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THE LICHEN AND MOSS FLORA OF
BETATAKIN CANYON AND VICINITY
NAVAJO NATIONAL MONUMENT, ARIZONA

by

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FOREWORD

This report is intended as a supplement to the preceding number in this series dealing with the Biological-Ecological Aspects of Betatakin Canyon. It is intended to supply an expert's analysis of the non-vascular lichen and moss flora that are so conspicuous on the bare sandstone, desert soil, and exposed woody stems of shrubs and trees. The work in the field was conducted in close cooperation with Superintendent Arthur White and the local personnel of the Navajo National Monument, Arizona and in accordance with plans developed in the Regional Office of the National Park Service in Santa Fe, New Mexico by David J. Jones, Interpretive Planner. Report preparation at the University of Utah has been done under the auspices of the Institute of Environmental Biological Research in the Division of Biological Sciences.

Angus M. Woodbury

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INTRODUCTION

A special investigation of the moss and lichen flora of Betatakin Canyon and vicinity was carried out from June 12 to 15, 1963, together with a brief survey of the vegetation in general as a background for the principal objectives. Specimens were collected, identified and deposited in the museum at headquarters of the Navajo National Monument.

TOPOGRAPHY AND CLIMATE

Situated in the Canyonland province of the Colorado Plateau, Betatakin Canyon is a short gorge, about a mile long, arising abruptly in an area of rolling upland hills and extends from west to east where it joins Tsegi Canyon. The highest elevation at the western end is about 7,200 feet where the canyon descends by bare rounded slick rock on the shoulders giving way to a series of sandstone ledges while the sides are precipitous cliffs of red Navajo Sandstone subtended by sandy slopes and ledges strewn with broken rocks. The maximum depth is about 700 feet and the width increases from about 250 feet to nearly 900 feet down canyon. The predominant red sandstone contains thin, lighter colored cherty layers and concretions which commonly weather out and lie free on the surface. Loose sandy soil lends a pervading reddish background against which low dark green juniper and pinyon pine trees together with a variety of shrubs are displayed.

The average annual precipitation is about 14 inches with considerable variation from year to year while the average annual temperature is about 46° F. A spring in the bottom of the canyon feeds a small brook which disappears lower down in the canyon while here and there seepage from certain bedding planes of the rocks provides the only other surface moisture.

THE VEGETATION

A juniper-pinyon pine community dominates the general aspect of the uplands and rocky slopes of the canyons. Both are small dark green, round-topped trees, averaging about fifteen feet tall forming a more or less continuous forest interrupted here and there by exposures of open slick rock while in ravines and areas of broken rocks a variety of lower shrubs are locally dominant. Among the shrubs, big sagebrush, bitter brush, cliff rose, mountain mahogany and Fendler's shrub are most frequent while Gambel oak, buffaloberry, Ephedra, service berry, wax currant, snowberry and ocean spray become less frequent in about that order.

Prickly pear cacti and a variety of colorful wild flowers are scattered in the open places among the larger plants. Among the latter, scarlet gilia, red pentstemon, blue larkspur and yellow-flowered Aplopappus, Hymenopappus, Actinia, Thelosperma, Psilostrophe and Cryptantha flava stand out most prominently. A considerable variety of smaller xerophytic herbs are less frequent although the low, densely tufted Fendler sandwort is quite abundant.

In the bottom of the canyon where drainage water becomes concentrated, augmented by that supplied by springs, a lush mesophytic vegetation is displayed. Here, brookside trees include willows, river birch, boxelder and dogwood while tall aspens and abundant Gambel oak occupy the upper end of the canyon. A few Douglas fir occur at the head of the canyon. A dense growth of under shrubs includes wild rose, chokecherry, service berry and snowberry with squawbush

The Vegetation

crowding down on the drier borders. Clematis is the only vine. Among the herbs meadow rue is especially abundant with wild geranium, Smilacina and sweetpea aggregated in dense patches in open places beneath the taller plants and around the edges of thickets.

Along the margins of the little brook and in open wet sandy spots, tall Equisetum, Juncus, sedges and several grasses often form local stands.

THE LICHEN FLORA

Lichens are abundant in the Betatkin area and although the number of species is limited, three morphological forms occur here. Crustose forms occur mainly on rocks with a few on the bark of trees and shrubs, the thalli being attached firmly to the substrata by hyphal rhizoids extending to the margins. As the plants grow larger, the thallus shrinks and cracks, forming angular areoles that result in a smooth or rough surface according to the species. Squamulose lichens produce small biscuit-like or scaly thalli in which the hyphal rhizoids are confined to the under part with the margins more or less free from the substrata. They may be simple or lobed to branched. Foliose forms are more or less leaf-like, usually larger and variously attached by true rhizoids, hyphal rhizoids, or by a central umbilicus.

Ecologically all of the local species are essentially xerophytic although a few are confined to specific habitats such as shady situations where water lasts longer. They may be classified as follows:

- Rock inhabitants (saxicolous lichens) (1) dry exposed rocks, (2) shaded.
- Soil inhabitants (Terricolous lichens) (1) xerophilous on exposed soils, (2) mesophilous on shaded soils and humus.
- Bark or wood inhabitants (Corticolous lichens) (1) bark of trees and shrubs, (2) dead decorticated stems and branches.

COMMUNITIES ON DRY EXPOSED ROCKS

Certain exposures of slick rock at the head of Betatakin Canyon harbor several species of lichens among which Lecidea auriculata and Endocarpon wilm-soides are the dominant constituents of the community. The former is whitish or ashy gray and forms large rounded, crusty colonies upwards to five or six centimeters across conspicuously spotting the surface while the latter is very small and forms very thin black colonies, much less conspicuous, and resembles a dark stain on the rocks. In each species the rounded colonies commonly coalesce in patterns and the larger Lecidea sometimes overlaps the smaller species.

Associated species are fewer and widely scattered but occur more frequently on loose rocks or local exposures of bedrock. The composition of the community together with brief descriptions of the species is as follows:

Lecidea auriculata T. Fr. is a crustose lichen in which the thallus is whitish, gray or brownish, chinky areolate and forms rounded colonies upwards to five or six centimeters across and produces black apothecia one to one and a half millimeters across, becoming more or less convex with a black margin which becomes concealed. The colonies often become eroded and sometimes only the outlines remain, with the persistent black apothecia intact. It is one of

Communities On Dry Exposed Rocks

the commonest and most conspicuous lichens on exposed slick rock although it occurs on cliffs, ledges and loose rocks. It commonly exfoliates the surface of open sandstone.

Lecidea cyanea (Ach.) Rohling is locally pale greenish-white, often with a slight bluish caste and forms rounded or irregular colonies with a black hypothallus around the margins. The surface is chinky areolate with the black apothecia flat to slightly convex and frequently frosted on the surface with a white powdery excrescence. It is not very abundant and occurs mainly on firmer sandstone, and hard concretions weathered out of bedrock.

Endocarpon wilmsoides Zahlb. is a small crustose lichen forming very thin black thalli disposed in rounded or variegated patterns on rocks everywhere and is perhaps the commonest species in this area. It grows on various rocks in many situations but locally it is favored by harder rocks and is frequent on cherty plate-like concretions weathered out of the softer sandstone. The fruiting bodies are perithecia immersed in the thallus and obscure.

Acarospora strigata (Nyl.) Jatta is a fairly abundant crustose species forming small irregular patches of rather large chalky white angular areoles frequently with a slight bluish caste or tinted peach-color by the red rocks. It has a marked tendency to become established on harder concretions and on small flat cherty rocks lying free on slick rock or soil. It also tends to aggregate on or toward the edges of flat rocks, usually on the shaded side. The apothecia occupy the center of some areoles forming small black angular depressions.

Lecanora melanophthalma (Lam. & D. C.) Ramond forms rather thick areoles becoming subfoliose with age and forming crenately lobed or divided greenish gray thalli reaching about an inch or more across. The surface is smooth to more or less wrinkled and usually bears numerous slightly raised apothecia with prominent thalline borders of the same color as the thallus and a concave olivaceous, lead-colored or blackish central disc up to two millimeters across. It grows solitary or in clusters on dry rocks.

Lecanora rubina (Vill.) Ach. is much like the last species but even more subfoliose and loosely attached, usually by a central umbilicus. The upper surface is grayish green and bears sessile apothecia which may become upwards to five millimeters across with light yellowish to reddish central discs and prominent thalline margins.

Candelariella vitellina (Ehrh.) Mull. Arg. grows on rocks in loosely aggregated areoles or more or less scattered granules of dull greenish yellow or mustard color. The apothecia are small, reaching slightly over one millimeter across with thalline borders and slightly darker yellowish central discs. Frequent here and there, but it is not very common.

Parmelia conspersa (Ehrh.) Ach. is a rather large greenish gray or straw colored foliose lichen with radiating branches, wrinkled and crenately lobed on the margins and becoming upward to ten or fifteen centimeters across although most of the local specimens are smaller. The margins and under surface are black and the plant is anchored by stout rhizoids. The apothecia have a rich

Communities on Dry Exposed Rocks

dark brown disc with a thalline margin of the same color as the thallus and become upwards to 12 millimeters across, flat or slightly concave. Locally it is not very common but occurs here and there, usually along drainage ways.

Caloplaca elegans (Link) T. Fr. grows in small radiating subfoliose thalli of bright yellowish-orange or reddish vermilion making a conspicuous display on dry rocks. The underside is usually whitish but becomes darker with age. Older thalli usually become granulose or coralloid in the middle. The apothecia are sessile with a thalline margin and a bright orange central disc. Locally it is occasional on dry rocks.

LICHENS OF SHADED ROCKS

Some lichens occur most frequently on dry shaded rocks where they are sometimes the dominant species. Many rock lichens conspicuous in exposed sunny situations extend to shady places as well. The two following species are especially favored by shade:

Dermatocarpon miniatum (L.) Mann. is largely confined to the shaded sides of rock and vertical cliffs where the rounded gray or lead-colored foliose thalli are attached by a central umbilicus with the free margins strongly ruffled. The plants are very brittle when dry and are often sprinkled with black dots on the surface marking the mouths of the sunken perithecia. It is locally abundant on shaded cliffs in the bottom of the canyon.

Physcia pulverulenta (Schreb.) Nyl. is a medium sized foliose lichen with a greenish gray or whitish thallus becoming much branched and forming long narrow lobes from a central crust, the margins entire or crenate and more or less ascending. The under side is also white and bears stout rhizoids of the same color which anchor the plant to the substratum. The apothecia are sessile with a dark brown or black central disc and a white thalline margin and range upwards to four millimeters across. Locally it is quite abundant on dry shaded rocks, especially on ledges and in crevices where it tends to become much divided and forms whitish powdery granules by which it propagates. In more humid regions it also grows on the trunks and branches of trees. Physcia stellaris (L.) Nyl. is similar but more closely applied to the substratum and lacks the powdery granules.

SOIL INHABITANTS

Numerous lichens grow on soil, being attached by hyphal rhizoids which penetrate between the particles and bind them together. These forms are of particular importance in stabilizing the soil and providing lodging for wind-blown material and seeds of higher plants. In open areas between various trees and shrubs they frequently produce a characteristic soil surface. Collema sp., Lecidea crenata, L. decipiens and Dermatocarpon hepaticum are especially abundant in some areas, forming little pointed or convex crests of anchored soil that resist wind erosion while the loose particles in the intervening spaces are carried away. Where Collema is dominant, the crests are black while the Lecideas and Dermatocarpon are dull brown, reddish brown, bright salmon pink or chalky white. Good examples of these features may be seen along the Sandal Trail and in crevices and on ledges above headquarters.

Soil Inhabitants

Collema sp. is locally abundant, especially on open soil between trees and shrubs where it may occur in small solitary clusters of blackish squamules or similar clusters may be more or less aggregated, forming convex or somewhat pointed crests all over the surface producing a characteristic appearance. The squamules are one to two millimeters across, granular or flatish and irregularly lobed or branched and are little more than dry gelatinous colonies of the blue-green alga Nostoc invaded by a lichen forming fungus. This becomes evident when the plants absorb precipitation water and swell up into rounded or irregularly lobed bodies of firm gelatinous texture, much like ordinary free-living Nostoc. It is commonly called jelly lichen. Here the alga is dominant and gives the lichen its characteristic form and texture while in most other lichens the fungus thallus imbeds the inconspicuous algal hosts within a matrix of interwoven hyphae which assume various forms and colors. At the time of fruiting, the fungus hyphae aggregate at the surface and form an apothecium.

Lecidea crenata (Tayl.) Stizenb. forms thick brownish red squamules usually with a white border and five or six millimeters across. Dense aggregations of these bodies form flat or convex strata on soil or soil covered rocks in many situations. Flat or strongly convex blackish apothecia are borne on the margins of the squamules at time of fruiting. In older colonies the white border spreads and finally involves the entire surface which becomes enlarged, more or less strongly convex and often cracked. In this state the lichen is called Lecidea crenata forma dealbata.

Lecidea decipiens (Ehrh.) Zahlb. is much like the last species but salmon colored or light pinkish with a white border. It is less abundant but frequent on dry soil of exposed ledges and open areas between trees.

Dermatocarpon hepaticum (Ach.) T. Fr. occurs closely appressed to the soil in rounded or irregular dull reddish-brown squamules, five to ten millimeters across aggregated in rather flatish colonies in open areas between trees and shrubs. The fruiting bodies are perithecia sunken in the thallus and revealed on the surface as black dots.

Toninia caeruleo-nigricans (Lightf.) T. Fr. is composed of small subglobose to somewhat lobed, dark dull greenish to blackish squamules more or less frosted with a whitish excrescence on the surface. It grows in loose or congested clusters on dry soil in a variety of situations but locally it is frequent on soil covered ledges and little banks below tufts of grass and around the bases of shrubs in rather open places.

Lecanora lentigera (Web.) Ach. is a rather thin, subfoliose form, somewhat areolate at the center with more or less lobed and crenate margins. The thalli are rounded or irregular in outline, pale greenish or yellowish white and commonly with a dense chalky white frosting on the surface. It becomes two to three centimeters across. The apothecia have a whitish thalline margin with a rich reddish brown or buff disc and range upwards to two millimeters across. It grows on dry open soil or around the bases of shrubs and herbs. It is rather infrequent locally.

Peltigera canina (L.) Hoffm. is a gray foliose form with short branches, upturned on the margins, whitish on the underside and anchored by coarse white rhizoids. It grows on dry soil and humus in shady places, usually on ledges or

Soil Inhabitants

around the bases of shrubs along drainage ways. The apothecia are large, flat and reddish brown, borne on the ends of somewhat elongated lobes and curved backward over the thallus when dry. The name canina refers to the dog, and it is commonly called dog lichen. In medieval times it was used in medicine as a cure for the bite of a mad dog.

Cladonia pycnidata var. pocillum Ach. grows on soil, humus and decaying wood in shaded places along drainage ways, on banks below shrubs or under overhanging rocks and ledges. The thallus consists of numerous loosely overlapping pale sage-green, ashy or olive-brown squamules from which arise short, erect, vase-shaped or trumpet-shaped bodies called podetia. In some places, the colonies become ten or twenty centimeters across. Both the squamules and podetia frequently produce dense masses of minute pale bluish or greenish white granular or powdery bodies which become detached and propagate the lichens vegetatively.

BARK OR WOOD INHABITANTS

Two corticolous lichens occur on the trunks and branches of trees and shrubs. Parmelia olivacea Ach. is a dark olive brown foliose form closely attached to the bark of pinyon pine and various large shrubs. The thallus is round, becoming irregular with age, the margins crenate or with rounded lobes, the surface quite smooth and polished. It rarely produces apothecia in this region.

Xanthoria parietina (L.) Th. Fr. is a bright orange-red plant forming rounded or irregular, much branched thalli one or two centimeters across and anchored by pale rhizoids beneath. The apothecia are slightly raised with prominent thalline margins colored like the thallus and a bright orange central disc.

THE MOSS FLORA

Thus far, eighteen kinds of mosses were found in the Betatakin region. This is a very good representation considering the dry climate and limited area. Most of these are the usual species found in the Canyonland Province at comparable elevations. The frequency follows the usual pattern where a few are abundant generally, the majority occasional or frequent locally while several are scanty. Some mosses are very specific in their habitat requirements. Fundamentally all mosses are mesophytic or hydrophytic in the active growing state but when moisture fails different genera and species show a variable degree of drought tolerance. Certain ones require abundant moisture for a short period and are dry most of the time; others require a minimum amount over longer periods while many must be damp or wet most of the time.

Tortula ruralis (Hedw.) Smith is a comparatively large moss growing abundantly in this area in large loose tufts on dry sandy soil under trees and shrubs and on sandstone ledges. The stems are erect and mostly simple, ranging upwards to three or four centimeters tall. When dry, the plants shrivel, the leaves becoming crisped and twisted, dark olivaceous or blackish and present an uninspiring aspect, but when moistened by precipitation water they absorb it very rapidly like a sponge, the leaves literally spring open, assume an oblong or ligulate form strongly recurved from the stems, become bright green tinged with red, each

The Moss Flora

one terminating in a long white hair point. In the moist state the plant is an object of beauty, life processes suddenly revive and growth resumes until failure of moisture brings these activities to a halt and the plants again shrivel to a state of suspended animation.

While this remarkable adaptation is most dramatically demonstrated by this species, to a lesser degree it is the way of all mosses.

This species of Tortula does not produce spore capsules very freely for two reasons: (1) the sexes occur on separate plants and most tufts are made up of one sex; (2) even when both sexes are present in the same tuft, water must be present at the critical time when the sex organs are mature in order to insure the discharge of sperms and provide a liquid medium through which they can swim to the eggs. If moisture is not present during this critical period, as is frequently the case in the dry climate of this region, fertilization fails and no capsules form. When present, the capsules are erect, cylindrical and a rich reddish brown, borne on long stalks arising from the tips of the stems. Occasionally fruited specimens may be found on sandstone ledges and soil banks below shrubs on north-facing slopes where water drains and lasts longest.

Mosses in general are very tenacious of life and are able to regenerate from fragments of leaves or whole stem which may be carried great distances by the wind. Tortula ruralis exercises this mode of vegetative propagation to a supreme degree in that it becomes abundantly established as the dominant moss under rather severe xerophytic conditions throughout this region.

Grimmia alpestris Nees is the dominant rock inhabiting moss of this area and is second only to Tortula ruralis in frequency and abundance. It is a small erect plant growing in compact, velvety, hemispherical or expanded convex cushions on dry exposed rocks. The colonies range upwards to ten centimeters across and when dry are generally blackish with a hoary surface due to white hair points on the leaves. Individually the plants are small, the stems about one centimeter tall with slender erect branches bearing minute narrowly tapering and closely appressed leaves.

While the sexes are separate, they are frequently mixed in the same tuft and since the eggs and sperms mature during late winter when moisture is abundant, spore capsules are often produced in abundance. The capsules are ovoid, about one and a half millimeters long, reddish brown and borne on short stalks just raising them above the tips of the leaves.

Grimmia anodon B.S.G. forms dense tufts similar to the last species but somewhat coarser in texture and lacks the smooth velvety surface. The leaves normally bear long white hair points but in exposed tufts they are often short or nearly lacking. The capsules are globose and hidden among the apical leaves on very short stalks.

While common on rocks in many situations, both of these species appear prominently on certain exposures of slick rock where precipitation water drains, the blackish colonies often dotting the lighter colored surface.

The Moss Flora

Encalypta vulgaris mutica Brid. grows typically in shaded crevices and on ledges although it occurs also on north-facing soil slopes, usually at the bases of shrubs on the lower side. It forms rather coarse green tufts one or two centimeters high, the closely branched stems bearing broadly ligulate leaves. Ordinarily it produces abundant cylindrical capsules exerted above the tips of the leaves and completely covered by prominent yellowish hoods with pointed tips recalling the shape of old fashioned candle extinguishers.

Pterygoneurum ovatum (Hedw.) Dixon is a small densely tufted soil inhabiting moss growing in small convex tufts and usually revealed by the densely fuzzy surface. The stems rarely exceed four or five millimeters high and bear clusters of minute ovate leaves terminating in coarse white hair points which at times become two or three times longer than the blades. The midrib of the leaf bears two to four vertical green lamellae on the upper surface in wing-like fashion, hence the name Pterygoneurum meaning winged nerve. Small reddish brown ovoid capsules on short stalks are frequently formed in abundance. The moss is not very common locally but occasionally appears on firm open soil around the bases of shrubs such as big sagebrush.

Barbula brachyphylla Sull. is a small erect, reddish brown moss growing in dense convex tufts on dry shaded rocks and soil. The leaves are close set and broadly ovate, tapering to a wide blunt tip with widely recurved margins. It appears on certain shaded cliffs near the bottom of the canyon, locally abundant. It rarely fruits.

Tortula mucronifolia Schwaegr. occurs sparingly here and there on damp shaded soil on overhanging ledges or among large rocks along drainage ways. Locally the plants are short, usually less than one centimeter high and loosely aggregated in small patches or scattered among other mosses. The oblong leaves taper to a sharp point and are bright green both moist and dry. The capsules are erect and cylindrical, three or four millimeters long, bright reddish brown and freely formed.

In similar situations Desmatodon obtusifolius (Schwaegr.) Jur. occurs in thin bright green patches two or three millimeters tall or scattered here and there among other mosses. It is a small moss with bluntly pointed oblong recurved leaves. Ordinarily it fruits freely but in dry climates capsules are rarely formed and none was seen in this area.

A form of Fissidens obtusifolius Wils. was found scattered very sparingly among other mosses on shaded ledges and at the bases of large rocks. It is a tiny moss with the leaves inserted edgewise on the stem so that the shoots are very flat and easily recognized.

In the same habitat four species of creeping mosses are found. Hypnum revolutum (Mitt.) Lindb. is typical on dry shaded soil and rocks, on ledges and in crevices, especially along drainage ways where water lingers longest. The stems are prostrate and pinnately branched like a tiny fern leaf. It forms thin to rather thick green to yellowish green mats which become upwards to ten or fifteen centimeters across. The leaves are ovate-oblong with slenderly tapering tips hooked to one side and all curved downward toward the soil in a characteristic manner. It rarely fruits.

The Moss Flora

Brachythecium utahense James is another prostrate creeping moss forming thin mats on soil at the bases of overhanging rocks, ledges and under exposed roots of trees. It is irregularly branched and bears small lanceolate leaves. Numerous shortly cylindrical erect capsules are borne on long stalks arising from tiny buds on the sides of the stems. Brachythecium collinum (Schleich.) B.S.G. is a closely related species of similar habit but with ovate, briefly acuminate leaves and shortly oblong unsymmetric capsules inclined or horizontal at the apex of the long stalks. It occurs sparingly in this area.

Leskea tectorum (Braun) Lindb. is a very slender, irregularly pinnately branched moss forming thin, tightly interwoven, dull olivaceous or blackish mats on dry rocks and bases of trees, usually on the north-facing exposures in shady places. It has exceedingly small ovate overlapping, dull green leaves and in North America it is not known to produce capsules.

In the bottom of the canyon in open places along the little brook where the soil is moist, a number of mosses favored by these conditions are locally abundant. Here two species of Bryum form bright green tufts or expanded sods which may become several centimeters across. The stems are erect and branched with slenderly pointed leaves and bear elongated pear-shaped, pendant, bright yellowish-brown capsules on long stalks arising from the tips of the stems. When dry, the capsules become contracted under the mouth in urn-like fashion. Superficially the two plants look much alike but Bryum angustirete Kindb. differs from Bryum creberrimum Hook. & Tayl. in having a very small mouth and lid on the capsules, best observed in the moist condition. Other microscopic differences also distinguish them.

Pottia heimii (Hedw.) Furn. is a short bright green species bearing erect cylindrical capsules with a conical lid terminating in a long bent beak. When fully mature, the lid raises above the mouth but remains persistent by a central columella extending from the mouth of the capsule in a characteristic manner.

Funaria microstoma B.S.G. is another short, loosely tufted bright green species with very long yellowish stalks bearing inclined or pendent pear-shaped, yellowish-brown, unsymmetric capsules with a bulge on the upper side and a very small oblique, bright red mouth covered by a low convex lid. When dry, the capsules become longitudinally furrowed in a characteristic manner. This species is rare in North America and its presence in this region is rather unusual. A considerable colony was found on a damp sandy area among thinly disposed grasses and sedges.

Several rather extensive colonies of Amblystegium juratzkanum Schimp. occur in very damp or wet places along the brook forming light green mats or somewhat erect tufts, often accumulating calcium deposits among the shoots. It is a small plant normally forming thin prostrate mats of pinnately branched stems with small widely spreading lanceolate leaves. Usually it fruits freely but all of the plants observed were without capsules.