

Expanding the distribution of the lichenized genus *Sarcographa* Fée in continental Ecuador

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ABSTRACT

The study of lichens in Neotropical regions has uncovered a remarkable diversity, much of which remains largely unexplored. Within this context, several species of *Sarcographa*, including the common and widespread *S. labyrinthica* (Ach.) Müll. Arg., *S. fissurinoides*, and *S. feei* had not been documented in Ecuador until now. This study expands the known geographical range of the species and provides new insights into the ecology and morphology of the genus *Sarcographa*.

KEYWORDS: crustose thallus, Graphidaceae, lowland tropical forests, neglected records, Neotropical biodiversity, Yasuní National Park

Ampliación de la distribución del género liquenizado *Sarcographa* Fée en el Ecuador Continental

RESUMEN

El estudio de los líquenes en regiones Neotropicales ha revelado una notable diversidad, gran parte de la cual sigue siendo en gran medida inexplorada. En este contexto, varias especies de *Sarcographa*, incluyendo las común y de amplia dispersión *S. labyrinthica* (Ach.) Müll. Arg., *S. fissurinoides* y *S. feei* no habían sido previamente documentadas en Ecuador. Este estudio amplía el rango geográfico conocido de las especies y proporciona nuevos conocimientos sobre su ecología y morfología.

PALABRAS CLAVE: biodiversidad neotropical, bosques tropicales de tierra bajas, Graphidaceae, líquenes, Parque Nacional Yasuní, talo crustáceo

Lichens are a highly diverse group of organisms, with an estimated number of nearly 20,000 known species worldwide, and potentially up to 30,000 still awaiting discovery, particularly in underexplored tropical regions (Ahmadjian 1987; Feuerer and Hawksworth 2007; Lücking *et al.* 2017). Particularly in Neotropical regions, the study of lichens has revealed a remarkable diversity, much of which remains insufficiently documented and understood (Lucheta *et al.* 2019). This is the case of Ecuador, a Neotropical country which despite the relatively small geographical surface, is expected to harbor approximately 2,700 species of lichens (Lücking *et al.* 2009), with 2,225 species currently recorded in its continental area (Yáñez-Ayabaca *et al.* 2023). Tropical lowland rainforests harbor a significant proportion of global lichen diversity, with families like Graphidaceae, Trypetheliaceae and Pyrenulaceae being among the most species-rich (Aptroot and Sipman 1997; Aptroot *et al.* 2016;

Lücking *et al.* 2017; Déleg *et al.* 2021), and Neotropical ones are no exception (Komposch and Hafellner 2000; Cáceres *et al.* 2007; Rivas-Plata and Lücking 2013), but were so far little studied for lichen diversity in Ecuador. Countries such as Venezuela, Colombia, Peru, and Brazil have made significant progress in cataloging their lichen biota (Ahti and Sipman 2013; Flakus 2013), and also the knowledge of Ecuador's lichen diversity has recently increased abruptly (Yáñez-Ayabaca *et al.* 2023). However, in some areas, especially in the Amazonian provinces of Morona Santiago, Orellana, Pastaza, and Sucumbíos, lichen diversity remains poorly understood in comparison with other provinces of Ecuador (Yáñez-Ayabaca *et al.* 2023). Recent efforts have led to the discovery of new species, such as *Heterodermia arvidssonii* Moberg (Moberg 2011), *Pyrenula flavoinpersa* Aptroot and Sipman (Aptroot *et al.* 2013) and *Dictyonema huaorani* Dal-Forno *et al.* (Schmull *et al.* 2014), yet much remains to be uncovered.

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The genus *Sarcographa*, characterized by its crustose thalli, lirellae, and distinctive white pruina (Lücking and Rivas-Plata 2008) is currently represented by four species in Ecuador, two being recorded from the Galápagos Islands only (*S. medusulina* and *S. ramificans*) and two from continental Ecuador (*S. fenicis* and *S. tricosia*; Yáñez-Ayabaca *et al.* 2023). Here, we provide the results from recent field studies in Yasuní (Vega *et al.* 2021; Déleg *et al.* 2021) and herbarium revisions in the Herbarium Berolinense, focusing on the *S. labyrinthica* complex.

The specimen of *Sarcographa labyrinthica* reported here was collected using standard epiphytic lichen sampling techniques on the Yasuní National Park, one of the most biodiverse areas on the planet, in the Ecuadorian Amazon (Bass *et al.* 2010). We also revised several instances of *S. labyrinthica* reported from Ecuador in GBIF and LICHCOL, with additional confirmed records of this species and of *S. fenicis*, a previously unlisted and confirmed record of *S. fissurinoides*, and the first reports of *S. feei* for Ecuador from the B herbarium.

***Sarcographa feei* (C.F.W. Meissn.) Müll. Arg**

This species has not been recognized as different from *Sarcographa labyrinthica* until recently (Lücking *et al.* 2023; Mardones *et al.* 2024), although it was mentioned as an uncommented entry in the lichen checklist for the Guianas (Hekking and Sipman 1988). It differs from *S. labyrinthica* in the morphology of the pseudostromata: whereas in the latter, the lirellae are much divided into finally angular discs directly bordering each other, in *S. feei* the originally lirelline character of the individual ascumata is largely maintained and the secondary transverse division of the lirellae leads to the formation of rounded discs separated by distinct areas of sterile whitish tissue (Figure 1a). *Sarcographa feei* is known from Costa Rica, Colombia and the Guianas and is here for the first time reported from Ecuador, from the northwestern province of Esmeraldas, based on material previously identified as *S. labyrinthica*.

Examined material: Ecuador, Esmeraldas, San Lorenzo, 30 m. Secondary rainforest; 12 VI 1982, Aptroot & Hensen 11071 (B; B 60 0178472).

***Sarcographa fenicis* (Vain.) Zahlbr.**

Sarcographa fenicis agrees with *S. labyrinthica* in the distinctly pseudostromatic ascumata (Figure 1b), with the lirellae becoming much divided and forming angular, directly adjacent discs without sterile whitish tissue separating them, the typically 3-septate ascospores, and the stictic acid chemistry. It differs from the latter in the immersed pseudostromata remaining more or less flush with the thallus and lacking a thickened whitish margin. Also, the discs are often thinly pruinose and darker than in *S. labyrinthica*. Previously, *Sarcographa fenicis* was reported from Ecuador only from Loja in the southern part of the country (Benítez *et al.* 2015; Yáñez-Ayabaca *et al.* 2023). However, several previously

unpublished collections identified as *S. labyrinthica* or *Glyphis cicatricosa* Ach. from western and central-western Ecuador (Manabí and Los Ríos provinces) also represent this species.

Examined material: Ecuador, Los Ríos, Quevedo, km 54 north, 200 m. Primary rainforest; 15 VII 1982, Aptroot & Hensen 11194 (B; B 60 0178470), 11205 (B; B 60 0178473); Ecuador, Manabí, Puerto Lopez, 50 m. Coastal area with *Cereus* savanna; 1 VIII 1982, Aptroot & Hensen 10465 (B; B 60 0177264), 10582 (B; B 60 0177261).

***Sarcographa fissurinoides* M. Cáceres & Lücking**

This species was only described recently (Cáceres 2007). It is most similar to *Sarcographa feei* in having pseudostromata with sterile whitish tissue separating the lirellae (Figure 1c). However, the lirellae remain mostly entire, with few transverse subdivisions, and the margins of the pseudostromata remain flush with the thallus, the young lirellae along the pseudostromat margins appearing fissurine. So far, the species was only known from the Atlantic rainforest in northeastern Brazil (Cáceres 2007; Menezes *et al.* 2013; Junior *et al.* 2021). The present specimen from Ecuador is an typical representative of this taxon and is the first report for Ecuador and outside Brazil. Previously, the only known records were from the type locality in Brazil, where the species occurs at 50 m elevation in the closed forest of the Mata Atlântica (Cáceres 2007).

Examined material: Ecuador, Esmeraldas, San Lorenzo, 30 m. Secondary rainforest; 12 VII 1982, Aptroot & Hensen 11053 (B; B 60 0178393).

***Sarcographa labyrinthica* (Ach.) Müll. Arg.**

Typical specimens of *Sarcographa labyrinthica* feature distinct pseudostromata elevated above the thallus (Figure 1d), with a distinct whitish margin and with the lirellae divided into angular discs bordering each other. The ascospores are almost exclusively 3-septate. The taxon had not been reported before from Ecuador (Yáñez-Ayabaca *et al.* 2023), but several specimens collected by A. Aptroot and R. Hensen in the early 1980s housed in B represent that species. In part of the Ecuadorian material, the younger pseudostromata feature sterile whitish tissue separating the discs, but the discs soon become angular and in well-developed pseudostromata the separating whitish tissue disappears, in contrast to *S. feei* (see above).

Examined material: Ecuador, Esmeraldas, San Lorenzo, 30 m. Secondary rainforest; 12 V 1982, Aptroot & Hensen 11041 (B; B 60 0178471); Ecuador, La Tola, 5 m. Coastal area; 13 VII 1982, Aptroot & Hensen 11173 (B; B 60 0178469); Ecuador, Los Ríos, Quevedo, km 54 north, 200 m., primary rainforest; 15 VII 1982, Aptroot & Hensen 11194 (B; adest in *S. fenicis* under B 60 0178470); Ecuador, Orellana, Yasuní National Park, Estación Científica Yasuní PUCE, 265 m, 22 II 2019, M. Vega 002 (HUTPL).

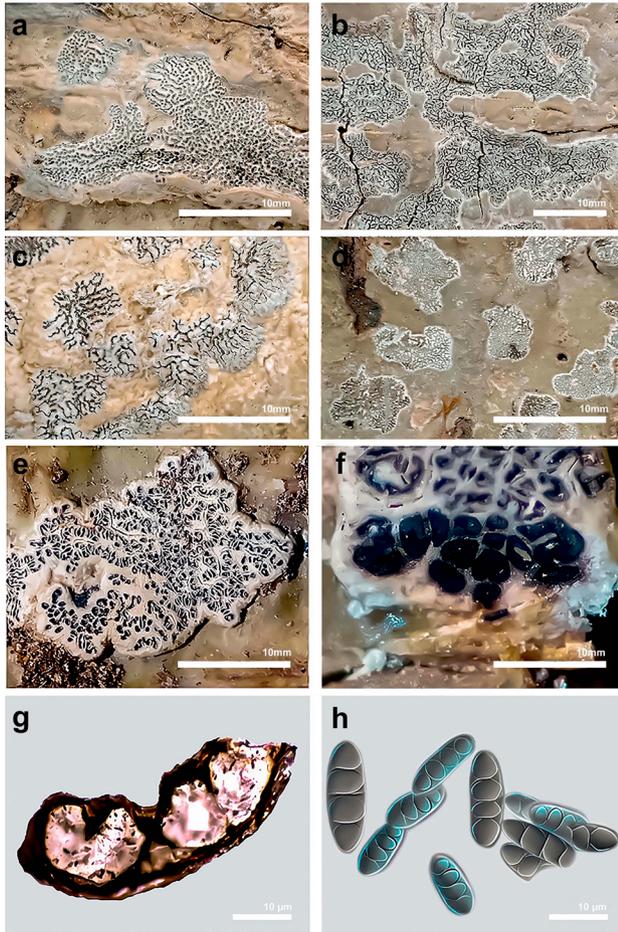


Figure 1. Neglected records of *Sarcographa* in Ecuador. **A** – Specimen from Esmeraldas (78°50'11.65" W, 1°16'2.18" N) *Sarcographa feei*; **B** – Specimen from Los Ríos (79°27'09.88" W, 0°59'06.10" S) *Sarcographa fenicis*; **C** – Specimen from Esmeraldas (78°50'11.65" W, 1°16'2.18" N) *Sarcographa fissurinoides*; **D** – *Sarcographa labyrinthica*. Structures of *Sarcographa labyrinthica* specimen from Yasuni (Voucher: Vega *et al.* 002 at HUTPL, 76°24'21.00" W, 0°40'33.00" S); **E** – Thallus with immersed lirellae; **F** – Transverse section showing carbonized exciple; **G** – Non-amyloid hymenium with evenly dispersed components; **H** – Spores with four distinct septa.

The Yasuni specimen of *S. labyrinthica* was collected at an elevation of 265 m, growing epiphytically on the bark of canopy trees. It is characterized by a crustose thallus with a yellowish to olive-green hue, often bearing branched lirellae that are 0.1-0.2 mm wide (Figure 1e). The exciple is fully carbonized at the base, with thick margins (Figure 1f), and the hymenium is non-amyloid (Figure 1g). The ascospores are typically 14-17.6 × 6-6.2 μm, exhibiting 3 slightly differentiated transverse septa with angular lumina (Figure 1h). The lirellae are deeply immersed to slightly erumpent and exhibit transverse fissures, a characteristic feature of the genus *Sarcographa* (Lücking and Rivas-Plata 2008). Secondary metabolites detected in *S. labyrinthica* include stictic, constictic, cryptostictic, and hypostictic acids. *Sarcographa labyrinthica* has been recorded in lowland tropical forests from several regions (Figure 2). In South

America, it has been found in Colombia (García-Martínez and Mercado-Gómez 2020), Venezuela (Komposch and Hafellner 2000), Guyana (Hekking and Sipman 1988), French Guiana and Brazil (Cáceres *et al.* 2014). In Central America and the Caribbean, it has been reported from Costa Rica (Lücking *et al.* 2008; Mardones *et al.* 2024), Cuba (Rosabal and Burgaz 2010), Puerto Rico (Mercado-Díaz and Sur 2009), Panama (Breuss 2008), Mexico, and Florida, U.S. (Archer 2009). In Africa (Figure 3) and Asia, it has been recorded from the Democratic Republic of the Congo and Gabon, from India, Thailand, Myanmar, Vietnam (Aptroot and Sparrius 2006), the Philippines, Singapore (Sipman 2010), Malaysia, and Indonesia (Ohmura *et al.* 2020). In Australasia (Figure 2), it has been found in Papua New Guinea, Australia, and New Zealand (Archer 2004; Singh and Sinha 2010; Ohmura *et al.* 2020). Whether all these reports represent the same taxon remains to be seen.

Key to the species of *Sarcographa* known from Ecuador

- 1a Thallus (medulla) and ascomata or stromata lacking secondary substances, in surface view P– and in microscopic section K–; ascomata in more or less stellate clusters, composed of narrow, more or less radiating, immersed lirellae without secondary divisions2
- 1b Thallus (medulla) and ascomata or stromata with stictic acid as major secondary substance, in surface view P+ orange(-red) and in microscopic section with a K+ persistently yellow efflux (stictic acid); ascomata either distinctly pseudostromatic with the lirellae secondarily divided or lirellae very long and radiating, prominent lirellae3
- 2a Ascospores consistently 3-septate*Sarcographa tricosia*
- 2b Ascospores predominantly 5-septate, although often with 3-septate ascospores intermingled*Sarcographa medusulina*
- 3a Ascomata not pseudostromatic; lirellae radiating, becoming prominent, with narrow disc; ascospores 7–11-septate, 30–55 μm long*Sarcographa ramificans*
- 3b Ascomata distinctly pseudostromatic; lirellae usually with secondary transverse divisions; pseudostromata immersed to erumpent; ascospores 3(–5)-septate, 15–25 μm long ... 4
- 4a Pseudostromata immersed, without differentiated margin; discs often thinly pruinose and dark*Sarcographa fenicis*
- 4b Pseudostromata erumpent to prominent or becoming sessile, with thin to distinct margin5
- 5a Individual lirellae initially fissurine, the disc becoming exposed towards the center or in mature pseudostromata; lirellae in mature pseudostromata radiating and with scattered transverse fissures; pseudostromata laterally with flush margins*Sarcographa fissurinoides*

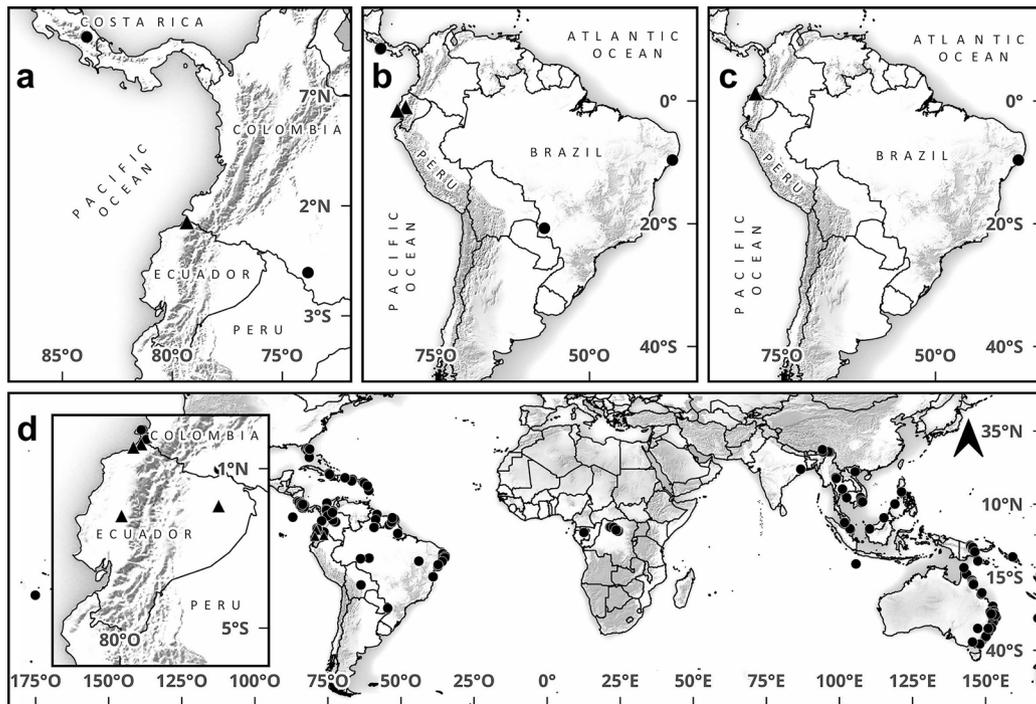


Figure 2. Global range of *Sarcographa*. Bibliographic records (circles) and new reports (triangles) presented in this study for **A** – *Sarcographa feei*, **B** – *S. fenicis*, **C** – *S. fissurinoides* (top right), **D** – *S. labyrinthica* (bottom). The inset highlights the records of *S. labyrinthica* in Ecuador.



Figure 3. Holotype of *Sarcographa labyrinthica* (Ach.) Müll. Arg. = *Glyphis labyrinthica* Ach. By Erik Acharius 1814 campo H-ACH:0885 Finnish Museum of Natural History H9501666. Available in Finnish Biodiversity Information Facility under Creative Commons license CC BY 4.0 DEED Attribution 4.0 International. Type locality Africa Guinea coord 10N -10W.

- 5b Individually lirellae initially not distinctly fissurine, soon becoming divided into numerous, small discs; pseudostromata laterally erumpent, with distinct whitish margin6
- 6a Individual lirellae radiating, becoming divided into rounded segments, separated by distinct whitish areas*Sarcographa feei*
- 6b Individual lirellae with frequent transverse fissures, eventually forming dense clusters of minute, angular discs not separated by whitish areas ...*Sarcographa labyrinthica*

Four new records of the genus *Sarcographa* have been added here, located in Esmeraldas, Los Ríos and Orellana provinces, in addition to those previously recorded. Thus, our results emphasize the need for further research into the lichen biota from Ecuador's lowland forests. Future studies should aim to assess the full extent of lichen diversity in the Amazon basin, particularly in canopy environments where many species remain under-sampled. Additionally, molecular analyses could provide further insights into the genetic diversity and potential cryptic speciation within *Sarcographa* and related genera in these highly biodiverse regions.

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