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Studies on *Phyllopsora* (*Ramalinaceae*) in Peru

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Abstract: Twenty species of *Phyllopsora* are recognized in Peru, 8 of which are described as new: *P. atrocarpa*, *P. brakoae*, *P. glaucescens*, *P. labriformis*, *P. lacerata*, *P. lividocarpa*, *P. nigrocincta*, and *P. soralifera*. Four new combinations are proposed: *Phyllopsora cinchonarum* (Fée) Timdal, *P. glaucella* (Vain.) Timdal, *P. leucophyllina* (Nyl.) Timdal, and for an extra-Peruvian species, *P. sorediata* (Aptroot & Sparrius) Timdal. The genera *Squamacidia* and *Triclinum* are synonymized with *Phyllopsora* and sorediate species are included in the genus for the first time. *Phyllopsora chodatinica*, *P. swinscowii*, and the acid deficient chemotype of *P. furfuracea* are new to the neotropics and *P. cuyabensis*, *P. glaucella* and *P. leucophyllina* are new to Peru. A key to the Peruvian species is provided.

Key words: Amazonas, lichens, *Squamacidia*, taxonomy, *Triclinum*, tropical rainforest

Introduction

The crustose to squamulose genus *Phyllopsora* Müll. Arg. consists of species growing primarily on bark on tree trunks in tropical and subtropical humid forests. More than 100 species names exist in the literature. The first modern regional revision of the genus was made by Swinscow & Krog (1981), who accepted 11 species in East Africa and gave anatomical and chemical information on the type specimens of many other species. Brako (1989, 1991) monographed the neotropical species, accepting 18 species and 8 varieties. Timdal & Krog (2001) studied newly collected material from East Africa and the Mascarene Islands, accepting 20 species, and Elix (2006*a*, *b*) described five new species from Australia and gave taxonomic and chemical comments on several other species.

In September and October 2006 I spent ten days at two research centres in the lowland tropical rainforest of the Amazonian Peru, focusing on *Eschatogonia* Trevis. (see Timdal 2008) and *Phyllopsora*. The *Phyllopsora* flora was fairly rich at the two localities, and 134 collections were made, including material of eight new species. Seventeen specimens remain undetermined, all acid deficient, which shows that there are still taxonomic problems in the genus.

Few specimens of *Phyllopsora* have previously been published from Peru. Brako (1991) cited material of six species: *P. buettneri* (Müll. Arg.) Zahlbr., *P. chlorophaea* (Müll. Arg.) Zahlbr., *P. corallina* (Eschw.) Müll. Arg., *P. furfuracea* (Pers.) Zahlbr., *P. intermediella* (Nyl.) Zahlbr., and *P. parvifoliella* (Nyl.) Müll. Arg. Two species (*P. buettneri* and *P. corallina*) were represented by five varieties, and these were split into chemotypes, bringing the number of taxa and chemotypes known from Peru to 12 (Table 1). Brako's (1991) material from Peru consisted of two specimens in H-NYL (*P. chlorophaea* and *P. furfuracea*) and 24 specimens in S (sometimes erroneously listed as UPS) collected by Rolf Santesson and his colleagues from Stockholm and Uppsala in 1981. The genus *Triclinum* Fée and the species *Triclinum cinchonarum* Fée were described from Peru (Fée 1825) and the names were typified by Jørgensen (2003)

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on a figure in the protologue with a *Phyllopsora* specimen from Brazil in W as the epitype.

The scope of the present paper is a revision of the Peruvian material referred to above. In order to understand the current taxonomy of the neotropical *Phyllopsora* species, I have studied all species, varieties and chemotypes accepted by Brako (1991), except for *P. fendleri* (Tuck. & Mont.) Müll. Arg., mainly by examination of material identified by her in BM, O, S and UPS. The synonyms listed here are generally restricted to the basionym of the accepted name and the name used by Brako (1991); for additional synonyms see Brako (1991).

Material and Methods

The field work was carried out in lowland rainforest in the Loreto province. The two localities are at Reserva Nacional Allpahuayo Mishana, within a distance of 2·3 km from Centro de Investigaciones Allpahuayo (3°57–58′S, 73°24–26′W, alt. 120–150 m, 75 sites), and at Jenaro Herrera, within a distance of 3·6 km from the research centre (4°52–54′S, 73°37–39′W, alt. 120–150 m, 58 sites). Five days were spent at each research centre and a few specimens were collected elsewhere in the Loreto province. In the lists of specimens examined, only the herbarium accession numbers are given; see http://data.gbif.org for additional specimen information including GPS readings at each site.

Santesson and co-workers' 24 collections cited by Brako (1991) have been studied, and an additional seven Peruvian specimens collected by them, which were not examined by her. The two specimens in H-NYL were not included. Many extra-Peruvian, neotropical specimens (mainly in BM) and relevant type material in B, BM, H, O, S, TUR, UPS, and W, have also been consulted.

Unless otherwise stated, all specimens cited in this paper have been subjected to thin-layer chromatography (TLC) using the standard methods of Culberson & Kristinsson (1970) and Culberson (1972), modified by Menlove (1974) and Culberson & Johnson (1982). Routine examinations were made in solvent systems B and/or C; for critical studies all three systems were used and sometimes two-dimensional chromatography was applied. Crystals of lichen substances were located in the compound microscope using polarized light. The ascospore measurements were made in squash preparations mounted in water. The lengths are given as $x \pm 1{\cdot}5 \times \mathrm{SD}$, where x is the mean value and SD the standard deviation.

Results

The morphology, anatomy, and secondary chemistry of *Phyllopsora* have been described in detail by Swinscow & Krog (1981) and Brako (1991), and the taxonomic importance of the various vegetative dispersal units were emphasized by Timdal & Krog (2001). A few new observations which expand the characterization of the genus should, however, be mentioned here:

1 Soredia, which have not previously been correctly reported from the genus, were found in four Peruvian species: *P. brakoae* Timdal, *P. labriformis* Timdal, *P. leucophyllina* (Nyl.) Timdal, and *P. soralifera* Timdal.
2 In some species, especially *P. cuyabensis* (Malme) Zahlbr. and *P. glaucescens* Timdal, the upper cortex was poorly or not developed, but a rather loose layer of hyphae covered the algal layer. This layer could not be assigned to either of the two types of cortices described for *Phyllopsora* by Swinscow & Krog (1981) which have generally been referred to by subsequent authors.
3 In two species having large ascending squamules (*P. glaucescens* and *P. lacerata* Timdal), a vein-like supportive tissue might occur at the base and lower part of well-developed squamules. The tissue was generally poorly defined.

A comparison of the taxonomy and nomenclature of the Peruvian species presented by Brako (1991) and in the present study is given in Table 1, and an overview of the secondary substances detected in the Peruvian specimens is provided in Table 2.

Discussion

Compared with the taxonomic treatment of Brako (1991), a narrower species concept is generally applied here. Thallus chemistry is regarded as being essential for the circumscription of species, although chemical variation within species occurs and sometimes chemotypes may be defined. Vegetative dispersal units occur in all Peruvian species

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TABLE 1. *Comparison of the taxonomy of the Peruvian* Phyllopsora *species presented by Brako (1991) and the present study*

Brako (1991)	Present study
P. buettneri var. *glauca* chemical strain I	*P. buettneri* chemotype 3
P. buettneri var. *glauca* chemical strain II	*P. chodatinica*
P. buettneri var. *munda*	*P. buettneri* chemotype 2
P. chlorophaea	*P. chlorophaea*
P. corallina var. *corallina*	Not treated
P. corallina var. *ochroxantha* chemical strain I	*P. ochroxantha*
P. corallina var. *ochroxantha* chemical strain III	*P. swinscowii*
P. corallina var. *santensis* chemical strain I	*P. santensis*
P. corallina var. *santensis* chemical strain II	*P. santensis*
P. furfuracea	*P. furfuracea*
P. intermediella	Not treated
P. parvifoliella	*P. parvifoliella*

except (probably) *P. glaucescens* and *P. nigrocincta* Timdal, and the taxonomy presented here is based on the assumption that only one type occurs in a species.

The six varieties of *P. corallina* accepted by Brako (1991) are a particular problem, and the taxa are here treated at the species level [Peruvian species: *P. glaucella* (Vain.) Timdal, *P. ochroxantha* (Nyl.) Zahlbr., *P. santensis* (Tuck.) Swinscow & Krog and *P. swinscowii* Timdal & Krog]. This solution is in accordance with the treatment of the paleotropical taxa, *P. africana* Timdal & Krog, *P. corallina*, *P. kiiensi*s (Vain.) Gotth. Schneid., *P. martinii* Swinscow & Krog and *P. swinscowii*, in Timdal & Krog (2001) and *P. rappiana* (Brako) Elix, *P. santensis*, and *P. swinscowii* by Elix (2006*a*). In this complex there seem to be minor correlations between secondary chemistry and morphology (colour and thickness of prothallus, shape and size of isidia, type and thickness of upper cortex, colour and pubescence of apothecia, and shape and size of ascospores). The morphological differences are more like statistical trends than diagnostic features, and the present taxonomy is admittedly heavily based on the secondary chemistry. In *P. buettneri* [excluding *P. albicans* Müll. Arg., *P. chodatinica* Elix, and *P. subhispidula* (Nyl.) Kalb & Elix], on the other hand, I fail to see any correlation between secondary chemistry and morphology, and merely three chemotypes of a single species are accepted.

The delimitation of some acid deficient species is still problematic, and I have had to leave several specimens unidentified, including the material published by Brako (1991) as *P. corallina* var. *corallina* and *P. intermediella*.

The circumscription of the genus is still unsatisfactory, especially towards the crustose genus *Bacidia* De Not. s. lat. In that case, I follow the circumscription of Swinscow & Krog (1981: 220–221), although their character B2 (here interpreted as ascus of *Bacidia*-type) is in my opinion not ''nearly always'', but always present in *Phyllopsora*. I here also include species with a less well defined upper cortex than those described as types 1, 1–2, and 2 by Swinscow & Krog (1981); for example, *P. cuyabensis* and *P. glaucescens*. Several specimens, many of them crustose and sterile, were collected during the field work but omitted from this paper because the balance of probability (cf. Swinscow & Krog 1981: 220) tipped towards *Bacidia*.

Eschatogonia differs mainly by its characteristic upper and lower cortex (being continuous over the margin) which is composed of a single layer of rounded or cuboid cells with a thick cell wall (Swinscow & Krog 1981; Brako 1991; Kalb 2004; Timdal 2008), by the absence of a prothallus, and by the absence of fibrils projecting from the margin of the squamules and the excipulum.

Physcidia Tuck. differs mainly by having zeorine apothecia [except *P. cylindrophora* (Taylor) Hue, which has biatorine apothecia] (Kalb & Elix 1995).

Bacidiopsora Kalb differs mainly by the thick-walled, multiseptate ascospores (Kalb 2004).

Squamacidia Brako was said to differ from *Phyllopsora* by its longer (24–40 × 2–2·5 μm) ascospores, different excipulum and different secondary chemistry (Brako 1989). It is

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TABLE 2. *Lichen substances* detected in Peruvian specimens of* Phyllopsora

Species/chemotype	none	atr	arg	narg	pan	vic	nvic	phy	cphy	mps	mnps	parv	fur	fpc	lob	sek	hsek	zeo	xan	unk1	unk2	pigm	fat
P. atrocarpa	·	·	·	·	·	·	·	·	·	·	·	·	·	M†	·	·	·	·	·	M	·	·	·
P. brakoae	x	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
P. buettneri 2	·	·	·	·	M	·	·	M	·	·	·	·	·	·	·	·	·	M	·	·	·	·	·
P. buettneri 3	·	·	·	·	·	M	·	·	·	·	·	·	·	·	·	·	·	M	·	·	·	·	·
P. chlorophaea	x	±	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
P. chodatinica	·	·	±	·	·	·	·	·	·	·	·	·	·	·	·	·	·	±	M	·	·	·	·
P. cinchonarum	·	·	·	·	·	·	·	·	·	·	·	·	·	M	M	·	·	·	·	·	·	·	·
P. cuyabensis	x	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
P. furfuracea 1	·	·	·	·	·	·	·	·	·	·	·	·	M	·	·	·	·	·	·	·	·	·	·
P. furfuracea 2	x	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
P. glaucella	·	·	·	·	·	M	M	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
P. glaucescens	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	M	·	·
P. labriformis	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	M	·	·
P. lacerata	x	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
P. leucophyllina	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	SM	M	·	·	·	·	·	·
P. lividocarpa	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	M	·	·	m
P. nigrocincta	·	·	·	·	·	·	·	·	·	·	·	·	·	M	·	·	·	·	·	·	·	M	·
P. ochroxantha	·	·	·	·	·	·	·	M	SM/m	·	·	·	·	·	·	·	·	·	·	·	·	·	·
P. parvifoliella	·	SM	·	·	·	·	·	·	·	·	·	M	·	·	·	·	·	·	·	·	·	·	·
P. santensis	·	·	M	±	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
P. soralifera	x	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
P. swinscowii	·	·	·	·	·	·	·	·	·	M/m	M	·	·	·	·	·	·	·	·	·	·	·	·

*atr: atranorin, arg: argopsin, narg: norargopsin, pan: pannarin, vic: vicanicin, nvic: norvicanicin, phy: phyllopsorin, cphy: chlorophyllopsorin, mps: methyl 2,7-dichloropsoromate, mnps: methyl 2,7-dichloronorpsoromate, parv: parvifoliellin, fur: furfuraceic acid, fpc: fumarprotocetraric acid, lob: lobaric acid, sek: sekikaic acid, hsek: homosekikaic acid, zeo: zeorin, xan: xanthones, unk1 and unk2: unknown substances, pigm: unknown orange pigment, fat: unknown fatty acid.

†M: major; SM: submajor; m: minor; ± : present or absent.

hard to accept ascospore length to be more than a species character in this group, and here I include in *Phyllopsora* several species (*P. atrocarpa* Timdal, *P. glaucescens*, *P. lacerata*, and *P. lividocarpa* Timdal) with comparable or longer ascospores than those of *Squamacidia*. The paleotropical *P. borbonica* Timdal & Krog (Timdal & Krog 2001), *P. longispora* Swinscow & Krog (Swinscow & Krog 1985), *P. conwayensis* Elix (Elix 2006*a*), and *P. sorediata* (Aptroot & Sparrius) Timdal also have long, acicular ascospores. An alternative would have been to include these long-spored species in *Squamacidia*, but there does not seem to be any other common morphological or chemical character to support such a circumscription of *Squamacidia*. The excipulum is well developed in *Squamacidia*, but it does not appear to be much different from that of other *Phyllopsora* species, for example, *P. nigrocincta*. A reduced conglutination in the excipulum in *Phyllopsora* merely reflects the presence of crystals of secondary substances. Chemically, *Squamacidia* differs from all other *Phyllopsora* species in containing lobaric acid and sometimes an unidentified pigment (in Thailand also divaricatic acid, according to Aptroot *et al.* 2007). The genus *Phyllopsora* has a rich chemistry, however, and many species produce substances or combinations of substances that are unique within the genus. Elix (2007) reported furfuraceic acid (minor substance) from Australian material of *Squamacidia*, a compound previously known only from five species of *Phyllopsora*, further indicating a close affinity between *Squamacidia* and *Phyllopsora*. Until molecular studies aid in discovering phylogenetic lineages in this group, it seems best to adopt a wide generic concept in *Phyllopsora*.

Triclinum, and the original species *T. cinchonarum*, were described from Peru (Fée 1825). Jørgensen (2003) typified the names on the figure in the protologue, and chose the holotype of *Physcidia endococcina* Zahlbr. [=*Squamacidia janeirensis* var. *endococcina* (Zahlbr.) Brako] as the epitype. This seems to be the only known neotropical lichen fitting Fée's description and figure. The species is here proven to occur in Peru, although only by the non-pigmented chemotype. The epitypification makes *Triclinum* the correct name for *Squamacidia*, and, if this genus is included in *Phyllopsora*, also the correct name for *Phyllopsora*. The name *Triclinum* is not adopted here, however, partly because of the still unsatisfactory circumscriptions of *Phyllopsora*, and partly because I believe the generic name *Phyllopsora* should be proposed for conservation if the present circumscription of the genus is followed.

A second species of *Triclinum*, *T. sorediatum* Aptroot & Sparrius, was recently described from Thailand (Aptroot *et al.* 2007). Judging from the description and figure in the protologue, that species also falls within the present circumscription of *Phyllopsora*. The species is discussed later in this paper and the necessary new combination is: **Phyllopsora sorediata (Aptroot & Sparrius) Timdal, comb. nov.**; basionym: *Triclinum sorediatum* Aptroot & Sparrius in Aptroot *et al.*, *Fungal Diversity* **24:** 130 (2007).

The Species

Phyllopsora atrocarpa Timdal sp. nov.

Thallus squamulosus, acidum fumarprotocetraricum et acidum ignotum continens; squamulae parvae vel mediocres, virides, laciniatae. Apothecia atrobrunnea. Ascosporae aciculares.

Typus: Peru, Loreto, Jenaro Herrera, within a distance of 3·6 km from the research centre, N of the road, site 116, 4°53.87′S, 73°38.85′W (WGS84), tree trunk in rainforest, 120–150 m alt., 28 September 2006, *E. Timdal* 10425 (O-L144795—holotypus) [unknown substance and fumarprotocetraric acid].

(Fig. 1A)

Prothallus thin, reddish brown. *Thallus* squamulose, effuse. *Squamules* small to medium sized, up to 0·4 mm wide, adnate when young, soon ascending and imbricate, isodiametric to elongated, becoming deeply dissected and proliferating, plane to weakly convex; *upper side* green, slightly shiny, epruinose; *margin* concolorous with upper side, not pubescent. *Lacinules* numerous,

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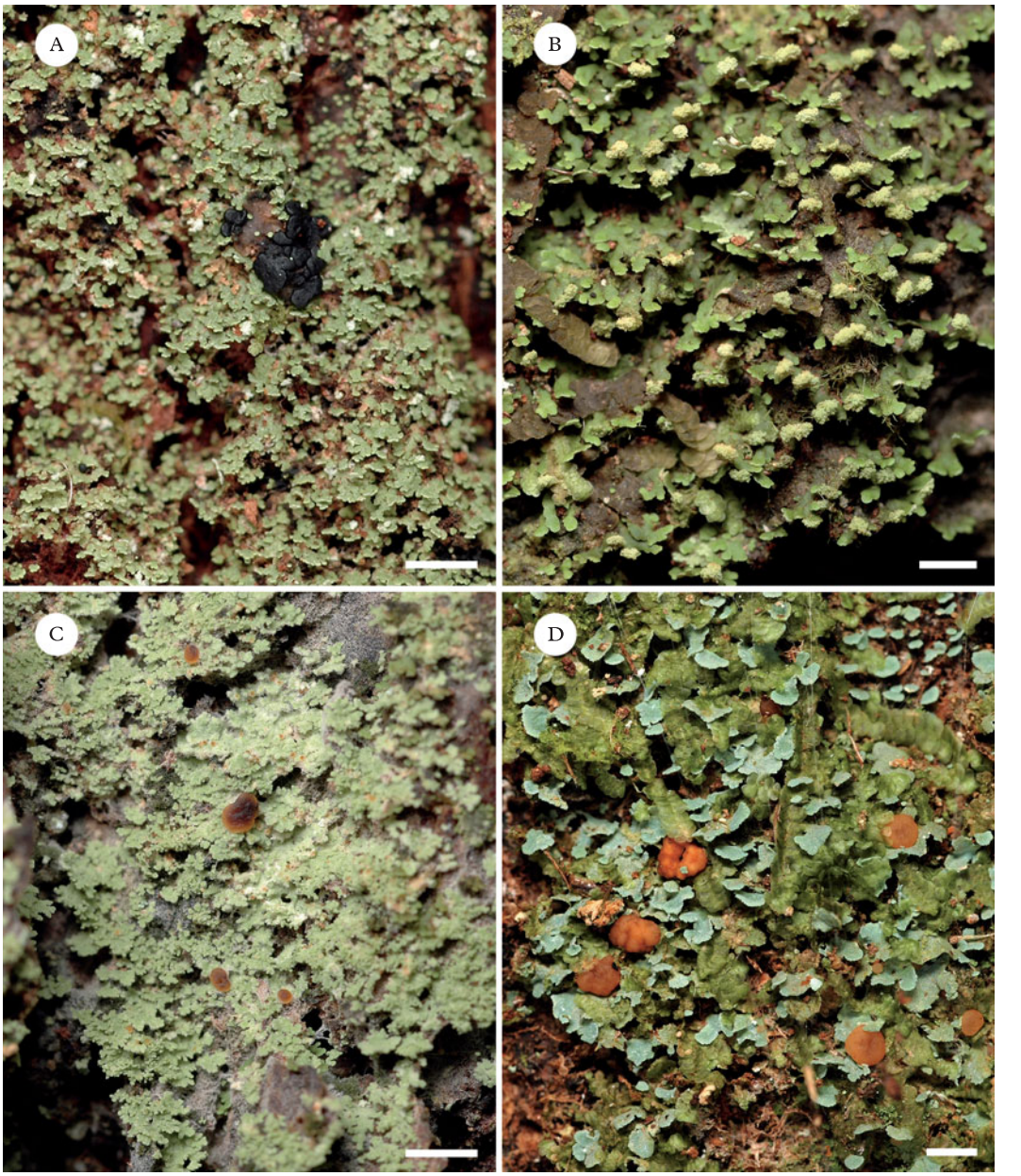


FIG. 1. Field photographs of *Phyllopsora* species. A, *P. atrocarpa* (holotype, O-L144795); B, *P. brakoae* (holotype, O-L144623); C, *P. cuyabensis* (O-L144628); D, *P. glaucescens* (holotype, O-L144788); Scales: A–D = 1 mm.

developing terminally on the lobes. *Upper cortex* of type 1–2, 10–20 µm thick, not containing crystals. *Medulla* containing colourless crystals dissolving in K (PD+ orange, K−).

Apothecia (seen in two collections) up to 0·6 mm diam., rounded to lobate, simple to conglomerate, more or less plane, brownish black, with a more or less persistent margin that is concolorous with the disc.

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Excipulum colourless, not containing crystals. *Hypothecium* medium grey to dark grey in upper part (subhymenium), colourless in lower part, not containing crystals, K−. *Epithecium* colourless. *Ascospores* acicular, simple or with 1–4 pseudosepta, 22·5–36·5 × 1·5–2 μm (n=20).

Pycnidia not seen.

Chemistry. An unknown substance in Rf classes 7:7:7 (major) and fumarprotocetraric acid (major).

Distribution and ecology. This species is known from one lowland locality in primary rainforest in the Peruvian Amazonas. It grew on bark on tree trunks, and was collected from four sites.

Notes. Among the lichen substances reported from *Phyllopsora*, the unknown substance resembles most closely 3-chlorostenosporic acid on the chromatograms (compared with the isotype of *P. conwayensis*, *Elix* 20190 *&* *Streimann*, B). It moves slightly higher in A, lower in B, and equally high in C. The colour of the unknown substance after development is slightly more yellow, but the fluorescence (dark brown with a green halo) is similar.

This lacinulate species is morphologically and chemically similar to *P. lividocarpa*, but differs in forming somewhat larger, more deeply dissected squamules, in having brownish black apothecia that lack crystals in the excipulum and epithecium, and in containing fumarprotocetraric acid in addition to the unknown substance. In *P. lividocarpa*, the apothecia are pale (sometimes brownish) grey to dark grey, crystals occur in the excipulum and epithecium, and an unknown fatty acid replaces fumarprotocetraric acid. Fumarprotocetraric acid also occurs in the isidiate species *P. cinchonarum* (Fée) Timdal and in the apotheciate species *P. nigrocincta*.

Additional specimens examined. *Loreto*: Jenaro Herrera, 3 collections from 3 sites, 2006, *Timdal* (O, L144746, -761, -779).

Phyllopsora brakoae Timdal sp. nov.

Thallus squamulosus, sine acido lichenoso; squamulae mediocres, mox ascendentes, elongatae, cinereovirides, sorediatae. Soralia labriformia. Apothecia ignota.

Typus: Peru, Loreto, Reserva Nacional Allpahuayo Mishana, within a distance of 2·3 km from Centro de Investigaciones Allpahuayo, N of the road, site 43, 3°58.48′S, 73°25.86′W (WGS84), tree trunk in rainforest, in "bosque de varillal seco"-forest, 120–150 m alt., 22 September 2006, *E. Timdal* 10253 (O-L144623—holotypus) [no lichen substances].

(Fig. 1B)

Prothallus not present. *Thallus* squamulose, effuse. *Squamules* medium sized, up to 0·5 mm wide, adnate when young, soon ascending, elongated, incised to deeply divided; lobes plane to weakly convex, partly linear; *upper side* greyish green, dull, epruinose; *margin* concolorous with upper side, not pubescent. *Soralia* common, on the lower side of the squamules near the tip, labriform, farinose; soredia up 40 μm diam. *Upper cortex* of type 2, 20–35 μm thick, not containing crystals. *Medulla* not containing crystals (PD−, K−).

Apothecia not seen.

Pycnidia not seen.

Chemistry. No lichen substances detected by TLC.

Distribution and ecology. Known only from the type locality, where it was found on bark on the trunk of a single, large tree. Other species collected from the same tree include *Crocynia pyxinoides* Nyl., *Eschatogonia dissecta* Timdal & R. Sant., *Phyllopsora cuyabensis*, and *P. soralifera*. The site was relatively well lit, being on a 'white sand' ridge.

Notes. The only other sorediate species of *Phyllopsora* are *P. labriformis*, *P. leucophyllina*, *P. soralifera* and *P. sorediata*. *Phyllopsora leucophyllina* differs mainly in forming a more circular thallus with radiating marginal squamules, having irregular patches of soralia mainly on the upper side, and in chemistry (sekikaic and homosekikaic acid). *Phyllopsora sorediata* differs in forming mainly adnate squamules with soralia on the

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upper side, a black, felty prothallus, and in containing atranorin, divaricatic acid and zeorin or protocetraric acid only (cf. Aptroot *et al*. 2007). See *P. labriformis* and *P. soralifera* for differences from those species.

Phyllopsora buettneri (Müll. Arg.) Zahlbr.

Catal. Lich. Univers. **4** (25)**:** 396 (1926); *Psora buettneri* Müll. Arg., *Englers Bot. Jahrb.* **15:** 511–521 (1893); type: Togo, Bismarksburg, *Büttner* [hb berol. 1892, L. Afr. no. 7] (G—holotypus, not seen; BM—isotypus, not examined by TLC) [pannarin and zeorin in holotype, according to Brako (1991)].

Prothallus usually well developed, reddish brown. *Thallus* squamulose, effuse or circular with radiating marginal squamules. *Squamules* large, up to 1 mm wide, adnate or ascending, elongated, incised to deeply divided, plane to weakly convex; *upper side* pale green to medium green, shiny and epruinose to weakly pruinose in inner part, usually pruinose and/or finely tomentose towards the lobe-ends; *margin* pale, pubescent. *Lacinules* numerous, developing from the tips of ascending lobes, mainly in the inner part of the thallus. *Upper cortex* of type 1 (–2), 30–70 µm thick, containing scattered crystals dissolving in K (PD−, K−). *Medulla* containing crystals partially dissolving in K (PD+ orange, K−).

Apothecia rare, up to 1·5 mm diam., rounded, simple to conglomerate, plane to weakly convex, medium brown to dark reddish brown, indistinctly marginate when young. *Excipulum* medium brown in inner part, dark reddish brown in the rim. *Hypothecium* pale to medium brown. *Epithecium* pale brown to colourless. No crystals in apothecia, all parts K−. *Ascospores* narrowly ellipsoid, simple, 11–14 × 3–3·5 µm (20 spores from one apothecium of chemotype 3).

Pycnidia not seen.

Chemistry. Chemotype 2: pannarin (major), phyllopsorin (major), and zeorin (major); chemotype 3: vicanicin (major) and zeorin (major) (in Peru; see *Notes* for chemical variation elsewhere).

Distribution and ecology. *Phyllopsora buettneri* is pantropical, with one chemotype (chemotype 1) occurring in the paleotropics and two chemotypes in the neotropics. In Peru, it is known only from two localities at *c*. 1000 m alt.

Notes. Brako (1991) divided *P. buettneri* into three varieties, var. *buettneri*, var. *glauca* (de Lesd.) Brako (with three chemical strains, I–III), and var. *munda* (Malme) Brako. This division was mainly based on chemical characters, but var. *glauca* was also characterized by smaller, more ascending, and less frequently pruinose squamules. The species included both lacinulate and isidiate specimens. Her Peruvian material fell within var. *glauca* chemical strains I and II and var. *munda*.

Timdal & Krog (2001) treated the African species of the *P. albicans*/*P. buettneri* complex, and accepted three species: the two lacinulate species, *P. buettneri* (one chemotype) and *P. albicans* (two chemotypes), and the isidiate species *P. subhispidula* (one chemotype). *Phyllopsora albicans* was placed in synonomy with the isidiate *P. corallina* var. *santensis* (Tuck.) Brako by Brako (1991).

Few Peruvian specimens fall within Brako's concept of *P. buettneri*, and it was beyond the scope of this paper to attempt a revision of this complex in the neotropics. In this paper, Brako's *P. buettneri* var. *buettneri* is referred to as *P. buettneri* chemotype 1 (paleotropical, containing pannarin and zeorin, identical with *P. buettneri sensu* Timdal & Krog 2001). Her Peruvian specimens of var. *glauca* chemical strain I are here treated as *P. buettneri* chemotype 3, those of var. *glauca* chemical strain II as *P. chodatinica*, and that of var. *munda* as *P. buettneri* chemotype 2. A specimen from Brazil (Parà province, 1849, *Spruce*, BM) identified by Brako (1991) as var. *glauca* chemical strain III contains argopsin and norargopsin, and belongs in *P. albicans* chemotype 1 *sensu* Timdal & Krog (2001). The statement by Kalb & Elix (1995) that *P. buettneri* var. *glauca* belongs in *P. subhispidula* further demonstrates the current confusion in the *P. albicans*/*P. buettneri*-complex. If the three

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chemotypes of *P. buettneri* recognized here are accepted as distinct species, the correct names for them are *P. buettneri*, *P. munda* (Malme) Zahlbr., and *P. melanoglauca* Zahlbr., respectively.

See *P. chodatinica* for discussion of the characters distinguishing *P. buettneri* from that species.

Specimens examined. Chemotype 2: *San Martin*: San Martin, Cerro Escalera (NE of Tarapoto), NW of the tunnel, 6°26′S, 76°15′W, *c.* 1000 m, 1981, *Santesson & Thor* P74:122 (S). Chemotype 3: *San Martin*: Lamas, Cerro Blanco (*c.* 58 km, road distance, W–WNW of Tarapoto), 6°25′S, 76°40′W, *c.* 1000 m, 1981, *Santesson & Thor* P73:4, P73:10 (S).

Phyllopsora chlorophaea (Müll. Arg.) Zahlbr.

In Schiffner, V., *Denkschr. Kaiserl. Akad. Wissensch.* **83:** 85–211 (1909); *Psora chlorophaea* Müll. Arg., *Flora* **70:** 320 (1887); type: Brazil: São Paulo, Apiahy [Apiaí], June 1881, *Puiggari* 1721 (G—holotypus, not seen) [no lichen substances, according to Brako (1991)].

Prothallus well developed, reddish brown. *Thallus* effuse, squamulose. *Squamules* small, up to 0·3 mm wide, at first adnate, isodiametric, and plane to weakly convex, soon becoming deeply incised, later ascending, flat to concave, and by repeated marginal proliferations becoming lacinulate; *upper side* medium to dark green, shiny, epruinose; *margin* concolorous, often finely pubescent. *Lacinules* coralloid and more or less imbricate. *Upper cortex* of type 1–2, 20–40 µm thick; *medulla* (and upper cortex) containing scattered crystals dissolving in K (extra-Peruvian chemotype 2 only) (PD −, K −).

Apothecia not rare, up to 1·5 mm diam., plane to convex, dark brown, when young more or less rounded, simple, and with a distinct, dark brown to black margin, later of more irregular shape and usually conglomerate and immarginate. *Excipulum* and *hypothecium* dark reddish brown throughout, containing scattered crystals dissolving in K (chemotype 2), K+ faintly purple. *Epithecium* pale brown to colourless. *Ascospores* narrowly ellipsoid to fusiform, simple, 7–12·5 × 2·5–3 µm (n=40).

Pycnidia not seen.

Chemistry. Chemotype 1: no lichen substances or trace of atranorin in Peru (see *Notes* for chemical variation elsewhere).

Distribution and ecology. This species is pantropical (cf. Brako 1991, Timdal & Krog 2001). It was rare in the localities studied. Brako (1991) reported an additional Peruvian specimen from the Puno province (H-NYL 20502).

Notes. *Phyllopsora chlorophaea* is recognized by its shiny, lacinulate squamules on a well-developed, reddish brown prothallus and by its dark reddish brown hypothecium and excipulum. Brako (1991) found no lichen substances in the neotropical material, but in African material two chemotypes were recognized by Timdal & Krog (2001), one acid deficient (chemotype 1) and one containing furfuraceic acid (=furfuracein, chemotype 2); both chemotypes may also contain a trace of atranorin.

Specimens examined. *Loreto*: Reserva Nacional Allpahuayo Mishana, 2006, *Timdal* (O, L144558). *San Martin*, Lamas, Cerro Blanco (*c.* 63 km, road distance, W-WNW of Tarapoto), 6°25′S, 76°40′W, *c.* 1200 m, 1981, *Santesson & Thor* P77:17, P77:22 (S).

Phyllopsora chodatinica Elix

Australasian Lichenology **59:** 23 (2006); type: Australia, Queensland, Blencoe Creek, Cardwell Range, 48 km NW of Cardwell, 18°03′S, 145°39′E, on mossy trunk in *Lauraceae – Syzygium – Prunus*-dominated forest, 740 m, 17 June 1986, *J. A. Elix* 20109 *& H. Streimann* (BRI—holotypus, CANB—isotypus; not seen) [chodatin and additional xanthones, according to Elix (2006*b*)].

Prothallus usually well developed, reddish brown. *Thallus* effuse, squamulose. *Squamules* medium sized to large, up to 0·8 mm wide, ascending, elongated, often imbricate, incised to deeply divided, plane to weakly convex; *upper side* yellowish green, more or less shiny, epruinose; *margin* concolorous with upper side or somewhat paler, finely pubescent. *Lacinules* numerous, developing from lobe-tips. *Upper cortex* of type 1, 25–40 µm thick, containing a few crystals dissolving in K (PD −, K −). *Medulla*

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containing crystals dissolving in K (PD+ orange or PD −, K −).

Apothecia seen in one collection, up to 1·2 mm diam., rounded, simple or slightly conglomerate, weakly to moderately convex, reddish brown, with an indistinct and often darker margin. *Excipulum* reddish brown (K+ faintly purple), darkest near the rim. *Hypothecium* pale brown. *Epithecium* colourless. Apothecium containing scattered groups of orange crystals dissolving in K (K+ yellow). *Ascospores* narrowly ellipsoid to fusiform, simple, 5–8 × 2–2·5 µm (*n*=20, from a single apothecium).

Pycnidia not seen.

Chemistry. One or more xanthones (=unknown B of Brako 1991) (major), argopsin (minor or lacking), and zeorin (minor or lacking).

Distribution and ecology. *Phyllopsora chodatinica* was described from Australia (Elix 2006b), and is here reported as new to the neotropics from Cuba, St. Vincent, and Peru. Assuming that Brako's (1991) *P. buettneri* var. *glauca* chemical strain II is conspecific with *P. chodatinica* (see *Notes*), the species occurs in New Guinea and widely in the West Indies, Central, and South America from Costa Rica and Cuba to Brazil. The three records of var. *glauca* chemical strain II (Brako 1991) from Kenya and Tanzania belong, judging from the chemical data given by Swinscow & Krog (1981), in *P. albicans* chemotype I *sensu* Timdal & Krog (2001).

Notes. The five Peruvian specimens were all identified as *P. buettneri* var. *glauca* chemical strain II by Brako and supplied with determination slips indicating identification of unknown substance B. Brako described unknown B as being UV+ dull orange. She noted that var. *glauca* differed morphologically from var. *buettneri* by its usually smaller, more ascending, and less frequently pruinose squamules.

Phyllopsora chodatinica was described from Australia by Elix (2006*b*) and compared with *P. albicans* from which it was distinguished by the presence of xanthones (mainly chodatin) and by the somewhat smaller ascospores (7–11 × 2·0–3·0 µm vs. 8–13 × 2·5–3·5 µm).

Unknown B (as interpreted from the Peruvian material) has the colour and orange fluorescence on the chromatograms like those of xanthones. However, comparison with a paratype of *P. chodatinica* (*Elix* 21023 *& Streimann*, dupl., O) failed to establish with certainty that unknown B is identical with chodatin, as the fluorescence of the main substance of the paratype was more brown than orange. Possibly more than one xanthone, having very similar Rf values, occurred both in the Peruvian specimens and in the paratype, making identification of the substances by standard TLC methods difficult. It is possible that chodatin occurs in the Peruvian material, but the inclusion of that material in *P. chodatinica* is rather based on the presence of xanthones in general. Two specimens from Cuba (*Tønsberg* 37724, 37923, BG) and one from St. Vincent (*Elliott* 135, BM) apparently showed the same substances as the Peruvian material and are here also identified as *P. chodatinica*. Probably the whole of Brako's (1991) *P. buettneri* var. *glauca* chemical strain II is identical with *P. chodatinica*.

Specimens examined. *Cuzco*: Paucartambo, *c.* 11 km S of Pillcopata, 12°54′S, 71°13′W, *c.* 850 m, 1981, *Santesson, Theler & Thor* P102:21 (S). *San Martin*: San Martin, Cerro Escalera (*c.* 20 km, road distance, NE of Tarapoto), 6°27′S, 76°15′W, 900–1100 m, 1981, *Santesson & Thor* P72:20, P72:53, P72:59, P72:73 (S).

Phyllopsora cinchonarum (Fée) Timdal comb. nov.

Triclinum cinchonarum Fée, *Essai crypt. écorc*. 147 (1825); type: Fée, *Essai crypt. écorc*.: Tab. 33, Fig. 4 (lectotypus; epitype: the holotype of *Physcidia endococcinea* Zahlbr., see below; both designated by Jørgensen 2003: 76).

Phyllopsora janeirensis (Müll. Arg.) Swinscow & Krog, *Lichenologist* **12:** 242 (1981); *Thalloidima janeirensis* Müll. Arg., *Hedwigia* **1892:** 280 (1892); *Squamacidia janeirensis* (Müll. Arg.) Brako, *Mycotaxon* **35** (1)**:** 8 (1989); type: Brazil, Rio de Janeiro, *Portella* s.n. (BM—holotypus) [lobaric acid, fumarprotocetraric acid].

Physcidia endococcinea Zahlbr., *Denkschr. Kaiserl. Akad. Wiss., Math.-Naturwiss. Kl.* **83:** 159 (1909); *Squamacidia janeirensis* var. *endococcinea* (Zahlbr.)

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Brako, *Mycotaxon* **35** (1)**:** 10 (1989); type: Brazil, São Paulo, in silvaticis prope Barra Mansa in districtu urbis Itapecirica, *c.* 1000 m, June 1901, *V. Schiffner* s.n. (W—holotypus) [atranorin, lobaric acid, scarlet pigment in R_F classes 1–2:1:1].

Prothallus well-developed, white. *Thallus* effuse, squamulose. *Squamules* medium sized, up to 0·5 mm wide, adnate to somewhat ascending, isodiametric to elongate, scattered when young, later often contiguous or imbricate, crenulate to incised, plane to weakly convex; *upper side* medium green, dull, epruinose; *margin* concolorous, faintly pubescent. *Isidia* common, attached marginally to the squamules, often long, simple or rarely branched. *Upper cortex* of type 1, 30–50 µm thick, containing crystals dissolving in K (PD − , K −). *Medulla* containing crystals dissolving in K (PD+ orange, K −).

Apothecia common, up to 1·5 mm diam., rounded, simple, plane to weakly convex, medium brown to dark brown, when young with a rather thick, paler, often weakly pubescent margin. *Excipulum* pale brown to colourless, containing crystals dissolving in K (K −). *Hypothecium* pale brown, containing crystals dissolving in K (K −). *Epithecium* pale brown, K − . *Ascospores* bacilliform to acicular, simple or with 1–2 pseudosepta, 26–41 × 2–3 µm (n=20, from a single specimen).

Pycnidia not seen.

Chemistry. Lobaric acid (major) and fumarprotocetraric acid (major) in Peru (see *Notes* for chemical variation elsewhere).

Distribution and ecology. This species is known from the West Indies, South America, Taiwan, the Philippines, Thailand and Australia (Brako 1989; Elix 2006*a*; Aptroot *et al.* 2007). It is corticolous and occurs both in shaded, humid rainforest habitats and in sun-exposed, dry savanna habitats (Brako 1989). The only previous report of the species from Peru is the original material of *Triclinum cinchonarum*. This material was collected by J. C. Mutis in Peru (no locality given) from the bark of *Cinchona lancifolia* Mutis.

Notes. This squamulose species with long isidia resembles *P. ochroxantha* and *P. swinscowii* morphologically, but differs in its chemistry, in forming a white prothallus, and in having longer ascospores. According to Brako (1989), this species (as *Squamacidia janeirensis*) contains lobaric and/or fumarprotocetraric acid, often also atranorin, an unknown substance, and/or an unknown straw-coloured or scarlet pigment. Specimens containing the pigment were referred to as var. *endococcina*. The Peruvian specimens examined did not contain this pigment, but Fée (1825) described the medulla of *Triclinum cinchonarum* as being "coccinea" and his figure shows a lichen with a scarlet medulla. Elix (2007) reported lobaric acid, secalonic acid A, norlobaric acid, furfuraceic acid, and an unknown pigment from var. *endococcina* from Australia, and a second chemotype, containing atranorin, divaricatic acid and zeorin, was reported from Thailand by Aptroot *et al.* (2007, as *T. cinchonarum*).

Lobaric acid is not known from any other species of *Phyllopsora*, but fumarprotocetraric acid occurs in the lacinulate species *P. atrocarpa* and the apotheciate species *P. nigrocincta*.

Specimens examined. *San Martin*: Lamas, Cerro Blanco (*c.* 58 km, road distance, W–WNW of Tarapoto), 6°25′S, 76°40′W, *c.* 1000 m, 1981, *Santesson & Thor* P73:28, P73: *s.n.* (S).

Phyllopsora cuyabensis (Malme) Zahlbr.

Catal. Lich. Univers. **10** (24): 377 (1939); *Lecidea cuyabensis* Malme, *Ark. Bot.* **28A, 7**: 48 (1936); type: Brazil, Mato Grosso, Serra da Chapada, Burití, 26 June 1894, *G. O. A. Malme* s.n., (S − holotypus, not examined by TLC) [no lichen substances, according to Brako (1991)].

(Fig. 1C)

Prothallus thin, patchily developed, mainly white but partly turning brownish red. *Thallus* squamulose, effuse. *Squamules* medium sized, up to 0·5 mm wide, mainly ascending and imbricate, not elongated, crenulate to incised, plane to weakly convex;

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upper side green, more or less covered by white tomentum, epruinose; *margin* pale, pubescent. *Isidia* scattered, coralloid. *Upper cortex* not developed, but rather a loose layer of hyphae covers the algal layer. *Medulla* not containing crystals (PD −, K −).

Apothecia common, up to 0·8 mm diam., rounded, simple or more rarely conglomerate, convex and immarginate even when young or more rarely with an indistinct margin, medium brown to dark brown. *Excipulum* pale brown. *Hypothecium* pale brown. *Epithecium* colourless to pale brown. No crystals in apothecia, all parts K −. *Ascospores* ellipsoid, simple, 7–8·5 × 2·5–3 µm (n=10).

Pycnidia not seen.

Chemistry. No lichen substances detected by TLC.

Distribution and ecology. Known from lowland localities (100–300 m alt.) in Guatemala, Brazil, and Paraguay (Brako 1991), and is here reported as new to Peru where it was found on tree trunks in rather well-lit, primary rainforest.

Notes. The species differs from all other *Phyllopsora* species except *P. glaucescens* in not forming an upper cortex but rather a loose layer of hyphae covering the algal layer. This gives the upper surface a rough, fibrillose appearance, like a *Crocynia* A. Massal. species. However, the ascus of *P. cuyabensis* contains a conical amyloid zone in the tholus, like the other species of *Phyllopsora*, and not a cylindrical zone as in *Crocynia*. *Phyllopsora glaucescens* differs in a number of characters, for example, the bluish green thallus colour, lack of isidia, and the acicular ascospores.

Specimens examined. *Loreto*: Reserva Nacional Allpahuayo Mishana, 3 collections from 2 sites, 2006, *Timdal* (O, L144620, -627, -628).

Phyllopsora furfuracea (Pers.) Zahlbr.

Flechten. Naturl. Pflanzenfam. T. 1, Abt. 1, Lief. 225*: 138 (1906); *Lecidea furfuracea* Pers. in C. Gaudichaud, *Voy. Uranie* (5): 192 (1827); type: Marianna Island, *C. Gaudichaud* s.n. (PC—lectotypus, selected by Brako 1991: 46; not seen).

Prothallus indistinct to well developed, white to reddish brown. *Thallus* effuse, formed partly by minute areolae which often fuse and form a continuous crust and partly by isidia developing directly from the prothallus; isidia often dominating. *Areolae* up to 0·1 mm wide, adnate, isodiametric, plane to weakly convex, medium to dark green, more or less shiny, epruinose, rarely pubescent along the margin. *Isidia* usually abundant, often long, medium to dark green, often with a brown tinge, simple to branched or sometimes coralloid, often curved, adnate to ascending. *Upper cortex* of type 2, 5–15 µm thick, not containing crystals (PD −, K −). *Medulla* containing crystals dissolving in K (chemotype 1) or not containing crystals (chemotype 2) (PD −, K −).

Apothecia common, up to 2 mm diam., of irregular shape, usually conglomerate, convex, pale brown to dark reddish brown, immarginate or with an indistinct, often slightly paler, sometimes (especially when young) pubescent margin. *Excipulum* pale brown, with scattered darker brown patches, containing colourless crystals dissolving in K (chemotype 1). *Hypothecium* pale brown in lower part, more reddish brown in upper part, containing some scattered colourless crystals dissolving in K (chemotype 1), K −. *Epithecium* pale brown. *Ascospores* narrowly ellipsoid, simple, 7–13 × 2–3 µm (n=40). *Pycnidia* not seen.

Chemistry. Chemotype 1: furfuraceic acid (major); chemotype 2: no lichen substances detected by TLC.

Distribution and ecology. This species is widely distributed in the tropics and subtropics and has been collected up to 850 m alt. from several localities in Peru. Brako (1991) reported an additional specimen from the Loreto province (H-NYL 20520).

Notes. According to Brako (1991), neotropical material contains furfuraceic acid (=furfuracein). Timdal & Krog (2001)

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found two chemical strains in the paleotropics, i.e. furfuraceic acid or no lichen substances. This second strain is here reported as new to the neotropics.

Specimens examined. Chemotype 1: *Cuzco*: Paucartambo, *c.* 3 km S of Pillcopata, 12°52′S, 71°13′W, *c.* 750 m, 1981, *Santesson, Theler & Thor* P101:29 (S); Paucartambo, *c.*11 km S of Pillcopata, 12°54′S, 71°13′W, *c.* 850 m, 1981, *Santesson, Theler & Thor* P102:22, P102:44 (S). *Loreto*: Reserva Nacional Allpahuayo Mishana, 3 collections from 3 sites, 2006, *Timdal* (O, L144543, -553, -635). *San Martin*: San Martin, Tarapoto, NE of Hotel de Turistas, 6°30′S, 76°20′W, *c.* 350 m, 1981, *Santesson & Thor* P70:82, P71:15, P71:42 (S).

Chemotype 2: *Loreto*: Reserva Nacional Allpahuayo Mishana, 6 collections from 6 sites, 2006, *Timdal* (O, L144603, -607, -612, -648, -652, -682); Jenaro Herrera, 3 collections from 3 sites, 2006, *Timdal* (O, L144770, -784, -803); east shore of Rio Ucayali, between Jenaro Herrera and Nauta, 4°34.04′S, 73°29.57′W, 120–150 m, 2006, *Timdal* (O, L144840, -841).

Phyllopsora glaucella (Vain.) Timdal comb. et stat. nov.

Lecidea breviuscula var. *glaucella* Vain., *Dansk Bot. Arkiv* **4, 11:** 21 (1926); *Phyllopsora corallina* var. *glaucella* (Vain.) Brako, *Mycotaxon* **35** (1)**:** 13 (1989); type: Mexico, Veracruz, Mirador, August 1841, *Liebmann* 7381a (TUR-VAIN 34026—holotypus) [vicanicin and norvicanicin].

Prothallus well developed, reddish brown. *Thallus* effuse, squamulose. *Squamules* medium sized, up to 0·5 mm wide, adnate to somewhat ascending, isodiametric to elongate, scattered when young, later often contiguous or imbricate, crenulate to incised, plane to weakly convex; *upper side* medium green, dull, epruinose; *margin* concolorous, faintly pubescent. *Isidia* scattered to common, attached marginally to the squamules, long, simple. *Upper cortex* of type 2, 25–30 µm thick, not containing crystals. *Medulla* containing crystals dissolving in K (PD −, K −).

Apothecia common, up to 1 mm diam., rounded when young, later of irregular shape, simple to conglomerate, plane to strongly convex, medium brown, with an indistinct, concolorous or slightly paler, often finely pubescent margin. *Excipulum* pale brown to colourless. *Hypothecium* pale brown. *Epithecium* colourless. No crystals in apothecia. *Ascospores* narrowly ellipsoid, simple, 6·5–9 × *c.* 2·5 µm (n=30).

Pycnidia not seen.

Chemistry. Vicanicin (major) and norvicanicin (major).

Distribution and ecology. *Phyllopsora glaucella* is known from USA (Florida), Mexico, the West Indies and South America south to Argentina (Brako 1991, as *P. corallina* var. *glaucella*). It is new to Peru.

Notes. Brako (1991) treated this taxon as a variety of *P. corallina*. It was said to differ from the other varieties in its chemical characters, i.e. mainly by the presence of vicanicin, and by several morphological characters: size of the squamules, thickness and type of upper cortex, shape and attachment of isidia, and size of the ascospores. The taxon is here given species rank in accordance with the treatment of Brako's other varieties of *P. corallina* (see Discussion). In addition to the holotype, I have examined only one extra-Peruvian specimen (Dominican Republic, *Harris* 20779, BM) of this species. Contrary to Brako (1991), I found no trace of argopsin in the holotype.

The Peruvian specimen was identified by Brako (1991) as *P. corallina* var. *ochroxantha* (Nyl.) Brako chemical strain III (see *P. swinscowii*), but it actually contains vicanicin and norvicanicin.

Specimen examined: San Martin: Lamas, Cerro Blanco (*c.* 63 km, road distance, W-WNW of Tarapoto), 6°25′S, 76°40′W, *c.* 1200 m, 1981, *Santesson & Thor* P77:23 (S).

Phyllopsora glaucescens Timdal sp. nov.

Thallus squamulosus, acidum ignotum continens; squamulae magnae, ascendentes, glaucescentes. Apothecia convexa, brunnea vel rufa. Ascosporae aciculares.

Typus: Peru, Loreto, Jenaro Herrera, within a distance of 3·6 km from the research centre, N of the road, site 111, 4°53.88′S, 73°38.90′W (WGS84), tree trunk in rainforest, 120–150 m alt., 28 September 2006,

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E. Timdal 10418 (O-L144788—holotypus) [unknown substance in R_F classes 8:7:8].

(Fig. 1D)

Prothallus not present. *Thallus* squamulose, effuse. *Squamules* large, up to 1·5 mm wide, ascending even when young, rounded or irregularly elongated, entire to deeply incised, often thickened in the central part by medullary hyphae forming a vein-like tissue; lobes plane to concave or rolled upwards; *upper side* bluish green, dull, finely tomentose; *margin* concolorous with upper side, finely tomentose. *Vegetative dispersal units* probably lacking (but see *Notes*). *Upper cortex* not developed, algal layer covered by a thin layer of loosely interwoven hyphae; this layer containing scattered crystals dissolving in K (K+ yellow). *Medulla* containing crystals dissolving in K (PD −, K+ yellow).

Apothecia not common, up to 0·8 mm diam., rounded, simple or conglomerate, weakly to strongly convex, pale brown to reddish brown, with an indistinct, more or less disappearing margin. *Excipulum* pale brown to colourless. *Hypothecium* pale brown. *Epithecium* pale brown to colourless. No crystals in apothecia, all parts K −. *Ascospores* acicular, with indistinct pseudosepta, 33·5–54·5 × 1·5–2 µm (n=40).

Pycnidia not seen.

Chemistry. An unknown substance in Rf classes 8:7:8, resembling atranorin in colour and fluorescence (major).

Distribution and ecology. This species is known from one lowland locality in the Peruvian Amazonas where it was found at six sites. It grew on bark on tree trunks in primary rainforest and also on the trunks of tree ferns.

Notes. The bluish green upper side is diagnostic. It may be confused with *P. labriformis*, which contains the same unknown substance, and *P. lacerata*; see those species for discussions. In a few squamules, the lobe tips possibly disintegrated into granular soredia.

Additional specimens examined. *Loreto*: Jenaro Herrera, 6 collections from 5 sites, 2006, *Timdal*, (O, L144802, -820, -822, -823, -824, -827).

Phyllopsora labriformis Timdal sp. nov.

Thallus squamulosus, acidum ignotum continens; squamulae magnae, ascendentes, virides, sorediatae. Soralia labriformia. Apothecia ignota.

Typus: Peru, Loreto, Jenaro Herrera, within a 3·6 km distance from the research centre, N of the road, site 112, 4°53.93′S, 73°38.91′W (WGS84), tree trunk in rainforest, 120–150 m alt., 28 September 2006, *E. Timdal* 10419 (O-L144789—holotypus) [unknown substance in R_F classes 8:7:8].

(Fig. 2A)

Prothallus not present. *Thallus* squamulose, effuse. *Squamules* large, up to 2 mm wide, ascending even when young, rounded or moderately elongated, entire or deeply incised; lobes weakly to moderately convex, up to 2 mm wide; *upper side* green, dull, epruinose; *margin* concolorous with upper side, not pubescent. *Soralia* common, on the lower side of the squamules along the margin, labriform, granulose, soredia up to 80 (–100) µm diam. *Upper cortex* of type 1–2, 10–20 µm thick, not containing crystals. *Medulla* containing crystals dissolving in K (PD −, K −).

Apothecia not seen.

Pycnidia not seen.

Chemistry. An unknown substance in Rf classes 8:7:8, resembling atranorin in colour and fluorescence (major).

Distribution and ecology. This new species is known from one lowland locality in the Peruvian Amazonas where it was found at three sites. It grew on bark on tree trunks in primary rainforest.

Notes. The four other sorediate species of *Phyllopsora*, *P. brakoae*, *P. leucophyllina*, *P. soralifera*, and *P. sorediata*, differ in forming smaller squamules with finer soredia. *Phyllopsora leucophyllina* contains sekikaic and homosekikaic acids, *P. sorediata* contains atranorin, divaricatic acid and zeorin or

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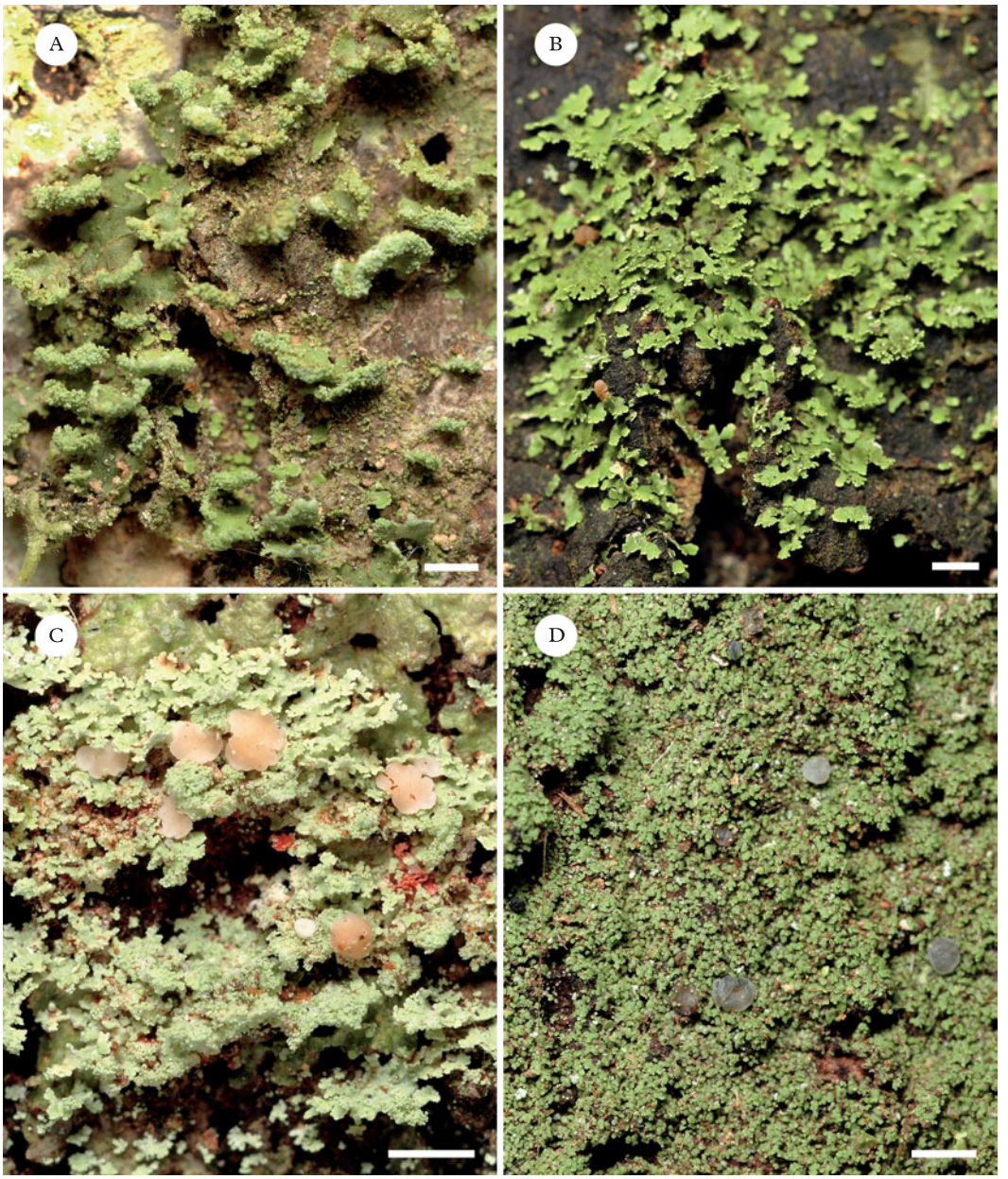


FIG. 2. Field photographs of *Phyllopsora* species. A, *P. labriformis* (O-L144743); B, *P. lacerata* (holotype, O-L144583); C, *P. leucophyllina* (O-L144796); D, *P. lividocarpa* (O-L144580); Scales: A–D=1 mm.

protocetraric acid only (Aptroot *et al.* 2007), and the two other species lack lichen substances. *Phyllopsora brakoae* further differs in forming narrower, partly linear squamules, *P. leucophyllina* in forming more regularly circular thalli, *P. soralifera* in forming mainly adnate squamules, and *P. sorediata* in forming a black, felty prothallus.

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The unknown substance also occurs in *P. glaucescens*, but this species differs in being (probably) non-sorediate and having a bluish green upper surface. See also *P. lacerata* for discussion.

Additional specimens examined. *Loreto*: Jenaro Herrera, 2 collections from 2 sites, 2006, *Timdal* (O, L144743, -831).

Phyllopsora lacerata Timdal sp. nov.

Thallus squamulosus, sine acido lichenoso; squamulae magnae, ascendentes, elongatae, plus minusve venosae, virides, laciniatae. Apothecia brunnea. Ascosporae bacilliformes vel aciculares.

Typus: Peru, Loreto, Reserva Nacional Allpahuayo Mishana, within a 2·3 km distance from Centro de Investigaciones Allpahuayo, N of the road, site 19, 3°57.31′S, 73°25.46′W (WGS84), tree trunk in rainforest, 120–150 m alt., 21 September 2006, *E. Timdal* 10213 (O-L144583—holotypus) [no lichen substances].

(Fig. 2B)

Prothallus not present. *Thallus* squamulose, effuse. *Squamules* large, up to 1 mm wide, ascending even when young, elongated, deeply incised or divided, more or less thickened in the lower part by medullary hyphae forming a vein-like tissue; lobes plane to weakly convex, up to 1 mm wide but often much narrower; *upper side* green, dull, epruinose; *margin* concolorous with upper side, not pubescent. *Lacinules* numerous, developing terminally on the lobes. *Upper cortex* of type 2, 10–15 µm thick, not containing crystals. *Medulla* not containing crystals (PD −, K −).

Apothecia (seen in type collection only) up to 0·7 mm diam., rounded, simple or conglomerate, plane to weakly convex, pale brown, with a thin, paler margin. *Excipulum* pale brown to colourless. *Hypothecium* pale brown to colourless. *Epithecium* colourless. No crystals in apothecia, all parts K −. *Ascospores* bacilliform to acicular, with a few indistinct pseudosepta, 19·5–32·5 × 1·5–2 µm (n=16).

Pycnidia not seen.

Chemistry. No lichen substances detected by TLC.

Distribution and ecology. This new species is known from two localities in Peru and one locality in Ecuador. In Peru, it grew on bark of trees in lowland primary rainforest. The specimen from Ecuador was collected from a tree trunk in mountain forest.

Notes. The species may be confused mainly with *P. glaucescens* and *P. labriformis* but differs in the deeply incised or divided squamules forming lacinules. It also differs from *P. glaucescens* in the pure green colour of the upper surface (not bluish) and the lack of lichen substances, and from *P. labriformis* in the presence of vein-like supportive tissue at the base of the squamules and in the lack of soralia.

Additional specimens examined. *Loreto*: Jenaro Herrera, 2 collections from 2 sites, 2006, *Timdal* (O, L144745, -751).—**Ecuador:** *Zamora-Chinchipe*: Cordillera Numbala, Reserva Biologica San Francisco, S of road Loja-Zamora, 3°58′S, 79°04′W, *c.* 1900 m, 2003, *Sipman & Mandl* 51411 (B).

Phyllopsora leucophyllina (Nyl.) Timdal comb. nov.

Lecidea leucophyllina Nyl. in J. Triana & J. E. Planchon, *Annal. Sci. Nat., Bot., sér. 4,* **19:** 347 (1863); type: Cuba, "in ins. Cuba", *C. Wright* (H-NYL 17345c, e—holotypus) [sekikaic acid and homosekikaic acid].

(Fig. 2C)

Prothallus not present. *Thallus* squamulose, forming circular thalli with radiating marginal squamules or partly effuse. *Squamules* medium sized, up to 0·5 mm wide, adnate when young, soon ascending, elongated, irregularly imbricate, incised or deeply divided, plane to weakly convex; *upper side* pale green, occasionally with patches of red pigment, dull, finely to moderately tomentose; *margin* somewhat paler, not pubescent. *Soralia* common, starting from the lower side near the tip of ascending squamules, later forming larger, irregular patches, farinose; soredia up to 50 µm diam. *Upper cortex* up to 15 µm thick, but partly poorly developed or absent, resembling type 1 but formed by more discrete hyphae, partly containing crystals dissolving

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in K (K−). *Medulla* containing crystals dissolving in K (PD−, K−).

Apothecia common, up to 0·6 (–1·0) mm diam., rounded to lobate, simple, weakly convex, pale brown, occasionally with patches of brown or red pigments, with an indistinct, more or less disappearing margin. *Excipulum* colourless, containing crystals dissolving in K (K−). *Hypothecium* pale brown in upper part, containing granules dissolving in K (K−). *Epithecium* colourless. *Ascospores* bacilliform to acicular, simple, 12·5–20 × 1·5–2 μm (n=50).

Pycnidia not seen.

Chemistry. Homosekikaic acid (major) and sekikaic acid (submajor).

Distribution and ecology. There seems to be very few published records of this species. I know only of the protologue (Cuba) and Sipman & Aptroot (1992) who reported the species as a forest epiphyte at four localities at 500–800 m alt. in Guyana. In Peru, the species grew on bark on tree trunks in rather well-lit rainforest.

Notes. The species was examined by Swinscow & Krog (1981, as *Lecidea leucophyllina*), but left without generic assignment. Brako (1989) stated that it belongs in an undescribed genus because of its ascus type, sorediate thallus, sekikaic acid, apothecia with refractile granules, and its long, septate, thin-walled ascospores. The wide concept of *Phyllopsora* adopted here includes species with a rather poorly developed upper cortex, soralia, unique chemistries, apothecia containing lichen substances, and long, poorly septate ascospores. Its ascus appears not to differ from those other species of *Phyllopsora*. The chemistry, homosekikaic acid and sekikaic acid, may indicate affinity with *Bacidiopsora*, which Kalb (2004) circumscribed partly by the presence of homosekikaic acid and hyperhomosekikaic acid. However, all these three substances also occur in *Physcidia* (Kalb & Elix 1995) and *Eschatogonia* (Timdal 2008), and two of them were recently reported from *Phyllopsora* (Elix 2006*b*, from *P. homosekikaica* Elix). It seems that the sekikaic acid complex is widely distributed in the squamulose species of the *Ramalinaceae* (and in the fruticose genus *Ramalina*).

The most similar sorediate species is perhaps *P. brakoae*; see that species for discussion.

Specimens examined. *Loreto*: Reserva Nacional Allpahuayo Mishana, 2006, *Timdal* (O, L144645); Jenaro Herrera, 3 collections from 3 sites, 2006, *Timdal* (O, L144762, -796, -811).

Phyllopsora lividocarpa Timdal sp. nov.

Thallus squamulosus, acida ignota continens; squamulae parvae, virides, laciniatae. Apothecia pallide vel obscure livida. Ascosporae aciculares.

Typus: Peru, Loreto, Jenaro Herrera, within a distance of 3·6 km from the research centre, N of the road, site 126, 4°53.66′S, 73°38.56′W (WGS84), tree trunk in rainforest, 120–150 m alt., 30 September 2006, *E. Timdal* 10447 (O-L144817—holotypus) [an unknown substance and an unknown fatty acid].

(Fig. 2D)

Prothallus thin, black, often poorly developed or absent. *Thallus* squamulose, effuse. *Squamules* small, up to 0·3 mm wide, adnate to ascending, isodiametric to elongated, rounded to crenulate or proliferating, plane to weakly convex; *upper side* green, slightly shiny, epruinose; *margin* concolorous with upper side, not pubescent. *Lacinules* numerous, developing terminally on the lobes. *Upper cortex* of type 1–2, 10–20 μm thick, not containing crystals. *Medulla* (and algal layer) containing colourless crystals dissolving in K (PD−, K−).

Apothecia common, up to 1 mm diam., rounded to crenulate or lobate, simple to conglomerate, plane to weakly convex, pale brown to almost colourless when young, later becoming medium grey to dark grey, with a more or less persistent margin which is usually darker than the disc. *Excipulum* medium grey at the margin, colourless in inner part, containing crystals dissolving in K (K−). *Hypothecium* medium grey in upper part (subhymenium), colourless in lower part, containing crystals dissolving

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in K (K −). *Epithecium* pale grey to colourless, containing crystals (or granules) dissolving in K. *Ascospores* acicular, with 1–4 pseudosepta, 21·5–33 × 1·5–2 µm (n=50).

Pycnidia not seen.

Chemistry. An unknown substance in Rf classes 7:7:7 (major) and an unknown fatty acid in 3:3:2–3 (minor).

Distribution and ecology. This new species is known from two localities in the Peruvian Amazonas where it occurred on tree trunks in lowland rainforest. It was common in both localities and was collected at 15 sites.

Notes. The species may be confused mainly with *P. atrocarpa*, with which it shares the same unknown substance, the presence of lacinules, and the acicular ascospores; see that species for discussion. The Australian *P. conwayensis* differs mainly in containing 3-chlorostenosporic acid, having more closely adnate squamules, having pale brown (not grey) apothecia, and in lacking crystals in the hypothecium. The excipulum and epithecium of *P. conwayensis*, however, are filled with crystals which dissolves in K, as in *P. lividocarpa* (examined in isotype, *Elix 20190 & Streimann*, B).

One specimen (O, L144653) differs chemically in containing only a yellow pigment (UV+ orange, K −) in Rf classes 6–7:6:7. More material is needed to determine whether it should be regarded as a chemical strain of *P. lividocarpa* or a separate species.

Additional specimens examined. *Loreto*: Reserva Nacional Allpahuayo Mishana, 5 collections from 5 sites, 2006, *Timdal*, (O, L144551, -580, -613, -614, -653); Jenaro Herrera, 11 collections from 10 sites, 2006, *Timdal* (O, L144729, -730, -735, -737, -742, -778, -806, -818, -834, -836, 146423).

Phyllopsora nigrocincta Timdal sp. nov.

Thallus crustosus vel squamulosus, acidum fumarprotocetraricum et pigmentum aurantiacum continens; areolae/squamulae parvae, cinereovirides. Apothecia atrocinerea vel atra. Ascosporae ellipsoideae vel fusiformes.

Typus: Peru, Loreto, Jenaro Herrera, within a distance of 3·6 km from the research centre, N of the road, site 124, 4°53.44′S, 73°37.39′W (WGS84), tree trunk in rainforest, 120–150 m alt., 29 September 2006, *E. Timdal* 10443 (O-L144813—holotypus) [fumarprotocetraric acid and an unknown orange pigment].

(Fig. 3A)

Prothallus thick, forming a broad zone up to 2 mm around the thallus, first bluish black, later turning reddish brown. *Thallus* crustose to almost squamulose, circular to effuse. *Areolae/squamules* small, up to 0·3 mm wide, isodiametric, rounded to crenulate, scattered to contiguous, sometimes forming weakly ascending, small squamules, up to 0·4 mm wide; *upper side* greyish green, dull, epruinose; *margin* paler than upper side, more or less pubescent. *Vegetative dispersal units* absent. *Upper cortex* 5–10 µm thick, formed by more or less collapsed hyphae, not containing crystals. *Medulla* (and algal layer) containing colourless crystals dissolving in K (PD − , K −); lower part of medulla containing orange crystals dissolving in K (K+ purple).

Apothecia common, up to 0·8 mm diam., rounded to crenulate or lobate, simple to conglomerate, plane to weakly convex, dark grey to black, with a persistent, dark orange to castaneous brown margin. *Excipulum* dark reddish brown (dark olivaceous-brown after orange pigments are dissolved), containing orange crystals dissolving in K with a strong K+ purple effusion. *Hypothecium* olivaceous-brown, not containing crystals, K − . *Epithecium* colourless. *Ascospores* ellipsoid to fusiform, simple, 5–8 × 2·5–3 µm (n=50).

Pycnidia not seen.

Chemistry. Fumarprotocetraric acid (major) and an orange pigment, K+ purple, in Rf classes 6:6:5–6 (major).

Distribution and ecology. This new species is known from two lowland localities in the Peruvian Amazonas where it grew on bark on tree trunks in primary rainforest. It was rather common at both localities, and was collected at 9 sites. The species often occurred in rather shady situations.

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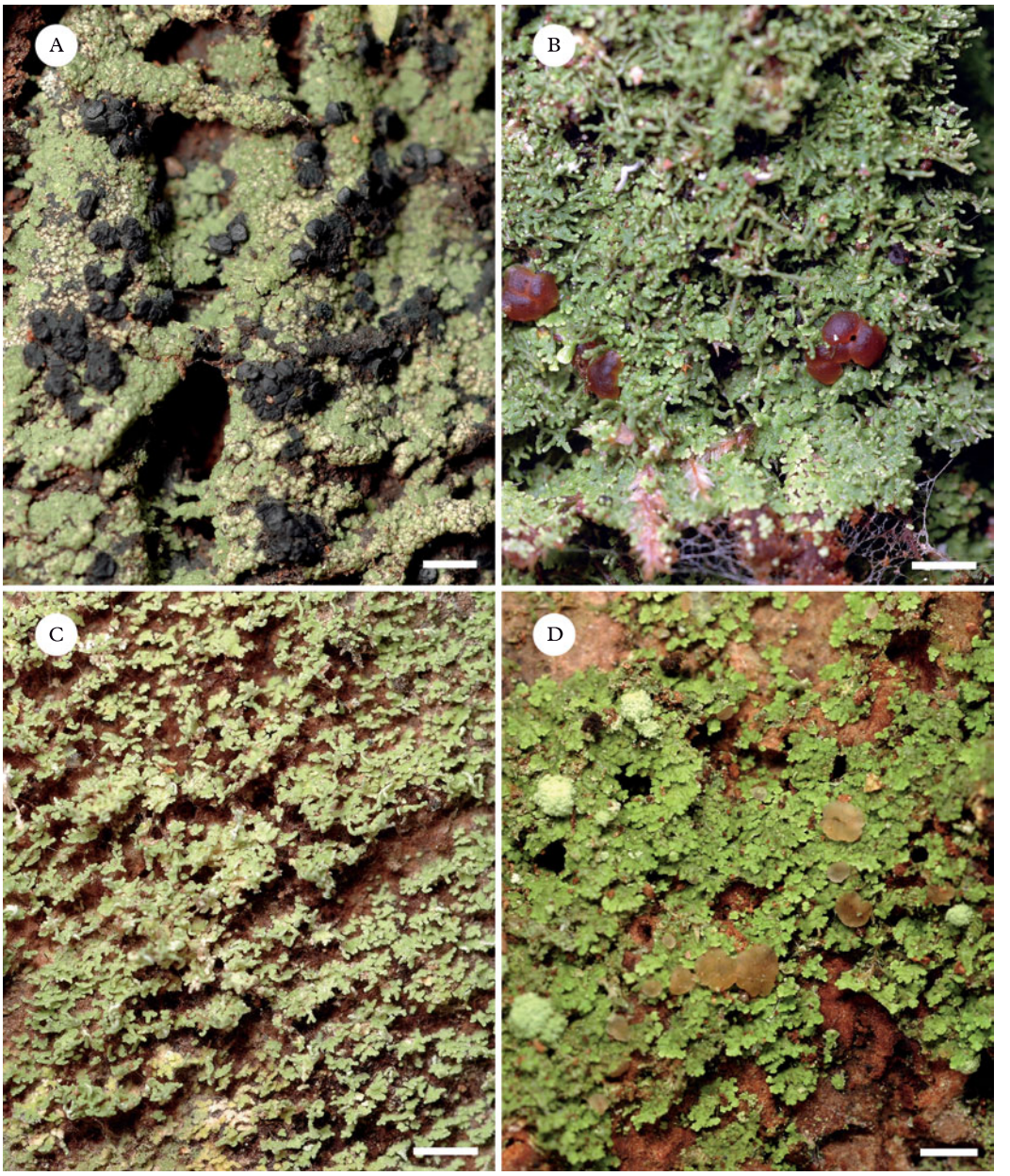


FIG. 3. Field photographs of *Phyllopsora* species. A, *P. nigrocincta* (O-L144651); B, *P. ochroxantha* (O-L144702); C, *P. parvifoliella* (O-L144633); D, *P. soralifera* (holotype, O-L144712); Scales: A–D = 1 mm.

Notes. The species can hardly be confused with any other *Phyllopsora* species, being apotheciate and having dark grey to black apothecia with an olivaceous brown hypothecium and an excipulum (and lower part of the medulla) filled with orange, K+ purple crystals.

Additional specimens examined. *Loreto*: Reserva Nacional Allpahuayo Mishana, 3 collections from 3 sites, 2006, *Timdal* (O, L144651, -689, -709); Jenaro

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Herrera, 5 collections from 5 sites, 2006, *Timdal* (O, L144731, -732, -757, -780, -837).

Phyllopsora ochroxantha (Nyl.) Zahlbr.

Catal. Lich. Univers. **10** (24)**:** 377 (1939); *Lecidea ochroxantha* Nyl., *Annal. Sci. Nat., Bot., sér. 4*, **11:** 223 (1859); *Phyllopsora corallina* var. *ochroxantha* (Nyl.) Brako, *Mycotaxon* **35** (1)**:** 13 (1989); type: Bolivia, Campolican, *Weddell* s.n. (H-NYL 20489—lectotypus selected by Swinscow & Krog 1981: 243) [phyllopsorin (major) and chlorophyllopsorin (minor)].

(Fig. 3B)

Prothallus well developed, reddish brown. *Thallus* effuse, squamulose. *Squamules* medium sized, up to 0·5 mm wide, adnate to somewhat ascending, isodiametric to elongate, scattered when young, later often contiguous or imbricate, crenulate to incised, plane to weakly convex; *upper side* medium green, dull to shiny, epruinose; *margin* concolorous, usually faintly pubescent. *Isidia* common, attached marginally to the squamules, often long, simple to slightly branched. *Upper cortex* of type 1–2, 20–30 µm thick, not containing crystals. *Medulla* containing crystals not, or only partially, dissolving in K (PD+ orange, K−).

Apothecia common, up to 1 (–1·5) mm diam., rounded when young, later of irregular shape, mainly simple, plane to strongly convex, medium brown to dark brown, with an indistinct, concolorous, often pubescent margin. *Excipulum* pale brown to colourless. *Hypothecium* colourless to medium brown. *Epithecium* colourless. No crystals in apothecia, all parts K−. *Ascospores* narrowly ellipsoid, simple, 6–8 × *c.* 2·5 µm (n=50).

Pycnidia not seen.

Chemistry. Phyllopsorin (major) and chlorophyllopsorin (submajor or minor).

Distribution and ecology. According to Brako (1991, as *P. corallina* var. *ochroxantha*) the species occurs widely in the Americas from Florida to Argentina. The Peruvian specimens grew on tree trunks in primary rainforests. It was rather common at both localities, collected at 15 sites.

Notes. Brako (1991) treated the taxon as a variety of *P. corallina*. It was distinguished from the other varieties by the presence of phyllopsorin, and characterized by several morphological characters: size of the squamules, shape and attachment of isidia, and size of the ascospores. The taxon is here given species rank in accordance with the treatment of Brako's other varieties of *P. corallina* (see Discussion).

Phyllopsora corallina var. *ochroxantha* was divided into three chemical strains by Brako (1991). Strain II differs from strain I in containing a subset (phyllopsorin, ± chlorophyllopsorin, ± zeorin) of the substances occurring in strain I (atranorin, phyllopsorin, chlorophyllopsorin, "methyl-phyllopsorate", "methyl-chlorophyllopsorate", and ± zeorin). I do not know of any other references to Brako's two phyllopsorates and have not seen substances fitting her characterizations in the Peruvian material (unless the names are synonyms of the two psoromates occurring in *P. swinscowii*). The Peruvian material contained phyllopsorin and chlorophyllopsorin only, which best fits strain II. See *P. swinscowii* for discussion on Brako's strain III and the chemistry of the synonym *P. glabriuscula* (Nyl.) Swinscow & Krog.

Specimens examined. *Loreto*: Reserva Nacional Allpahuayo Mishana, 12 collections from 11 sites, 2006, *Timdal* (O, L144557, -597, -650, -665, -668, -676, -677, -692, -695, -702, -708, -843); Jenaro Herrera, 4 collections from 4 sites, 2006, *Timdal* (O-L144727, -759, -805, -809). *San Martin*: Lamas, Cerro Blanco (*c.* 63 km, road distance, W-WNW of Tarapoto), 6°25′S, 76°40′W, *c.* 1200 m, 1981, *Santesson & Thor* P77:18, P77:53 (S).

Phyllopsora parvifoliella (Nyl.) Müll. Arg.

In Th. Durand & H. Pittier, *Bull. Soc. r. Bot. Belg.* **32***:* 131 (1893); *Lecidea parvifoliella* Nyl. in J. Triana & J. E. Planchon, *Annal. Sci. Nat., Bot., sér. 2*, **19:** 339 (1863); type: Cuba, *Wright* [Wright, *Lich. Cub. no.* 182] (H-NYL 20545—holotypus, BM—isotypus [atranorin and parvifoliellin, in both holotype and isotype].

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(Fig. 3C)

Prothallus thin, patchily to well developed, reddish brown. *Thallus* effuse, squamulose. *Squamules* medium sized, up to 0·5 mm wide, adnate to ascending, narrowly elongated, scattered or partly imbricate, deeply divided, plane to weakly convex; *upper side* medium green, dull, epruinose; *margin* concolorous with upper side, not pubescent. *Isidia* present or absent, long, cylindrical, marginal on the squamules or developing by elongation of squamules and sometimes not clearly distinct from these. *Upper cortex* of type 1, 15–30 µm thick, containing crystals dissolving in K (K−). *Medulla* containing crystals which are only partly dissolving in K (PD−, K−).

Apothecia common, up to 1 mm diam., rounded, simple or slightly conglomerate, weakly to moderately convex, medium brown to reddish brown, with an indistinct, darker, not pubescent margin. *Excipulum* medium brown to reddish brown. *Hypothecium* pale to medium brown. *Epithecium* pale brown to colourless. No crystals in apothecia, all parts K−. *Ascospores* broadly ellipsoid, simple, 5–6·5 × 2–2·5 µm (n=60).

Pycnidia not seen.

Chemistry. Atranorin (submajor) and parvifoliellin (major).

Distribution and ecology. A neotropical species occurring from USA (Florida) to Brazil (Brako 1991). My five Peruvian specimens grew on bark on tree trunks in primary rainforest.

Notes. Apparently, Brako (1991) erroneously used the name parvifoliin for parvifoliellin, and reported the substance from *P. parvifolia* (Pers.) Müll. Arg. rather than *P. parvifoliella*. She reported a trace of argopsin (with a query) from *P. parvifoliella*, but according to Elix (2006*a*) the characteristic substance of *P. parvifoliella* is parvifoliellin. The two isotypes of this species and the six Peruvian specimens examined here all contained atranorin and parvifoliellin (compared with *P. rappiana*, Australia, *Elix* 36867, duplicate, O). All specimens (extra-Peruvian) of *P. parvifolia* that I have examined have been acid deficient.

Phyllopsora rappiana contains atranorin and parvifoliellin (Brako 1991; Elix 2006*a*), like *P. parvifoliella*. Its delimitation from *P. parvifoliella* was not discussed by Brako (1991) or Elix (2006*a*), but from Brako's description and key it seems to be based mainly on *P. rappiana* having longer ascospores (6·5–10 × 2·5–3·5 µm). No other lichen species are known to produce parvifoliellin.

Cylindrical, ascending isidia often develop from the tip of well-developed squamules, but are absent in some collections (e.g. the type material and O-L144672 and -844). This absence of isidia is here interpreted as representing a juvenile stage and is without taxonomic significance.

Specimens examined. *Loreto*: Iquitos, Explorama Lodge (=*c.* 50 km NE of Iquitos), Lake trail, 3°27′S, 72°57′W, *c.* 100 m, 1981, *Santesson* P7:3 (S); Reserva Nacional Allpahuayo Mishana, 5 collections from 4 sites, 2006, *Timdal* (O-L144633, -646, -647, -672, -844).

Phyllopsora santensis (Tuck.) Swinscow & Krog

Lichenologist **12:** 236 (1981); *Lecidea santensis* Tuck. *Am. J. Sci. Arts, Ser. 2,* **25:** 428 (1858); *Phyllopsora corallina* var. *santensis* (Tuck.) Brako, *Mycotaxon* **35** (1)**:** 14 (1989); type: USA, South Carolina, Santee Canal, 1849, *Ravenel* 182 (FH—holotypus, not seen) [argopsin and norargopsin, according to Brako (1991)].

Prothallus poorly developed or partly absent, white. *Thallus* effuse, squamulose. *Squamules* small to medium sized, up to 0·4 mm wide, adnate or more rarely somewhat ascending, more or less isodiametric, scattered when young, later mostly contiguous, crenulate, weakly to moderately convex; *upper side* medium dull to shiny, epruinose; *margin* concolorous, rarely finely pubescent. *Isidia* patchily developed, often lacking in parts of the thallus, short, simple. *Upper cortex* of type 1–2, 20–30 µm thick, not containing crystals. *Medulla* containing crystals partly dissolving in K (PD+ orange, K−).

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Apothecia common, up to 1·2 mm diam., rounded, simple or conglomerate, weakly to strongly convex, medium brown to dark brown, sometimes with an indistinct, concolorous or paler margin when young, soon becoming emarginate. *Excipulum* pale brown to colourless. *Hypothecium* pale brown to colourless. *Epithecium* medium brown. No crystals in apothecium, all parts K − . *Ascospores* narrowly ellipsoid, simple, 7·5–10·5 × 2·5–3 μm (n=40).

Pycnidia not seen.

Chemistry. Argopsin (major) and norargopsin (major or lacking).

Distribution and ecology. *Phyllopsora santensis* has a wide distribution in the Americas, from USA (South Carolina) to Paraguay, and also occurs in Taiwan, the Philippines and Australia (Brako 1991; Elix 2006*a*).

Notes. Swinscow & Krog (1981) erroneously applied the name *P. santensis* for *P. subhispidula* (cf. Timdal & Krog 2001). Brako (1991) treated it as a variety of *P. corallina*, primarily circumscribed by the presence of argopsin, and discussed its morphological differences from var. *ochroxantha*. It is here treated at the species level in accordance with the treatment of Brako's other varieties of *P. corallina*; see further under Discussion.

Two chemical strains were accepted by Brako (1991): I: argopsin, norargopsin, ± atranorin, and ± zeorin, and II: argopsin only. In my material, the specimen from Loreto contained argopsin (plus unidentified terpenoids, possibly contaminant), the other specimens contained argopsin and norargopsin. Isidia may be patchily developed in this species and are lacking in the specimen from Loreto.

Specimens examined. *Loreto*: Iquitos, Explorama Lodge (=*c.* 50 km NE of Iquitos), Lake trail, 3°27′S, 72°57′W, *c.* 100 m, 1981, *Santesson* P7:19 (S). *San Martin*: San Martin, Tarapoto, NE of Hotel de Turistas, 6°30′S, 76°20′W, *c.* 350 m, 1981, *Santesson & Thor* P70:47 (S); 350–500 m, P76:14, P76:18, P76:19 (S).

Phyllopsora soralifera Timdal sp. nov.

Thallus squamulosus, sine acido lichenoso; squamulae mediocres, adnatae vel interdum leviter ascendentes, isodiametricae vel elongatae, virides, sorediatae. Soralia mox capitata. Apothecia brunnea. Ascosporae bacilliformes vel aciculares.

Typus: Peru, Loreto, Reserva Nacional Allpahuayo Mishana, within a distance of 2·3 km from Centro de Investigaciones Allpahuayo, N of the road, site 78, 3°58.80′S, 73°25.59′W (WGS84), tree trunk in rainforest, 120–150 m alt., 24 September 2006, *E. Timdal* 10342 (O-L144712—holotypus) [no lichen substances].

(Fig. 3D)

Prothallus not present. *Thallus* squamulose, effuse. *Squamules* medium sized, up to 0·5 mm wide, adnate or sometimes weakly ascending, isodiametric or elongated, crenulate to incised, plane to weakly convex; *upper side* medium green, dull, epruinose; *margin* concolorous with upper side, not pubescent. *Soralia* common, developing from the margin of the squamule, soon capitate on the upper side, farinose; soredia up to 40 μm diam. *Upper cortex* of type 2, 10–30 μm thick, not containing crystals. *Medulla* not containing crystals or containing small amounts of crystals not dissolving in K (possibly calcium oxalate) (PD − , K −).

Apothecia rare (seen in the type material only), up to 0·8 mm diam., rounded, simple or conglomerate, weakly to moderately convex, pale brown, with an indistinct, concolorous margin. *Excipulum* pale brown to colourless. *Hypothecium* pale brown to colourless. *Epithecium* colourless. No crystals in apothecia, all parts K − . *Ascospores* bacilliform to acicular, with (1–) 3 (–4) indistinct pseudosepta, 17–27·5 × 2–2·5 μm (n=20).

Pycnidia not seen.

Chemistry. No lichen substances detected by TLC.

Distribution and ecology. This new species is known from two lowland localities in the Peruvian Amazonas. It was rather common at the first locality (11 sites), but more rare at the second (2 sites). The species grew on bark on tree trunks in primary rainforest.

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Notes. This species most closely resembles *P. brakoae*, but its squamules differ in being mainly adnate to the substratum (not soon becoming ascending) and in forming capitate soralia on the upper side of the squamules (not labriform, on the underside), cf. Figs 1B and 3D. Apothecia are unknown in *P. brakoae*. The three other sorediate species of *Phyllopsora*, *P. labriformis*, *P. leucophyllina*, and *P. sorediata*, contain lichen substances. *Phyllopsora labriformis* differs morphologically in forming ascending squamules with labriform soralia, *P. leucophyllina* in usually forming more or less circular thalli with radiating marginal squamules, and *P. sorediata* in forming a black, felty prothallus (cf. Aptroot *et al*. 2007).

Additional specimens examined. Loreto: Reserva Nacional Allpahuayo Mishana, 11 collections from 11 sites, 2006, *Timdal* (O-L144602, -624, -660, -663, -666, -670, -684, -688, -703); Jenaro Herrera, 2 collections from 2 sites, 2006, *Timdal* (O-L144755, -785).

Phyllopsora swinscowii Timdal & Krog

Mycotaxon **77:** 88 (2001); type: Mauritius: Black River, along the path from Plaine Champagne towards Piton de la Petite Rivière Noire, 20°25′S, 57°25′E, 600 m alt., 1991, *H. Krog & E. Timdal* MAU9/50 (O—holotypus) [methyl 2,7-dichloropsoromate and methyl 2,7-dichloronorpsoromate].

Prothallus well developed, reddish brown. *Thallus* effuse, squamulose. *Squamules* medium sized, up to 0·5 mm wide, adnate to somewhat ascending, isodiametric to elongate, scattered when young, later often contiguous or imbricate, crenulate to incised, plane to weakly convex; *upper side* medium green, dull to shiny, epruinose; *margin* concolorous, usually faintly pubescent. *Isidia* common, attached marginally to the squamules, often long, simple to slightly branched. *Upper cortex* of type 1–2, 20–30 µm thick, not containing crystals. *Medulla* containing crystals not, or only partially, dissolving in K (PD+ yellow, K−).

Apothecia not common, up to 1 (–1·5) mm diam., rounded when young, later of irregular shape, mainly simple, plane to strongly convex, medium brown to dark brown, with an indistinct, concolorous, often pubescent margin. *Excipulum* pale brown to colourless. *Hypothecium* colourless. *Epithecium* colourless. No crystals in apothecia, all parts K−. *Ascospores* narrowly ellipsoid, simple, 5·5–8 × *c*. 2·5 (*n*=24).

Pycnidia not seen.

Chemistry. Methyl 2,7-dichloropsoromate (major to minor) and methyl 2,7-dichloronorpsoromate (major).

Distribution and ecology. *Phyllopsora swinscowii* is reported here as new to the neotropics, but assuming that it is identical with Brako's *P. corallina* var. *ochroxantha* chemical strain III, the species has a wide distribution in the neotropics from Florida to Brazil (Brako 1991). It also occurs in Australia (Brako 1991; Elix 2006*a*) and East Africa and Mauritius (Timdal & Krog 2001). My Peruvian specimens were all collected on bark on tree trunks in primary rainforest. It was common at the first locality (12 sites), but not collected at the second.

Notes. Brako's (1991) *Phyllopsora corallina* var. *ochroxantha* chemical strain III was characterized by the presence of chlorophyllopsorin and an unknown substance (Brako 1991). Elix *et al*. (1990) identified methyl 2,7-dichloropsoromate and methyl 2,7-dichloronorpsoromate from a duplicate of one of the specimens which Brako (1991) placed in strain III (Ecuador, *Brako* 7460, ANUC). My TLC examination of another specimen (*Harris* 15383, BM) also showed the same substances. Although I have never found chlorophyllopsorin in *P. swinscowii*, it seems that Brako's (1991) var. *ochroxantha* strain III is identical with *P. swinscowii*. However, *P. swinscowii* is morphologically very similar to *P. ochroxantha*, and more studies are needed to decide whether Brako (1991) is correct in treating it merely as a chemotype of that taxon. Her single specimen of chemotype III from Peru (*Santesson & Thor* P77:23) contains vicanicin and norvicanicin and is here identified as *P. glaucella*.

Phyllopsora glabriuscula was placed in synonomy with var. *ochroxantha* (chemotype

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not indicated) by Brako (1991), and reported to contain unknown substances both by herself and by Swinscow & Krog (1981). TLC examination of the holotype (H-NYL 20534) showed phyllopsorin and chlorophyllopsorin as in *P. ochroxantha* s. str., and not the chemistry of *P. swinscowii* as could be suspected.

Specimens examined. *Loreto*: Reserva Nacional Allpahuayo Mishana, 17 collections from 12 sites, 2006, *Timdal* (O-L144556, -560, -561, -564, -565, -567, -568, -569, -582, -589, -595, -600, -617, -636, -655, -659, -687); north shore of Rio Nanay, between Nina Ruma and Santa Clara, 3°47.7′S, 73°23.1′W, 120–150 m, 2006, *Timdal* (O, L144846).

Key to the Peruvian species of *Phyllopsora*

1 Thallus sorediate 2
Thallus not sorediate 5

2(1) Soralia on the lower side of ascending squamules, labriform 3
Soralia developing from the tip (often lower side) of the squamules, becoming capitate or forming irregular patches on the upper side 4

3(2) Squamules elongated, partly linear, not containing lichen substances . . . . . **P. brakoae**
Squamules rounded or moderately elongated, containing an unidentified substance . . . . . **P. labriformis**

4(2) Thallus circular to partly effuse, containing sekikaic and homosekikaic acid . . . . . **P. leucophyllina**
Thallus effuse, not containing lichen substances . . . . . **P. soralifera**

5(1) Thallus isidiate 6
Thallus lacinulate or not, never isidiate 14

6(5) Isidia attached directly to the prothallus or to a crustose thallus . . . . . **P. furfuracea**
Isidia attached to squamules 7

7(6) Upper cortex lacking, algal layer covered by loose hyphae . . . . **P. cuyabensis**
Upper cortex present 8

8(7) Not containing lichen substances (*P. corallina* s. str. and *P. intermediella*-complexes present in the Peruvian material) . . . . . Not treated
Containing lichen substances 9

9(8) Prothallus white or absent 10
Prothallus reddish brown 11

10(9) Ascospores bacilliform to acicular; thallus containing lobaric acid and/or fumarprotocetraric acid . . . . . **P. cinchonarum**
Ascospores narrowly ellipsoid; thallus containing argopsin and often norargopsin . . . . . **P. santensis**

11(9) Thallus PD − 12
Thallus PD+ yellow or orange 13

12(11) Thallus containing atranorin and parvifoliellin; ascospores broadly ellipsoid, 5–6·5 µm long . . . . . **P. parvifoliella**
Thallus containing vicanicin and norvicanicin; ascospores narrowly ellipsoid, 6·5–9 µm long . . . . . **P. glaucella**

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13(11) Thallus containing phyllopsorin and chlorophyllopsorin (PD+ orange) . . . . . **P. ochroxantha**
Thallus containing methyl 2,7-dichloropsoromate and methyl 2,7-dichloronorpsoromate (PD+ yellow) . . . . . **P. swinscowii**

14(5) Thallus bluish green . . . . . **P. glaucescens**
Thallus greyish green to medium green 15

15(14) Not containing lichen substances 16
Containing lichen substances 18

16(15) Squamules with vein-like supportive tissue . . . . . **P. lacerata**
Squamules without vein-like tissue 17

17(16) Excipulum and hypothecium dark reddish brown . . . . . **P. chlorophaea**
Excipulum and hypothecium pale to medium brown (undetermined Peruvian material) . . . . . Not treated

18(15) Thallus crustose to almost squamulose; lower part of medulla and excipulum containing orange, K+ purple crystals . . . . . **P. nigrocincta**
Thallus squamulose; thallus and excipulum not containing orange crystals . 19

19(18) Squamules with pubescent margin, medium sized to large 20
Squamules with glabrous margin, small to medium sized 21

20(19) Squamules more or less pruinose, effuse or forming circular thalli with radiating marginal squamules, containing zeorin and either vicanicin or pannarin and phyllopsorin . . . . . **P. buettneri**
Squamules not pruinose, effuse, containing xanthones and often argopsin . . . . . **P. chodatinica**

21(19) Ascospores ellipsoid; thallus containing atranorin and parvifoliellin (non-isidiate morphotype) . . . . . **P. parvifoliella**
Ascospores acicular; thallus containing an unknown substance (plus fumarprotocetraric acid or a fatty acid) 22

22(21) Apothecia brownish black; squamules PD+ orange (fumarprotocetraric acid) . . . . . **P. atrocarpa**
Apothecia pale brown to almost colourless when young, later medium grey to dark grey; squamules PD − (fatty acid) . . . . . **P. lividocarpa**

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