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Standard Paper

Towards a dynamic checklist of lichen-forming, lichenicolous and allied fungi of Ecuador – using the *Consortium of Lichen Herbaria* to manage fungal biodiversity in a megadiverse country

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Abstract

A checklist of *Lichen-forming, Lichenicolous and Allied Fungi of Ecuador* is presented with a total of 2599 species, of which 39 are reported for the first time from the country. The names of three species, *Hypotrachyna montufariensis*, *H. subpartita* and *Sticta hypoglabra*, previously not validly published, are validated. *Pertusaria oahuensis*, originally introduced by Magnusson as '*ad interim*', is validated as *Lepra oahuensis*. The form *Leucodermia leucomelos* f. *albociliata* is validated. Two new combinations, *Fissurina tectigera* and *F. timida*, are made, and *Physcia mobergii* is introduced as a replacement name for the illegitimate *P. lobulata* Moberg non (Flörke) Arnold. In an initial step, the checklist was compiled by reviewing literature records of Ecuadorian lichen biota spanning from the late 19th century to the present day. Subsequently, records were added based on vouchers from 56 collections participating in the *Consortium of Lichen Herbaria*, a Symbiota-based biodiversity platform with particular focus on, but not exclusive to, North and South America. Symbiota provides sophisticated tools to manage biodiversity data, such as occurrence records, a taxonomic thesaurus, and checklists. The thesaurus keeps track of frequently changing names, distinguishing taxa currently accepted from ones considered synonyms. The software also provides tools to create and manage checklists, with an emphasis on selecting vouchers based on occurrence records that can be verified for identification accuracy. Advantages and limitations of creating checklists in Symbiota versus traditional ways of compiling these lists are discussed. Traditional checklists are well suited to document current knowledge as a 'snapshot in time'. They are important baselines, frequently used by ecologists and conservation scientists as an established naming convention for citing species reported from a country. Compiling these lists, however, requires an immense effort, only to inadequately address the dynamic nature of scientific discovery. Traditional checklists are thus quickly

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out of date, particularly in groups with rapidly changing taxonomy, such as lichenized fungi. Especially in megadiverse countries, where new species and new occurrences continue to be discovered, traditional checklists are not easily updated; these lists necessarily fall short of efficiently managing immense data sets, and they rely primarily on secondary evidence (i.e. literature records rather than specimens). Ideally, best practices make use of dynamic database platforms such as Symbiota to assess occurrence records based both on literature citations and voucher specimens. Using modern data management tools comes with a learning curve. Systems like Symbiota are not necessarily intuitive and their functionality can still be improved, especially when handling literature records. However, online biodiversity data platforms have much potential in more efficiently managing and assessing large biodiversity data sets, particularly when investigating the lichen biota of megadiverse countries such as Ecuador.

Keywords: biodiversity inventories; Galapagos; new combinations; new names; new species; species lists; Symbiota

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Introduction

Ecuador is located in one of the world's global biodiversity hotspots (Mittermaier *et al.* 1998). As such, it has been included among the 17 most megadiverse countries; it has been argued that, per km^2, the country might support the highest species diversity on Earth (Mittermaier *et al.* 1997).

Our knowledge about Ecuador's biodiversity nevertheless remains biased. The country is identified as a hotspot largely because of its iconic flora and fauna, although the large majority of less conspicuous species remains neglected (Bungartz *et al.* 2012). This bias is not exclusive to Ecuador (Clark & May 2002) and was widely recognized decades ago by the Darwin Declaration as a 'taxonomic impediment to sound management and conservation of biodiversity' (Environment Australia 1998). This, even though the nations of the world explicitly recognize the 'intrinsic values of biological diversity … for maintaining life-sustaining systems of the biosphere' (Secretariat of the Convention of Biological Diversity 1992; p. 3, preamble).

Lichenized fungi are one important group of the 'neglected majority' of biodiversity in Ecuador; species that Linnaeus (1753) derogatorily called '*rustici pauperimi*', the 'poor peasants among the plants'. Lichens of course are not plants, but fascinating, complex symbiotic systems (Schwendener 1867; Spribille *et al.* 2016; Tagirdzhanova *et al.* 2023), equally threatened, equally diverse, and ecologically just as important as other organisms as part of a complex web of life. Consequently, fungi are just as threatened and deserve as much attention as other, more iconic organisms (Mueller *et al.* 2022).

Species inventories for lesser-known groups of organisms are necessary to objectively assess which elements of biological diversity are threatened in order to devise effective conservation strategies. Species checklists represent a baseline of biodiversity knowledge, a first reference point. Unfortunately, compiling these lists is academically not rewarding. Renowned scientific journals tend to refuse publication of 'mere species lists' if they do not at least include a substantial number of taxonomic novelties or groundbreaking phylogenies. In the 'race for impact', compiling checklists is the cumbersome grind work of biodiversity data collecting.

Some authors of checklists decide to adopt alternative publishing venues, not competing for space in scientific journals: The *Cumulative Checklist for the Lichen-forming, Lichenicolous and Allied Fungi of the Continental United States and Canada* is published intermittently online by Ted Esslinger, updated at irregular intervals, each with its dedicated version number (in parallel the list is also published in *Opuscula Philolichenum*; Esslinger 2021). Regularly keeping this checklist up to date is an impressive feat for a region where 5823 species of lichenized, lichenicolous and allied fungi have been reported.

In megadiverse countries, maintaining and regularly updating such large checklists is time- and resource-intense, resources that many of the most megadiverse countries may not be able to afford. These limited resources are not just financial constraints: access to scientific literature, training and education, and information technology infrastructure are all significant impediments.

Modern online biodiversity database systems, such as Symbiota (Gries *et al.* 2014), provide an attractive, open-source option, where several authors can collaborate to jointly manage large biodiversity data sets, with built-in tools for compiling, updating and publishing species lists. Traditional checklists are static, and due to the pace of scientific discovery and frequent taxonomic upheaval (especially in poorly known species groups), they become rapidly outdated (e.g. Hawksworth *et al.* 1980; Weber 1986, 1993; Elix & McCarthy 1998; Burgaz 2006; Nöske *et al.* 2007; Westberg *et al.* 2021; Printzen *et al.* 2022). In recent years, checklists have increasingly been published online, where new versions can be updated more frequently, yet most of these online checklists are still compiled manually, without the benefit of modern database systems (e.g. Feuerer 2007; Feuerer & Hawksworth 2007; Esslinger 2021). An exception is the *Annotated Checklist of Fungi of Colombia* (Cossu *et al.* 2022), where a local Microsoft Access database was used to compile the initial checklist, linked to species profiles then published online. Another example is the case of a recent checklist of epiphytic lichens in beech forests from Europe (Hurtado *et al.* 2023), created as an open and dynamic database which is available online and permits the updating of data by other users.

Integrated biodiversity data platforms like the *Consortium of Lichen Herbaria* (Consortium of Lichen Herbaria 2023) unite a community of biodiversity scientists who share common interest in a particular group of organisms, in this case: lichenized, lichenicolous, and allied fungi. Initially, this Symbiota platform was launched as the *Consortium of North American Lichen Herbaria*[1], the *Consorcio de Herbarios de Líquenes en América Latina*, and *Arctic Lichens*, but participation now includes institutions from North and Latin America, Europe, Asia, and Oceania, as well as personal collections.

Based on Symbiota, the Consortium provides sophisticated tools for efficiently managing biodiversity data. The user can easily switch between English and Spanish, and a French version is in development. The Consortium is accessible online at no cost and scientists can collaborate across nations or even continents. A Symbiota Support Hub provides detailed documentation, tutorials, organizes monthly meetings, supports campaigns and training workshops.

We use Ecuador here as an example to outline best practices to build, maintain and update large biodiversity checklists for a

[1]Launched in 2009, the *Consortium of North American Lichen Herbaria* and SEINet were among the first Symbiota biodiversity data platforms ever established. Since then, Symbiota has grown to now support more than 50 individual biodiversity data portals.

megadiverse country, using Symbiota tools integrated in the *Consortium of Lichen Herbaria*.

The first scientists reporting lichens from the area that now constitutes Ecuador, were Alexander von Humboldt and Aimé Bonpland. During their voyage through the Andes, they cited several species, most notably when ascending Chimborazo, Ecuador's highest mountain (von Humboldt & Bonpland 1807, p. 70: '… vers le sommet du Chimborazo, j'ai trouvé sur une arête de rocher l'*umbilicaria pustulata* et le *verrucaria geographica:* ce sont les derniers êtres organisés que nous ayons vus fixés au sol à ces grandes hauteurs …' ('… towards the summit of Chimborazo, I found *Umbilicaria pustulata* and *Verrucaria geographica* on a stone ridge: these are the last organized beings that we have seen attached to the ground at such great heights …')). Their famous illustration of the volcano, 'Géographie des plantes Équinoxiales: Tableau physique des Andes et Pays voisins' depicts a 'Région de Lichens' between 4600 and 4900 m altitude (Fig. 1).

Despite these early observations, it took another 60 years before additional species were reported from the country; most of these early historical records are today difficult to assess and despite these early accounts (Leighton 1866; Nylander 1874; Müller 1879; Roumeguère 1879; Zahlbruckner 1905, 1907; Navás 1908) lichens remained subsequently largely ignored. Diels (1937) for example, publishing his *Beiträge zur Kenntnis der Vegetation und Flora von Ecuador* (*Contribution to Understanding Vegetation and Flora of Ecuador*) ignored lichens, unless their sheer abundance couldn't be overlooked, when he occasionally mentioned a small number of species.

Modern lichenology arrived in the country late, only in the second half of the 20th century, with sporadic visits by foreign lichenologists, taking their collections home and publishing treatments focusing mostly on select taxonomic groups (e.g. Jørgensen 1973, 1975, 1989, 1997, 1998; Galloway 1985; Galloway & Arvidsson 1990; Gierl & Kalb 1993; Yoshimura & Arvidsson 1994; Lücking 1999).

This began to change with ecological studies of bryophytes and lichens in tropical cloud forests of Southern Ecuador, where studies now reported a broader variety of species from different groups; yet these studies were still confined only to parts of the country (Nöske & Sipman 2004; Nöske 2005; Mandl 2007; Nöske *et al.* 2007, 2008). The trend to publish individual taxonomic treatments continues (e.g. Ahti 2000; Ferraro & Lücking 2005; Lücking *et al.* 2005; Frisch 2007; Knudsen *et al.* 2008; Lücking 2008; Magain *et al.* 2018, 2023; van den Boom & Elix 2022), with researchers also increasingly depositing their collections in the country (e.g. many collections by Lücking were deposited in Ecuador's National Herbarium in Quito (QCNE)). Around the same time, Ecuadorian students at the Universidad Central de Quito increasingly started collections as part of local species inventories and smaller taxonomic revisions (Paredes Martínez 2006; Yánez-Ayabaca 2009; Yánez-Ayabaca & Eliasaro 2009). At the Universidad Técnica Particular de Loja, under the direction of Spanish lichenologists María Prieto and Gregorio Aragón, Ecuadorian student Cevallos (2012) compiled the first checklist of lichens from continental Ecuador. Also, in 2009, several ecological studies were initiated in Ecuadorian montane forests and páramos (Benítez *et al.* 2012, 2015, 2018, 2019; González *et al.* 2017*a*, *b*, 2019) and a diverse lichen collection was built up at the herbarium HUTPL.

In recent years, a research group under the direction of Ángel Raimundo Benítez Chávez at the Universidad Técnica Particular de Loja has continued to add to the lichen collection at HUTPL, focusing on ecological studies in several parts of the country (e.g. Benítez *et al.* 2012, 2018, 2019; Ochoa-Jiménez *et al.* 2015; Bustamante *et al.* 2018; Vega *et al.* 2021), often in collaboration with María Prieto, Gregorio Aragón, Isabel Martínez and Noelia Fernández-Prado (e.g. Fernández-Prado *et al.* 2022, 2023).

Unusually well-known are the lichenicolous fungi of Ecuador. Spanish lichenologist Javier Etayo assembled a large collection at the Pontificia Universidad Católica del Ecuador, publishing the first catalog of lichenicolous fungi of Ecuador (Etayo 2017).

In the Galapagos, systematic interest in lichenized fungi began in the 1960s, when US American lichenologist William A. Weber joined the Galapagos International Scientific Project. Weber would go on to visit the islands many times, systematically assembling a collection of Galapagos lichens at the University of Colorado, publishing inventory results (Weber 1966); and then compiling a first checklist with updates (Weber 1986, 1993) that was subsequently included in the *Catalogue of the Lichens of the Smaller Pacific Islands* (Elix & McCarthy 1998).

Most recently, the Charles Darwin Foundation for the Galapagos Islands (CDF) launched a comprehensive inventory of lichenized fungi in the archipelago, hiring German lichenologist Frank Bungartz as staff scientist and his Dutch colleague André Aptroot as consultant. The ongoing inventory resulted in a series of visits by international lichenologists, with publications on many different taxonomic groups (Aptroot & Bungartz 2007; Tehler 2007; Aptroot & Sparrius 2008; Aptroot *et al.* 2008; Bungartz 2008; Tehler *et al.* 2009; Bungartz *et al.* 2009, 2013*a*, *b*, *c*, 2015, 2016*a*, *b*, 2018, 2020*a*, *b*; Yánez-Ayabaca *et al.* 2012, 2013).

Here, the Grupo Ecuatoriano de Liquenología (GEL) and collaborators jointly present the first checklist *Lichen-forming, Lichenicolous and Allied Fungi of Ecuador*, uniting both biodiversity inventories from continental Ecuador, and its insular province, the archipelago of the Galapagos (Yánez-Ayabaca *et al.* 2023).

We are excited to dedicate this publication to our much-admired colleague, Pier Luigi Nimis, on the occasion of his 70th birthday and much-deserved retirement. As a globally renowned expert on lichens and pre-eminent lichenologist of Italy, Pier Luigi Nimis continues to be the pioneer and visionary of *ITALIC – the information system on Italian lichens*.

Methods

Outline of Symbiota tools

Our checklist of *Lichen-forming, Lichenicolous and Allied Fungi of Ecuador* (Yánez-Ayabaca *et al.* 2023; Supplementary Material Files S1–4, available online) was built using tools available in the *Consortium of Lichen Herbaria*, one of 54 Symbiota Portals, each representing a collaborative community of collections and researchers, bringing together 1700+ individual collections, of which 880+ are managed live online, with more than 89 million occurrence records (Gries *et al.* 2014).

The *Consortium of Lichen Herbaria* currently includes 181 institutions and personal collections, from North and Latin America, Europe, Asia and Oceania, assembling more than 3.5 million occurrence records, of which approx. 2 million (*c.* 60%) are geo-referenced, more than 1 million (*c.* 32%) imaged, and around 3 million (*c.* 86%) are identified to species (as of January 2023; https://lichenportal.org/).

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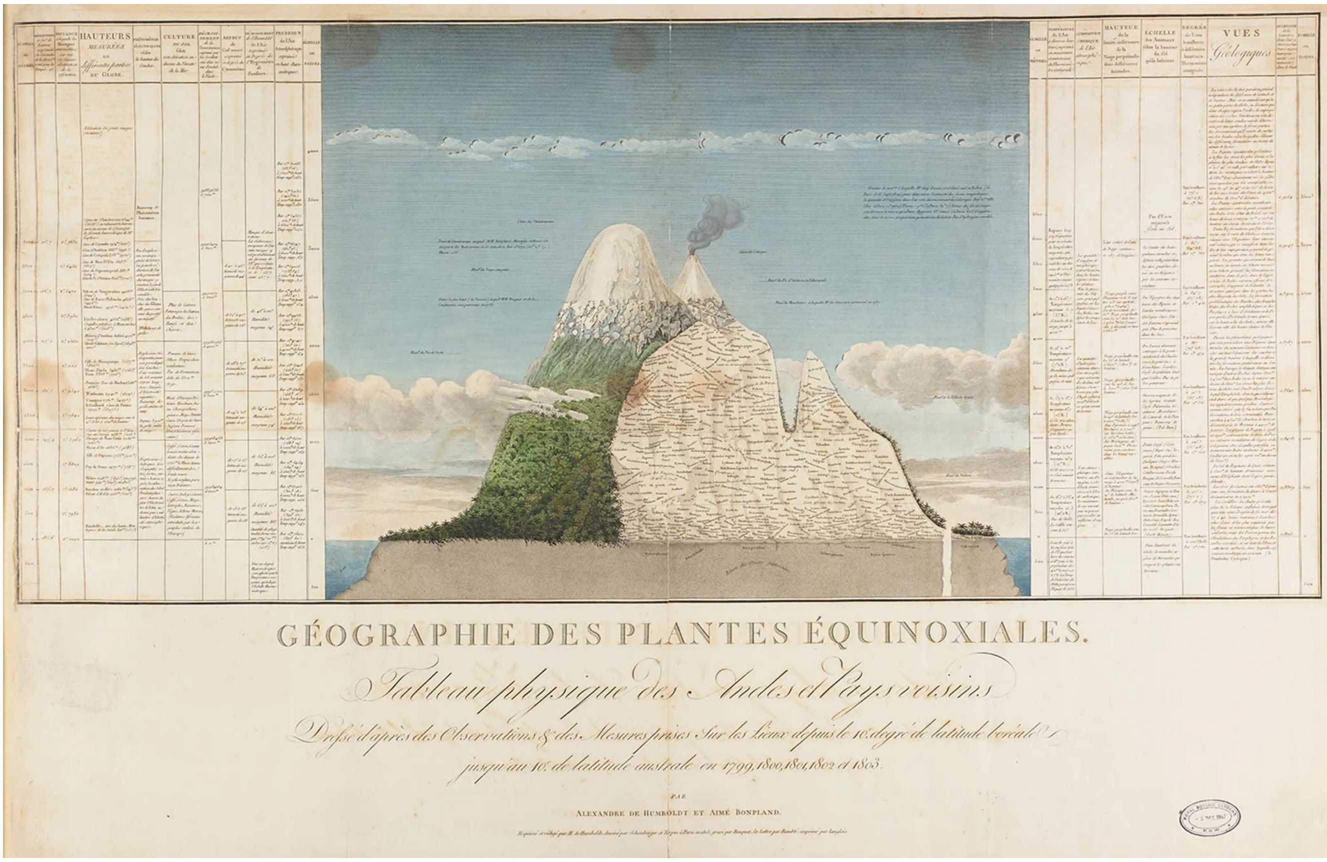

Figure 1. Vegetation and physical geography of Chimborazo Volcano in Ecuador, according to von Humboldt & Bonpland (1807). In colour online.

Detailed documentation and tutorials on the functionality and tools provided by Symbiota are available through the Symbiota Support Hub (https://biokic.github.io/symbiota-docs/). Bell & Landrum (2021), using the SEINet Portal Network (SEINet: https://swbiodiversity.org/) as an example, explain in detail how tools built into Symbiota portals can be used to create checklists. Here we provide only a brief overview; for more detail, the reader is referred to the cited resources.

Like any other checklist, Symbiota checklists can be compiled manually simply as a list of taxon names (species, subspecies, varieties or forms). It is also possible to upload lists in batch (from a CSV spreadsheet). For each name added, the user has the option to add additional information, such as Habitat, Abundance, Notes, Editor Notes, and Source. Name records can be displayed with or without their synonyms (managed by a taxonomic thesaurus). It is further possible to configure checklists to automatically display the fields for Habitat, Abundance, Notes, and Source. Editor Notes are managed internally by the system; they are intended to be comments shared between collaborating authors of a checklist and cannot be viewed by anyone but the checklist editors. Habitat, Abundance, Notes are fields displayed without their label. This allows use of these fields for almost any information; the labels Habitat, Abundance, and Notes are essentially only placeholders. For example, we used Habitat for highlighting whether a species is lichenicolous or even a non-lichenized 'allied' fungus. We used the Abundance field to denote whether a species is endemic to Ecuador or considered native/indigenous, and we used the Notes field for taxonomic and any other comments.

Traditional checklists rely for their source data on published literature records of species reported from a country or region. Symbiota was primarily designed to utilize occurrence records (a sophisticated voucher tool can be used to query specimen-based records or observations from all participating collections, based on user-defined criteria). We used a combined approach to compile our species list, based both on selecting voucher specimens (if identifications were considered reasonably reliable), and literature records entered into the Source field.

Currently Symbiota does not offer any sophisticated literature management system; literature citation tools are still under development. As a workaround, to combine advantages of both voucher- and literature-based source data (see the discussion below), we use the Source field in combination with a text document to manually keep track of literature citations. Where available, literature records for each species are cited as 'source', and a PDF of the complete reference list can be downloaded. Some taxa are cited based on literature records only, others based on specimen records, some on both (e.g. *Allographa argentata* is included because of a recent publication by van den Boom *et al.* (2022), but also documented by a specimen in a collection: *Benitez, A.* 30 (HUTPL).

Assembling and compiling source data

In a first step, we downloaded the checklist of lichens published for Ecuador from Tassilo Feuerer's Global Information System (Feuerer 2007). The system is regrettably no longer online, but we nevertheless managed to obtain the data through https://web.archive.org/.

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The data were parsed-out into table format, including both a list of taxon names and their literature records. With the Symbiota batch-upload tool, the data were used to compile a first draft.

Added to these records was a list of lichens and lichenized fungi from continental Ecuador, an unpublished master's thesis by Cevallos (2012). The thesis itself includes a reference list, but unfortunately does not indicate which species record refers to a particular literature citation. This information was added from a spreadsheet compiled as part of the thesis, shared by María Prieto. To add additional records, we consulted the online database *Recent Literature on Lichens* (Culberson *et al.* 2021); this yielded many reports not cited by Cevallos (2012), several of these published more recently.

For lichenicolous fungi, Etayo (2017) was consulted. The majority of specimens cited are deposited in the Colección de Líquenes del Fungario de la Pontificia Universidad Católica del Ecuador (QCAM) and/or in Javier Etayo's personal herbarium (hb. Etayo). Both collections are members of the Consortium; thus, where possible, the records of lichenicolous fungi are now linked to their vouchers in these collections. Specimen data entry of lichens and lichenicolous fungi at QCAM is still in progress, which explains why some species cited by Etayo (2017) could not yet be linked to QCAM vouchers. In some instances, additional records of lichenicolous fungi were also added, based on more recently published literature (e.g. Diederich *et al.* 2022; van den Boom *et al.* 2022).

The voucher tool in Symbiota automatically matches occurrence records from participating herbaria and personal collections against parameters defined by the user. Thus, it is possible, for example, to query Consortium records from all collections, from a few collections, or from a single collection only; in each case, for a particular country or region (in our case, Ecuador). Queries can also be configured to list geo-referenced occurrences only, within a user-defined polygon ('geo-fence').

Queries can then be used to link these records as vouchers to a checklist, either in batch (i.e. based on the criteria defined by the query), or selectively by adding records individually, considering only those whose identifications are trusted or have been verified. Using a variety of different queries, occurrence records from the following collections[2] were linked as vouchers for those specimens only, where identifications were deemed reliable: ALA, ASU, BALT, BG, BRY, CANB, CDS, CMN, COLO, DUKE, FH, F, GB, HAW, hb. Esslinger, hb. Etayo, HUTPL, ILLS, QCNE (INABIO), KANU, LD, LSU, MICH, MIL, MIN, MOR, MSC, NY, O, OMA, OSC, PC, PH, QCAM, S, SBBG, SRP, TNS, UBC, UC, UPS, US, USU, UNT, UT and WIS.

As a result, the current checklist includes species documented either by literature citations, or vouchers, or both. A list of taxa with information on types collected in Ecuador available in Index Fungorum (http://www.indexfungorum.org/) was shared by Paul Kirk; where possible these specimens were linked as vouchers. As part of this project no specimens were borrowed from the collections cited above; only as part of the Galapagos Lichen Inventory have specimens previously been examined.

Hierarchical checklists

The option to create hierarchical checklists in Symbiota allows for an efficient way to organize large biodiversity inventories, according to geography, taxonomic scope, or thematic objective. For example, in collaboration with the International Union for the Conservation of Nature (IUCN), the Consortium provides a Global Checklist of IUCN Red-Lists of Lichens. This list serves as 'parent', that is, it is compiled automatically from two 'child' checklists: one checklist of threatened species (CR, EN, VU), and another of species of least concern (LC).

Our checklist is another example of using hierarchical Symbiota checklists. The master's thesis published by Cevallos (2012) focused on continental Ecuador, excluding the Galapagos. For the archipelago, we relied on occurrence records compiled as part of the Galapagos Lichen Inventory (Bungartz *et al.* 2013*d*), published by the Charles Darwin Foundation dataZone (2023; https://www.darwinfoundation.org/en/datazone). A snapshot of the CDS lichen collection, available through the Consortium, forms the foundation for our checklist *Lichen-forming, Lichenicolous and Allied fungi from the Galapagos* (Bungartz *et al.* 2023), including a draft red-list assessment of endemic Galapagos lichens, both feeding their data as child checklists into the Ecuador parent checklist. Notes and source data from a child checklist are not automatically merged with the parent checklist data, but visible only if fields in the parent are empty. This can be inconvenient, occasionally, because it means that the data from child and parent checklists need to be merged manually; however, it also provides flexibility to add different comments and citations to parent and child checklists.

The Galapagos Checklist also makes use of another feature of child checklists: species exclusion lists. During any biodiversity inventory, assessments of species reported from a country or region typically need to be revised and updated, newly reported species need to be added and some previous reports considered erroneous. In Symbiota, species exclusion lists allow for the construction of child checklists of species previously erroneously reported. Unlike typical child checklists, these do not automatically feed their records into the parent. They are separate lists, linked to the parent only for reference, which contain taxa that have previously been reported, but are now considered erroneous. Currently, only the Galapagos Checklist makes use of species exclusion lists. Moving forward the current Ecuador Checklist will continue to be updated. Some of the species records now included, especially ones listed as preliminary and/or problematic, may in future updates be considered erroneous and then need to be moved to the species exclusion list. A voucher tool built into Symbiota facilitates reviewing how identifications of vouchers

[2]The terminology surrounding institutions, herbaria, collections, specimens, material, vouchers, reports, records, etc. can be confusing; generally, we tried to adopt the following terminology:

herbarium – mycologists often argue that the term 'herbarium' as applied to a collection of fungal specimens is ill-conceived, because these specimens are not plants; they suggest 'fungarium' as an alternative, but lichen specimens are collections of symbiotic organisms and 'fungarium' ignores that aspect; the term 'lichenarium' is occasionally proposed as an alternative, but this seems overly construed and implies that different terms would need to be used for different kinds of fungal specimens associated with different symbionts, hosts or substrata. The term collection does not seem tainted and is preferred here as an alternative.

collection – we intentionally use the term collection not as applied to one individual specimen, but instead in the sense of an assemblage of several specimens, either by a private collector or an institution.

voucher – as used here, the term voucher refers to a specimen that acts as a *record* for reporting a particular taxon (species, subspecies, variety, or form).

record – a record, as applied here, is the basis why a particular taxon (species, subspecies, variety, or form) has been included in the checklist; for the purpose of this publication it can be a specimen record or a literature record. Frequently, authors also use the term **occurrence record**, which includes not just records based on specimens (added to checklists as vouchers), specimens cited in the literature, but also observations. Observations (based only on images, or even verbal reports) are not considered here reliable records; they generally have been ignored.

report – in the context of the scientific literature, authors often use report as synonymous with a record cited in the literature; strictly speaking it is the species in a checklist (or generally in the literature) that is being reported, based either on specimen records, or on literature records, or on both.

change. For literature records, a note explaining why a record is no longer accepted should be added.

Documenting change

Symbiota does not automatically record version histories for its checklists. An option promoted by Esslinger (2021) is adding version numbers with publication dates. However, Symbiota was not designed to be static; rather, checklists are meant to be dynamic to facilitate adding new records and regularly updating the taxonomy. One option to document change, is to add a 'date-last-updated'. While this doesn't preserve prior versions, it at least informs users, how recently a checklist was modified. A better option, in our opinion, is to use report capabilities built into Symbiota to create a snapshot of a particular version and add a version number and publication date. The first such report is available as download from the *Consortium of Lichen Herbaria* website in PDF format; every major update will subsequently be added.

Taxonomic thesaurus

A taxonomic thesaurus that links accepted names to their synonyms is built into Symbiota. This thesaurus is integrated into batch upload tools, which match names to be added against the thesaurus. Names can only be added to a checklist if they are included in the thesaurus. Names not yet available in the thesaurus, but validly published, were added; spelling errors were corrected following Index Fungorum (Index Fungorum Partnership 2023; https://www.indexfungorum.org/) and/or MycoBank (Crous *et al.* 2004; https://www.mycobank.org/). As part of this process, a few errors in Index Fungorum and/or MycoBank were discovered and corrected. The thesaurus of the Consortium was used to match names cited in the literature and identifications of voucher specimens against current taxonomy, often following Index Fungorum and/or MycoBank. However in many instances these repositories remain incomplete or even disagree. Considerable effort was invested to consult original literature to establish a consensus (see Discussion).

Results

The checklist published online in the *Consortium of Lichen Herbaria* is also made available here (Supplementary Material Files S1–4, available online). The list documents a total of 2599 species (2610 taxa including subspecies, varieties and forms), in 513 genera, in 130 families. Of these, 349 species are based not on literature reports, but vouchers are linked to the checklist as occurrence records available in 56 herbaria, representing 31% of the 181 institutions and personal collections participating in the Consortium.

For the Galapagos, 310 species had previously been reported based on vouchers, not literature records (Bungartz *et al.* 2023). This means that these records are not new to Ecuador. This leaves 39 species reported for the first time from the country, based on vouchers. As far as we know, these were not previously reported in any publication.

The data set that we received from Index Fungorum included 324 names of taxa originally described from Ecuador, which means these are represented by type specimens collected in the country. Reviewing available literature, we were able to find additional information on types from Ecuador, and the checklist now includes references to 336 type specimens; of these, 166 are represented in the 56 collections and linked to the Checklist as vouchers.

A total of 14% (375) of the species now included in our checklist are lichenicolous fungi. The majority, 369 species, were previously reported by Etayo (2017). Additional records were found in more recent publications, and some records were added based on vouchers from contributing collections.

Two species in our checklist, *Halojulella avicenniae* (Borse) Suetrong *et al.* and *Pyrenographa irregularis* (Wehm.) R.C. Harris, are not lichenized. They nevertheless have been included as 'saprophytic fungi related to either lichens or lichenicolous fungi', a category also recognized by Esslinger (2021) in his *North American Checklist*.

For the Galapagos, 89 species are currently considered endemic (95 if endemic varieties are included), 14 are considered questionably endemic (15 if possibly endemic varieties are included), that is, species likely to also occur on the continent, possibly even widely distributed throughout South America (Bungartz *et al.* 2023). For the Galapagos, this represents a rate of approximately 11% of species considered endemic (13% if questionable endemics are included). An assessment of lichen endemism for the entire country of Ecuador is currently impossible, but the 93 species reported to be endemic to the Galapagos here represent 3.4% (4% if questionable endemics are included) of the total number of species included in the Ecuador Checklist.

The number of vouchers cited in the checklist provides some indication of how thoroughly lichen biodiversity in the country has been studied. Continental Ecuador can roughly be divided into three major regions: El Oriente represents the upper Amazon, east of the Andes; La Sierra refers to the high Andes, often including their eastern and western foothills; La Costa is the region along the Ecuadorian Pacific coast. These regions are subdivided administratively into political provinces. The Galapagos as part of the country is a fourth region, represented by a single administrative province only.

In continental Ecuador the mountain regions of La Sierra are represented by 4102 vouchers linked to the checklist (22% of the total), followed by El Oriente, with 1101 vouchers (6%), and La Costa, with only 197 vouchers (1%). The Galapagos Checklist is represented by 13 281 vouchers (71%). Table 1 lists the number of vouchers for each province. It illustrates a strong sampling bias; collections from the Galapagos are over-represented, a result of the Galapagos Lichen Inventory (Bungartz *et al.* 2013*d*, 2023). This bias is also apparent in the distribution map automatically generated by the Consortium, based on geo-referenced voucher specimens (Fig. 2).

Assessing the quality of checklist records, both from the literature and based on vouchers, is not without challenges. As part of the Galapagos Lichen Inventory all specimens cited as vouchers have been thoroughly vetted, and only specimens where the material has been examined and identifications could be confirmed were included as vouchers (Bungartz *et al.* 2023). Records of species previously reported in the literature but no longer confirmed and now considered erroneous, have been excluded. Consequently, not all specimens from the Galapagos in the Consortium have been linked to the checklist as vouchers. Although most of these excluded specimens have been studied, identifications are frequently not up-to-date and consequently this material has not been included. This is unfortunately not an unusual scenario, as many institutional lichen

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Table 1. Number of vouchers linked to the checklist *Lichen-forming, Lichenicolous and Allied Fungi of Ecuador* (Yánez-Ayabaca *et al.* 2023) in the *Consortium of Lichen Herbaria*.

La Sierra		La Costa		El Oriente		Galápagos	
Province	Vouchers	Province	Vouchers	Province	Vouchers	Province	Vouchers
Azuay	801	El Oro	174	Morona-Santiago	126	Galápagos	13 281
Bolívar	14	Esmeraldas	6	Napo	623		
Cañar	9	Guayas	2	Orellana	8		
Carchi	339	Manabí	15	Pastaza	177		
Chimborazo	224	Santa Elena	0	Sucumbíos	13		
Cotopaxi	275			Zamora-Chinchipe	154		
Imbabura	475						
Loja	628						
Los Ríos	11						
Pichincha	882						
Tungurahua	444						
Santo Domingo de los Tsáchilas	0						
Total	**4102**		**197**		**1101**		**13 281**
	22%		**1%**		**6%**		**71%**

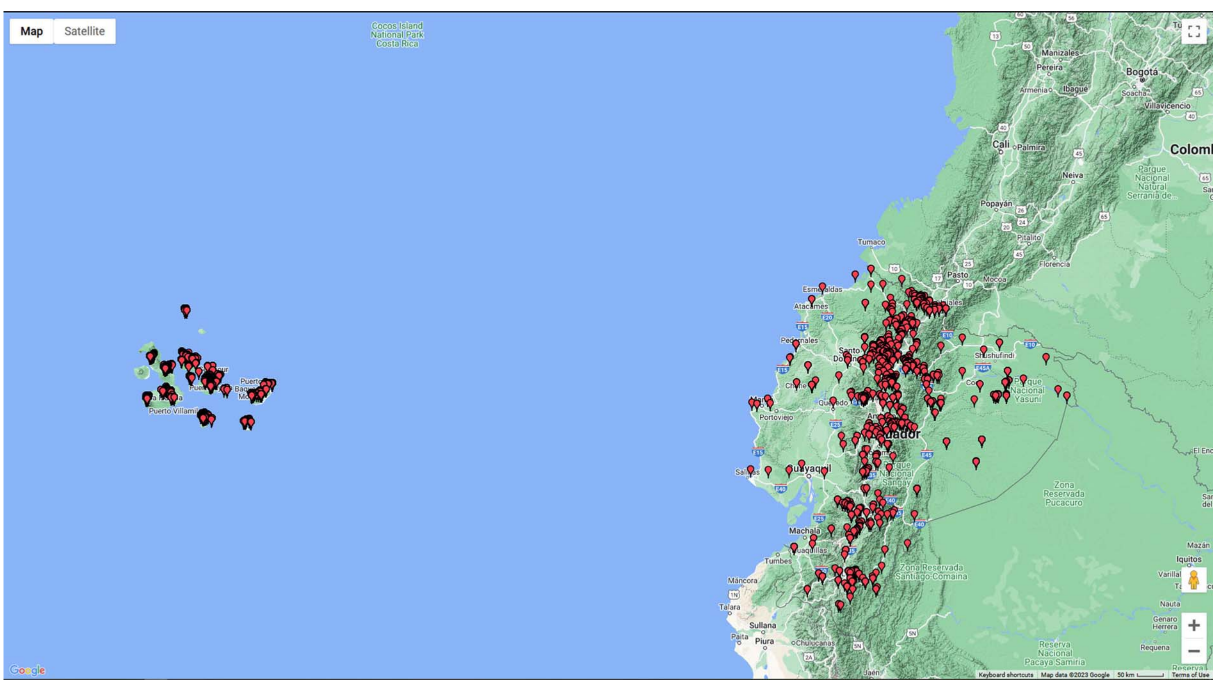

Figure 2. Distribution map automatically generated from geo-referenced vouchers of lichenized, lichenicolous and allied fungi in Ecuador included in the checklist (for the original, uncorrected map with vouchers that have incorrect geo-references see Fig. 6). In colour online.

collections suffer from a backlog of data entry and as a result, specimen identifications in the Consortium are not always updated. Additionally, many specimens, particularly those recently collected and deposited at CDS, still require additional research. Some represent reports new to the archipelago, new to Ecuador or even new to South America. Others still need to be described as new to science. Also, thirteen species in the current Galapagos Checklist are considered 'preliminary', suggesting that for these records, additional research is necessary (Bungartz *et al.* 2023).

For continental Ecuador, not all available records available in the Consortium were included as vouchers either, but here we had to be less selective in assessing whether identifications should be considered reliable. Generally, specimens identified by an expert, with an established track record of lichens from the region or for a particular taxonomic group, have been included as

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vouchers. Also, all species with holotypes from Ecuador were added to the list, the reference to the type specimen cited and where possible, linked as a voucher. Some of the names based on types from Ecuador obviously have changed and are listed as homotypic or heterotypic synonyms. For heterotypic synonyms, a comment was added, including which taxon name the type specimen cited refers to.

Apart from names included based on vouchers, literature records were generally added, but at least 106 species cited in the literature must be considered problematic. Sixty-four of these species records have no modern record, meaning that they are based on reports published prior to the 1970s; some include the first reports of these lichen species from the country (e.g. von Humboldt & Bonpland 1807; Leighton 1866; Nylander 1874; Müller 1879; Roumeguère 1879; Zahlbruckner 1905, 1907; Navás 1908). Using the taxonomic thesaurus, we tried to assess what these old literature reports most likely refer to, often including a comment with the citation, indicating the name under which the taxon was first cited, for example, *Flavopunctelia flaventior* (Stirton) Hale was first reported from Ecuador by Müller (1879) and Roumeguère (1879) as *Parmelia andreana* Müll. Arg.

Resolving what these old records refer to was not always possible. For at least 31 records the taxonomy remains unresolved. An example is *Parmelia camtschadalis* f. *tenuis* Müll. Arg. reported from Ecuador by Müller (1879) who suggested that it resembles *Physcia leucomelos* (L.) Michx. (Müller used the spelling '*leucomela*'), which today is considered a synonym of *Leucodermia leucomelos* (L.) Kalb. Previously, Leighton (1866) reported the taxon *Parmelia camtschadalis* (Ach.) Eschw. itself, not forma *tenuis*. *Parmelia camtschadalis* is a homotypic synonym of *Xanthoparmelia camtschadalis* (Ach.) Hale and it is possible that all these records represent the same species, possibly even *X. camtschadalis*, a species which, however, was not reported from South America by Nash *et al.* (1995). It is also possible, of course, that the forma *tenuis* cited by Müller (1879) refers to a different species, or that this forma or both records are not even a *Parmelia* s. lat. (based on the statement by Müller 1879). Only future revisions of the current checklist may tell how to best deal with these records. One option would have been to entirely ignore records from the early literature that cannot be confirmed. However, this would ignore baseline data of the species reported from the country very early on. Ideally, these records should further be investigated, trying to establish what material these reports are based on. For now, it seems best not to exclude such problematic taxa, but rather add a comment, where no modern records are available and/or the taxonomy remains unresolved.

Managing the taxonomy of accepted names versus synonyms using the taxonomic thesaurus of the Consortium has been useful in assessing the names reported in the literature. Uploading data sets in batch, as well as matching names included in Feuerer (2007) or Cevallos (2012) against the taxonomic thesaurus helped eliminate common spelling errors. Names added to the checklist manually were also matched against the taxonomic thesaurus. Those that could not be matched and were not just spelling errors were added either as synonyms or accepted names based on Index Fungorum and/or MycoBank, and according to available literature. Since the majority of collections present in the Consortium are from North America, names of taxa from the Neotropics were occasionally missing from the thesaurus. These names accordingly had to be added to allow them to be included in the checklist.

Taxonomic Section

Several names now included in the checklist are validated here. In her master's thesis, Yánez-Ayabaca (2009) introduced *Hypotrachyna everniusnica*, *H. montufariensis*, and *H. subpartita*. None of these were validly published despite good evidence that at least *H. montufariensis* and *H. subpartita* constitute good species. For these we therefore provide valid descriptions.

Hypotrachyna montufariensis Yánez-Ayabaca & Eliasaro sp. nov.

MycoBank No.: MB 847706

Superficially similar to *H. producta*, but with smaller thalli, less than 5 cm diam., lobes flat, whitish grey, narrower than those of *H. producta*, only 1–3 mm wide, with subterminal, not terminal, orbicular to subcapitate soralia, and a distinctly rhizinate, but not papillate lower surface.

Type: Ecuador, Carchi, Cantón Montúfar, San Gabriel, Bosque de Arrayanes, 0°33′04.6″N, 77°47′12.7″W, in open, well-lit forest, on branches and trunks of Arrayán (*Luma apiculata*), 2798 m alt., 24 December 2007, *A. Yánez-Ayabaca* 1274a (UPCB—holotype!).

(Fig. 3)

Thallus corticolous, up to 5 cm diam., loosely adnate. *Lobes* plane, sublinear, 1.0–3.0 mm wide, subdichotomously branched, slightly imbricate, sometimes pruinose, with truncate apices, the lobe margin entire to slightly crenate, with rhizines projecting beyond the lobe margin, but lacking cilia. *Upper surface* whitish grey, smooth, shiny, slightly undulate, emaculate. *Soralia* subterminal, orbiculate to subcapitate, with granular soredia. *Medulla* white. *Lower surface* black, shiny and ±rugose in the centre, attenuating

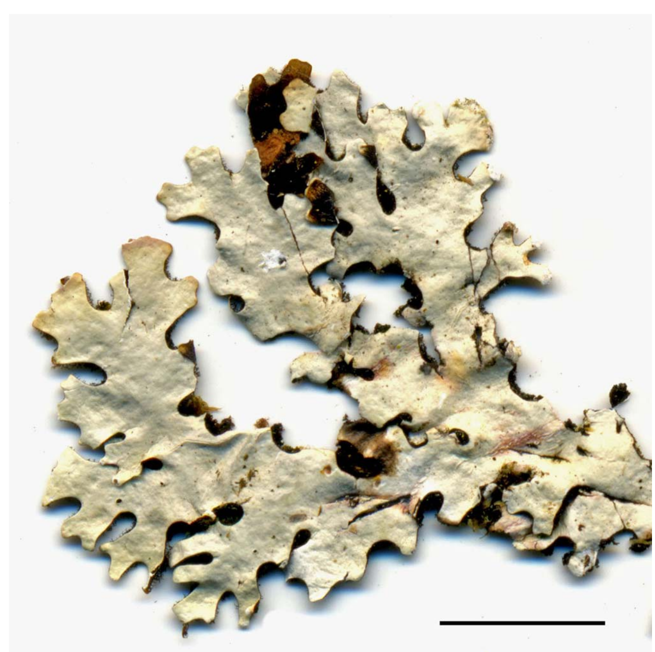

Figure 3. Thallus of *Hypotrachyna montufariensis* (*Yánez-Ayabaca* 1274a (UPCB—holotype!)). Scale = 1 cm. In colour online.

into a smooth and shiny, 0.4–0.8 mm wide, brown marginal zone. *Rhizines* black, dichotomously and densely branched, 0.2–0.5 mm long, with tangled-up apices, distributed homogeneously across the lower surface. *Photobiont* trebouxioid.

Apothecia and *pycnidia* not observed.

Chemistry. Upper cortex K+ yellow, UV− (atranorin); medulla K−, C± red, KC+ bright red, UV− (anziaic acid).

Etymology. The name is derived from the county Montúfar in the Ecuadorian province of Carchi, where the type was collected. The county was named after Carlos de Montúfar y Larrea-Zurbano, who studied humanities and philosophy in Quito. Montúfar not only fought for the independence of Ecuador from Spain, he also accompanied Humboldt and Bonpland during their expedition through the Andes. The correct Latinization of his surname is Montefarius; therefore, the correct spelling referring to the county of Montufar by adding the Latin syllable '*-ensis*' is accordingly '*montufariensis*'.

Distribution and ecology. The species is apparently uncommon and is currently known only from its type locality, the Bosque de Arrayanes, a popular ecotourism destination near the town of San Gabriel. These woodlands of large trees form an open gallery forest also named La Catedral for its resemblance to an enormous hall of large columns, the broad trunks of the trees.

Remarks. *Hypotrachyna montufariensis* is characterized by its orbicular to subcapitate, subterminal soralia and anziaic acid in its medulla. *Hypotrachyna ducalis* (Jatta) Hale, *H. eitenii* (Hale) Hale, *H. partita* Hale, *H. rachista* (Hale) Hale, *H. subpartita* and *H. producta* Hale all also produce anziaic acid also in their medulla. *Hypotrachyna ducalis* and *H. eitenii* do not have vegetative propagules, whereas *H. partita, H. rachista* and *H. subpartita* have isidia instead of the soralia characteristic for *H. montufariensis*. Although, *H. producta* is also sorediate, it is distinguished from *H. montufariensis* by much larger thalli (up to 9 cm diam.), dark grey, broader lobes (to 6mm wide) with revolute apices where the capitate, terminal soralia are formed, and the brown marginal zone of the lower surface is distinctly papillate, with few or no rhizines. By comparison, *H. montufariensis* has a smaller thallus (typically less than 5 cm diam.), its lobes are whitish grey, flat and narrow (1–3 mm wide), it forms orbicular to subcapitate soralia not at the lobe apex, but subterminally, and the marginal zonal of the lower side is rhizinate and not papillate.

Material of H. producta *studied for comparison.* **Ecuador:** *Imbabura*: Cotacachi, Reserva Ecológica Cotacachi Cayapas, Páramo, 0°18′09.4″N, 78°22′44.2″W, 3304 m alt, 2007, *A Yánez-Ayabaca* 1249 (UPCB).

Hypotrachyna subpartita Yánez-Ayabaca & Eliasaro sp. nov.

MycoBank No.: MB 847707

Distinguished from *H. partita* by isidia not evenly dispersed across the thallus surface, but aggregating in clusters, which are restricted to the thallus centre and are absent from the thallus margin.

Type: Ecuador, Carchi, Espejo, Reserva Ecológica El Ángel, Páramo de Frailejones, on *Espeletia* spp., 0°40′38.9″N, 77°52′36.3″W, 3700 m alt., 1 November 2006, *A. Yánez-Ayabaca* 600 (UPCB—holotype!).

Figure 4. Thallus of *Hypotrachyna subpartita* (*Yánez-Ayabaca* 600 (UPCB—holotype!)). Scale = 1 cm. In colour online.

(Fig. 4)

Thallus corticolous, up to 6 cm diam., loosely to closely adnate. *Lobes* sublinear, 1.5–3.5 mm wide, dichotomously branched, moderately to distinctly imbricate, with truncate to subtruncate apices, delimited by a distinct, black, smooth to slightly crenate margin, lacking cilia. *Upper surface* whitish grey, plane, smooth, shiny, emaculate, scarcely to moderately isidiate. *Isidia* laminal, mostly

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aggregating in clusters in the thallus centre, absent or scarce along the margin, concolorous with the thallus at their base, brown tipped, cylindrical, single to sparsely branched, erect to rarely recumbent, 0.1–1.0 mm long, sometimes with branched cilia. *Medulla* white. *Lower surface* moderately rhizinate, black, rugose, opaque to shiny in the centre, with a smooth, dark brown, 0.4–1.4 mm wide marginal zone. *Rhizines* black, dichotomously and densely branched, 0.3–1.1 mm long, with tangled apices, distributed homogeneously across the lower surface. *Photobiont* trebouxioid.

Apothecia and *pycnidia* not observed.

Chemistry. Upper cortex K+ yellow, UV− (atranorin); medulla K−, C+ and KC+ red, UV− (anziaic acid and traces of lecanoric acid).

Etymology. The name indicates that the species resembles *H. partita* (for differences with which the two can be distinguished, see 'Remarks').

Distribution and ecology. Until now the species has only rarely been collected. It may be restricted to the 'páramo de frailejones' and *Polylepis* forests of the high Andes in northern Ecuador. Frailejones have a unique growth form. They form small, stout trunks tipped by a rosette of broad leaves. The genus of frailejones, *Espeletia*, is endemic to northern Ecuador, Colombia and Venezuela. *Polylepis* is a genus of small trees or shrubs, endemic to mid- and high elevations of the Andes, where it forms low, open, scattered forests to extensive shrublands.

Remarks. *Hypotrachyna subpartita* is characterized by cylindrical, simple to branched isidia and traces of anziaic and lecanoric in its medulla. *Hypotrachyna partita* is another isidiate species containing anziaic acid in its medulla. However, *H. partita* forms isidia all across its surface from the centre to the margin (i.e. both laminal and marginal) and these are more or less evenly dispersed and not aggregating in clusters.

Hypotrachyna subpartita also has wider lobes (4–7 mm) with rounded instead of truncate apices and a densely rhizinate lower surface (Hale 1975). *Hypotrachyna rachista* is another isidiate species, found in the study area that only produces anziaic acid in its medulla, but its isidia are mainly confined to the lobe margin; its thallus lobes are distinctly linear, with a black lower surface, but frequently with a narrow white margin close to the tip of the lobes.

Additional specimens examined (paratypes). **Ecuador:** *Carchi*: Espejo, El Ángel, *Polylepis* Lodge, Bosque de *Polylepis*, on *Polylepis*, 0°42′26.5″N, 77°58′49.1″W, 3580 m alt., 2007, *A Yánez-Ayabaca* 1401a (UPCB); 0°40′40.2″N, 77°52′35.0″W, 3739 m alt., 2007, *A. Yánez-Ayabaca* 1458a (UPCB).

Hypotrachyna *species not formally described here*

Hypotrachyna everniusnica is not formally described. It remains preliminarily included in the checklist as a *nomen nudum*. The description in Yánez-Ayabaca (2009) discusses that specimens assigned to this taxon are chemically identical and morphologically similar both to *H. meyeri* (Zahlbr.) Streimann (described from Ecuador) and *H. sinuosa* (Sm.) Hale (reported from Ecuador). Hale (1975) suggested that *H. meyeri* and *H. sinuosa* were synonymous, whereas Swinscow & Krog (1979) believed the two taxa were distinct species, distinguished by location and shape of their soralia. Without molecular evidence it seems premature to formally describe yet another morphotype, *H. everniusnica*, also distinguished only by the shape of its soralia, as a new species.

Fissurina tectigera (Eschw.) Lücking & Bungartz comb. nov.

MycoBank No.: MB 847708

Basionym: *Graphis tectigera* Eschw., in Martius, *Icon. Pl. Crypt.* **2**, 10 (1834) [1828–34], MycoBank No.: MB 386268.

Previous versions of the Galapagos Checklist (Bungartz *et al.* 2013*d*) include the combination *Fissurina tectigera*, informally proposed by Robert Lücking when he examined the Galapagos specimens. Here we formally establish the new combination.

Fissurina timida (Vain.) Lücking & Bungartz comb. nov.

MycoBank No.: MB 847709

Basionym: *Graphis timida* Vain., *Proc. Amer. Acad. Arts & Sci.* **58** (3), 142 (1923), MycoBank No.: MB 386276.

Previous versions of the Galapagos Checklist (Bungartz *et al.* 2013*d*) include the combination *Fissurina timida*, informally proposed by Robert Lücking when he examined the Galapagos specimens. Here we formally establish the new combination.

Lepra oahuensis H. Magn. ex Bungartz, A. W. Archer & Elix sp. nov.

MycoBank No.: MB 847727

Originally described as *Pertusaria oahuensis* H. Magn., in A. H. Magnusson & A. Zahlbruckner, *Arkiv för Botanik* **31A** (6), 57 (1944), nom. inval. Art. 38.1(a) (Shenzhen), MycoBank No.: MB 369077.

Lepra oahuensis H. Magn. ex A.W. Archer & Elix, *Australasian Lichenology* **82**, 132 (2018), nom. inval. Art. 36.1(a) (Shenzhen), MycoBank No.: MB 822552.

Type: USA, Hawaii, Oahu, Waianae, near Kolekole pass, on smooth bark, 3 September 1938, *O. Selling* s. n. (S—holotype!).

For a diagnosis, see the detailed description in Bungartz *et al.* (2015, p. 347) under '*Pertusaria oahuensis*'.

Lepra oahuensis was previously reported as *Pertusaria oahuensis* from Australia by Archer & Elix (2014), and subsequently from Ecuador by Bungartz *et al.* (2015). Both provided descriptions with illustrations, but did not realize that the name had to be considered invalid according to Article Art. 36.1(a) (Turland *et al.* 2018), because Magnusson in Magnusson & Zahlbruckner (1944) published the name as '*ad interim*' indicating that he considered it to be provisional. Unfortunately, this also means that the combination proposed by Archer & Elix (2018) is also invalid, since it is based on an invalid basionym. The taxon is considered well characterized and the name is therefore formally validated here by explicitly referring the name *Lepra oahuensis* to its description as *Pertusaria oahuensis* in Bungartz *et al.* (2015, p. 347).

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Leucodermia leucomelos f. *albociliata* (Hue) Bungartz comb. nov.

MycoBank No.: MB 847779

Basionym: *Anaptychia leucomelos* f. *albociliata* Hue, *Nouv. Arch. Mus. Hist. Nat., Paris, 4 sér.* **1**, 107 (1899), MycoBank No.: MB 547263.

Kalb in Mongkolsuk *et al.* (2015) introduced the new genus *Leucodermia* Kalb with *L. leucomelos* (L.) Kalb as the type, including an illustration of *L. leucomelos* f. *albociliata*, characterized by its distinctive white cilia (Mongkolsuk *et al.* 2015: fig. 1C). This combination was, however, never formally established because a MycoBank number was only registered for the species (i.e. *Leucodermia leucomelos* MB 813827) and not forma *albociliata*. The combination is validly published here by providing the missing MycoBank number.

Physcia mobergii Bungartz nom. nov.

MycoBank No.: MB 847728

Replaced synonym: *Physcia lobulata* Moberg nom. illegit., *Nordic J. Bot.* **10**(3), 333 (1990), nom. illegit., Art. 53.1 (Shenzhen), MycoBank No.: MB 126960.

Non *Physcia lobulata* (Flörke) Arnold, *Flora (Regensburg)* **67**, 248 (1884) MycoBank No.: MB 400717.

Moberg (1990) published the name *Physcia lobulata*, unaware that the combination had been proposed previously by Arnold (1884) based on *Lecanora lobulata* Flörke (*Deutsche Lich.* **2**, 10 (no. 14) (1815)). Although Arnold (1884, p. 248) published this combination as '*Ph. lobulata* Smft.' by referring to Sommerfelt (1826), not citing a basionym, the name *Physcia lobulata* (Flörke) Arnold is still valid according to ICN article 41.3 example 3 (Turland *et al.* 2018), because Sommerfelt (1826, p. 87) cited *Lecanora lobulata* Flörke correctly, although only indirectly.

Specimens identified as *Physcia lobulata sensu* Moberg are reported here from the Galapagos (Bungartz *et al.* 2023), and we therefore formally introduce a replacement name in honour of Roland Moberg, who originally described the species being unaware that the name he chose would be illegitimate.

Sticta hypoglabra B. Moncada & Lücking sp. nov.

MycoBank No.: MB 848612

'*Sticta hypoglabra*' B. Moncada & Lücking, in Moncada, *El Género* Sticta *(Schreb.) Ach. en Colombia: taxonomía, ecogeografía e importancia* (thesis), 90 (2012), nom. inval. (Turland *et al.* 2018: Art. 29.1, 30.9).

Differing from *Sticta scabrosa* in glabrous lobe surface, medulla K+ cadmium yellow, blue-grey marginal isidia, no cilia and ventral tomentum absent towards margin of lobes.

Type: Colombia, Valle del Cauca, Municipio Santiago de Cali, Corregimiento Pance, Vereda El Topacio, Farallones de Cali, Centro de Educación Ambiental El Topacio, sendero La Cascada, 3°19′30″N, 76°39′W, 1700 m alt., 9 August 2011, *Lücking, R.* 33573 & *B. Moncada* (UDBC—C-0010561, holotype; B—isotype). GenBank ITS barcoding marker accession numbers for the sequences of the holotype: KC732669.1 and KC732670.1.

(Fig. 5)

Thallus forming suborbicular rosettes or becoming irregular, up to 10 cm diam., moderately branched, with 3–5 lobes per 5 cm radius; ramification anisotomous to pleurotomous. *Lobes* subcoriaceous, brittle, laciniate to ligulate with rounded tips, flat to involute, margins entire to sinuous, not thickened; lobe internodes (4) 5–11(–13) mm long, (5)6–10(–12) mm wide. *Upper surface* rough to smooth, shiny, grey-brown when fresh, darkening when dry (thalli exposed to direct sunlight are usually darker), glabrous, without papillae, but with abundant, usually indistinct, irregular, cream-coloured maculae, lobe margins of the same colour as the thallus centre to slightly darker. *Cilia* absent. *Vegetative propagules* isidia, abundant, mainly marginal, aggregated, simple to branched or coralloid, individual isidia cylindrical and round in cross-section, minute, only up to 0.2 mm long and 0.05 mm wide, typically paler than the thallus, pale greyish blue to pale brown, rarely becoming deep brown, with a shiny surface. *Cephalodia* absent. *Lower surface* uneven to undulate, cream to dark brown towards the centre, covered by two different *tomentum* types: an irregularly spongy to fasciculate *primary tomentum* composed of thick, smooth, greyish brown to chocolate brown hyphae with white apices, most pronounced in the thallus centre, thinner and fading or absent along the margin, and a light-coloured arachnoid *secondary tomentum*. *Rhizines* absent. *Cyphellae* abundant, in the thallus centre 1–20 per cm^2, and 61–100 per cm^2 towards the margin, scattered, rounded to irregular, urceolate with a wide pore, (0.1)0.3–0.5(1) mm diam., immersed to prominent, forming below the level of the tomentum, with raised, involute cream-coloured to brown margins, not lined by the tomentum, the basal membrane of the cyphellae cream-coloured to pale yellow, K+ cadmium yellow, C−, KC−, P−. Some thalli stalked, *peduncle*, if present, lacking cyphellae. *Upper cortex* paraplectenchymatous, 25–35 µm thick, composed of two strata; *upper stratum* pale brown to golden brown, of a single cell layer with small and pachydermatous cells, 2.5–5 µm diam., with walls 1.25–2.5 µm thick and rounded to isodiametric lumina, 1.25–2.5 µm diam.; *lower stratum* composed of 2–3 layers of larger, leptodermatous cells, 5.61–11.25 µm diam., with walls 0.61–1.25 µm thick and rounded to isodiametric lumina, 5–10 µm diam. *Photobiont* a species of *Nostoc*; photobiont layer 60–75 µm thick, with individual cells 12.5–25 µm diam. *Medulla* 87.5–187.5 µm thick, composed of hyphae 2.5 µm wide, interspersed with yellow-orange crystals, K+ cadmium yellow, C−, KC−, P−. *Lower cortex* paraplectenchymatous, 20–30 µm thick, composed of 2–3 cell layers, cortical cells 6.25–15 µm diam., with walls 1.25–2.5 µm thick. *Upper tomentum* absent. *Primary lower tomentum* composed of fascicles of separate, branched hyphae, 12–20 septate, 230–600 µm long with free apices; *secondary lower tomentum* composed of branching, moniliform hyphae, 20–27.5 µm long with free apices. *Cyphellae* 100–800 µm diam., basal membrane somewhat wider, 150–700 µm diam., cavity 80–150 µm deep; cells of basal membrane lacking papillae on the outside.

Apothecia unknown.

Pycnidia immersed.

Etymology. The epithet of this species refers to the absence of a tomentum from the margin of the lower surface, a characteristic

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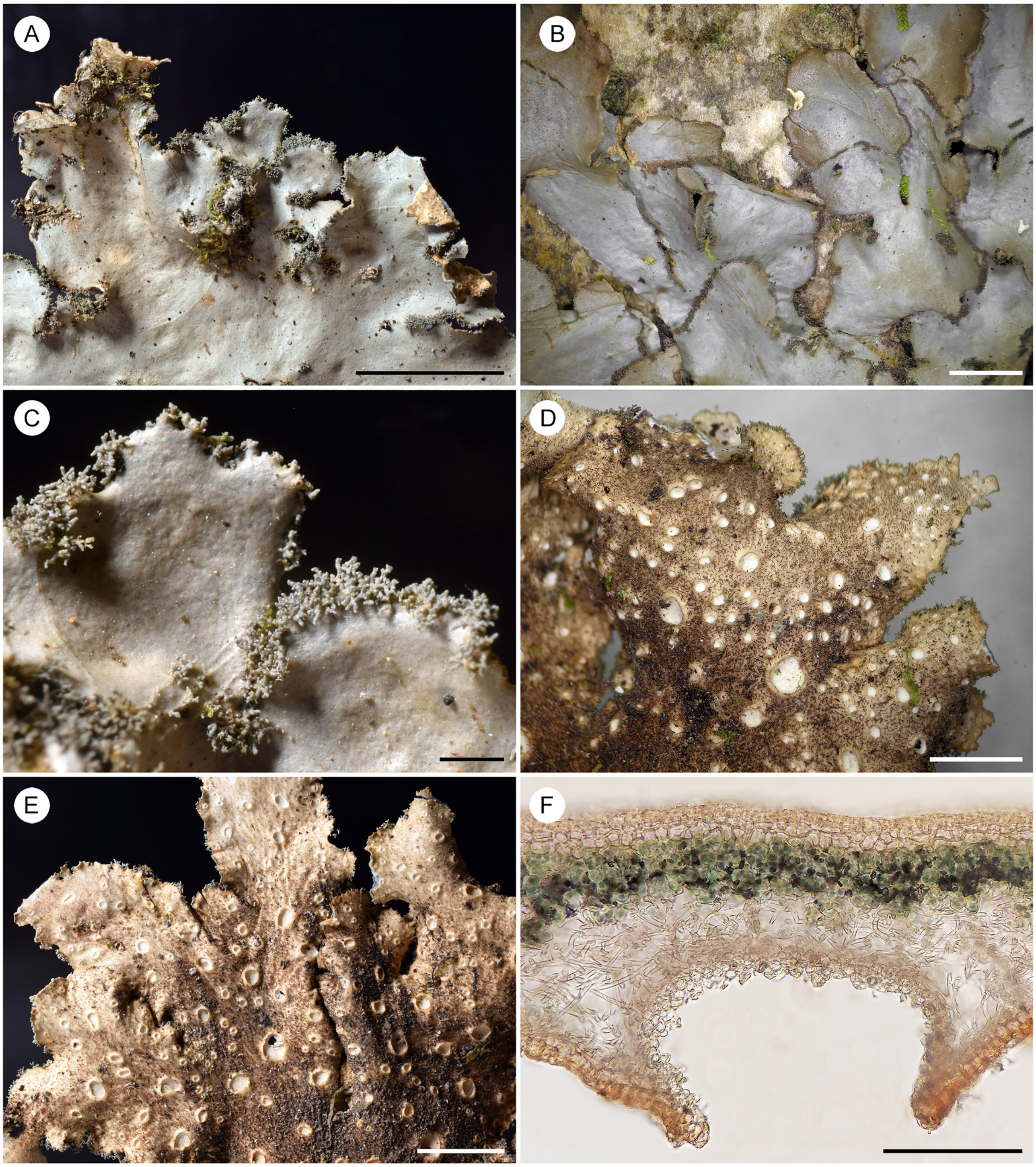

Figure 5. *Sticta hypoglabra*. A, herbarium specimen. B, specimen *in situ*. C, close-up marginal isidia. D & E, lower surface detail with primary tomentum and cyphellae. F, thallus section showing cyphellae. Scales: A & B = 10 mm; C = 1 mm; D & E = 2 mm; F = 100 μm. A & C–F = *Lücking* & *Moncada* 33573 (holotype); B = *Lücking* & *Moncada* 33541 (paratype). In colour online.

that differentiates it from similar species in the *Sticta weigelii* morphodeme, such as *S. andina* B. Moncada *et al.*, *S. beauvoisii* Delise, *S. scabrosa* B. Moncada *et al.*, as well as other species with marginal isidia.

Distribution and ecology. First collected in the Colombian Andes, between 600–2680 m altitude, also reported here from the Andes of Ecuador, generally expected to occur in the tropical, sub-Andean and Andean forests, in open places, but typically not fully exposed to direct sunlight. The species grows on bark and rock, and it is generally associated with species of the bryophyte genus *Plagiochila*.

Taxonomic note. The name invalidly introduced in Moncada (2012) is formally validated here; even though this doctoral dissertation is publicly available online, it was not published with a Standard Serial Number (ISSN) or an International Standard Book Number (ISBN) and therefore does not constitute effective publication (Turland *et al.* 2018: Art. 29.1 and 30.9).

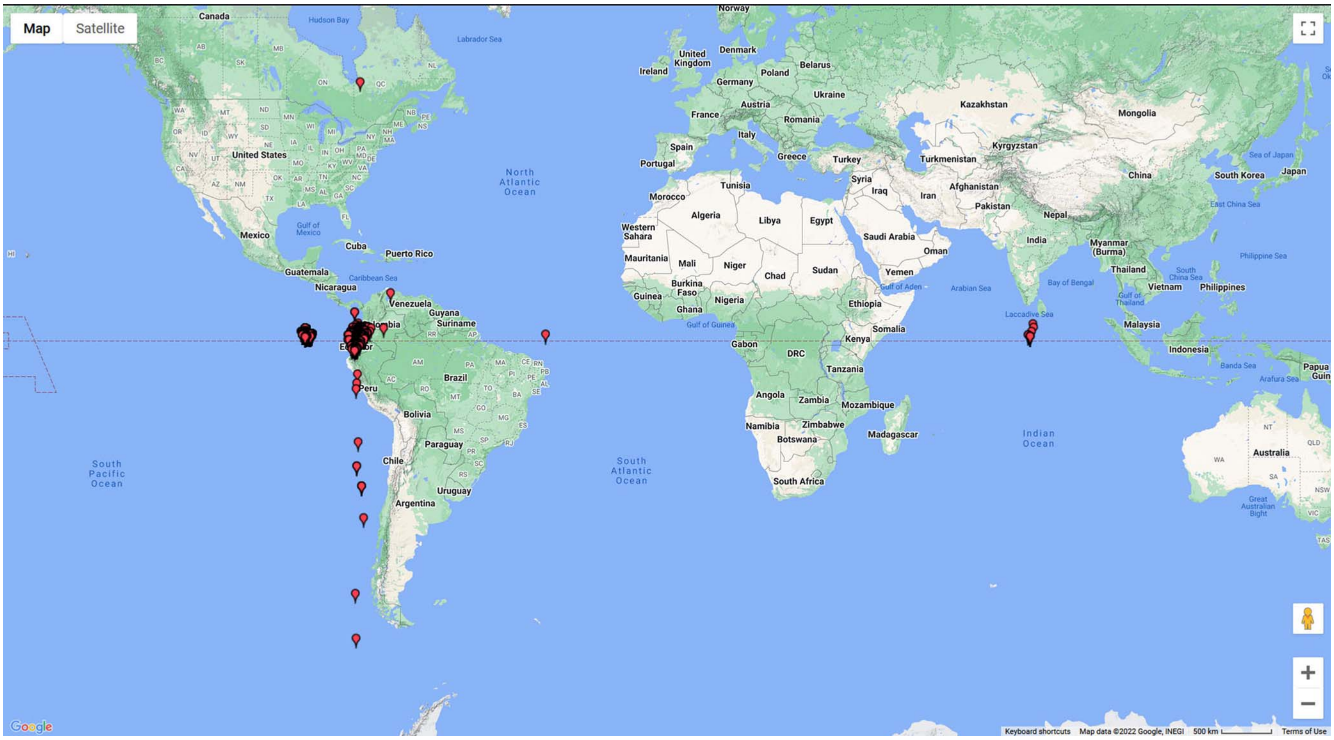

Figure 6. The original distribution map, automatically generated from geo-referenced vouchers of lichenized, lichenicolous and allied fungi in Ecuador included in the Checklist; some of the vouchers clearly have erroneous geo-reference data that need to be corrected (see the updated map in Fig. 2). In colour online.

Remarks. *Sticta hypoglabra* is a species of the *S. weigelii* group with a cyanobacterial photobiont. It can be distinguished by its fragile and minute marginal isidia that are simple to coralloid, a thallus that is frequently lighter in colour than other species in the group; most characteristic is its greyish brown primary tomentum, composed of hyphae with white apices, well developed in the thallus centre, but absent towards the margin.

Morphologically most similar is the widely distributed *Sticta scabrosa* (Moncada *et al.* 2021), a species distinguished from *Sticta hypoglabra* by a scabrous tomentum on its upper surface and the presence of phyllidia instead of isidia. Another similar species is *S. tunjensis* B. Moncada & Lücking (Moncada & Lücking 2012). Both *S. hypoglabra* and *S. tunjensis* are less common than *S. scabrosa* and they are both possibly more restricted in their distribution. Unlike *S. hypoglabra*, *S. tunjensis* produces at least a few cilia, and it has a K+ pale yellow medulla, whereas the medulla of *S. hypoglabra* reacts distinctly K+ cadmium yellow. The tomentum of *S. tunjensis* is white to cream-coloured and has less numerous cyphellae, towards the margin of its lower surface only 41–60 per cm^2 (along the margin *S. hypoglabra* has 61–100 cyphellae per cm^2).

Additional specimens examined. **Colombia:** *Antioquia*: Municipio Frontino, Carretera a El trapiche, Hacienda Córcega, 900 m alt., 1990, *P. A. Silverstone* 5950 (B, CUVC). *Boyacá*: Municipio Moniquirá, km. 36 vía Moniquirá, 2600 m, 1996, *C. Gantiva* 19 (UDBC). *Cesar*: Municipio Río de Oro, Bosque 08° 16′50.7″N, 73°25′01.1″W, 1714 m alt., 2010, *B. Moncada* 4182 (UDBC); *ibid.*, 1701 m alt., 2010, *B. Moncada* 4254 (UDBC); *ibid.*, 1714 m alt., 2010, *B. Moncada* 4406 (UDBC). *Cundinamarca*: Municipio Chipaque, Vereda Marilandia, vía Santuario., 2400 m alt., 2011, *B. Moncada* 4841b (UDBC). *Meta*: Municipio Villavicencio, Bosques de Bavaria, al N de la ciudad, cerca al Río Guatiquía, 600 m alt., 1984, *J. Aguirre* 5679 & *H. Sipman* (B, COL). *Risaralda*: Mun. Santa Rosa de Cabal, Hacienda La Gaviota, Oeste Termales de Santa Rosa, 1980 m alt., 1986, *J. Wolf* 1069 (B, COL). *Tolima*: Municipio Ibagué, PNN Los Nevados, Transepto Rancho-El Silencio, 2680 m alt., 2007, *A. Galindo* 75 (UDBC). *Valle del Cauca*: Municipio Santiago de Cali, Corregimiento Pance, Vereda El Topacio, Farallones de Cali, Centro de Educación Ambiental El Topacio, sendero La Cascada, 3°19′30″N, 76°39′W, 1600 m alt., 2011, *R. Lücking* 33537, 33541, 33573 (UDBC, B).—**Ecuador:** *Pinchincha*: Andes, Cantón San Miguel de Los Bancos, Las Cascadas near Mindo, above the footpath to Cascada Nambillo, just above the footpath crossing towards cascada Las Orchideas, 0°4′43.7″N, 78°45′38.3″W, 1417 m alt., dense, shaded secondary rainforest, 2012, *M. Dal Forno* 1916 (B).

Discussion

Species are the fundamental elements of the web of life, providing ecosystem services that sustain the biosphere that humanity depends on. It is ironic that the biologically most diverse countries on earth often lack adequate resources to 'take stock' of their biological resources. Species checklists are the fundamental baselines for documenting biological diversity. Political institutions, ecologists and conservation biologists rely on these checklists to establish regulatory frameworks for species conservation.

Modern biodiversity information systems (GBIF, LIAS, ITALIC, Symbiota) provide tools to better assess what we currently know about biodiversity on this planet. Although these biodiversity data platforms come with a learning curve, they offer great potential to more efficiently manage and assess large biodiversity data sets.

None of these tools are perfect. Johnston *et al.* (2018) discuss data practices, using Symbiota to build a species list of darkling beetles (*Tenebrionidae*) from the Algodones Dunes in California. Franz *et al.* (2014) summarize what they learned

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from using Symbiota to compile a checklist of Weevils (*Curculionoidea*) for North America. Brown *et al.* (2018, 2020) present how they used the UC Santa Barbara Collection Network, one of the Symbiota portals, to document progress towards an inventory of ant species from Santa Barbara County in California. Here we provide another example, a Symbiota checklist of *Lichen-forming, Lichenicolous and Allied Fungi from Ecuador*. Built in the *Consortium of Lichen Herbaria*, we use this checklist as an example to outline best practices and discuss some of the inherent limitations of the system.

Documenting diversity – dynamic updates of 'snapshots in time'?

We have always compiled checklists by hand, so why change this now? Traditional checklists are 'snapshots in time'. These classic publications are static and not easily updated, but it can be argued that they are therefore best suited to document biodiversity at a given point in time. Political institutions are reluctant to change; they rely on reasonably stable frameworks; they do not easily deal with new discoveries and frequent changes in taxonomy. Unfortunately, new discoveries and advances in taxonomy are a reality. Names of taxa change. This is particularly true when working with poorly known species groups (e.g. lichens) in megadiverse countries (e.g. Ecuador). Our current checklist documents 2599 species of lichenized, lichenicolous and allied fungi from Ecuador. This is not a particularly long list for a megadiverse country.

When Bill Weber published the results of his lichen inventory for Galapagos, just one province of Ecuador, as few as 228 species were reported from the archipelago (Weber 1986). A few decades later this number has more than tripled; 795 species are included in the current Galapagos Checklist (Bungartz *et al.* 2023) but, based on material only preliminarily reviewed, it can be estimated that at least 200 species remain undocumented. Compared to the archipelago, species diversity on mainland Ecuador remains much less investigated. If a similar trend as documented from the Galapagos is extrapolated, conservative estimates of species counts on the continent could easily reach 6000. This is approximately the same number of species currently reported for the entire continental United States and Canada (Esslinger 2021). Even numbers as high as 9000 species of lichenized, lichenicolous and allied fungi would not be unexpected for a country like Ecuador.

These numbers are not reasonably dealt with by compiling lists manually. 'Taking stock' of biodiversity is critical for species conservation. Therefore, it is necessary to develop more efficient methods of compiling species checklists. Database systems such as the *Consortium of Lichen Herbaria* offer tools for rapidly, dynamically and efficiently updating checklists. These tools do not provide for automatically generating version numbers with dates-last-updated and preserving these versions as 'snapshots'. Nevertheless, as we demonstrate here, it is possible and strongly recommended to manually generate these reports, creating periodic snapshots as PDFs which can be downloaded, with version number and date-last-updated.

Specimens versus literature ≠ quantity or quality?

Occurrence records based on specimens deposited in natural history collections are notorious for their identification inaccuracy. For their source data, traditional checklists therefore rely on 'verified' literature records of species reported from a country or region. Thus, traditional checklists for example often rely on specimens cited in taxonomic treatments based on the assumption that these records have been reviewed by experts and are therefore necessarily more reliable than any other records. Herbarium specimens do not generally have the same reputation. Has the material ever been reviewed by an expert? How long ago? Or has it perhaps quickly been identified only by a student? Is the identification of that specimen reliable? Can this occurrence record be considered accurate?

The assumption that literature reports are inherently more reliable than specimen-based occurrence records is not necessarily correct. Why would material studied for a monograph of a genus published several decades ago be considered more accurate than recently collected specimens, especially if these new collections are now examined with more advanced tools than were available decades ago?

It is a myth that specimen identifications in large data repositories cannot be assessed for identification accuracy. Smith *et al.* (2016) used phylogeny-based predictive niche modelling to assess occurrence records from the Global Biodiversity Information Facility (GBIF) identified as *Dolichousnea longissima* (Ach.) Articus. They concluded that records from the tropics should be considered erroneous (i.e. misidentifications of morphologically similar specimens). Both Müller (1879) and Roumeguère (1879) reported *D. longissima* from Ecuador, not citing any material; and no modern specimen records for Ecuador exist, at least not in the Consortium. In the Galapagos, the morphologically similar *Usnea mexicana* Vain. is common, and even abundant in parts of the highlands. The historic records of Müller (1879) and Roumeguère (1879) quite possibly refer to this species but, strictly speaking, this assumption can only be confirmed if specimens that these historical records are based on can be found and re-examined. This example illustrates that at least some historical literature records must be cited with caution, whereas it is at least possible to re-examine specimens and thus correct erroneous identifications. Thus, while species records must not indiscriminately be added to a checklist based on specimens, it is equally necessary to be selective when reviewing the literature. Generally ignoring specimens, arguing that these records are universally unreliable, unnecessarily deprives researchers of biodiversity information that may someday be verified.

Smith *et al.* (2016), however, also argue that it is unrealistic to expect that millions of specimens in historical collections would be re-examined. This argument seems valid, particularly when morphology, anatomy or chemistry of specimens needs to be studied, assuming that molecular characters remain inaccessible due to the fragmented nature of their DNA. Several recent studies have, however, demonstrated that it is possible to obtain DNA from historical collections (Sohrabi *et al.* 2010; Redchenko *et al.* 2012; Bendiksby *et al.* 2014; Schmull *et al.* 2014; Gueidan *et al.* 2019; Kistenich *et al.* 2019; Gueidan & Li 2022) and high-throughput sequencing has been proposed as one viable option for the routine DNA barcoding of even larger historical collections (Dal Forno *et al.* 2022). It is therefore not inconceivable that these tools will eventually allow us to more accurately assess specimen records. Database platforms like Symbiota can help to keep track of how specimen identifications change. Its voucher tool includes a tab listing specimen identification conflicts; that is, a list of specimens cited as vouchers, where the current identification no longer matches the name under which this voucher is cited in the checklist. This provides for a much more efficient way to update checklists than is possible reviewing traditional literature records.

Dynamic databases versus static literature records

Constructing checklists in Symbiota from select vouchers has additional benefits compared to citing literature records. Specimen data from vouchers frequently include information useful to assess the quality of checklists, identifying gaps and sampling bias. Although this information can also be assembled manually from specimen records cited in the literature, Symbiota automatically generates distribution maps from the geo-referenced vouchers. These maps not only help to identify areas less intensely surveyed, they can also be used to spot and correct mistakes, and when specimen identifications are updated, these maps also are automatically updated (Fig. 6).

Analyzing collection information from vouchers included in a checklist with powerful databases like Symbiota has other conceivable applications. Which particular substrates were these vouchers collected on? Does this mean, perhaps, that most species in a country are saxicolous, terricolous, corticolous, or foliicolous? Or does it simply reflect sampling bias? Should researchers target specific substrata or habitats? Natural history collections are typically not assembled following unbiased sampling strategies. Identifying regions within a country, or particular habitats, or ecological groups that require more attention, goes beyond assembling mere lists of species. Analyzing collection data from vouchers may help to improve biodiversity inventory strategies. Clearly, analyzing collection data has its limits. This is especially true for old specimen records that frequently lack habitat information. If habitat information was recorded for such specimens, it is often sparse; even for modern records, ecological data are typically not routinely collected in any standardized way. However, if this information is available and, even better, if it has been collected in a standardized way (Fig. 7), database systems offer a more efficient way to compile and analyze data than extracting the information manually from the literature.

Limitations of database systems or limitations of data availability?

It is only fair to say that manually compiling specimen records from the literature, visiting collections, and studying specimens has advantages. Compiling checklists in this 'traditional way', an author is not limited to information available in any particular database or platform. Occurrence records made available by biodiversity data portals necessarily remain incomplete. The *Consortium of Lichen Herbaria* is no exception. Many important collections are not represented. Even those that are participating often face considerable data entry backlog issues. Some of the largest historical collections are still not fully databased. Suggesting that this might be an argument against using the tools provided by platforms like Symbiota nevertheless seems odd. One could argue that the time and effort to manually compile traditional checklists would be better invested in improving existing database systems. This has the additional benefit of making checklist data more broadly available, facilitating collaboration, particularly in countries where knowledge transfer and education of a new generation of biodiversity scientists remains a challenge.

Taxonomic stability versus shifting phylogenies and the taxonomic thesaurus

A significant challenge when establishing checklists as reference frameworks for what is currently known of the biodiversity in a country, is taxonomic stability. Naming fungi is governed by the *International Code of Nomenclature for algae, fungi, and plants* (Turland *et al.* 2018), a framework of rules that necessarily tolerates different taxonomic opinions. Scientific names are basically hypotheses and although the Code regulates which names are legitimate and valid, it cannot assess which of these hypotheses are supported by scientific evidence, which names should be accepted, and which are better treated as synonyms.

Chapter F of the Code (Turland *et al.* (2018), superseded in parts by May *et al.* (2019)) requires fungal names to be registered. Name repositories like Index Fungorum and MycoBank have adopted systems that distinguish names *currently* accepted from their synonyms. Both systems are not entirely congruent; accepted names and their synonyms are not universally agreed upon. They do not generally represent consensus among the scientific community. Occasionally, the two repositories may even be inconsistent. Despite efforts to align information in both databases, names are sometimes spelled differently, and different (or incomplete) source records are provided. No big database system is free of mistakes, and it frequently requires significant effort to determine which record is correct.

The taxonomic thesaurus of the *Consortium of Lichen Herbaria* uses fdex (Bates 2023) to compare these discrepancies, but occasionally deviates from the synonymies suggested by either one of these repositories. Generally, a pragmatic approach is preferred. Thus, for the *Trypetheliaceae* the synthesis by Aptroot & Lücking (2016) has been followed, whereas many recent generic segregates proposed by Kondratyuk and co-authors are widely considered problematic. For some of these generic segregates, the use of chimeric data has been documented (e.g. Vondrák *et al.* 2018; Llewellyn 2019; Wilk *et al.* 2021), while for others, the phylogenetic hypotheses cannot be tested, because sequence alignments for phylogenetic analyses were not made available (e.g. Kondratyuk *et al.* 2019*a*, *b*, 2022). Particularly problematic is the situation now in *Teloschistaceae*, where 'the number of genera has increased tenfold in the last decade' (Gaya 2021).

Even if achieving taxonomic consensus is not always possible, Symbiota provides tools to accommodate different points of view. By default, Symbiota checklists display species names the way they were originally uploaded, but it is possible to change this view, presenting a list according to the central taxonomic thesaurus. This allows authors to create checklists following their own taxonomic concept. In theory, the system can handle even several different taxonomic thesauri, each one in itself consistent and complete, but reflecting different taxonomies (i.e. different taxonomic opinions). However, in practice, managing even a single taxonomic thesaurus is challenging due to the sheer volume of names.

For most users of a checklist (ecologists, conservation managers, regulators), taxonomic 'finesse' is largely irrelevant. Whether a taxon is called *Usnea longissima* or *Dolichousnea longissima* may cause heated debates in academia, it doesn't affect whether the species occurs in Ecuador or not. For the way Symbiota checklists are presented this may pose a problem, because the two display options (Original Checklist vs Central Thesaurus) may result in different statistics (i.e. different numbers of species, and different total taxon names). This is not a problem for homotypic synonyms; for example, *Usnea longissima* or *Dolichousnea longissima* just represent different names for the same taxon. However, whether taxa based on different types should be considered heterotypic synonyms, is a matter of debate. The option to display a checklist how it was originally compiled allows authors to deviate from the central thesaurus. This is a way to express different taxonomic opinion, an option to display

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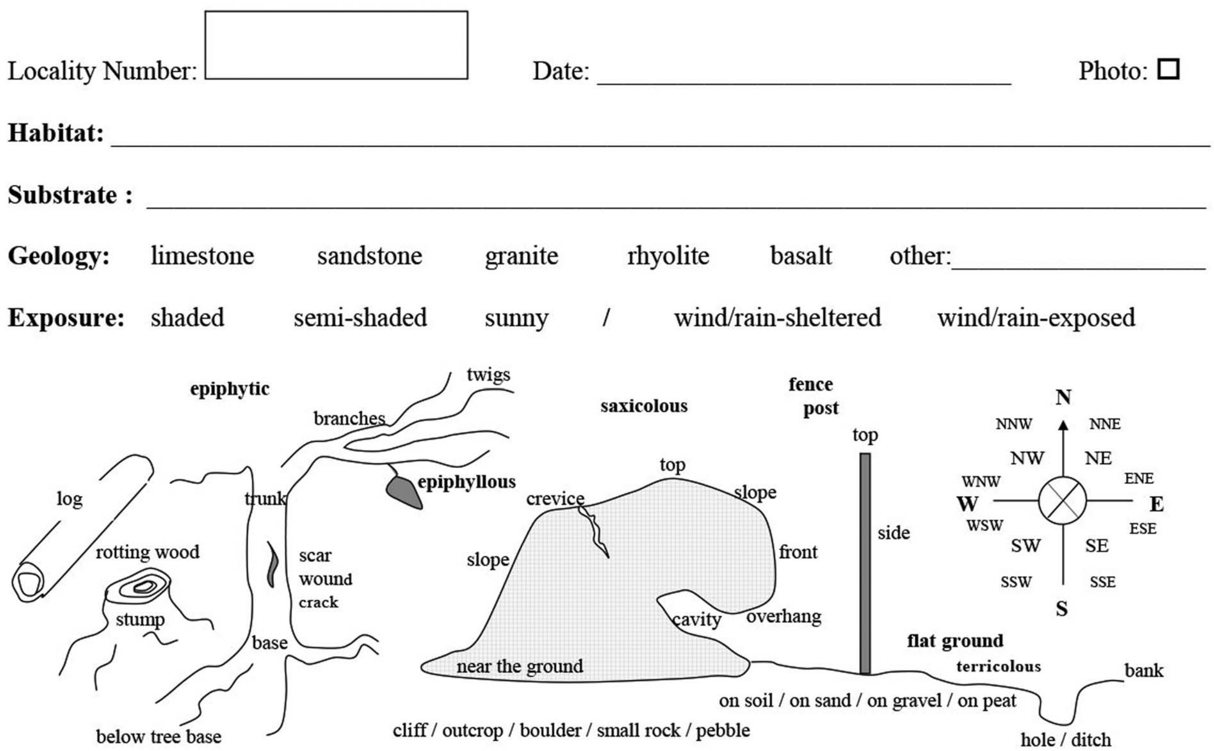

Figure 7. A simple data collection form used during the Galapagos Lichen Inventory, designed to rapidly record standardized macro- and microhabitat information in the field. Although the ecological data collected this way cannot replace ecological studies, a minimum of habitat data can nevertheless efficiently be recorded as part of a collection routine. This standardized habitat data can be parsed out from databases and may help to better assess ecological preferences of species included in biodiversity surveys.

checklists either as 'originally entered' or 'according to the central thesaurus'. However, this option may result in different statistics, for example: is a particular taxon to be considered a synonym and thus not counted as a distinct species; or should that taxon be considered distinct and counted as a separate species? For the end user the different display options and, as a result, different statistics may be confusing.

For practical purposes, the Checklist of Ecuador (Yánez-Ayabaca *et al.* 2023) therefore follows the central thesaurus of the Consortium; all names uploaded in batch were matched against the thesaurus; names manually added were also compared against this currently accepted taxonomy. In both cases, accepted names and their synonyms were checked against both Index Fungorum and MycoBank, as well as current scientific literature, to reach a pragmatic consensus. This doesn't mean that all species names reported from Ecuador in the scientific literature could be resolved. However, the system provides options to add comments regarding which names are considered problematic, and for what particular reason. Checklists are thus to be considered research tools. They should be used to further investigate the basis of records of names included in these lists. They are essentially research hypotheses about the biodiversity in a particular country or region. Some of these records (such as *Dolichousnea longissima*) will ultimately need to be treated as erroneously reported, and then added to a Symbiota species exclusion list.

Conclusions

Compiling species checklists using a database system such as Symbiota is an efficient way of managing large biodiversity data sets, emphasizing occurrence records based on critically selected voucher specimens from participating natural history collections. These records can be augmented by species cited in the literature, which reflects a more traditional approach to publishing checklists. Primarily designed to allow efficient updating of checklists, Symbiota can nevertheless be used to generate versioned checklists utilizing built-in reports. Using the taxonomic thesaurus of the system provides efficient ways to keep track of taxonomic change. Although taxonomic consensus may not generally be possible, the system provides tools to accommodate different opinions. We believe creating checklists using platforms like Symbiota should be more widely considered by the scientific community, especially when dealing with previously much-neglected species groups like lichenized fungi in megadiverse countries like Ecuador. Ultimately, combining different checklists has the potential to better aggregate biodiversity information for these much-neglected groups, across regions and political boundaries, reaching a broader consensus of what is currently known, potentially even at a global scale.

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Online Resources. **CDF dataZone:** https://www.darwinfoundation.org/en/datazone
Consortium of Lichen Herbaria: https://lichenportal.org/
fdex: https://www.mycoportal.org/fdex/
GBIF: https://www.gbif.org/
Index Fungorum: http://www.indexfungorum.org/
ITALIC 7.0: https://italic.units.it/
LIAS: http://www.lias.net/
MycoBank: https://www.mycobank.org/
SEINet Portal Network: https://swbiodiversity.org
Symbiota: https://symbiota.org/

Supplementary Material. The Supplementary Material for this article can be found at https://lichenportal.org/portal/checklists/checklist.php?clid=1283 and (with an explanation of Files S1–4 below) at https://doi.org/10.1017/S0024282923000476.

Supplementary Material File S1. 2023-05-02_Yanez-Ayabaca_etal_Symbiota-Checklist_Lichens-Ecuador_ version_1.pdf
This document is a PDF of the checklist of the checklist of *Lichen-forming, Lichenicolous and Allied Fungi of Ecuador* available on the Consortium of Lichen Herbaria. It documents the current version of the checklist at the time of publication; the direct link where this webpage can be accessed: https://lichenportal.org/portal/checklists/checklist.php?clid=1283.

Supplementary Material File S2. DarwinCore-archive_linked-vouchers_ Symbiota-Checklist_Lichens-Ecuador_version_1_UTF-8.zip
A complete set of the raw data checklist data in Darwin Core Archive format (DWC-A), with the following files:
- CITEME.txt – how to credit the data download.
- eml.xml and meta.xml – metadata schemas explaining the Darwin Core format in XML.
- identifications.csv – specimen identifications of the vouchers used to compile the checklist.
- multimedia.csv – image library links.
- occurrences.csv – occurrence records of the vouchers included in the checklist.

Supplementary Material File S3. Full-Species-List_vouchers_Symbiota-Checklist_Lichens-Ecuador_ version_1_UTF-8.csv
Raw checklist data in a single spreadsheet (flat file in CSV format, i.e., comma separated values). For each species included in the checklist, occurrence records used as vouchers are necessarily repeated. Species names with several vouchers are necessarily duplicated.

Supplementary Material File S4. Full-Species-List_Symbiota-Checklist_ Lichens-Ecuador_version_ 1_UTF-8.csv
Raw checklist data without vouchers in a single spreadsheet (flat file in CSV format, i.e., comma separated values). This table includes just the list of names with comments and references, but without any vouchers.

References

Ahti T (2000) Cladoniaceae. *Flora Neotropica* **78**, 1–362.

Aptroot A and Bungartz F (2007) The lichen genus *Ramalina* on the Galapagos. *Lichenologist* **39**, 519–542.

Aptroot A and Lücking R (2016) A reversionary synopsis of the *Trypetheliaceae* (*Ascomycota*: *Trypetheliales*). *Lichenologist* **48**, 763–982.

Aptroot A and Sparrius L (2008) Crustose *Roccellaceae* in the Galapagos Islands, with the new species *Schismatomma spierii*. *Bryologist* **111**, 659–666.

Aptroot A, Sparrius LB, LaGreca S and Bungartz F (2008) *Angiactis*, a new crustose lichen genus in the family *Roccellaceae* with species from Bermuda, the Galápagos Islands, and Australia. *Bryologist* **111**, 510–516.

Archer AW and Elix JA (2014) A new species and three new reports of *Pertusaria* in Australia (lichenized *Ascomycota*, *Pertusariaceae*). *Australasian Lichenology* **75**, 28–41.

Archer AW and Elix JA (2018) New combinations of Australian species in the genus *Lepra* Scop. *Australasian Lichenology* **82**, 130–136.

Arnold F (1884) Die Lichenen der fränkischen Jura. *Flora* (*Regensburg*) **67**, 227–258.

Bates ST (2023) *fdex: a simplified names database, primarily for projecting taxonomic hierarchy of fungal taxa. fdex aggregated data: Index Fungorum API (accessed 10 August 2022) and MycoBank export download ('8th of June 2021' version)*. Purdue University Northwest, Hammond. [WWW resource] URL https://www.mycoportal.org/fdex/. [Accessed 2 May 2023].

Bell ME and Landrum LR (2021) Making Checklists with the SEINet Database/Symbiota Portals. *Canotia* **17**, 1–24.

Bendiksby M, Mazzoni S, Jørgensen MH, Halvorsen R and Holien H (2014) Combining genetic analyses of archived specimens with distribution modeling to explain the anomalous distribution of the rare lichen *Staurolemma omphalarioides*: long-distance dispersal or vicariance? *Journal of Biogeography* **41**, 2020–2031.

Benítez Á, Prieto M, González Y and Aragón G (2012) Effects of tropical montane forest disturbance on epiphytic macrolichens. *Science of the Total Environment* **441**, 169–175.

Benítez A, Prieto M and Aragón G (2015) Large trees and dense canopies: key factors for maintaining high epiphytic diversity on trunk bases (bryophytes and lichens) in tropical montane forests. *Forestry* **88**, 521–527.

Benítez A, Aragón G, González Y and Prieto M (2018) Functional traits of epiphytic lichens in response to forest disturbance and as predictors of total richness and diversity. *Ecological Indicators* **86**, 18–26.

Benítez Á, Aragón G and Prieto M (2019) Lichen diversity on tree trunks in tropical dry forests is highly influenced by host tree traits. *Biodiversity and Conservation* **28**, 2909–2929.

Brown Z, Tan E and Seltmann K (2018) Ants of Santa Barbara County, California. Symbiota Checklist. *UC Santa Barbara Collection Network*. [WWW resource] URL https://symbiota.ccber.ucsb.edu/checklists/checklist.php?cl=11. [Accessed 2 May 2023].

Brown Z, Tan E and Seltmann K (2020) *Progress toward an inventory of the ants (*Hymenoptera_ Formicidae*) of Santa Barbara County, California*. UC Santa Barbara, Cheadle Center for Biodiversity and Ecological Restoration. [WWW document] URL https://escholarship.org/uc/item/20q4n7xx. [Accessed 2 May 2023].

Bungartz F (2008) Cyanolichens of the Galapagos Islands – the genera *Collema* and *Leptogium*. *Sauteria* **15**, 139–158.

Bungartz F, Lücking R and Aptroot A (2009) The lichen family *Graphidaceae* (*Ostropales*, *Lecanoromycetes*) in the Galapagos Islands. *Nova Hedwigia* **90**, 1–44.

Bungartz F, Ziemmeck F, Tirado N, Jaramillo P, Herrera H and Jiménez-Uzcátegui G (2012) The neglected majority: biodiversity inventories as an integral part of conservation biology. In Wolff M and Gardener M (eds), *The Role of Science for Conservation*. London: Routledge, pp. 137–160.

Bungartz F, Benatti MN and Spielmann AA (2013*a*) The genus *Bulbothrix* (*Parmeliaceae*, *Lecanoromycetes*) in the Galapagos Islands: a case study of superficially similar, but overlooked macrolichens. *Bryologist* **116**, 358–372.

Bungartz F, Dután-Patiño VL and Elix JA (2013*b*) The lichen genera *Cryptothecia*, *Herpothallon* and *Helminthocarpon* (*Arthoniales*) in the Galapagos Islands, Ecuador. *Lichenologist* **45**, 739–762.

Bungartz F, Hillmann G, Kalb K and Elix JA (2013*c*) Leprose and leproid lichens of the Galapagos with a particular focus on *Lepraria* (*Stereocaulaceae*) and *Septotrapelia* (*Pilocarpaceae*). *Phytotaxa* **150**, 1–28.

Bungartz F, Ziemmeck F, Yánez Ayabaca A, Nugra F and Aptroot A (2013*d*) CDF Checklist of Galapagos lichenized Fungi. In Bungartz F, Herrera H, Jaramillo P, Tirado N, Jiménez-Uzcátegui H, Ruiz D, Guézou A and Ziemmeck F (eds), *Charles Darwin Foundation Galapagos Species Checklist*. Puerto Ayora: Charles Darwin Foundation. [WWW document] URL https://www.darwinfoundation.org/en/datazone/checklist. [Accessed 3 December 2013].

Bungartz F, Elix JA, Yánez-Ayabaca A and Archer AW (2015) Endemism in the genus *Pertusaria* (*Pertusariales*, lichenized *Ascomycota*) from the Galapagos Islands. *Telopea* **18**, 325–369.

Bungartz F, Giralt M, Sheard J and Elix JA (2016*a*) The lichen genus *Rinodina* (*Physciaceae*, *Teloschistales*) in the Galapagos Islands, Ecuador. *Bryologist* **119**, 60–93.

Bungartz F, Elix JA, Kalb K and Giralt M (2016*b*) New and overlooked species from the Galapagos Islands: the generic concept of *Diploicia* reassessed. *Lichenologist* **48**, 489–515.

Bungartz F, Truong C, Herrera-Campos MA and Clerc P (2018) The genus *Usnea* (*Parmeliaceae*, *Lecanoromycetes*) in the Galapagos Islands. *Herzogia* **31**, 571–629.

Bungartz F, Elix JA and Printzen C (2020*a*) Lecanoroid lichens in the Galapagos Islands: the genera *Lecanora*, *Protoparmeliopsis*, and *Vainionora* (*Lecanoraceae*, *Lecanoromycetes*). *Phytotaxa* **431**, 1–85.

Bungartz F, Søchting U and Arup U (2020*b*) *Teloschistaceae* (lichenized *Ascomycota*) from the Galapagos Islands: a phylogenetic revision based on morphological, anatomical, chemical, and molecular data. *Plant and Fungal Systematics* **65**, 515–576.

Bungartz F, Ziemmeck F, Yánez-Ayabaca A and Nugra F (2023) Lichen-forming, lichenicolous and allied fungi from Galapagos (Ecuador). Symbiota Checklist. *Consortium of Lichen Herbaria*. URL https://lichenportal.org/portal/checklists/checklist.php?clid=1278&pid. [Accessed 2 May 2023].

Burgaz AN (2006) Check-list of lichenized and lichenicolous fungi of Madrid Community (Spain). *Flora Mediterranea* **16**, 57–110.

Bustamante A, Gusmán E and Benítez Á (2018) Primeros registros de los géneros *Phyllopeltula* y *Reimnitzia* (líquenes epífitos) para el Ecuador. *Gayana Botanica* **75**, 535–538.

Cevallos G (2012) *Checklist de líquenes y hongos liquenícolas de Ecuador continental*. Master's thesis, Universidad Rey Juan Carlos (Madrid).

Charles Darwin Foundation (2023) dataZone. URL https://www.darwinfoundation.org/en/datazone. [Accessed 5 March 2023].

Clark DE and May RM (2002) Taxonomic bias in conservation research. *Science* **297**, 191–192.

Consortium of Lichen Herbaria (2023) *Consortium of Lichen Herbaria – building a Global Consortium of Bryophytes and Lichens as keystones of cryptobiotic communities*. [WWW resource] URL https://lichenportal.org/. [Accessed 5 March 2023].

Cossu TA, Lücking R, Vargas-Estupiñán N, Carreto J, Vasco-Palacios AM, Moncada B, Kirk P, de Almeida RF, Gaya E, Coca LF, *et al.* (2022) Annotated checklist of fungi of Colombia. In de Almeida RF, Lücking R, Vasco-Palacios A, Gaya E and Diazgranados M (eds), *Catalogue of Fungi of Colombia*. Kew: Royal Botanic Gardens, pp. 209–510.

Crous PW, Gams W, Stalpers JA, Robert V and Stegehuis G (2004) MycoBank: an online initiative to launch mycology into the 21st century. *Studies in Mycology* **50**, 19–22.

Culberson WL, Egan RS, Esslinger TL, Hodkinson BP and Lendemer JC (2021) *Recent literature on lichens*. [WWW resource] URL https://nhm2.uio.no/lichens/rll.html. [Accessed 5 March 2023].

Dal Forno M, Lawrey JD, Moncada B, Bungartz F, Grube M, Schuettpelz E and Lücking R (2022) DNA barcoding of fresh and historical collections of lichen-forming basidiomycetes in the genera *Cora* and *Corella* (*Agaricales*: *Hygrophoraceae*): a success story? *Diversity* **14**, 284.

Diederich P, Millanes AM, Wedin M and Lawrey JD (2022) *Flora of Lichenicolous Fungi. Volume 1:* Basidiomycota. Luxembourg: National Museum of Natural History.

Diels L (1937) Beiträge zur Kenntnis der Vegetation und Flora von Ecuador. *Bibliotheca Botanica* **116**, 1–208.

Elix JA and McCarthy PM (1998) Catalogue of the lichens of the smaller Pacific Islands. *Bibliotheca Lichenologica* **70**, 1–361.

Environment Australia (eds) (1998) *The Darwin Declaration*. Australian Biological Resources Study, Environment Australia, Canberra. URL https://www.dcceew.gov.au/science-research/abrs/publications/darwin. [Accessed 24 October 2022].

Esslinger T (2021) A Cumulative Checklist for the Lichen-Forming, Lichenicolous and Allied Fungi of the Continental United States and Canada, Version 24. *Opuscula Philolichenum* **20**, 100–394 (first version of this checklist published online 1997; being updated at irregular intervals at https://www.ndsu.edu/pubweb/~esslinge/chcklst/chcklst7.htm. [Accessed 24 October 2022] and simultaneously published in *Opuscula Philolichenum*).

Etayo J (2017) Hongos liquenícolas de Ecuador. *Opera Lilloana* **50**, 1–535.

Fernández-Prado N, Prieto M, Martínez I and Aragón G (2022) Líquenes epífitos de los Tepuyes de la cuenca alta del río Nangaritza, cordillera del Cóndor (Ecuador). *Caldasia* **44**, 108–118 (incl. Material Suplementario; http://www.revistas.unal.edu.co/index.php/cal).

Fernández-Prado N, Aragón G, Prieto M, Benítez A and Martínez I (2023) Differences in epiphytic trunk communities in secondary forests and plantations of southern Ecuador. *Forestry* **96**, 20–36.

Ferraro LI and Lücking R (2005) The genus *Gomphillus* (*Ostropales*: *Gomphillaceae*) in the Americas, with the new species *Gomphillus pedersenii* from Argentina. *Bryologist* **108**, 491–496.

Feuerer T (ed.) (2007) *Checklists of lichens and lichenicolous fungi. Version* 1 *May* 2007. [WWW resource] URL https://web.archive.org/web/20070513190414/http://www.checklists.de/. [Accessed 8 May 2018].

Feuerer T and Hawksworth D (2007) Biodiversity of lichens, including a world-wide analysis of checklist data based on Takhtajan's floristic regions. *Biodiversity and Conservation* **16**, 85–98.

Franz N, O'Brian CW, Shirota SD, Shillingburg MT and Gilbert EE (2014) Assembling a virtual Weevils of North America checklist with Symbiota – preliminary insights. In *Proceedings of the* 12*th Biennial Conference of Research on the Colorado Plateau*. Reston, Virginia: US Geological Survey, pp. 49–59.

Frisch A (2007) *Compsocladium kalbii* sp. nov. from the Ecuadorian Andes. *Bibliotheca Lichenologica* **96**, 73–86.

Galloway DJ (1985) Nomenclatural notes on *Pseudocyphellaria* II: some Southern Hemisphere taxa. *Lichenologist* **17**, 303–307.

Galloway DJ and Arvidsson L (1990) Studies in *Pseudocyphellaria* (Lichens) II. Ecuadorian species. *Lichenologist* **22**, 103–135.

Gaya E (2021) Keynote Presentation. Yellow, orange, red alert: how to make sense of processes of diversification and genera delimitation in the *Teloschistaceae*. In *The* 9*th Symposium of the International Association for Lichenology Program and Abstract Book*, p. 58.

Gierl C and Kalb K (1993) Die Flechtengattung *Dibaeis*. Eine Übersicht über die rosafrüchtigen Arten von *Baeomyces* sens. lat. nebst Anmerkungen zu *Phyllobaeis* gen. nov. *Herzogia* **9**, 593–645.

González Y, Aragón G, Benítez A and Prieto M (2017*a*) Changes in soil cryptogamic communities in tropical Ecuadorean páramos. *Community Ecology* **18**, 11–120.

González Y, Aragón G, Burgaz AR and Prieto M (2017*b*) Records of terricolous lichens from páramos of southern Ecuador. *Mycotaxon* **132**, 153–175.

González Y, Aragón G and Prieto M (2019) Nuevos registros de líquenes terrícolas en los páramos ecuatorianos. *Caldasia* **41**, 445–449.

Gries C, Gilbert EE and Franz NM (2014) Symbiota – a virtual platform for creating voucher-based biodiversity information communities. *Biodiversity Data Journal* **2**, e1114.

Gueidan C and Li L (2022) A long-read amplicon approach to scaling up the metabarcoding of lichen herbarium specimens. *MycoKeys* **86**, 195–212.

Gueidan C, Elix JA, McCarthy PM, Roux C, Mallen-Cooper M and Kantvilas G (2019) PacBio amplicon sequencing for metabarcoding of mixed DNA samples from lichen herbarium specimens. *MycoKeys* **53**, 73–91.

Hale MA (1975) Revision of the lichen genus *Hypotrachyna* (*Parmeliaceae*) in Tropical America. *Smithsonian Contributions to Botany* **25**, 1–73.

Hawksworth D, James P, and Coppins B (1980) Checklist of British lichen-forming, lichenicolous and allied fungi. *Lichenologist* **12**, 1–115.

Hurtado P, Aragón G, Martínez I, Mayrhofer H and Prieto M (2023) The epiphytic lichens on *Fagus sylvatica* L. in beech forests of Europe: towards an open and dynamic checklist. *Mediterranean Botany* **44**, e84299.

Index Fungorum Partnership (2023) *Index Fungorum*. [WWW resource] URL http://www.indexfungorum.org [Accessed 5 March 2023].

Johnston MA, Aalbu RL and Franz NM (2018) An updated checklist of the *Tenebrionidae* sec. Bousquet et al. 2018 of the Algodones Dunes of California, with comments on checklist data practices. *Biodiversity Data Journal* **6**, e24927.

Jørgensen PM (1973) On some *Leptogium* species with short *Mallotium* hairs. *Svensk Botanisk Tidskrift* **67**, 53–58.

Jørgensen PM (1975) Contributions to a monograph of the *Mallotium*-hairy *Leptogium* species. *Herzogia* **3**, 433–460.

Jørgensen PM (1989) *Omphalina foliacea*, a new basidiolichen from America. *Nordic Journal of Botany* **9**, 85–95.

Jørgensen PM (1997) Further notes on hairy *Leptogium* species. *Symbolae Botanicae Upsalienses* **32**, 113–130.

Jørgensen PM (1998) *Acantholichen pannarioides*, a new basidiolichen from South America. *Bryologist* **101**, 444–447.

Kistenich S, Halvorsen R, Schrøder-Nielsen A, Thorbek L, Timdal E and Bendiksby M (2019) DNA sequencing historical lichen specimens. *Frontiers of Ecology and Evolution* **7**, 5.

Knudsen K, Elix JA and Reeb V (2008) A preliminary study of the genera *Acarospora* and *Pleopsidium* in South America. *Opuscula Philolichenum* **5**, 1–22.

Kondratyuk SY, Lőkös L, Farkas E, Jang SH, Liu D, Halda J, Persson PE, Hansson M, Kärnefelt I, Thell A, *et al.* (2019*a*) Three new genera of the *Ramalinaceae* (lichen-forming *Ascomycota*) and the phenomenon of presence of 'extraneous mycobiont DNA' in lichen associations. *Acta Botanica Hungarica* **61**, 275–323.

Kondratyuk SY, Lőkös L, Jang SH, Hur JS and Farkas E (2019*b*) Phylogeny and taxonomy of *Polyozosia*, *Sedelnikovaea* and *Verseghya* of the *Lecanoraceae* (*Lecanorales*, lichen-forming *Ascomycota*). *Acta Botanica Hungarica* **61**, 137–184.

Kondratyuk SY, Lőkös L, Kondratiuk AS, Kärnefelt I, Thell A, Farkas E and Hur JS (2022) Contributions to molecular phylogeny of lichens 3: new monophyletic branches of the *Trapeliaceae* and *Xylariaceae*. *Acta Botanica Hungarica* **64**, 97–135.

Leighton WA (1866) XVII. Lichenes Amazonici et Andini lecti a Domino Spruce. *Transactions of the Linnean Society of London* **25**, 433–460.

Linnaeus C (1753) *Species Plantarum, Vol. 1*. Stockholm: L. Salvii.

Llewellyn T (2019) *Revisiting generic concepts in the* Teloschistaceae *(lichen-forming* Ascomycota*) using molecular phylogenetics, algorithmic taxa delimitation and molecular networks*. Master's thesis, Queen Mary University of London.

Lücking R (1999) Foliicolous lichens and their lichenicolous fungi from Ecuador, with a comparison of lowland and montane rain forest. *Willdenowia* **29**, 299–335.

Lücking R (2008) Foliicolous lichenized fungi. *Flora Neotropica* **103**, 1–866.

Lücking R, Sérusiaux E and Vězda A (2005) Phylogeny and systematics of the lichen family *Gomphillaceae* (*Ostropales*) inferred from cladistic analysis of phenotype data. *Lichenologist* **37**, 123–170.

Magain N, Truong C, Goward T, Niu D, Goffinet B, Sérusiaux E, Vitikainen O, Lutzoni F and Miadlikowska J (2018) Species delimitation at a global scale reveals high species richness with complex biogeography and patterns of symbiont association in *Peltigera* section *Peltigera* (lichenized *Ascomycota*: *Lecanoromycetes*). *Taxon* **67**, 836–870.

Magain N, Miadlikowska J, Goffinet B, Goward T, Pardo-De la Hoz CJ, Jüriado I, Simon A, Mercado-Diaz J, Barlow T, Moncada B, *et al.* (2023) High species richness in the lichen genus *Peltigera* (*Ascomycota*, *Lecanoromycetes*): 34 species in the dolichorhizoid and scabrosoid clades of sect. *Polydactylon*, including 24 new to science. *Persoonia* (in press).

Magnusson AH and Zahlbruckner A (1944) Hawaiian lichens. II. The families *Lecideaceae* to *Parmeliaceae*. *Arkiv för Botanik* **31A**, 1–109.

Mandl N (2007) *Bryophyte and macrolichen diversity of the* Purdiaea nutans *forest in southern Ecuador and its relationship to soil, climate, and vegetation structure*. Ph.D. thesis, Georg-August Universität zu Göttingen.

May TW, Redhead SA, Bensch K, Hawksworth DL, Lendemer J, Lombard L and Turland NJ (2019) Chapter F of the *International Code of Nomenclature for algae, fungi, and plants* as approved by the 11th International Mycological Congress, San Juan, Puerto Rico, July 2018. *IMA Fungus* **10**, 21.

Mittermeier RA, Robles-Gil P and Mittermeier CG (eds) (1997) *Megadiversity: Earth's Biologically Wealthiest Nations*. Mexico City: Cemex.

Mittermeier RA, Myers N, Thomsen JB, da Fonseca GAB and Olivieri S (1998) Biodiversity hotspots and major tropical wilderness areas: approaches to setting conservation priorities. *Conservation Biology* **12**, 516–520.

Moberg R (1990) The lichen genus *Physcia* in Central and South America. *Nordic Journal of Botany* **10**, 319–342.

Moncada B (2012) *El género* Sticta *(Schreb.) Ach. en Colombia: taxonomía, ecogeografía e importancia*. Ph.D. thesis, Universidad Nacional de Colombia (Bogotá).

Moncada B and Lücking R (2012) Ten new species of *Sticta* and counting: Colombia as a hot spot for unrecognized diversification in a conspicuous macrolichen genus. *Phytotaxa* **74**, 1–29.

Moncada B, Mercado-Díaz JA, Smith CW, Bungartz F, Sérusiaux E, Lumbsch HT and Lücking R (2021) Two new common, previously unrecognized species in the *Sticta weigelii* morphodeme (*Ascomycota*: *Peltigeraceae*). *Willdenowia* **51**, 35–45.

https://doi.org/10.1017/S0024282923000476 Published online by Cambridge University Press

Mongkolsuk P, Meesim S, Poengsungnoen V, Kawinnat B, Schumm F and Kalb K (2015) The lichen family *Physciaceae* in Thailand – II. Contributions to the genus *Heterodermia* sensu lato. *Phytotaxa* **235**, 1–66.

Mueller GM, Cunha KM, May TW, Allen JL, Westrip JRS, Canteiro C, Costa-Rezende DH, Drechsler-Santos ER, Vasco-Palacios AM, Ainsworth AM, *et al.* (2022) What do the first 597 global fungal Red List assessments tell us about the threat status of Fungi? *Diversity* **14**, 2–23.

Müller J (1879) Lichenes æquinoctiali-americani: a Cl. Ed. André, annis 1875–1876, praesertim in editioribus Ecuador (E.) et in Nova Granata (N. Gr.) lecti. *Revue Mycologique* **1**, 163–171.

Nash TH, III, Gries C and Elix JA (1995) A revision of the lichen genus *Xanthoparmelia* in South America. *Bibliotheca Lichenologica* **56**, 1–157.

Navás L (1908) Algunos líquenes sudamericanos. *Boletín de la Real Sociedad Española de Historia Natural* **8**, 394–399.

Nöske NM (2005) *Effekte anthropogener Störung auf die Diversität kryptogamischer Epiphyten (Flechten, Moose) in einem Bergregenwald in Südecuador*. Ph.D. thesis, Georg-August Universität zu Göttingen.

Nöske NM and Sipman HJM (2004) Cryptogams of the Reserva Biológica San Francisco (Province Zamora-Chinchipe, Southern Ecuador) II. Lichens. *Cryptogamie, Mycologie* **25**, 91–100.

Nöske NM, Mandl N and Sipman HJM (2007) Lichenes – checklist Reserva Biológica San Francisco (Prov. Zamora-Chinchipe, S. Ecuador). *Ecotropical Monographs* **4**, 101–117.

Nöske NM, Hilt H, Werner FA, Brehm G, Fiedler K, Sipman HJM and Gradstein SR (2008) Disturbance effects on diversity of epiphytes and moths in a montane forest in Ecuador. *Basic and Applied Ecology* **9**, 4–12.

Nylander W (1874) Animadversiones circa Spruce Lichenes Amazonicos et Andinos. *Flora* (*Regensburg*) **57**, 70–73.

Ochoa-Jiménez DA, Cueva-Agila A, Prieto M, Aragón G and Benítez Á (2015) Changes in the epiphytic lichen composition related with air quality in the city of Loja (Ecuador). *Caldasia* **37**, 333–343.

Paredes Martínez ET (2006) Macrolichens of the Ecological Reserve Páramo El Ángel and the Guandera Biological Station. *Lyonia* **9**, 67–73.

Printzen C, Brackel W von, Bültmann H, Cezanne R, Dornes P, Eckstein J, Eichler M, John V, Killmann D, Nimis PL, *et al.* (2022) Die Flechten, flechtenbewohnenden und flechtenähnlichen Pilze Deutschlands – eine überarbeitete Checkliste. *Herzogia* **35**, 193–393.

Redchenko O, Vondrák J and Košnar J (2012) The oldest sequenced fungal herbarium sample. *Lichenologist* **44**, 715–718.

Roumeguère C (1879) Les lichens Neo-Grenadins et Ecuadoriens, récoltés par M. Ed. André. *Revue Mycologique* **1**, 160–162.

Schmull M, Dal-Forno M, Lücking R, Cao S, Clardy J and Lawrey JD (2014) *Dictyonema huaorani* (*Agaricales*: *Hygrophoraceae*), a new lichenized basidiomycete from Amazonian Ecuador with presumed hallucinogenic properties. *Bryologist* **117**, 386–394.

Schwendener S (1867) Über die wahre Natur der Flechtengonidien. *Verhandlungen der Schweizerischen Naturforschenden Gesellschaft* **57**, 9–11.

Secretariat of the Convention of Biological Diversity (1992) Section I: Convention on Biological Diversity, 5 June 1992. In Secretariat of the Convention of Biological Diversity (eds), Handbook of the Convention on Biological Diversity. London: Earthscan Publications, pp. 3–28.

Smith EB, Johnston MK and Lücking R (2016) From GenBank to GBIF: phylogeny-based predictive niche modeling tests accuracy of taxonomic identifications in large occurrence data repositories. *PLoS ONE* **11**, e0151232.

Sohrabi M, Myllys L and Stenroos S (2010) Successful DNA sequencing of a 75 year-old herbarium specimen of *Aspicilia aschabadensis* (J. Steiner) Mereschk. *Lichenologist* **42**, 626–628.

Sommerfelt C (1826) *Supplementum Florae Lapponicae, quam edidit Dr. Georgius Wahlenberg*. Christianiae: Typis Borgianis et Gröndahlianis.

Spribille T, Tuovinen V, Resl P, Vanderpool D, Wolinski H, Aime MC, Schneider K, Stabentheiner E, Toome-Heller M, Thor G, *et al.* (2016) Basidiomycete yeasts in the cortex of ascomycete macrolichens. *Science* **353**, 488–492.

Swinscow T and Krog H (1979) *Macrolichens of East Africa*. London: British Museum (Natural History).

Tagirdzhanova G, Saary P, Cameron ES, Garber AI, Díaz Escandón D, Goyette S, Tuovinen Nogerius V, Passo A, Mayrhofer H, Holien H, *et al.* (2023) Evidence for a core set of microbial lichen symbionts from a global survey of metagenomes. *bioRxiv*, preprint doi: https://doi.org/10.1101/2023.02.02.524463.

Tehler A (2007) The *Roccella lirellina* and *R. galapagoensis* aggregates, taxonomy and nomenclature. *Bibliotheca Lichenologica* **95**, 517–530.

Tehler A, Irestedt M, Bungartz F and Wedin M (2009) Evolution and reproduction modes in the *Roccella galapagoensis* aggregate (*Roccellaceae*, *Arthoniales*). *Taxon* **58**, 438–456.

Turland NJ, Wiersema JH, Barrie FR, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Kusber W-H, Li D-Z, Marhold K, *et al.* (eds) (2018) International Code of Nomenclature for Algae, Fungi, and Plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Regnum Vegetabile No. 159. Glashütten: Koeltz Botanical Books.

van den Boom PPG and Elix JA (2022) New records of buellioid (*Caliciaceae*, *Ascomycota*) and *Rinodina* lichens (*Physciaceae*, *Ascomycota*) from the Caribbean and Ecuador. *Herzogia* **35**, 630–635.

van den Boom P, Divakar P, Ertz D, Etayo J, Moberg R and Sipman HJM (2022) New or otherwise interesting records of lichens and lichenicolous fungi from mainland Ecuador and surroundings with descriptions of five new species. *Acta Botanica Hungarica* **64**, 417–450.

Vega M, Déleg J and Benítez Á (2021) Primer registro del liquen *Pyrenula hirsuta* para Sudamérica. *Neotropical Biodiversity* **7**, 75–77.

von Humboldt A and Bonpland A (1807) *Essai sur la Géographie des Plantes Accompagné d'un Tableau Physique des Régions équinoxiales*. Paris: Levrault.

Vondrák J, Shahidin H, Moniri MH, Halıcı G and Košnar J (2018) Taxonomic and functional diversity in *Calogaya* (lichenised *Ascomycota*) in dry continental Asia. *Mycological Progress* **17**, 897–916.

Weber WA (1966) Lichenology and bryology in the Galapagos Islands, with checklists of the lichens and bryophytes thus far reported. In Bowman RI (ed.), *The Galápagos. Proceedings of the Symposium of the Galápagos International Scientific Project*. Berkeley: University of California Press, pp. 197–200.

Weber WA (1986) The lichen flora of the Galápagos Islands, Ecuador. *Mycotaxon* **27**, 451–497.

Weber WA (1993) Additions to the Galápagos and Cocos Islands lichen and bryophyte floras. *Bryologist* **96**, 431–434.

Westberg M, Moberg R, Myrdal M, Nordin A and Ekman S (2021) *Santesson's Checklist of Fennoscandian Lichen-forming and Lichenicolous Fungi*. Uppsala: Museum of Evolution, Uppsala University.

Wilk K, Pabijan M, Saługa M, Gaya E and Lücking R (2021) Phylogenetic revision of South American *Teloschistaceae* (lichenized *Ascomycota*, *Teloschistales*) reveals three new genera and species. *Mycologia* **113**, 278–299.

Yánez-Ayabaca A (2009) *Os Gêneros* Hypotrachyna *e* Everniastrum *(*Parmeliaceae, Ascomycota *liquenizados) nas Províncias de Carchi e Imbabura na região Andina do Equador*. Master's thesis, Universidade Federal do Paraná (Curitiba).

Yánez-Ayabaca A and Eliasaro S (2009) *Hypotrachyna carchiensis*, a new species in *Parmeliaceae* from Ecuador. *Mycotaxon* **109**, 337–340.

Yánez-Ayabaca A, Dal-Forno M, Bungartz F and Lücking R (2012) A first assessment of Galapagos basidiolichens. *Fungal Diversity* **52**, 225–244.

Yánez-Ayabaca A, Ahti T and Bungartz F (2013) The family *Cladoniaceae* (*Lecanorales*) in the Galapagos Islands. *Phytotaxa* **129**, 1–33.

Yánez-Ayabaca A, Benítez Chávez Á, Batallas R, Naranjo D, Etayo J, Prieto M, Cevallos G, Caicedo E, Scharnagl K, McNerlin B, *et al.* (2023) Lichen-forming, Lichenicolous and Allied Fungi of Ecuador. Symbiota Checklist. *Consortium of Lichen Herbaria*. URL https://lichenportal.org/portal/checklists/checklist.php?clid=1283. [Accessed 2 May 2023].

Yoshimura I and Arvidsson L (1994) Taxonomy and chemistry of the *Lobaria crenulata* group in Ecuador. *Acta Botanica Fennica* **150**, 223–333.

Zahlbruckner A (1905) Flechten, im Hochlande Ecuadors gesammelt von Prof. D. Hans Meyer im Jahre 1903. *Beihefte zum Botanischen Centralblatt* **19**(2, 1), 75–84.

Zahlbruckner A (1907) *Flechten*. In H. Meyer (ed.), *In den Hoch-Anden von Ecuador*. Berlin: Reimer, pp. 514–516.