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A synopsis of the yellow-green, usnic acid-producing, species of *Xanthoparmelia* in Colorado

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ABSTRACT. – The genus *Xanthoparmelia* belongs to one of the largest and most species-rich foliose lichen families - Parmeliaceae. It occurs primarily in arid regions around the world. In the United States, *Xanthoparmelia* is extremely abundant in the southern Rocky Mountains and adjacent high plains of Colorado, where species play significant ecological roles. The present study emphasizes the examination of type material, protologues, study of new field collections as well as existing herbarium material, data from thin layer chromatography, and information on species distributions to delimit species of non-melanin-containing (i.e., yellow-green) members of *Xanthoparmelia* in Colorado, U.S.A. Using the University of Colorado Herbarium (COLO) collection in addition to collections made by the authors, a total of 18 species belonging to five different chemical groups are recognized as occurring in Colorado. *Xanthoparmelia arseneana* is placed in synonymy with *X. novomexicana*. In addition, two species are excluded from Colorado: *X. taractica* and *X. hypopsila*. A dichotomous key and a species treatment that includes type citations, morphological descriptions, chemical information, and geographical distributions is included. This treatment is the first to focus on this abundant yet taxonomically challenging lineage solely in Colorado.

KEYWORDS. – Biodiversity, Boulder County, chemistry, foliose lichens, Parmeliaceae, Thin Layer Chromatography, TLC.

INTRODUCTION

The family Parmeliaceae is one of the most species-rich lineages of lichens, consisting of over 2,000 recognized, primarily foliose species (Del Prado et al. 2007; Lücking et al. 2017; Thell et al. 2012). With over 800 species, the most species-rich genus within the family is *Xanthoparmelia* (Vain.) Hale (Amo de Paz et al. 2010b; Hale 1990; Leavitt et al. 2012), which is globally distributed but especially diverse in several areas including Australia (McCarthy 2003) and North America (Esslinger 2021). Species of *Xanthoparmelia* encompass a broad range of ecologies, but most preferentially inhabit arid regions such as low- to mid-elevation deserts, grasslands and shrublands (Barcenas-Peña et al. 2018). However, numerous species occupy wetter environments ranging from high alpine ecosystems to temperate forests (Debuke et al. 2015; Hale 1990; Leavitt et al. 2011a; Knudsen et al. 2017; Tsurykau et al. 2018). In North America, western mountainous portions of the United States are particularly species-rich (Nash and Elix 2004). In areas such as the southern Rocky Mountains and Sierra Nevada Mountains, species of *Xanthoparmelia* are among the most abundant and ecologically important lichens, where they contribute conspicuously to saxicolous communities in the plains to the foothills to the high peaks of the alpine ecozone (Hale 1990; Leavitt et al. 2011b; Leavitt et al. 2013).

Xanthoparmelia was first introduced as a section of *Parmelia* Ach. by the Finnish lichenologist Vainio (1890) to delimit the foliose yellow-green group of parmelioid lichens, which derive their

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characteristic color from the presence of usnic acid in the upper cortex (Hale 1973). Historically, morphological and chemical features in addition to reproductive modes were heavily relied upon to help characterize taxa in this species-rich genus (Blanco et al. 2004). However, as molecular data have continued to accumulate, it has become apparent that earlier methods are both insufficient and at times misleading when estimating species numbers and limits in the group (Amo de Paz et al. 2010a; Blanco et al. 2004; Leavitt et al. 2016). Molecular analyses have further demonstrated a number of previously segregated genera (e.g., *Neofuscelia* Essl., *Almbornia* Essl., *Xanthomaculina* Hale, *Paraparmelia* Elix and J.Johnst., and *Namakwa* Hale) are phylogenetically embedded within *Xanthoparmelia* (Amo de Paz et al. 2010a; Blanco et al. 2004; Elix 2003; Thell et al. 2004, 2006).

Thus, *Xanthoparmelia* as now delimited is markedly different than as originally circumscribed by Vainio (1890), including not only the iconic yellow-green foliose species but additionally others with gray or brown thalli, as well as subcrustose species. These taxa nonetheless share *Xanthoparmelia*-type lichenan in the cell walls, diverse medullary chemistries, and most commonly occur in arid to semi-arid environments (Blanco et al. 2004, 2006; Thell et al. 2006).

In the field, the yellow-green species *Xanthoparmelia* can be particularly difficult to distinguish from one another. As numerous prior authors have discovered, closely related species can be nearly indistinct morphologically (i.e., they share the same lower cortex color, spore morphology, medulla and algal structure, and lobe morphology; Benedict et al. 1990; Hale 1990). Lichenologists have in turn capitalized on metabolic differences to aid in identification (Giordani et al. 2002; Hale 1990; Sanders 2011). However, molecular data have called into question the utility of only chemotaxonomy and/or morphological features to delimit species of *Xanthoparmelia* (Leavitt 2011a, 2012, 2016). This sentiment applies particularly well to *Xanthoparmelia*, where chemistry has been heavily relied upon for species circumscriptions. Recent progress in molecular phylogenetics has fostered a new understanding of the problem of "chemovariants" in *Xanthoparmelia* and is challenging current species delimitations (Blanco et al. 2006; Leavitt et al. 2011a, 2012, 2018; Grewe et al. 2017; Meiser et al. 2017). Although it is clear that more molecular, morphological, and chemical analyses are needed to best determine how to delimit species in this group, it is nonetheless important to continue to build the foundation of field-based approaches that will in turn enlighten comparative molecular, morphological, and chemotaxonomic studies.

The goal of the present study was to re-assess nomenclature and taxonomy of usnic acid-producing species of *Xanthoparmelia* that occur in the southern Rocky Mountains and adjacent high plains and basins of Colorado. Prior studies have demonstrated that species of *Xanthoparmelia* are both exceptionally diverse in Colorado as well as difficult to identify owing to the presence of chemovariants, non-monophyly of previously recognized species, ecological abundance, niche overlap, and poorly defined geographical ranges of taxa (Brodo et al. 2001; Leavitt et al. 2012; Nash and Elix 2004; St. Clair 1999; Thell et al. 2012). The present contribution represents a first attempt to delimit the diversity of this subset of *Xanthoparmelia* within Colorado specifically. Our objectives were to: (1) contribute an account of total diversity of *Xanthoparmelia* in Colorado; (2) ground this study in an extensive review of type material and protologues of all names; and (3) present a first dichotomous key to the species of usnic acid-producing *Xanthoparmelia* in Colorado. This synopsis was based primarily on a review of the 277 existing specimens housed at the University of Colorado (COLO) Herbarium supplemented by ~100 new voucher specimens collected for this study. The resulting species accounts include morphological descriptions as well as chemical circumscriptions as determined through Thin Layer Chromatography

MATERIALS AND METHODS

Field, Herbarium, and Curatorial Work. – To help understand diversity of *Xanthoparmelia* in Colorado, we collected new voucher specimens throughout Boulder County between June-October 2015; we additionally incorporated field collections (made by us) from other localities throughout the state. Field sites ranged from highly disturbed cattle pastures to little manipulated montane areas. Elevations at new collection sites ranged from 1615-1920 m (5300-6300 ft) in Boulder County, and at elevations below 1524 m (5,000 ft) and above 3962 m (13,000 ft) elsewhere in Colorado. New field collections were made both on and off trail, with permits provided by the City of Boulder's Open Space and Mountain Parks Program and by the US Forest Service. In total, 80 new field collections were made as part of this study by the first author, and these collections were supplemented by 10 others made by the second author. All specimens were deposited into the COLO Herbarium and data are available via COLO's database (https://botanydb.colorado.edu/index.php).

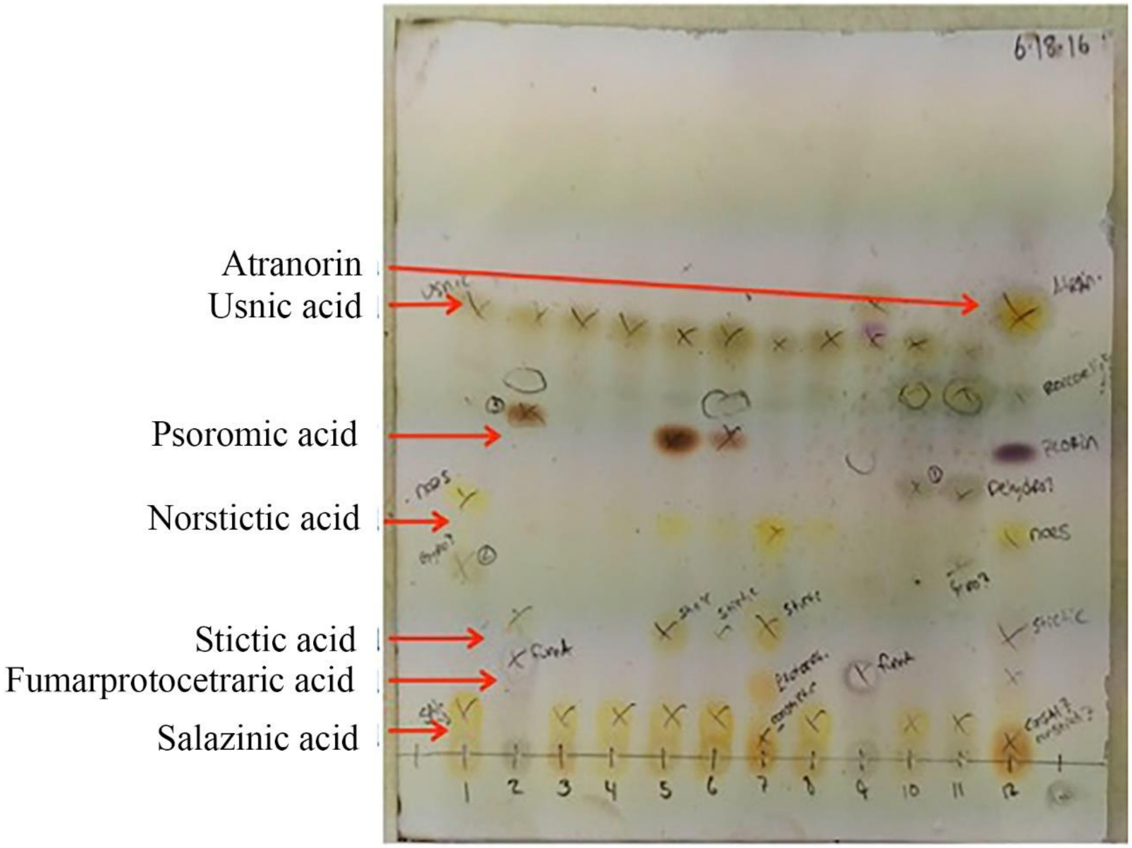

Figure 1. Thin layer chromatography (TLC) plate run in Solvent C illustrating all major lichen secondary compounds in Colorado *Xanthoparmelia*. Each lane represents a different thallus sample. Note usnic acid is an example of a major compound, while norstictic acid is an example of a trace compound.

In addition to new field collections, we surveyed all collections of Colorado *Xanthoparmelia* housed at COLO: 277 specimens. Following study of these collections, annotations and chemical annotations were made. All measurements provided in the taxonomic treatment were taken from Colorado material only, using microscopy and imaging instrumentation and software described below. Structural measurements most commonly reflect two to four samples per structure per individual collection. The minimum and maximum measurement recorded yield the given range. Measurements and imaging were taken with a professional grade Nikon D7100 digital SLR equipped with a 105 mm 1:1 macrolens and ring flash, a professional grade Olympus SZX10 stereomicroscope, and Olympus BX51 compound epiflourescence microscope with Nomarski and *plan* optics, and a Retiga 200R firewire-enable imaging system.

A top priority of this study was to leave a clear platform for future researchers while maintaining the integrity of the COLO herbarium natural history collection. To do so, we conducted spot tests and Thin Layer Chromatography on new collections in addition to all existing collections housed at COLO. Even though several existing collections at COLO contained earlier TLC annotation slips, these collections were universally re-sampled for TLC study because of discrepancies among earlier researcher results. Care was taken to limit the amount of damage to any one specimen. Results from all new TLC assays were recorded via paper annotation slips inserted into specimen packets.

Chemical Assays. – Following standard protocols outlined in Brodo et al. (2001), we utilized K (potassium hydroxide), C (sodium hypochlorite), KC (potassium hydroxide followed by sodium hypochlorite), and P (*p*-phenyldiamine) spot tests to aid in the identification process of all examined specimens. Our analyses incorporated spot test results derived from prior testing of type material as provided via annotations on specimens, to help categorize all X*anthoparmelia* specimens into chemical groups. We further conducted our own upper cortex and medullary spot tests on all material accessed by us during this study; we focused on medulla spot tests due to the importance of this zone to *Xanthoparmelia* chemistry (Hale 1990; Nash and Elix 2004). Upper cortex UV tests were also performed, using a short-wave UV light following protocols in Brodo et al. (2001).

Thin Layer Chromatography (TLC; Elix 2014) was used to identify lichen metabolites in all specimens examined including all Colorado material, whether newly collected by us or already existing in COLO. For all TLC runs, an approximately 0.5 x 0.5 mm portion of the thallus (cortex + medulla) was placed into an individual ceramic well, avoiding reproductive structures that could contribute chemical anomalies (Hale 1955). Samples were soaked in acetone for approximately 1 minute and then spotted onto silica chromatography plates using a 10 µl pipette until a color ring depicting sufficient solute appeared on the plate. TLC was run using Solvent C as outlined in Culberson (1972). At the conclusion of the run, plates were examined under short-wave and long-wave UV light, where spot locations and colors visible under both wavelengths were marked. Plates were then run under water and examined while being warmed to detect fatty acids as hydrophobic spots. Finally, plates were "charred" to promote spot color development by treatment with 10% sulfuric acid followed by heat at 110°C (Culberson & Kristinsson 1970). Plates were scored for lichen compounds approximately one hour after charring to avoid any color fading and discoloration over time. Chemicals were identified following standardized Rf values provided in Elix (2014) (Figure 1).

Species Concepts. – Our approach for delimiting species of usnic acid-producing *Xanthoparmelia* in Colorado first relied upon study of type specimens coupled with protologue descriptions (where available). Following this, our concepts were informed by examination of morphological features, structural measurements (conidial measurements were not included in this study), and chemical assays (TLC, spot tests) of all specimens included in this study. Instances in which our collections and/or COLO herbarium collections were in conflict with information from species, protologues, or type material are noted below, and we have attempted to resolve such issues.

We here exclude *Xanthoparmelia taractica* and *X. hypopsila* from the present treatment of Colorado *Xanthoparmelia*. Although previously included in some North American treatments (Nash and Elix 2004; St. Clair 1999), upon exhaustive review of literature, we feel it is unlikely that these species occur in the United States (Hale 1990). Several treatments consider *Xanthoparmelia. taractica* to occur only from Argentina (from where the species was described) to Mexico as well as Australasia (Elix et al. 1986; Hale 1990; Nash 1974). Regarding *X. hyposila*, Hale (1988) considered the species to be strictly South American and South African, and considered North American material to best be treated under a separate name—*X. angustiphylla*. This taxonomy has since been followed in most subsequent North American keys (Brodo et al. 2001; Hale 1990), although some herbaria continue to file specimens from North America under *Xanthoparmelia hypopsila* (CNALH 2022). Further investigation that includes broad molecular sampling will be helpful to comprehensively assess relationships among these taxa.

Map Generation. – We used National Geographic TOPO! Version 3.4.2 (2003) to generate geographical coordinates for specimens of *Xanthoparmelia* from Colorado that were not previously georeferenced. These data together with existing georeferenced specimen data were then exported into ArcGIS Version 10.2 software, which was used to generate distribution maps.

RESULTS AND DISCUSSION

After reviewing protologues, type materials, chemical assay results, and morphologies of all specimens included in this study, we recognize a total of 18 species of *Xanthoparmelia* occurring in the state of Colorado. Of these, nine reproduce primarily through asexual lichenized diaspores (*X. chlorochroa*, *X. conspersa*, *X. idahoensis*, *X. lavicola*, *X. mexicana*, *X. mougeotii*, *X. neochlorochroa*, *X. plittii*, *X. vagans*) and nine reproduce sexually (*X. coloradoensis*, *X. cumberlandia*, *X. lineola*, *X. monticola*, *X. novomexicana*, *X. psoromifera*, *X. stenophylla*, *X. subdecipiens*, *X. wyomingica*; Table 1). Four species are strictly vagrant (*Xanthoparmelia chlorochroa*, *X. idahoensis*, *X. neochlorochroa*, *X. vagans*), a term here taken as both a mode of reproduction and a distinct growth-habit found in Colorado *Xanthoparmelia* (as well as in other areas). While vagrant lichens utilize fragmentation as the primary mode of reproduction (Rosentreter 1993), the occurrence (albeit rare) of apothecia, conidia, and isidia suggests much is left to discover about reproductive biology of these species. Geographical maps depicting distributions of all 18 species found in Colorado are shown in Figure 2.

Taxon	Primary Reproduction			Primary Chemical Constituents				
	Asexual	Sexual	Vagrant	Fumar. Acid	Psoromic acid	Salazinic Acid	Stictic Acid	Atranorin
X. chlorochroa			x			x		
X. coloradoensis		x				x		
X. conspersa	x						x	
X. cumberlandia		x					x	
X. idahoensis			x			x		
X. lavicola	x				x			
X. lineola		x				x		
X. mexicana	x					x		
X. monticola		x		x				
X. mougeotii	x						x	
X. neochlorochroa			x					
X. novomexicana		x		x				
X. plittii	x						x	
X. psoromifera		x			x			
X. stenophylla		x				x		
X. subdecipiens		x						x
X. vagans			x				x	
X. wyomingica		x				x		

Table 1. Tabular comparison of recognized Colorado *Xanthoparmelia* species, including primary mode of reproduction, and primary chemical constituents in addition to usnic acid.

Five primary chemical groups were delimitated to encompass the chemical diversity of all 18 taxa (Table 2; Figure 2). Chemical Group 1—the salazinic acid group—contains seven species; Chemical Group 2—the stictic acid group—contains five species; Chemical Group 3—the psoromic acid group—contains two species; Chemical Group 4—the fumarprotocetraric acid group—contains two species; and Chemical Group 5—the atranorin group—contains one species. All species were assigned to one and only one group except for *X. neochlorochroa*, which was not included in any group as it is chemically defined only by a lack of salazinic acid. All taxa additionally contained usnic acid, which is characteristic of the genus, as well as minor and/or trace amounts of additional chemical constituents (e.g., norstictic acid, consalazinic acid).

Chemical groups for the most part do not appear to be restricted to any specific habitat or elevation (however, exceptions exist; see Figure 2). Group 1 and Group 2 contain the greatest number of species (seven and five, respectively) and were also the most commonly occurring, as assessed by numbers of collections. Species in both groups occur throughout the state. Group 3 and Group 4 species were represented by the least number of collections in Colorado, yet these species have relatively broad geographical ranges. Group 5 species (i.e., *X. subdecipiens*) occurs only on the western slope. Whereas the COLO lichen collection houses excellent representation of Colorado *Xanthoparmelia*, distribution maps coupled with personal observations by the authors make clear that more field collections of *Xanthoparmelia* are needed, particularly in the eastern plains, to yield a more well-rounded understanding of distributions of species across the state.

After review of 367 Colorado specimens, one new synonym is proposed as part of this treatment: *X. arseneana* is placed in synonymy with *X. novomexicana*. This decision was made based on the similarities as deduced from protologue descriptions, type information, chemistry, and morphology. Priority was assigned using the earliest published name (McNeill et al. 2012; Turland et al. 2017). Additionally, *X. taractica* and *X. hypopsila* are excluded from the present treatment of Colorado.

In addition, examination of these specimens suggests that TLC data along with information on reproductive mode and population niche/ecology together represent the most efficient means of species identification in this region. Spot test results, while useful, are much more susceptible to subjective determination and generally provide less robust information than TLC results. For example, both stictic and psoromic acid produce K+ yellow medulla spot tests, and both psoromic acid and nosrtictic acid react P+ yellow/golden (Elix 2014). Therefore, further investigation would be required for a reliable identification. Standardized R_F values provide a much more reliable method of identifying even minor compounds of lichen-

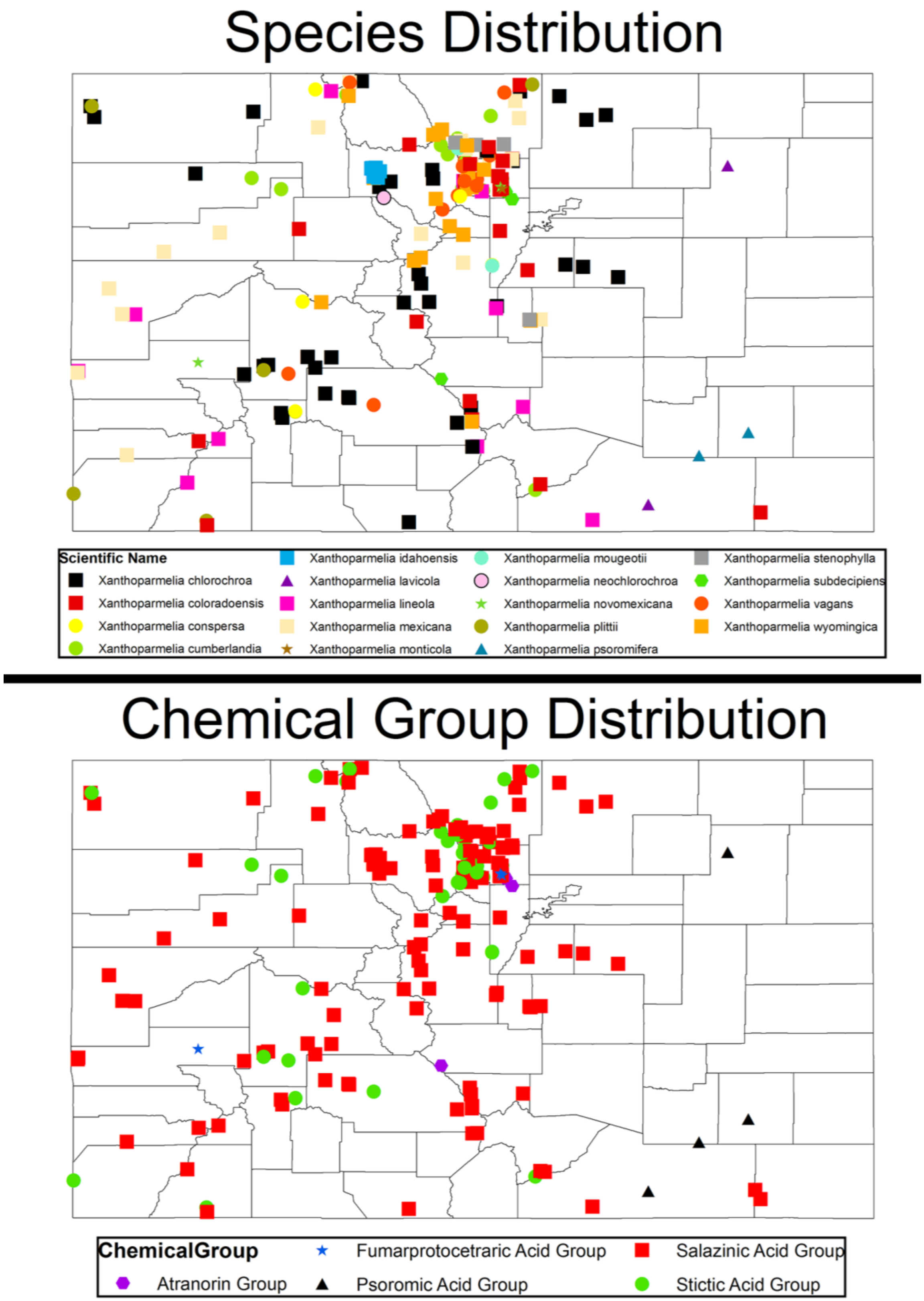

Figure 2. Geographic distributions of species (top panel; see Table 1) and chemical groups (bottom panel, see Table 2) in Colorado, U.S.A. based on specimens examined for this study.

Group Number and Name	Taxon	Number of COLO vouchers
Group 1: Salazinic Acid Group	*X. chlorochroa*	45
Group 1: Salazinic Acid Group	*X. coloradoënsis*	117
Group 1: Salazinic Acid Group	*X. idahoensis*	10
Group 1: Salazinic Acid Group	*X. lineola*	49
Group 1: Salazinic Acid Group	*X. mexicana*	43
Group 1: Salazinic Acid Group	*X. stenophylla*	7
Group 1: Salazinic Acid Group	*X. wyomingica*	26
		Total: 297
Group 2: Stictic Acid Group	*X. conspersa*	2
Group 2: Stictic Acid Group	*X. cumberlandia*	16
Group 2: Stictic Acid Group	*X. mougeotii*	2
Group 2: Stictic Acid Group	*X. plittii*	19
Group 2: Stictic Acid Group	*X. vagans*	12
		Total: 51
Group 3: Psoromic Acid Group	*X. lavicola*	6
Group 3: Psoromic Acid Group	*X. psoromifera*	2
		Total: 8
Group 4: Fumarprotocetraric Acid Group	*X. monticola*	3
Group 4: Fumarprotocetraric Acid Group	*X. novomexicana*	3
		Total: 6
Group 5: Atranorin Group	*X. subdecipiens*	5
		Total: 5

Table 2. Number of vouchers for each species housed at COLO and organized by chemical group.

forming fungi. Future studies may seek to reconcile these delimitations, based primarily on morphology and chemistry, with sequence data from these collections.

Recent molecular evolutionary interest in *Xanthoparmelia* has sought to understand whether traditionally circumscribed species represent evolutionary lineages (i.e., whether species are reciprocally monophyletic; Amo de Paz et al. 2010a; Blanco et al. 2006; Leavitt 2010). In particular, Leavitt et al. (2011b) demonstrated that traditionally circumscribed species were not supported by molecular data. Their study included six species that occur in Colorado, and the authors found that these species belong to three polymorphic population clusters. Further studies by Leavitt et al. (2012) confirmed that chemical and morphological characteristics overestimate the number of species compared to species delimitation based on molecular data. Thus, previous notions of species delimitations across lichens and in particular within *Xanthoparmelia* may or may not be supported following incorporation of molecular phylogenomic data (Del Prado et al. 2010; Leavitt et al. 2011a, 2016) spanning all Colorado taxa. Recent techniques including RAD sequencing are demonstrating utility for resolving species relationships in lichens (Grewe et al. 2017; Leavitt et al. 2012) as well as in other lineages (Daniel & Tripp 2018; Tripp et al. 2017). Colorado *Xanthoparmelia* would be an excellent study system in which to further assess discrepancies between species groups defined based on morphological and chemical features versus those based on molecular phylogenomic methods.

TAXONOMIC TREATMENT

The following treatment is based on examination of type specimen digital loans, study of protologues, study of previously accessioned COLO material, and study of new material collected by the authors. All material in the specimens cited sections includes a unique identifier, which refers to barcodes affixed to COLO material. Spot test and TLC data listed under each species entry were taken from our observations of Colorado-only material. Characters that we found to be invariant across all species in Colorado, based on our material, are excluded from mention in the species accounts below. For example, thalli of all species and specimens studied here are considered foliose and contain a white medulla with a continuous algal layer.

KEY TO THE SPECIES OF *XANTHOPARMELIA* IN COLORADO

1a. Thallus sorediate or isidiate 2
1b. Thallus not sorediate or isidiate 6

2a. Thallus sorediate .... *X. mougeotii*
2b. Thallus isidiate 3

3a. Medulla: K+ red (salazinic, sometimes w/ norstictic) .... *X. mexicana*
3b. Medulla: K+ yellow or orange (psoromic or stictic) 4

4a. Thallus with psoromic acid (K+ yellow) .... *X. lavicola*
4b. Thallus with stictic acid (K+ yellow-orange) 5

5a. Lower surface black .... *X. conspersa*
5b. Lower surface pale to dark brown .... *X. plittii*

6a. Thallus vagrant, usually forming rosettes 7
6b. Thallus loosely to tightly adnate on rocks, pebbles, soil or bark 11

7a. Thallus with stictic acid (K+ yellow-orange) .... *X. vagans*
7b. Medulla without stictic acid (K+ red, K+ yellow to red) 8

8a. Thallus without salazinic acid, with norstictic acid (K+ yellow to red) .... *X. neochlorochroa*
8b. Thallus with salazinic acid (K+ red) 9

9a. Thallus with maculate upper surface .... *X. idahoensis*
9b. Thallus lacking maculate upper surface *10*

10a. Lobes dichotomously branched and deeply divided, apothecia not present……….…… *X. chlorochroa*
10b. Lobes subdichotomously branched, apothecia infrequent to moderately common……… *X. wyomingica*

11a. Thallus with salazinic acid (K+ red) 12
11b. Thallus without salazinic acid (K-, K+ yellow, or K+ yellow to orange) 15

12a. Thallus loosely adnate to substrate, lobes narrow (0.5–2 mm wide) 13
12b.Thallus tightly to loosely adnate to substrate; lobes wide (1–9 mm wide) 14

13a. Lobes separate to partially overlapping to convolute; growing on pebbles or moss or dirt; occurring at 3000 m+ elevation .... *X. wyomingica*
13b. Lobes partially to fully overlapping, tightly shingled towards center of thallus; growing on rock; occurring at 2000-3000 m+ elevation .... *X. stenophylla*

14a. Thallus tightly adnate to rock substrate; lobes closely appressed to substrate 1-3 mm wide..... *X. lineola*
14b. Thallus loosely adnate to rock substrate; lobes typically lifting away from substrate 1-9 mm wide......... .... *X. coloradoensis*

15a. Thallus with stictic acid (K+ yellow-orange) .... *X. cumberlandia*
15b. Thallus without stictic acid (K- or K+ yellow) 16

16a. Thallus with psoromic acid (K+ yellow) .... *X. psoromifera*
16b. Thallus without psoromic acid (K-) 17

17a. Thallus with atranorin (cortex) and protoconstipatic acids (medulla) (both major to trace) (K- and P-)... .... *X. subdecipiens*
17b. Thallus with fumarprotocetraric acid (K-, P+ orange to red) 18

18a. Thallus adnate or tightly adnate on rock substrate .... *X. novomexicana*
18b. Thallus loosely adnate to rock substrate .... *X. monticola*

ACCOUNTS OF THE SPECIES

Xanthoparmelia chlorochroa (Tuck.) Hale, Phytologia 28: 486. 1974. ≡ *Parmelia chlorochroa* Tuck., Proc. Amer. Acad. Arts 4: 383. 1860. **TYPE: U.S.A.** NORTH DAKOTA: Missouri River, 1859-1860, *F.V. Hayden s.n.* (FH[image!], lectotype [designated by Berry, Ann. Mo. Bot. Gard. 2: 70. 1941); H [H9503765] [image!], MSC [MSC0122044] [image!], US [00068756] [image!], isolectoypes).

FIGURE 3.

DESCRIPTION. – **Thallus** vagrant. **Lobes** irregular; dichotomously branched and deeply divided, 3−8 mm wide; separate to subimbricate and strongly convolute; margins entire to crenate. **Upper surface** yellow-green, smooth, cracking and darkening towards older portions of thallus. **Lower surface** dark brown to black, shiny; rhizines black. **Apothecia** not seen. **Pycnidia** infrequent to occasional, black, sunken below upper cortex.

CHEMISTRY. – Upper cortex: usnic acid (major); medulla: salazinic acid (major), consalazinic acid (minor), norstictic acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ red, C-, KC-, P+ orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia chlorochroa* is relatively common in the southern Rocky Mountains across an elevation range of approximately 1524−3048 m (5000−10000 ft), particularly in northern portions of Colorado (Figure 2) (CNALH 2016). It is a vagrant species commonly found on soil. The Navajo use it to create dyes for rugs, and it has also been known to poison livestock and elk (Brodo et al. 2001, Daily et al. 2008).

NOTES. – Ample confusion has existed regarding delimitation of vagrant *Xanthoparmelia* species worldwide. Lack of apothecia, presence of salazinic acid, and occurrence only in the Americas distinguish *X. chlorochroa* from other vagrant species found elsewhere in North America and beyond (Hale 1990, Rosentreter 1993). *Xanthoparmelia chlorochroa* is most frequently confused with *X. vagans* (compare Figures 2 and 19), which is similar morphologically but can be differentiated by the presence of stictic acid rather than salazinic acid (Hale 1990, and here confirmed).

TLC conducted on the isolectotype at US (researcher unknown) also confirmed the presence of salazinic and usnic acids; however, at some unspecified but presumably later date (i.e., because of relative positional placements of TLC annotations on the packet), a different researcher (also unknown) added “stictic acid +” to the label, which we here presume to be an error. TLC conducted on all Coloradan material housed at COLO representative of this species recovered only salazinic and usnic acids as major compounds (norstictic was also commonly present in trace amounts).

Additional specimens examined. – **U.S.A.** COLORADO. ALAMOSA CO.: Great Sand Dunes National Monument, 5 mi S of headquarters, 10.vi.1954, *S. Shushan s.n.* (COLO-L-0047587). Boulder Co.: Rabbit Mountain, E of Lyons, 4.x.1997, *W.A. Weber s.n.* (COLO-L-0047569); base of Steamboat Mountain, 2 mi NW of Lyons, 12.iii.1959, *W.A. Weber s.n.* (COLO-L-0047575). CONEJOS CO.: 5 mi W of Antonito, along roadside, 18.vii.1952, *W.A. Weber s.n.* (COLO-L-0047563); W bank of (and directly above) Conejos River, W of Plataro Reservoir, 37°18’33”N 106°35’54”W, 10850 ft, 4.vi.2013, *E.A. Tripp 4547* (COLO-L-0049977). CUSTER CO.: 8 mi W of Westcliffe, Alvarado Picnic Grounds, 13.vi.1952, *T.P. Maslin s.n.* (COLO-L-0047557). DOUGLAS CO.: Castlewood Canyon State Park, on the Arkansas Divide, 5 mi S of Franktown, vicinity of Bridge Canyon Overlook, 28.ix.2002, *W.A. Weber s.n.* (COLO-L-0047539). ELBERT CO., 14 mi E of Elbert, 13.v.1951, *W.A. Weber 5991* (COLO-L-0047545); ca. 7 mi NW of Elbert, 3.vii.1956, *R.P. Higgins s.n.* (COLO-L-0047551). GRAND CO.: ca. 4 mi SE of Kremmling, 1.ii.1972, *D.W. Reichert 262* (COLO-L-0047496); Shadow Mountain National Recreation Area, Table Mountain, 30.vii.1957, *J. Douglass s.n.* (COLO-L-0047521); between Parshall and Kremmling, 11.v.1952, *W.A. Weber 7323* (COLO-L-0047527); SE of road and 1.4 road mi E of Granby, 25.vii.1957, *J. Douglass s.n.* (COLO-L-0047533); Bureau of Land Management, ca. 2.2 air mi NE of Kremmling, S of Wolford Mountain in the vicinity of Cow Gulch, 30.viii.2014, *B. Elliot 16352* (COLO-L-0050857). GUNNISON CO.: 0.25 mi. S of US50, on Colorado Highway 114, 1.vi.1955, *J. Douglass s.n.* (COLO-L-0047484); 4 mi SW of

Figure 3. *Xanthoparmelia chlorochroa*, one of four vagrant *Xanthoparmelia* in Colorado. It frequently has dichotomous branching, lacks apothecia, and is probably the most common vagrant lichen found in the state.

Gunnison, 16.vii.1953, *W.A. Weber s.n.* (COLO-L-0047508); 4 mi SW of Gunnison, along roadside, 16.vii.1953, *W.A. Weber s.n*. (COLO-L-0047514); along Gunnison River Canyon, 2-5 mi W of Sapinero, 29.v.1952, *W.A. Weber s.n.* (COLO-L-0047520); 8.5 mi S of Gunnison, 14.viii.1952, *M.L. Mattoon s.n.* (COLO-L-0048363). HINSDALE CO.: Mesa Seco, near Slumgullion Pass, 24.vii.1964, *W.A. Weber s.n.* (COLO-L-0047472); above Slumgullion Pass, 16.viii.1951, *G. Alexander s.n.* (COLO-L-0047490). JACKSON CO.: 4.7 mi SE of Pearl, road to Big Creek Lake, 9.vii.1956, *M.M. Douglass s.n.* (COLO-L-0047478). LA PLATA CO.: just N of Bondad at junction of Florida and Animas Rivers, 12.vi.1955, *S. Shushan s.n.* (COLO-L-0047460). LARIMER CO.: 12 mi NW of Wellington, 19.iv.1952, *W.A. Weber s.n.* (COLO-L-0047454). MOFFAT CO.: Douglas Mountain, triangulation point above the Copper Mine, 29.vii.1960, *M. MacLeod 147* (COLO-L-0047466); N end of Dinosaur National Monument, at entrance of Green River into the Canyon of Lodore, ca. 1 mi S of Browns Park, 29.vii.1962, *S. Flowers s.n.* (COLO-L-0047519). MONTROSE CO.: above Cimarron Creek, 5 mi S of Cimarron, 8.viii.1954, *S. Shushan s.n.* (COLO-L-0047483). PARK CO.: 4 mi S of Fairplay, 6.vi.1952, *W.A. Weber s.n.* (COLO-L-0047471); near N end of Antero Reservoir, 29.v.1955, *J. Douglass s.n.* (COLO-L-0047489); Nordamerika, S of Fairplay, 6.vii.1952, *S. Shushan s.n.* (COLO-L-0047507); 3 mi W of Florissant, just over Teller-Park County line, 12.iv.1954, *S. Shushan s.n.* (COLO-L-0047513); Hoosier Pass campground, 4.vii.1954, *S. Shushan s.n.* (COLO-L-0047477); S/W bank of South Fork of the South Platte River, along County Road 22, E of Weston Pass, 39.083795 -106.139743, 10313 ft, 27.vi.2015, *E.A. Tripp 5600* (COLO-L-0051289). RIO BLANCO CO.: valley of Strawberry Creek. 7 mi NW of Meeker, 10.v.1952, *W.A. Weber 7380* (COLO-L-0047501). SAGUACHE CO.: Great Sand Dunes National Park, Mineral King Trail off Brook Trout Rd., Grats Parcel of Baca Grande Subdivision near Crestone, W base of Sangre de Cristo Range; 27.i.2001, *J. Erdman 44* (COLO-L-0047453); 0.6 mi from Old Agency Ranger Station on Los Pinos Pass Rd., 1.vi.1955, *J. Douglass s.n.* (COLO-L-0047459); Cochetopa Park, just S of summit of Cochetopa Pass, 10.viii.1955, *W.A. Weber s.n.* (COLO-L-0047465); 3 mi NW of Cochetopa Pass on Colorado Highway 114, 1.vi.1955, *J. Douglass s.n.* (COLO-L-0047495). WELD CO.: 7 mi N of Nunn on Highway 85, 8.iv.1955, *J. Douglass s.n.* (COLO-L-0047506); Pawnee National Grassland, 20 km ENE of Ault along Rte. 12, 9.viii.1984, *T.H. Nash III 25761* (COLO-L-0047512); Pawnee National Grassland, 20 mi E of Ault, 18.ii.1994, *J. K. Nelson 1670* (COLO-L-0047518).

Xanthoparmelia coloradoensis (Gyel.) Hale, Mycotaxon 33: 402. 1988. ≡ *Parmelia ioannis-simae* var. *coloradoensis* Gyel., Repert. Spec. Nov. Regni Veg. 31: 287. 1931. **TYPE: U.S.A.** COLORADO: Caribou ("Cariberu"), 3109 m. (10200 ft) elevation, 18.ii.1916, *I.W. Clokey 14* (US 00344632 [image!], lectotype (designated by Hale 1990: 87); BP[image!], isolectotype).

FIGURE 4.

DESCRIPTION. – **Thallus** adnate to loosely adnate; saxicolous. **Lobes** sublinear; moderately divided, 1−9 mm wide; minimally to moderately imbricate; margins browning towards tips; apices usually crenate. **Upper surface** yellow-green, smooth, cracking and darkening towards older portions of thallus. **Lower surface** pale brown; rhizines brown, frequent. **Apothecia** frequent, sessile, disks light to dark brown, margins subconvex. **Ascospores** ellipsoid, non-septate, colorless, 6−7 × 4−5 µm. **Pycnidia** frequent, black, sunken below upper cortex.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: salazinic acid (major), consalazinic (minor), norstictic acid (minor). Spot tests: cortex: K-, C-, KC-, P- medulla: K+ dark orange to red, C-, KC-, P+ orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia coloradoensis* is primarily found within the southern Rocky Mountains but also occurs in mountainous areas of Arizona, New Mexico, Baja California del Sur, and in California coastal sage communities (Hale 1990, Nash 2002). The species grows in an extremely broad diversity of habitats in Colorado (Figure 2) ranging from sagebrush plains to coniferous forests.

NOTES. – *Xanthoparmelia coloradoensis* is member to the largest chemical group in Colorado, which includes *X. lineola, X. chlorochroa,* and *X. wyomingica* (see Figure 2*).* All contain salazinic, consalazinic, norstictic, and usnic acids. It can be easy to confuse *X. coloradoensis*, *X. lineola*, and *X. wyomingica* at first glance. Variation between the three is primarily related to lobe morphology: *X. lineola* (Figure 9) is tightly adnate (to rocks) with narrow lobes while *X. wyomingica* (Figure 20) is extremely loosely adnate with convoluted lobes. *X. coloradoensis* falls in the middle of this spectrum, having broader lobes than those of *X. lineola* but being moderately to loosely adnate to its rocky substrate (Hale 1990).

Spot tests conducted by V. Gyelnik annotated on the isolectotype were somewhat contradictory ("Thallus P-, Medulla: K+ not red, (possibly) KC+ red, C-, P+ yellow", verbatim from Gylenik's annotation label). However, the TLC results performed by Hale in 1989 on the isolectotype are compatible with the spot test results found consistently across all Colorado material, which were determined by the authors to be accurate.

Additional specimens examined. – **U.S.A.** COLORADO. BACA CO.: vicinity of Dodge Ranch, SW of Utleyville, 4500 ft, 4.ix.1955, *S. Shushan s.n.* (COLO-L-0047975). BOULDER CO.: W side of Steamboat Mt., 3 mi. NW of Lyons, ca. 5600 ft, 7.ii.1954, *W.A. Weber s.n.* (COLO-L-0048103); first Flatiron just above mouth of Gregory Canyon, 1800 m.s.m., 6.vii.1976, *W.A. Weber s.n.* (COLO-L-00448011); Rocky Mountain National Park, Longs Peak Valley, 2774 m, 14.ix.1932, *W. Kiener 80* (COLO-L-0047763), 10.viii.1935, *W. Kiener 3042* (COLO-L-0047769); Lytle Formation, Dakota Group, ca. 4 mi N of Boulder, T1N, R71W, SEC1, 6100 ft, 1.viii.1959, *R.A. Anderson s.n.* (COLO-L- 0048077); NW slope of Green Mountain, SW of Boulder, 2286 m, 2.ii.1952, *S. Shushan s.n.* (COLO-L-0047731); White Rocks, 8 mi NE of Boulder on N side of Boulder Creek, 30.xi.1975, *W.A. Weber s.n.* (COLO-L-0048060); Colorado Front Range W of Boulder, junction of Peak-to-Peak Highway and Gold Hill Rd., 13.vi.1998, 2743 m, *W.A. Weber s.n.* (COLO-L-0047586); White Rocks Nature Preserve, 40.05335 -105.15531, 569 m, 22.vii.2014, *E.A. Tripp 4840* (COLO-L-0050574); White Rocks Nature Preserve, 40.05352 -105.15909, 1580 m, 6.viii.2014, *E.A. Tripp 4855* (COLO-L-0050587); 1 mile NE of Gold Hill along Lefthand Creek, 2256 m, 4.vi.1967, *C.M. Wetmore 16082* (COLO-L-0047780); City of Boulder Open Space, Johnson Property, NE corner of property, just S of intersection of Nelson Rd. and 39th St., 40.145179° -105.265515°, 5568 ft, 19.vi.2015, *V. Diaz 2* (COLO-L-0055900), 40.144591°, -105.26385°, 5550 ft, 19.vi.2015, *V. Diaz 7* (COLO-L-0055882); City of Boulder Open Space, Austin-Russell Property, along Blue Ski Jump and Bell/ Baird Trails, approx. 0.5 mi S of Baseline Rd., 39.992928° -105.289204°, 5821 ft, 26.vi.2015, *V. Diaz 9* (COLO-L-0055821), 39.995266° -105.287005°, 5821 ft, 26.vi.2015, *V. Diaz 14* (COLO-L-0055881), 39.992928°, -105.289204°, 5821 ft, 26.vi.2015, *V. Diaz 19* (COLO-L-0055816); City of Boulder Open Space, Austin-Russell Property, along

Figure 4. *Xanthoparmelia coloradoensis* is one of the many salazinic acid-containing species in Colorado. Note the looser adnation to the rock and slightly more foliose appearance compared to *X. lineola*.

Chataqua Trail, approx. 0.5 mi S of Baseline Rd., 39.995266° -105.287005°, 5821 ft, 26.vi.2015, *V. Diaz 10* (COLO-L-0055822); City of Boulder Open Space, Circle of Friends Property, along Sunshine Canyon Trail on S side of Sunshine Canyon Drive, 40.022072° -105.300673°, 5587 ft, 26.vi.2015, *V. Diaz 13* (COLO-L-0055812), *V. Diaz 18* (COLO-L-0055871); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail, approx. 0.45 mi from trailhead, 40.026184° -105.30068°, 5931 ft, 10.vii.2015, *V. Diaz 45* (COLO-L-0055876), 40.025893° -105.30021°, 5931 ft, 10.vii.2015, *V. Diaz 48* (COLO-L-0055889); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail, approx. 0.5 mi from trailhead, 40.027523° -105.302771°, 5557 ft, 10.vii.2015, *V. Diaz 46* (COLO-L-0055798), *V. Diaz 59* (COLO-L-0055826);City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail, approx. 0.4 mi from trailhead, 40.025633° -105.300146°, 5931 ft, 10.vii.2015, *V. Diaz 50* (COLO-L-0055796), *V. Diaz 57* (COLO-L-0055824); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail, approx. 0.3 mi from trailhead, 40.022115°, -105.2982°, 5931 ft, 10.vii.2015, *V. Diaz 58* (COLO-L-0055825); City of Boulder Open Space, Schneider Property, approx. 0.5 mi W of N Foothills Parkway/US 36, 40.079388° -105.290551°, 5328 ft, 26.vi.2015, *V. Diaz 17* (COLO-L-0055815), 40.079394°, -105.289748°, 5328 ft, 26.vi.2015, *V. Diaz 21* (COLO-L-0055887); 40.079628°, -105.289906°, 5328 ft, 26.vi.2015, *V. Diaz 26* (COLO-L-0055845); City of Boulder Open Space, Schneider Property, approx. 1.5 mi W of N Foothills Parkway/US 36, 40.079681° -105.294781°, 5328 ft, 26.vi.2015, *V. Diaz 27* (COLO-L-0055883), 40.079779° -105.295412°, 5328 ft, 26.vi.2015, *V. Diaz 28* (COLO-L-0055790); City of Boulder Open Space, Bergheim-Wood Property, along Flatirons Loop Trail, approx. 75 ft W of intersection w/ Bluebell Trail, 39.991142°, -105.287716°, 6148 ft, 29.vi.2015, *V. Diaz 31* (COLO-L-0055835); City of Boulder Open Space, Bergheim-Wood Property, along Woods Quarry Trail, approx. 280 ft W from intersection w/ Mesa Trail, 39.987509° -105.286632°, 6382 ft, 29.vi.2015, *V. Diaz 32* (COLO-L-0055836); City of Boulder Open Space, Bergheim-Wood Property, along Bluebell-Baird Trail, approx. 270 ft N of intersection w/ Flatirons Loop Trail, 39.991763° -105.287501°, 6123 ft, 29.vi.2015, *V. Diaz 34* (COLO-L-0055838); City of Boulder Open Space, Bergheim-Wood Property, along Flatirons Loop Trail, approx. 75 ft W of intersection w/ Bluebell Trail, 39.991142° -105.287716°, 6148 ft, 29.vi.2015, *V. Diaz 35* (COLO-L-0055789); City of Boulder Open Space, Bergheim-Wood Property, along Flatirons Loop Trail, just S of intersection w/ Bluebell-Baird Trail, 39.992425° -105.288971°, 6200 ft, 29.vi.2015, *V. Diaz 36* (COLO-L-0055872), *V. Diaz 40* (COLO-L-0055894); City of Boulder Open Space, Bergheim-Wood Property, along Mesa Trail, approx. 360 ft NW of McClintock Upper Trail, 39.990579° -105.286879°, 6148 ft, 29.vi.2015, *V. Diaz 37* (COLO-L-0055873); City of Boulder Open Space, Bergheim-Wood Property, along Mesa Trail, approx. 350 ft N of intersection w/ Woods Quarry Trail, 39.986494° -105.286149°, 6208 ft, 29.vi.2015, *V. Diaz 38* (COLO-L-0055893), *V. Diaz 39* (COLO-L-0055788); City of Boulder Open Space, Bergheim-Wood Property, along Mesa Trail, approx. 75 ft S of McClintock Upper Trail, 39.990115° -105.285999°, 6117 ft, 29.vi.2015, *V. Diaz 41* (COLO-L-0055787), *V. Diaz 42* (COLO-L-0055839); City of Boulder Open Space, Hogan Brothers Property, approx. 250 ft E of S Cherryvale Rd., 39.962469° -105.211265°, 5546 ft, 17.vii.2015, *V. Diaz 60* (COLO-L-0055827); City of Boulder Open Space, Hogan Brothers Property, approx. 210 ft E of S Cherryvale Rd., 39.962783° -105.211411°, 5546 ft, 17.vii.2015, *V. Diaz 61* (COLO-L-0055878), *V. Diaz 64* (COLO-L-0055874); City of Boulder Open Space, Hogan Brothers Property, approx. 500 ft E of S Cherryvale Rd., 39.962132° -105.211481°, 5547 ft, 17.vii.2015, *V. Diaz 63* (COLO-L-0055793); City of Boulder Open Space, Van Vleet Property, just W of S. Cherryvale Rd. and just S of Marshallville Ditch, 39.974252° -105.213577°, 5463 ft, 17.vii.2015, *V. Diaz 66* (COLO-L-0055805); City of Boulder Open Space, Jewel Mountain Property, approx. 50 ft E of Plainview Rd. and approx. 400 ft S of Coal Creek, 39.877702° -105.268981°, 6464 ft, 24.vii.2015, *V. Diaz 69* (COLO-L-005580); City of Boulder Open Space, Fraiser Farms Property, at the intersection of Mesa and Upper Big Bluestem Trails, 39.953578° -105.279707°, 6092 ft, 14.viii.2015, *V. Diaz 74* (COLO-L-0055886); City of Boulder Open Space, East Rudd Property, along Davidson Ditch just S of Marshall Valley Trail, 39.954074° -105.21845°, 5608 ft, 20.viii.2015, *V. Diaz 76* (COLO-L-0055800); City of Boulder Open Space, Flatirons Vista Property, approx. 50 ft S of Prairie Vista Trail, 39.922773° -105.24055°,6054 ft, 27.viii.2015, *V. Diaz 77* (COLO-L-0055801); City of Boulder Open Space, Hedgecock Property, just S of S. Boulder Creek W. Trail, approx. 460 ft E of intersection w/ Mesa Trail, 39.94552° -105.261629°, 5736 ft, 12.x.2015, *V. Diaz 81* (COLO-L-0055804). CHAFFEE CO.: 5 mi E of Buena Vista, 8500 ft, 6.vi.1952, *S. Shushan s.n.* (COLO-L-0048017). CUSTER: CO. 8 mi W of Westcliffe, 8000 ft, 13.vi.1952, *T.P. Maslin s.n.* (COLO-L-0048096). DOLORES CO.: 10.2 road mi NE of Rico Liza Rd. Head Pass, 9800 ft, 16.vi.1954, *J. Douglass s.n.* (COLO-L-0048040). DOUGLAS CO.: Jackson Gulch, 7800 ft, 28.vi.1952, S. *Shushan s.n.* (COLO-L-0048053). EAGLE CO.: benches of Eagle River 6 mi W of Gypsum, 6100 ft, 14.v.1954, *W.A. Weber s.n.* (COLO-L-0048121). HINSDALE CO.: San Juan Mountains, Cataract Lake Basin, flat alpine plains of unnamed mountain, off trail and above (to E of) Cataract Lake, 37.850995 -107.421704, 13,000 ft, 11.vi.2015, *E.A. Tripp 5688* (COLO-L-0051196), *E.A. Tripp 5682* (COLO-L-0051190). HUERFANO CO.: E of Spanish Peak, S of La Veta, 11500 ft, 17.viii.1955, *S. Shushan s.n.* (COLO-L-0048048). Lake CO.: Mosquito Range, near summit of unnamed peak between Ptarmingan Peak and Horseshoe Couliour, 39.159492 -106.176807, 13,700 ft, 28.vi.2015, *E.A. Tripp 5583* (COLO-L-0051275), *E.A. Tripp 5592* (COLO-L-0051284). LARIMER CO.: Estes Park, 9 mi SE of; or 14 mi NW of Lyons, off Denver Highway, 7500 ft, 26.vii.1949, *W. Kiener 24767* (COLO-L-0047629); 19 mi N of LaPorte, 1981m, 29.iv.1954, *S. Shushan s.n.* (COLO-L-0047793); 11 mi E of Trail Ridge Campground, 8500 ft, 29.vii.1951, *S. Shushan s.n.* (COLO-L-0048050). MESA CO.: ca. 7 mi. SW of Whitewater, above East Creek N of Gibbler Gulch, 1.vi.1973, *W.A. Weber s.n.* (COLO-L-0047745). MONTROSE CO.: 4 mi W of Montrose on Colorado highway 90, 1585 m, 3.ix.1971, *G.K. Arp 1722* (COLO-L-0047885). PARK CO.: 3 mi W of Florissant, just over Teller-Park County line, 2469 m, 12.iv.1954, *S. Shushan s.n*. (COLO-L-0047757). Buffalo Peaks, top of saddle separating Four Mile Creek and Buffalo Meadow drainages, 2.viii.1991, 3475 m, *R.E. Abbot 275* (COLO-L-0047592).

Xanthoparmelia conspersa (Ehrh. ex Ach.) Hale, Phytologia 28: 485. 1974. ≡ *Lichen conspersus* Ehrh. ex Ach., Lichenogr. Suec. Prodr. (Linköping) p. 118. 1798. **TYPE: SWEDEN:** without location or collector, (H-ACH [H9502091] [image!], lectotype designated by Gyelnik (1930: 31).

FIGURE 5.

DESCRIPTION. – **Thallus** adnate to loosely adnate; saxicolous. **Lobes** irregular; moderately divided, 1−4 mm wide; separate to moderately imbricate, at times subconvolute; margins browning, apices usually crenate. **Upper surface** yellow-green, smooth, cracking and darkening towards older portions of thallus. **Lower surface** black, shiny; rhizines black with black rhizines, occurring frequently. **Isidia** at first globose, then becoming cylindrical and branching moderately; at times black or brown on tips. **Apothecia** infrequent

Figure 5. *Xanthoparmelia conspersa* is one of the isidiate species in Colorado. The lobe width (1−4 mm) and moderate adnation to the substrate are characteristic of what many think of as classic *Xanthoparmelia*.

to common, sessile; disks light to dark brown; margins subconvex and slightly crenate. **Ascospores** ellipsoid, non-septate, colorless, 6−7 × 5 µm. **Pycnidia** occurring frequently black, sunken below upper cortex.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: stictic acid (major), norstictic acid (minor). Spot tests: cortex: K-, C-, KC-, P- medulla: K+ yellow-orange, C-, KC-, P+ orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia conspersa* is very common in the U.S.A., particularly in the eastern U.S. (Hale 1990, Nash 1974). In Colorado, it can be found primarily in northern portions of the state at elevations ranging from 1829–3200 m (6000−10500 ft) in a wide range of habitats, from disturbed cattle ranches to undisturbed subalpine montane regions (Figure 2).

NOTES. – *Xanthoparmelia conspersa* is the type species of the genus and the namesake of the *X. conspersa* group, which comprises *X. conspersa*, *X. tinctina* (Mah. & Gillet) Hale, *X. piedmontensis* (Hale) Hale, *X. plittii*, *X. dierythra*, *X. mexicana*, and *X. subramigera* (Gyeln.) Hale. This group has been the focus of recent studies investigating many areas of lichenology including population diversity, secondary metabolites, and air pollution (Armstrong 2017, Matteucci et al. 2017, Puy-Alquiza et al. 2017). The species in this group are characterized by presence of isidia, black to light brown lower surfaces, and presence of one of four diagnostic acids: stictic, norstictic, salazinic, and fumarprotocetraric. Of these traits, *X. conspersa* has isidia, stictic acid, and a black lower surface.

Despite its importance as a widespread and abundant species as well as its status as type of the genus, there has been extensive discrepancy as to the delimitation of *Xanthoparmelia conspersa* historically. Over the last two centuries, that this species is predominately isidiate has been propagated throughout the literature (Hale 1990, Nash and Elix 2004). However, in the protologue written by Jakob Ehrhart (and validated by Acharius), there is clear mention of apothecia on the material he was examined. There is no mention of isidia. In addition, and to make matters more confusing, there are two specimens in H-ACH on the same sheet that have both been annotated as the lectotype. Gyelnik (1930) inadvertently lectotypified one

Figure 6. *Xanthoparmelia cumberlandia* is one of the most prominent fertile, stictic acid-containing species in Colorado. It is easily separated from the substrate, which is characteristic of this species.

of the two specimens by noting that the top (abundantly isidiate) specimen was representative of *Parmelia isidiata* (Anzi.) Gyel. and the bottom (abundantly fertile) representative of *X. conspersa* (Hale and Kurokawa 1964, Hale 1990). Thus, the protologue and Gyelnik's actions seem to suggest that *X. conspersa* is, in fact, a fertile species. However, upon close examination of the physical specimen by T. Ahti and J.C. Lendemer (as requested by us in preparation for this study), we confirm that both the top and bottom specimens bear isidia, thus confirming the long-held concept that *X. conspersa* is indeed isidiate. Hale's later attempt (1964; also see Hale 1990) to re-lectotypify the name with a different specimen (the top rather than the bottom) should be considered as superfluous given that Gyelnik's original lectotypification is not in conflict with the protologue.

Additional specimens examined. – **U.S.A.** COLORADO. HINSDALE CO.: Cebolla Creek Campground, 9400 ft, 29.vii.1964, *W.A. Weber s.n.* (COLO-L-0048000). GILPIN CO.: road to Corona, 11.vii.1918, *C.C. Plitt s.n.* (COLO-L-0048277). GUNNISON CO.: along East River just below Emerald Lake, 3200 m, 13.vii.1955, *W.A. Weber s.n*. (COLO-L-0047701). JEFFERSON CO.: Bancroft property, The Castle, just N of Wellington Lake, 9.vii.1976, *W.A. Weber s.n.* (COLO-L-0047803). ROUTT CO.: Slopes of Hahn's Peak, 3 mi E of Columbine, 2743 m, 22.vi.1965, *W.A. Weber s.n.* (COLO-L-0047671).

Xanthoparmelia cumberlandia (Gyel.) Hale, Phytologia 28: 486. 1974. ≡ *Parmelia subconspersa* var. *cumberlandia* Gyel. Repert. Spec. Nov. Regni Veg. 36: 164. 1934. **TYPE: U.S.A.** MAINE: Cumberland, vii.1907, *E.B. Chamberlain s.n.* (BP [image!]!, lectotype designated by Hale 1990: 98).

FIGURE 6.

DESCRIPTION. – **Thallus** adnate to loosely adnate; saxicolous. **Lobes** irregular, 1−8 mm wide, separate to subimbricate, flat to convolute; margins black at tips, apices mostly crenate. **Upper surface** yellow-green; epruinose, smooth, areolate and darkening towards older portions of thallus. **Lower surface** pale brown; rhizines brown to black. **Apothecia** infrequent to common, sessile; disks light to dark brown; margins subconvex and slightly crenate. **Ascospores** ellipsoid, non-septate, colorless, 6−7 x 4−5 µm. **Pycnidia** common, black, sunken below upper cortex.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: stictic acid (major), norstictic acid (minor), constipatic acid (trace). Spot tests: cortex: K-, C-, KC-, P- medulla: K+ yellow to orange, C-, KC-, P+ orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia cumberlandia* is very common across many portions of North America (Hale 1990; Nash and Elix 2004; Pringle et al. 2003). It however seems to be relatively uncommon in Colorado, where it occurs primarily in the southern Rocky Mountains in coniferous forests to alpine tundra over approximately 2286 m elevation (7500 ft).

NOTES. – *Xanthoparmelia cumberlandia* is generally considered to be the non-isidiate counterpart of the asexual species *X. plittii* (Figure 15) in that the two share chemistry and other (non-reproductive) morphological features. However, in the protologue for *X. cumberlandia*, Gyelnik clearly stated that the type specimen has a black underside., this correlates with examination of an image of the lectotype by the authors. (the holotype was presumably destroyed in Bouly de Lesdain's herbarium in Dunkirk, France during WWII). This is problematic because current usage of the name includes solely specimens with pale undersides. It may be that an alternative, existing name for specimens that otherwise fit the above concept of *X. cumberlandia* but have pale undersides is ultimately needed. If a name is not found, a new name for a fertile, stictic acid-containing species with a pale underside that occurs in North America may be warranted. Further study in comparison to specimens annotated as *X. plittii* (Figure 15) is also needed because the two taxa share numerous features.

Additional specimens examined. – **U.S.A.** COLORADO. BOULDER CO.: just NW of Boulder, 1829 m, 6.iv.1962, *W.A. Weber s.n*. (COLO-L-0047517); Upper Gregory Canyon, ca. 1 mi W of Boulder and 1 mi N of Green Mountain summit, 1940-1980 m, 10.x.1974, *G. Kunkel s.n.* (COLO-L-0047897); 5 mi NW of Eldora on trail from 4th of July Canyon, to Arapahoe Glacier, 3048-3353 m, 20.viii.1957, *S. Shushan s.n.* (COLO-L-0047666); Boulder Canyon near Tungsten, 12 mi W of Boulder, 2438 m, 29.iv.1959, *S. Shushan s.n.* (COLO-L-0047672); Rocky Mountain National Park, Longs Peak, 3368 m, 17.ix.1933, *W. Kiener 507* (COLO-L-0047683); City of Boulder Open Space, Austin-Russell Property, along Blue Ski Jump and Bell/ Baird Trails, approx. 0.5 mi S of Baseline Rd., in gravelly area among conifer trees, saxicolous, 39.996228°, -105.289193°, 6095 ft, 26.vi.2015, *V. Diaz 12* (COLO-L-0055891). CUSTER CO.: South Colony Creek basin, 37.98333 -105.50000, 3566 m, 8.vii.1941, *W. Kiener 10281* (COLO-L-0047719). EL PASO CO.: Golf Links, 2600 m, 6.ix.1904, *F. E. Clements s.n*. (COLO-L-0047695). GARFIELD CO.: White River National Forest, trail from Trappers Lake to Coffin Lake, ca. 30 mi E of Bufo Rd., 2957 m, 13.vii.1957, *S. Shushan s.n.* (COLO-L-0047725). GRAND CO.: near base of south slope of Jackstraw Mountain, 1.5 mi W of Timber Lake, 3219-3292 m, 4.vii.1962, *R.A. Anderson 2330* (COLO-L-0047707); Tonahutu Creek Trail, 1 mi E of Granite Falls, base of Snowdrift Peak, 3078-3139 m, 27.vii.1962, *R.A. Anderson 2422* (COLO-L-0047713). GUNNISON CO.: trail along Copper Creek to summit of Conundrum Pass, ca. 10 mi NE of Gothic, 10500 ft, 5.viii.1955, *W.A. Weber s.n.* (COLO-L- 0048074). HUERFANO CO.: Apishapa Pass. 10.vi.1960, *S. Shushan s.n.* (COLO-L-0047499). JEFFERSON CO.: lower slopes of spurs of "The Castle," Bancroft property NW of Willington Lake, 22.vi.1976, *W.A. Weber s.n.* (COLO-L-0048301). RIO BLANCO CO.: White River National Forest, Lost Creek Campground, 10 mi NW of Bufo Rd., 2286 m, 12.vii.1957, *S. Shushan s.n.* (COLO-L-0047689); S ridge of Mt. Zirkel, Park Range, E of Slavonia above Gold Creek, 3444 m, 28.vii.1956, *S. Shushan s.n.* (COLO-L-0047677).

X***anthoparmelia idahoensis*** Hale, Mycotaxon 34: 547. 1989. **TYPE: U.S.A.** IDAHO. LEMHI CO.: SE of Salmon, T 21N, R 22E, Sec 28, sites nearly barren of vascular vegetation and surrounded by shade scale *Artemisia confertifolia*, 1219 m. (4000 ft), 4.vi.1986, on calcareous laucustrine ash soil, *R. Rosentreter 3828* (US [00075673] [image!], holotype; SRP [00075673] [image], isotype).

FIGURE 7.

DESCRIPTION. – **Thallus** vagrant. **Lobes** sublinear, dichotomously branched, deeply divided 1–4 mm wide, sometimes black at apices; margins subcrenate. **Upper surface** yellow-green, strongly maculate, cracking and darkening towards older portions of thallus. **Lower surface** pale yellow to brown, shiny; rhizines infrequent. **Apothecia** not seen. **Pycnidia** not seen.

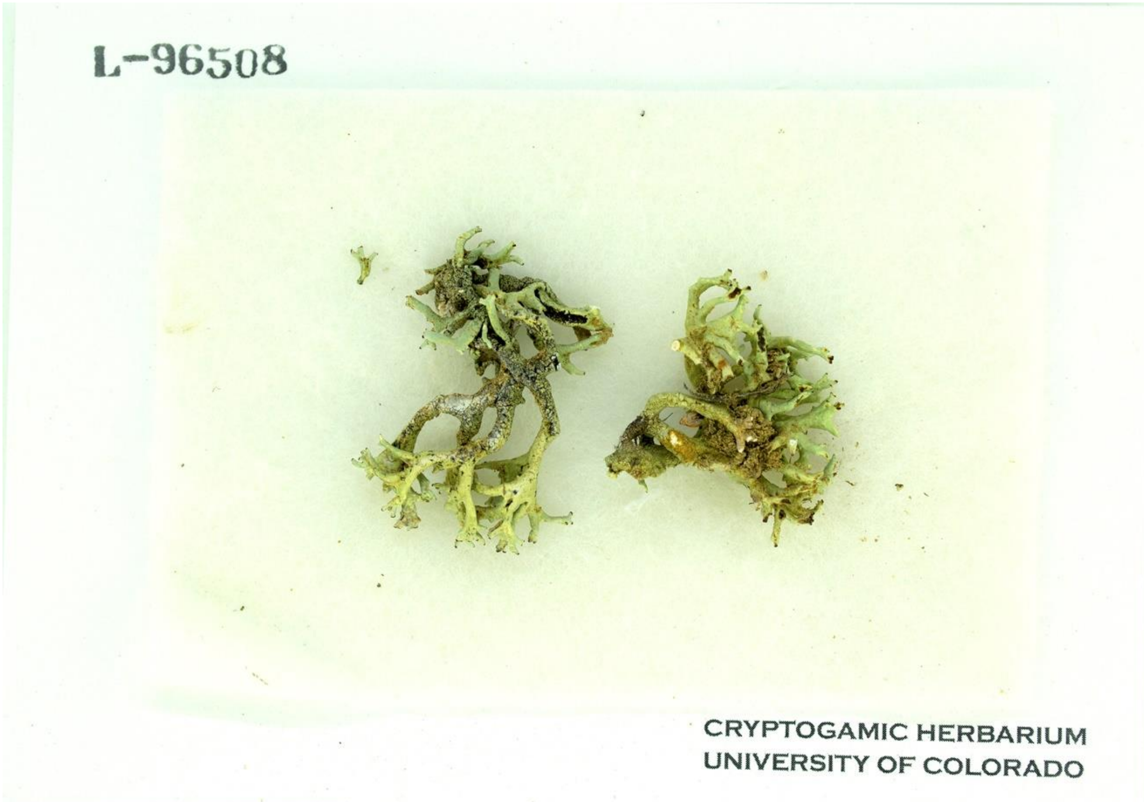

Figure 7. *Xanthoparmelia idahoensis* is characterized by its maculate surface (cracks in the upper cortex and photobiont layer that expose the white medulla below) with maculae visible under a dissecting microscope.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: salazinic acid (major), consalazinic acid (trace). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ red, C-, KC-, P+ orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia idahoensis* is currently only known to occur in very limited barren ("badlands") portions of Colorado and Idaho, U.S.A., and Saskatchewan, Canada, and is very rare (Goffinet et al. 2001, Rosentreter 1993). In Colorado, the COLO Herbarium only documents the species from Grand County, at an elevation of approximately 2377 m (7800 ft) (Figure 2). *Xanthoparmelia idahoensis* grows in cold, arid areas with low abundances of vascular vegetation (Goffinet et al. 2001). This species is considered by the Idaho Department of Fish and Game to be critically imperiled within the state of Idaho (Moseley et al. 1974).

NOTES. – *Xanthoparmelia idahoensis* greatly resembles *X. chlorochroa* (Figure 3) in chemistry, morphology, and habit. One must however examine the upper cortex to find the maculate surface of the former (Figure 7), which distinguishes these two species.

Upon studying the COLO specimens of *Xanthoparmelia idahoensis*, we encountered slight variation in spot tests (K+ yellow or orange instead of red); we also detected two unknown accessory compounds during TLC in two of the specimens. One occurred at an R_F value of approximately 35−40, turning brown with a blue halo under acid and heat. The other compound resolved at an R_F value of approximately 60, also turning brown with a blue halo under heat. Because of uncertain taxonomic status of these two specimens, they are excluded from this treatment but are under further study.

Additional specimens examined. – **U.S.A.** COLORADO. GRAND CO.: T2N, R81W, S26, 40°06′N 106°25′W, 2300 m, 17.vi.1995, *R. Rosentreter 9339* (COLO-L-0051162); approx. 8.2 air mi N of Kremmling on the E side of Hwy 9, 7630 ft, 31.viii.2014, *B. Elliot 16364* (COLO-L-0050864); approx. 8.3 air miles N of Kremmling, E of Wolford Mountain Reservoir near CR 25, 40.17763 -106.39828, 2338 m, 29.viii.2014, *B. Elliot 16342* (COLO-L-0050876); approx. 7.7 air mi N of Kremmling, E of Wolford Mountain Reservoir

Figure 8. *Xanthoparmelia lavicola* is the only isidiate species in Colorado with psoromic acid. Chemistry is required to differentiate *X. lavicola* and other asexual *Xanthoparmelia* species in Colorado.

near CR 25, 40.16910 -106.39707, 2335 m, 29.viii.2014, *B. Elliot 16345* (COLO-L-0050851); approx. 6.2 air mi NE of Kremmling, E of Wolford Mountain Reservoir near CR 25, 40.14727 -106.36011, 2414 m, 30.viii.2014, *B. Elliot 16348* (COLO-L-0050853); approx. 2.2 air mi NE of Kremmling, S of Wolford Mountain in the vicinity of Cow Gulch, near wooden power line, 40.09117 -106.37737, 2344 m, *B. Elliot 16351* (COLO-L-0050856); approx. 8.2 air mi N of Kremmling on the E side of Hwy 9, 40.17088 -106.43558, 2323 m, *B. Elliot 16363* (COLO-L-0050874), 40.17524 -106.42466, 2310 m, 31.viii.2014, *B. Elliot 16372* (COLO-L-0050869), 40.17051 -106.42274, 2316 m, 31.viii.2014, *B. Elliot 16373* (COLO-L-0050872).

Xanthoparmelia lavicola (Gyel.) Hale, Mycotaxon 33: 404. 1988. ≡ *Parmelia lavicola* Gyel., Repert. Spec. Nov. Regni Veg. 36: 157. 1934. **TYPE: MEXICO:** La Estrella, 9.ix.1928, *Frére Amable 600* (BP [image!], lectotype designated by Hale 1990: 74).

FIGURE 8.

DESCRIPTION. – **Thallus** suborbicular; tightly to moderately adnate; saxicolous. **Lobes** subirregular; somewhat divided, 1−3 mm wide; subimbricate, flat to subconvolute; margins usually black, apices crenate. **Upper surface** yellow-green; epruinose, smooth, shiny, moderately to densely isidiate. **Lower surface** pale; rhizines dark brown, occurring frequently. **Apothecia** not seen. **Pycnidia** not seen. **Isidia** at first globose, then becoming cylindrical and branching moderately; at times black or brown on tips.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: psoromic acid (major), unknown compound (trace), 2′-*O*- demethylpsoromic acid (trace), norstictic acid (trace). Spot tests: cortex: K-, C-, KC-, P- medulla: K+ yellow, C-, KC-, P+ yellow to orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia lavicola* occurs primarily in southwestern Arizona and northeastern Mexico (Nash and Elix 2004). Colorado specimens have been collected from both the eastern and western slopes in prairie and rocky areas at low elevations ranging from 1433–1676 m (4700–5500 ft; Figure 2). It should be noted that of the five collections housed at COLO, three were vouchered from White Rocks Open Space in the City of Boulder, which is a unique outcropping of Fox Hills sandstone (Tripp 2015).

NOTES. – *Xanthoparmelia lavicola* resembles *X. mexicana* (Figure 10) as well as *X. plittii* (Figure 15) morphologically, however *X. lavicola* has a thallus that is more consistently tightly adnate. Regardless of thallus adnation, *X. lavicola* can readily be characterized by the presence of psoromic acid as a major metabolite, which is otherwise rare in western North American *Xanthoparmelia* as a whole (Nash & Elix 2004; see Table 2 herein).

TLC conducted by M.E. Hale on the lectotype housed at BP (as annotated on the packet in 1987) indicated the presence of psoromic and norpsoromic acids; TLC conducted at a later date by an unknown researcher indicated the presence of fumarprotocetraric and usnic acids. We here err on the side of M. Hale's circumscription as a taxonomic expert in this group, acknowledging more work including additional TLC is needed on type material. We therefore circumscribe *X. lavicola* as a species that contains psoromic acid, not fumarprotocetraric acid, in agreement with Hale's original documentation (Barcenas-Peña 2021; Egan et al. 2002; Hale 1990).

Additional specimens examined. – **U.S.A.** COLORADO. BOULDER CO.: City of Boulder Open Space, Hedgecock Property, just S of S. Boulder Creek W. Trail; approx. 460 ft E of intersection w/ Mesa Trail, 39.94552° -105.261629°, 5736 ft, 12.x.2015, *V. Diaz 82* (COLO-L-0055794). JEFFERSON CO.: 7 mi S of Boulder, on Rocky Flats Pediment, 26.vi.1973, *G. Kunkel C-42* (COLO-L-0047859); White Rocks Open Space, 5146 ft., 4.x.2014, *E.A. Tripp 4839* (COLO-L-0050573), *E.A. Tripp 4874* (COLO-L-0050604). LAS ANIMAS CO.: W bank of Trinchera Creek, 25 mi E of Trinidad, 1676 m, 4.vii.1957, *S. Shushan s.n.* (COLO-L-0047831). WASHINGTON CO.: 6 mi WNW of Akron, 1433 m, 6.vi.1954, *S. Shushan s.n*. (COLO-L-0047848).

Xanthoparmelia lineola (Berry) Hale, Phytologia 28: 486. 1974. ≡ *Parmelia lineola* E.C. Berry, Ann. Missouri Bot. Gard. 28: 77. 1941. **TYPE: U.S.A.** ARIZONA. APACHE CO.: "Open woods, 3 miles northwest of Ft. Defiance" (*fide protologue*), 12.vi.1938, *L.Hubricht B1170*; NY [02607268] [image!], isotype **designated here (Mycobank #10006076**).

FIGURE 9.

DESCRIPTION. – **Thallus** usually orbicular; tightly adnate to substrate; saxicolous. **Lobes** irregular; at times dichotomously branched and divided, 1−3 mm wide; separate (usually at margins) to imbricate; margins blackening. **Upper surface** yellow-green, smooth and shiny, intensely cracking and darkening towards older portions of thallus. **Lower surface** dark brown; rhizines dark brown, occurring frequently. **Apothecia** common, sessile, disks light to dark brown; margins subconvex and slightly crenate. **Ascospores** ellipsoid, non-septate, colorless; 7−8 x 4−5 μm. **Pycnidia** frequent to occasional, black, sunken below upper cortex.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: salazinic acid (major), consalazinic acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ red, C-, KC-, P+ orange, UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia lineola* has been collected extensively in the southwestern United States and tends to grow at moderate to high elevations between 914–3658 meters (3000–12000 ft) on sun-exposed rocks in arid environments (Berry 1941; Nash 1974 Nash and Elix 2004; CNALH 2016). In Colorado, this species is found throughout the southern Rockies in mountainous regions from elevations ranging between 1829–3048 m (6000−10000 ft; Figure 2).

NOTES. – *Xanthoparmelia lineola* is a member of the salazinic acid containing group that includes *X. chlorochroa* (Figure 3), *X. coloradoensis* (Figure 4), *X. idahoensis* (Figure 7), *X. lineola* (Figure 9), *X. mexicana* (Figure 10), *X. stenophylla* (Figure 17), and *X. wyomingica* (Figure 20). It can be distinguished from these other species by being the most tightly adnate member of this group.

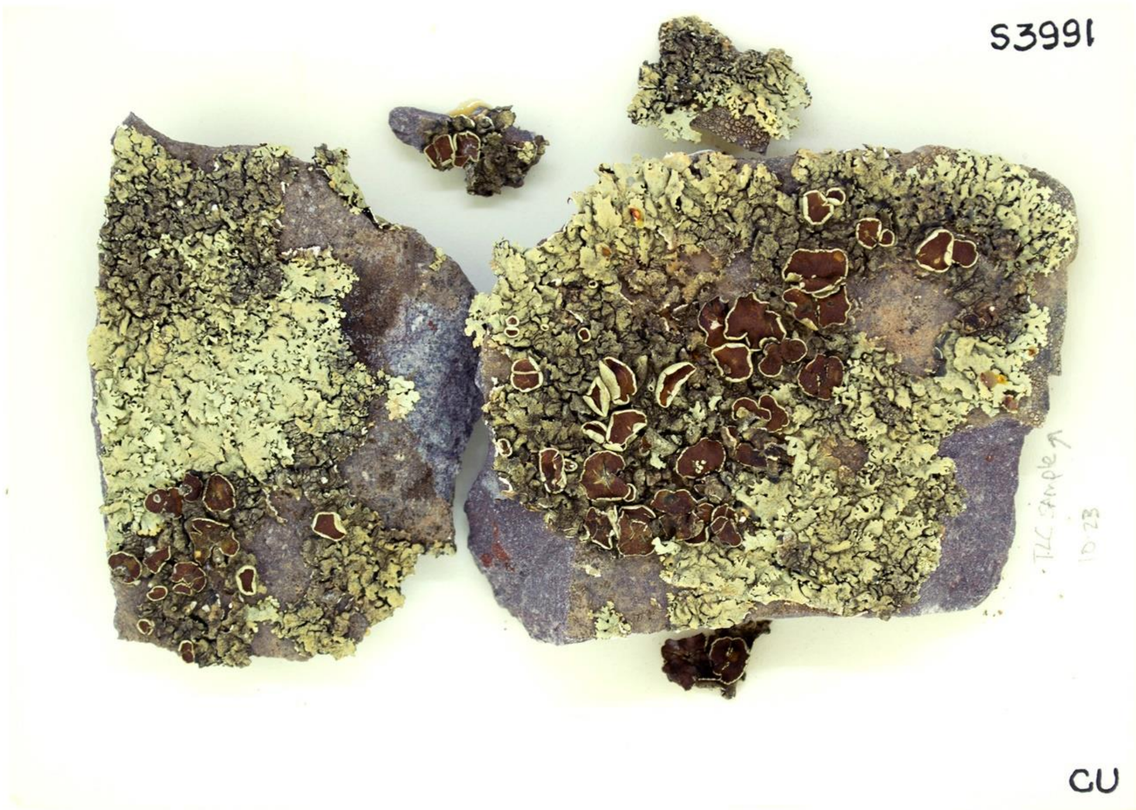

Figure 9. *Xanthoparmelia lineola* is one of the most common salazinic acid-containing species in Colorado. Note its very tight adnation to the rock, which what separates it from *X. coloradoensis* and *X. wyomingica*.

Hale (1990) cited the holotype (collection B11700) being located at US. However, the specimen he appeared to examine at the US herbarium is labeled collection B1181. Berry clearly cited B1170 as the type specimen in the protologue cited above. While it is possible to speculate Berry mistakenly switched the labels between the two specimens with the intent of designating the US specimen as the type, the authors will adhere to what is stated in the protologue and assign collection B1170 located at NY the type specimen.

Additional specimens examined. – **U.S.A.** COLORADO. ALAMOSA CO.: Great Sand Dunes National Monument, trail to Mosca Pass, 10.vi.1954, *S. Shushan s.n.* (COLO-L-0047581). BOULDER CO.: Boulder Canyon ca. 0.5 mi up from mouth, 1800 m, 7.vii.1976, *W.A.Weber s.n.*, (COLO-L-0048005); Boulder Canyon near Tungsten, 8000 ft, 29.iv.1959, *S. Shushan s.n.* (COLO-L-0048023); Steamboat Mountain, 2 mi. NW of Lyons, 1829 m, 15.x.1972, *W.A. Weber s.n.* (COLO-L-0047740); summit of Niwot Ridge, 3505 m, 19.vii.1951, *M.E Hale s.n*. (COLO-L-0047805); Roosevelt National Forest, between backyard of 6251 Lefthand Canyon and Cocktail Rock, 0.3 mi W of Lee Hill Rd. and 0.2 mi S of Lefthand Canyon Dr., 2195 m, 28.iii.2014, *E.A. Tripp 4893* (COLO-L-0050912), *E.A. Tripp 4894* (COLO-L-0050913); City of Boulder Open Space, Johnson Property, NE corner of property, just S of intersection of Nelson Rd. and 39th St., 40.144196° -105.265447°, 5568 ft, 19.vi.2015, *V. Diaz 1* (COLO-L-0055817), 40.143867° -105.265403°, 5568 ft, 19.vi.2015, *V. Diaz 5* (COLO-L-0055879), 40.144591° -105.26385°, 5550 ft, 19.vi.2015, *V. Diaz 6* (COLO-L-0055819), 40.144961° -105.265085°, 5568 ft, 26.vi.2015, *V. Diaz 16* (COLO-L-0055814); City of Boulder Open Space, Schneider Property, approx. 3.5 mi W of N Foothills Parkway/US 3, 40.079317° -105.292306°, 5328 ft, 26.vi.2015, *V. Diaz 8* (COLO-L-0055820); City of Boulder Open Space, Schneider Property, approx. 0.5 mi W of N Foothills Parkway/US 36, 40.079628° -105.289906°, 5328 ft, 26.vi.2015, *V. Diaz 22* (COLO-L-0055888), 40.079394° -105.289748°, 5328 ft, 26.vi.2015, *V. Diaz 23* (COLO-L-0055843); City of Boulder Open Space, Schneider Property, approx. 1.5 mi W of N Foothills Parkway/US 36, 40.079514° -105.295446°, 5328 ft, 26.vi.2015, *V. Diaz 25* (COLO-L-

0055890); City of Boulder Open Space, Bergheim-Wood Property, along Mesa Trail, approx. 75 ft S of McClintock Upper Trail, 39.990115° -105.285999°, 6117 ft, 29.vi.2015, *V. Diaz 33* (COLO-L-0055837); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx. 0.4 mi from trailhead, 40.025633° -105.300146°,5931 ft, 10.vii.2015, *V. Diaz 55* (COLO-L-0055834); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx. 0.45 mi from trailhead, 40.025893° -105.30021°, 5931 ft, 10.vii.2015, *V. Diaz 56* (COLO-L-0055823); City of Boulder Open Space, Van Vleet Property, just W of S. Cherryvale Rd. and just S of Marshallville Ditch, 39.974252° -105.213577°, 5463 ft, 17.vii.2015, *V. Diaz 65* (COLO-L-0055892); City of Boulder Open Space, Yunker Property, approx. 1500 ft N of Marshall Rd. and approx. 1.5 mi W of intersection w/ the Denver Turnpike, 39.965496, -105.195661°, 5693 ft, 17.vii.2015, *V. Diaz 68* (COLO-L-0055884); City of Boulder Open Space, Abbey Property, just off of N Fork Shanahan Trail approx. 380 ft N of intersection w/ Leigh Connector-S, 39.965576° -105.260345°, 5755 ft, 24.viii.2015, *V. Diaz 73* (COLO-L-0055799); City of Boulder Open Space, Flatirons Vista Property, approx. 100 ft S of Prairie Vista Trail, 39.921914° -105.243967°, 6054 ft, 27.viii.2015, *V. Diaz 78* (COLO-L-0055802); City of Boulder Open Space, Matterhorn Property, approx. 400 ft W of Foothills Parkway and 0.5 mi S of Davidson Ditch, 39.946363° -105.238597°, 5629 ft, 27.viii.2015, *V. Diaz 79* (COLO-L-0055885); City of Boulder Open Space, Hedgecock Property, just S of S. Boulder Creek W. Trail; approx. 460 ft E of intersection w/ Mesa Trail, 39.94552° -105.261629°, 5736 ft, 12.x.2015, *V. Diaz 80* (COLO-L-0055803). CUSTER CO.: San Isabel National Forest, 2 mi N of Ophir Campground, 2560 m, 13.vi.1951, *S. Shushan s.n.* (COLO-L-0047799). JACKSON CO.: along E edge of Big Creek Lake, E slope of Park Range, 24 mi W of Cowdrey, 2804 m, 29.v.1955, *S. Shushan s.n*. (COLO-L-0047781). LA PLATA CO.: 10-12 mi N of Hesperus, 2743 m, 9.vi.1958, *S. Shushan s.n.* (COLO-L-0047775). LAS ANIMAS CO.: 0.4 mi N of Morley, 2256 m, 10.vi.1951, *S. Shushan s.n.* (COLO-L-0047787); Comanche National Grassland, vicinity of Picketwire Canyon and Withers Campground, above (W of) Purgatory River, Saxicolous, 37.658953 -103.571774, 5.vi.2015, *E.A. Tripp 5638* (COLO-L-0051297), *E.A. Tripp 564*0 (COLO-L-0051299); Chancellor Ranch, unnamed N-facing Canyon that drains into the Purgatory River, E of Route 143 just S of its crossing of the Purgatory, 37.345259 -103.893802, 7.vi.2015, *E.A. Tripp 5673* (COLO-L-0051335). MONTROSE CO.: above West Paradox Creek, W end of Paradox Valley, below Buckeye Reservoir, 38.42000 -109.03600, 1768 m, 30.v.1960m, *W.A. Weber s.n.* (COLO-L-0047751). SAN JUAN CO.: South Mineral Creek Campground, 2926 m, 26.vi.1954, *J. Douglass s.n*. (COLO-L-0047739).

Xanthoparmelia mexicana (Gyel.) Hale, Phytologia 28: 486. 1974. ≡ *Parmelia mexicana* Gyel., Repert. Spec. Nov. Regni Veg. 31: 281. 1931. **TYPE: MEXICO:** San Jeronimo, 7.x.1926, *Frére Amable 676* (BP [image!], lectotype designated by Hale 1990: 74: 147).

FIGURE 10.

DESCRIPTION. – **Thallus** moderately to tightly adnate to substrate; saxicolous. **Lobes** irregular; somewhat divided, 3−10 mm wide; separate to imbricate; margins usually dark brown entire to crenate. **Upper surface** yellow-green; epruinose, smooth, cracking and becoming rugose towards older portions of thallus. **Lower surface** pale brown; rhizines dark brown. **Apothecia** not seen. **Isidia** at first globose, then becoming cylindrical and branching frequently; at times black or brown on tips. **Pycnidia** infrequent to occasional, black, sunken below upper cortex.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: salazinic acid (major), norstictic acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ yellow to red, C-, KC-, P+ orange-red; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia mexicana* is almost exclusively found in western North America, particularly in the southwestern region of the United States (Hale 1990, Nash and Elix 2004). In Colorado, it can be found in the southern Rockies, most commonly on the eastern slope in canyons or on ridges at elevations from 1524–2743 m (5000−9000 ft; Figure 2).

NOTES. – *Xanthoparmelia mexicana* is considered the isidiate counterpart of *X. lineola* (Figure 9) and is the most common salazinic-containing asexual species found in the state.

Figure 10. *Xanthoparmelia mexicana* is one of the most common asexual *Xanthoparmelia* in Colorado. Note the resemblance in moderate to tight adnation, lobe size and shape, and color to other asexual species.

Additional specimens examined. – **U.S.A.** COLORADO. BOULDER CO.: S base of Steamboat Mountain, 1.5 mi N of Lyons, 1676 m, 10.iii.1959, *S. Shushan s.n.* (COLO-L-0047818); Upper Gregory Canyon, ca. 1 mi W of Boulder and 1 mi N of Green Mountain Summit, 1940–1980 m, 17.v.1975, *G. Kunkel s.n.* (COLO-L-0047824); Lytle Formation, Dakota Ridge, Rabbit Mountain, 4 mi NE of Lyons just above the Little Thompson River, 1585–1631m, 15.viii.1960, *R.A. Anderson s.n.* (COLO-L-0047830); Wild Basin, 1.5 mi up Finch Lake Trail, 2743 m, 29.vi.1962, *R.A. Anderson 2206* (COLO-L-0047836); Boulder Canyon, ca. 0.5 mi up from mouth, 1800 m, 7.vii.1976, *W.A. Weber s.n*. (COLO-L-0047842); City of Boulder Open Space, Circle of Friends Property, along Sunshine Canyon Trail on S side of Sunshine Canyon Drive, 40.023385° -105.302384°, 5633 ft, 26.vi.2015, *V. Diaz 15* (COLO-L-0055813); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx. 0.5 mi from trailhead, 40.027523° -105.302771°, 5557 ft, 10.vii.2015, *V. Diaz 43* (COLO-L-0055840); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx. 0.4 mi from trailhead, 40.0254° -105.299847°, 5931 ft, 10.vii.2015, *V. Diaz 47* (COLO-L-005579), *V. Diaz 49* (COLO-L-0055830); City of Boulder Open Space, Circle of Friends Property, on W-facing slopes just W off of Mount Sanitas Trail, 40.026754° -105.30149°, 5931 ft, 10.vii.2015, *V. Diaz 51* (COLO-L-0055795); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx 0.2 mi from trailhead, 40.021883° -105.29828°, 5931 ft, 10.vii.2015, *V. Diaz 53* (COLO-L-0055832), *V. Diaz 54* (COLO-L-0055833); City of Boulder Open Space, Jewel Mountain Property, approx. 50 ft E of Plainview Rd. and approx. 400 ft S of Coal Creek, 39.877702° -105.268981°,6464 ft, 24.vii.2015, *V. Diaz 70* (COLO-L-0055808); City of Boulder Open Space, Fraiser Farms Property, at the intersection of Mesa and Upper Big Bluestem Trails, 39.953578° -105.279707°, 6092 ft, 14.viii.2015, *V. Diaz 75* (COLO-L-0055875). EL PASO CO.: Bear Creek Canyon, W of Colorado Springs, 12.vi.1918, *C.C. Plitt s.n.* (COLO-L-0047812). GARFIELD CO.: 5 mi N of Rifle, W side of Rifle Creek along S edge of Grand Hogback, 2 mi SW of Rifle Gap, 1800 m, 12.vi.1974, *W.A. Weber s.n.* (COLO-L-0047871); 9.8 mi W of Grand Valley, 4.ix.1957, *S. Shushan s.n.* (COLO-L-0047877). JACKSON CO.: Big Creek Lake, ca. 24 mi NW of Cowdrey, E slope of Park Range, 2804 m, 29.v.1955, *S. Shushan s.n.* (COLO-L-0047829). LARIMER CO.: Rocky Mountain National Park, ESE of Endovalley Campground, on extensive N-facing talus, 2658–2707 m, 17.vi.1966, *R.A. Anderson 5407* (COLO-L-0047811); Owl Canyon, 9.7 mi N of Teds Place (junction of Highways 287 and 14), 1829 m, 6.iv.1955, *S. Shushan s.n.* (COLO-L-0047817); Rocky Mountain National Park, SW slope of Deer Mountain, 2667–2804 m, 25.viii.1962, *R.A. Anderson 3567* (COLO-L-0047823); Mummy Range, Mt. Chiquita, 3414–3627 m, 14.vii.1963, *R.A. Anderson 4019* (COLO-L-0047835); 4.5 mi SW of Ft. Collins, just above Horsetooth Reservoir, Sec. 32, & T. 6 N Sec. 5, 1661–1798 m, 1.vii.1960, *R.A. Anderson s.n.* (COLO-L-0047837); near Horseshoe Park and road to Endovalley Campground, 2652–2804 m, 23.vii.1962, *R.A. Anderson 2801* (COLO-L-0047841); South Lateral Moraine, 2469–2591 m, 17.vii.1962, *R.A. Anderson 2642* (COLO-L-0047847); Estes Park, 9 mi SE of, or 14 mi NW of Lyons, off Denver highway, 2286 m, 26.vii.1949, *W. Kiener 24765* (COLO-L-0047853). MESA CO.: ca. 7 mi SW of Whitewater on benches above East Creek north of Gibbler Gulch, 1.vi.1973, *W.A. Weber s.n.* (COLO-L-0047813), *W.A. Weber s.n.* (COLO-L-0047878). N end of Colorado National Monument, ca. 3 mi S of Fruita, Dakota-Morrison formation, base of escarpment, 1372 m, 12.v.1955, *S. Shushan s.n.* (COLO-L-0047819), *S. Shushan s.n.* (COLO-L-0047825). MONTEZUMA CO.: Beaver Creek, 6 mi N of McPhee, 2286 m, 12.vi.1958, *S. Shushan s.n*. (COLO-L-0047872). MONTROSE CO.: Escarpment above West Paradox Creek, W end of Paradox Valley, below Buckeye Reservoir, 38.42000 -109.03600, 1768 m, 30.v.1960, *W.A. Weber s.n.* (COLO-L-0047866). PARK CO.: 11.3 mi E of Jefferson on road to Lost Creek Park, 3048 m, 3.vii.1955, *S. Shushan s.n*. (COLO-L-0047860). SUMMIT CO.: E of Lake Dillon near Keysone, 39.60000 -106.00000, 2700 m, 11.ix.1981, *W.A. Weber s.n*. (COLO-L-0047854).

Xanthoparmelia monticola (J.P.Dey) Hale, Mycotaxon 33: 404. 1988. ≡ *Parmelia monticola* J.P.Dey, Castanea 39: 360. 1974. **TYPE: U.S.A.** NORTH CAROLINA. BUNCOMBE CO.: Craggy Dome in the Great Craggy Mountains. On rock of outcrop in heath bald, 1972, *J.P. Dey 1509* (DUKE [0000170] [image!], holotype; NY [1231673] n.v., isotype).

FIGURE 11.

DESCRIPTION. – **Thallus** loosely adnate; saxicolous. **Lobes** sublinear; 1‒2.5 mm wide; contiguous to imbricate; margins blackening, entire to crenate. **Upper surface** yellow-green; epruinose, smooth. **Lower surface** light to dark brown; rhizines light to dark brown, occurring frequently. **Apothecia** common, substipitate, light to dark brown, margins smooth. **Ascospores** absent in Colorado material. **Pycnidia** frequent to occasional, black, sunken below upper cortex.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: fumarprotocetraric acid (major), physodalic acid (trace), protocetraric acid (trace). Spot tests: cortex: K-, C-, KC-, P-; medulla: K-, C-, KC-, P+ orange to red; UV-.

ECOLOGY AND DISTRIBUTION. – To our knowledge, there are only four records of *Xanthoparmelia monticola* in Colorado, three from Boulder County and one from Larimer county at elevations between approximately 1829–2700 m (6000‒8900 ft; Figure 2). We have seen and studied the three located at COLO (cited below), which were made on the eastern slope. It is possible that additional material may exist, albeit under different names in other herbaria, however this seems relatively unlikely given the amount of material studied by earlier experts including M. Hale and T. Nash. It may therefore be an uncommon to rare species in Colorado, considering the limited number of voucher specimens that exist- COLO (3) and ASU (1). *Xanthoparmelia monticola* is globally ranked by the Nature Conservancy as a G2 species, a rank given to species with only 6‒20 populations known worldwide (Perlmutter 2009).

NOTES. – The presence of physodalic acid is very rare in *Xanthoparmelia* (Hale 1990*)*. This in addition to the production of fumarprotocetraric and trace protocetraric acid makes this species very chemically distinctive It might be most commonly confused with *X. novomexicana* (Figure 14), which also contains fumarprotocetraric acid. However, *X. novomexicana* lacks physodalic acid and is also much more tightly adnate.

While Dey did not describe protocetraric acid in the protologue, there was mention of traces of an unknown substance that he stated may possibly represent sublimbatic acid. Because protocetraric and sublimbatic acid have very similar R_F values (Elix 2014), it is possible that the unknown trace described by Dey was actually protocetraric acid. In addition, Dey also stated there were traces of stictic acid in the holotype. It was later concluded (by J. Johnston in 1983, as annotated on the specimen) that the stictic acid traces were due to a contaminant fragment of *Xanthoparmelia conspersa*.

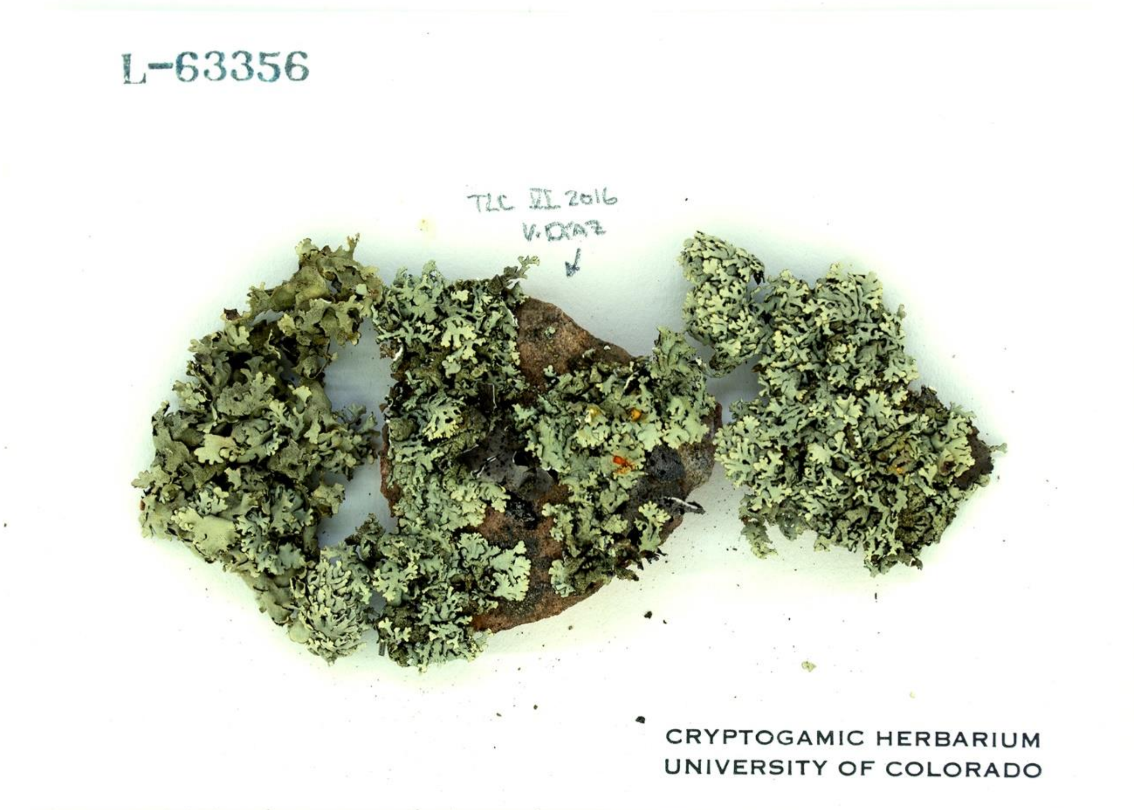

Figure 11. *Xanthoparmelia monticola* is differentiated from the chemically identical *X. novomexicana* by its looser adnation level. Note the lobes lifting off of the substrate.

Additional specimens examined. – **U.S.A.** COLORADO. BOULDER CO.: Shanahan Mesa, a colluvial fan spreading out from the base of Bear Peak, S edge of Boulder, 1900 m, 2.v.1998, *W.A. Weber s.n.* (COLO-L-0047843); City of Boulder Open Space, Johnson Property, NE corner of property, just S of intersection of Nelson Rd. and 39th St., 40.144196° -105.265447°, 5568 ft., 19.vi.2015, *V. Diaz 3* (COLO-L-0055818); City of Boulder Open Space, Austin-Russell Property, along Blue Ski Jump and Bell/ Baird Trails, approx. 0.5 mi S of Baseline Rd., 39.996228°, -105.289193°, 6095 ft, 26.vi.2015, *V. Diaz 11* (COLO-L-0055811). LARIMER CO.: Estes Park, 9 miles SE of, or 14 mi NW of Lyons, off Denver Highway, 2286 m, 26.vii.1976, *W. Kiener L45981* (COLO-L-0048049).

Xanthoparmelia mougeotii (Schaer. in D. Dietr.) Hale, Phytologia 28: 488. 1974. ≡ *Parmelia mougeotii* Schaer. in D. Dietr., Deutschl. Kryptog. Gewächse 4 Abth.: 118. 1846. **TYPE:** Tab 288, f 288 (lower half of plate) [image!], lectoype designated by Elix & Thell 2011: 141). **REPLACEMENT TYPE: FRANCE:** Vosges, Bruyères, "*Ad saxa silacea in summo m. Heledré prope Brujerium* Mougeot." [*fide specimen*], *Schaerer, Lich. Helv. Exs. No. 548* (UPS [image!], epitype designated by Elix & Thell (2011: 141); FH [image!], isoepitype).

FIGURE 12.

DESCRIPTION. – **Thallus** tightly adnate; saxicolous. **Lobes** irregular; deeply divided, 3–10 mm wide; separate to imbricate; margins darkening, entire to crenate at apices. **Upper Surface** dark yellow-green and sometimes partially brown in older sections; shiny, cracking in older portions of thallus. **Lower Surface** dark brown, shiny; rhizines dark brown. **Soredia** frequent; in orbicular clumps; light yellow-green. **Apothecia** not seen. **Pycnidia** infrequent, sunken below upper cortex, black.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: stictic acid (major), constictic acid (trace), norstictic acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla K+ yellow, C-, KC-, P+ orange; UV-.

Figure 12. *Xanthoparmelia mougeotii* is distinctive from other asexual species in that it is the only sorediate *Xanthoparmelia* known from Colorado.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia mougeotii* is the only currently identified sorediate species of this genus in Colorado, and very rare with only eight confirmed records within the state, all collected in one general area of Rocky Mountain National Park at 2682–2774 m (8800–9100 ft) in Spruce Canyon in the same year (Figure 2). While it initially appears that *X. mougeotii* is restricted to subalpine habitats, the ecology and full distribution of *X. mougeotii* is difficult to decipher until more Colorado collections of this species are made. In other regions of the United States, it has been collected almost exclusively on the Pacific Coast at lower elevations (Hale 1990; Leavitt 2010).

NOTES. – The above description is based on the only two specimens representing this species that are housed at COLO in addition to study of the protologue and the original material cited above. The secondary metabolites cited above were taken from Nash and Elix 2004 because the COLO collections are extremely sparse and too scant for destructive sampling.

Elix and Thell (2011) typified the name when they designated the illustration cited above as lectotype and the Schaerer exsiccate at UPS as a neotype (an error to be corrected to epitype). Note that Hale (1974, 1990) incorrectly cited Schaerer (1850) as the protologue, rather than the earlier edition of the work in 1846. Additionally, Elix and Thell (2011) incorrectly cited the starting page number of the protologue as 24 instead of 118, which has been corrected above.

Additional specimens examined. – **U.S.A.** COLORADO. LARIMER CO.: Rocky Mountain National Park, Spruce Canyon, along Spruce Creek, ca. 1 mi from mouth of Forest Canyon, 40.34967˚N, 105.67576˚W, 2682–2774 m, 14.vi.1966, *R.A. Anderson 5302* (COLO-L-0047890, COLO-L-0047896).

Figure 13. *Xanthoparmelia neochlorochroa* resembles other vagrant taxa in that it has dichotomous branching and forms rosettes.

Xanthoparmelia neochlorochroa Hale, Mycotaxon 30: 324. 1987. **TYPE: U.S.A.** IDAHO. LEMHI CO.: 18.vi.1973, *D.E. Anderegg 1480* (US [00051120] [image!], holotype).

FIGURE 13.

DESCRIPTION. – **Thallus** vagrant. **Lobes** sublinear; dichotomously branched and deeply divided, 3–15 mm wide; separate to subimbricate; margins sometimes blackening at tips. **Upper surface** yellow-green; smooth, cracking and darkening towards older portions of thallus. **Lower surface** pale to dark brown and shiny; rhizines brown, occurring frequently**. Apothecia** not seen. **Pycnidia** infrequent, sunken below upper cortex, black.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: connorstictic acid (trace), norstictic acid (major). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ yellow to red, C-, KC-, P+ orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia neochlorochroa* occurs in northern Colorado on north-facing mountain slopes between elevations of 1829–2438 m (6000–8000 ft; Figure 2). Prior authors have shown that vagrant lichens thrive in areas with low vascular plant biomass, low-nutrient soil, elevated frequencies of drought, and higher exposure to wind (MacCracken et al. 1983, Rosentreter 1993). Vagrant lichens are also common in grazing lands, which has led to poisoning of livestock (Dailey et al. 2008).

NOTES. – This species resembles *Xanthoparmelia chlorochroa* (Figure 3) morphologically but differs chemically owing to its lack of salazinic acid. Note that the R_F value of salazinic acid is 4, while the R_F value of connorstictic acid is 3 (Elix 2014). This can pose difficulties in separating *Xanthoparmelia chlorochroa* and *X. neochlorochroa,* as the latter manufactures connorstictic acid in trace amounts.

Figure 14. *Xanthoparmelia novomexicana* is characteristically very tightly adnate, similar to *X. lineola*. This is also useful in differentiating between *X. monticola* which is chemically identical.

Additional specimens examined. – **U.S.A.** COLORADO. GRAND CO.: approx. 2.2 air mi NE of Kremmling. S of Wolford Mountain in the vicinity of Cow Gulch, near wooden power line, 40.10158 -106.38417, 2387 m, 30.viii.2014, *B. Elliot 16350* (COLO-L-0050855). MOFFAT CO.: 13 mi NE of Craig, 40.66667 -107.46667, 1965 m, 26.viii.1975, *S. Shushan 8909* (COLO-L-0047950). SUMMIT CO.: approx. 10.5 air mi S of Kremmling and 2 mi N of Green Mountain Reservoir, E of Hwy 9 near junction of Hwy 9 and Rd. 381, 39.91787 -106.32752, 2362 m, 30.viii.2014, *B. Elliot 16358* (COLO-L-0050875).

Xanthoparmelia novomexicana **(**Gyel.) Hale, Phytologia 28: 488. 1974. ≡ *Parmelia novo-mexicana* Gyel., Repert. Spec. Nov. Regni Veg. 36: 161. 1934. **TYPE: U.S.A.** NEW MEXICO. Las Vegas, 18.ii.1930, *Frére Arséne Brouard 20647* (BP [image!], lectotype designated by Hale 1990: 166).

= *Xanthoparmelia arseneana* (Gyel.) Hale, Phytologia 28: 486. 1974. ≡ *Parmelia arseneana* Gyel., Ann. Mycol. 36: 269. 1938. **TYPE: U.S.A.** NEW MEXICO: Las Vegas, Gallinas Cañon N., ca. 2300 m.s.m. alt., 1930, *Frére Arséne 21191* (BP [image!], lectotype designated by Hale 1990: 166).

FIGURE 14.

DESCRIPTION. – **Thallus** tightly to moderately adnate; saxicolous. **Lobes** sublinear; 5–20 mm wide; strongly imbricate towards center of thallus, and non-imbricate at margins; plane to slightly convex margins browning a tips; apices entire to moderately crenulate. **Upper surface** yellow-green; epruinose, smooth and occasionally rugose, areolate, and blackening towards the center. **Lower surface** pale and darkening towards tips; rhizines dark brown to black, occurring frequently. **Apothecia** moderately present, sessile, disks brown, margins subconvex and slightly crenate. **Ascospores** ellipsoid, non-septate, colorless; 8–9 × 4–5 µm. **Pycnidia** frequent, sunken below upper cortex, black.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: fumarprotocetraric acid (major), protocetraric acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla: K-, C-, KC-, P+ orange to red; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia novomexicana* is found in montane western regions in North America from Washington and Montana, U.S.A., south into Oaxaca, Mexico (CNALH 2016, Hale 1990, Nash and Elix 2004). The ecology of this species is relatively restricted compared to other *Xanthoparmelia* species, as it is typically only found at elevations ranging from 2073–3353 m (6800–11000 ft) (Nash 1974).

NOTES. – *Xanthoparmelia novomexicana* is morphologically similar to *X. lineola* (Figure 9) but differs chemically in that it contains fumarprotocetraric acid instead of salazinic acid (Table 2) thus yielding a K- medulla (vs. K+ red in *X. lineola*). In addition, *X. novomexicana* has a much more limited range compared to *X. lineola* (Nash 1974).

TLC conducted on the lectotype at BP (researcher unknown; packet annotated in 1987) indicated the presence of succinprotocetraric acid. J.A. Elix also conducted TLC on the same specimen (annotated on the packet on 23 March 2004), and he noted the presence of confumarprotocetraric (trace) and virensic (minor) acids.

The decision to here propose *Xanthoparmelia arseneana* as a synonym of *X. novomexicana* is based on the examination of protologue descriptions, type specimens (the holotype designated in the protologue was presumably destroyed in Bouly de Lesdain's Herbarium in Dunkerque, France during WWII), as well as Hale's determination of this synonymy in his 1990 publication. In the protologue of *X. novomexicana*, Gyelnik stated the underside of the thallus was "blackening". Based on this phrasing, we interpret this as the underside is otherwise pale, with blackening towards the inner portions. In addition, Gyelnik had a tendency of describing species that, within modern species delimitations, have been determined to be one in the same. (Hale 1990).

Additional specimens examined. – **U.S.A.** COLORADO. BOULDER CO.: Boulder Canyon ca. 0.5 mi up from mouth, 1800 m, 7.vii.1976, *W.A.Weber s.n.* (COLO-L-0048127); First Flatiron, just above mouth of Gregory Canyon, 1800 m, 6.vii.1976, *W.A. Weber s.n.* (COLO-L-0047891). HUERFANO CO.: Apishapa Pass, S of La Veta, 10.vi.1960, *S. Shushan s.n*. (COLO-L-0047499).

Xanthoparmelia plittii (Gyel.) Hale, Phytologia 28: 488. 1974. ≡ *Parmelia plittii* Gyel. Repert. Spec. Nov. Regni Veg. 31: 287. 1931. **TYPE: U.S.A.** MARYLAND. BALTIMORE CO.: Liberty Road at Gwynna Falls, 31.iii.1908, *C.C. Plitt s.n.* (BP [image!], lectotype designated by Hale 1990: 175).

FIGURE 15.

DESCRIPTION. – **Thallus** moderately to tightly adnate; saxicolous. **Lobes** irregular; moderately to deeply divided, 0.1–3.5 mm wide; non-imbricate to moderately imbricate; margins usually black. **Upper surface** yellow-green; shiny and epruinose; smooth, cracking and blackening with age. **Lower surface** pale, shiny; rhizines dark brown. **Apothecia** not seen. **Isidia** frequent to dense, cylindrical, then branching and darkening with age. **Pycnidia** moderate, black sunken below upper cortex.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: stictic acid (major), norstictic acid (minor), constictic acid (trace), cryptostictic acid (trace), unknown compound (trace). Spot tests: cortex: K-, C-, KC, P-; medulla: K+ yellow to orange, C-, KC+ red, P+ yellow then dark orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia plittii* is found very prevalently across both North and South America, including commonly in eastern North America (Brodo et al. 2001, Hale 1990, Nash and Elix 2004). In Colorado, it is abundant in the southern Rocky Mountains, on both the eastern and western slopes between 1768–2865 m (5800–9400 ft; Figure 2).

NOTES. – *Xanthoparmelia plittii* is considered the isidiate counterpart of the fertile *X. cumberlandia* (Figure 6). Both share ecological, chemical, and morphological features but differ in reproductive mode. *Xanthoparmelia plittii* also resembles *X. conspersa* (Figure 5), however the latter species has a black lower surface and is occasionally fertile (both in Colorado material and found on type specimen; *C.C. Plitt, s.n*).

Figure 15. *Xanthoparmelia plittii* is the most common stictic acid-containing asexual species of *Xanthoparmelia* in Colorado. Similarity to *X. mexicana* means TLC is necessary to differentiate the two.

Additional specimens examined. – **U.S.A.** COLORADO. BOULDER CO.: City of Boulder Open Space, Johnson Property, NE corner of property, just S of intersection of Nelson Rd. and 39th St., 40.144196° -105.265447°, 5568 ft, 19.vi.2015, *V. Diaz 4* (COLO-L-0055880); City of Boulder Open Space, Circle of Friends Property, along Sunshine Canyon Trail on S side of Sunshine Canyon Drive, 40.022072° -105.300673°, 5587 ft, 26.vi.2015, *V. Diaz 20* (COLO-L-0055877); City of Boulder Open Space, Schneider Property, approx. 0.5 mi W of N Foothills Parkway/US36, in dry, 40.079628° -105.289906°, 5328 ft, 26.vi.2015, *V. Diaz 24* (COLO-L-0055844); City of Boulder Open Space, Hogan Brothers Property, approx. 200 ft. E of S Cherryvale Rd., 39.962798° -105.211992°, 5546 ft., 17.vii.2015, *V. Diaz 62* (COLO-L-0055828); City of Boulder Open Space, Van Vleet Property, approx. 20 ft. W of S Cherryvale Rd. in Marshall Ditch, on banks of Marshall Ditch in sun-exposed area, 39.974564° -105.213802°, 5463 ft, 17.vii.2015, *V. Diaz 67* (COLO-L-0055806); City of Boulder Open Space, Abbey Property, just off of N Fork Shanahan Trail approx. 380 ft. N of the intersection w/ Leigh Connector-S, 39.965576° -105.260345°, 5755 ft, 14.viii.2015, *V. Diaz 72* (COLO-L-0055809). GUNNISON CO.: Lytle Formation, Dakota Group, T1N R71W SEC1, 5800–6400 ft, 1.viii.1959, *R.A. Anderson s.n*. (COLO-L-0047617); Blue Mesa Cutoff road at Hole-in-the-wall, 2438 m, 27.vii.1955, *W.A. Weber s.n.* (COLO-L-0047928). HINSDALE CO.: Cebolla Creek Campground, between Cathedral and Slumgullion Pass, 2865 m, 29.vii.1964, *W.A. Weber s.n*. (COLO-L-0047865). LA PLATA CO.: 3 mi N of Bondad, just E of Animas River, 1829 m, 12.vi.1955, *S. Shushan s.n.* (COLO-L-0047922). LARIMER CO.: Dakota Ridge, 22 mi N of Ft. Collins, 2 mi SE of Table Mt., 1920–1981 m, 23.x.1959, *R.A. Anderson s.n.* (COLO-L-0047916). MOFFAT CO.: at the northern end of Dinosaur National Monument, the entrance of the Green River into the Canyon of Lodore, about 1 mi S of Browns Park, above camp, 29.vii.1962, *S. Flowers s.n*. (COLO-L-0047910). MONTEZUMA CO.: ca. 30 mi W of Cortez, vicinity of junction of Yellowjacket and McElmo Creek, 1463 m, 10.vi.1958, *S. Shushan s.n.* (COLO-L-0047904).

Figure 16. *Xanthoparmelia psoromifera* is morphologically similar to its asexual counterpart *X. lavicola*. Due to the tight adnation and lobe type, it often resembles *X. lineola* and *X. novomexicana*.

Xanthoparmelia psoromifera **(**Kurok. ex Hale) Hale, Phytologia 28: 488. 1974. ≡ *Parmelia psoromifera* Kurok. ex Hale TheBryologist 70: 418. 1967. **TYPE: MEXICO.** JALISCO: 25 km S of Guadalajara, vii.1961, *M. Wirth 22* (US [00068977] [image!], holotype!).

FIGURE 16.

DESCRIPTION. – **Thallus** moderately to tightly adnate; saxicolous. **Lobes** sublinear; moderately divided 0.1–4 mm wide; non-imbricate; flat to subconvolute; margins starting to brown at tips. **Upper surface** yellow-green; epruinose and shiny, smooth and becoming rugose and blackening towards older portions of the thallus. **Lower surface-** pale brown; rhizines brown, occurring frequently. **Apothecia** moderate, sessile, disks brown, margins subconvex and slightly crenate. **Ascospores** ellipsoid, non-septate, colorless; 6–7 × 4–5 µm. **Pycnidia** infrequent to frequent, sunken below upper cortex, black.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: psoromic acid (major), *2-O*-demethylpsoromic acid (trace). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ yellow, C-, KC-, P+ dark yellow; UV-.

ECOLOGY AND DISTRIBUTION. – The chemically unusual *X. psoromifera* is rarely found in Colorado. Based on available data (COLO Herbarium, CNALH 2016), only two collections to date have been made in the state on the eastern slope plains (Figure 2). It is most commonly found in the southwestern North America (CNALH 2016, Hale 1990, Nash and Elix 2004).

NOTES. – *Xanthoparmelia psoromifera* is considered to be the non-isidiate counterpart of *X. lavicola* (Figure 8), and besides reproductive structures, the two resemble one another morphologically and chemically. Both are the only known psoromic acid-containing *Xanthoparmelia* species in Colorado, and occur rarely in the state.

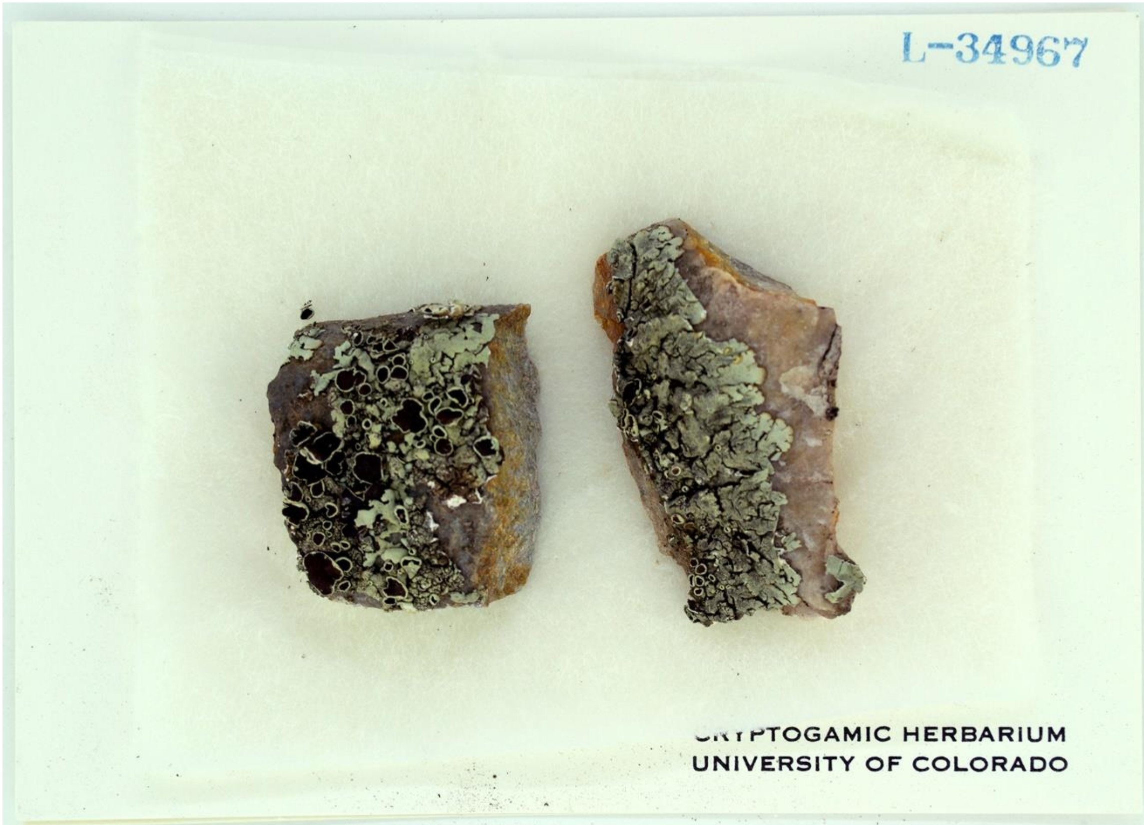

Figure 17. *Xanthoparmelia stenophylla* forms tight mats, often in rosettes. Its loose adnation results in a high morphological resemblance to *X. wyomingica*.

Additional specimens examined. – **U.S.A.** COLORADO. BENT CO.: vicinity of Raven's Nest, E on Rd. T from Hwy 101S and S on Route 16, 6.vi.2015, *E.A. Tripp 5656* (COLO-L-0051313). LAS ANIMAS CO.**:** Comanche National Grassland, vicinity of Picketwire Canyon and Withers Campground, above (W) Purgatory River, 5.vi.2015, *E.A. Tripp 5630* (COLO-L-0051253).

Xanthoparmelia stenophylla (Ach.) Ahti & D. Hawksw., Lichenologist 37: 363. 2005. ≡ *Parmelia conspersa* var. [*ß*] *stenophylla* Acharius, Methodus (Acharius) 206. 1803. ≡ *Parmelia stenophylla* (Ach.) Heugel, Corresp. Naturf. Ver. Riga 8: 109 1855. **TYPE:** Sweden?, "Habitat ad montes" [*fide* protologue], *s.d., s.c.* (H-ACH [9502092] [image!], lectotype designated by Hale (1990: 192); BM-ACH 607[n.v.], isolectotype).

FIGURE 17.

DESCRIPTION. – **Thallus** orbicular; adnate to loosely adnate; saxicolous. **Lobes** irregular; 0.5–1.5 cm wide; heavily imbricate; at times convolute; blackening at margins, at times crenate. **Upper surface** yellow-green; smooth, shiny. **Lower surface** dark brown; rhizines black. **Apothecia** moderately occurring, sessile, disks light to dark brown, margins somewhat convolute. **Ascospores** absent in Colorado material. **Pycnidia** occurring moderately, sunken below upper cortex, black.

CHEMISTRY. – Upper cortex: usnic acid (major); medulla: salazinic acid (major). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ red. C-, KC-, P+ orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia stenophylla* is generally found at medium to high elevations ($\geq$2134 m, 7000 ft) in the state. Colorado material has been collected primarily in mountainous terrain on the eastern slope of the Rocky Mountains (Figure 2).

NOTES. – This species is a member of the diverse salazinic acid-containing group in Colorado that can be challenging to identify in the field. While *Xanthoparmelia*. *stenophylla* shares numerous features (including narrow lobes and being loosely adnate to substrates) with *X. wyomingica* (Figure 20), one can differentiate the former by its much less convoluted, slightly broader lobes and overall flat, mat-like growth form. It is also more likely to be found growing on rocks (albeit somewhat loosely among rocks) whereas *X. wyomingica* is more likely to be found growing on loose pebbles or soil.

There has been some dispute over the nomenclatural validity of the name *Xanthoparmelia stenophylla* over the past several decades (Ahti and Hawksworth 2005, Hale 1990). This has resulted in collections of this species being identified under different names, which in turn has led to inconsistent herbaria filing. Ahti et al. (2005) resolved the issue and provided the combination in *Xanthoparmelia*, but it should be noted that many herbaria have yet to update specimen names, which are still filed under *X. somloënsis*.

Additional specimens examined. – **U.S.A.** COLORADO. BOULDER CO.: 0.8 mi S of Eldora, S shore of Lake Eldora, 9000 ft, 26.x.1952, *W.A. Weber s.n.* (COLO-L-0047987); 1 mi SE of Science Lodge and ca. 8 mi N of Nederland, W of Peak to Peak Hwy, 9500 ft, 17.v.1958, *S. Shushan s.n.* (COLO-L-004993). EL PASO CO.: N slope of Pikes Peak, 13300 ft, 1.viii.1955, *S. Shushan s.n.* (COLO-L-0048034). LARIMER CO.: Mummy Range, SE of Lawn Lake, base of Mummy Mountains, 3316–3365 m, 19.vi.1962, *R.A. Anderson 2074* (COLO-L-0047505); 8.0 mi WSW of Loveland, Cottonwood Canyon, 7000 ft, 5.iv.1952, *M.L. Matton s.n.* (COLO-L-0048018); Estes Park, 9 mi SE of, or 14 mi NW of Lyons, off of Denver Highway, 7500 ft, 26.vii.1949, *W. Kiener 24819* (COLO-L-0048031); Trail Ridge, N of Toll Memorial, 11800 ft, 27.viii.1962, *R.A. Anderson s.n.* (COLO-L-0048012). COUNTY UNKNOWN: *C.L. Hayward s.n.* (COLO-L-0048260).

Xanthoparmelia subdecipiens (Vain. ex Lynge) Hale, Phytologia 28: 489. 1974. ≡ *Parmelia subdecipiens* Vain. ex Lynge, Rev. Bryol. Lichenol. 10: 89. 1937. **TYPE: SOUTH AFRICA.** CAPE PROVINCE: Klapmuts, *P. van der Bÿl s.n.* (TUR [image!], holotype).

FIGURE 18.

DESCRIPTION. – **Thallus** adnate to substrate; saxicolous. **Lobes** irregular; moderately to deeply divided, 1.0–3.0 cm wide; separate to slightly imbricate; occasionally inner lobes subconvolute; margins darkening; apices usually crenate. **Upper surface** yellow-green; darkening and becoming rugose with age. **Lower surface** pale brown; rhizines pale brown, occurring frequently. **Apothecia** frequent, sessile, disks light to dark brown, at times subconvex. **Ascospores** ellipsoid, non-septate, colorless; 8–9 × 6–7 µm. **Pycnidia** frequent, sunken below upper cortex and black.

CHEMISTRY. – Upper cortex: usnic acid (major), atranorin (major or trace). Medulla: 3 unidentified fatty acids (major), protoconstipatic (minor), constipatic (trace), dehydroconstipatic (trace). Spot tests: cortex: K+yellow, C-, KC-, P-; medulla: K-, C-, KC-, P-; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia subdecipiens* is common in southern California and in the mountains of Arizona and New Mexico (Hale 1990, Nash and Elix 2004). In Colorado, it occurs along the western slope at elevations ranging from 1463–2896 m (4800–9500 ft; Figure 2), particularly on mesa tops and roadsides.

NOTES. – *Xanthoparmelia subdecipiens* shares several morphological features with *X. lineola* (Figure 9), however the former is generally more loosely adnate and does not contain salazinic acid, in contrast to the latter. Diagnostic characteristics are its negative P test and the presence of atranorin, a compound that rarely occurs in Colorado *Xanthoparmelia*. For unknown reasons, we were only successful in obtaining clear and reproduceable TLC results among Colorado material following heavy spotting and, where possible, multiple runs per collection.

TLC conducted on the holotype by F.A. Brusse (annotated on 8 March 1977) indicated the presence of aliphatic acids "?", and five unknown compounds. It can be assumed that these unknown compounds included compounds listed among the secondary metabolites above, as they were later found in a more recent TLC run of the holotype by J. Johnston. Among Colorado material at COLO, we did identify 3 aliphatic acids (constipatic, dehydroconstipatic, protocosntipatic) in our TLC assays.

Figure 18. *Xanthoparmelia subdecipiens* resembles a number of *Xanthoparmelia* species, including *X. cumberlandia* and *X. lineola*. The unique atranorin-containing chemistry makes it unique among *Xanthoparmelia* species in Colorado.

Additional specimens examined. – **U.S.A.** COLORADO. **BOULDER CO.:** Shanahan Mesa, a colluvial fan spreading out from the base of Bear Peak, S edge of Boulder, 1900 m, 2.v.1998, *W.A. Weber s.n.* (COLO-L-0047986). **FREMONT CO.:** 5 mi SW of Coaldale, on US Hwy 50, 2591 m, 7.vi.1958, *S. Shushan s.n.* (COLO-L-0047980). **JEFFERSON CO.:** 7 mi S of Boulder, on Rocky Flats Pediment, ridge S of farm buildings, 26.vii.1973, *G. Kunkel s.n.* (COLO-L-0047962), 09.vii.1973, *G. Kunkel C-32* (COLO-L-0047968), 26.vii.1973, *G. Kunkel C-55* (COLO-L-0047974).

Xanthoparmelia vagans (Nyl.) Hale, Phytologia 28: 490. 1974. ≡ *Endocarpon vagans* Nyl., Expos. Synopt. Pyrenocarp. p. 13. 1858. **TYPE: ECUADOR:** *s.d.*, *s.c.*, (H-NYL [H9505472] [image!], holotype).

FIGURE 19.

DESCRIPTION. – **Thallus** vagrant, usually free-growing over but not attached to soil or rocks. **Lobes** sublinear; 0.5–3.5 mm wide; somewhat convex; dark brown/ black margins; deeply divided; usually crenate at apices. **Upper Surface** yellow-green; epruinose; smooth. **Lower Surface** brown; rhizines brown, frequently occurring. **Apothecia** not seen. **Pycnidia** frequent, sunken below upper cortex, black.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: stictic acid (major), norstictic acid (minor), constictic acid (trace), cryptostictic acid (trace), unknown compound (trace). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ yellow- dark orange, C-, KC+ pink, P+ orange; UV-.

ECOLOGY AND DISTRIBUTION. – Vagrant lichens are most commonly found in steppes, tundras, deserts, and alpine regions around the world (Perez 1997, Rosentreter 1993). They are believed to be primarily wind dispersed, and their high surface to volume ratios are thought to be beneficial in water-limited

Figure 19. *Xanthoparmelia vagans* resembles other vagrant Colorado *Xanthoparmelia* in lobe type and growth form. However, it is separated from those species by the stictic acid chemistry.

environments (Perez 1997, Rosentreter 1993, Weber 1977). *Xanthoparmelia vagans* is found in Colorado on both the eastern and western slopes in canyons, plains, and in mountainous areas (Figure 2). It is the only vagrant lichen known within the state to contain stictic acid.

NOTES. – *Xanthoparmelia vagans* is one of the few vagrant species in the genus occurring in Colorado. It is highly similar to *X. chlorochroa* (Figure 4) but differs by the presence of stictic acid in the medulla, which yields a K+ yellow spot test (vs. a K+ red reaction in *X. chlorochroa*, which contains salazinic acid).

Additional specimens examined. – **U.S.A.** COLORADO. BOULDER CO.: Wild Basin, NE slope of Mt. Copeland 0.5 mi S of Ouzel Lake, 11000 ft, 28.vi.1962, *R.A. Anderson 2124* (COLO-L-0048070); Continental Divide, summit of Rollins Pass, 11800 ft, 22.vii.1960, *S. Shushan s.n.* (COLO-L-0048051); Little Royal Gorge of Como Creek, tributary to North Boulder Creek; gorge below and W of Peak-to-Peak Highway between Caribou Ranch and CU Mountain Research Station, 40.01969 -105.51417, 2713 m, 29.iv.2000, *W.A. Weber s.n.* (COLO-L-0048180); Niwot Ridge, E of Navajo Peak, E slope of Front Range, 3658 m, 23.ix.1956, *S. Shushan s.n.* (COLO-L-0048241); 1 mi SE of Science Lodge and ca. 8 mi N of Nederland, 9500 ft, 17.v.1958, *S. Shushan s.n.* (COLO-L-0047993); Rocky Mountain National Park, Longs Peak, Elynetum, 3200 m, 3.ix.1935, *W. Kiener 3443* (COLO-L-0047511). GUNNISON CO.: Cebolla Canyon, 7.vii.1961, *S. Flowers s.n.* (COLO-L-48054). JACKSON CO.: Big Creek Lake, ca. 24 mi NW of Cowdrey, E slope of Park Range, 9200 ft, 29.v.1955, *S. Shushan s.n.* (COLO-L-0048052). LARIMER CO.: Stonewall Creek Canyon, 6100 ft, 4 mi NNW, 16.xi.1975, *F.J. Hermann 26981* (COLO-L-0048024); Estes Park, 9 mi SE of, or 14 mi NW of Lyons, off Denver Highway, 7500 ft, 26.vii.1949, *W. Kiener 24760* (COLO-L-0048006). SAGUACHE CO.: Rio Grande National Forest, La Garita Mountains, vicinity of Carnero Pass, 38.01667 -106.40000, 3000 m, 10.vii.1993, *B. Goffinet 3358* (COLO-L-0048197).

Figure 20. *Xanthoparmelia wyomingica* forms rosettes similar to *X. chlorochroa*; however the lobes are less convolute than *X. chlorochroa*, and it is not entirely free-growing.

Xanthoparmelia wyomingica (Gyel.) Hale, Phytologia 28: 490. 1974. ≡ *Parmelia digitulata* var. *wyomingica* Gyel., Ann. Mycol. 36: 277. 1938. **TYPE: U.S.A.** WYOMING. Big Horn Mts., 19.viii.1898, *T.A. Williams 316* (BP [image!], lectotype designated by Hale (1990: 226); US [00068794] [image!], isotype).

FIGURE 20.

DESCRIPTION. – **Thallus** often forming rosettes; loosely adnate to almost vagrant; saxicolous/terricolous. **Lobes** sublinear; subdichotomously branched primarily narrow, 0.5–2.0 cm wide; separate to imbricate; at times tips convolute; margins black and crenate. **Upper Surface** yellow-green; shiny, smooth. **Lower Surface** light to dark brown; rhizines light to dark brown, occurring frequently. **Apothecia** infrequent to moderately frequent; substipitate; disks light to dark brown. **Ascospores** hyaline, simple, 6–7 × 4–5 μm**. Pycnidia** frequent to occasional, black, sunken below upper cortex.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: salazinic acid (major), consalazinic acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ yellow to red, C-, KC-, P+ orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia wyomingica* is most commonly found in the southern Rocky Mountains at elevations of 2743 m (9000 ft) and higher (Eversman 1995, Hale 1990). It is a species that prefers arid habitats and often co-occurs with *X. chlorochroa* (Figure 2).

NOTES. – *Xanthoparmelia wyomingica* is potentially confusable with *X. chlorochroa* (Figure 3), *X. coloradoensis* (Figure 4), and *X. lineola* (Figure 9) because all four are similar chemically. However, *X. wyomingica* differs from *X. coloradoensis* and *X. lineola* in that it occasionally grows on loose pebbles and/or soil instead of rock. In addition, while *X. chlorochroa* is fully vagrant and usually lacks apothecia, presence of sexual structures in *X. wyomingica* is comparatively more frequent. *Xanthoparmelia chlorochroa*, *X. coloradoensis*, and *X. lineola* are also generally found at lower elevations.

Additional specimens examined. – **U.S.A.** COLORADO. BOULDER CO.: Windy Gap, ca. 7 mi NW of Nederland (ca. 1 mi NW of Caribou), 9600 ft, 5.vii.1958, *R.A. Pursell 3299* (COLO-L-0048063); Roosevelt National Forest, Mt. Audubon, 4.5 mi WNW of Ward, 40°6′10″N 105°35′15″W, 11800 ft, 30.vii.1967, *R.S. Egan El-709* (COLO-L-0048068); 5 mi. NW of Eldora on trail from 4th of July Canyon to Arapahoe Glacier, 10000–11000 ft, 20.viii.1957, *S. Shushan s.n.* (COLO-L-0047999); Niwot Ridge, Front Range between Ward, 3505–3658 m, 14.vii.1994, *W.A. Weber s.n.* (COLO-L-0048174); S side of Route 103/Riverside Drive, just E of Raymond, ~100 m uphill from Rd., 40.16026 -105.44878, 2365 m, 8.xi. 2014, *E.A. Tripp 5131* (COLO-L-0050951); City of Boulder Open Space, Bergheim-Wood Property, along Mesa Trail, approx. 360 ft. NW of McClintock Upper Trail, 39.990579° -105.286879°, 6014 ft, 29.vi.2015, *V. Diaz 30* (COLO-L-0055846); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx. 0.4 mi from trailhead, 40.025633° -105.300146°, 5931 ft, 10.vii.2015, *V. Diaz 52* (COLO-L-0055831). Clear Creek Co.: Summit Lake, Mount Evans, 5.vii.1990, 3901 m, *W.A. Weber s.n.* (COLO-L-0047580); 400 yards E of Summit Lake near Mt. Evans, 12780 ft, 4.ix.1951, *S. Shushan s.n.* (COLO-L-0047976); SW of Georgetown, along road to Argentine Pass, 7.6 km from Guanella Pass Rd., 39.66667 -105.75000, 1036 m, 30.vii.1975, *R.A. Anderson s.n.* (COLO-L-0048253). CUSTER CO.: South Colony Creek, 11700 ft, 8.viii.1941, *W. Kiener 10281* (COLO-L-0047964); Humbolt Peak, 13000 ft, 28.viii.1938, *W. Kiener 9427* (COLO-L-0047970); South Colony Creek basin, 3566 m, 8.vii.1941, *W. Kiener 10282* (COLO-L-0048247). El Paso Co.: summit of Pikes Peak, 14100 ft, 1.viii.1955, *S.Shushan s.n.* (COLO-L-0048028]. Grand Co.: Never Summer Mountains, Mt. Richthofen, 3414–3658 m, 16.viii.1962, *R.A. Anderson 3386* (COLO-L-0048265); 1 mi N of Kremmling, off Highway 40, 40.08000 -106.41000, 2287 m, 31.viii.2011, *R. Rosentreter 17385* (COLO-L-0048271); Frazer Experimental Forest, above Fool Creek, 3505 m, 1.viii.1953, *W.A. Weber s.n.* (COLO-L-0048295). GUNNISON CO.: trail along Copper Creek to summit of Conundrum Pass, Elk Mountains, ca. 10 mi NE of Gothic, 39.00300 -106.94200, 3871 m, 4.viii.1955, *W.A. Weber s.n.* (COLO-L-0048289). JACKSON CO.: summit of Flattop Mountain, headwaters of Gold Creek, Park Range S of Mount Zirkel, 3658 m, 29.vii.1956, *S. Shushan s.n.* (COLO-L-0048283). LARIMER CO**.:** Beaver Meadows, 2576 m, 16.ix.1962, *R. A. Anderson 3718* (COLO-L-0048248); Larimer, Neota Wilderness, SE of Cameron Pass of Highway 14, near twin knobs on S side of Coral Creek drainage, 7 mi in on Long Draw Rd., 3414m, 20.viii.1992, *J.K. Nelson 1389* (COLO-L-0048254); Neota Wilderness, southeast of Cameron Pass of Highway 14, summit of Mt. Neota, 3566 m, 8.viii.1992, *J. K. Nelson 1222* (COLO-L-0048307). PARK CO.: Hoosier Ridge, E of Hoosier Pass, between Alma and Breckenridge, 3505–3810 m, 10.vii.1959, *S. Shushan s.n.* (COLO-L-0048242); E end of Hoosier Ridge, ca. 11 mi N of Fairplay, 3962 m, 8.vii.1956, S. *Shushan s.n.* (COLO-L-0048266).

EXCLUDED NAMES (RECOGNIZED AS CURRENT NAMES BUT NOT REPRESENTATIVE OF SPECIES THAT OCCUR IN COLORADO).

Xanthoparmelia hypopsila (Müll. Arg.) Hale, Phytologia 28:488. 1974. ≡ *Parmelia hypopsila* Müll. Arg., Flora (Regensburg) 70: 317. 1887. **TYPE: URUGUAY:** 1886, *J. Arechavaleta y Balpardo 12* (G [G00292908] [image!], holotype).

Xanthoparmelia taractica (Kremp.) Hale, Phytologia 28: 485. 1974. ≡ *Parmelia taractica* Kremp., Flora 61: 439. 1878. **TYPE: ARGENTINA**: "Regiones alpinae Andium, ad terram, inter gramina" (*fide protologue*), 1872-1874, *P.G. Lorentz & G. Hieronymus 27* (M [M0024921] [image!], holotype; G [G00294521] [image!], US [00069064] [image!], isotypes).

CONCLUSION

The overarching goal of the present study was to provide a concise and user-friendly (i.e., a product usable by a diverse audience including ecologists and land managers) synopsis of Coloradan species of usnic acid-producing *Xanthoparmelia*. This work includes dichotomous keys and an abridged taxonomic treatment of species present in the state. Our study is grounded in examination of type specimens (primarily high-resolution images), protologues, study of morphology, study of anatomy, and TLC assays. This work contributes a readily accessible means of identifying species based on morphology and chemistry, however molecular data are needed to further assess the degree to which these species and chemical groups are or are not monophyletic. It provides a foundation on which to build further information regarding the ecology and evolution of lichens of the southern Rocky Mountains and adjacent high plains.

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Literature Cited

Acharius, E. 1803. *Methodus qua omnes detectos Lichenes: secundum organa carpomorpha, ad genera, species et varietates*. F.D.D. Ulrich, typis C.F. Marquard, Stockholm.

Ahti, T. and D.L. Hawksworth. 2005. *Xanthoparmelia stenophylla*, the correct name for *X. somloënsis*, one of the most widespread usnic acid containing species of the genus. The Lichenologist 37: 363–366.

Amo de Paz, G., H.T. Lumbsch, P. Cubas, J.A. Elix, A. Crespo. 2010a. The genus *Karoowia* (Parmeliaceae, Ascomycota) includes unrelated clades nested within *Xanthoparmelia*. Australian Systematic Botany 23: 173–184.

Amo de Paz, G., H.T. Lumbsch, P. Cubas, J.A. Elix, A. Crespo. 2010b. The morphologically deviating genera *Omphalodiella* and *Placoparmelia* belong to *Xanthoparmelia* (Parmeliaceae). The Bryologist 113: 376–386.

Armstrong, R.A. 2017. A study of fragmentation rates in lichen populations on rock surfaces using the Kaplan-Meir estimator and Cox regression. Annales Botanici Fennici 54: 169–178.

Barcenas-Peña, A, S.D. Leavitt, JP. Huang, F. Grewe and H.T. Lumbsch. 2018. Phylogenetic study and taxonomic revision of the *Xanthoparmelia mexicana* group, including the description of new species (Permeliaceae, Ascomycota). Mycokeys 40: 13–28.

Barcenas-Peña, A, S.D. Leavitt, F. Grewe, H.T. Lumbsch. 2021. Diversity of *Xanthoparmelia* (Parmeliaceae) species in Mexican xerophytic scrub vegetation, evidenced by molecular, morphological and chemistry data. Anales del Jardín Botánico de Madrid 78: 1–11.

Benedict, J.B. and T.H. Nash III. 1990. Radial growth and habitat selection by morphologically similar chemotypes of *Xanthoparmelia*. The Bryologist 93: 319–327.

Berry, E.C. 1941. A monograph of the genus *Parmelia* in North America, north of Mexico. Annals of the Missouri Botanical Garden 28: 31–146.

Blanco, O., A. Crespo, J. Elix, D.L Hawksworth and H.T Lumbsch. 2004. A molecular phylogeny and a new classification or parmelioid lichens containing *Xanthoparmelia*-type lichenan (Ascomycota: Lecanorales). Taxon 53: 959–975

Blanco, O., A. Crespo, R.H. Ree and H.T. Lumbsch. 2006. Major clades of parmelioid lichens (Parmeliaceae, Ascomycota) and the evolution of their morphological and chemical diversity. Molecular Phylogenetics and Evolution 39: 52–69.

Brodo, I.M., S.D. Sharnoff and S. Sharnoff. 2001. *Lichens of North America*. Yale University Press, New Haven and London.

Consortium of North American Lichen Herbaria [CNALH.] 2016. http://lichenportal.org/portal/index.php. [Accessed.vii.2016]

Culberson, C.F. and H. Kristinsson. 1970. A standardized method for the identification of lichen products. Journal of Chromatography A 46: 85–93.

Culberson, C.F. 1972. Improved conditions and new data for identification of lichen products by standardized thin-layer chromatographic method. Journal of Chromatography A 72: 113–125.

Dailey, R.N., D.L. Montgomery, J.T. Ingram, R. Siemion, M. Vasquez and M.F. Raisbeck. 2008. Toxicity of the lichen secondary metabolite (+)-usnic acid in domestic sheep. Veterinary Pathology Online 45: 19–25.

Daniel, T.F. and E.A. Tripp. 2018. *Louteridium* (Acanthaceae): Taxonomy, phylogeny, reproductive biology, and conservation. Proceedings of the California Academy of Sciences 65: 41–106.
Deduke, C., N.M. Halden and M.D. Piercey-Normore. 2015. Comparing element composition of rock substratum with lichen communities and the fecundity of *Arctoparmelia* and *Xanthoparmelia* species. Botany 94: 41–51.
Del Prado, R., Z. Ferencová, V. Armas-Crespo, G.A De Paz, P. Cubas and A. Crespo. 2007. The arachiform vacuolar body: An overlooked shared character in the ascospores of a large monophyletic group within Parmeliaceae (*Xanthoparmelia* clade, Lecanorales). Mycological Research 111: 685–692.
Del-Prado, R., P. Cubas, H.T. Lumbsch, P.K. Divakar, O. Blanco, G. Amo de Paz, M.C. Molina and A. Crespo. 2010. Genetic distances within and among species in monophyletic lineages of Parmeliaceae (Ascomycota) as a tool for taxon delimitation. Molecular Phylogenetics and Evolution 56: 125–133.
Egan, R.S., S. Morgan, C.M. Wetmore, D. Ladd. 2002. Additions to the Lichen flora of Nebraska. Transactions of the Nebraska Academy of Sciences and Affiliated Societies 28: 1–13.
Elix, J.A., J. Johnston and P.A. Armstrong. 1986. A revision of the lichen genus *Xanthoparmelia* in Australasia. Bulletin of the British Museum. Natural History. Botany 15): 163–362.
Elix, J.A. 2003. The lichen genus *Paraparmelia*, a synonym of *Xanthoparmelia* (Ascomycota, Parmeliaceae). Mycotaxon 87: 395–403.
Elix, J.A. and A. Thell. 2011. *Xanthoparmelia*. *In:* Nordic Lichen Flora, Vol. 4, Nordic Lichen Society, p.131-138.
Elix, J.A. 2014. *A Catalogue of Standardized Chromatographic Data and Biosynthetic Relationships for Lichen Substances, Third Edition*. Published by the author, Canberra.
Esslinger, T.L. 2021. A cumulative checklist for the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada, version 24. Opuscula Philolichenum 2021: 100-394.
Eversman, S. 1995. Lichens of alpine meadows on the Beartooth Plateau, Montana and Wyoming, USA. Arctic and Alpine Research 27: 400–406.
Giordani, P., P. Nicora, I. Rellini, G. Brunialti and J.A. Elix. 2002. The lichen genus *Xanthoparmelia* (Ascomycotina, Parmeliaceae) in Italy. The Lichenologist 34: 189–198.
Goffinet, B., R. Rosentreter and E. Sérusiaux. 2001. A second locality for *Xanthoparmelia idahoensis* Hale, an endangered vagrant lichen, new to Canada. Evansia 18: 59–59.
Grewe, F., J.-P. Huang, S.D. Leavitt and H.T. Lumbsch. 2017. Reference-based RADseq resolves robust relationships among closely related species of lichen-forming fungi using metagenomic DNA. Scientific Reports 7(1): 9884.
Gyelnik, V. 1930. Lichenologiai Kozlemenyek 20–45. Mogyor Botonikai Lapok 29: 25–35.
Hale, M.E. 1955. *Xanthoparmelia* in North America. I. The *Parmelia conspersa-stenophylla* group. Bulletin of the Torrey Botanical Club 82: 9–21.
Hale, M.E. 1964. The *Parmelia conspersa* group in North America and Europe. The Bryologist 67: 462–473.
Hale, M.E. and S. Kurokawa. 1964. Studies on *Parmelia* subgenus *Parmelia*. Contributions from the United States National Herbarium 36: 121–191.
Hale, M.E. 1967. New taxa in *Cetraria*, *Parmelia*, and *Parmeliopsis*. The Bryologist 70: 414–422.
Hale, M.E. 1973. Fine structure of the cortex in the lichen family Parmeliaceae viewed with the scanning-electron microscope. Smithsonian Contributions to Botany 10: 1–92.
Hale, M.E. 1987. A monograph of the lichen genus *Parmelia* Acharius *sensu stricto* (Ascomycotina: Parmeliaceae). Smithsonian Contributions to Botany 66: 1–55.
Hale, M. E. 1988. New combinations in the lichen genus *Xanthoparmelia* (Ascomycotina: Parmeliaceae). Mycotaxon 33: 401–406.
Hale, M.E. 1990. A synopsis of the lichen genus *Xanthoparmelia* (Vainio) Hale (Ascomycotina, Parmeliaceae). Smithsonian Contributions to Botany 74: 1–250.
Knudsen, K., J.C. Lendemer, M. Schultz, J. Kocourková, J.W. SheaRd., A. Pigniolo and T. Wheeler. 2017. Lichen biodiversity and ecology in the San Bernardino and San Jacinto Mountains in southern California (USA). Opuscula Philolichenum 16: 15–138.
Leavitt, S. 2010. Assessing traditional morphology-and chemistry-based species circumspections in lichenized Ascomycetes: Character evolution and molecular species delimitation in common Western North American lichens. Ph.D. Dissertation Brigham Young University, Provo, Utah, USA. Pp.1–244.
Leavitt, S.D., L.Aecolo. Johnson and L.L. St. Clair. 2011a. Species delimitation and evolution in morphologically and chemically diverse communities of the lichen-forming genus *Xanthoparmelia* (Parmeliaceae, Ascomycota) in western North America. American Journal of Botany 98: 175–188.
Leavitt, S.D., L.A. Johnson, T. Goward and L.L. St.Clair. 2011b. Species delimitation in taxonomically difficult lichen-forming fungi: An example from morphologically and chemically diverse *Xanthoparmelia* (Parmeliaceae) in North America. Molecular Phylogenetics and Evolution 60: 317–332.
Leavitt, S.D., M.P. Nelsen and L.L. St. Clair. 2012. Treading in murky waters: Making sense of diversity in *Xanthoparmelia* (Parmeliaceae, Ascomycota) in the Western United States. Bulletin of the California Lichen Society 19: 58–70.
Leavitt, S.D., M.P. Nelsen, H.T. Lumbsch, L.A. Johnson and L.L. St. Clair. 2013. Symbiont flexibility in subalpine rock shield lichen communities in the Southwestern USA. The Bryologist 116: 149-161.

Leavitt, S.D., F. Grewe, T. Widhelm, L. Muggia, B. Wray and H.T. Lumbsch. 2016. Resolving evolutionary relationships in lichen-forming fungi using diverse phylogenomic datasets and analytical approaches. Scientific Reports 6: 22262

Leavitt, S.D., P.M. Kirika, G.A. De Paz, J.-P. Huang, J.-S. Hur, F. Grewe and H.T. Lumbsch. 2018. Assessing phylogeny and historical biogeography of the largest genus of lichen-forming fungi, *Xanthoparmelia* (Parmeliaceae, Ascomycota). The Lichenologist 50: 299–312.

Lendemer, J.C. 2012. Perspectives on chemotaxonomy: Molecular data confirm the existence of two morphologically distinct species within a chemically defined *Lepraria caesiella* (Stereocaulaceae). Castanea 77: 89–105.

Lendemer, J.C. and J.L. Allen. 2020: A revision of *Hypotrachyna* subgenus *Parmelinopsis* (Parmeliaceae) in eastern North America. The Bryologist 123: 265–332.

Lücking, R., B.P. Hodkinson and S.D. Leavitt. 2017. The 2016 classification of lichenized fungi in the Ascomycota and Basidiomycota–Approaching one thousand genera. The Bryologist 119: 361–417.

MacCracken, J.G., E.L. Alexander, D.W. Uresk. 1983. An important lichen of southeastern Montana rangelands. Journal of Range Management 36: 35–37.

Matteucci, E., A. Occhipinti, R. Piervittori, M.E. Maffei and S.E. Favero-Longo. 2017. Morphological, secondary metabolite and ITS (rDNA) variability within usnic acid-containing lichen thalli of *Xanthoparmelia* explored at the local scale of rock outcrop in W-Alps. Chemistry and Biodiversity 14: e1600483.

McCarthy, P.M. 2003. Catalogue of Australian lichens. Flora of Australia Supplementary Series, 19: 1–237.

McNeill, J., F.R. Barrie, W.R. Buck, V. Demoulin, W. Greuter, D.L. Hawksworth and W.F. Prud'homme Van Reine. 2012. International Code of Nomenclature for algae, fungi and plants, Vol.154. Königstein: Koeltz Scientific Books.

Meiser, A., J. Otte, I. Schmitt and F. Dal Grande. 2017. Sequencing genomes from mixed DNA samples-evaluating the metagenome skimming approach in lichenized fungi. Scientific Reports 7: 14881.

Moseley, R.K. and A. Pitner. 1974. Rare bryophytes and lichens in Idaho: Status of our knowledge. Idaho Department of Fish and Game. Boise, Idaho.

Nash III, T.H. 1974. Chemotaxonomy of Arizonan lichens of the genus *Parmelia* subgen. *Xanthoparmelia*. Bulletin of the Torrey Botanical Club 101: 317–325.

Nash III, T.H. and J.A. Elix. 2004 *Xanthoparmelia. In:* T.H. Nash III, B.D. Ryan, P. Diederich, C. Gries, and F. Bungartz (eds.): Lichen Flora of the Greater Sonoran Desert Region, Vol. 2. Lichens Unlimited, Arizona State University, Tempe, Arizona, pp. 566–604.

Pérez, F.L. 1997. Geoecology of erratic lichens of *Xanthoparmelia vagans* in an equatorial Andean paramo. Plant Ecology 129: 11–28.

Perlmutter, G.B. 2009. Contributions to the lichen flora of North Carolina: A preliminary checklist of lichens of the Uwharrie Mountains. Opuscula Philolichenum 6: 65–72.

Pringle, A., D. Chen and J.W. Taylor. 2003. Sexual fecundity is correlated to size in the lichenized fungus *Xanthoparmelia cumberlandia*. The Bryologist 106: 221–226.

Puy-Alquiza, M.J., R. Miranda-Aviles, G.A. Zanor, M.M. Salazar-Hernández and V.Y. Ordaz-Zubia. 2017. Study of the distribution of heavy metals in the atmosphere of the Guanajuato City: Use of saxicolous lichen species as bioindicators. Ingeniería. Investigación y Tecnología 18: 111–126.Rosentreter, R. and B. McCune. 1992. Vagrant Dermatocarpon in western North America. The Bryologist 95: 15–19.

Rosentreter, R. 1993. Vagrant lichens in North America. The Bryologist 96: 333–338.

Sanders, W.B. 2011. Lichens: The interface between mycology and plant morphology whereas most other fungi live as an absorptive mycelium inside their food substrate, the lichen fungi construct a plant-like body within which photosynthetic algal symbionts are cultivated. Bioscience 51: 1025–1035.

Schaerer, L.E. 1850. *Enumeratio Critica Lichenum Europaeorum*. Bernae, pp.30-54

St. Clair, L.L. 1999. *A Color Guidebook to Common Rocky Mountain Lichens*. U.S. Forest Service, San Juan-Rio Grande National Forest, Provo and Durango, Colorado.

Thell, A., T. Feuerer, I. Kärnefelt, L. Myllys and S. Stenroos. 2004. Monophyletic groups within the Parmeliaceae identified by ITS rDNA, β-tubulin and GAPDH sequences. Mycological Progress 3: 297–314.

Thell, A., T. Feuerer, J.A. Elix and I. Kärnefelt. 2006. A contribution to the phylogeny and taxonomy of *Xanthoparmelia* (Ascomycota, Parmeliaceae). The Journal of the Hattori Botanical Laboratory 100: 797–807.

Thell, A., A. Crespo, P.K. Divakar, I. Kärnefelt, S.D. Leavitt, H.T. Lumbsch and M.R. Seaward. 2012. A review of the lichen family Parmeliaceae–history, phylogeny and current taxonomy. Nordic Journal of Botany 30: 641–664.

TOPO!. 2003. National Geographic Version 3.4.2.

Tripp, E.A. 2015. Lichen inventory of white rocks open space (city of Boulder, Colorado). Western North American Naturalist 75: 301–310.

Tripp, E.A., Y.H.E. Tsai, Y. Zhuang and K.G. Dexter. 2017. RAD seq dataset with 90% missing data fully resolves recent radiation of *Petalidium* (Acanthaceae) in the ultra-arid deserts of Namibia. Ecology and Evolution 7: 7920–7936.

Tsurykau, A., V. Golubkov and P. Bely. 2018. The lichen genus *Xanthoparmelia* (Parmeliaceae) in Belarus. Folia Cryptogamica Estonica 55: 125–132.

Turland, N.J. and J.H. Wiersema. 2017. Synopsis of proposals on nomenclature–Shenzhen 2017: A review of the proposals concerning the International Code of Nomenclature for algae, fungi, and plants submitted to the XIX International Botanical Congress. Taxon 66: 217–274.

Vainio, E.A. 1890. Étude sur la classification naturelle et la morphologie des lichens du Brésil, Acta Societas pro Fauna et Flora Fennica 7: 1–247.

Weber, W.A. 1977. Environmental modification and lichen taxonomy. *In:* Seaward, M.R.D. (ed.): *Lichen Ecology*. Academic Press, London. pp. 9–29.