

***Parmotrema trippianum* (Parmeliaceae): a Morphologically Distinct New Species in the *P. reticulatum* Complex and Key to North American *Parmotrema* with Salazinic Acid**

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Abstract

Parmotrema trippianum sp. nov. is described as new to science and named in honor of the lichenologist, botanist, and biodiversity scientist Dr. Erin Manzitto-Tripp. The new species grows on rocks in rich, mesic, montane canyons in the Colorado Front Range of the southern Rocky Mountains and the Chiricahua Mountains of Arizona. Phylogenetically, it is a member of the *Parmotrema reticulatum* species complex, and indeed, does share some morphological similarities with members of this species complex, including the production of medullary salazinic acid, reticulate maculae, and submarginal soredia. However, it differs from these and other species by its production of abundant lobules and cortical warts, from which pustular consoredia erupt, these forming large, subarbuscular agglomerations. Nuclear ribosomal Internal Transcribed Spacer phylogenies of closely related species and an identification key to *Parmotrema* with salazinic acid known from North America are presented to facilitate future identification of specimens derived from this diverse group.

Key words: Internal Transcribed Spacer, IUCN conservation assessment, lichenized fungi, pustules, species complex, species description

Introduction

Parmotrema A. Massal. is estimated to be the 10th most diverse genus of lichenized fungi with roughly 300 currently accepted species globally (Lücking *et al.*, 2017). Species are primarily distributed in semiarid, maritime, subtropical, open habitats (Spielmann & Marcelli, 2020). Macromorphologically, most species reproduce asexually and are characterized by broad, loosely attached lobes with rounded, ciliate apices; generally simple rhizines that taper to or are completely absent from the margin; and, if fertile, substipitate or perforate apothecia [as in the type species: *Parmotrema perforatum* (Jacq.) A. Massal.] (Hale, 1974; Louwhoff & Crisp, 2000; Blanco *et al.*, 2005). Micromorphologically, the genus also invariably exhibits an upper cortex of palisade plectenchyma, a pored epicortex, and (usually) large, thick-walled ellipsoid ascospores (Hale, 1973; Elix, 1993; Barbosa & Marcelli, 2010).

Parmotrema is a ‘hyperdiverse’ genus (*sensu* Lücking *et al.*, 2016), and is estimated to have diversified relatively recently, from the middle to late Miocene: ~13 Ma (Amo de Paz *et al.*, 2011) or ~23 Ma (Divakar *et al.*, 2017), suggesting that the genus has exhibited a relatively fast diversification rate, despite its primarily asexual reproductive mode. High diversification rates are a hallmark of Parmeliaceae in general (Huang *et al.*, 2019; Nelsen *et al.*, 2020), likely leading to a considerable number of species complexes and/or cryptic species (see below; Crespo & Pérez-Ortega, 2009), incomplete lineage sorting (Rundell & Price, 2009), hybridization (Keuler *et al.*, 2022), narrow endemism (Bungartz & Spielmann, 2019; Spielmann & Marcelli, 2020), and secondary contact after long-distance dispersal (Del-Prado *et al.*, 2016; Keuler *et al.*, 2020).

The group containing the *Parmotrema reticulatum* (Taylor) M. Choisy species complex has a particularly long and storied taxonomic history. It was first recognized as a subsection: *Parmelia* sect. *Hypotrachyna* **Irregulares* by

Vainio in 1890, who later elevated it to a section *Parmelia* sect. *Irregulares* in 1923. In 1990, it was recognized at the generic level: *Rimelia* Hale & Fletcher, lectotypified by *Parmelia cetrata* Ach. (Hale & Fletcher, 1990). These authors differentiated *Rimelia* from *Parmotrema* primarily by the invariable presence of reticulate maculae (which contributes to the formation of areolate-fissured upper surfaces), some squarrose rhizines, and relatively small, thin-walled ascospores.

Rimelia has since been proposed to be synonymous with *Parmotrema* based on molecular evidence (Blanco *et al.*, 2005). Nonetheless, many species in the group remain somewhat difficult to classify (Spielmann & Marcelli, 2020), particularly *Parmotrema reticulatum* (Hale & Fletcher, 1990; Divakar *et al.*, 2005; Del Prado *et al.*, 2011; 2016; Ahn & Moon, 2016).

Del Prado *et al.* (2011) proposed the presence of eight species-level lineages within *P. reticulatum* (and two in *P. pseudoreticulatum* (Tav.) Hale) that are chemically and morphologically indistinguishable, suggesting a large amount of cryptic diversity in the group. With increased sampling and rigorous genetic distance analyses, the same workers concluded that *P. reticulatum* consists of seven species-level lineages while *P. pseudoreticulatum* is monophyletic (Del Prado *et al.*, 2016). Furthermore, their analyses suggested that complex has a relatively recent origin in the Miocene (~9.6 Ma), which likely contributes to the lack of phenotypic divergence in the group.

Some authors accept *P. clavuliferum* (Räsänen) Streimann as a distinct species within the complex based on its distinctly stalked, capitate soralia produced on long, lacinate lobes that lack rhizines and have a white lower surface (Ahn & Moon, 2016; Bungartz & Spielmann, 2019; Masson *et al.*, 2024), while others do not (Hawksworth *et al.*, 2008; Hale & Fletcher, 1990; Egan *et al.*, 2016). Multiple other species complexes are recognized in *Parmotrema*, including: *P. perforatum* (Widhelm *et al.*, 2016), and *P. crinitum* (Ach.) Choisy (Stelate *et al.*, 2022), *P. tinctorum* (Despr. ex Nyl.) Hale (Roca Valiente *et al.*, 2013), among others (Del Prado *et al.*, 2019). Despite the large range of morphological and ecological diversity exhibited by *Parmotrema reticulatum* s.l., it is still clearly distinguishable from other morphologically similar species, these often endemic to small geographic regions and lacking genetic support (Louwhoff & Elix, 2000; Bungartz & Spielmann, 2019; Spielmann & Marcelli, 2020; Masson *et al.*, 2024).

During general lichen collection efforts throughout the Front Range of Colorado in the southern Rocky Mountains, USA, the first and second authors discovered some populations of an apparently rare saxicolous macrolichen similar to *Parmotrema reticulatum*, but were otherwise unable to arrive at an appropriate determination for the specimens due to a number of differences. Further research confirmed that the specimens represent an undescribed species, which we here name: *Parmotrema trippianum* sp. nov., drawing upon morphological, chemical, ecological, and phylogenetic evidence.

Methods

Field Work—At the time of publication, we are conducting ongoing general (‘floristic’) lichen inventories throughout the public lands of Colorado, including all U.S. Forest Service (USFS) land (including wilderness), Bureau of Land Management (BLM) land, the City of Boulder Open Space and Mountain Parks (OSMP), and Jefferson and Boulder County Open Spaces (JCOS and BCPOS).

This field collection effort has been largely organized and spearheaded by Dr. Erin Manzitto-Tripp as part of an ongoing project to comprehensively document the lichen biota of the southern Rocky Mountains of Colorado. Since the goal of this project is to comprehensively document all lichen species found in Colorado, we are targeting varied, unique, and otherwise lichenologically rich sites. In the field, we utilize ‘expert-based wandering’ and opportunistic collecting of lichens growing on all substrates to efficiently capture as many species as possible with a three-person team (the two first authors and Dr. Manzitto-Tripp). See Manzitto-Tripp & Watts (2025) for a complete list of publications on Colorado lichens to date.

To collect herbarium vouchers, we record latitude, longitude, and habitat characteristics, then use three-pound hammers (i.e., club hammers), rock and wood chisels, and pruning clippers to remove the lichens intact from their substrate. Specimens are transferred first to paper bags, and then to paper packets immediately upon returning from the field, given a collector number, and finally identified and curated for accessioning at the University of Colorado Museum of Natural History Herbarium (COLO Herbarium; Theirs, accessed 2026). When it is difficult to arrive at an appropriate name for the specimen, or the specimen is suspected of being new to science or the region, we subsample it (< 1 cm² of tissue) for DNA extraction and barcoding in the Manzitto-Tripp molecular laboratory at the University of Colorado Boulder, as was done for the current new species.

Lab Work—Dry tissue from five specimens of the new species (*J. Watts 1809, 4616, & 4638* & *S. Raynor 6581 & 6622*) was transferred to round bottom 2 mL microcentrifuge tubes with 2 mm diameter metal beads, treated with liquid nitrogen, and ground to a powder in a Geno/Grindr 2000 (SPEX SamplePrep, Metuchen, NJ, USA). Genomic DNA was extracted via a modified cetyltrimethylammonium bromide (CTAB) method (Doyle & Doyle, 1987). Polymerase Chain Reaction (PCR) was conducted to amplify the nuclear ribosomal Internal Transcribed Spacer (nrITS) gene using ITS4 (5'-TCC TCC GCT TAT TGA TAT GC-3') and ITS5 (5'-GGA AGT AAA AGT CGT AAC AAG G-3') primers manufactured by Integrated DNA Technologies (Coralville, IA) (White *et al.*, 1990). 25 µL reactions were conducted with the following final concentrations in 1X PCR buffer (Invitrogen, Carlsbad, CA, USA): 0.025 U/µL Taq-polymerase, 0.2 mM dNTPs, 0.2 mM forward and 0.2 mM reverse primer, 2.5 mM MgCl₂, 0.4 mg/mL Bovine Serum Albumin (BSA), and 1 µL of genomic template (concentration not measured). Reactions were conducted using T100 Thermal Cyclers (Bio-Rad; Hercules, CA). Reaction conditions were: 3 mins at 95 °C (initial denaturation), followed by 35 cycles of: 1 min at 95 °C (denaturation), 30 secs at 56 °C (annealing), 30 secs at 72 °C (elongation), and finally 10 mins at 72 °C (final elongation). Gel electrophoresis was used to confirm successful amplification and PCR products were cleaned with EXO-SAP. Exonuclease I (EXO) and rShrimp Alkaline Phosphatase (rSAP) were added to the PCR products at 0.4 U/µL and 0.08 U/µL, respectively, and incubated at 37 °C for 30 mins, followed by deactivation at 95 °C for 5 mins. The cleaned PCR products were sent to Eurofins Genomics for bidirectional Sanger Sequencing. Two reads per sample were quality-checked and assembled in CodonCode Aligner (Centerville, MA, USA), and the resultant consensus sequences were used in phylogenetic analyses.

Phylogenetic Analysis—To place the new species in the *Parmotrema reticulatum* species complex, we utilized two nrITS matrices of differing evolutionary extent to estimate two maximum likelihood phylogenetic hypotheses. Both matrices consisted of the five nrITS sequences of *Parmotrema trippianum* *sp. nov.* and then either 1) sequences from *Parmotrema* and closely related genera as outgroups (n = 66 accessions), or 2) nearly all sequences of *P. reticulatum*, *P. pseudoreticulatum*, and *P. clavuliferum* available from Genbank with *P. aff. cetratum* as an outgroup (<https://www.ncbi.nlm.nih.gov/genbank/>) (n = 262 sequences). Approximately 10 sequences that were too short and/or did not align properly because of low sequence quality, etc. were excluded. For clades within the *P. reticulatum* species complex, we numbered clades following Del-Prado *et al.*, (2011), and continued numbering for novel clades uncovered by our phylogenetic analysis. For both matrices, homologous sequences were aligned to each other using Multiple Alignment Fast Fourier Transform MAFFT v.7 and default settings (<https://mafft.cbrc.jp/alignment/server/index.html>) (Katoh & Standley 2013). The alignment was trimmed using PhyDE-1 (<http://www.phyde.de>). Alignment one consisted of 71 terminals and 563 sites while alignment two consisted of 267 terminals and 541 sites. Maximum likelihood methods were implemented to reconstruct phylogenetic relationships using W-IQ-TREE (Nguyen *et al.* 2015; Trifinopoulos *et al.* 2016). Model selection was undertaken to decipher a best fitting model of DNA sequence evolution using Bayesian Information Criterion (BIC) based model selection (Kalyaanamoorthy *et al.* 2017). Support for nodes of the tree were estimated using ultrafast bootstrap support (BS) (Anisimova *et al.* 2011; Minh *et al.* 2013). Support values ≥90% were taken to be indicative of strong support for a given relationship, whereas relationships with values of 80–89% were considered moderately supported, and relationships with values 70–79% were considered weakly supported. For the *Parmotrema* phylogeny, nodes with less than 45% BS were collapsed into polytomies. For the *P. reticulatum* species complex phylogeny, support values for short terminal branches are not shown for simplicity.

Herbarium Study—All specimens held at COLO under the taxon: *Parmotrema reticulatum* and collected in North America (n = 148) were examined for morphological characteristics. We placed particular emphasis on examination of the reproductive propagules. Specimens were annotated when necessary, and those belonging to the new species were noted and set aside for further study (see Selected Specimens Examined, Taxonomy section). All specimens were examined under an Olympus SZX16 stereoscope. Spot tests using standard reagents (K, C, KC, P, N). Thin Layer Chromatography (TLC) in solvent C was conducted following Culberson (1972) and using Elix (2022), Spielmann & Marcelli (2020), and Masson *et al.*, (2024) to identify substances.

Conservation Assessment—We assessed the conservation status of the new species based on guidelines from the International Union for Conservation of Nature (IUCN) (IUCN Standards and Petitions Committee, 2024). Under the guidelines, any species with an estimated population size of 51–250 individuals should be considered Endangered, and any with an estimated population size of ≤ 50 individuals should be considered Critically Endangered. Following Yahr *et al.*, (2024), we considered a single individual as any 1 m² surface (in this case, rock) covered by the lichen being assessed.

Results & Discussion

Results from our phylogenetic analyses suggest that *Parmotrema trippianum* *sp. nov.* represents a moderately supported, reciprocally monophyletic clade amongst closely related species (82% BS, Fig. 1; 81% BS, Fig. 2). Novel sequences generated for this study are archived on GenBank (accession numbers: QB114037–QB114043). Herbarium study demonstrates the species is morphologically and ecologically distinct from all previously described species of *Parmotrema* (Fig. 3; Table 1), as well as all the other salazinic acid-containing *Parmotrema* in North America (See Dichotomous Key). Extensive novel collection efforts targeting steep, montane, north-facing canyon walls of the Colorado Front Range, where the new species is expected to occur, have only yielded two extant populations. A review of COLO specimens revealed an additional nine historical populations, suggesting the species is of great conservation concern, and is therefore assessed as the IUCN Category: Critically Endangered, although we do expect more populations to be discovered in the future (See Fig. 4 for a map of all localities).

TABLE 1. Pustulate-sorediate *Parmotrema* lacking isidia with reticulate maculae, cortical atranorin, and medullary salazinic acid.

	<i>P. trippianum</i>	<i>P. asperum</i>	<i>P. neopustulatum</i>	<i>P. granulare</i>	<i>P. marcellii</i>	<i>P. nudum</i>	<i>P. ruminatum</i>
Cortex	retained	retained	flaking	retained	retained	retained	flaking
Marginal rhizines	present	usually absent	present	absent	absent	absent	absent
Agglomerations	subarbuscular	capitate	capitate	absent	subarbuscular	absent	absent
Laciniae	absent	present	absent	present	absent	absent	absent
Cilia	present	present	present	present	present	present	absent
Distribution	Colorado & Arizona, USA	Brazil	Australia & Philippines	Taiwan	Brazil	Uruguay	Hawaii

The topology of the *Parmotrema* phylogeny is congruent with the most recent worldwide nrITS phylogeny of the genus presented in Masson *et al.*, (2024), although with reduced representation (Fig. 1). *Parmotrema trippianum* is situated within a larger clade with *P. cetratum* (Ach.) Hale and *P. reticulatum* s.l., formerly known as *Rimelia* (Fig. 1; See Introduction), here discussed as the *P. reticulatum* species complex. Within the *Parmotrema reticulatum* species complex, it is most closely related to North American *P. cetratum* and clade 1 of *P. reticulatum* sensu Del-Prado *et al.*, (2011), which each form strongly supported monophyletic clades (Fig. 1). An accession of each *P. subisidiosum* (Müll. Arg.) Hale and *P. hypotropum* (Nyl.) Hale is recovered within the *P. reticulatum* species complex (Fig. 1), suggesting that these specimens may have been misidentified. However, *Parmotrema subisidiosum* does share numerous characteristics with *P. reticulatum* s.l. (rhizines to the margin, reticulate maculae, salazinic acid in the medulla) and may well be another morphologically distinct member of the species complex. South American accessions of *P. cetratum* form a clade distinct from North American *P. cetratum*, suggesting that the fertile counterpart to *P. reticulatum* s.l. may also exhibit some level of cryptic speciation hitherto unexplored. Del-Prado *et al.*, (2019) suggests that this phenomenon may be widespread in *Parmotrema*, including *P. cetratum*. Furthermore, an accession of *P. crinitum* from Colorado is recovered as most closely related to an accession of *P. crinitum* belonging to clade A2 sensu Stelate *et al.*, (2022) (Fig. 1).

With increased and more targeted sampling (n = 262 sequences), *Parmotrema trippianum* *sp. nov.* is still recovered as most closely related to *P. reticulatum* clade 1 (81% BS; Fig. 2). Clades 2 & 3 are sister to clade 1 and *P. trippianum*. *Parmotrema pseudoreticulatum* is recovered as sister to all other clades of *P. reticulatum* s.l. and is made up of two distinct clades (7 & 10) (Fig. 2). *Parmotrema clavuliferum* is most closely related to *P. reticulatum* clade 13 and is in a larger, moderately supported clade with *P. reticulatum* clades 5, 6, & 12 (Fig. 2). Importantly, current global sampling of the *P. reticulatum* species complex is geographically biased, with many accessions from Spain and Portugal, as well as Asia (See Del-Prado *et al.* 2011; 2016; Ahn & Moon, 2016). Most broad floristic regions have at least one sequence, but many remain poorly sampled, thus rendering our knowledge of biogeography and speciation in the complex still incomplete. Furthermore, the nrITS barcode remains by far the best-sequenced gene for the *Parmotrema reticulatum* species complex, which limits our understanding of the evolutionary processes that may underly cryptic speciation in these closely related organisms (Kausarud, 2023).

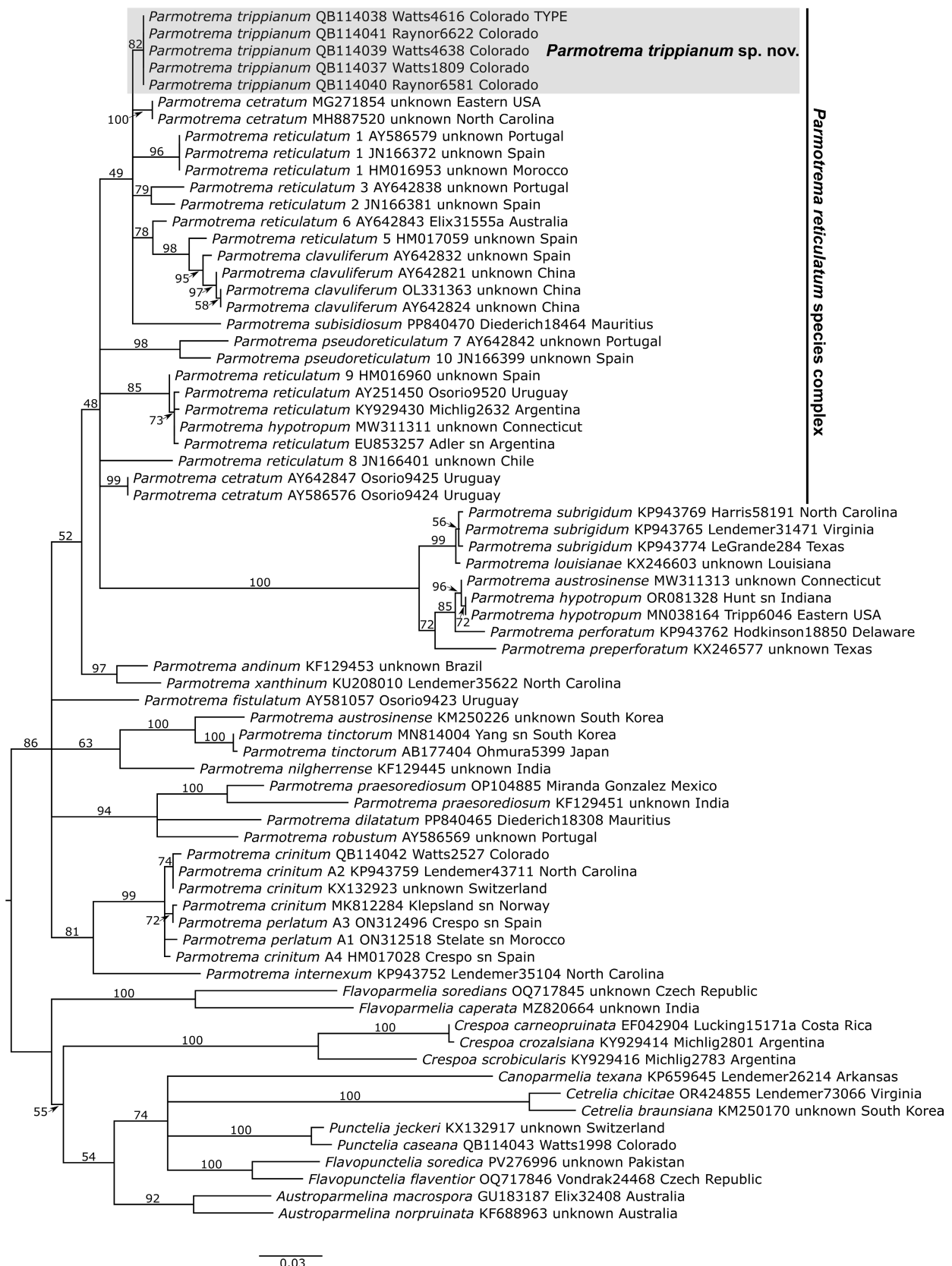


FIGURE 1. A maximum likelihood phylogenetic hypothesis of *Parmotrema* based on the nuclear ribosomal Internal Transcribed Spacer (nrITS) gene. Five accessions of *Parmotrema trippianum* sp. nov. are indicated by the grey box at the top. The *Parmotrema reticulatum* species complex is indicated by the black vertical bar on the right. Bootstrap Support (BS) is indicated for each node. Nodes with very low BS (<45) were considered unsupported and collapsed into polytomies. *Parmotrema* is rooted with closely related genera in the Parmeliaceae. The labels follow the format: taxon, clade number [if applicable, sensu Del Prado *et al.*, (2011) for *P. reticulatum* and Stelate *et al.*, (2022) for *P. crinitum*], Genbank accession number, collector number (if listed), and country (or state when in the USA).

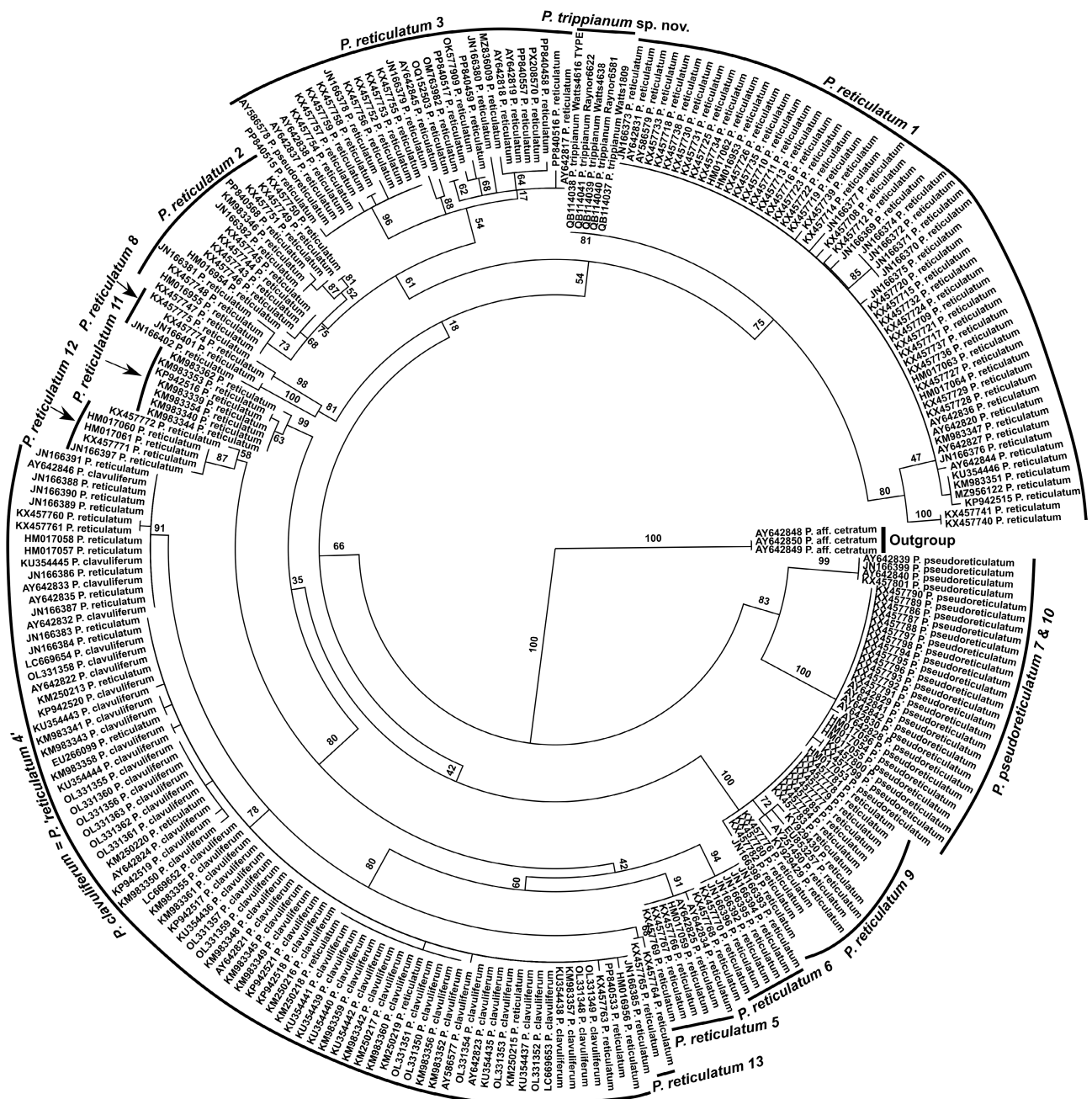


FIGURE 2. A maximum likelihood phylogenetic hypothesis of the *Parmotrema reticulatum* species complex based on nearly all accessions available on Genbank of the nuclear ribosomal Internal Transcribed Spacer (nrITS) gene. The phylogeny is rooted with *P. aff. cetratum* and clades representing *P. clavuliferum*, *P. pseudoreticulatum*, and *P. trippianum* sp. nov. are denoted. *Parmotrema reticulatum* in the broad sense is represented by 10 clades (1–13, excluding 4, 7, & 10), these numbered following Del-Prado *et al.*, (2011). Clades 11, 12, & 13 are newly recognized in this contribution. Genbank number and species (as listed on Genbank) are indicated for all terminals.

A growing body of evidence suggests cryptic speciation is particularly common in fungi, and especially those ‘species’ that reproduce primarily asexually (Otálora *et al.*, 2010; Lücking *et al.*, 2014; Zhang *et al.*, 2022). Several mechanisms for this have been proposed, the most common being cryptic sexual reproduction (Kück & Pöggeler, 2009; Dyer & O’Gorman, 2011), which rapidly generates genetic diversity and facilitates reproductive isolation required for speciation via recombination without producing obvious sexual reproductive structures or traditional sexes (Heitman, 2015). The addition of obligate algal and/or cyanobacterial symbionts further complicates the reproductive processes of lichenized fungi (Tripp & Lendemer, 2018). The use of a single genetic marker on a limited subset of specimens that exhibit a narrowly defined set of characteristics (in this case, specimens lacking lobules, with atranorin and salazinic acid, reticulate maculae, and submarginal, subpustulate-soredia that are sometimes capitate and restricted to lacinulae, i.e., in *P. clavuliferum*) further muddies our understanding of speciation, cryptic speciation, and the dynamics of recent

radiations of lichenized fungi (Kausserud, 2023). The discovery of the morphologically distinct species: *Parmotrema trippianum*, and its recovery within the *Parmotrema reticulatum* species complex provides further evidence that *P. reticulatum* may not be a ‘cryptic species complex’ in the strict sense but rather a recent radiation containing some cryptic and non-cryptic species that exhibit nuanced differentiating characters. The recognition of *P. clavuliferum* and *P. pseudoreticulatum* as distinct taxa (with distinct morphological characteristics) also supports this notion. See Table 1 and Spielmann & Marcelli (2020) for other named species (many of which are not sequenced) that may, upon further study, be revealed to be phylogenetically situated within the *P. reticulatum* species complex. Future studies that sample specimens from a broader morphological gamut and utilize multiple genes or next generation sequencing methods would provide more phylogenetic resolution and, ultimately, insight into when geography, morphology, and genetics concur in recent radiations of lichenized fungi, and when they do not (Lücking *et al.*, 2021).

Taxonomy

***Parmotrema trippianum* J. Watts & Raynor sp. nov.** (Fig. 3)

Mycobank # 865684

Diagnosis:—A member of the *P. reticulatum* species complex (sorediate with cortical atranorin, medullary salazinic acid, reticulate maculae, and usually rhizinate margins) with lobules intermixed with the pustulate-soredia and consoredia, most similar to the Brazilian species *P. marcellii* Gerlach & Eliasaro but with a chocolate brown sparsely to regularly rhizinate lower surface margin, in contrast to the reddish-brown erhizinate lower surface margin of *P. marcellii*. It is distinguished from *P. reticulatum* s.s. by its abundant lobules that give rise to pustulate-soredia and its tendency to form subarbuscular agglomerations of consoredia, and from *P. neopustulatum* Kurok. by its retained upper surface areoles, lobules giving rise to pustules, and pustules decomposing into consistently ecorticate soredia and consoredia that do not blacken.

TYPE:—U.S.A. Colorado: Larimer County, Roosevelt National Forest, Big Thompson Canyon, ~0.5 miles down the canyon from the intersection with Noels Draw Lane and Glen Comfort; large, nearly vertical north-facing granite cliff covered in foliose lichens and surrounded by sparse *Pinus ponderosa*, expansive population about 2–6 meters off the ground, saxicolous on granitic rock. 7127 ft. elevation, 40.392392 N, -105.426192 W. October 21st 2025. *J. Watts & S. Raynor 4616* (Holotype: COLO!; Isotypes: NY!, BYU!, KU!).

Description:—*Thallus* ashy white, lobate, loosely adnate, colony forming, individual rosettes up to 15 cm in diameter. *Lobes* irregularly branched, imbricate, 2–10 mm wide. *Surface* shiny, marginally continuous and smooth, becoming cracked along maculae. *Margin* ciliate, crenulate and darkening from very dark brown to gray. *Maculae* distinct, reticular, laminal, originating cracks. *Cilia* black, simple, irregular in length and density, 0.2–0.7 mm long. *Lobules* common, dorsiventral, spatulate, occasionally rhizinate, disintegrating to form dense agglomerations of capitate to subarbuscular pustules. *Pustules* usually submarginal on downturned lobe apices or subapical on lobules. *Soredia and consoredia* originating from pustules or papillose warts, coarse and conglutinated (35–) 50–70 (–125) µm diameter. *Laciniae* absent. *Isidia* absent. *Medulla* white. *Lower surface* black, shiny, weakly scrobiculate to smooth, irregularly cracked, rhizinate. *Marginal zone* chocolate brown, gradually fading to shiny black centrally, 1–3 mm wide, rhizinate. *Rhizines* black, simple to rarely bifurcate, up to 1.5 mm long, 0.02–0.12 mm wide, frequent centrally, less frequent marginally.

Apothecia unknown. *Pycnidia* common, submarginal to occasionally laminal, emerging from white papillae, conspicuous with prominent margin when fully developed, ostiole black; *Conidia* filiform; 7–11 µm long, <1 µm wide.

Chemistry:—*Spot Tests:* cortex K+ yellow, C-, KC- (remaining yellow), P+ pale yellow, UV-; medulla K+ yellow to blood red, C-, KC-, P+ strong yellow, UV-. *TLC in solvent C:* atranorin, salazinic acid, and consalazinic acid.

Etymology:—The new species is named in honor of Dr. Erin Manzitto-Tripp, formerly Erin Tripp. Erin has had tremendous personal and professional influence on JLW and SJR as their graduate advisor, field companion, and close friend. Through her current positions at the University of Colorado Boulder, as Associate Professor in the Ecology and Evolutionary Biology Dept., Curator of Botany (COLO Herbarium) in the Museum & Field Studies (University of Colorado Museum of Natural History), she has enabled continued botanical and lichenological exploration of Colorado through excellent curation, education, mentorship, as well as her own extensive personal collection and taxonomic work. An exceptional field biologist and instinctive natural historian, Dr. Manzitto-Tripp has made significant contributions

to taxonomic, systematic, and floristic knowledge, particularly in *Ruellia* L. and other Acanthaceae, as well as North American lichens, among other topics. By our count, she has described at least 33 species of vascular plants and 27 species of lichens, provided numerous new combinations, and described multiple tribes, sections, and genera. She has advanced methods in RAD-seq and posed fundamental questions about species rarity, biotic interactions, and reproductive biology using both plant-pollinator interactions and alga-fungus symbioses as systems. Erin has authored multiple field guides, reflecting her unwavering commitment to sharing her love of lichens (and flowering plants) with the public. Her boundless passion for the natural world is contagious. She has positively impacted so many students, curious visitors to the herbarium, etc. with her enthusiasm for collection-based research. We are humbled to honor Erin with *Parmotrema trippianum*, a species that embodies her joy of biodiversity discovery and passion for species and habitat protection. Anyone fortunate enough to encounter this new species in the field will understand why we study lichens.



FIGURE 3. Morphology plate of the Holotype of *Parmotrema trippianum* sp. nov. A.) Habitat at the holotype locality. B.) Rosette-forming thallus exhibiting lobules and agglomerations of pustulate soredia. C.) Colony-forming thallus bearing young lobules, some becoming pustulate. D.) Subarbuscular agglomeration of consoredia arising from pustules. Scale bars: B: 8 mm; C: 10 mm; D: 1 mm.

Habitat & Distribution:—So far as is known, the species is restricted to high-light, steeply- slanted to vertical, north faces of mesic, mossy and lichen-rich rocks in temperate, continental, montane forested canyons from ca. 6,000–

8,500 ft. elevation. It co-occurs with: *Flavoparmelia baltimorensis* (Gyeln. & Főriss) Hale, *Flavopunctelia flaventior* (Stirton) Hale, *Heterodermia exuberans* J. Watts, E. Tripp, & Raynor, *Hypotrachyna brittanica* (D. Hawksw. & P. James) Coppins, *Lepraria gracilescens* (Nyl.) Lendemer & Hodk., *Pannaria tavaresii* P.M. Jørg., *Parmelia saxatilis* (L.) Ach., *P. sulcata* Taylor, *Physcia thomsoniana* Essl., *Punctelia graminicola* (B. de Lesd.) Egan, *P. rudecta* (Ach.) Krog, and *Xanthoparmelia stenophylla* (Ach.) Ahti & D. Hawksw. It is known from the Front Range of Colorado and the Chiricahua Mountains of Arizona, and is also expected to occur in other well-preserved, montane canyons and forested mountains of the SW United States.

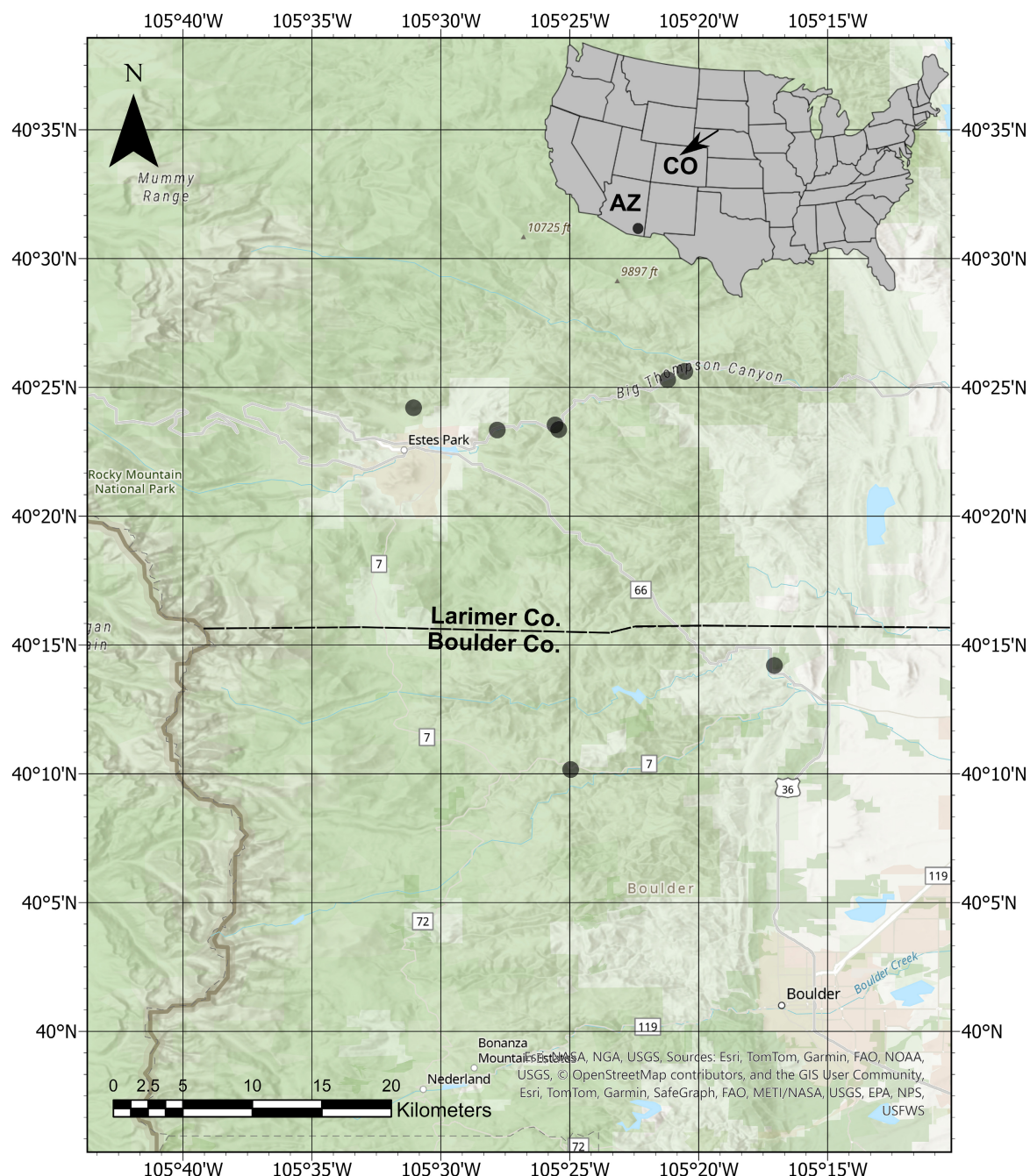


FIGURE 4. A map of all known populations of *Parmotrema trippianum* sp. nov. The arrow on the inset map shows the location of the eastern foothills of the Front Range of the southern Rocky Mountains shown by the larger map. The dot on the inset map indicates the Chiricahua Mountains where two historical populations of the new species are known. The brown line shows the continental divide. The dashed line shows the county line. Pink shaded areas are heavily developed (i.e., Estes Park and Boulder).

Conservation Assessment:—*Parmotrema trippianum* is assessed as Critically Endangered (CR) following IUCN guidelines and considerations in Yahr *et al.* (2024). So far, the species is known from 15 specimens derived from 11 populations spanning three counties across two states (See Selected Specimens Examined). Though we expect the species to be more broadly distributed than is currently known, extensive field work in the foothills of the Colorado

Front Range over the last three years has only yielded one extensive population of the species (the type locality) and one small population just ~2 km upslope from the type locality, suggesting it is locally rare. Examination of 148 specimens held under *P. reticulatum* at COLO yielded only nine specimens corresponding to *P. trippianum*, suggesting that it may have also been rare in the past. We therefore assess the species as CR and suggest an estimated population size of ~40 individuals (10 x 4 to account for undercollection of lichens in the southwestern United States), given its apparent past and present rarity and narrow ecological niche.

Notes:—*Parmotrema trippianum* is characterized by its reticulate maculae, retained non-flaking upper surface areoles, subarbuscular, pustulate-consoredia that originate subapically from dorsiventral lobules or submarginally on lobes, and a brown underside margin that is rhizinate to the margin. In the broad sense, this novel taxon would have previously been included in *P. reticulatum*. *Parmotrema reticulatum* is a widespread, broadly applied name that has been used for sorediate species of *Parmotrema* with salazinic acid and reticulate maculae. This aggregate, however, has been shown to represent a multitude of somewhat cryptic species (Del Prado *et al.*, 2011; Del-Prado *et al.*, 2016), including at least two other named species: *P. clavuliferum* and *P. pseudoreticulatum*. Other taxa have been described without sequences in regional treatments and may well also be later discovered to be phylogenetically situated within the *P. reticulatum* species complex (Louwhoff & Elix 2000; Spielmann & Marcelli 2009; Spielmann & Marcelli, 2020). Differences between these and *P. trippianum* are discussed below. So far as is known, *P. trippianum* is sister to North American accessions of *P. cetratum*: a fertile species that lacks any asexual propagules or pustules, and *P. reticulatum* clade 1 sensu Del-Prado *et al.*, (2011) (Fig. 1; Fig. 2).

Parmotrema trippianum is morphologically most similar to *P. neopustulatum* from Australia and *P. asperum* Benatti, Marcelli & Elix and *P. marcellii* from Brazil. *Parmotrema neopustulatum* is differentiated by its flaking cortex and lobule formation (originating from the pustules), while *P. asperum* differs by the presence of abundant laciniae. *Parmotrema marcellii* forms subarbuscular agglomerations of pustulate soredia, like *P. trippianum*, but the agglomerations lack lobules, unlike in *P. trippianum* where the lobules are intermixed with pustulate consoredia. Additionally, *P. marcellii* exhibits a distinctly reddish brown, erhizinate lower surface margin (Da Cruz Lima Gerlach & Eliasaro, 2014). These species also differ ecologically from the new species, occurring in tropical to subtropical maritime habitats at low elevations, as do many other species with salazinic acid, asexual reproductive propagules, and reticulate maculae. Other species of *Parmotrema* can be differentiated from *P. trippianum* by maculae type including punctiform to linear maculae in *P. anchietanum* Marcelli, Benatti & Elix, irregularly punctiform in *P. ventanicum* (Adler & Elix) Blanco, Crespo, Divakar, Elix & Lumbsch, and effigurate in *P. petropoliense* (Zahlbr.) Spielmann & Marcelli. *Parmotrema reticulatum* s.s., *P. pseudoreticulatum*, and *P. cristiferum* (Taylor) Hale lack pustules and bear true soredia (these rarely subpustular) on marginal to submarginal crescent-shaped or linear soralia. *Parmotrema pseudoreticulatum* is additionally differentiated by its broad, erhizinate marginal zone and *P. cristiferum* lacks cilia. In the broad sense, *P. reticulatum* may form somewhat capitate, submarginal, subpustular soredia on revolute lobe margins, but the authors can find no reports of this species having lobules that disintegrate into pustulate-soredia. *Parmotrema lacteum* Marcelli & A.A. Spielm. and *P. subisidiosum* differ by bearing true isidia, while *P. clavuliferum* and *P. marcellianum* A.A. Spielm. & Bungartz develop distinct clavules with white to white-mottled undersides. Other pustulate species have key distinct features clearly differentiating them from *P. trippianum*, including abundant lacinule presence in *P. granulare* (Asahina) A.A. Spielm. & Marcelli, cilia absence in *P. ruminatum* (Zahlbr.) O. Blanco, A. Crespo, Divakar, Elix & Lumbsch, and the lack of agglomerations in *P. nudum* (Hue) A.A. Spielm. & Marcelli. A taxonomic and phylogenetic revision of the group is greatly needed to clarify distributions, morphologies, and evolutionary relationships in the difficult, recently divergent group.

Selected Specimens Examined:—U.S.A. ARIZONA: Cochise Co., Cave Creek, Chiricahua Mountains near Southerwestern Research Station, on limestone, 15 April 1957, *Weber & Shushan* S8788 (COLO!). COLORADO: Boulder Co., South St. Vrain Canyon, 8 road miles W of Lyons, saxicolous, *Anderson* 6724 (COLO!). Larimer Co., Roosevelt National Forest, Big Thompson Canyon just down the canyon from Glen Comfort, sunny roadside boulder at base of steep north-facing canyon wall, on granitic rock, 7105 ft. elevation, 40.39269 N, -105.426515 W. 2 June 2024. *J. Watts*, *C. Adamchak*, & *J. Beighle* 1809 (Topotype: COLO!).

Dichotomous Key to *Parmotrema* with Salazinic Acid in North America including Mexico

(Brodo 2016; Egan *et al.*, 2016; Nash & Elix 2002; Spielmann & Marcelli, 2020)

1. Asexual propagules present 2
1. Asexual propagules absent 22
2. Thallus isidiate or lobulate, occasionally grading into soredia 3

2.	Thallus sorediate, without isidia or lobules.....	10
3.	Cortex with usnic acid only, atranorin absent, K-, thallus yellow green; known from Florida and southern Mexico.....	
	 <i>P. flavescens</i> (Krempelh.) Hale	
3.	Cortex with atranorin (accompanied by usnic acid in <i>P. subtinctorium</i> , otherwise usnic acid absent), K+ yellow, thallus gray, bluish grey, or grey green.....	4
4.	Lower surface brown throughout often darkening at center, with fine rhizines mixed with sparse longer rhizines, rhizinate to the margin without broad bare zone.....	5
4.	Lower surface black with brown margin, without dense fine rhizines, with or without a broad bare zone at the margin.....	7
5.	Maculae reticulate, thallus with abundant marginal lobules, lacking isidia; only known from southern Mexico in NA.....	
	 <i>P. lobuliferum</i> (Riberiro & Mercelli) Blanco <i>et al.</i>	
5.	Maculae effigurate, thallus isidiate, lacking lobules.....	6
6.	Lower surface without abundant prominent veins, salazinic acid accompanied by norlobaridone and loxodin (TLC required); eastern and southwestern USA throughout Mexico.....	
	 <i>P. subtinctorium</i> (Zahlbr.) Hale	
6.	Lower surface with abundant prominent veins, salazinic acid not accompanied by norlobaridone and loxodin; known from southeast USA.....	
	 <i>P. neotropicum</i> Kurok.	
7.	Upper surface conspicuously cracked and maculate.....	8
7.	Upper surface cracks and maculae absent to inconspicuous.....	9
8.	Thallus isidiate, often also bearing soredia but never bearing lobules or orbicular agglomerations; usually found corticolous on trees more rarely found on rocks; southeast USA and Mexico.....	
	 <i>P. subisidiosum</i> (Müll. Arg.) Hale	
8.	Thallus lobulate, isidia absent, lobules accompanied by soredia and consoredia originating from pustules, occasionally coalescing into orbicular agglomerations, upper surface reticulately maculate; only found saxicolous on cliffs and rocky outcroppings; so far only known from the southern Rocky Mountains Front Range of Colorado and the Chiricahua Mountains of southern Arizona.....	
	 <i>P. trippianum</i> J. Watts & Raynor (also see couplet 21)	
9.	Thallus with arbusculate laciniae, isidia absent; salazinic acid only, medulla UV-; only found on trees; known from Florida and Mexico.....	
	 <i>P. coralliforme</i> (Hale) Hale	
9.	Thallus isidiate, laciniae absent; salazinic acid accompanied by lichexanthone, medulla UV+ yellow to gold; usually found on trees but occasionally found on rocks; known from the southern USA and throughout Mexico.....	
	 <i>P. ultralucens</i> (Krog) Hale	
10.	Cilia absent on lobe margin; in southeastern USA and Mexico with one additional voucher from southern Arizona.....	
	 <i>P. cristiferum</i> (Taylor) Hale	
10.	Cilia present on lobe margin.....	11
11.	Cortex with usnic acid, K-, KC+ gold; found in southern Mexico.....	
	 <i>P. mirandum</i> (Hale) Hale	
11.	Cortex with atranorin, K+ yellow.....	12
12.	Lower surface brown throughout often darkening at center, rhizinate to the margin with fine rhizines mixed with sparse longer rhizines.....	13
12.	Lower surface black with brown margin, with a broad bare zone at the margin or rhizinate to the margin with sparse longer rhizines but without dense fine rhizines.....	14
13.	Lower surface pale brown; soralia elongate to crescent-shaped, marginal or laminal; usually found on trees but rarely found on rocks; known from the southern Appalachian Mountains and Mexico.....	
	 <i>P. subsumptum</i> (Nyl.) Hale	
13.	Lower surface medium to dark brown becoming black centrally; soralia linear, restricted to the lobe margins; found on trees, especially conifers; known from throughout Mexico.....	
	 <i>P. leucosemothetum</i> (Hue) Hale	
14.	Lower surface margin with a broad bare zone without rhizines, upper surface not cracked to irregularly cracked primarily on central lobes.....	15
14.	Lower surface margin with sparse to abundant rhizines, upper surface finely to reticulately cracked throughout the thallus.....	19
16.	Lobes laciniate, sublinear (2-7 mm wide), often C+ (LM) from traces of gyrophoric acid.....	
	 <i>P. paramoreliense</i> W.L. Culb. & C.F. Culb.	
16.	Lobes not laciniate, broad and rounded to irregular, C- without gyrophoric acid.....	17
17.	Upper surface strongly cracked and maculate on the older central lobes; known from throughout Mexico.....	
	 <i>P. leucosemothetum</i> (Hue) Hale	
17.	Upper surface not strongly cracked or maculate centrally.....	18
18.	Soredia marginal, linear to orbicular, sorediate, lobes not becoming revolute; found in northeastern USA south through the Appalachian Mountains, coastal California, and throughout Mexico.....	
	 <i>P. stuppeum</i> (Taylor) Hale	
18.	Soredia apical on lobe tips in orbicular patches, sorediate lobes becoming revolute; found in eastern USA and Mexico.....	
	 <i>P. margaritatum</i> (Hue) Hale	
19.	Norlobaridone present in addition to salazinic acid (TLC required); a rare species only known from the Appalachian Mountains and southern Mexico.....	
	 <i>P. commensuratum</i> (Hale) Hale (rare chemotype, not usually with salazinic)	
19.	Salazinic acid only, without additional compounds.....	20
20.	Soredia farinose mixed with sparse larger granules, not mixed with isidia; a common widespread species throughout temperate and tropical climates globally.....	
	 <i>P. reticulatum</i> (Taylor) M. Choisy	
20.	Soredia coarse, originating from pustules, usually mixed with eroding isidia or lobules.....	21
21.	Soredia mixed with eroding isidia, soredia never coalescing into orbicular agglomerations; usually found corticolous on trees more rarely found on rocks; southeast USA and Mexico.....	
	 <i>P. subisidiosum</i> (Müll. Arg.) Hale	
21.	Soredia mixed with spatulate lobules, soredia conglutinated, occasionally coalescing into orbicular agglomerations; only found saxicolous on cliffs and rocky outcroppings; so far only known from the southern Rocky Mountains Front Range of Colorado and the Chiricahua Mountains of southern Arizona.....	
	 <i>P. trippianum</i> J. Watts & Raynor (also see couplet 8)	
22.	Marginal cilia on lobes absent.....	23
22.	Marginal cilia on lobes present.....	24
23.	Lobes broad and rounded (8-20 mm wide), apothecia common; common throughout Mexico, rarely found in USA in southeast,	

- midwest, and southern California..... *P. latissimum* (Fée) Hale
23. Lobes lacinate, deeply and narrowly divided, often not rounded apically, apothecia not known; a rare species only known from southern Mexico *P. acutatum* Kurok. 25
24. Lower surface rhizinate to the margin 27
24. Lower surface with a broad bare zone at the margin..... 27
25. Lower surface mostly tan to light brown or brown; frequent short fine rhizines intermixed with long rhizines; a rare species only known from Mexico *P. subcaperatum* (Krempelh.) Hale 26
25. Lower surface mostly jet black, only brown near the margin; sparse long slender rhizines throughout 26
26. Thallus lobate with rounded lobes present that often develop into laciniae, lobes simple to furcate, margins with short cilia up to 1.3 mm long; usually found on trees, though rarely also collected on rocks; in both eastern USA and Mexico..... *P. cetratum* (Ach.) Hale
26. Thallus lacking rounded lobes, completely composed of slender laciniae that are usually irregularly branched (subdichotomous to subpalmate), margins with long cilia up to 3 mm; growing on rock or soil over rock; only known from southern California..... *P. herrei* (Zahlbr.) Spielmann & Marcelli
27. Bare zone on lower surface margin white to tan; found in western Mexico *P. arteagum* R.S. Egan 28
27. Bare zone on lower surface margin brown to black 28
28. Upper surface maculate present and conspicuous; only known from eastern Mexico..... *P. permaculatum* (Hale) Kurok. 29
28. Upper surface maculate absent to inconspicuous..... 29
29. Lobes linear and elongated (2-5 mm wide), becoming laciniate; apothecia becoming flat and perforate at maturity; spores 16-21 µm long; found throughout Mexico *P. moreliense* (B. de Lesd.) W.L. Culb & C.F. Culb
29. Lobes rounded apically, lacinate or not; apothecia cupuliform to urcelate, not becoming flat or perforated at maturity; spores <16 µm long..... 30
30. Laciniae absent, lobes crenate centrally; submarginal pycnidia with or without prominent margin and not restricted to central lobes, lobes with small to medium marginal cilia (0.5-2.2 mm long), spores 10-14 µm long; mainly found on rocks; currently only known from Arkansas and Missouri..... *P. despectum* Kurok.
30. Lacinate centrally, laciniae festooned with submarginal to subapical, black rimmed pycnidia restricted to central laciniae, lobes with long marginal cilia (< 3.5 mm), spores 14-16 µm long; found both on trees and on rocks; eastern and southwest USA and Mexico..... *P. euryacum* (Hue) Hale

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Data Availability: Novel sequences generated as a part of this project are available on Genbank (See Figures 1 & 2 for accession numbers).

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Author Contributions: JLW & SJR recognized the species as new and wrote the description. JLW wrote the first draft of the manuscript with significant additions from SJR. JLW did the labwork and phylogenetic analysis and made the figures. SJR wrote the first draft of the key. AH, JRA, and DC managed the COLO Herbarium, accessioned the specimens, and provided significant comments on the manuscript.

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