The Lichenologist **40**(1): 31–38 (2008) © 2008 British Lichen Society
doi:10.1017/S0024282908007457 *Printed in the United Kingdom*

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

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Abstract: Four species of *Eschatogonia* are recognized in Peru: *E. angustiloba* Timdal sp. nov., *E. dissecta* Timdal & R. Sant. sp. nov., *E. minuta* Timdal & R. Sant. sp. nov., and *E. prolifera* (Mont.) R. Sant. African and South American material of *E. prolifera* are shown to belong in two different chemical strains. *Eschatogonia prolifera* is new to Guinea, Peru and Suriname. A key to all six known species of the genus is given.

Key words: Amazonas, lichens, taxonomy, tropical rainforest

Introduction

The tropical rainforest genus *Eschatogonia* Trevis. (*Ramalinaceae*) consists of three species (Kalb 2004): *E. marivelensis* (Vain.) Kalb, *E. prolifera* (Mont.) R. Sant., and *E. triptophyllina* (Nyl.) Kalb. These species are squamulose and corticolous, and the genus is apparently related to *Bacidiopsora* Kalb, *Phyllopsora* Müll. Arg., and *Squamacidia* Brako. *Eschatogonia*, however, differs from these genera mainly by its characteristic cortex, which is composed of a single layer of rounded or cuboid cells with a thick cell wall (Swinscow & Krog 1981; Brako 1991; Kalb 2004). The cortex covers both the upper and lower sides of the squamules and is continuous over the margin of the squamule (Fig. 1C). In the other three genera, the upper cortex consists of several cell layers, and a lower cortex is lacking.

During fieldwork in Peru in 2006, I had the opportunity to collect material of *Eschatogonia*. Four species were identified, three of which are described as new below. This study also includes material in UPS collected by Rolf Santesson and his colleagues from Stockholm and Uppsala in 1981. They studied the lichen mycobiota in many provinces in Peru, and *Eschatogonia* spp. were collected at five localities in the tropical rainforest in Tarapoto (San Martin province), and in one locality in Paucartambo (Cuzco province). A study was partly written up, but not published, by Santesson and has been generously put at my disposal by him. To my knowledge, there are no previous reports of the genus from Peru.

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Material and Methods

The fieldwork was carried out in a lowland rainforest in Loreto province. The two localities are at Reserva Nacional Allpahuayo Mishana, within a 2·3 km distance 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 3·6 km distance from the research centre (4°52–54′W, 73°37–39′W, alt. 120–150 m, 58 sites). Five field days were spent at each research centre. Although the work was concentrated on the genus *Phyllopsora*, 106 collections of *Eschatogonia* were made. In the lists of specimens examined, only the herbarium accession numbers are given; see data.gbif.org for additional specimen information including GPS readings at each site.

In addition to Santesson *et al.*'s and my own collections, 19 specimens of *Eschatogonia* in B, 10 specimens in UPS (including an isotype of *E. prolifera*) and type material of *E. marivelensis* (BM and TUR-VAIN 20360) and of *E. triptophyllina* (H-NYL 17338) were examined. With one exception, these collections were all extra-Peruvian. Several of the extra-Peruvian collections could not be identified, which indicates that further studies of the genus are needed.

All specimens cited in this paper have been subjected to thin-layer chromatography using the standard

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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. The ascospore measurements were made on squash preparations in water. The lengths are given as $x \pm 1{\cdot}5 \times$ SD, where x is the mean value and SD the standard deviation; the breadths are approximate values only because of the difficulties of precisely measuring the narrow acicular spores.

The Species

Eschatogonia angustiloba Timdal sp. nov.

Differt ab *Eschatogonia prolifera* lobis angustioribus, linearibus, plusminusve revolutis.

Typus: Peru, Loreto, Jenaro Herrera, within a 3·6 km distance from the Research Centre, N of the road, site 92, 4°53.97′S, 73°38.89′W (WGS84), tree trunk in rainforest, 120–150 m alt., 27 September 2006, *E. Timdal* 10382 (O-L144752—holotypus) [chemotype 1].

(Fig. 1A & B)

Prothallus absent. *Thallus* effuse, squamulose. *Squamules* medium sized to large, 1–2 mm broad, deeply divided into 0·1–0·3(–0·6) mm broad, more or less linear lobes, loosely adnate to the substratum or ascending, often imbricate; lobes plane to weakly convex or revolute, upper side green, often with a yellow or brown tinge, glabrous, epruinose, sometimes finely maculate; margin concolorous with the upper side. Lobules scattered, developing from the margin of the squamules both laterally and terminally. *Medulla* containing crystals dissolving in K (PD −, K −).

Apothecia not common, up to 1 mm diam., rounded, simple or partly conglomerate, weakly to moderately convex, pale brown, with an indistinct margin when young, but later becoming emarginate. *Ascospores* narrowly ellipsoid to bacilliform, simple to 1-septate, 9–13 × 2·5–3 µm (n=50, from 2 specimens of chemotype 1).

Pycnidia not seen.

Chemistry. Chemotype 1: two unidentified substances (both major) and zeorin (minor); chemotype 2: sekikaic acid (major), homosekikaic acid (submajor), and zeorin (minor); chemotype 3: sekikaic acid (major), zeorin (minor) and an unidentified terpenoid (minor); chemotype 4 (extra-Peruvian): an unidentified substance (major) and zeorin (minor).

The two unidentified substances in chemotype 1 move very close to sekikaic acid and homosekikaic acid respectively on the chromatograms in all three solvent systems, but differ in UV fluorescence after development. They are UV+ rusty brown with an orange halo whereas sekikaic acid and homosekikaic acid are dark brown with a green halo. All four compounds are brown in visible light after development, but after a few days the unknown compounds turn orange whereas sekikaic acid and homosekikaic acid turn reddish brown. The unidentified terpenoid in chemotype 3 moves lower than zeorin in all three solvent systems and the unidentified substance in chemotype 4 moves close to sekikaic acid in solvent systems A and C, and above homosekikaic acid in B.

Distribution and ecology. *Eschatogonia angustiloba* is known from six localities in the Peruvian Amazonas at *c.*100–1000 m alt. and from one collection from Suriname. The Peruvian localities are all in primary tropical rainforest, and the species was found corticolous on the lower part of the tree trunks. It was found together with *E. prolifera* at 4 sites with *E. dissecta* at 2 sites, and with *E. minuta* at 4 sites.

Notes. The new species is apparently closely related to *E. prolifera*, but differs morphologically in forming narrower, linear and often somewhat revolute lobes. The two species have been observed in the field growing side by side (e.g., Fig. 1B, O-L144776). In other collections (O-L144616, -618, -698, -714), *E. prolifera* occurs as immixture and is recognized morphologically by its broader, more irregular lobes. Chemically, South American material of *E. prolifera* (chemotype 1 with didymic acid) is distinct from all chemotypes of *E. angustiloba*. The

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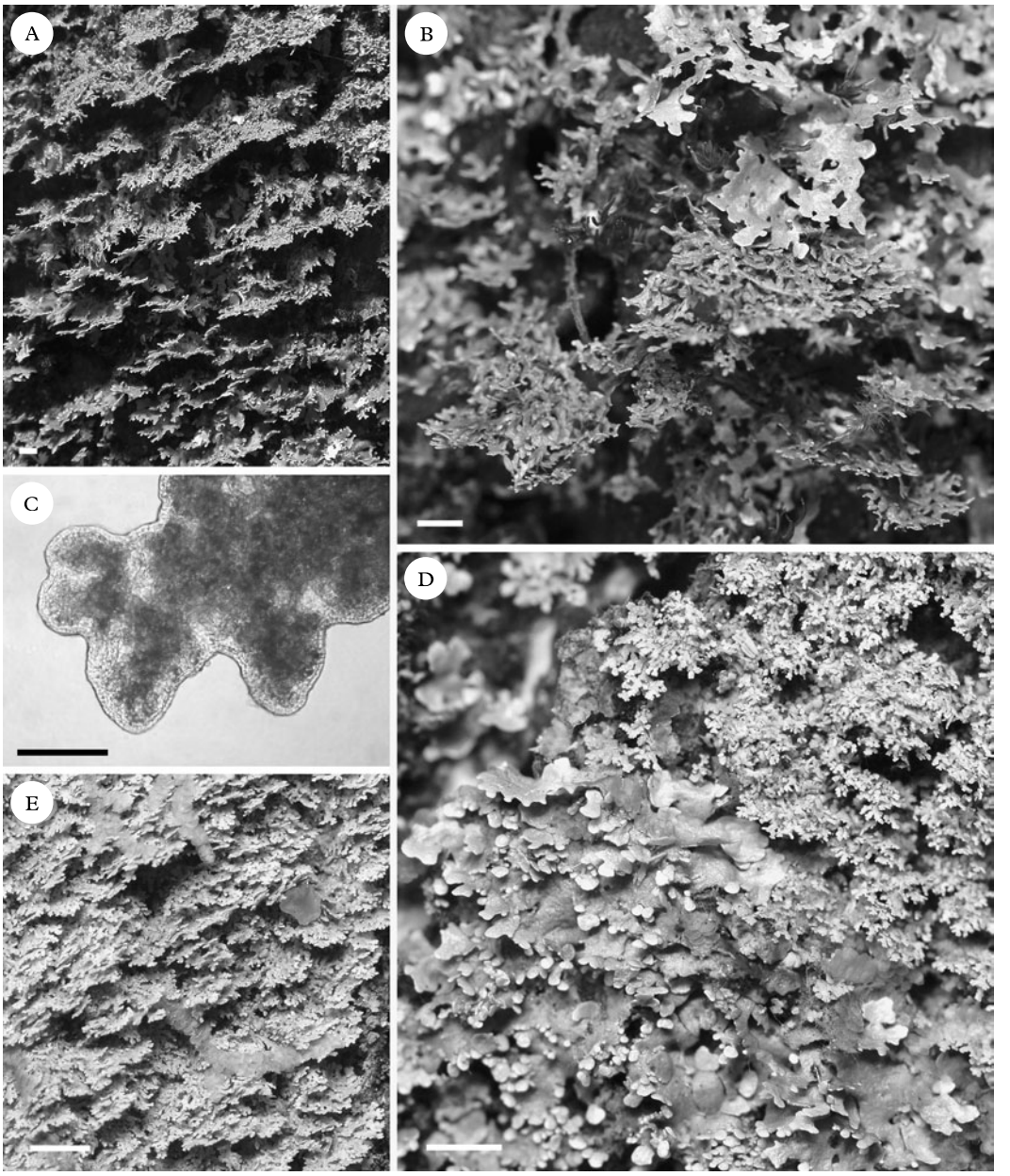


FIG. 1. *Eschatogonia* species, field (A, B, D, E) and light microscopy (C) photographs. A, *E. angustiloba* (O-L144698); B, *E. angustiloba* (bottom) and *E. prolifera* (top) (O-L144776); C, *E. dissecta*, dorsal view in water, showing the single-layered cortex covering the margin of a squamule (O-L144807); D, *E. dissecta* (top right) and *E. prolifera* (bottom left) (O-L144715); E, *E. dissecta* (holotype, O-L144719). Scales: A, B, D & E=1 mm; C=100 µm.

African material of *E. prolifera* (chemotype 2), however, is chemically similar to chemotype 2 of *E. angustiloba*.

There is no evident morphological difference between the three chemotypes occurring in Peru. The material of chemotypes 2

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and 3 is sterile, however, so any apothecial characters could not be considered. A sterile specimen from Suriname (*Bekker* 1107b, UPS) represents a fourth chemotype. More fertile material is needed in order to evaluate the taxonomic status of the four chemotypes of *E. angustiloba*.

Additional specimens examined. Chemotype 1: **Peru:** *Loreto*: Reserva Nacional Allpahuayo Mishana, 3 collections from 3 sites, 2006, *Timdal* (O, L144576, -698, -706); Jenaro Herrera, 12 collections from 11 sites, 2006, *Timdal* (O, L 144714, -726, -752, -764, -772, -776, -777, -791, -792, -794, -833, -835).

Chemotype 2: **Peru:** *Loreto*: Reserva Nacional Allpahuayo Mishana, 2 collections from 2 sites, 2006, *Timdal* L144616, -618 (O). *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* P72:1 (UPS); San Martin, Cerro Escalera (NE of Tarapoto), NW of the tunnel, 6°26′S, 76°15′W, *c*. 1000 m, 1981, *Santesson & Thor* P74:2 (UPS); Lamas, Cerro Blanco (*c*. 58 km, road distance, W–WNW of Tarapoto), 6°25′S, 76°40′W, *c*. 1000 m, 1981, *Santesson & Thor* P73:9 (UPS).

Chemotype 3: **Peru:** *Loreto*: Jenaro Herrera, 2 collections from 2 sites, 2006, *Timdal* (O, L144744, -828). *Cuzco*: Paucartambo, *c*. 11 km S of Pillcopata, 12°54′S, 71°13′W, *c*. 850 m, 1981, *Santesson, Tehler & Thor* P102:1 (UPS).

Extra-Peruvian collection examined: **Suriname:** *Bekker* 1107b (UPS, chemotype 4).

Eschatogonia dissecta Timdal & R. Sant. sp. nov

Squamulae mediocres, 0·5–1 mm latae, profunde dissectae; sporae aciculares, 26–40 µm longae; thallus acidum homosekikaicum vel acidum hyperhomosekikaicum continens.

Typus: Peru, Loreto, Jenaro Herrera, within a 3·6 km distance from the Research Centre, N of the road, site 81, 4°53.47′S, 73°38.99′W (WGS84), tree trunk in rainforest, 120–150 m alt., 26 September 2006, *E. Timdal* 10349 (O-L144719—holotypus) [homosekikaic acid and hyperhomosekikaic acid].

(Fig. 1C–E)

Prothallus absent. *Thallus* effuse, squamulose. *Squamules* medium sized, 0·5–1 mm broad, at first adnate, plane to weakly convex, more or less isodiametric, soon becoming elongated, crenulate, deeply dissected, ascending and often partly imbricate; lobes 0·08–0·2 mm broad, plane to weakly convex, upper side green, glabrous, epruinose, emaculate; margin concolorous with upper side. Lobules scattered, developing from the margin of the squamules, both laterally and terminally. *Medulla* containing crystals dissolving in K (PD −, K −).

Apothecia not rare, up to 0·8(–1·5) mm diam., rounded when young, often becoming irregular, simple or conglomerate, weakly concave or weakly convex, pale brown, with a paler, more or less persistent, often somewhat flexuous margin. *Ascospores* acicular, simple or indistinctly 1(–3)-septate, 26–40 × *c*. 1·5 µm (n=50).

Pycnidia not seen.

Chemistry. Homosekikaic acid and/or hyperhomosekikaic acid.

Distribution and ecology. *Eschatogonia dissecta* is known from French Guiana, Venezuela and Peru. In Peru, it is known from three localities in the Amazonas at *c*. 100–1000 m alt. The localities are all in a primary tropical rainforest, and the species was found corticolous on the lower part of tree trunks.

Notes. The species contains either homosekikaic acid (9 collections), hyperhomosekikaic acid (9 collections) or both substances (11 collections). In specimens containing only one substance as major, traces of the other substance may occur.

Eschatogonia marivelensis and *E. triptophyllina* both lack lichen substances (Swinscow & Krog 1981; Timdal 1992; Kalb 2004) and have reddish brown apothecia. The species are known from only three and one collection, respectively, and a discussion of any morphological differences is difficult because of insufficient knowledge of their variation. The holotype of *E. marivelensis* forms somewhat more elongated, almost entirely adnate squamules. The ascospores [*c*. 25–35 × 2–2·5 µm, as *Toninia marivalensis* (Timdal 1992)] are similar to those of *E. dissecta*. The lectotype of *E. triptophyllina* differs from *E. dissecta* in forming even more finely crenulate and dissected squamules. The ascospores are acicular, but there are conflicting records of the size: 23–32 µm long (protologue) and 40–55 µm long (Swinscow & Krog 1981). Like Kalb (2004), I could not find ascospores in the lectotype.

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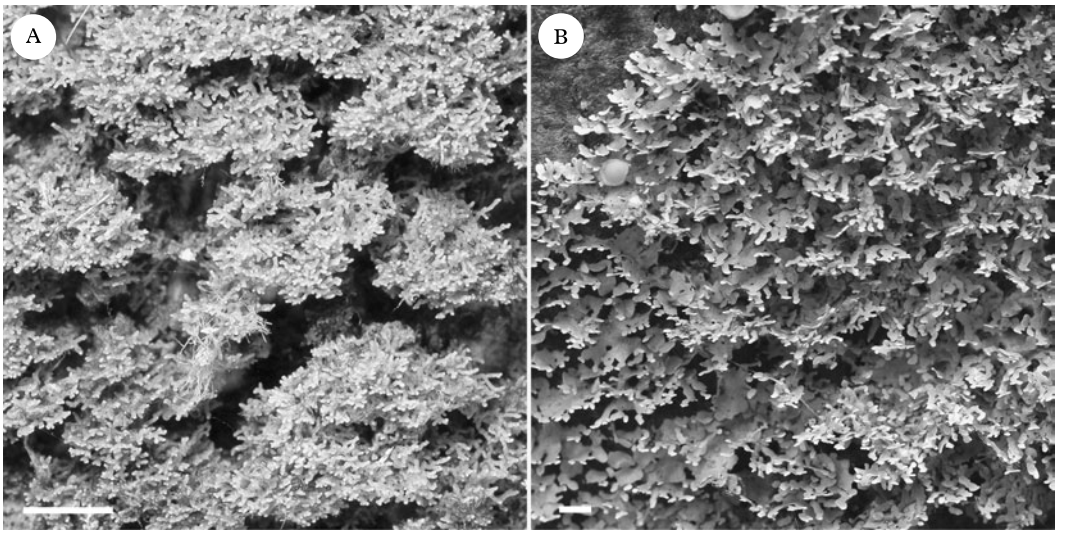


FIG. 2. *Eschatogonia* species, field photographs. A, *E. minuta* (holotype, O-L144753); B, *E. prolifera* (O-L144586). Scales: A & B=1 mm.

Eschatogonia dissecta differs from *E. angustiloba* and *E. prolifera* in forming smaller and more dissected squamules, in having acicular ascospores, and in containing homosekikaic and/or hyperhomosekikaic acid and lacking zeorin. It has been observed growing side by side with *E. prolifera* (Fig. 1D).

Eschatogonia minuta differs from *E. dissecta* by its narrower, partly terete, more or less coralloid squamules, shorter ascospores, and the lack of lichen substances.

Additional specimens examined: **Peru:** *Loreto*: Reserva Nacional Allpahuayo Mishana, 14 collections from 12 sites, 2006, *Timdal* (O, L144542, -544, -545, -570, -587, -601, -610, -626, -637,-658, -664, -683, -694, -701); Jenaro Herrera, 11 collections from 9 sites, 2006, *Timdal* (O, L144715, -716, -719, -722, -740, -754, -756, -783, -786, -807, -825). *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* P72:2 (UPS).

Extra-Peruvian collections examined: **French Guiana:** Sipman 31642 (B); Aptroot 15380 (UPS).—**Venezuela:** Jentzsch 42 (B).

Eschatogonia minuta Timdal & R. Sant. sp. nov.

Squamulae minutae, 0·3–0·6 mm latae, coralloideae; sporae aciculares, 16–25 µm longae; thallus acidis lichenico destitutus.

Typus: Peru, Loreto, Jenaro Herrera, within a 3·6 km distance from the Research Centre, N of the road, site 93, 4°53.99′S, 73°38.91′W (WGS84), tree trunk in rainforest, 120–150 m alt., 27 September 2006, *E. Timdal* 10383 (O-L144753—holotypus) [no lichen substances detectable by TLC].

(Fig. 2A)

Prothallus absent. *Thallus* effuse, squamulose. *Squamules* small, 0·3–0·6 mm broad, at first adnate, soon ascending and becoming coralloid; lobes 0·04–0·06 mm broad, flattened or partly terete, upper side green, more or less glabrous, epruinose, emaculate; margin concolorous with upper side. Lobules absent. *Medulla* without crystals.

Apothecia rare, up to 0·6 mm diam., rounded, simple or becoming conglomerate, weakly to moderately convex, pale brown to medium brown, with an indistinct margin or emarginate. *Ascospores* acicular, simple or indistinctly 1-septate, 16–25 × *c.* 1·5 µm (n=40).

Pycnidia not seen.

Chemistry. No lichen substances detectable by TLC.

Distribution and ecology. *Eschatogonia minuta* is known from El Salvador,

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Venezuela, and Peru. In Peru, it has been collected from four localities in the Amazonas at *c.* 100–1200 m alt. The localities were all in primary tropical rainforest, and the species was corticolous on the lower part of the tree trunks.

Notes. *Eschatogonia minuta* differs from all other species of *Eschatogonia* in forming coralloid, very narrow and partly terete lobes. The ascospores are longer than those of *E. angustiloba* and *E. prolifera*, and shorter than those of *E. dissecta*, *E. marivelensis* and *E. triptophyllina*.

Additional specimens examined: **Peru:** *Cuzco*: Paucartambo, *c.* 11 km S of Pillcopata, 12°54′S, 71°13′W, *c.* 850 m, 1981, *Santesson, Tehler & Thor* P102:2 (UPS). *Loreto*: Reserva Nacional Allpahuayo Mishana, 2 collections from 2 sites, 2006, *Timdal* (O, L144574, -707); Jenaro Herrera, 4 collections from 4 sites, 2006, *Timdal* (O, L144749, -753, -832, L146948). *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* P77:8 (UPS).

Extra-Peruvian collections examined: **El Salvador:** Welz 471 (B).—**Venezuela:** *Goetzke & Blüthgen* 7 (B).

Eschatogonia prolifera (Mont.) R. Sant.

In T. D. V. Swinscow & H. Krog, *Macrolichens of East Africa*: 86 (1988);—*Biatora prolifera* Mont., *Annales des Sciences Naturelles* **16:** 52 (1851);—*Eschatogonia montagnei* Trevis., *Caratteri di dodici nuovi generi di Licheni*: 2 (1853), nom. illeg. (Art. 52.1, superfluous name); type: French Guiana, "Guyana, hb. Montagne" (UPS, L-129880—isotype) [didymic acid and accessory substances].

(Fig. 2B)

Prothallus absent. *Thallus* effuse, squamulose. *Squamules* large, 1–4 mm broad, varying from broad in peripheral parts of thallus to elongated in the central part but often more or less irregular in shape, deeply divided into lobes, 0·5–2(–3) mm wide, loosely adnate to the substratum or ascending, often partly imbricate; lobes plane to weakly convex, upper side green, often with a yellow or brown tinge, glabrous, epruinose, sometimes finely maculate; margin concolorous with upper side. Lobules numerous, developing from the margin of the squamules both laterally and terminally, often proliferating. *Medulla* containing crystals dissolving in K (PD −, K −).

Apothecia not rare in Peru, up to 1 mm diam., rounded, simple or partly conglomerate, moderately to strongly convex, pale to medium brown, with a pale, indistinct margin when young but soon becoming emarginate. *Ascospores* narrowly ellipsoid to bacilliform, simple to 1-septate, 9·5–15 × 2·5–3 µm (n=50, from 5 specimens of chemotype 1).

Chemistry. Chemotype 1: didymic acid (major) and accessory compounds (minor to trace); chemotype 2: homosekikaic acid (major), sekikaic acid (submajor) and zeorin (major).

Distribution and ecology. There seem to be very few published records of the species. In addition to the type collection (French Guiana) and the two collections from Guyana reported by Sipman & Aptroot (1992), I only know of the general statement by Swinscow & Krog (1988) that the species occurs in Kenya, Tanzania, West Africa and tropical America. I have examined specimens from Guyana, Suriname, French Guiana, Peru, Guinea, and Kenya. The species is confined to tropical rainforests, and grows on bark on tree trunks, often among bryophytes. It was common at the two localities visited in Peru.

Notes. Swinscow & Krog (1988) reported sekikaic acid, 4′-*O*-methylnorhomosekikaic acid and zeorin from East African material of *E. prolifera*, whereas Kalb & Elix (1995) and Kalb (2004) state that the species contains didymic, condidymic, and subdidymic acids. In my material, all South American specimens contained didymic acid and accessory compounds (chemotype 1), and the two African specimens contained sekikaic acid, homosekikaic acid, and zeorin (chemotype 2). I did not detect 4′-*O*-methylnorhomosekikaic acid, but unfortunately Swinscow & Krog (1988) did not indicate from which specimen(s) this compound was identified. I have been unable to

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locate their examined material from Tanzania.

There do not seem to be any morphological differences in the thallus between the African and South American material. Apothecia were not found in the African material, so that any differences in apothecial characters could not be considered. Apothecia were also lacking in the African material examined by Swinscow & Krog (1988).

Additional specimens examined. **Peru:** *Loreto*: Reserva Nacional Allpahuayo Mishana, 40 collections from 35 sites, 2006, *Timdal* (O, L144547, -548, -550, -554, -555, -562, -566, -572, -573, -575, -577, -579, -585, -586, -588, -591, -593, -594, -599, -606, -608, -615, -619, -631, -634, -649, -654, -657, -667, -669, -671, -675, -681, -686, -691, -693, -696, -700, -710, -842); Jenaro Herrera, 16 collections from 12 sites, 2006, *Timdal* (O, L144728, -734, -739, -766, -773, -774, -775, -782, -793, -798, -799, -800, -801, -812, -816, -839). *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* P77:2 & P77:*s.n.* (UPS); Lamas, Strasse Yurimaguas-Tarapoto km 56, 200 m, 1982, *Gradstein* s.n. (B, 60 0048382).

Extra-Peruvian material examined: **French Guiana:** *Cremers* 8771 (B), *Cremers et al.* 10380, 10489 (B), *Sipman* 50860, 50930 (B), *Aptroot* 15622 (UPS).—**Guyana:** *Bleij & Biesmeijer* 3I115 (B), *Sipman & Aptroot* 18812 (B).—**Suriname:** *Aptroot* 14884 (UPS), *Florschütz & Maas* 3281 (UPS), *Zielman* 1376B (UPS).—**Guinea:** *Santesson* 10575 (UPS).—**Kenya:** *Santesson* 20878 (BM, O, UPS).

Key to the species of *Eschatogonia*

1 Ascospores narrowly ellipsoid to bacilliform; lobes often broad, (0·1–)0·2–2 (–3) mm; thallus containing zeorin or didymic acid (and additional substances) 2

Ascospores acicular; lobes usually narrower, 0·04–0·2 mm broad; not containing zeorin or didymic acid 3

2(1) Lobes 0·1–0·3(–0·6) mm broad, more or less linear, plane to revolute; thallus containing zeorin and additional substances (e.g. sekikaic and homosekikaic acid) but not didymic acid . . . . . **E. angustiloba**

Lobes 0·5–2(–3) mm broad, more or less irregular, plane to weakly convex; thallus containing didymic acid aggregate (in South America) or sekikaic acid, homosekikaic acid and zeorin (in Africa) . . . . . **E. prolifera**

3(1) Lobes 0·04–0·06 mm wide, partly terete, coralloid, soon ascending; ascospores 16–25 µm long; thallus not containing lichen substances . . . . . **E. minuta**

Lobes 0·08–0·2 mm wide, flattened, not coralloid, adnate when young, later more or less ascending; ascospores longer than 23 µm; thallus containing lichen substances or not 4

4(3) Thallus containing homosekikaic and/or hyperhomosekikaic acid; apothecia pale brown . . . . . **E. dissecta**

Thallus not containing lichen substances; apothecia reddish brown 5

5(4) Lobes short, richly and minutely crenulate to incised, becoming more or less ascending . . . . . **E. triptophyllina**

Lobes elongated, deeply incised, sparingly crenulate, remaining mostly adnate . . . . . **E. marivelensis**

I am grateful to Rolf Santesson, UPS, for generously placing his collections at my disposal and to the curators of B, BM, H, TUR, and UPS for the loan of specimens. The fieldwork was made possible by the hospitality of the Instituto de Investigaciones de la Amazonía Peruana in connection with the 13th GBIF Governing Board meeting in Iquitos.

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Accepted for publication 30 *October* 2007

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