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THE LICHEN FLORA OF COLORADO: *CETRARIA* *CORNICULARIA*, *DACTYLINA*, AND *THAMNOLIA*

BY WILLIAM A. WEBER* AND SAM SIUSHAN*

The study of the lichen flora of the Rocky Mountain region is a relatively virgin field of taxonomic research. Although the lichens are conspicuous elements of the vegetation, and although they occupy almost all possible ecologic niches — aquatic, terrestrial, saxicolous, and corticolous — they have been ignored by the majority of botanists. Yet their importance in the flora must be acknowledged, and their relevance to our understanding of taxonomy, ecology, phytogeography, and evolution should not be underestimated.

This paper is the first in a series which, it is hoped, will culminate in a complete lichen flora of Colorado. With the present state of knowledge it is impossible to present this flora in a logical order because of the many groups which are very poorly understood. Therefore, the work will be projected on the generic rather than the family level, and the generic treatments will be published as the record for each group becomes reasonably complete. We shall not attempt, in this first short paper, to present an introduction to general lichenological study. To assist beginners, however, a list of books and articles on this phase will be included in the bibliography.

Although the four genera chosen for this first article may not be very closely related taxonomically, it is apparent that they share a similar general appearance and habitat preference which justify their consideration as a unit. With two exceptions — namely, *Cetraria fendleri* and *C. pinastri*, which are corticolous — the species treated are all foliose or fruticose lichens of the alpine tundra.

The specimens examined in this study were primarily from the University of Colorado Herbarium, which contains, at this writing, about 5,500 lichen specimens. The majority of the specimens cited were collected by the authors. For certain critical specimens other herbaria have been consulted, but we have not been able to examine all the known collections of these taxa, which are scattered through many herbaria. Unless otherwise indicated, the specimens cited are deposited in the University of Colorado Herbarium. The letter "S", which usually accompanies the citation, is a code letter denoting University of Colorado accessions.

HISTORICAL SKETCH

Literature. Papers dealing exclusively with the Colorado lichen flora are exceedingly few, and none are comprehensive. Dr. Walter Kiener, who for many

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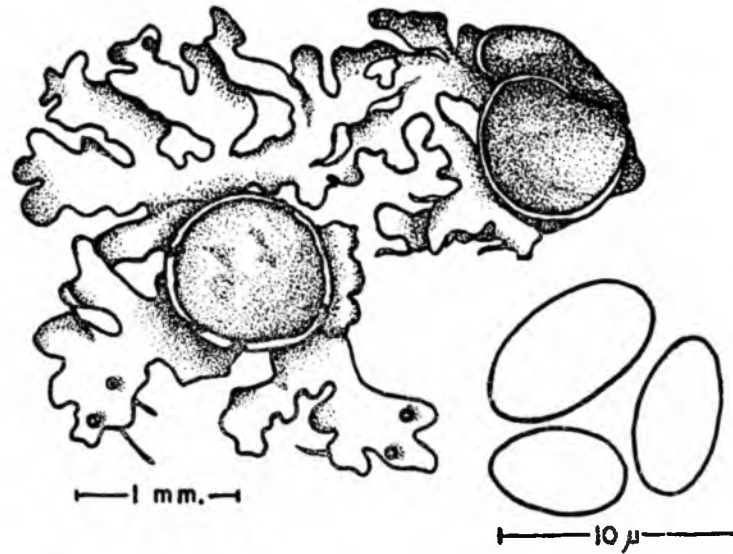


FIG. 1. *Cetraria fendleri*, thallus and spores, drawn from Brandegees 87, in herb. Farlow

years was an alpinist and guide on Long's Peak, wrote a short paper on the species of *Peltigera* found in that area (Kiener, 1939). The value of this paper now is mainly historical, inasmuch as the data have been reevaluated by Thomson (1950) in his study of *Peltigera* in North America. Two short papers on lichens of southern Colorado have been published by James H. Craft, Professor of Biology at Adams State College at Alamosa. The first was a note recording *Peltigera scabrosa* in Mineral County, representing an extension of range south from Montana (Craft, 1952); the second was an annotated list of 36 species of lichens from several southern Colorado counties, mostly determined by Dr. A. W. Herre (Craft, 1953).

Two lists of lichens appear in early works on the Colorado flora. The first included 52 species and was compiled by Henry Willey for T. C. Porter and for John M. Coulter's *Synopsis of the Flora of Colorado*, 1874. Collectors' names were not mentioned, and localities were noted only occasionally — namely, Horseshoe Mountain [Park County], White House Mountain [Ouray County], and La Plata Mountain [Chaffee County], all above 11,000 feet altitude. The specimens presumably are in the Tuckerman Herbarium, which is now part of the Farlow Cryptogamic Herbarium at Harvard University.

The second list of Colorado lichens appeared in a paper by Britton and Vail (1895), which was an enumeration of the plants collected by the Swiss protozoologist, Eugene Penard, in the Front Range near Boulder and Colorado Springs. The lichenological portion was contributed by J. Müller-Arg. and consists of an an-

notated list of 28 species¹, with localities, dates, and collection numbers. Two new taxa were described in this paper — namely, *Candelaria vitellina* var. *rosulans* Müll.-Arg., and *Rinodina penardiana* Müll.-Arg. The latter name apparently was overlooked by Zahlbruckner (1931), who did not include it in the *Catalogus Lichenum Universalis*.

Scattered references to Colorado lichens are found in the larger works of a regional nature by Tuckerman and by Fink, and in shorter papers by other authors. The most important of these are the works of Tuckerman, for example, his *Synopsis of the North American Lichens*, Part I, 1882, and Part II, 1888. It is probably reasonable to assume that specimens from the "Rocky Mountains", cited as having been collected by E. Hall, F. V. Hayden, or C. C. Parry, represent collections made either in Colorado, or in Wyoming, or in Idaho. Tuckerman lists 71 species in this manner, including several specifically mentioned as occurring in Colorado. Tuckerman almost always cited the collector's name, among whom were E. Hall, T. S. Brandegee, F. V. Hayden, George Vasey, J. T. Rothrock, J. Wolf, I. A. Lapham, C. C. Parry, C. G. Pringle, and J. M. Coulter. Tuckerman evidently had at hand the specimens listed by Willey in 1874, for he specifically mentioned several of these (e.g., *Solorina saccata*). He also (1878) listed 25 Colorado lichens from Twin Lakes, Montezuma Pass, South Park, and the South Platte River in his report on the lichens collected by Wolf and Rothrock on the Wheeler expedition. Bruce Fink, in his *Lichen Flora of the United States* (1935) specifically mentions Colorado in the citation of ranges for 53 species of lichens.

Collectors. Relatively few of the mycological specialists who have collected in Colorado did any work with the lichens. Ellsworth Bethel, who collected fungi from 1893 to 1925 (Ewan, 1950), occasionally collected lichens, but these collections are extremely meager. Most of the 19th century collectors picked up at least a few of the conspicuous foliose or fruticose types, but only rare individuals, such as Baker, Earle, Tracy, Brandegee, Hall, and Parry, collected any variety. Even so, the lichens comprise only a very small fraction of their collections.

The following names stand out in the roster of lichenological collectors in Colorado, and it is to these men that one turns for the few herbarium records. Charles C. Plitt, who for many years (1915–1932) was curator of the Lichen Department of the Sullivant Moss Society, collected lichens in Colorado in 1918, 1921, 1927, and 1928, according to citations of his specimens by Llano (1950). Plitt's collections are now in the U. S. Department of Agriculture Herbarium at Beltsville, Maryland (formerly at Washington, D. C.; see Anonymous, 1934).

Frederic E. Clements and E. S. Clements distributed *exsiccata* of mycological specimens under the title *Cryptogamae Formationum Coloradensium* during the

¹ This list included *Cetraria* (*Nephromopsis*) *ciliaris* Ach. and *Cetraria fahlunensis* Schaer. These two specimens have been examined and redetermined by the authors as *Parmelia exasperatula* Nyl. and *Parmelia bisjuncta* Erichs., respectively.

period 1905 to 1908. This set included a number of lichens, collected in the vicinity of Pikes Peak and Colorado Springs.

The most thorough sampling of the lichen flora, including numerous crustose species, was made by Dr. Walter Kiener in the vicinity of Long's Peak. These specimens have been widely distributed, and it was a set of the Kiener lichens which formed the nucleus of the lichen collection at the University of Colorado.

In 1952, Henry A. Imshaug collected extensively throughout the Rocky Mountains. His Colorado collections, not yet distributed, were made chiefly in the Sawatch Range, the Elk Mountains, the Front Range, the Culebra Range, and at high altitudes on Mount Massive, Mount Evans, Pikes Peak, and Long's Peak (Imshaug, 1952).

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CETRARIA Ach.

Thallus foliose, horizontally spreading or ascending to stiffly erect, free or attached to the substrate by rhizinae or haptera, variously branched and lobed, smooth or sorediate, flat, canaliculate, or involute, in the latter event the margins sometimes coalescing; thallus dorsiventrally differentiated, with an upper and lower cortex; dorsal cortex of palisade hyphae perpendicular to the surface; ventral cortex of anastomosing hyphae parallel to the surface; medulla cottony, white or yellow; pseudocyphellae present or absent; apothecia marginal or nearly so, attached more or less obliquely to the dorsal surface, sessile to subpedicellate, saucer-shaped to convex, lecanoroid, flesh-colored to brown, the hypothecium colorless; asci short-clavate, 6-8-spored (8 *vide* Fink), the spores hyaline, 3-12 x 3-7 microns (at least in United States species), ellipsoidal

or spherical, thin-walled; paraphyses short, unbranched to branched; pycnidia usually marginal, immersed in papillae or spines, brown to black, ca. 0.1 mm. in diameter; fulcræ endobasidial; pycnoconidia straight, ellipsoidal, clavate, or cylindrical, or constricted in the middle ("bone-shaped"); algae *Chlorococcum* (fide Hillmann, Maas Geesteranus) or *Protococcus* (fide Fink). — Name from Latin, *cetra*, a sort of leather shield. (Parmeliaceae)

KEY TO THE SPECIES

- A. Thallus yellow, straw-colored, to greenish-yellow, never with marginal spines.
 B. Thallus horizontal, foliose, rosette-forming; margins upturned, yellow-soresiate; on bark 7. *C. pinastri*
 BB. Thallus erect-foliose or fruticose, not soresiate; on soil and moss, alpine.
 C. Thallus chrome-yellow, short (less than 1 cm. tall); margin not strongly crisped; medulla yellow 8. *C. tilesii*
 CC. Thallus pale lemon-yellow or greenish-straw-colored, usually over 1 cm. tall; margins strongly crisped; medulla white.
 D. Base of thallus yellow-orange; surface reticulate, flat or concave 6. *C. nivalis*
 DD. Base of thallus red to purple; surface smooth, involute 3. *C. cucullata*
 AA. Thallus brown to dark olivaceous green; marginal spines present or absent.
 E. Pseudocyphellae absent, thallus flat, prostrate or weakly ascending, not involute or crisped; marginal spines absent (there may be sparse marginal rhizinae).
 F. Thallus rosette-forming, on bark; rhizinae mostly ventral; apothecia common; pycnidia dorsal as well as marginal 4. *C. fendleri*
 FF. Thallus elongate, on tundra mosses; rhizinae mostly marginal; apothecia rare (lacking in Colorado specimens); pycnidia usually marginal 1. *C. commixta*
 EE. Pseudocyphellae present, thallus erect-foliose, usually strongly involute; marginal spines present, often numerous.
 G. Pseudocyphellae restricted to the ventral surface immediately adjacent to the margins; medulla Pd² negative 2. *C. crispa*
 GG. Pseudocyphellae distributed generally over ventral surface; medulla Pd positive, orange to red 5. *C. islandica*

1. CETRARIA COMMIXTA (Nyl.) Th. Fr., Lich. Scan. 1: 109. 1871.

Platysma commixtum Nyl. (1860)

Lichen fahlunensis L. (1753)

²The symbols denote the following chemicals:

K: potassium hydroxide (KOH), a 40% aqueous solution.

Pd: paraphenylenediamine or 1,4-benzenediamine (C₆H₄(NH₂)₂), a saturated solution in 95% ethyl alcohol. The solution should be freshly prepared, although reactions may be obtained after several hours.

I: iodine crystals plus potassium iodide (I₂ plus KI), 1 gram of each plus 100 cc. distilled water.

C: calcium hypochlorite (CaOCl₂), a saturated aqueous solution. Sanitation HTH, which contains 70% calcium hypochlorite and 30% inert ingredients works very nicely and can be procured from the Mathieson Chem. Corp., Baltimore, Maryland. Use freshly prepared solution.

K + C: K is placed upon the specimen and after 10–15 seconds C is added. The reaction is immediate and may be fleeting.

These tests, which indicate the presence or absence of certain lichenic acids, or starch, should be performed on small fragments of thallus under a binocular dissecting microscope. A drop or two of reagent is used on separate fragments. Some of these chemicals, particularly Pd, will age and discolor herbarium paper; hence their use directly on herbarium sheets should be avoided.

Platysma fahlunensis Vainio (1886), not Nyl. (1860)
Cetraria fahlunensis Vainio (1905), not Schaer. (1833)

Thallus minute, the individuals not over 5 mm. long, prostrate or ascending, loosely grouped, the branches flattened, very narrow at the base, widening above, the major branches 0.25–0.50 mm. wide (up to 0.7 mm. at the dichotomies), spreading almost at right angles, giving a fiabellate appearance to the thallus, the ultimate lobules dichotomized, their tips very blunt and rounded; upper surface of thallus dark olivaceous green or bronze brown, somewhat lustrous, the lower surface paler, tan; thallus margin slightly thicker than the center, simulating a narrow rim; isidia or soredia absent; medulla white; rhizinae very sparse, marginal, as long as the width of the thallus lobes (about 0.33 mm.); pycnidia black, marginal or dorsal submarginal, ca. .008 mm. in diameter, wart-like, globose, with a prominent terminal depression; pycnoconidia ellipsoidal, 3–4 x 1 microns; apothecia (absent in the Colorado specimens) terminating the lobes, circular, 1–4 mm. wide; amphithecium wrinkled, darker or lighter brown, the disk almost concolorous, slightly lustrous, smooth, concave; spores ellipsoid, 8–10 x 4–5 microns; K–, Pd–, I–, C–, K plus C–.

ILLUSTRATIONS: **Plate 1A**; Anders (1928), Plate XXVI, 10 (as *fahlunensis*). The illustration of *C. fahlunensis* in Nearing (1947), page 154, Fig. XII-1 and 2, applies to *C. hepatizon* if his description of a black underside of the thallus is correct. Fink's description in the Lichen Flora of the United States (1935) also seems to apply to *C. hepatizon* rather than to *C. commixta*. The name *C. fahlunensis* has been applied to both species.

HABITAT: over mosses in rock crevices of boulderfield, 12,800 ft. alt.; very rare.

SPECIMENS EXAMINED: CLEAR CREEK CO.: over mosses, south shore of Summit Lake, Mount Evans, 12,800 ft. alt., 1 Aug. 1953, *Weber & E. Dahl* (S 1595), verified by J. W. Thomson; same locality, 22 July 1955, *Shushan & Weber* (S 5616). EL PASO CO.: over mosses under rock overhangs, summit of Pikes Peak, 14,100 ft. alt., 1 Aug. 1955, *Shushan* (S 5672). These collections seem to be the first records for this lichen in the United States.

It is possible that the closely related species, *C. hepatizon* (Ach.) Vainio and *C. polyschiza* (Nyl.) Jatta, may also occur in the Colorado Rocky Mountains. These may be distinguished as follows (Thomson, correspondence):

Pycnoconidia ellipsoid, medulla K– and Pd– *C. commixta*

Pycnoconidia "bone-shaped", thicker at the ends than in the middle.

Medulla K+ yellow, Pd (slowly) red; lobes 1 mm. broad *C. hepatizon*

Medulla K–, Pd–, the lobes less than 1 mm. broad *C. polyschiza*

Cetraria hepatizon has a dark undersurface, and in some forms shows whitish marginal soredia, while both *C. polyschiza* and *C. commixta* have a pale undersurface. Apparently the only feature differentiating *C. polyschiza* from *C. commixta* is the shape of the pycnoconidium.

2. *CETRARIA CRISPA* (Ach.) Nyl. in Bull. Soc. Linn. Normand. ser. 4. 1: 202. 1887.*Cetraria islandica* var. *crispa* Ach. (1810)*Lichen islandicus* var. *tenuifolius* Retz. (1779)*Cetraria tenuifolia* (Retz.) Howe f. (1915)

Similar to *Cetraria islandica* but differing in the following details: pseudocyphellae restricted to the submarginal area of the ventral surface of the thallus, infrequently on the ventral surface proper; thallus Pd negative, K-, I + violet to blue-black, C-, K plus C-.

ILLUSTRATIONS: **Plate 1B**; Anders(1928), Plate XXV, 3 (as *C. islandica* f. *crispa*); Galløe (1948), plate 79, as *C. islandica* var. *tenuifolia*.

HABITAT: subalpine and alpine, on soil, over moss, sometimes on decaying wood (one specimen on top of tree-stump at 9,000 ft. alt.).

SPECIMENS EXAMINED: BOULDER CO.: on old stump, deep forest, ravine, "Little Royal Gorge" of Como Creek, 1 mi. s. of University Camp, 9,000 ft. alt., 5 July 1950, *Weber* (S 2997); mossy tundra, Upper Green Lakes, north of Kiowa Peak, 11,500 ft. alt., T. 1 N., R. 47 W., Sec. 13, Boulder Watershed, 21 July 1953, *Weber & Dahl* (S 1443). CLEAR CREEK CO.: ¼ mi. north of Summit Lake, Mount Evans, 12,600 ft. alt., 25 Aug. 1954, *Shushan & Weber* (S 2917, S 2924); trail from Stevens Mine to summit of Gray's Peak, 13,700 ft. alt., 11 July 1950, *Weber 5654* (S 1925).

EL PASO CO.: northwest slope of Pikes Peak, 13,300 ft. alt., 1 Aug. 1955, *Shushan*

(S 5695). GRAND CO.: tundra above Fool Creek, Fraser Experimental Forest, 11,500

ft. alt., 1 Aug. 1953, *Weber & Dahl* (S 1683 A). GUNNISON CO.: Queen's Basin, near

Gothic, 12,000 ft. alt., 3 July 1949, *Langenheim* (S 1984). PARK CO.: tundra around

Wheeler Lake, upper end of Platte Gulch, north of Mount Lincoln, 12,300 ft. alt.,

3 July 1954, *Weber & Shushan* (S 2852); in spruce forest, north slope, 11.3 mi.

east of Jefferson towards Lost Creek Park, 10,000 ft. alt., 3 July 1955, *Shushan*

(S 5542).

3. *CETRARIA CUCULLATA* (Bell.) Ach., Method. Lich. 293. 1803.*Lichen cucullatus* Bellardi (1788)

Erect-foliose, the thallus consisting of strap-like lobes up to 3 cm. tall and 4 mm. wide, a few times dichotomously branched, the margins inrolled, with the opposite edges often meeting or coalescing; margins of thallus undulate, usually with a narrow brown edge around the apical lobes and showing minute dark brown to black globose pycnidia along the margin, these often becoming confluent to form a narrow black rim; pycnoconidia "bone-shaped"; base of thallus tubular and up to 2 mm. in diameter, wine-colored; dorsal surface smooth to slightly lacunose, sometimes mottled, pale chalcedony yellow (R, Plate 17),³ sea foam yellow (R, Plate 31), straw yellow (R, Plate 16), or pale green yellow (R, Plate 5); ventral surface smooth or slightly to distinctly lacunose, typically slightly lighter in color than the dorsal surface; apothecia (not seen in Colorado specimens) up to 1 cm. long, disk chestnut-brown, the margin narrow, entire; spores ellipsoid, 7-8 x 3-3.5 microns; K+ faint yellow, Pd-, I-, C-, K plus C + intense yellow.

³ Color standards of Ridgway (1912).

ILLUSTRATIONS: **Plate 2A**; Anders (1928), Plate XXVI, 5; Galløe (1948), vol. 7, Plate 84 (colored); Hillmann (1936), p. 286, Fig. 22; Nearing (1947), p. 140, Fig. XI-3a.

HABITAT: among mosses, grasses, and *Selaginella*, on alpine tundra from 11,500 to 13,000 ft. alt.

SPECIMENS EXAMINED: CLEAR CREEK CO.: over mosses, 500 ft. north of Summit Lake, Mount Evans, 12,800 ft. alt., 4 Sept. 1951, *Shushan* (S 209); on tundra above Lincoln Lake near Mt. Evans highway, ca. 11,500 ft. alt., 25 Aug. 1954, *Weber & Shushan* (S 3754). PARK CO.: on tundra, south side of Hoosier Ridge, east of Hoosier Pass, 12,500 ft. alt., 8 July 1951, *Weber* (S 242a).

Cetraria cucullata and *C. nivalis* are aptly called "lettuce lichens" because of the resemblance of their thalli to small lettuce-leaves. The species occur together and are differentiated by the narrower lobes, red-purple base, and wavy, inrolled margins of *C. cucullata*, and the broad lobes, orange-yellow base, and essentially plane margins of *C. nivalis*. The brown-rimmed apical lobes of *C. cucullata* constitute a reliable supplemental character in doubtful specimens. *C. nivalis* is the more abundant species.

4. CETRARIA FENDLERI (Nyl.) Tuck., Gen. Lich. 280. 1872.

Parmelia fendleri Nyl. (1857), *nomen nudum*.

Platysma fendleri Nyl. (1860)

Thallus foliose, forming rosettes up to 2 cm. in diameter (only about 1 cm. in the Brandegee collection) although usually smaller; lobes overlapping, sometimes coalescing, typically less than 2 mm. long, up to 1 mm. wide, terminating in blunt or rounded lobules; thallus olivaceous black (R, Plate 48) or dark ivy green (R, Plate 48) above; ventral surface white to tan, smooth or wrinkled, bearing short pale to dark brown rhizinae, these sometimes also marginal; apothecia up to 4 mm. in diameter (the largest in the Brandegee specimen 1.6 mm. wide), not always clearly marginal; disk flat, concave, sometimes convex, or irregular, carob brown (R, Plate 14) or chestnut brown (R, Plate 14); exciple smooth to crenulate or lobulate, sometimes disappearing; spores hyaline, ellipsoid, 4.4–11.0 x 2.6–5.0 microns; pycnidia common, black, marginal or superficial, approximately 0.1 mm. in diameter; K–, Pd–, I–, C–, K plus C–.

ILLUSTRATIONS: **Fig. 1; Plate 2B**; Nearing (1947), p. 155, Fig. XII-8, showing a specimen with the "pointed" lobes mentioned in most descriptions.

HABITAT: on trees and wood; the Colorado specimen is on some type of coniferous bark. In New Mexico the habitat is the bark of *Pinus edulis* (RIO ARRIBA CO.: ca. 3 mi. northeast of Regina, ca. 7,200 ft. alt., *Shushan* (S 5781)).

SPECIMENS EXAMINED: "Colorado", *T. S. Brandegee 87* (in herb. Tuckerman, Farlow Herbarium).

The Brandegee specimen, which constitutes the only Colorado record, was probably collected in southwestern Colorado or in the Canyon City region. This collection differs from material from eastern United States (e.g. *Culberson 3122*, from

Wisconsin, *in herb.* Colo., *Tuckerman* in 1852, from Maryland, *Austin* in 1869, from New Jersey, *in herb.* Tuck.) by having very small apothecia with scarcely crenulate margins, and the spores are rather large (5.5–8.7 x 3.5–5.0 microns) compared with 4.8–6.1 x 2.6–3.0 microns (*Culberson 3122*), 4.4–6.1 x 2.6 (*Austin*), and 5.2–7.8 x 3.0–3.9 microns (*Tuckerman*). The lobes of the thallus on all of the material examined show knobs and lobules, but, contrary to the descriptions of Fink (1935), *Tuckerman* (1882, p. 33), and *Nearing* (1947), they are hardly “toothed” or “denticulate”.

Cetraria fendleri appears to be closely related to *C. saepincola* (Ehrh.) Ach., a corticolous species commonly found on *Betula* in northern America and Europe. In view of the possibility that *C. saepincola* may occur in Colorado a comparison of the species is desirable. *Cetraria saepincola* has an ascending thallus which might be called erect-foliose, leather-brown in color, with an undulating margin. The pycnidia are almost exclusively marginal, and, contrary to the descriptions by American authors (*Fink*, 1935; *Tuckerman*, 1882; *Nearing*, 1947), the thallus bears sparse rhizinae (see *Galløe*, 1948, p. 44, and Plate 75, 76; we have verified *Galløe*'s observation in our study of American material). *C. fendleri* has a more prostrate, rosetiform thallus, usually distinctly olivaceous in color, with plane margins. The pycnidia are scattered over the surface as well as the margins, and the thallus bears rather numerous rhizinae on the ventral surface and sometimes a few along the margins.

5. CETRARIA ISLANDICA (L.) Ach., Method. Lich. 293. 1803.

Lichen islandicus L. (1753)

Thallus erect-foliose, solitary to usually gregarious, coriaceous, sometimes lustrous, plane or canaliculate, 3.0–4.5 (–10) cm. long, the dorsal surface usually smooth, the ventral surface smooth to slightly reticulate-lacunose, the primary axis narrow to broad, dichotomously or irregularly branched, the edges smooth and rounded, slightly thickened, crisped or sometimes involute and coalescent, more or less thickly beset with short (0.1–0.5 [–1.0] mm.) blunt-tipped, simple, forked, or trifid spines, these rarely also on the ventral surface associated with the pseudocyphellae; thallus color varied, the upper surface some shade of brown, *e.g.* bistre (R, Plate 29), light brownish olive (R, Plate 30), the ventral surface lighter, *e.g.* snuff brown (R, Plate 29), rarely concolorous with the dorsal surface; thallus base frequently reddish or wine-colored; pseudocyphellae round or irregularly shaped, scattered over the ventral surface, sometimes appearing as raised blisters or flat depressions, those near the margin frequently confluent and elongate; medulla white; apothecia rare, submarginal on the lobes, the disk reddish-brown, up to or exceeding 1 cm. in diameter; spores 6–10 x 3–5 microns; pycnidia marginal, sessile, near the lobe tips or terminating the spines, black, subglobose, ca. 0.1 mm. in diameter; thallus K positive, orange, at first only around the margins of the pseudocyphellae but later spreading over the thallus (Colorado specimens are uniform in this reaction), Pd positive, orange-red, I positive, violet to blackish, C–.

ILLUSTRATIONS: **Plate 3A**; *Anders* (1928), Plate XXV, 2, 4–7; *Galløe* (1948),

Plate 77 (colored), 78, 79, 80; Harris (1901), p. 43, Fig. 2; Nearing (1947), p. 138, Fig. XI-1.

HABITAT: on soil and over mosses, subalpine and alpine tundra.

SPECIMENS EXAMINED: BOULDER CO.: tundra, Upper Green Lakes, north of Kiowa Peak, 11,500 ft. alt., 21 July 1953, *Weber & Dahl* (S 1443a); on ground among spruces, Long Lake, South St. Vrain Creek 5 mi. west of Ward, 10,400 ft. alt., 30 June 1937, *Kiener 5238* (S 4021). CLEAR CREEK CO.: common in moss along shore of Summit Lake, Mount Evans, 12,700 ft. alt., 4 Sept. 1953, *Weber* (S 1409). GRAND CO.: on tundra above Fool Creek, Fraser Experimental Forest, 11,500 ft. alt., 1 Aug. 1953, *Weber & Dahl* (S 1683). LARIMER CO.: Fall River Pass, Trail Ridge Road, Rocky Mountain Nat. Park, 11,900 ft. alt., 28 June 1953, *Shushan* (S 1421). PARK CO.: tundra, Wheeler Lake, head of Platte Gulch north of Mount Lincoln, 12,300 ft. alt., 3 July 1954, *Shushan & Weber* (S 2723).

Cetraria islandica and *C. crispa* are often found growing intermixed. Both species show a wide variation in size and width of thallus lobes; the only reliable morphological distinction separating them seems to be in the distribution of the pseudocyphellae.

A third related species, *Cetraria hiascens* (E. Fr.) Th. Fr. (*C. delisei* [Bory] Th. Fr.) may be present in the Colorado Rocky Mountains. This species is characterized by having the ultimate lobes proliferated into numerous narrow lobules, the thallus base pale, and in having a negative reaction with both iodine and paraphenylenediamine.

6. CETRARIA NIVALIS (L.) Ach., Method. Lich. 294. 1803.

Lichen nivalis L. (1753)

Thallus erect-foliose, 2-4 (-8) cm. high, solitary or gregarious; width broader than in *C. cucullata*, up to 25 mm. wide above, about 6 mm. broad at base, not strongly tubular-rolled, irregularly flabellate-lobed, with crisped, sinuate-laciniate tips, slightly to usually deeply reticulate-lacunose, occasionally perforate, lacking isidia or soredia; both sides of the thallus similarly colored, whitish-green, pale chalcedony yellow (R, Plate 17), or primuline yellow (R, Plate 16), not shining, orange-yellow or ochraceous at the base; rhizinae or spines absent; lower surface occasionally showing scattered whitish pseudocyphellae exposing the whitish medulla; apothecia rare (absent in Colorado material), subterminal on the lobes, or lateral, 3-20 mm. wide, the thalloid exciple thin, crenulate, the disk plane or slightly convex, yellowish flesh-colored to light ochraceous or leather-brown; spores ellipsoid or oval, 3-5 x 5-11 microns; pycnidia globose, marginal or scattered over the surface, sessile or on short papillae, black, ca. 0.1 mm. in diameter, sometimes becoming confluent to form a thin dark rim on the lobes; K+ faint yellow, Pd-, I-, C-, K plus C+ intense yellow.

ILLUSTRATIONS: **Plate 4A**; Anders (1928), Plate XXVI, 6; Galløe (1948), Plate 81 (colored), Plate 82, 83; Nearing (1947), p. 141, Fig. XI-3c; Hillmann (1936), p. 290, Fig. 23.

HABITAT: on soil, tundra, mixed with lichens, mosses, or herbaceous plants.

SPECIMENS EXAMINED: BOULDER CO.: subalpine meadow just below Albion Village, Green and Albion Lakes Valley; on soil; ca. 10,500 ft. alt., 22 Sept. 1954, *Shushan & A. W. Johnson* (S 3905). CLEAR CREEK CO.: $\frac{1}{4}$ mi. n. of Summit Lake, Mt. Evans, 12,700 ft. alt., 4 Sept. 1951, *Shushan & Weber* (S 1408); 13,500 ft. alt., trail from Stevens Mine to summit of Gray's Peak, 11 July 1950, *Weber 5656* (S 1922). EL PASO CO.: northwest slope of Pikes Peak, 13,300 ft. alt., 1 Aug. 1955, *Shushan* (S 5699). GUNNISON CO.: tundra, east slope, East Maroon Pass, 12,000 ft. alt., near Gothic, 6 Aug. 1948, *Langenheim* (S 1986); 2 mi. s.e. of Monarch Pass, 12,000 ft. alt., 4 Aug. 1947, *Hayward* (S 10,299). LARIMER CO.: on ground among mosses, Flat-Top Mt., 12,100 ft. alt., 18 Aug. 1934, *Kiener 1861* (S 4016); Trail Ridge Road, Fall River Pass, Rocky Mt. Nat. Park, 11,900 ft. alt., 28 June 1953, *Shushan* (S 1419). SUMMIT-PARK CO.: tundra, south side of Hoosier Ridge, 12,500 ft. alt., 8 July 1951, *Weber* (S 242).

7. *CETRARIA PINASTRI* (Scop.) Röhl., *Deutschl. Flora* 3, Abt. 2: 113. 1813.

Lichen pinastri Scop. (1772)

Cetraria juniperina var. *pinastri* (Scop.) Ach. (1803)

Foliose, forming rosettes up to 3.5 cm. in diameter (crowding frequently alters the typical rosette form); attached by pale ventral rhizinae, the thallus lying flat on substrate except for upturned, undulating margins (less than 5 mm. high); margins yellow-sorediate; dorsal surface smooth to slightly lacunose, sometimes yellow-sorediate, especially in the central portion, color dull green yellow (R, Plate 17), citron yellow (R, Plate 16), Rinne's green (R, Plate 18); ventral surface lacunose, maize yellow (R, Plate 4), or sea foam yellow (R, Plate 31), occasionally with scattered soredia; apothecia and pycnidia absent on Colorado specimens; K—, Pd—, I—, C—, K plus C—.

ILLUSTRATIONS: Plate 4B; Anders (1928), Plate XXVI, 2; Galløe (1948), Plate 69 (colored), Plate 70; Fink (1935), Plate 36a; Nearing (1947), p. 156, Fig. XII-3 and 4.

HABITAT: on fallen logs, stumps, on twigs, and on bark, among and over mosses on bases of coniferous trees, ca. 6,000 to 11,000 ft. alt. Especially abundant on bark of *Pseudotsuga* in the foothills.

SPECIMENS EXAMINED: BOULDER CO.: Green Mt. trail, s.w. of Boulder, 7,000 ft. alt., 2 Feb. 1952, *Weber & Shushan* (S 432); on old wood, 0.8 mi. s. of Eldora, south shore of Lake Eldora, 9,000 ft. alt., 26 Oct. 1952, *Weber & Shushan* (S 1095); base of *Pseudotsuga taxifolia* and *Pinus ponderosa*, west of Kossler's Lake, 7,500 ft. alt., 7 May 1953, *Shushan* (S 1414); just above Albion Village, Green and Albion Lakes Valley, on bark in spruce forest, 11,000 ft. alt., 22 Sept. 1954, *Shushan & A. W. Johnson* (S 3875); same locality, 10,500 ft. alt. (S 3907). DOUGLAS CO.: 7 mi. s.w. of Sedalia, on *Pseudotsuga*, 6,700 ft. alt., 24 May 1952, *Shushan & Weber* (S 581); Devil's Head Campground, on old wood, 8100 ft. alt., 28 June

1952, *Shushan & Weber* (S 1062). EL PASO CO.: on old stump, n. slope, forest, 0.5 mi. w. of Palmer Lake, 22 July 1954, *Shushan* (S 2858). GRAND CO.: lodgepole pine forest above East St. Louis Creek, Fraser Experimental Forest, 9,000 ft. alt., 1 Aug. 1953, *Weber & Dahl* (S 1651). GUNNISON CO.: on bark, spruce-fir forest north of Gothic, 10,000 ft. alt., 8 Aug. 1954, *Shushan & Weber* (S 2816). JACKSON CO.: on bark in pine forest, Big Creek Lake, northwest of Cowdrey, 9,200 ft. alt., 29 May 1955, *Shushan* (S 5331). LARIMER CO.: on decaying log on forest floor, Trail Ridge, west slope, 10,800 ft. alt., 20 Sept. 1938, *Kiener 7106* (S 378). MINERAL CO.: 1 mi. s.w. of Wolf Creek Pass, spruce-fir forest, 9,400 ft. alt., 6 June 1952, *Shushan & Weber* (S 662). PARK CO.: on decayed logs in spruce forest, 11.3 mi. east of Jefferson towards Lost Creek Park, 10,000 ft. alt., 3 July 1955, *Shushan* (S 5535). SAN JUAN CO.: on decayed wood in Engelmann spruce forest, South Mineral Campground 7 mi. w. of Silverton, 10,000 ft. alt., 21 Aug. 1951, *G. Alexander* (S 264). SUMMIT CO.: on logs, deep wet spruce forest along Monte Cristo Creek, north base of Hoosier Pass, 10,800 ft. alt., 4 July 1954, *Shushan & Weber* (S 2632).

Cetraria pinastri is easily recognized by its foliose, greenish-yellow thallus with upturned, yellow-sorediate margins. Small specimens may be distinguished from *Xanthoria fallax*, which they sometimes resemble, by the latter's white medulla (*C. pinastri* has a yellow medulla). The thallus of *X. fallax* stains deeply red-purple with KOH; *C. pinastri* shows no reaction. The dorsal surface of *X. fallax* has an orange tinge, and when apothecia are present their orange color and their bilocular spores clearly distinguish that species.

Candelaria concolor, another yellow-green lichen occurring on bark, has much-branched lobes which are only up to 1.5 mm. wide in clearly foliose forms; the thallus is often reduced to scattered squamules.

A related species, *Cetraria juniperina* (L.) Ach. (see **Plate 3B**), is to be expected in northern Colorado. It is an erect-foliose form commonly found on the branches of *Pinus ponderosa*. The thallus of *C. juniperina* is bright yellow, typically esorediate, conspicuously reticulate-lacunose, and commonly bears large brown apothecia with undulate, finely-lobulate margins. The species is abundant throughout northwestern United States and Canada. According to Imshaug (correspondence) the correct name for the northwestern American plant is *C. canadensis* Räsänen (1952).

8. CETRARIA TILESII Ach., Synops. Lich. 228. 1814.

Cetraria juniperina var. *tilesii* Th. Fr. (1861)

Cetraria juniperina var. *terrestris* Schaer. (1823) [*sensu* Tuck., 1882, p. 37]

Thallus erect-foliose, forming imbricated or crowded mats, the individuals up to 3 mm. wide and up to 10 mm. long, irregularly branched, the short lobes thick, compressed, angulose, with lightly undulate margins and blunt, rounded tips; dorsal surface smooth to slightly lacunose,

with a wax-like luster, light greenish yellow (R, Plate 5), green-mottled toward the center, becoming brownish-yellow at the base; ventral surface empire yellow (R, Plate 4); medulla yellow, that of the basal portion frequently white; soredia absent, but soredia-like protrusions of the medulla occurring at breaks in the thallus; apothecia (*vide* Fries, 1871-1874, p. 105) up to 8 mm. in diameter, spores ellipsoid, 6-8 microns long, 4-6 microns wide (unknown in American material); pycnidia infrequent, on marginal or dorsal surface of thallus, dark brown, sessile or on short, conical stalks; K-, Pd-, I-, C-, K plus C-.

ILLUSTRATIONS: **Plate 5A.**

HABITAT: in tufts of moss or *Selaginella*, on tundra.

SPECIMENS EXAMINED: BOULDER CO.: Upper Green Lakes, north of Kiowa Peak, T. 1 N., R. 74 W., Sec. 13, 11,500 ft. alt., 21 July 1953, *Weber & Dahl* (S 1441). CLEAR CREEK CO.: in *Selaginella* tufts, summit of Mount Evans, 14,260 ft. alt., 1 July 1952, *Weber & H. Grant* (S 758); in moss tufts, Summit Lake, Mount Evans, 12,600 ft. alt., 25 Aug. 1954, *Shushan & Weber* (S 2916); tundra just above Lincoln Lake, Mt. Evans, 12,000 ft. alt., 18 Aug. 1954, *Shushan & Weber* (S 3395); in moss, n.w. slope of tundra ridge just n. of summit of Loveland Pass, 12,500 ft. alt., 11 July 1954, *Weber* (S 2698). EL PASO CO.: northwest slope of Pikes Peak, 13,300 ft. alt., 1 Aug. 1955, *Shushan* (S 5698). GUNNISON CO.: in moss, seepage area, summit of North Italian Mt., 13,200 ft. alt., 25 July 1955, *Weber* (S 5871).

Cetraria tilesii is easily recognized by its alpine habitat on soil or in moss tufts, its thickish, waxy yellow thallus, lack of soredia, and short, crowded masses of erect thalli.

CORNICULARIA Ach.

Thallus fruticose, free or attached by hapteres, lacking rhizinae, chestnut-brown to black, smooth, lustrous, rigid, divaricately much-branched, terete or somewhat flattened, not dorsiventrally differentiated, the branch tips acute, often furcate, somewhat channeled; cortex plectenchymatous, sparingly pseudocyphellate; medulla white, loose, cottony, the medullary area often becoming hollow; apothecia circular, lateral, terminal, or subterminal, sessile, the disk concolorous with the thallus; thalloid exciple smooth to crenulate or spinulose; hypothecium hyaline; paraphyses brown-tipped, usually unbranched, conglutinate and septate; asci 8-spored, the spores hyaline, non-septate, 6.5-10 x 3-5 microns; pycnidia immersed in thalline tubercles; fulcra endobasidial, the pycnoconidia acicular or fusiform-thickened. Taxonomic position uncertain, the genus variously placed in Parmeliaceae near *Cetraria*, or in Usneaceae near *Alectoria*. — Name from diminutive of Latin, *cornu*, a horn.

CORNICULARIA TENUISSIMA (L.) A. Zahlbruckner in Ann. Naturh. Mus. Wien 42: 64. 1928.

Lichen tenuissimus L. (1763)

Lichen aculeatus Schreb. (1771)

Cornicularia aculeata Ach. (1803)

Thallus fruticose, growing solitary or in mats, rigid, divaricately branched, cylindrical to

somewhat compressed, lustrous, smooth or sometimes wrinkled, 0.5–1.0 mm. in diameter, up to 2 cm. tall, although usually shorter, the ultimate branchlets terminated by several blunt papillae; color ranging from shades of tan with reddish tinge to deep browns or almost black, e.g. light seal brown (R, Plate 39), argus brown (R, Plate 3), Isabella color (R, Plate 30), the terminal portions of the thallus usually darkest; medulla white, cottony, the thallus often becoming hollow toward the base; shallow white pseudocyphellae occasional; apothecia (absent in Colorado material) subterminal, chestnut, the margin ciliate; spores ellipsoid, 6–9 x 3–4 microns; pycnidia borne at the tips of short spinules arising at any point on the thallus; K–, Pd–, I–, C–, K plus C–.

ILLUSTRATIONS: **Plate 5B**; Anders (1928), Plate XXVI, 11; Galløe (1948), Plate 87 (colored), Plate 88, 89, 90; Howard (1950), Plate 9, Fig. D; Nearing (1947), p. 137, Fig. XI-Oa, p. 138, Fig. XI-Ob.

HABITAT: on bare spaces in tundra, commonly mixed with *Cetraria islandica* and other fruticose alpine lichens.

SPECIMENS EXAMINED: BOULDER CO.: Upper Green Lakes Valley north of Kiowa Peak, T. 1 N., R. 74 W., Sec. 13, 11,500 ft. alt., 21 July 1953, *Weber & Dahl* (S 1446, S 1456). CLEAR CREEK CO.: Summit Lake, Mt. Evans, 12,700 ft. alt., 14 July 1953, *Weber* (S 500); tundra slope just above Lincoln Lake, east slope, Mt. Evans, 12,000 ft. alt., 19 Aug. 1954, *Shushan* (S 2894). EL PASO CO.: northwest slope of Pikes Peak, 13,300 ft. alt., 1 Aug. 1955, *Shushan* (S 5700); summit of Pikes Peak, 14,100 ft. alt., 1 Aug. 1955, *Shushan* (S 5683). GUNNISON CO.: north slope, summit of Ohio Peak, Anthracite Range southwest of Irwin, 12,000 ft. alt., 16 July 1955, *Weber* (S 5841); north of Conundrum Pass, east of Gothic, 12,000 ft. alt., 5 Aug. 1955, *Weber & Shushan* (S 5811). LARIMER CO.: on ground in climax Elynetum, Willow Basin, Long's Peak, 11,050 ft. alt., 14 Sept. 1933, *Kiener 592* (S 379); Trail Ridge Road, Fall River Pass, 11,900 ft. alt., Rocky Mt. Nat. Park, 28 June 1953, *Shushan* (S 1418). PARK CO.: tundra ridge, North Star Mt., west of summit of Hoosier Pass, 12,300 ft. alt., 4 July 1954, *Weber & Shushan* (S 2853).

DACTYLINA (Nyl.) Tuckerman

Thallus podetiiform, the podetia subcylindrical to inflated, smooth; medulla arachnoid, solid or not filling the thallus; cortical layer of firmly packed hyphae, the outermost layer consisting of thick-walled hyphae running perpendicular to the surface; apothecia very rare, apical or lateral, with thalloid exciple; hypothecium hyaline, the hymenium narrow; spores small, globose to ellipsoid, simple (or in one instance uniseptate? see Lyngé, 1933, p. 34); pycnidia more or less immersed in the thallus; fulcra exobasidial, the pycnoconidia cylindrical, straight or curved; algal component green, *Protococcus* (*vide* Fink, 1935). Taxonomic position: according to Lyngé, 1933, *Dactylina* belongs in Parmeliaceae, near *Cetraria* and *Cornicularia*, differing from these genera in having immersed pycnidia. — Name from Greek, *daktylos*, a finger.

DACTYLINA MADREPORIFORMIS (Ach.) Tuck. in Proc. Amer. Acad. 5: 398. 1862.
Dufourea madrepорiformis Ach. (1810) *fide* Lynge (1933)

Thallus cylindrical, somewhat inflated, lacunose, smooth or wrinkled, up to 2 cm. high and 1 (-2) mm. in diameter, dichotomously branching from a narrow base, filled with white cottony medullary hyphae or almost hollow, the tips of the branches blunt, brown; thallus pale chalcedony yellow (R, Plate 17), with darker green or lighter yellow shades, frequently mottled with green or yellow; apothecia very rare (absent in Colorado specimens), lateral, pale chestnut, shining, 2-4 mm. in diameter, with a thick, crenate, thalloid exciple; spores hyaline, 7-10 x 4-5 microns; pycnidia common, ca. 0.1 mm. in diameter, globose or subglobose, dark brown to black, protruding slightly, not restricted to any particular portion of the thallus; K-, C-, I-, Pd-, K plus C intense yellow.

ILLUSTRATIONS: **Plate 6A**; Lynge (1933), Plate I, Fig. 2, and Plate II, Fig. 1, 2, 3 (apothecia).

HABITAT: on the ground in bare areas between tundra grasses, or intermingled with mosses and tundra plants, at high altitudes.

SPECIMENS EXAMINED: BOULDER CO.: base of 'Krummholz', north slope of Niwot Ridge, 11,500 ft. alt., 13 Feb. 1954, *Albert W. Johnson* (S 4566). CLEAR CREEK CO.: 400 yds. east of Summit Lake, Mt. Evans, 12,780 ft. alt., 4 Sept. 1951, *Shushan & Weber* (S 283); 13,500 ft. alt., along trail from Stevens Mine to summit of Gray's Peak, 11 July 1950, *Weber 5655* (S 1921). EL PASO CO.: northwest slope of Pikes Peak, 13,300 ft. alt., 1 Aug. 1955, *Shushan* (S 5694). GRAND CO.: tundra above head of Fool Creek, Fraser Experimental Forest, 11,500 ft. alt., 1 Aug. 1953, *Weber & Dahl* (S 1671). GUNNISON CO.: North Italian Mt., among sedges and grasses, n.e. of Gothic, 13,200 ft. alt., July 1950, *Langenheim* (S 399); southwest of Conundrum Pass, east of Gothic, 12,300 ft. alt., 5 Aug. 1955, *Shushan & Weber* (S 5812). LARIMER CO.: on soil among mosses, Trail Ridge Road, Fall River Pass, Rocky Mt. Nat. Park, 11,900 ft. alt., 28 June 1953, *Shushan* (S 1420); on soil in alpine meadow, Mount Alice, 12,700 ft. alt., 15 Sept. 1937, *Kiener 6182* (S 4024). PARK CO.: south side of alpine ridge below North Star Mt., west side of Hoosier Pass, 12,500 ft. alt., 7 July 1951, *Weber* (S 238); same locality, 4 July 1954, *Weber & Shushan* (S 2851).

This species is unmistakable. No other Colorado alpine lichen combines the fruticose form, brown-tipped dichotomous branching, yellow color, and hollow stems of *Dactylina*.

The genus *Dactylina* contains two other species native to the American Arctic, which conceivably might be found in Colorado. *Dactylina arctica* (Hook.) Nyl. has simple or sparingly branched brown podetia which are highly inflated and mitten-like or elongate-balloon-shaped. It is widely distributed in the Arctic regions of both hemispheres, and occurs in the Canadian Rockies. *Dactylina*

ramulosa (Hook.) Tuck. is similar to *D. madreporiformis* but smaller, bearing short, acute knob-like branches all along the thallus and many nipple-like branches at the tips, and with a pruinose surface, at least near the apical portion. The podetium is usually quite hollow. The medulla turns orange-red with KOH and with Pd. *D. ramulosa* is also circumpolar and has been collected as far south as the Canadian Rocky Mountains in northern Alberta.

Dactylina madreporiformis is one of the few examples of boreal species which occur in the southern Rocky Mountains and in the Arctic and alpine regions of Europe and Asia but which are absent or extremely rare in the New World Arctic. Lynge (1933, Fig. 2) found no *D. madreporiformis* in the western hemisphere, except in the high mountains of Utah, Colorado, and northern New Mexico. The species is found in Spitzbergen, Franz Josef Land, Novaya Zemlya and the northeast coast of Siberia, and also in the great mountain masses of the Eurasian continent. Its distribution somewhat parallels that of *Lloydia serotina*, the Alp Lily, which is a common species in Colorado, but is absent from the Canadian Arctic except in coastal Alaska and adjacent Yukon.

Lynge (1933) cited specimens from Park County: Mt. Lincoln (collector unknown, herb. London), El Paso County: Pikes Peak (*leg. Plitt*, in herb. Harvard; and *leg. DuRoi*, in herb. DR), and Chaffee County: San [St.] Elmo (*leg. Brandegee*, in herb. Harvard, London, Oslo). These were not re-examined for the present study.

A most peculiar form of *D. madreporiformis* was collected at Summit Lake, Mount Evans (*Shushan & Weber*, S 3761), in which the podetia were flat, with a distinct dorso-ventral aspect. The lower cortex (white) measured 25 microns thick, while the upper cortex (green) measured 30 microns; the medulla was 190 microns thick. Only scattered algal cells were present adjacent to the lower cortex while a solid band, 30 microns thick, of algae subtended the upper cortex. In its flattened condition, the thallus was only $\frac{1}{4}$ as thick as most normal thalli. The plants were flaccid and decumbent to prostrate. Their chemical reactions were normal.

THAMNOLIA Ach. in Schaer.

Thallus podetiiform, the podetia elongate, cylindrical, straight or curved, simple or sparingly branched, hollow, corticate, very smooth, with acute apices; apothecia doubtfully present;⁴ pycnidia immersed in small warts, light-colored; fulcra endobasidial, multi-articulate; pycnoco-

⁴Lynge (1937), p. 193, states: "Its apothecia have repeatedly been described, Räsänen was the last to give us a description (*Thamnolia vermicularis* (Sw.) Schaer. mit Apothezien und Sporen gefunden, Annales Botanici Societatis Vanamo, Vol. II, No. 6, Helsinki 1932). The former items of information have been proved to be incorrect. The author has not seen Räsänen's fertile plants. Even if they should belong to the lichen, the taxonomical position of the genus *Thamnolia* is very unclear."

nidia short, cylindric, straight or slightly curved; algal component *Pleurococcus* (fide Fink, 1935). Taxonomic position uncertain, variously placed in Usneaceae and Roccellaceae by different authors, but until fertile plants are found, best placed in Lichenes Imperfecti. - Name from Greek, *thamnos*, a shrub.

THAMNOLIA VERMICULARIS (Sw.) Schaer., Enumer. Critic. Lich. Europ., 243. 1850.

Lichen vermicularis Sw. (1781)

Podetia erect, decumbent, or prostrate, solitary or gregarious, hollow, terete to compressed, up to 4 mm. wide and 4 cm. long, icicle-shaped but usually broadest at the middle; simple or irregularly, not dichotomously, branched; smooth, wrinkled, or rugulose, sometimes farinose, the branch tips attenuate or truncate, sometimes brown, the cortex sometimes perforated; color white, pearl gray (R, Plate 52), pale smoke gray (R, Plate 46), pale gull gray (R, Plate 53), or other shades of gray; apothecia unknown; pycnidia not seen; K+ yellow, Pd+ orange to yellow-orange, C-, IKI + gray-violet.

ILLUSTRATIONS: **Plate 6B**; Anders (1928), Plate XXVII, 7; Zahlbruckner (1907), Fig. 118; Nearing (1947), p. 92, Fig. VII-1.

HABITAT: on tundra, mixed with other tundra lichens and grasses.

SPECIMENS EXAMINED: BOULDER CO.: sedge-grass-herb community, tundra, Green Lakes Valley between Green Lake no. 4 and Kiowa Peak, T. 1 N., R. 74 W., Sec. 13, 11,600 ft. alt., 22 July 1952, *V. E. Favier* (S 474). CLEAR CREEK CO.: tundra above Lincoln Lake near Mt. Evans Highway, ca. 11,500 ft. alt., 25 Aug. 1954, *Weber & Shushan* (S 3753); 500 yds. north of Summit Lake, Mt. Evans, 12,500 ft. alt., 4 Sept. 1951, *Weber & Shushan* (S 269). EL PASO CO.: northwest slope of Pikes Peak, 13,300 ft. alt., 1 Aug. 1955, *Shushan* (S 5697). GRAND CO.: tundra above Fool Creek, Fraser Experimental Forest, 11,500 ft. alt., 1 Aug. 1953, *Weber & Dahl* (S 1672). GUNNISON CO.: alpine climax, 2 mi. s.e. of Monarch Pass, 12,000 ft. alt., 4 Aug. 1947, *C. L. Hayward* (S 10,290); North Italian Mt., n.e. of Gothic, 13,200 ft. alt., growing with sedges and grasses on a fairly well-developed soil, July 1950, *Langenheim* (S 398); east slope, tundra, East Maroon Pass, 12,000 ft. alt., near Gothic, 6 Aug. 1948, *Langenheim* (S 1985); southwest of Conundrum Pass, east of Gothic, 12,300 ft. alt., 5 Aug. 1955, *Weber & Shushan* (S 5813). LARIMER CO.: Fall River Pass, Trail Ridge Road, Rocky Mt. Nat. Park, 11,900 ft. alt., 28 June 1953, *Shushan* (S 1417). PARK CO.: tundra ridge, North Star Mt., west of summit of Hoosier Pass, 12,300 ft. alt., 3 July 1954, *Weber & Shushan* (S 2854). COUNTY UNCERTAIN: on ground, Elynetum, Willow Basin, Long's Peak, 11,050 ft. alt., 14 Sept. 1933 [Boulder or Larimer County], *Kiener* 588 (S 1505); intermittent streamlet above Granite Pass, Long's Peak, 12,000 ft. alt., 13 Sept. 1932 [Boulder or Larimer County], *Kiener* 637 (Rocky Mt. Herb.)

Thamnolia may be mistaken at first for dried wisps of tundra grasses, but, once one recognizes it as a lichen, its pearl-gray color and icicle-like form is distinctive. Nearing (1947) notes a resemblance to *Clavaria*-type fungi. Among the other tundra lichens, a few species of *Cladonia*, e.g. *C. gracilis elongata*, superficially resemble *Thamnolia*, but these are brownish and greenish, and they often have basal squamules or cup-terminated podetia.

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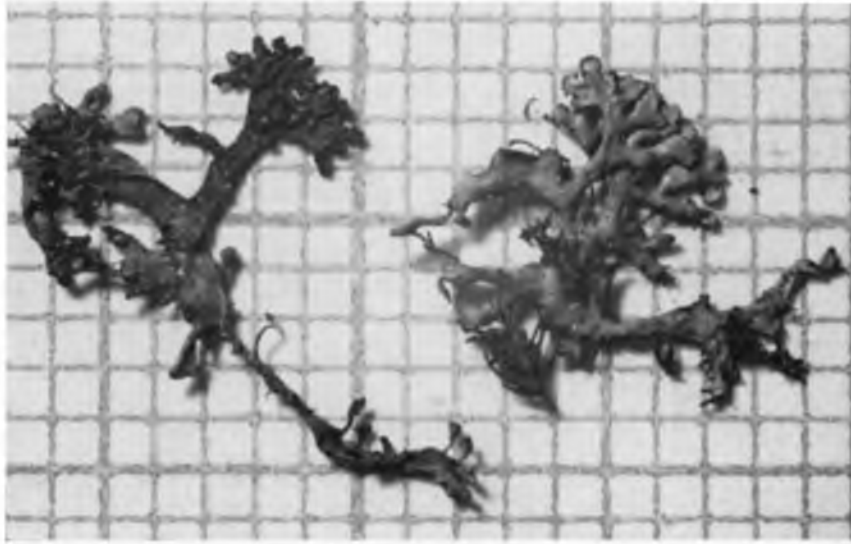
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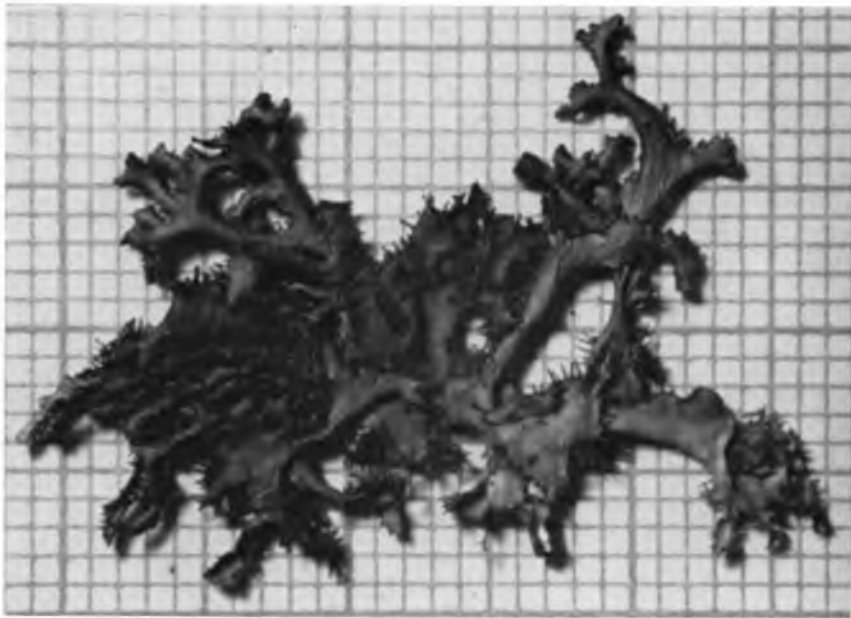
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PLATES 1-6

PLATE 1



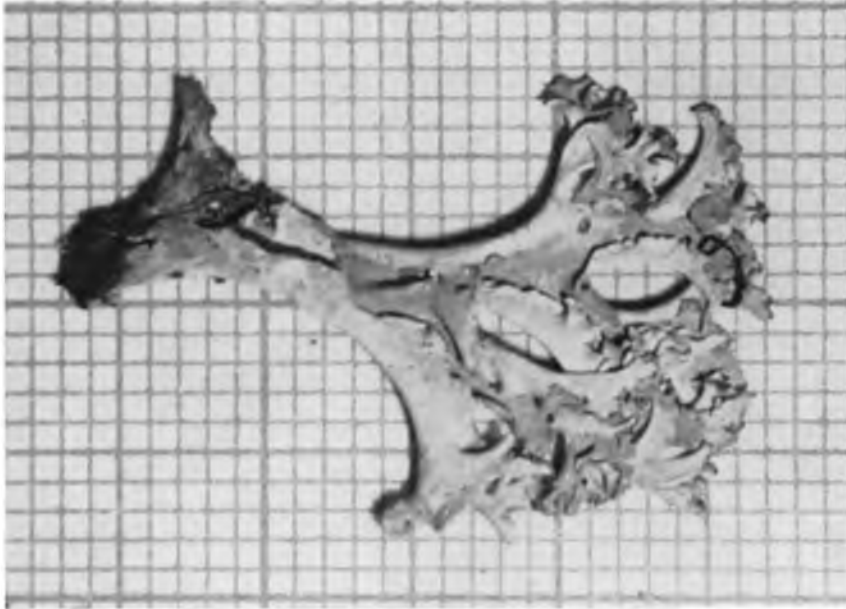
A. *Cetraria commista* — S 1595, Clear Creek County; left, dorsal aspect; right, ventral aspect



B. *Cetraria crispa* — S 1443, Boulder County

(Scale: All specimens were photographed against a background of millimeter cross-section paper.)

PLATE 2

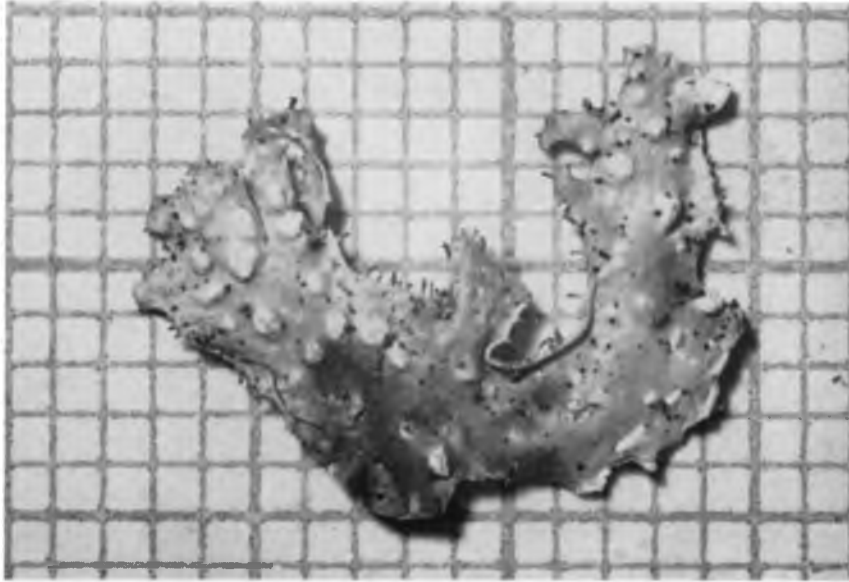


A. *Cetraria cucullata* — S 209, Clear Creek County

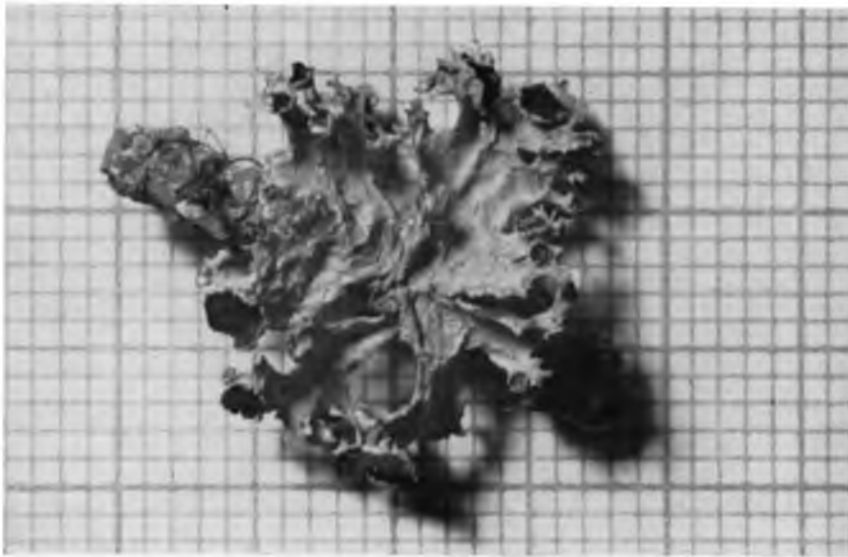


B. *Cetraria fendleri* — Alabama, Peters (in herb. Farlow).

PLATE 3

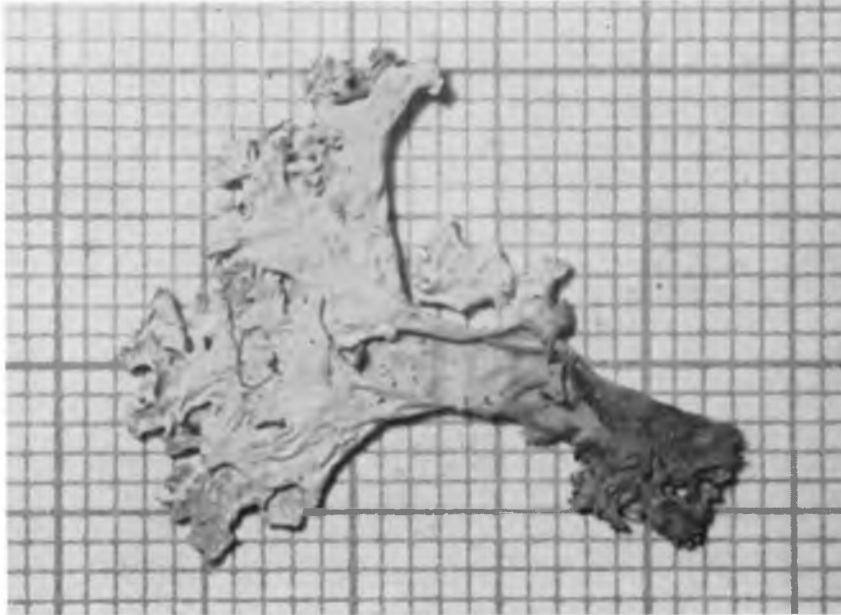


A. *Cetraria islandica* — S 1409, Clear Creek County; ventral view showing pseudocyphellae; for general aspect, see *C. crispata*, Plate 1B.

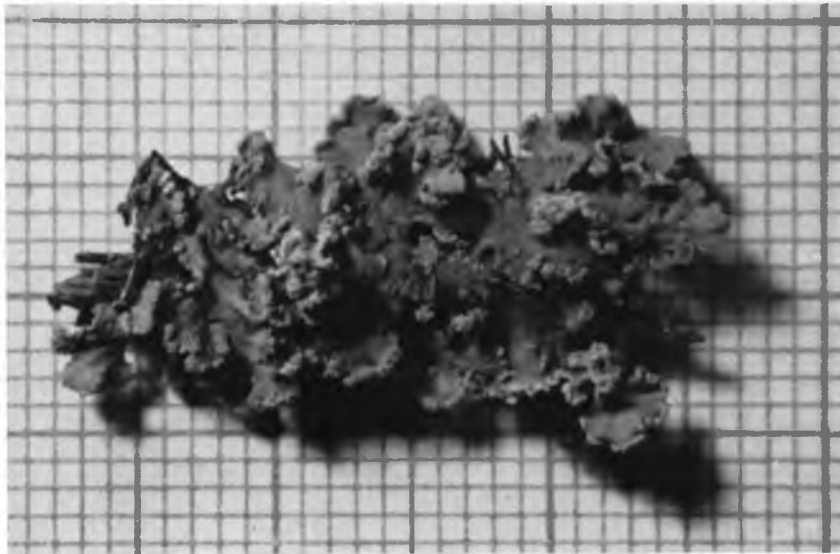


B. *Cetraria juniperina* — S 871, British Columbia, T. P. Maslin

PLATE 4

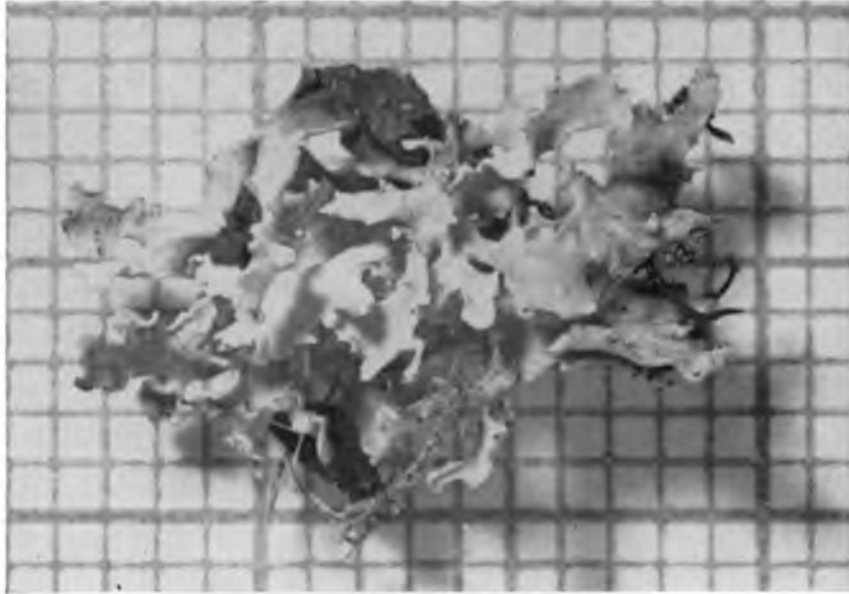


A. *Cetraria nivalis* — S 1408, Clear Creek County

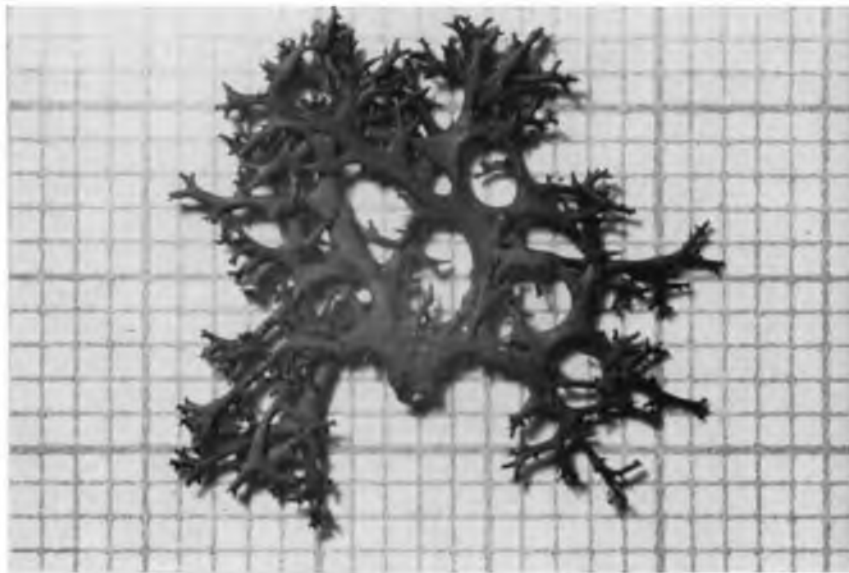


B. *Cetraria pinastri* — S 581, Douglas County

PLATE 5

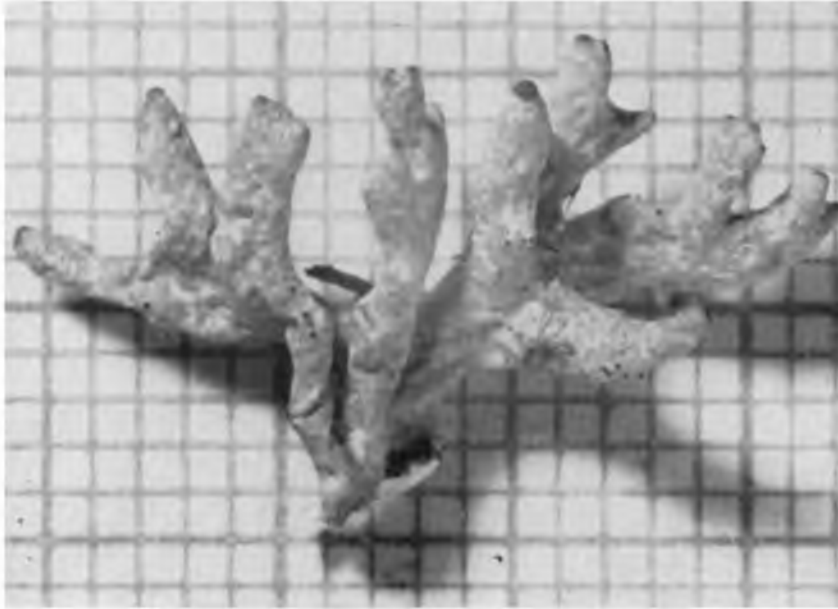


A. *Cetraria tilesii* — S 1441, Boulder County



B. *Cornicularia tenuissima* — S 2853, Park County

PLATE 6



A. *Dactylina madreporiformis* — S 238, Park County



B. *Thamnolia vermicularis* — S 398, Gunnison County