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Notes on the Ecology of Iowa Lichens

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NOTES ON THE ECOLOGY OF IOWA LICHENS.

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Many interesting features are presented by this group of organisms, some of which have been investigated more or less thoroughly, while others have received comparatively little attention. The work with Iowa Lichens has consisted almost entirely of reporting and describing species, with only very limited reference to structural modifications of thalli, and the relation between this and the ability of lichens to withstand adverse atmospheric conditions. In this, lichens are perhaps the most remarkable organisms in existence, and the full investigation of the secrets of this power offers an excellent field for the student of special problems.

The work, of which a partial result is here presented, was undertaken at the State University with the view of adding some observation along the line suggested. Further work of this kind would probably reveal many more interesting results.

All plants give off water in transpiration and it is well known that in many higher plants this process is more or less well controlled. This is especially true of xerophytic plants. Many of the lichens are extreme xerophytes, and the escape of moisture must be checked if they are to persist. Many forms regulate this by some modification of structure.

These structural adaptations are not so marked as in the vascular xerophytes yet certain modifications of the same general nature as those presented by the latter, may be observed. In collecting material the tree forms were found to be smaller in pastures, and the more exposed places, than the same species on the same kind of trees at the border of timber and other more protected places.

Those species growing on rocky cliffs varied greatly in size from the top of the cliff to the base, those at the crest being smaller than the same species growing at the base or in protected crevices of rock. In general, the species in the more exposed places are characterized by reduction of thallus.

Loss of water is prevented, by lichens, in various ways. Some species check it by a well developed cortex which is usually on the upper surface, more rarely on the lower surface. This cortex may be a well developed layer of thick-walled cells several layers in thickness, or it

may be much reduced. The thickness of the cell wall varies in different thalli as does the cortical layer. In other species there is no true cortex but a covering of closely interwoven hyphæ, which serves the purpose of a cortex to a limited degree.

Some facts of interest were observed in regard to the variation in cortex of some of the species. *Dermatocarpon* has a well developed cortex above and below, the lower cortex, however, being developed to a lesser degree. Those specimens collected from the xerophytic Sioux quartzite of Lyon county, Iowa, show a thicker cortex than those from Muscatine and Johnson counties. They are smaller, more harsh to the touch and when soaked become tougher and not so soft as the Johnson and Muscatine county material.

Parmelias have an upper and more or less well developed lower cortex and are closely attached to the substratum, thus reducing transpiration.

Among *Placodiums* a cortex is developed in all except the crustose forms. *Placodium elegans*, collected from the exposed rocky cliffs at the Palisades in Linn county, had a thicker cortex than the same species collected from less exposed places. The *Lecanoras* have no cortex but in *Lecanora rubina* there is a heavy covering of closely interwoven hyphæ which probably is a protection against excessive evaporation. This species is well adapted to the xerophytic conditions of exposed ledges and is represented most abundantly by specimens from the Sioux quartzite of Lyon county, where exposure is extreme. In *Peltigera canina* there is a well developed upper cortex only. As a rule the cortex is best developed in the most xerophytic species.

Excessive transpiration is also checked by reduction of the apothecia in both numbers and size. Generally those forms growing on exposed rocks as the Sioux quartzite do not show large or exposed apothecia. *Rinodina* and *Dermatocarpon* have immersed apothecia. *Peltigera* collected from the exposed crests of hills had much reduced apothecia while the same species growing in the shade and protected places had large spreading disks. Among the cliff forms the apothecia of any species varied greatly in size from the top of the cliffs to the base except in cases where the whole cliff was protected; here there was no well marked variation. The specimens of *Placodium elegans* collected from the crevices of the cliffs of the Palisades in Linn county and from Turkey creek in Johnson county had larger disks than those growing on the exposed face of the rocks.

These facts may account in part at least for the persistence of these ***organisms in areas*** where other forms of plant life do not thrive.

The great resisting power of lichens has long been recognized in a general way. Some observations were made for the purpose of more accurately determining this power. In the following experiments the resistance of the algal cells of some lichens to heat and drying was tested. To obtain an absolute result, the lichens would have to be grown in connection with the experiment. This was not possible on account of the limited time to be devoted to the experiments, and impractical, for it would be impossible to eliminate all other factors affecting the growth of the lichens.

The algal cells were selected because they respond more readily to change. The most accurate results possible could be obtained only by careful observation of these cells subjected to heat and drying, and the comparison of them with fresh ones from the same thallus. Any change in the appearance of the protoplasts or cell walls would indicate a change in composition or organization of the cell. No attempt, however, was made to determine the change, if any, in the composition of the cell contents. The main point was to ascertain the decrease in water content, the change in organization of the cell, and its ability to recover from this. Each of the sets of experiments consisted in heating specimens of the selected species of lichens, which were chosen from various habitats.

In the first experiment the following species were used: *Dermatocarpon miniatum* (L.) Fr., *Peltigera canina* (L.) Hoffm., *Cladonia rangiferina* (L.) Webb., *Placodium elegans* (Link) Ach., *Cetraria ciliaris* Ach., *Parmelia caperata* (L.) Ach., and *Physcia stellaris* (L.) Nyl. The temperatures ranged from 27 7/9° C. to 101° C. during the six hours of the experiment. Comparatively fresh, healthy, vigorous representatives of the various species were chosen, and all except *Placodium elegans* were selected from shady places. An examination of the material at the outset showed it to contain only the usual numbers of dead algal cells in the thalli. The specimens, cut in small pieces, were placed in shallow glass dishes in the evaporating oven. Burning the specimens was prevented in all cases except *Dermatocarpon* and *Physcia* in which the hyphæ were slightly browned at the end of the experiment. An hourly record of temperature was made, and a piece of each species removed, except at 11:00 a. m. and 1:00 p. m., and placed in distilled water for twenty-four hours to soften it for examination to determine if the algal cells could be restored to their normal condition. For mounting, the specimens were crushed, as the algal cells only were to be studied.

Following is briefly given the temperature of the oven, the time at which the various specimens were removed, and any change noted when compared with a fresh piece of the same thallus. The specimens were placed in the oven at 8:00 o'clock a. m., the temperature being 27 7-9° C.

Cladonia rangiferina (L.) Webb., collected from the shady bluffs at Wyoming Hill, north of Muscatine.

9:00 A. M., Temperature 77 2-3° C.

The algal cells were changed from bright green to yellowish green. The protoplasts with their nuclei seemed normal.

10:00 A. M., Temperature 83 8-9° C.

The cells unchanged, except that the color had become yellow.

12:00 M., Temperature 82 2-9° C.

This specimen was greenish yellow like that removed at 9 a. m., and the protoplasts were somewhat shrunken, but the nuclei appeared normal.

2:30 P. M., Temperature 101° C.

The algal cells had become transparent, but were still yellowish green, and the protoplasts were shrunken into irregular masses. The gelatinous sheaths were much thinner, and nuclei were seen in nearly all cells.

Dermatocarpon miniatum (L.) Fr., collected from the shady north face of the rocky bluffs north of Iowa City.

9:00 A. M., Temperature 77 2-3° C.

All the algal cells appeared normal.

10:00 A. M., Temperature 83 8-9° C.

The color was changed to yellowish green, and a slight shrinkage of the protoplasts had taken place. The nuclei appeared normal.

12:00 M., Temperature 82 2-9° C.

The color of the algal cells was yellowish green, and the protoplasts were somewhat shrunken, and no cell showed a nucleus.

2:30 P. M., Temperature 101° C.

The color was changed to light brown, the cell contents were clear and shrunken into irregular masses, and the hyphæ were light brown, indicating that this specimen was slightly scorched, although under conditions not different from the others.

Parmelia caperata (L.) Ach., collected from a butternut tree in the woods at Mid River, northwest of Iowa City.

9:00 A. M., Temperature 77 2-3° C.

The color was changed from dark green to yellowish green, the nuclei were plainly visible, and the cells apparently normal.

11:00 A. M., Temperature 83 8-9° C.

The algal cells showed no difference from those removed from the oven at 9:00 o'clock.

12:00 M., Temperature 82 2-9° C.

The color was changed to light yellow, and the protoplasts were slightly shrunken. Most cells showed nuclei.

2:30 P. M., Temperature 101° C.

The color had become yellowish brown, and the protoplasts were shrunken. Nuclei were visible in some of the cells.

Peltigera canina (L.) Hoffm., collected from the exposed rocky slope north of Iowa City.

9:00 A. M., Temperature 77 2-3° C.

There was no change in the bright green color, nor were the cells shrunken. The cells were smaller than those of the fresh specimen, but this may have been a variation in the plant.

10:00 A. M., Temperature 83 8-9° C.

There was no perceptible change in the cells.

12:00 M., Temperature 82 2-9° C.

The color had changed to yellowish green, and some cells appeared slightly shrunken.

2:30 P. M., Temperature 101° C.

The algal cells had lost almost all their color; the contents were transparent and shrunken into irregular masses. The hyphæ were slightly brown.

Cetraria ciliaris Ach., collected from an old pine board fence one and one-half miles northwest of Earlville.

9:00 A. M., Temperature 77 2-3° C.

The color had changed from bright green to yellowish green. The cells were unshrunken and nuclei visible.

10:00 A. M., Temperature 83 8-9° C.

The color had changed to yellowish green, the protoplasts were considerably shrunken, but the granular appearance was still retained by some cells.

12:00 M., Temperature 82 2-9° C.

The color was yellowish green, the sheaths were thinner, and the protoplasts shrunken into irregular masses.

2:30 P. M., Temperature 101° C.

The color was still yellowish green, the protoplasts were greatly shrunken, and the walls thinner. Very few dead cells were present.

Placodium elegans (Link) Ach., collected from the tops of the bluffs near the boat house at the Palisades in Linn county.

9:00 A. M., Temperature 77 2-3° C.

The algal cells were normal with few dead cells.

10:00 A. M., Temperature 83 8-9° C.

The color had changed from bright green to greenish brown and the protoplasts were somewhat shrunken.

12:00 M., Temperature 82 2-9° C.

The color was greenish brown and the protoplasts were very much shrunken.

2:30 P. M., Temperature 101° C.

All the green color had disappeared, the protoplasts were much shrunken, the hyphæ were light brown, and many dead cells were present. This condition may not have been due to heating, as the specimen may have been taken from an old part of the thallus.

Physcia stellaris (L.) Nyl., collected from a butternut tree in the woods near Bayfield.

9:00 A. M., Temperature 77 2-3° C.

The algal cells were normal.

10:00 A. M., Temperature 83 8-9° C.

The color changed from green to yellowish green, and the protoplasts were somewhat shrunken.

12:00 M., Temperature 82 2-9° C.

The color was yellowish green, the protoplasts were greatly shrunken and the gelatinous sheaths were very thin.

2:30 P. M., Temperature 101° C.

The color had become greenish brown and the protoplasts were greatly shrunken. Not many empty cells were present.

The algal cells of the species used in this experiment, with the exception of those of *Peltigera*, changed from bright green to yellowish green at the end of the second hour, with the maximum temperature 83 8-9° C. *Cetraria*, however, was greatly bleached at the end of the first hour with the temperature at 77 2-3° C. With the exception of *Cetraria*, *Dermatocarpon* and *Physcia*, the algal cells began to show a shrinkage at the end of the third hour, with a temperature of 83 8-9° C. *Physcia*, *Dermatocarpon* and *Cetraria* showed a shrinkage at the end of the second hour, with a temperature of 83 8-9° C.

The purpose of the following experiment was to determine the relative resistance of those lichens from the Sioux quartzite of Iowa, collected by Professor Shimek in 1896, and kept in the Herbarium of the University of Iowa during the intervening sixteen years, as compared with

the resistance of those collected from the same region June 30, 1913, six days before the experiment. The temperature was recorded each hour, and pieces of various thalli removed and placed in distilled water. The specimens chosen were *Parmelia conspersa, Lecanora rubina* and *Dermatocarpon miniatum.* The examination of the specimens before heating showed a slight difference in the shade of green of the algal cells, that of the old specimens being less brilliant than the color of the new ones, but there was no difference in the water content.

The oven was started at 9:00 o'clock A. M., with a temperature of 26 2-3° C. Following is briefly given the time at which each specimen was removed, the temperature, and a comparison of the old with the new thalli.

Lecanora rubina (Lam. & DC.).

9:00 A. M., Temperature 26 2-3° C.

The algal cells of the new specimen were slightly darker green than those of the old specimen. The protoplasts were normal.

10:00 A. M., Temperature 50° C.

The specimens showed no change.

11:00 A. M., Temperature 68 1-3° C.

The old specimen was bleached to very light yellow, and many empty algal cells were present, but none of the cell contents of either old or new showed any shrinkage. The old specimen was probably from a less vigorous part of the thallus, as the other parts of the same thallus were not so affected.

12:00 M., Temperature 79 4-9° C.

Both old and new specimens were bright yellowish green, and a few cells in each showed a slight shrinkage.

1:00 P. M., Temperature 90 5-9° C.

The old specimen had many empty algal cells. Those which were not empty were yellowish green, and all the cells of both old and new specimens were considerably shrunken.

2:00 P. M., Temperature 102 7-9° C.

The protoplasts of both old and new specimens were greatly shrunken, but the algal cells of the new specimens were brighter yellow.

Parmelia conspersa (Ehrh.) Ach.

9:00 A. M., Temperature 26 2-3° C.

The old specimen showed many dead algal cells and many cells were somewhat shrunken. This was a very poor part of the thallus.

10:00 A. M., Temperature 50° C.

The algal cells of both old and new specimens were bright yellowish green, and all cells were unshrunken.

11:00 A. M., Temperature 68 1-3° C.

The algal cells were still bright yellowish green, and a few cells of each specimen were slightly shrunken.

12:00 M., Temperature 79 4-9° C.

The algal cells of both specimens were slightly shrunken and yellowish green.

1:00 P. M., Temperature 90 5-9° C.

The algal cells showed no further change of color, but the protoplasts were more shrunken than at 12 o'clock.

2:00 P. M., Temperature 102 7-9° C.

All the algal cells were greenish yellow, and were considerably shrunken.

Dermatocarpon miniatum (L.) Fr.

9:00 A. M., Temperature 26 2-3° C.

The algal cells of both old and new specimens were dark green and unshrunken.

10:00 A. M., Temperature 50° C.

The cells were not changed from those of 9 o'clock.

11:00 A. M., Temperature 68 1-3° C.

The algal cells showed no shrinkage and the color was yellowish green.

12:00 M., Temperature 79 4-9° C.

There was no change in color of the algal cells. They were still yellowish green and unshrunken.

1:00 P. M., Temperature 90 5-9° C.

The algal cells from the old specimen were bright green, with very few cells shrunken. The new specimen was yellowish green and slightly shrunken. The cortex of the old specimen was thicker than that of the new specimen.

2:00 P. M., Temperature 102 7-9° C.

The algal cells were yellowish green, with some bright green cells in both new and old specimens. The cells were slightly shrunken in both.

The comparison in this experiment of fresh material with that which had been in the herbarium sixteen years brought out the following interesting results.

The old specimens of *Dermatocarpon* did not seem to be affected by their life in the herbarium, and did not show the effects of drying and

heating sooner than the fresh ones. The old specimen of *Lecanora* lost its color and was greatly shrunken sooner than the fresh one.

A second experiment with other material from the same collections corresponded in all results to the one given here, and further emphasized the fact that these xerophytic forms can withstand drying to a remarkable degree.

A comparison of the resisting power of those shade inhabiting species with the xerophytic forms probably would bring out some further facts of interest. The effect of heat upon the color of the shaded and exposed species was equal, but the water content of the cells in the specimens from shade was reduced sooner than that in those from the Sioux quartzite.

CONCLUSIONS.

The following conclusions are suggested by the work recorded here:

Lichens vary in adaptation to habitat; this applies to both different species and to different individuals of the same species.

Variation in habitat is explained, at least in part, by structural adaptations.

Lichens show a remarkable power of resistance to drouth.

OSKALOOSA.