 m. S 30896 (1); S 30983 [SNP] (5); S 31004, 31005 (6).
- Cladonia furcata** (Huds.) Schrad. - On road banks in cloud forest and stunted forest along Tourist Trail, 2600-3500 m. H 29262 (52); S 30980 (5); S 30992 (6); S 31014a (7); S 31103 pr.p. (9).
- Cladonia gymnopoda** Vain. - On road banks in cloud forest and stunted forest along Tourist Trail, 2500-3500 m. H 29137 (49); H 28076 (52); S 230981 (5); S 31099 (9); S 31202 [SNP] (13); S 31313, 31314 (17). TLC!
- Cladonia macilenta** Hoffm. - On mossy road bank in mossy forest along Tourist Trail, 2600-2700 m. H 29061 (49); S 30996 (6). Thallus K+ yellow.
- Cladonia** cf. **melaleuca** Nuno - On mossy road banks in cloud forest along Tourist Trail

and Mesilau Trail, 1800-2800 m. H 28940 (43); H 29058 (48); H 29237 (49); S 30941 (3); S 31267, 31269, 31275 (16). TLC: thamnolic acid. The material resembles *Cladonia melaleuca* (holotype in TNS seen; Nuno 1972: 162) by the richly branched, largely melanotic podetia bearing small squamules. It differs by its scarcer, more elongate squamules and by the absence of barbatic acid. Since *C. melaleuca* is based on a single collection, its range of variation is unknown, and the Kinabalu specimens may form a modified population of it.

Cladonia melanocaulis Stenr. - Along Tourist Trail, c. 3500 m. H 28590 (52).

Cladonia ochrochlora Flk. - On road banks in cloud forest and stunted forest along Tourist Trail, 2600-3100 m. H 29068 (49); H 28046 (50); S 30979 (5); S 30999, 31001 (6); S 31016 cf. (7); S 31100 (9); S 31264 (16). TLC: (S 30999) fumarprotocetraric acid. Nr. S 31016 deviates by its conspicuous melanotic basal podetial parts. *Cladonia malayana* Nuno (1975: 289; type in TNS seen) is fairly similar, and differs mainly by its chemistry: in addition to fumarprotocetraric acid, it contains protolichesterinic and lichesterinic acids. Morphologically it produces similar scyphoid, largely corticate podetia, which show some small soresiate patches, mainly below the scyphi, which may spread over the upper part of the podetia and become confluent. Its podetia remain thinner, 0.6-1 mm thick, and shorter, up to c. 2 cm long.

Cladonia phyllopora (Vain.) Stenr. - On mossy road banks in stunted cloud forest along Tourist Trail, 2500-2700 m. S 30962 (4); S 30997 (6).

Cladonia cf. **pyxidata** (L.) Hoffm. - On road bank in stunted cloud forest above Carson's Camp, 2700 m. S 31006 (6). TLC: fumarprotocetraric acid.

Cladonia scabriuscula (Del.) Nyl. - On mossy road banks in stunted cloudforest along Tourist Trail, 2400-2800 m. S 31278 (16); S 31333 (19).

Cladonia squamosa (Scop.) Hoffm. var. **subs-**

quamosa (Nyl. ex Leight.) Vain. - Along Tourist Trail, c. 3500 m. H 28068 (52).

Cladonia vulcani Savics - On mossy road bank in stunted cloudforest along Tourist Trail, 2700-3100 m. S 30993, 30994, 30995, 31000 (SNP), 31002 (6); S 31102 [SNP] (9); S 31324 (18). TLC! Specimens S 30993 and S 31324 belong to the usnic acid-deficient strain reported already by Huovinen et al. (1989: 144).

Coccocarpia erythroxyli (Spreng.) Swinsc. & Krog - In tree crowns of lowland- and montane forest and in stunted forest higher up, widespread, 700-2900 m. H 28538, 28542, 29105 (32); H 28798, 28810 (33); H 28128, 28131, 28150, 28226, 28556, 28782 (34); H 29142a (35); H 28493 (36); H 28251 (38); H 29132, 29249 (41); H 28495 (44); H 28698 (45); H 28967 (46); H 22895 (50); S 30967 [SNP] (4); S 31416 (26); S 31498 (27); Clemens 50582 [US].

Coccocarpia palmicola (Spreng.) Arv. & D. Galloway - In tree crowns of lowland-, montane - and cloudforest, widespread, 700-2300 m. H 28547 (32); H 29142 (35); H 28466 (38); H 29235 (39); H 28042 (40); H 29054, 29086, 29251 (41); H 28625, 28930 (48); S 30943 (3); S 31392 [SNP] (24); S 31426 (26); S 31497 [SNP] (27).

Coccocarpia pellita (Ach.) Müll. Arg. em. R. Sant. - In tree crowns in mossy forest and cloud forest, widespread, 1600-3100 m. H 28972 (35); H 28361 (41); H 28407 (42); S 30932 (2); S 31073 (8); S 31369 [SNP] (21); S 29445 (23).

Coenogonium lepriurii (Mont.) Nyl. - In mossy montane forest near Park headquarter and along Mesilau Trail, 1600-1650 m. H 28130, 28194 (34) (both det. Vezda, 1973); S 31374 (23).

Collema actinoptychum Nyl. - On *Coffea* in cultivated area near Kundason, c. c. 1400 m. H 29003, filed under *C. pulcellum* (Degelius 1974: 125).

Collema pulcellum Ach. var. **subnigrescens** (Müll. Arg.) Degel. - On *Coffea* in cultivated area near Kundason, c. 1400 m. H 29003 (Degelius 1974: 125).

- Crocynia gossypina** (Sw.) Massal. - In montane forest along Mesilau trail, 1600-1700 m. H 28183, 28562 (34); H 28776 (38). All det. Lois Brako, 1987. TLC (H 28562) barbatic acid, (H 28183, 28776) norstictic acid.
- Cyphothecia candida** (Kremp.) R. Sant. - On leaves of undergrowth in lowland forest near Poring, 700 m. S 29512 (27).
- Cyphellostereum laeve** (Fr.) Reid - On mossy road bank in mossy montane forest along Tourist Trail, 1900 m. S 30907 (1).
- Cyphellostereum pusiolum** (Berk. & Curtis) Reid - On mossy road bank in mossy montane forest along Tourist Trail, 1800 m. S 31373 (22).
- Dibaeis absoluta** (Tuck.) Kalb & Gierl - On mossy road bank in mossy oak forest along Tourist Trail, 1900 m. S 30895 (1). Gierl & Kalb 1993: 615.
- Dibaeis stipitata** Kalb & Gierl - Tourist Trail between Layang and Paka Cave, 2700-2900 m. H 28317 (50), acc. to Gierl & Kalb 1993:617.
- Dibaeis weberi** (Thoms.) Kalb & Gierl - On mossy road bank in mossy oak forest and cloud forest along Tourist Trail, 1900-2500 m. S 30894 (1); S 31316 (17). Gierl & Kalb 1993: 630.
- Dictyonema irpicinum** Mont. - In stunted mossy cloudforest near Paka shelter, 3100 m. S 31080 (8).
- Dictyonema ligulatum** (Kremp.) A. Zahlbr. - In mossy montane forest and cloudforest along Mesilau Trail and Tourist Trail, 1600-2300 m. H 28175 (34); H 28775 (38); H 29234 (39a); H 28011, 28041, 28044 (40); H 29191 (41); H 28738 (45); S 30919 [SNP] (1); S 31356 (20).
- Dictyonema sericeum** (Sw.) Berk. - In mossy montane forest along Mesilau Trail and Tourist Trail, 1500-1900 m. H 29033 (33); H 28445 (36); H 28770 (38); H 29219 (39); S 30916 (1).
- Dimerella dilucida** (Kremp.) R. Sant. - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29447 (23).
- Dimerella epiphylla** (Müll. Arg.) Malme - On leaves of undergrowth in montane forest near Park HQ and in lowland forest near Poring, 700-1700 m. S 29488 (24); S 29513 (27).
- Dimerella fallaciosa** (Müll. Arg.) Vezda - On leaves of undergrowth in lowland forest near Poring, 700 m. S 29514 (27).
- Dimerella flavicans** Vezda - On leaves of undergrowth in lowland forest near Poring, 700 m. S 29515 (27).
- Dimerella lisowskii** Vezda - On leaves of undergrowth in lowland forest near Poring, 750 m. S 29551 (28).
- Dimerella zonata** (Müll. Arg.) R. Sant. - On leaves of undergrowth in lowland forest near Poring, 750 m. S 29552 (28).
- Echinoplaca diffluens** (Müll. Arg.) R. Sant. - On leaves of undergrowth in lowland forest near Poring, 750 m. S 9554 (28).
- Echinoplaca epiphylla** Fée - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29451 (23).
- Echinoplaca heterella** (Stirt.) R. Sant. - On leaves of undergrowth in lowland forest near Poring, 750 m. S 29555 (28).
- Echinoplaca pellicula** (Müll. Arg.) R. Sant. - On leaves of undergrowth in lowland forest near Poring and in montane forest near Park HQ, 750-1650 m. S 29452 (23); S 29556 (28).
- Ephebe ocellata** Henssen - On granite rock in the summit area, 4050 m. S 31153 [SNP] (10).
- Everniastrum catawbiense** (A. Zahlbr.) Hale ex Sipman - On branches of shrubs and stunted trees along Tourist Trail, 2800-3800 m. S 31159 (11); S 31279 (16). TLC! No difference could be found with South-American representatives of this species, therefore the name *Parmelia curtata* Kurok., introduced to distinguish between the palaeotropical representatives and the neotropical ones, has not been used.
- Fellhanera rhapsidophylli** (Rehm) Vezda - On leaves of undergrowth in lowland forest near Poring, 700 m. S 29517, 29518 (27).
- Fellhanera semecarpi** (Vain.) Vezda - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29499 (25).
- Graphina cinereoalba** (Vain.) A. Zahlbr. - Epiphyte in montane forest near Park HQ, c.

- 1650 m. S 31413 (25).
- Gyalectidium filicinum** Müll. Arg. - On leaves of undergrowth in lowland forest near Poring, 700 m. S 29519 [SNP] (27).
- Gymnoderma coccocarpum** Nyl. - On tree roots and trunks in mossy forest and cloud-forest along Tourist Trail and "Gurulau Spur", 1600-2800 m. H 28174 (34); H 28636 (48); S 31266 (16); S 31364 (21). Yoshimura & Sharp 1968: 638
- Haematomma wattii** (Stirt.) A. Zahlbr. - In tree crown in montane forest and cloudforest near Tourist Trail, and along Mesilau Trail, 1600-2500 m. H 28217 (34); S 31327 [SNP] (18); S 31360 (20); S 31438 (26).
- Heterodermia barbifera** (Nyl.) W.A. Weber - In stunted forest along Tourist Trail and Mesilau Trail, 1600-3200 m. H 28192, 28213 (34); H 28441 (36); H 28358, 29190 (41); H 28408 (42); H 28053, 28606, 28953 (50); S 31034 [SNP] (7); S 31074 (8); S 31092 (9); S 31215 (13).
- Heterodermia corallophora** (Tayl.) Skorepa - Along Mesilau Trail, c. 1600-1700 m. H 29287 (34); H 29143 (35); H 28716 pr.p. (38).
- Heterodermia diademata** (Tayl.) Awas. - Along Mesilau Trail, c. 1600 m. H 28435 (36).
- Heterodermia galactophylla** (Tuck.) W. Culb. - Along Mesilau Trail, c. 1600 m. H 28437 (36).
- Heterodermia hypoleuca** (Ach.) Trevis. - Along Mesilau Trail, c. 1700-1800 m. H 28716 (38); H 29255 (41).
- Heterodermia isidiophora** (Vain.) Awas. - In tree crowns in montane forest near Park HQ and along Mesilau Trail and Tourist Trail, and in lowland forest near Poring, 700-2900 m. H 29018 (30); H 28527 (32); H 28436 (36); H 28274 (38); H 28398 (42); H 28052 pr.p. (50); S 30930 [SNP] (1); S 31496 (27). TLC!
- Heterodermia japonica** (Sato) Swinsc. & Krog - In stunted trees in cloudforest, or in tree crowns in montane forest, along Mesilau Trail and Tourist Trail, 1500-3600 m. H 29096 (31); H 28541, 29129 (32); H 28814 (33); H 28680 (45); H 29239 (49); H 28667 (50); H 28999 (52); S 31035 [SNP] (7); S 31063 [SNP] (8); S 31089 (9); S 31176 (12); S 31391 [SNP] (24). TLC!
- Heterodermia leucomelos** (L.) Poelt ssp. **boryi** (Fée) Swinsc. & Krog - On stunted trees of cloudforest and in tree crowns of montane forest, along Tourist Trail and Mesilau Trail, 1400-3600 m. H 28531, 29107 (32); H 28193, 28222 (34); H 29144 (35) [B, US]; H 28443, 28480 (36); H 29144 (37); H 28355 (41); S 31179 (12); S 31240 [SNP] (13); S 31431 (26). TLC: (H 28193, H 28222, S 31179, S 31240) atranorin, zeorin; (S 31431) atranorin, zeorin, unkn. terpenoids, salazinic acid.
- Heterodermia leucomelos** ssp. **leucomelos** - Along Mesilau Trail, c. 1800 m. H 28379 (42). TLC: (det. Hale) norstictic, salazinic acids.
- Heterodermia obscurata** (Nyl.) Trev. - In tree crown in lowland forest near Poring, 700 m. S 31501 (27).
- Heterodermia speciosa** (Wulf.) Trev. - In montane and stunted high-altitude forest along Mesilau Trail and Tourist Trail, 1400-3600 m. H 28525 (32); H 28438 (36); H 28326 (45); H 28583a (50); H 28584 (52); S 31091 (9); S 31186 (12). TLC!
- Heterodermia squamulosa** (Degel.) W. Culb. - In stunted high-altitude forest along Tourist Trail, 2700-3600 m. H 28052 (50); H 28583, 28619, 29000 (52); S 31062 [SNP] (8); S 31090 (9); S 31177 (12); S 31216 (13). TLC!
- Hypogymnia pseudobitteriana** (Awas.) Awas. - In stunted mossy forest on ridge near Lowii shelter, 2300 m. S 31347 (20). TLC: atranorin, physodic acid, 2 unkn. spots.
- Hypogymnia vittata** (Ach.) Gas. - On tree trunk in dwarfed forest near Sayat Sayat hut, 3800 m. S 31165 (11).
- Hypogymnia zeylanica** (R. Sant.) Awas. & Singh - On branches in stunted, mossy forest and in tree crowns in montane forest, along Tourist Trail, 1650-2800 m. S 30933 (2); S 30950 (3); S 31280 [SNP] (16); S 31353 (20); S 31441 [SNP] (26).

TLC: atranorin, physodic acid, 2 unknown spots.

Hypotrachyna adducta (Nyl.) Hale - On tree crowns in montane forest and in stunted cloudforest along Tourist Trail, 1650-2800 m. S 31304 (16); S 31424 (26). TLC!

Hypotrachyna brevirhiza (Kurok.) Hale - Epiphyte in cultivated area near Kundason, c. 1400 m. H 29002.

Hypotrachyna citrella (Kurok.) Hale - On shrubs of dwarfed forest near Sayat Sayat, 3800 m. S 31158 (11). TLC! The species is applied sensu Kurokawa 1986a.

Hypotrachyna consimilis (Vain.) Hale - In tree crowns in mossy montane forest along Tourist Trail, 1900 m. S 30928a (1). TLC!

Hypotrachyna costaricensis (Nyl.) Hale - In tree crowns in mossy forest and in stunted cloud forest, widespread, 1600-3800 m. H 28448 (36); H 28548, 29199 (37); H 28451 (39); H 28384 (42); H 28699 (45); H 28336, 29059 (49); H 28057, 28318, 28644 (50); H 28072, 28600, 28998 (52); S 31031 (7); S 31169 (11). TLC!

Hypotrachyna exsecta (Tayl.) Hale - In tree crowns in montane forest and in stunted cloud forest along Tourist Trail and Mesilau Trail, 1400-3500 m. H 29116b (32); H 29284 (34); H 28486 (36); H 28269 (38); H 29089 (41); H 28934 (48); H 29165 (49); H 28071, 28597 (52); S 30927 (1); S 31281 (16); S 31446a (26). Hale 1972: 434, as *Parmelia adjuncta* Hale. TLC: (S 31446a) atranorin, barbatic acid agg.; (S 30927, 31281) atranorin, barbatic acid agg., echinocarpic acid; atranorin, barbatic, 4-O-demethylbarbatic, echinocarpic acids (Hale 1972: 434, as *Parmelia adjuncta* Hale). Following Kurokawa (1986: 265) the presence or absence of echinocarpic acid has not been considered as a good criterion for the delimitation of species within this group, and *H. adjuncta* is united with *H. exsecta*.

Hypotrachyna imbricatula (A. Zahlbr.) Hale - In tree crowns of montane forest and in mossy forest along Mesilau Trail and Tourist Trail, 1500-2600 m. H 28989

(30); H 29116a (32); H 28822 (33); H 28342 [holotype of *Parmelia addita* Hale]; H 28191, 28220, 28557, 29024, 29049, 29277 (34); H 28374 (41); H 28241A (44); S 31445, 31445a (26). Hale 1972: 433, as *Parmelia addita*; Hale 1972: 436, as *Parmelia orientalis* Hale. TLC: (S 31446a) atranorin, barbatic acid agg.; (H 28557, det. Hale) atranorin, barbatic, 4-O-demethylbarbatic, echinocarpic acids; (H 28191, 29024) with fumarprotocetraric acid in place of echinocarpic acid (Hale 1972: 433); (28989, 29116a, det. Culberson): atranorin, barbatic, obtusatic, 4-O-demethylbarbatic, norobtusatic acids.. *Hypotrachyna addita* (Hale) Hale (basionym *Parmelia addita* Hale) and *H. orientalis* (Hale) Hale (basionym *Parmelia orientalis* Hale) are included in *H. imbricatula* following Kurokawa (1986).

Hypotrachyna kinabalensis (Hale) Hale - In mossy forest and cloudforest along Tourist Trail and Mesilau Trail, common, 1600-2600 m. H 28728a, 29189, 29195 (37); H 28263 (38); H 29106 (39); H 28937, 29282 (39a); H 28019 (40); H 29243 [US holotype of *Parmelia kinabalensis* Hale; LD, SAN, TNS, UPS isotypes], 28356, 29092 (41); H 28065, 28327 [DUKE, US], 28697, 28740, 28757 (45); H 28210 (46); H 28633, 28931 (48); H 29152 (49); S 30952 [SNP] (3); S 31337 (19); S 31348 (20). Hale 1965: 205, as *Parmelia kinabalensis* Hale. TLC (S 30952, 31337, 31348; H 28740, 29289): atranorin, norstictic, salazinic acids. Evidently the indication of atranorin and norstictic acid only by Hale (1965: 205) was based on early observations with inadequate methods, since specimens in US bearing this indication appeared to contain salazinic acid as well. As far as is known this is an endemic taxon of Mount Kinabalu, where it is fairly common. A striking feature of the species is its reddish apothecia.

Hypotrachyna laevigata (Sm.) Hale - Epiphyte in mountain forest and mossy forest along Summit Trail, 1650-2800 m. S 30927a

(1); S 31281 (16); S 31446 (26). TLC: (S 30927a, 31281, 31446) atranorin, barbat-ic acid agg., echinocarpic acid. This unusual chemical strain is included in the species following Kurokawa (1986: 259).

Hypotrachyna microblasta (Vain.) Hale - In tree crowns and stunted trees of mossy forest along Tourist Trail and Mesilau Trail, 1400-2900 m. H 29014 (30); H 28537 (32); H 28203 (34); H 28275 (38); S 31033, 31051 (7). TLC: atranorin, usnic, trace norstictic, salazinic acids.

Hypotrachyna osseoalba (Vain.) Hale & Park - In tree crowns of montane forest near Park HQ and Mesilau Trail, 1500-1700 m. H 28519 (33); H 28269, 28283, 28715 (38); H 28430 (39); S 31423 [SNP] (26). TLC: (S 31423) lichexanthone, unkn. pale spots, (fumar)protocetraric acid.

Hypotrachynaphyscioides (Nyl.) Hale - In tree crowns in mossy montane forest along Mesilau Trail and Tourist Trail, 1600-1900 m. H 29116 (32); H 28143, H 28196, H 28220 (34); H 28728 (37); H 28374 (41); S 30927a (1); S 31398 [SNP] (24); S 31433 (26); Thrower 1816 (US), 7 Apr 1973, Kiau View Trail. TLC: (S 31398, 31433) atranorin, barbat-ic acid agg., (S 30927a) id. + echinocarpic acid; (H 29116, det. Culberson) barbat-ic + obtusatic acids; (H 28143, 28196, det. Hale) barbat-ic + 4-O-demethylbarbat-ic acids. The species is treated here in a wide sense, including *H. massartii* (Hue) Hale and *H. scytodes* (Kurok.) Hale, following Kurokawa (1986).

Hypotrachyna pseudosinuosa (Asah.) Hale - In mossy forest on ridge near Ubah shelter, 2050 m. S 31365 (21). TLC!

Hypotrachyna reducens (Nyl.) Hale - In stunted forest near Sayat Sayat, 3500-3600 m. H 28571, 28599, 28824 (52); S 31194 (12). TLC: (S 31194) usnic, trace norstictic, salazinic acids.

Hypotrachyna rhabdiformis (Kurok.) Hale - In mossy forest along Mesilau Trail and Tourist Trail, 1600-2600 m. H 28225 (34); H 28761 (45); H 29152A (49); S 31349 (20). TLC: (S 31349, H 28761, H 29152a) atranorin, norstictic, salazinic

acids. Hale (1975:62) gives the chemistry as atranorin and norstictic acid. Evidently this was based on early observations with inadequate methods, since the specimens in US with this indication appeared to contain salazinic acid as well in a TLC analysis.

Hypotrachyna rockii (A. Zahlbr.) Hale - In tree crowns of montane forest along Tourist Trail and Mesilau Trail, 1400-1700 m. H 29017A (30); H 28796 (33); H 28993 (39).

Hypotrachyna sinuosa (Sm.) Hale - In mossy forest, stunted forest and among dwarfshrubs along Mesilau Trail and Tourist Trail, 1700-4050 m. H 28228 (39); H 29055 (41); H 28396, 28404 (42); H 28692 (45); H 29157 (49); H 28051, 28320, 28769, 28947 (50); H 28073, 28092, 28568, 28570, 28592, 29001, 29260 (52); S 31114 [SNP] (9); mixed with S 31148 = *Melanelia panniformis* (10); S 31160, 31175 (11); S 31245 (13). TLC: (S 31160) usnic, trace norstictic, galbinic, salazinic acids; (S 31114, 31175, 31245) usnic, trace norstictic, salazinic acids.

Icmadophila ericetorum (L.) Zahlbr. - In stunted, mossy forest near Paka Cave, c. 3100 m. S 31056 (8); S 31119 (9). Identified by C. Gierl, 1992.

Immersaria athrocarpa (Ach.) Rambold & Pietschmann - On granite rock in the summit area, 4050 m. S 31144 (10).

Lasioloma arachnoideum (Kremp.) R. Sant. - On leaves of undergrowth in lowland and montane forest, near Park HQ and Poring, 750-1700 m. S 19454, 29455 (23); S 29490 [SNP] (24); S 29558 (28).

Lecanora intricata (Ach.) Ach. - On granite rock in the summit area, 4050 m. S 31146 (10).

Lecanora polytropia (Ehrh.) Rabenh. - On granite rock in the summit area, 4050 m. mixed with S 31148 = *Melanelia panniformis* (10).

Leioderma solediatum D. Galloway & P.M. Jørg. - In tree crowns of mossy forest and in stunted trees at higher elevation, along Tourist Trail, 1700-3200 m. S 30953 [SNP] (vs., small, insufficient specimen)

(3); S 31096 (9); S 31213 (13); S 31282 (16); S 31395 [SNP] (24).

Leprocaulon arbuscula (Nyl.) Nyl. - montane forest epiphyte. Throuwer 1772 [FH, HKU] (Lamb & Ward 1974: 519). TLC: (Lamb & Ward l.c., Strain II) atranorin, protoctetraric and physodalic acids.

Leprocaulon pseudoarbuscula (Asah.) Lamb & Ward - On tree trunks in mossy forest along Tourist Trail, 1900-2800 m. H 28640 (48); S 30914 (1); S 31265 (16). TLC: (S 30914) thamnolic acid, unkn. grey spot (A: 2); (S 31265) squamatic, thamnolic acids, unkn. pale spot UV+ (A: 2); (H 28640) thamnolic, trace squamatic acids.

Leptogium laceroides Bouly de Lesd. - In stunted, mossy forest near Paka Cave, 3100 m. S 31108 (9).

Letrouitia muralis Hafellner - On bark in lowland forest near Poring, 700 m. S 31510 (27).

Lobaria adscripturiens (Nyl.) Hue - In mossy forest along Mesilau Trail, 1400-1600 m. H 28270 [US, NICH] (34); H 29278 [US, NICH] (38); H 29126 (32) (all according to Yoshimura 1971: 309).

Lobaria clemensiae Vain. - In mossy forest along Mesilau Trail, 1400 m. H 29124 (32) (Yoshimura 1971: 262).

Lobaria crassior Vain. - In mossy forest along Mesilau Trail, 1600 m. H 28204 (34) (Yoshimura 1971: 314).

Lobaria discolor (Bory in Del.) Hue - In mossy forest near Park HQ, 1650 m. S 31078, cf. (8); S 31400 (25). Thallus K+ yellow, medulla C+ red or C-. TLC: gyrophoric acid present or (S 31078) without substances.

Lobaria ferax Vain. - In mossy forest along Mesilau Trail and Tourist Trail, 1600-3100 m. H 28178 (34) (Yoshimura 1971: 271); H 29136 [US, NICH] (44) (Yoshimura 1971: 271). TLC: (S 31078) no substances found; cortex K+ yellow, medulla K-, C-.

Lobaria insularis Vain. - In mossy forest along Mesilau Trail, 1800 m. H 28025 [US, NICH] (40) (Yoshimura 1971: 259).

Lobaria isidiophora Yoshim. - In mossy forest

along Mesilau Trail and Tourist Trail, 1400-3100 m. H 29016 (30) (Yoshimura 1971: 277); H 28976, 29109 (31) (Yoshimura 1971: 277); H 28109 (40) (Yoshimura 1971: 277); H 28712 (38) (Yoshimura 1971: 277); S 31086 (8); Iwatsuki 1536 [NICH] (Yoshimura 1971: 277). TLC: (H 29016, H 29109, S 31086) norstictic, stictic, constictic acids. Gyrophoric acid, stated to be always present in *L. isidiophora* by Yoshimura (1971: 276), was not found by TLC. Only a weak spot test demonstrated its local presence. Therefore the separation of *L. isidiophora* from *L. meridionalis* Vain. seems questionable. As in *L. isidiosa*, the isidia are mostly scattered and not produced in soredium-like patches like in isidiate forms of *L. pulmonaria* (L.) Hoffm. This difference was noted already by Vainio (1913: 128) when describing *L. meridionalis*.

Lobaria isidiosa (Müll. Arg.) Vain. - In mossy forest along Mesilau Trail and Tourist Trail, and near Park HQ, 1500-3100 m. H 28748 (40) (Yoshimura 1971: 296); H 28621 (48); H 28763 (50) (Yoshimura 1971: 296); H 29183 (37) (Yoshimura 1971: 296); H 28440, 28487 (36), det. Yoshimura 1970; H 29032 (33), det. Yoshimura 1970; H 28663 (50), det. Yoshimura 1970; H 28621, (48), det. Yoshimura 1970; S 30940 (3); S 31106 (9); S 31335 (19); S 31494 [SNP] (26); Menzel et al. 4996 [B]. TLC (S 30915, 30940, 31106, 31335, 31494): trace norstictic, stictic, constictic acids. Yoshimura (1971) reports for the species in addition terpenoids. *Lobaria isidiosa* is very similar to *L. pseudopulmonaria*, and differs only by the presence of isidia. These are normally coralloid, but sometimes they are mainly flattened, e.g. in H 28621. The species is also close to *L. retigera* (Bory) Trev., which according to Swinscow & Krog (1988: 145) may contain stictic acid agg. It differs by producing deciduous isidia on soredium-like patches. The sharp thallus ridges, which *L. isidiosa* shares with *L. pseudopulmonaria*, are

conspicuous on the available Kinabalu material, but are regularly absent in material from elsewhere in Southeast Asia.

- Lobaria pseudopulmonaria** Gyeln. - In mossy forest along Mesilau Trail and Tourist Trail, 1600-2900 m. H 28036, 29139 (35); H 28458 (38); H 29223 (39a); H 28748, 29078 (40); H 28354 (41); H 28390 (42); H 28939 (43); H 28045, 28610, 28763 (50); S 30915 (1); Iwatsuki 1190 [NICH] (Yoshimura 1971: 293); M.Togashi s.n. [TNS] (Yoshimura 1971: 293); Moleswoth-Allen 1555 [L, 957, 108-209] (Yoshimura 1971: 293). TLC: (S 30915) trace norstictic, stictic, constictic acids (medulla C-); (H 28036, 28045, 28610, 29078) trace norstictic, stictic, ?trace menegazziaic, constictic acids. All Hale collections identified by Yoshimura in 1970.
- Lobaria subscrobiculata** Vain. - In mossy forest along Mesilau Trail, 1600-1900 m. H 28178 (34), vidi Yoshimura; H 28237 [US, NICH] (44) (Yoshimura 1971: 268); H 28235 (vidi Yoshimura), 29136 (44). TLC!
- Massalongia carnosa** (Dicks.) Körb. - On *Lepospermum* in upper cloudforest along Tourist Trail, 3200 m. S 31242a (13).
- Mazosia bambusae** (Vain.) R. Sant. - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29458 (23).
- Mazosia melanophthalma** (Müll. Arg.) R. Sant. - On leaves of undergrowth in montane and lowland forest near Park HQ and Poring, 750-1650 m. S 29459, 29460 (23); S 29560 (28). In all three specimens the spores are 4-celled.
- Mazosia paupercula** (Müll. Arg.) R. Sant. - On leaves of undergrowth in lowland forest near Poring, 700 m. S 29520 (27).
- Mazosia phyllosema** (Nyl.) A. Zahlbr. - On leaves of undergrowth in lowland- and montane forest near Poring and Park HQ, 700-1650 m. S 29461 (23); S 29521 (27); S 29561 (28).
- Mazosia rotula** (Mont.) Mass. - On leaves of undergrowth in lowland forest near Poring, 700-750 m. S 29522 (27); S 29562 (28).
- Mazosia pilosa** Kalb & Vezda - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29500 (25).
- Megalospora atrorubicans** (Nyl.) A. Zahlbr. ssp. **atrorubicans** - In tree crown of montane forest near Park HQ, 1700 m. S 29491, 31388 (24).
- Megalospora coccodes** (Bél.) Sipman ssp. **nigricans** (Müll. Arg.) Sipman - In tree crown of montane forest near Kundason, 1400 m. H 29131 (32).
- Megalospora halei** Sipman - In dwarfed cloud-forest along Tourist Trail, 2700-3600 m. H 28671 [US, holotypus], 28048, 29028 (51); H 28067 (52); S 31189 (12); S 31232 (13).
- Megalospora pruinata** (Müll. Arg.) Sipman ssp. **fusca** Sipman - In tree crown of montane forest near Park HQ, 1650 m. S 31439a (26).
- Megalospora pruinata** (Müll. Arg.) Sipman ssp. **lamii** (Groenh.) Sipman - In mossy forest along Mesilau Trail, 1600 m. Hale 28449 (36).
- Megalospora sulphurata** Mey. ssp. **sulphurata** - In tree crowns in lowland and montane forest and in stunted cloudforest, widespread and common, 700-1900(-3500) m. H 28991, 29100 (31); H 29073, 29118 (32); H 28819 (33); H 28205, 28785, 29273 (34); H 28489 (36); H 28037 (37); H 28017 (40); H 28247, 28496 (44); H 29062 (49); H 28594 (51); H 28585 (52); S 30972 (4); S 30987 [SNP] (5); S 31057 (8); S 31300 (16) (vs., with apoth. primordia); S 31411, 31414 [SNP] (25); S 31475, 31481, 31483 [SNP] (26); S 31504 (27).
- Megalospora tuberculosa** (Fée) Sipman - In mossy forest along Mesilau Trail and Tourist Trail, 1700-3200 m. H 29217 (39a). S 31054 (7); S 31127 [SNP] (9); together with S 31251 = *Catinaria* sp. (13); S 31342 (19).
- Melanelia panniformis** (Nyl.) Essl. - On granite rock in the summit area, 4050 m. S 31148 [SNP] (10). TLC: perlatolic acid.
- Menegazzia cf. terebrata** (Hoffm.) Massal. - In tree crowns of montane forest and in

stunted forest upwards, widespread and common, 1700-3800 m. S 30929 [SNP] (1); S 30949 (SNP), 30954 (3); S 31036, 31038 (7); S 31093 (9); S 31161 (11); S 31178 (12); S 31396 [SNP] (24). TLC: (S 31036, 31161, 31178) trace atranorin, stictic, menegazziaic, constictic acids. The specimens fit *M. terebrata*, except that the lobes are more separated than in European material. The genus *Menegazzia* is well represented on Mount Kinabalu by several seemingly well-separated populations: a small-sized, fertile type without vegetative reproduction, a small-sized one with capitate soralia, a large-sized, sorediate form, a small-sized, sorediate one and a type with rugulose lobe surface. All seem to have the same chemistry.

Mycoblastus affinis (Schaer.) Schauer - In tree crown of montane forest near Park HQ, 1650 m. S 31484 (26).

Myriotrema concretum (Fée) Hale - In mossy forest along Tourist Trail, 1650-3100 m. H 28208 (46); H 29150 (49), also distributed as *Vezda Lich. Sel. Exs.* 1153; S 31440 (26); S 31125 (9). TLC (S 31440): psoromic acid.

Myriotrema exile (Hale) Hale - In mossy forest along Mesilau Trail, 1900 m. H 28249 [US, holotype] (44) (Hale 1978: 381, as *Thelotrema exile* Hale); S 31308 (16).

Myriotrema hartii (Müll. Arg.) Hale - On trees in montane forest at beginning of Tourist Trail, c. 1500 m. H 28801 (33). TLC: psoromic acid and unknown traces.

Myriotrema microporum (Mont.) Hale - In montane forest along Mesilau Trail and near Park HQ, 1400-2050 m. H 29125 (32); H 28812, 28817 (33); H 29147 (35); S 30884 (1); S 31370 (21); S 31474, 31479 (26). TLC: (S 30884, 30886, 31474) psoromic acid, unkn. spot; (S 31370, 31479) psoromic acid.

Myriotrema microstomum (Müll. Arg.) Hale - In montane mossy forest along Mesilau Trail, near Park HQ and along Summit Trail, 1700-1900 m. H 28026 (40); H 28399 (42); S 30890, 30890a, 30890b, 30909, 30923 (1); S 31387 (24). TLC: (S

30909, 30923, 31387, 30890) protocetraric? acid (A:2,3).

Myriotrema scabridum (Hale) Hale - In stunted mossy forest along Summit Trail, c. 2600-2900 m. H 28055 [US, holotype] (50) (Hale 1978: 380, as *Phaeotrema scabridum* Hale); H 28346 (49).

Myriotrema terebratulum (Nyl.) Hale - In forest along Mesilau Trail, c. 1600 m. H 28154 (34).

Nephroma helveticum Ach. - In mossy forest and stunted cloudforest along Tourist Trail and Mesilau Trail, 1600-3100 m. H 28200, 28301 (34); H 28484 (36); H 28276 (38); S 31060 (8); S 31112 (9); Clemens 51353 [US].

Nephromopsis delavayi Hue - In stunted mossy forest along Tourist Trail, 2900-3100 m. S 31025 (7); S 31113 (9); Kadhum 50, 7. Dec. 1987 (US). TLC: (fumar)protocetraric, trace salazinic? acids.

Nephromopsis stracheyi (Bab.) Müll. Arg. - In stunted cloudforest along Tourist Trail, 2600-2900 m. S 30975 (5); S 31027 (7). TLC: usnic acid, 2 unknown spots (A:4-5).

Normandina pulchella (Borr.) Nyl. - In stunted forest along Tourist Trail, probably widespread but underrepresented in the collections because it occurs usually in small quantities, 3200 m. S 31223 [SNP] (13).

Ocellularia crassa (Müll. Arg.) Hale - In forest along Mesilau Trail, c. 1700 m. H 28473 (38).

Ocellularia deformis Nagarkar & Hale - In mossy forest along Mesilau Trail, 1800 m. H 28377 [US, holotype] (41) (Nagarkar & Hale 1989: 442).

Ocellularia globosa Hale - In mossy stunted forest along Tourist Trail, c. 2700-2900 m. H 28657 [US, holotype] (50) (Hale 1974: 492).

Ocellularia kinabalensis Nagarkar & Hale - In stunted forest along Mesilau Trail, c. 1900 m. H 28245 [US, holotype] (44) (Nagarkar & Hale 1989: 444).

Opegrapha puiggarii Müll. Arg. - On leaves of undergrowth in lowland forest near

- Poring, 700 m. S 29524 (27).
- Oropogon salazinicum** Essl. - In mossy forest along Tourist Trail, 1900-2800 m. H 28693 (45); S 31272 (16). Esslinger 1989: 31. TLC!
- Orphniospora moriopsis** (Massal.) D. Hawksw. - On granite rock in the summit area, 4050 m. S 31152 (10).
- Pannaria rubiginosa** (Ach.) Bory - In stunted cloudforest along Tourist Trail, 2900-3800 m. S 31029 [SNP] (7); S 31174 (11); S 31197 [SNP] (12). TLC: (S 31174) pannarin.
- Parmelia erumpens** Kurok. - In tree crown of montane forest near Kundason, 1400 m. H 29017 (30).
- Parmelia sectilis** Hale - In mossy forest along Tourist Trail and Mesilau Trail, 1600-2400 m. H 28786 (34); H 29050 (40); H 28378, 29090 (41); H 28241 (44); H 28507, 28630, 28935 (48); S 30958 (3); S 31336 (19). TLC!
- Parmeliella brisbanensis** (C. Knight) P.M. Jørg. & D. Galloway - In mossy forest below Layang Layang, 2400 m. S 31330 (19).
- Parmeliella mariana** (E. Fr.) P.M. Jørg. & D. Galloway - In montane and cloud forest along Tourist Trail, 1650-3500 m. Polak in Herb. Leuckert 2502d [B]; S 29462 (23).
- Parmelinella wallichiana** (Tayl.) Elix & Hale - In tree crowns of montane forest and in mossy forest along Mesilau Trail and Tourist Trail, 1400-2600 m. H 29071 (32); H 28807 (33); H 28707 (38); H 29063 (49); S 31444 (26). TLC!
- Parmelinopsis subfatiscens** (Kurok.) Elix & Hale - On rock in subalpine zone along Tourist Trail, c. 3500 m. H 28071 (52).
- Parmotrema corniculans** (Nyl.) Hale - In montane forest, c. 1600 m. H 28180 (34); Lee KLU 20806 [US].
- Parmotrema cristiferum** (Tayl.) Hale - In tree crown of montane forest near Kundason, 1400 m. H 29108 (32).
- Parmotrema gardneri** (Dodge) Sér. - In montane forest near Park HQ and along Mesilau Trail, 1600-1700 m. H 28182, 28564, 28789 (34); H 28477 (36); H 28264A, 28272 (38); S 31427 (26). TLC!
- Parmotrema gloriosum** (Kurok.) Streim. - In tree crowns of mossy forest along Mesilau Trail and Tourist Trail, 1500-2600 m. H 29031 (33); H 28010, 29242 (40); H 28503 (48); H 29156 (49); S 31338 (19). TLC!
- Parmotrema mellissii** (Dodge) Hale - In montane forest along Mesilau Trail, 1700 m. H 28260 (38); H 28432 (39).
- Parmotrema merrillii** (Vain.) Hale - In montane forest near Park HQ and along Mesilau Trail and Tourist Trail, 1300-1700 m. H 28516 (33); H 28216A, 28805 (34); H 28460 (38); S 31425 (26); Clemens 32425 [BO] (Hale 1965a: 299, as *Parmelia merrillii* Vainio); Throter 1705 [US]. TLC!
- Parmotrema subarnoldii** (des Abb.) Hale - On fallen crown branch in tall forest along Kiau View Trail near Park HQ, c. 1650 m. S 31429 (26). TLC!
- Parmotrema subrugatum** (Kremp.) Hale - Common in montane and mossy forest, often in tree crowns, along Mesilau Trail and Tourist Trail, 1500-2900 m. H 28517 (33); H 28216 (34); H 29140 (35); H 28727 (37); H 28281, 28469, 28705 (38); H 29229 (39a); H 28039, 28749 (40); H 28386 (42); H 28500 (44); H 28686, 28679, 28754 (45); H 28959 (46); H 28575 (48); H 29151 (49); H 28946 (50); S 30912 (SNP), 30920 [SNP] (1); S 30935 (2); S 30938 (3); S 30963 [SNP] (4); S 31263 (16); S 31339 (19); S 31393 [SNP] (24); S 31399 [SNP] (25). TLC!. Since many specimens are without apothecia, the possibility cannot be excluded that part belongs to related species, e.g. *P. corniculans* (Nyl.) Hale.
- Parmotrema tinctorum** (Nyl.) Hale - In tree crowns of montane and lowland forest near Mesilau Trail, Park HQ and Poring, 700-1650 m. H 29127 (32); H 28565 (34); S 31428 (26); S 31499 [SNP] (27).
- Parmotrema ultralucens** (Krog) Hale - In tree crown of montane forest near Kundason, 1400 m. H 29132 (32). TLC!
- Peltigera canina** (L.) Willd. - On mossy road bank in stunted forest, c. 2500 m. S 31323 (18).

- Peltigera dolichorrhiza** (Nyl.) Nyl. - On road banks in mossy forest, 1650-3100 m. S 31087 (8); S 31379 (23).
- Peltigera melanocoma** Mont. & v. d. Bosch - On road bank in stunted mossy forest, c. 2500 m. S 31322 (18).
- Pertusaria confusa** Archer - Epiphytic along Mesilau Trail and Tourist Trail, c. 1600-2200 m. H 28735 (37); H 28409 (42); H 28942 (43); H 28513 (48). TLC: picrolichenic acid, lichexanthone.
- Pertusaria epitheciifera** Sipman, sp. nov. (description see below) - In stunted high-altitude forest near Paka Shelter, 3100-3200 m. S 31058 (8); S 31234, 31257 (cf.) (13).
- Pertusaria gyalectoides** Vezda - In stunted cloud forest along Tourist Trail, 2800-3200 m. S 31233 (13); S 31298 (16).
- Pertusaria velata** (Turn.) Nyl. - Epiphyte along the lower part of Mesilau Trail, c. 1400-1700 m. H 28545 (32); H 29283 (39a). TLC: lecanoric acid.
- Phaeographina montagnei** (v. d. Bosch) Müll. Arg. - In tree crowns of montane forest along Tourist Trail and near Park HQ, 1400-2000 m. H 29095 (31); H 28965 (46); S 31458 (26).
- Phaeographina prosiliens** (Mont. & v. d. Bosch) Müll. Arg. - In montane, mossy forest along Tourist Trail and Mesilau Trail, 1700-2500 m. H 28421 (39); H 28690 (45); S 30969 (4).
- Phaeographis kinabalensis** Sipman, sp. nov. (description see below) - On smooth, soft bark in forest, 1650-2700 m. H 28007 (40); H 28373 (41); H 28401 (42); H 28330 (45); S 30910 (1); S 31007 (6); S 31463 (16).
- Phaeophyscia endococcinodes** (Poelt) Essl. - In montane forest along Mesilau Trail, c. 1600 m. H 28297 (34); H 28446 (36); H 29189 (37). Esslinger 1978: 301.
- Phyllobathelium nigrum** R. Sant. & Tibell - On leaves in undergrowth of lowland forest near Poring, 700 m. S 29526 (27).
- Phyllophiale alba** R. Sant. - On leaves in undergrowth of lowland forest near Poring, 700-750 m. S 29527 [SNP] (27); S 29563 [SNP] (28).
- Phylloporis multipuncta** (R. Sant.) Vezda - On leaves in undergrowth of lowland forest near Poring, 700-750 m. S 29528 (27); S 29564 [SNP] (28).
- Phylloporis phyllogena** (Müll. Arg.) Vezda - On leaves in undergrowth of lowland forest near Poring and montane forest near Park HQ, 700-1700 m. S 29463 (23); S 29492 (24); S 29529 (27); S 29565 (28).
- Physma byrsaeum** (Ach.) Müll. Arg. - On trees, 1400 m. H 28974 (31).
- Physma pseudoisidiatum** Aptroot & Sipman - On trees, 1400 m. H 28983 (31).
- Placopsis auriculata** Lumbsch et Kashiw. - On loamy road bank near Layang Layang, 2500 m. S 31320 (17). Recently described from Papua New Guinea (Lumbsch & Kashiwadani 1993).
- Platismatia regenerans** W.L. Culb. & C.F. Culb. - In usually stunted and exposed, mossy forest along Mesilau Trail and Tourist Trail, 1800-2800 m. H 29084 (41); H 28395 (42); H 28064 (45); H 28207 [US holotype] (46); H 28642, 28932 (48); S 30951 [SNP] (3); S 31277 (16); Culberson & Culberson 1968: 548.
- Polepsidium oxytonum** (Ach.) Rabenh. - On granite rock in the summit area, 4050 m. S 31140 (10).
- Polychidium stipitatum** Vezda & W.A. Weber - In stunted cloudforest and mossy forest along Tourist Trail, 2050-3200 m. S 31244 (13); S 31297 (16); S 31363 (21).
- Porina conica** R. Sant. - On leaves in undergrowth of lowland forest near Poring, 700-750 m. S 29530 (27); S 29566 (28).
- Porina cupreola** (Müll. Arg.) Schilling - On leaves in undergrowth of lowland forest near Poring, 750 m. S 29567 (28) (Sipman 1991: 261).
- Porina epiphylla** (Fée) Fée - On leaves in undergrowth of lowland forest near Poring and of montane forest near Park HQ, 700-1650 m. S 29464 (23); S 29531 (27); S 29568 (28).
- Porina epiphyloides** Vezda - On leaves in undergrowth of lowland forest near Poring and of montane forest near Park HQ, 700-1650 m. S 29465 (23); S 29532 (27); S 29569 (28).

- Porina pseudofulvella** Sér. - On leaves in undergrowth of montane forest near Park HQ and of lowland forest near Poring, 700-1700 m. S 29466 (23); S 29493 (24); S 29533 (27).
- Porina homalea** R. Sant. - On leaves in undergrowth of lowland forest near Poring, 750 m. S 29571 (28).
- Porina limbulata** (Kremp.) Vain. - On leaves in undergrowth of montane forest near Park HQ, 1700 m. S 29494 (24).
- Porina nitidula** Müll. Arg. - On leaves in undergrowth of lowland forest near Poring, 750 m. S 29572 (28).
- Porina pallescens** R. Sant. - On leaves in undergrowth of lowland forest near Poring, 750 m. S 29573 (28).
- Porina rubentior** (Stirt.) Müll. Arg. - On leaves in undergrowth of montane forest near Park HQ, 1650-1700 m. S 29468 [SNP] (23); S 29495 (24).
- Porina semecarpi** Vain. - On leaves in undergrowth of lowland forest near Poring, 700 m. S 29534 (27).
- Porina virescens** (Kremp.) Müll. Arg. - On leaves in undergrowth of lowland forest near Poring and in montane forest near Park HQ, 700-1650 m. S 29469 (23); S 29536 (27); S 29574 (28).
- Pseudocyphellaria argyracea** (Del.) Vain. - In mossy forest along Mesilau Trail and Tourist Trail, 1600-3100 m. H 28479 (36), det. R.C. Harris 1971; S 31116 [SNP] (9).
- Pseudocyphellaria beccarii** (Kremp.) D. Galloway - Epiphyte in mossy montane and cloud forest, 1650-3100 m. S 30960 (4); S 31084 (8); S 31377 (23).
- Pseudocyphellaria crocata** (L.) Vain. - In mossy forest and stunted cloudforest, 1700-3600 m. H 28252 (38); S 31024 (7); S 31079 (8); S 31105 (9); S 31188 [SNP] (12).
- Pseudocyphellaria desfontainii** (Del.) Vainio - In stunted mossy forest, 3100 m. S 31104 (9). Identified by D. Galloway, 1993.
- Pseudocyphellaria diplomorpha** (Müll. Arg.) D. Galloway - In montane and stunted mossy forest, 1650-3100 m. S 31075 (8); S 31383 (23). Identified by D. Galloway, 1993.
- Pseudocyphellaria neglecta** (Müll. Arg.) H. Magn. - In mossy cloudforest near Mempoing Shelter, 2500 m. S 30961 (4).
- Pseudocyphellaria sulphurea** (Schaer.) D. Galloway - In mossy forest and stunted cloud forest along Tourist Trail, 1650-3100 m. S 31085 (8); S 31377a (23); Wolseley [BM], 1988; Polak in Herb. Leuckert 2504 [B] (det. H.Sipman 1989).
- Psoroma sphinctrinum** (Mont.) Nyl. - In montane forest, 1400-1600 m. H 28300 (31); H 28988 (34).
- Pyrgillus javanicus** (Mont. & v. d. Bosch) Nyl. - In montane forest near Park HQ, 1650 m. S 31435 (26).
- Pyrgillus cubanus** Nyl. - Epiphyte in tall forest near Park HQ, c. 1650 m. S 31449 (26).
- Raciborskiella janeirensis** (Müll. Arg.) R. Sant. - On leaves in undergrowth of lowland forest near Poring, 700 m. S 29537 (27).
- Ramalina javanica** Nyl. - Epiphyte in stunted, open forest along Summit Trail, 3200-3600 m. S 31182 (12); S 31217 [SNP] (13). TLC: usnic, sekikaic, salazinic acids.
- Relicina acrobotrys** (Kurok.) Hale - In montane forest along Mesilau Trail, 1400-1600 m. H 28540, 29123 (32); H 28126 (34).
- Relicina amphithrix** Hale - In montane forest along Mesilau Trail and Tourist Trail, 1400-1900 m. H 29076 (32); H 28820 (33); H 28239 (44). TLC: (H 29076) salazinic, echinocarpic acid, det. Hale.
- Relicina columnaria** Elix & Johnston - In mossy forest along Mesilau Trail and Tourist Trail, 1800-2400 m. H 28641, 28750 (40); H 29031 (41); S 31331 (19). Elix & Johnston (1990: 272) state that Hale 28641, 28750, 29031 are not *R. fluorescens* but this species; chemistry: usnic, ± trace atranorin, echinocarpic, trace conechinocarpic acids
- Relicina fluorescens** (Hale) Hale (with alectronic acid) - In mossy forest along Mesilau Trail and Tourist Trail, 1600-2200 m. H 29146 [LD, US] (35) (Hale 1965: 203, as *Parmelia fluorescens* Hale); H 29048 (40); H 29053, 29088, 29248 (41); H 28944 (43) (Hale 1965: 203, as *P. fluorescens*); H 29232 [WIS, US], 28233 [DUKE, PUH,

UPS, US] (44) (Hale 1965: 203, as *P. fluorescens*); H 28322, 28694, 28703 (45) (Hale 1965: 203, as *P. fluorescens*); H 28637 [US holotype, SAN, TNS isotypes] (47) (Hale 1965: 202, as *P. fluorescens*; Hale 1975: 21); H 28510, 28639, 28641, 28826 (48) (Hale 1965: 203, as *P. fluorescens*). TLC: usnic, alectoronic acid, all specimens except the following three; usnic, echinocarpic acid (H 29088, 28703, 28826).

Relicina luteoviridis (Kurok.) Hale - In montane forest near Kundason, 1400 m. H 29069 (32).

Relicina planiuscula (Kurok.) Hale - In mossy forest along Mesilau Trail and Tourist Trail, 1400-2600 m. H 28546 (32); H 28815 (33); H 28257 (38); H 28040, 29035 (40); H 28372 (41); H 28400, 28402 (42); H 28234 (44); H 28063, 28700 (45); H 29265 (46); H 28063, 28508, 28580, 28581 (48); H 29168 (49); S 30928 [SNP] (1); S 31355 (20). TLC!

Relicina schizospatha (Kurok.) Hale - In montane forest along Mesilau Trail and near Park HQ, 1400-1650 m. H 29117 (32); H 28156, 28157, 28222, 29026, 29037, 29285 (34); S 31443 (26). TLC!

Relicinopsis intertexta (Mont. & v. d. Bosch) Elix & Verdon - In montane and mossy forests along Mesilau Trail and Tourist Trail, 1400-2600 m. H 28813 (33); H 28206 (34); H 29065 (49).

Rhizocarpon geographicum (L.) DC. - On granite rock in the summit area, 4050 m. S 31145, 31150 (19).

Rimelia reticulata (Tayl.) Hale & Fletcher - In montane forests along Mesilau Trail and Tourist Trail, 1400-1900 m. H 29013 (30); H 28539 (32); H 28520 (33); H 28787 (34); H 28478 (36); H 28253, 28280, 28707A (38); H 28419 (39); H 28246 (44); S 31397 [SNP] (24); S 31430 (26). Many specimens in NY were determined by Kurokawa as *Parmelia clavulifera*.

Rimularia furvella (Nyl. ex Mudd) Hertel & Rambold - On granite rock in the summit area, 4050 m. Accompanying in S 31148 = *Melanelia panniformis* (10) The thallus

is sterile, C+ red.

Sarcographa intricans (Nyl.) Müll. Arg. - In tree crown of montane forest, 1650 m. S 31410 (25).

Sarrameana septata Sipman & Aptroot - In stunted cloudforest near Sayat Sayat, 3200-3800 m. S 31172 (11); S 31200 (12); S 31253 (13). This species, recently described from New Guinea (Aptroot & Sipman 1991), has a much wider distribution, and was recently reported from the South Island of New Zealand (Vezda et al. 1992: 16).

Semigyalecta paradoxa Vain. - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29470 (23); S 29501 (25).

Siphula decumbens Nyl. - On thin humus cover on rock and on treebark in stunted cloudforest along Tourist Trail, occasionally in mossy forest along Mesilau Trail and near Park HQ, (1700-)2600-3500 m. H 28647, 29085 (41); H 29158 (49); H 28319 (51); H 28075, 28309, 29135 (52); S 31011 (6); S 31020 (7); S 31071 (8); S 31124 [SNP] (9); S 31386 (24). TLC: (S 31011, 31071, 31124, 31210, 31386) thamnolic acid. The Hale-collections were determined by R. Santesson in 1968.

Sphaerophorus diplotypus Vain. - On tree-trunks in mossy forest along Mesilau Trail and Tourist Trail, 1600-2700 m. H 28179 (34) (Ohlsson 1973: 118); H 29052 (41) (Ohlsson 1973: 117); H 29159 (49) (Ohlsson 1973: 118); S 30913 (1); S 30957 [SNP] (3); S 31009 [SNP] (6); S 31315 (17); S 31332 (19); S 31358 (21). TLC: (S 30913, 31009, 31315, 31332, 31358) sphaerophorin, stictic, constictic acids; (H 29052) strain 1, sphaerophorin, stictic and constictic acids (Ohlsson 1973: 117); (H 28179, 29159) strain 2, sphaerophorin (Ohlsson 1973: 118).

Sphaerophorus formosanus (A. Zahlbr.) Asah. - In stunted cloudforest along Tourist Trail, 2900-3100 m. S 31023 (7); S 31069 (8). TLC: sphaerophorin, stictic, cryptostictic, constictic acids.

Sphaerophorus kinabaluensis (Sato) Ohlsson - In mossy forest and cloudforest along Mesilau Trail and Tourist Trail, 1800-

3000 m. H 29141 (Ohlsson 1973: 130); H 28522 (Ohlsson 1973: 130); H 29231, 28414 (Ohlsson 1973: 130); H 29266, 28502 (Ohlsson 1973: 130); H 28359 (41) (Ohlsson 1973: 130); H 28656 [Herb. Univ. Ibaraki, Mito HOLOTYPUS, TNS, US isotypes] (50) (= Sato, Lich. Exot. no. 842) (Sato 1967: 108, as *Pseudosphaerophorus kinabaluensis* Sato) (Ohlsson 1973: 128, 130); S 31354 (20); Clemens 10602 [FH] (Ohlsson 1973: 130). TLC (S 31254): sphaerophorin, stictic, cryptostictic, constictic acids.

Sphaerophorus murrayi Ohlsson in Tibell - In stunted, mossy forest near Paka shelter, occasionally lower down, along Mesilau Trail, (1400-)2700-3200 m. H 29134 (32) (Ohlsson 1973: 175); H 28650 (50) (Ohlsson 1973: 175); S 31068, 31072 (8); S 31209 (13); H. Polak in Herb. Leuckert 2502b [B]. TLC: (S 31068, 31072, 31209) sphaerophorin, ?protocetraric acid: (H 29134, 28650) chemotype 1, sphaerophorin and protocetraric acid (Ohlsson 1973: 175).

Stereocaulon graminosum Schaer. - On porphyric or granitic rock outcrops along Tourist Trail, 2900-4050 m. S 31017 (7); S 31136, 31137 (10); S 31167 (c. soled!) (11). TLC: atranorin, stictic, menegazziaic acids, unkn.

Stereocaulon granulans Sipman sp. nov. (description see below) - In dwarfed forest near Sayat Sayat, c. 3800 m. S 31154 (11).

Stereocaulon halei Lamb - On mossy road banks along Tourist Trail, 1900-2500 m. S 30918 (1); S 30964 (4). TLC!

Stereocaulon massartianum Hue - On road banks and rock outcrops along Tourist Trail, 1800-3800 m. H 28996 (52); S 30917 [SNP] (1); S 30965 [SNP] (4); S 31077 (8); S 31156 (11); S 31371 (22); Polak in Herb. Leuckert 2503b [B]; Menzel c.s. 4998b [B]. TLC: (S 30917) atranorin, norstictic, stictic, menegazziaic acids, unkn.; (S 31077) atranorin, norstictic, connorstictic acids; (S 31156, 31371) atranorin, norstictic, stictic, menegazziaic, ?constictic acids.

Stereocaulon massartianum v. **chlorocarpoides** (A. Zahlbr.) Lamb - On rocks in stream (at lower elevation) and on rock outcrops and road banks, 1600-3000 m. H 28515 (36); H 29197 (37); H 28450 (39); H 28066 pr.p. (52); Clemens 34260 [BO], 27.VII.1933, det. Lamb; Clemens 32339 [BO], 24.V.1933, 10500 ft., Manai Parai, above Kamburanga, det. Lamb. TLC: (H 28515, 28450) norstictic acid, det. Lamb; (H 29197) lobaric acid, det. Lamb; (H 28066 pr.p.) stictic acid, det. Lamb.

Stereocaulon staufferi Lamb var. **borneense** Lamb - On porphyric and granitic outcrops along Tourist Trail, 2900-4050 m. H 29238 (49); H 28310 [US holotypus, FH isotypus] (52) (Lamb 1977: 304); H 28089, 29263 (52) (det. Lamb); S 31012, 31013 (7); S 31138 (10); S 31157 (11); Polak in Herb. Leuckert 2503 [B]; Menzel et al. 4998 [B]. TLC!

Strigula orbicularis E.M. Fries - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29473 (23).

Strigula macrocarpa Vain. - On leaves of undergrowth in montane forest near Park HQ, 1650-1700 m. S 29474 (23); S 29496 (24).

Strigula nemathora Mont. - On leaves of undergrowth in lowland forest near Poring, 700 m. S 29539 (27).

Strigula nitidula Mont. - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29475 (23); S 29503 (25).

Strigula smaragdula E. Fries - On leaves of undergrowth in montane forest near Park HQ and in lowland forest near Poring, 700-1650 m. S 29502 [SNP] (25); S 29538 (27).

Strigula subtilissima (Fée) Müll. Arg. - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29476 (23).

Tephromela armeniaca (DC) Hertel & Rambold - On granite rock in the summit area, 4050 m. S 31149 (10).

Tephromela atra (Huds.) Hafellner - On branches in tree crowns of montane forest and of stunted trees higher up, along Tourist Trail, 1650-2900 m. S 30986 [SNP] (5); S 31032 (SNP), 31048 (7); S 31489 [SNP]

(26).

Thelotrema colobicum Nyl. - In tree crown of montane forest near Park HQ, 1650 m. S 31451, 31467 (26).

Thelotrema piluliferum Tuck. - In mossy forest along Mesilau Trail and Tourist Trail, 1800-3100 m. H 29087 (41); H 29097 (50); S 31128 (9); S 31302, 31307, 31309 (16). TLC! In nr. 31307 and 31309 parts of the thallus bear tall cylindrical isidia. They are dispersed over the thallus in a rather irregular way: some thallus parts, including the crowded apothecium warts, are equally covered with isidia, while other parts with equally many apothecia are completely without; some parts without apothecia and with only isidia differ slightly in colour. This suggests that the isidia do not belong to *T. piluliferum* but to another lichen partly overgrowing it.

Thelotrema porinoides Mont. & v. d. Bosch - In mossy forest along Mesilau Trail, 1800 m. H 29209 (40).

Thelotrema subweberi Sipman sp. nov. (description see below) - In stunted forest near Villosa Shelter and Paka Shelter, 2900-3200 m. S 31045 [SNP] (7); S 31248 (13); S 31260 (15).

Thelotrema weberi Hale - In stunted cloudforest along Tourist Trail, 2700-3600 m. H 28654 (50) (Hale 1974: 498); S 31190 (12); S 31250 (13). TLC!

Trapelia mooreana (Caroll) P. James - On loamy road bank near Layang Layang, 2500 m. S 31312 (17).

Trapeliopsis gelatinosa (Flk.) Coppins & P. James - On mossy road bank in mossy forest below Kamaranga, 1900 m. S 30893 (1).

Tricharia albostrigosa R. Sant. - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29477 (23).

Tricharia helminthospora R. Sant. - On leaves of undergrowth in montane forest near Park HQ, 1650 m. S 29479 (23).

Tricharia vainioi R. Sant. - On leaves of undergrowth in montane forest near Park HQ and in lowland forest near Poring, 700-1650 m. S 29504 (25); S 29575 (28).

Trichothelium alboatrum Vain. - On leaves of undergrowth in lowland forest near Poring, 700 m. S 29540 (27).

Trypethelium aeneum (Eschw.) A. Zahlbr. - In tree crown in montane forest near Park HQ, 1650 m. S 31459 (26).

Umbilicaria africana (Jatta) Krog & Swinsc. - On granite rock in the summit area, 4050 m. S 31130 (10).

Usnea baileyi (Stirt.) A. Zahlbr. - On tree crown in montane forest near Park HQ, 1650 m. S 31417 (26). TLC: trace usnic acid, norlobaridone, norstictic acid.

Usnea flexilis Stirt. - In tree crowns of mossy forest and on stunted trees, along Tourist Trail, 2300-3200 m. S 30939 (3); S 30974 (5); S 31067 (8); S 31097 (9); S 31220 (13); S 31286 (16); S 31334, 31340 [SNP] (19). TLC: (S 30939, 30974, 31067, 31097 (SNP), 31286 (SNP), 31334). TLC: trace usnic, echinocarpic, protocetraric acids.

Usnea misamisensis (Vain.) Mot. - In tree crowns of montane forest along Tourist Trail, 1650-2400 m. S 30944 (3); S 31329 (19); S 31345 (20); S 31421, 31422 (26). TLC: (S 30944, 31421, 31422) usnic, trace norstictic, stictic, menegazziaic, cryptostictic, ?constictic acids.

Usnea rubicunda Stirt. - On tree crown in montane forest near Park HQ, 1650 m. S 31419 (26). TLC: usnic, trace norstictic, stictic, menegazziaic, cryptostictic, ?constictic acids.

Xanthoria candelaria (L.) Th. Fr. - On granite rock in the summit area, 4050 m. Accompanying in S 31148 = *Melanelia panniformis* (10).

B. The collecting localities of Sipman & Tan (S) and Hale (H).

Collection H. Sipman & B. Tan, 9-15 May 1989: (1) c. 1900 m, S-slope of Mount Kinabalu, along Summit Trail, in mossy oak forest on slope below Kandis Shelter; (2) c. 2000 m, S-slope of Mount Kinabalu, along Summit Trail, in mossy cloud forest on mountain ridge near Ubah Shelter; (3) c. 2300 m, S-slope of Mount Kinabalu, along Summit Trail, in mossy cloud forest on mountain ridge near Lowii Shelter; (4) c. 2500 m, S-slope

of Mount Kinabalu, along Summit Trail, in mossy cloud forest near Mempoening Shelter; (5) c. 2600 m, S-slope of Mount Kinabalu, along Summit Trail, in light, stunted *Dacrydium* forest on mountain ridge with ultrabasic rock near Carson's Camp; (6) c. 2700 m, S-slope of Mount Kinabalu, along Summit Trail, on road bank in stunted cloud forest on mountain ridge above Carson's Camp; (7) c. 2900 m, S-slope of Mount Kinabalu, along Summit Trail, porphyric rock flats in stunted forest below Villosa Shelter; (8) c. 3100 m, S-slope of Mount Kinabalu, along Summit Trail, stunted mossy cloud forest near Paka Shelter; (9) c. 3100 m, S-slope of Mount Kinabalu, along Summit Trail, stunted, disturbed mossy forest near Paka Cave; (10) c. 4050 m, summit of Mount Kinabalu, along Summit Trail, on granitic rock near Low's Peak; (11) c. 3800 m, S-slope of Mount Kinabalu, along Summit Trail, in dwarfed forest near Sayat Sayat hut; (12) c. 3600 m, S-slope of Mount Kinabalu, along Summit Trail, stunted forest with many Podocarpaceae \pm halfway between Sayat Sayat and Laban Rata; (13) c. 3200 m, S-slope of Mount Kinabalu, along Summit Trail, stunted, open, *Leptospermum*-dominated forest; (14) c. 3100 m, S-slope of Mount Kinabalu, along Summit Trail, stunted mossy forest near Paka Shelter; (15) c. 3100 m, S-slope of Mount Kinabalu, along Summit Trail, ultrabasic rock outcrop near helipad near Paka Shelter; (16) c. 2800 m, S-slope of Mount Kinabalu, along Summit Trail, stunted mossy forest on mountain ridge \pm halfway between Villosa Shelter and Carson's Camp; (17) c. 2500 m, S-slope of Mount Kinabalu, along Summit Trail, mossy forest with clearings between Carson's Camp and Layang Layang radio station; (18) c. 2500 m, S-slope of Mount Kinabalu, along Summit Trail, clearings in stunted mossy forest on ridge near Layang Layang radio station; (19) c. 2400 m, S-slope of Mount Kinabalu, along Summit Trail, mossy forest on steep slope below Layang Layang radio station; (20) c. 2300 m, S-slope of Mount Kinabalu, along Summit Trail, stunted mossy forest on ridge near Lowii Shelter; (21) c. 2050 m, S-slope of Mount Kinabalu, along Summit Trail, mossy forest on ridge near Ubah Shelter; (22) c. 1800 m, S-slope of Mount Kinabalu, c. 1 km before Power Station along

road from Headquarters, on rocky roadbank in oakforest; (23) c. 1650 m, S-slope of Mount Kinabalu, surroundings of Headquarters, mossy oak forest in valley along Silau Silau Trail; (24) c. 1700 m, S-slope of Mount Kinabalu, surroundings of Headquarters, low forest on ridge along Kiau View Trail; (25) c. 1650 m, S-slope of Mount Kinabalu, surroundings of Headquarters, tall forest on slope along Kiau View Trail, near Ranau highway; (26) c. 1650 m, S-slope of Mount Kinabalu, surroundings of Headquarters, tall forest on slope along Kiau View Trail near Ranau highway. From crown branches of felled tree; (27) c. 700 m, Poring Hot Springs area on SE-slope of Mount Kinabalu, tall forest on slope along trail to Air Terjun waterfall, between springs and Sungai Kipungit; (28) c. 750 m, Poring Hot Springs area on SE-slope of Mount Kinabalu, tall forest on slope along trail to Air Terjun waterfall, near Kawasam Gua Kelawar; (29) c. 1100 m, Poring Hot Springs area on SE-slope of Mount Kinabalu, forest on slope along trail to Air Terjun waterfall, near 6. Fall.

Collection M. E. Hale, Aug. 1964: (30) c. 1400 m, felled trees in cabbage area, Mesilau Trail near Kundason; (31) c. 1400 m, felled trees near mile 36, Ranau Road; (32) c. 1400 m, felled trees near Sosopodon Shelter (near Kundason); (33) c. 1500 m, felled trees on new road to Kamaranga roadhead; (34) c. 1600 m, along Mesilau Trail on the plateau from Mesilau River to Kundason; (35) c. 1600 m, near campsite on W. Mesilau River; (36) c. 1600 m, landslide area near R.S. campsite, E. Mesilau River; (37) c. 1600 m, near campsite, Mesilau Trail at W. Mesilau River; (38) c. 1700 m, ascending Mesilau Trail from W. Mesilau River; (39) c. 1700 m, dry slope near E. Mesilau River; (39a) c. 1700 m, dry forest above E. Mesilau River; (40) c. 1800 m, mossy woods, Mesilau Trail to W. Mesilau River; (41) c. 1800 m, open ridge between E. and W. Mesilau Rivers; (42) c. 1800 m, Askews Overlook, Mesilau Trail; (43) c. 1800 m, exposed ridge on Mesilau Trail above W. Mesilau River; (44) c. 1900 m, small ridge just above E. Mesilau River; (45) c. 1900 m, sheltered woods just below Kamaranga radio tower, Tourist Trail; (46) c. 2000 m, just above Kamaranga radio tower, Tourist trail; (47) c. 2200 m, between Kamaranga and the second radio tower, Tourist Trail; (48) c. 2200

m, woods below second radio tower (above Kamaranga), Tourist Trail; (49) c. 2600 m, vicinity of Layang Layang, Tourist Trail; (50) 2700-2900 m, Tourist Trail between Layang Layang and Paka Cave; (51) c. 2900 m, Tourist Trail between Layang Layang and Paka Cave; (52) c. 3500 m, open woods at base of slabs on Tourist Trail.

C. List of collectors

The following alphabetical list of collectors is presented as an illustration of the history of lichenological exploration. The names have been compared with Index Herbariorum (Regnum Vegetabile 2(1954), 9(1957), 86(1972), 93(1976), 109(1983), 114(1986), 117(1988)); additions from this source are given in {}. Herbaria where material is preserved, collecting numbers and dates are added when known. Since part of the material of these collectors is not completely identified, some are not mentioned in the above enumeration of the species.

No great effort was made to detect old collections in the relevant herbaria, therefore the list is probably not very complete. It shows that the first explorer of the mountain, Low, already collected lichens. A substantial increase in collecting activity came after c. 1960, probably due to a better road connection with the coast. The main contribution to the lichenological exploration was by Mason E. Hale. He collected about 1300 specimens. Most of the available literature records for Kinabalu lichens refer to his collections and five new taxa were based on them.

W.L. Chew, E.J.H. Corner, A. Stainton [BM]: nrs. 2006, 2086, 3-8.VIII.1961 (Royal Society North Borneo Expedition 1961).
Clemens [BO, FH, H]: nrs. 10602, 32425, d.d. 1933 {J. Clemens & M. Clemens née Strong, 1915-17, 1929, 1931-33}.
Corner, see Chew et al.
J.-P. Frahm, see Menzel et al.
W. Frey, see Menzel et al.
Mason E. Hale [US, dupl. in B, DUKE, LD, NICH, PUH, SAN, TNS, UPS, WIS]: nrs.

28019-29282, Aug. 1964.
Ding Hou [L]: nr. 228, 27 May 1966.
Z. Iwatsuki [NICH]: nrs. 1190, 1536.
J. Klotz & C. Strobel [hb. Gierl]: two *Dibaeis* specimens.
H. Kürschner, see Menzel et al.
David W. Lee [KLU]: s.n., KLU 20819, KLU 20837, 14. June 1974.
H. Low [BM]: {1851 or 1858}.
M. Menzel, J.-P. Frahm, W. Frey, H. Kürschner, in part with M. A. H. Mohamed (= Haji Mohamed) [B]: 8 specimens collected during bryological fieldwork for the BRYOTROP project, August 1986. cf. Menzel (1988).
W. Meijer [L]: nrs. 10302, 10377, 1960.
M. Mizutani [TNS]: nr. 2252, 1963.
Haji Mohamed [KLU]: nr. 5813, 28 May 1982.
M. A. H. Mohamed, see. Menzel et al.
B. Moleswoth-Allen [L]: nr. 1555 {Mrs. B.E.G. Moleswoth-Allen, 1948-x}.
M. Nuno [TNS]: 3 Aug. 1976.
H. Polak [B]: herb. Leuckert nrs. 2502-2504b, 24-27.VII.1981.
H. Sipman & B. Tan [B, SNP]: nrs. 29427-29576, 30881-31519, 9-15 May 1989.
Stainton, see Chew et al.
Benjamin C. Stone [KLU]: nrs. 11438, 11439, 8 May 1973.
C. Strobel, see J. Klotz & C. Strobel.
B. Tan, see H. Sipman & B. Tan.
Thrower [FH, HKU, US]: nrs. 1772, 1816, d.d. 1973 {Stella L. Thrower}.
M. Togashi [TNS] (also cited as M.T.): nr. 66931, d.d. 1966; nr. 66925?, 21 sept. 1975.
P. Wolseley [BM]: 1988.

D. Descriptions of new species

Pertusaria epitheciifera Sipman, sp. nov.
Type: MALAYSIA, Sabah, S-slope of Mount Kinabalu, along Summit Trail, coord. c. 06° 05' N, 116° 35' E, alt. c. 3200 m, epiphyte in stunted, open, *Leptospermum*-dominated forest. 12 May 1989, H. Sipman & B. Tan 31234 [B holo, SNP iso].
(Figure 2a-c, 3)

Diagnosis: *Pertusaria* ascomatis exsertis, cupularibus, hymenio 125-160 μm crasso, paraphysibus paulo ramificantibus et ad apicem moniliformibus ramosis epithecio formantibus, sporis octonis, 30-50 x 15-25 μm , acido thamnolico in thallo, excipulo medullare et epithecio continens.

Description:

Thallus crustose, corticolous, c. 2-5 cm diam., to c. 300 μm thick but often much thinner, smooth or tuberculate, pale grey to white, dull, composed of an arachnoid layer of c. 5 μm thick hyphae covered with small crystals, covered by a c. 15 μm thick, hyaline, necrotic cortical layer of conglutinated hyphae; algae *Trebouxia*-like, c. 7-10 μm diam., concentrated in a narrow layer below the cortical layer; crystals of the arachnoid layer dissolving in KOH-solution with production of a yellow exudate; hypothallus inapparent; thallus tubercles white, dull, round to somewhat irregularly warted, 0.2-0.8 mm diam., 0.1-0.6 mm high; soredia and isidia absent (except in one specimen, see note).

Apothecia numerous, cupular to flat with prominent margins, with strongly constricted base, 1-2(-3) mm diam., c. 0.8 mm high; margins whitish, containing algae, entire or slightly crenulate, prominent, flexuose in the largest apothecia, 0.2-0.3 mm wide; disc pale pinkish to yellowish brown, becoming paler or blackish when old, mostly heavily white-pruinose; epihymenium granular, pale brown; hymenium colourless, not interspersed, c. 125-160 μm high, I-negative except for a distinct I+ blue coat around the asci; ascogenous hyphae in a narrow, c. 15-25 μm thick, I+ blue layer; hypothecium colourless, thin; excipulum of same constitution as thallus, with a c. 40-70(-100) μm thick cortical layer of pachydermatic prosoplectenchyma and an algal layer below this; crystals of medullary excipulum and epithecium dissolving in KOH-solution with production of a yellow exudate; asci cylindrical, c. 120 x 40 μm , with well-developed tholus with or without ocular chamber (fig. 2a); I-staining of tholus blue, slightly paler in a diffuse zone in the center, around the ocular chamber if present; paraphyses anastomosing in the lower third of the hymenium, higher up unbranched, septate every 10-30 μm , c. 1.5 μm thick, at tips coralloid-

branched and more or less moniliform over a length of c. 10-20 μm , with shorter, swollen, brown-pigmented cells, c. 5-10 μm long and 2-3 μm wide (fig. 2c), covered by crystals; spores c. 8 per ascus, more or less biseriolate, simple, oblong to ovoid, 30-50 x 15-25 μm , finally with a c. 2 μm thick wall (fig. 2b), but often seen in thin-walled stage, without gelatinous sheet.

Pycnidia not observed.

Chemistry: thallus and apothecia P+ orange, K+ yellow, C-, KC-; TLC: thamnolic acid. K-reaction in microscope sections showed that thamnolic acid is present in thallus medulla, medullary excipulum and epithecium as tiny crystals, which dissolve in KOH-solution with production of a yellow exudate.

Distribution and ecology: *Pertusaria epitheciifera* is known from the subalpine zone of Mount Kinabalu and some mountain ranges in Papua New Guinea, at 2300-3200 m. It grows on bark of stunted trees and on canopy branchlets in taller forest.

Additional specimens seen:

MALAYSIA, Sabah: S-slope of Mount Kinabalu, along Summit Trail, c. 06° 05' N, 116°35' E, alt. c. 3100 m, stunted mossy cloud forest between Paka Shelter and helipad, 10 May 1989, H. Sipman & B. Tan 31058 [B, SNP]; ibidem, alt. c. 3200 m, epiphyte in stunted, open, *Leptospermum*-dominated forest. 12 May 1989, H. Sipman & B. Tan 31257 (c. sor.) [B, SNP].

PAPUA NEW GUINEA, Eastern Highlands Province: Mount Gahavisuka Nature reserve, 8 km N of Goroka, alt. 2300 m, 145°25' E, 6°01' S, A. Aptroot 18748 [herb. Aptroot]; Madang Province: Huon Peninsula, Finisterre range, Yupna valley, Teptep village, trail in NNW direction, towards Bambu Airfield, alt. c. 2650 m, 146°33' E, 5°57' S, on fallen crown branchlets in disturbed mountain forest, 30 July 1992, H. Sipman 32716 [B]; Simbu Province: Mount Wilhelm, between Pindaunde valley and Keglsugl, subalpine forest, alt. 2800 m, 145°05' E, 5°48' S, 5-8 Aug. 1992, A. Aptroot 32603 [herb. Aptroot].

Notes: *Pertusaria epitheciifera* is very distinct from other species of *Pertusaria* in its cupular apothecia with constricted base and in the

differentiated paraphyse tips. Otherwise, it seems close to some species of *Pertusaria* with disciform ascomata by its little-branched paraphyses, its ascus apex and its large, thick-walled spores. It bears also a considerable resemblance to *Thamnochrolechia verticillata* Aptroot & Sipman, in its cupular apothecia, ascus apex, spore size, presence of thamnolic acid and ecology. Differences are in the smaller, less exerted, non-proliferating apothecia with thinner margins, the I-negative hymenial jelly, the less branched paraphyses with differentiated tips, and the larger spores without gelatinous sheet, which are not uniseriately arranged in the asci. The cortical layer of the exciple forms one more difference: In *T. verticillata* it is, contrary to the original description, c. 100 µm thick and composed of dense, thick-walled, not agglutinated hyphae. These similarities suggest that *Thamnochrolechia* is also related to *Pertusaria* subgenus *Pionospora*. In view of its distribution, *P. epitheciifera* may be a primitive species, ancestor to both *Pertusaria* and *Thamnochrolechia*, and perhaps even *Ochrolechia*. However, a closer investigation by TEM of their ascus structures, which show little differentiation upon iodine-staining, seems required to bring more clarity to the taxonomy of this complex.

One specimen, nr. 31257, shows round, c. 0.2-0.4 mm wide soralia in abundance on thallus and apothecium margin. These soralia produce fine (c. 50 µm diam.) soredia. Since the apothecia are in poor condition, it remains unclear whether soredium-production occurs more regularly in *P. epitheciifera*, whether it marks a separate taxonomic unit, or whether it is merely infection-induced.

The youngest stage of the apothecia is wart-like, 0.5 mm diam. On top a perforation appears, exposing the disc. This lies initially in a cavity. Successively the lateral parts of the warts grow to form a ring-shaped structure c. 1 mm diam. In this stage the species has a superficial resemblance to *Thelotrema weberi* or *T. subweberi*. Finally the margins diverge to form a cupular structure. Since the cavity of the youngest apothecia is not always well-developed, it is considered to be an apomorphic character.

***Phaeographis kinabalensis* Sipman, sp. nov.**

Type: Malaysia, Sabah, Kinabalu National Park, Vicinity of Layang Layang, Tourist Trail, elev. ca. 2600 m, August 1964, Mason E. Hale 28340 (US holo, B iso).
(Figure 2d, 4, 5)

Diagnosis: Thallus corticola, cinereoalba, c. 5-25 cm diametro, acidum norsticticum continens; lirellae prominentes, basi constrictae, (1-)1.6-2 mm latae, c. 0.8 mm altae, 1 cm longitudine superantes, longitudinaliter striatae, disco clauso, excipulo rufo a strato thallino pallido tecto; hymenium c. 350-450 µm altum, pellucidum; sporae unicae (ad ternae), pallide fuscocinereae, c. 125-250 x 35-45 µm, transversaliter 15-20-septatae, sine septis longitudinalibus, a solutione iodii non coloratae.

Thallus corticolous, ashy white, turning pale brown in the herbarium, large, c. 5-25 cm diam., smooth, dull, continuous, c. 0.5 mm thick, of which c. 30 µm epiphloeodic, the rest endophloeodic, with many c. 30 µm diam. crystals, largely covered by lirellae; thallus hyphae more compacted towards the surface but no clearly differentiated cortex present; algae dispersed mainly in the upper 100 µm of the thallus, irregularly rounded, c. 5-10 µm diam. (*Trentepohlia*-type). Ascocarps prominent, with constricted base, (1-)1.6-2 mm wide, c. 0.8 mm tall, often over 1 cm long, frequently constricted and splitting in smaller parts, straight or flexuose, occasionally branching, longitudinally densely striate with c. 5-10, often faint, striae, opening by a longitudinal groove (fig. 4); disc not visible in surface view; excipulum in cross section compact and orange-brown with crystal aggregates in its central part, thalloid, with algae, in its outer part, interrupted at intervals of c. 150 µm by a c. 50 µm thick, compact, yellowish layer which probably consists of remains of an old hymenium, sometimes with small dark-brown labial tips bordering the hymenium; hymenium c. 350-450 µm high, of about the same width, clear; paraphyses c. 1 µm thick, unbranched, rounded at apex but hardly thickened, scarcely exerted beyond the hymenial

jelly; spores 1(-3) per ascus, c. 125-250 x 35-45 μm , transversely c. 15-20-septate, brownish grey, pale at the apices, not stained by iodine solution, with c. 5 μm thick outer wall which is swollen at the septa (fig. 2d).

Chemistry: norstictic acid.

Distribution and ecology: Thus far known only from Mount Kinabalu, where it grows on smooth, soft bark in montane, mossy forest at 1650-2700 m.

Additional specimens seen:

MALAYSIA, Sabah, Mount Kinabalu: Mesilau Trail to W. Mesilau River, c. 1800 m, Hale 28007 [US]; open ridge between E. and W. Mesilau Rivers, c. 1800 m, Hale 28373 [US]; Askevs Overlook, Mesilau Trail, c. 1800 m, Hale 28401 [US]; sheltered woods just below Kambaranga radio tower, Tourist Trail, c. 1900 m, Hale 28330 [US]; along Summit Trail, alt. c. 1900 m, in mossy oak forest on slope below Kandis Shelter, 9 May 1989, Sipman & Tan 30910 [B, SNP]; along Summit Trail, alt. c. 2700 m, on road bank in stunted cloud forest on mountain ridge above Carson's Camp, 10 May 1989, Sipman & Tan 31007 [B, SNP]; along Summit Trail, alt. c. 2800 m, stunted mossy forest on mountain ridge \pm halfway between Villosa Shelter and Carson's Camp, 12 May 1989, Sipman & Tan 31463 [B, SNP].

Notes: The taxonomy of the family Graphidaceae is at present very unclear and for most specimens from Kinabalu it appeared impossible to determine whether they fit any of the described species in the available literature. Therefore most material has been left unidentified. *Phaeographis kinabalensis* is, however, so distinct by its very large, grey, transversely septate spores that it seems acceptable to provide a formal description: it is almost certainly not treated in the literature, since it would have been easily recognized even from very incomplete descriptions because of its large spores.

The pigmentation and outer wall layer of the spores develop after the full size is reached. Thus hyaline, seemingly full-grown spores measuring c. 170 x 30 μm are found, which lack

the outer wall layer and have thin septa with thickened corners. The spores remain unstained by iodine-solution in all stages. The larger spore sizes apply to those formed single in the ascus; the others remain smaller.

Stereocaulon granulans Sipman, sp. nov.

Type: Malaysia, Sabah, S-slope of Mount Kinabalu, along Summit Trail, coord. c. 06° 05' N, 116°35'E, alt. c. 3800 m, in dwarfed forest near Sayat Sayat hut, 11 May 1989, leg. H. Sipman & B. Tan 31154 (B holo, SNP iso).

(Figure 6)

Diagnosis: Pseudopodetiis erectis, 2-4 cm longis, frequenter dichotome ramosis, praecipue in partibus terminalibus, a basi c. 1 mm crasso gradatim attenuatae in apices c. 0.3 mm crassos; phyllocladiis cylindricis, in partibus inferioribus pseudopodetiorum, c. 0.5 mm longis et 0.2 mm crassis; cephalodiis protosacculatis, ad c. 1.5 mm latis, algis nostocoideis continentibus; granulis corticatis deciduis productis in ramis apicalibus; atranorinam, acidum sticticum et substantias associatas continentibus.

Primary thallus consisting of terete, upright-standing, mostly unbranched phyllocladia measuring up to 4 mm in length and 0.3 mm in width, surrounding the podetia. Pseudopodetia erect, 2-4 cm long, gradually attenuated from a c. 1 mm thick basal part into c. 0.3 mm wide terminal branches, dichotomously branched several times, more strongly branched in their apical parts, attached at their base to rock, decorticated except at the tips, pinkish white and mostly with smooth surface. Phyllocladia present only on the lower part of the pseudopodetia, terete, mostly unbranched, c. 1.5 mm long, c. 0.2 mm thick, usually upward bent. Cephalodia of protosacculate type, to c. 1.5 mm in diam., grey, often with a brownish tinge and slightly pellucid, scrobiculate, older ones more or less cracked, very shortly stalked, mostly present near the base of the podetia; cortical layer c. 40 μm thick, composed of pachydermatic papaplectenchyma, lumina c. 3 μm wide; internally compact, with c. 3 μm diam. spherical blue-green photobiont cells in glomerules (probably *Nostoc*) separated

by strands of prosoplectenchymatic mycobiont tissue. Corticate granules present, covering the terminal branches but readily falling off and leaving most of the branches with eroded surface, rounded or slightly elongate with dark-brown tip, ca. 0.1 mm in diam.

Apothecia and pycnidia unknown.

Chemistry: atranorin, stictic acid and some associates, including menegazziaic acid and a trace of norstictic acid.

Distribution and ecology: *Stereocaulon granulans* is so far known only from the type collection, found on an open but rather sheltered granite rock in the alpine zone of Mount Kinabalu.

Notes: The genus *Stereocaulon* was revised by Mackenzie Lamb (1977, 1978) and all Kinabalu material was easily identified, except for a single plant. This has a very characteristic mode of vegetative reproduction by corticate granules, which develop over a considerable length of the pseudopodium tips, leaving the lower parts of them completely decorticated. This phenomenon seems not known from any other species of *Stereocaulon* and the combination with protosacculate cephalodia makes it most probable that it constitutes an undescribed species.

The corticate granules are closely similar to isidia, and could as well be termed globose isidia, except for their small size. They appear to develop into phyllocladia when they remain attached.

The presence of well-developed pseudopodia and pseudosacculate cephalodia indicate that *S. granulans* belongs to Subgenus and Section *Holostelidium* (Lamb 1977:197). The absence of apothecia makes it impossible to decide to which subsection it belongs.

Thelotrema subweberi Sipman, sp. nov.

Type: MALAYSIA, Sabah, S-slope of Mount Kinabalu, along Summit Trail, coord. c. 06° 05' N, 116°35'E, alt. c. 3100 m, epiphyte in scrub on ultrabasic rock near helipad near Paka Shelter, 12 May 1989, H. Sipman & B. Tan 31260 (B holo, SNP iso).

(Fig. 7)

Diagnosis: A *Thelotrema weberi* similissime differt sporis (11-)19-25-ter transversaliter septatis, cellulis magnis, magnitudine (45-)60-150(-220) x 12-20(-35) µm.

Thallus muscicolous or corticolous, often covering large areas over 10 cm diam., usually inapparent or forming a thin, dull, pale varnish on the substrate, without vegetative propagules, up to c. 50-80 µm thick; cortical layer thin, composed of strongly agglutinated hyphae, c. 5 µm thick; algal cells subglobose, c. 8 µm diam. Apothecia strongly emergent, subcylindrical or almost globose, basally constricted, plentiful, uncarbonized, without columella, round, c. 0.5-1.5 mm diam., 0.4-1 mm high, pale brownish white, smooth; pore c. 0.2-0.5 mm wide, with more or less exserted, often brownish and white-pruinose rim; proper excipulum laterally separating from the thalline margin, visible as a ring deep inside the pore; hymenium c. 200-250 µm high, clear; paraphyses not thickened at apex; spores hyaline, bacillar, c. (11-)19-25-septate, 2-4(-8) per ascus, I+ purplish, (45-)60-150(-220) x 12-20(-35) µm.

Chemistry: norstictic acid, sometimes with traces of connorstictic acid; one specimen with an additional unidentified substance.

Distribution and ecology: The available collections suggest that *T. subweberi* is widespread in the humid alpine zone of the high mountains of the Palaeotropics, being most common above c. 3500 m. It may grow directly on bark, usually soft bark. Most collections are from thick or thin, moribund moss covers over tree trunks or more often on rock.

Additional specimens seen:

MALAYSIA, Sabah: S-slope of Mount Kinabalu, along Summit Trail, coord. c. 06° 05' N, 116°35'E, alt. c. 2900 m, stunted forest near Villosa Shelter, 10 May 1989, Sipman & Tan 31045 [SNP]; same loc., alt. c. 3200 m, epiphyte in stunted, open, *Leptospermum*-dominated forest, 12 May 1989, S 31248 [B, SNP].

PAPUA NEW GUINEA, Simbu province: Mount Wilhelm, Pindaunde valley, along the trail to the summit peak, coord. c. 145°03'E, 5°47'S, alt.

4000 m, on top of exposed ridge, in short grass vegetation with rock outcrops and scattered shrublets, epilithic, 13 March 1987, H. Sipman 22050 [B]; same loc., alt. 4260 m, on mossy rock on track to summit, May 1966, D. McVean 66251 [CBG]; same loc., alt. 3750 m, on mossy rock face W of lake, May 1966, D. McVean 66191 [CBG]; same loc., 4200 m, alpine vegetation, A. Aptroot 33107 [hb. Aptroot]. Madang province: Huon peninsula, Finisterre range, Yupna valley, Teptep village, trail in NNW direction towards Bambu, mountain forest, on tree, 2300-2750 m, 30-31 July 1992, A. Aptroot 32038 [hb. Aptroot].

Notes: *Thelotrema subweberi* closely resembles *T. weberi* Hale. This occurs in the same habitat and is indistinguishable morphologically and chemically. The only difference is in the spores. Those of *T. weberi* are muriform, densely celled and with 1-2 per ascus (Hale 1981: 270), while those in *T. subweberi* are transversely septate only, with very large cells and up to 8 per ascus. The strong similarity in everything but spore septation makes one question the taxonomic value of this character. However, it is so constant that there seems no doubt about the specific distinction between both species.

The spore size shows an unusual range of variation. This depends in part on the variable number of spores per ascus: with decreasing number per ascus, the spores tend to be larger.

The collection from the lowest elevation (Aptroot 32038) is remarkable because of its particularly small spores, 45-70 x 10 µm, 12-16 celled, 4-8 per ascus. Chemically it differs in the presence of an additional substance, which resembles constrictic acid chromatographically in solvent A.

4. Phytogeographical observations

A Altitudinal zonation

The altitudinal distribution of the species is presented in figure 1. Instead of vegetation zones as described in the literature, of which the limits are often difficult to establish in the field, a division in 500 m-intervals was used.

Figure 1 shows that the number of species known from the lowland forest, below 1000 m,

is low for such a habitat. Investigations in the Neotropics (Sipman 1991a) have shown that lowland forest may contain over one hundred species of foliicolous lichens alone. The low figure probably reflects the fact that the exploration has not been very representative. The only available information about lichens below 1000 m is from a few hours' visit to Poring, where lichens from undergrowth and occasional fallen crown branches were examined. The most important lichen habitat for lichens in high forest, the canopy, has hardly been investigated. Species recorded from this zone consist largely of foliicolous taxa, e.g. representatives of the genera *Dimerella*, *Echinoplaca*, *Mazosia*, *Porina*. Families such as Graphidaceae, Pannariaceae, Thelotremataceae and Trypetheliaceae, which are generally common in lowland forest, are certainly undercollected and moreover the available material has been incompletely identified. Evidently at this elevation crustose lichens far exceed foliose and fruticose lichens in species numbers.

Information about the zone between 1000 and 1500 m is scarce, and mainly restricted to a few collections made by Hale in cultivated areas outside the actual Park boundaries, and concerns several species which have not been seen in undisturbed forest in the park, e.g. *Collema actinoptychum*, *C. pulcellum*, *Hypotrachyna brevibriza*, *Parmelia erumpens*, *Parmotrema cristiferum*, *P. ultralucens*, *Physma byrsaeum*, *P. pseudoisidiatum*. Consequently they may be restricted to cultivated areas, although experience from other areas suggests that they might also occur high in the canopy of undisturbed forest. The highest number of species was encountered in the next interval, between 1500 and 2000 m, in montane forest. This certainly reflects the fact that most exploration has been done here. Mason Hale spent a considerable time on the Mesilau trail at these elevations, and the Park Headquarters is situated at this elevation, with its good facilities for investigations. It is difficult to say whether the lichen flora in this interval is rich in comparison to similar sites elsewhere in the tropics, since no comparable published information is available. Certainly the exploration cannot be considered as exhaustive, because tree crowns have hardly been investigated. A

considerable part of the encountered species were collected on leaves in the undergrowth, e.g. species of the genera *Arthonia*, *Calenia*, *Mazosia*, *Porina*, *Strigula*, *Tricharia*. It is the uppermost interval where a diverse foliicolous lichen flora was observed. Also well represented in this zone are foliose lichens from the families Parmeliaceae, Lobariaceae and Physciaceae. The high number of species found reflects not only the high diversity present, but also the rather good taxonomic knowledge of these groups, which include the genera *Heterodermia*, *Hypotrachyna*, *Lobaria*, *Parmotrema*, *Relicina*. The zone also has a good representation of lichens belonging to groups which are not well-known taxonomically and which are therefore scarcely represented on the list because most collections are not yet completely identified, e.g. the genera *Sticta* and *Usnea* and the families Graphidaceae and Thelotremaaceae. Although the number of foliose and fruticose taxa has increased strongly, as compared with lower elevations, the lichen flora is still dominated by crustose species. Road banks provide a series of *Cladonia* and *Stereocaulon* species.

Above this zone there is a strong drop in species number, as one enters the mossy forest. The excessive humidity appears to be unfavorable for lichen growth and particularly in sheltered sites the humidity seems to prevent almost any lichen growth. Lichens prefer exposed ridges or the crowns of emergent trees. The latter tend to be full of *Usnea*, well visible from a distance, but scarcely accessible for a closer examination. The available lichen flora consists largely of foliose and fruticose species. Well represented genera include: *Anzia*, *Bryoria*, *Cetrelia*, *Heterodermia*, *Hypogymnia*, *Hypotrachyna*, *Menegazzia*, *Lobaria*, *Parmotrema* (*P. subrugatum*), *Pseudocyphellaria*, *Usnea*. Tree-trunks and roots may have *Sphaerophorus* and *Gymmoderma*. The represented species become often more abundant at higher zones, up to c. 3500 m, and disappear rapidly in lower zones. Foliicolous lichens hardly occur at this elevation. Even road banks do not show a rich lichen flora, they are mostly covered by bryophytes.

Above 2500 m lichen abundance and diversity again increase. This zone is drier being more frequently above the clouds, and the very

humid circumstances, which favor growth of bryophytes at the expense of lichens, are restricted to dense and sheltered patches of forest. The stunted forest which dominates here, carries an often showy lichen flora, mainly composed of the genera listed above for the underlying zone. Foliicolous lichens are rare, and crustose lichens are usually not as abundant as foliose and fruticose taxa. Due to this scarcity of crustose lichens, the lichen flora is poorer than in stunted mountain forests in temperate zones of the world. The road banks are often loaded with well-developed *Cladonia* and *Stereocaula*. The first natural rock outcrops occur, with a.o. *Cladonia fenestralis* and *Stereocaulon staufferi*. These species are not found on man-made road banks. The low percentage of lichens restricted to this altitudinal zone (fig. 1) suggests that the lichen flora at this, and higher, altitudes consists mainly of species, which are widespread in mountain forest at lower elevations in Borneo.

Towards the summit there is a gradual decrease in species number. Between 3000 and 3500 m the lichen flora is very similar to the underlying zone, except that shade- and moisture-loving genera such as *Sphaerophorus*, *Sticta* become less abundant. A few lichens are found only in this high-altitude forest: *Everniastrum catawbiense*, *Hypogymnia vittata*, *Leptogium* spp., *Ramalina javanica*, *Sarrameana septata*, *Pertusaria epitheciifera*.

Above c. 3500 m the lichen flora can be considered as very restricted. It does not seem to differ greatly from that present below 3500 m, and is mainly less abundant and less diverse.

Above 4000 m, on the summit plateau, the lichen flora is even more restricted. It concerns an area of rather limited size where no properly developed trees or shrubs occur, and with hardly any soil accumulation. Consequently there are almost no epiphytic or terrestrial lichens and the few lichens found here come mostly from a few rockfaces. Since epilithic lichens have hardly been observed elsewhere, this zone has few species in common with other zones, as indicated in fig. 1.

The poverty of the lichen flora above 3000 m is unexpected and in contrast with temperate mountains, where the zone around the tree line tends to be rich in lichens: The stunted

trees provide good habitats for epiphytic lichens, the available soil usually has numerous specialized lichens and the rocks tend to be covered with a great variety of them. This is not the case on the top of Mount Kinabalu: the stunted trees, in so far as they are available, are comparable with tree line situations elsewhere except that crustose lichens tend to be much rarer; soil is hardly present and soil lichens occur only locally; and the rock faces, even though they consist of hard granite, are almost always bare except for very few slightly overhanging faces. The explanation for this situation is presently unclear. Gibbs (1914) suggests that strong erosion of the granite and heavy rainfall might be responsible for the scarcity of plant life near the summit. Rapid erosion does not fit well with the strong consistency of the rock and the almost gravel-free landscape, however. The fact that the few available lichens were found mostly on slightly overhanging rockfaces suggests, that they need shelter against rain and/or insolation.

B Geographical affinities.

An account of the geographical affinities of a tropical lichen flora is necessarily very preliminary, since knowledge of both taxonomy and distribution of tropical lichens are very incomplete. Accordingly there is little certainty about the ranges of the lichens growing on Mount Kinabalu. Any new investigation can show that distribution ranges are very different from what was assumed. In general, experience from better-known groups suggests that ranges of lichens tend to be wide, and the occurrence of lichen endemism on a single mountain is unlikely.

Nevertheless the species list shows that at least 11 taxa that have been found so far only on the mountain: *Cladonia fenestralis*, *Hypotrachyna kinabalensis*, *Myriotrema exile*, *M. scabridum*, *Ocellularia deformis*, *O. globosa*, *O. kinabalensis*, *Phaeographis kinabalensis*, *Sphaerophorus kinabaluensis*, *Stereocaulon granulans*, *S. staufferi* var. *borneensis*. It concerns often taxa found at high altitude, above c. 3000 m (exceptions *H. kinabalensis*, *M. exile*, *O. deformis*, *O. kinabalensis* and *S. kinabalensis* from the montane forest). In three instances close relatives have been found on other SE

Asian mountains. In several cases it concerns poorly known groups, where almost nothing is known about ranges. In a few cases it concerns fairly conspicuous and easily recognizable taxa (*Cladonia fenestralis*, *Hypotrachyna kinabalensis*, *Phaeographis kinabalensis*), for which endemism seems likely.

A remarkable similarity exists between Mount Kinabalu and the high mountains of New Guinea. This is demonstrated by a number of taxa known only from these two areas: *Megalospora halei*, *Pertusaria epitheciifera*, *P. gyalectoides*, *Placopsis auriculata*, *Polychidium stipitatum*, *Sarameana septata* (also recently reported from New Zealand: Vezda et al. 1992), *Stereocaulon staufferi* and *Thelotrema subweberi*. *Pertusaria gyalectoides*, *Placopsis auriculata* and *Polychidium stipitatum* are recorded here for the first time from outside New Guinea.

A remarkable element, found at high elevations, mainly on the summit plateau, concerns species having major distributions in temperate areas: *Arctoparmelia separata*, *Arthrorhaphis citrinella*, *Candelariella vitellina*, *Catolechia wahlenbergii*, *Ephebe ocellata*, *Immersaria athroocarpa*, *Lecanora intricata*, *L. polytropa*, *Massalongia carnosia*, *Melanelia panniformis*, *Mycoblastus affinis*, *Orphniospora moriopsis*, *Pleopsidium oxtonum*, *Tephromela armeniaca*. Most of them are known to have a bipolar distribution and are reported from other high mountains in the tropics.

A pantropical high-mountain element seems to be represented by *Umbilicaria africana*.

The general affinities of the mountain are with other SE Asian mountains, as demonstrated by the occurrence of many species of the genera *Anzia*, *Bryoria*, *Cetrelia*, *Cladonia*, *Hypogymnia*, *Hypotrachyna*, *Lobaria*, *Megalospora*, *Menegazzia*, *Relicina*, *Sphaerophorus*, *Stereocaulon*.

Acknowledgements

Much appreciated support has been received in the first place from the staff of Kinabalu Park and Dr. B. Tan, who made the fieldwork possible; Dr. H. Mohamed (Kuala Lumpur) helped with the shipping of the specimens; the herbarium staff of TNS

and US promptly provided specimens on loan; the staff of US took great care of me during my visit and provided a printout with very useful information on Parmeliaceae and type specimens from the US database; Dr. T. Ahti kindly gave his opinion on some *Cladoniae* (the responsibility for the identifications remains completely mine, however). Dr. D. Galloway (London), Mrs. Claudia Gierl (Regensburg) and O. Vitikainen (Helsinki) kindly provided identifications of *Pseudocyphellaria*, *Dibaeis* and *Icmadophila*, and *Peltigera* specimens, respectively. Dr. A. Aptroot (Baarn) gave useful comments on the manuscript. Mrs. T. Ritter, as always, willingly provided skillful technical support with TLC and photography.

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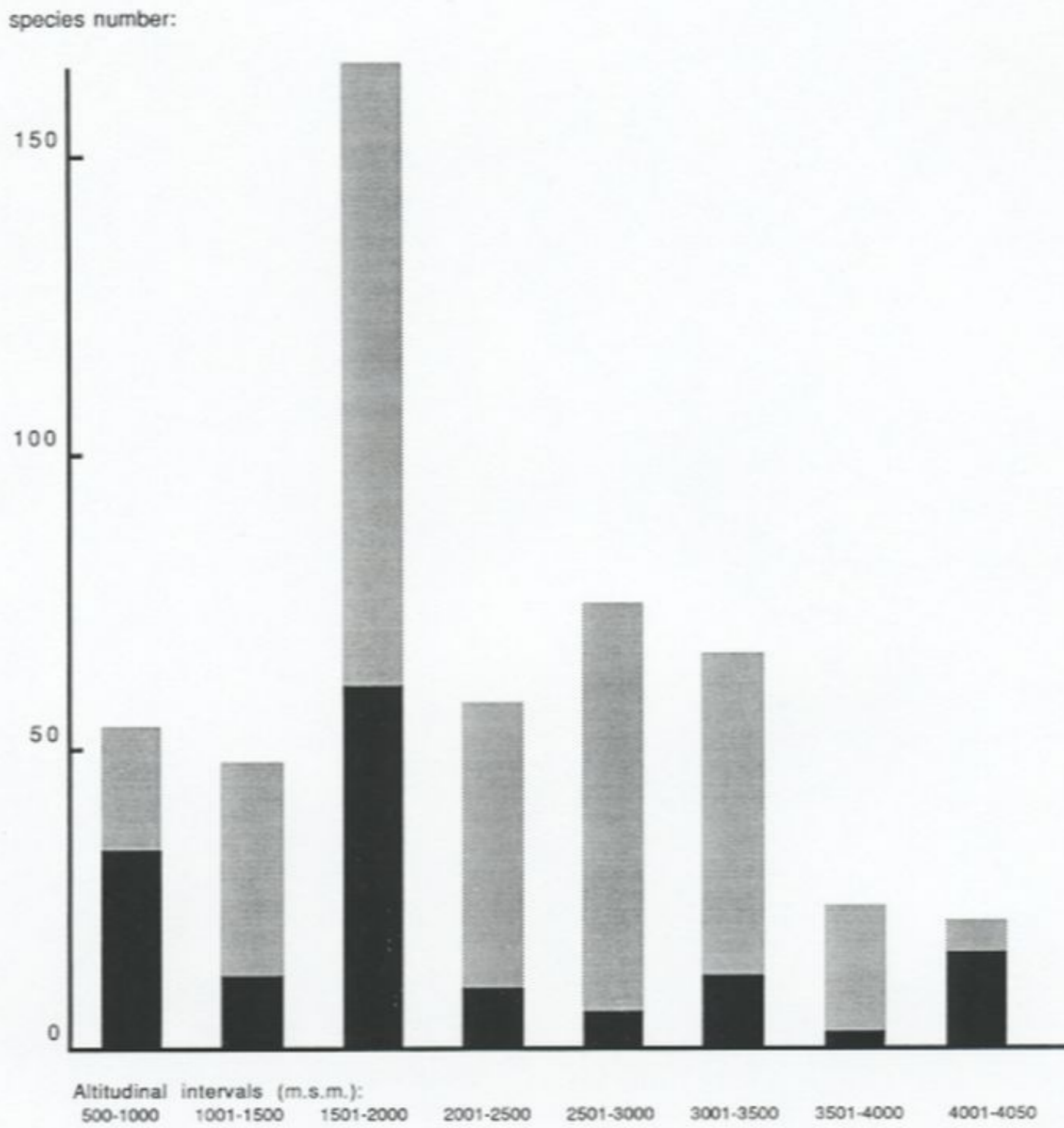


Figure 1. Altitudinal distribution of lichens on Mount Kinabalu; indicated are species numbers per 500 m-interval; the dark part of the columns represents those species found only in the interval, the grey part those species found also in other intervals.

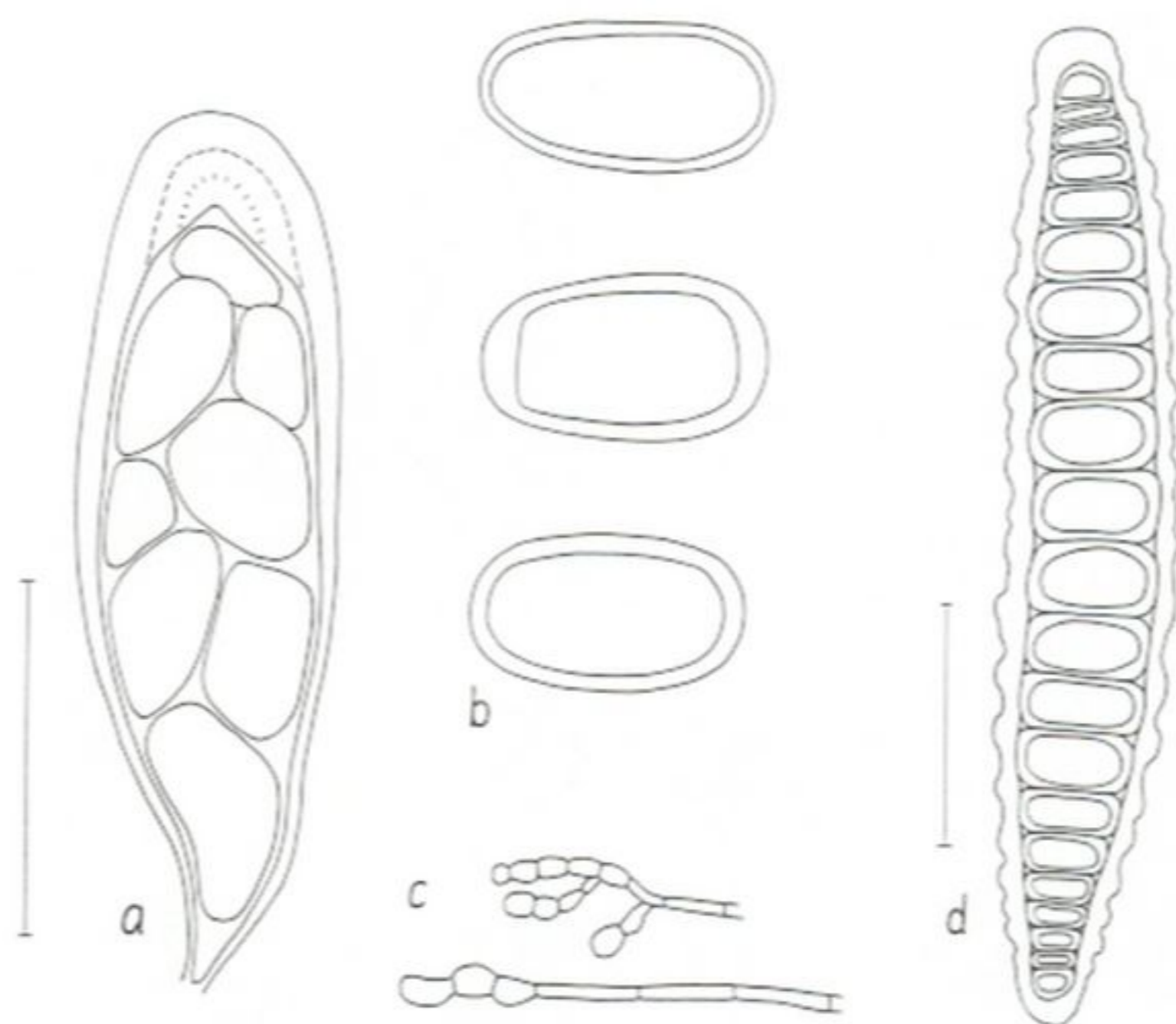


Figure 2. Details of *Pertusaria epitheciifera* and *Phaeographis kinabalensis*, schematically; a-c: *P. epitheciifera*: a) ascus, b) three spores, c) paraphyse tips; d: *P. kinabalensis*, spore. Scale (same for a-c) = 50 μm .

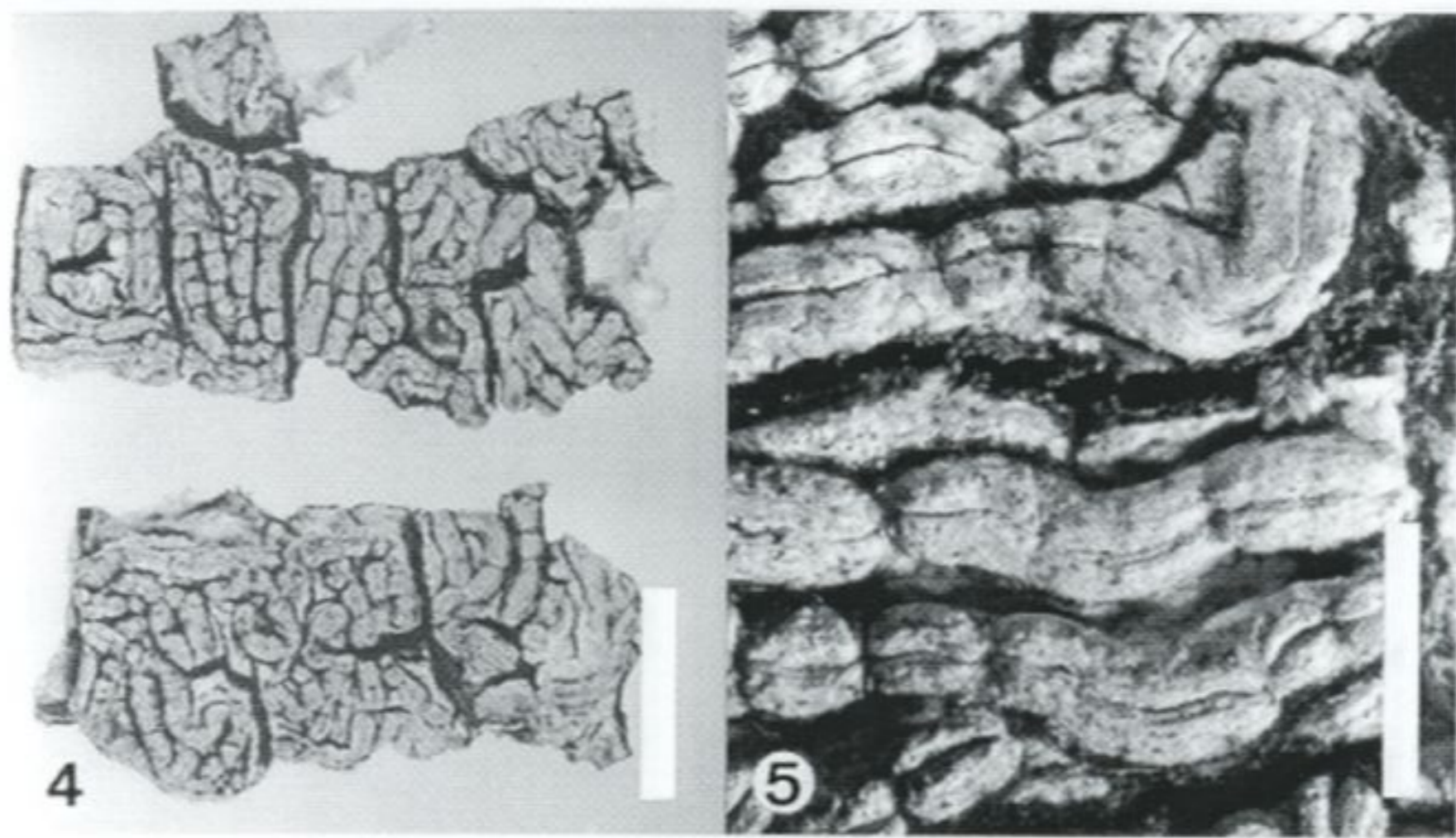


Fig. 3-5. External morphology. 3: *Pertusaria epitheciifera*, part of type collection; scale = 2 mm; 4: *Phaeographis kinabalensis*, thallus fragments (Sipman 31007); scale = 20 mm; 5: *Phaeographis kinabalensis* (Sipman 31007), detail showing the crowded, slightly furrowed lirellae; scale = 2 mm.

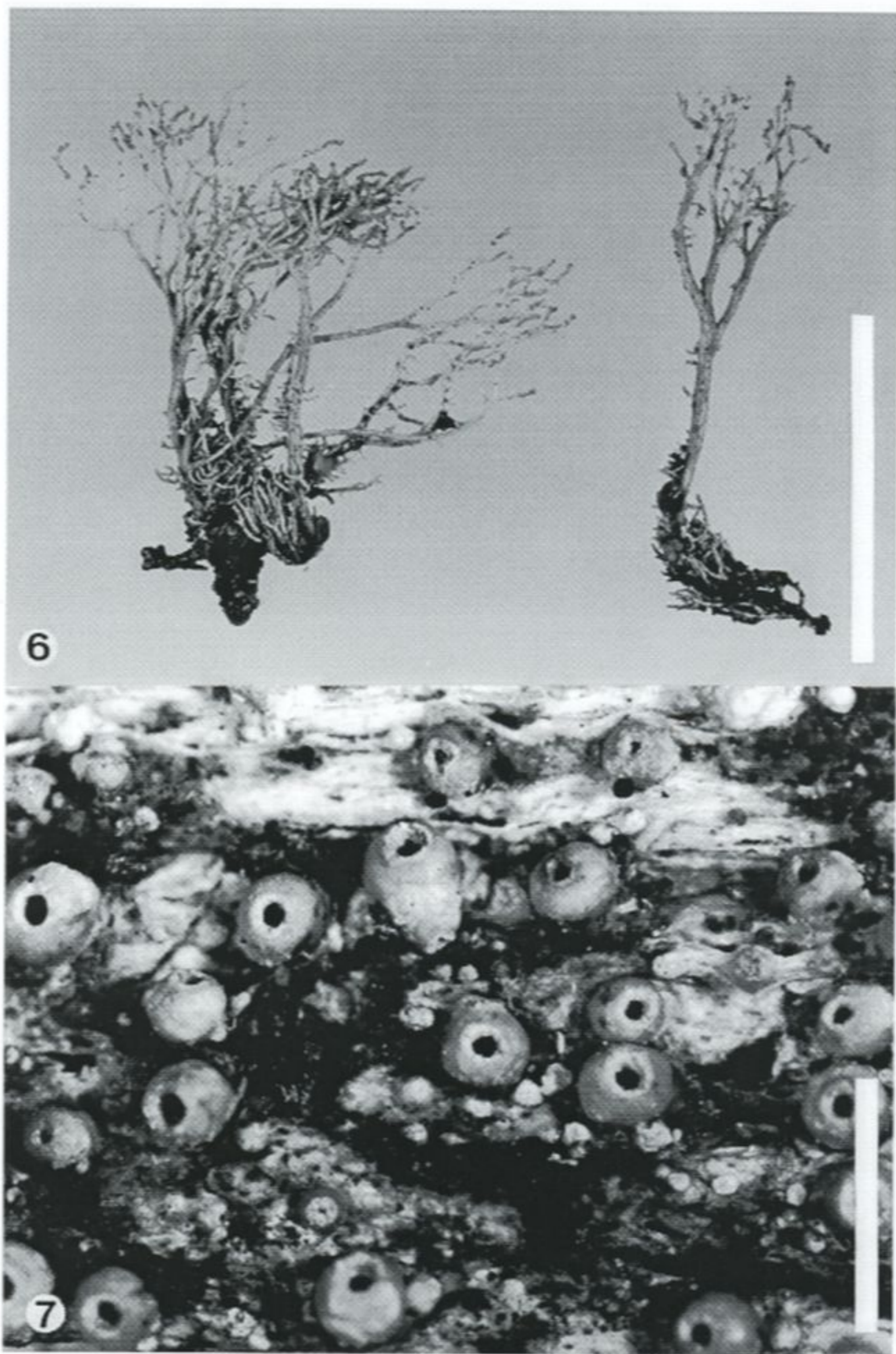


Fig. 6-7. External morphology. 6: *Stereocaulon granulans*, part of type collection; scale = 20 mm; 7: *Thelotrema subweberi*, part of type collection; scale = 2 mm.