# The Lichens of Long Island, New York: A Vegetational and Floristic Analysis

**Irwin M. Brodo**

Holder, Graduate Student Honorarium for 1959 and 1960

New York State Museum and Science Service

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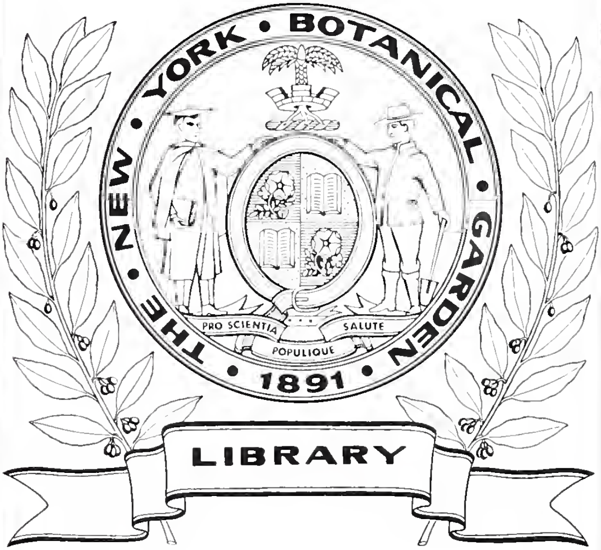

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# The Lichens of Long Island, New York: A Vegetational and Floristic Analysis[1]

**by Irwin M. Brodo[2]**

## ABSTRACT

THE LICHEN VEGETATION OF LONG ISLAND is discussed in broad perspective, yet with considerable detail, in an attempt to present a relatively complete picture of an important segment of the North American east coast lichen flora. A floristic list based on complete collections made throughout Long Island and some adjacent islands is supplemented by a number of investigations of local problems in lichen ecology.

The ecological studies consist of transect analyses along the island's north shore, transplant experiments concerning the vertical distribution of corticolous species as well as the city effect, analyses of the present distributions of various species by vegetation type, and observations on succession and related phenomena in terricolous, saxicolous, and corticolous communities.

A habitat classification is used to group assemblages of lichens into "communities." Some discussion is presented on the relative merits of such a loose classification as compared with a more formal lichen "union" or "association" system used by many European workers.

A consideration of some of the environmental factors influencing lichen microdistributions is presented along with some supporting measurements and correlations, but no extensive work along these lines is pursued.

The effect of New York City on Long Island lichen distributions is discussed. Empirical data and theoretical considerations are used in concluding that the lichen distributions are influenced by air pollution as well as city-induced drought, with the former acting over longer distances than the latter.

Placing the Long Island lichen flora into phytogeographic perspective involved setting up a scheme of "elements" and "subelements" for eastern North America into which the lichens could be fit. The presence of Long Island species in Asia and Europe was noted and consideration was given to problems of migration and vicariism.

The lichen flora consists of 261 species. Keys to the identification of these species, including keys to sterile material, precedes an extensive annotated list. Included under each species in this list is reference to material seen, notes on habitat ecology, a statement on North American and world-wide distribution, and where necessary, notes on nomenclature, morphological and chemical variation, and closely related and/or confusing species.

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[1] Manuscript submitted for publication January 4, 1966.

[2] Curator of Lichens, National Museum of Canada, Ottawa, Ontario.

Three species are described as new: *Polyblastiopsis quercicola, Pertusaria subpertusa,* and *Lepraria zonata.* In addition, three new combinations are made: *Micarea prasina* var. *sordidescens* (Nyl.) Brodo, *Parmelia michauxiana* var. *laciniata* (Hale) Brodo, and *Buellia curtisii* (Tuck.) Imsh. in Brodo.

# Acknowledgements

This work was begun in 1959 with the help of an honorarium from the New York State Museum and Science Service and was continued through 1960 under the same auspices. In 1961-62 the work was continued with the aid of a graduate fellowship from the National Science Foundation, which provided the opportunity for uninterrupted research to complete the study. The present monograph is based on a dissertation in partial fulfillment of the requirements for a Ph.D. degree from the Department of Botany and Plant Pathology at Michigan State University, East Lansing.

The encouragement, help, and guidance of Dr. Eugene Ogden during this period is especially appreciated.

The skilled and dedicated help of Dr. Henry Imshaug was my greatest asset throughout my studies. His guidance, advice, and good humor were truly an inspiration. Dr. John Cantlon's many critical comments and valuable suggestions are greatly appreciated. Drs. Ervin Barnes, Edward Cantino, Roland Fischer, and the late Dr. Philip Clark, all contributed suggestions and comments on the manuscript. Dr. Mason E. Hale, Jr., in the final reading of the manuscript, offered many valuable comments and unpublished data for which I am very grateful.

I especially would like to thank Mr. Roy Latham, not only for lending me his entire lichen collection which was of such fundamental importance to this work, but for his amiable and informative letters concerning the Long Island of past years, and for his companionship on several exciting and fruitful field trips. Of the many Long Island residents and naturalists who led me to rich or relatively inaccessible collecting areas, I would like to extend special thanks to Mr. Leroy Wilcox, Mr. Gilbert Raynor, and Miss Linda Quinby. Dr. George Woodwell's help in securing a room and laboratory facilities at Brookhaven National Laboratory is greatly appreciated, as is Mr. Frank McKeaver's hospitality and guidance on Nantucket Island.

My most sincere gratitude goes to my very patient and tireless wife, Fenja, for her many and varied assistances.

Thanks are due to the following lichenologists for identifying or verifying Long Island material in their special fields of interest; T. Ahti *(Cladina)*, W. L. Culberson *(Cetraria)*, F. Erbisch *(Chaenotheca)*, A. W. Evans *(Cladonia)*, M. E. Hale *(Parmelia)*, W. Harris *(Polyblastiopsis, Leptorhaphis)*, A. Henssen *(Placynthium)*, A. W. C. T. Herre *(Usnea)*, G. Howard *(Ochrolechia)*, I. M. Lamb *(Stereocaulon)*, A. H. Magnusson *(Ramalina)*, E. D. Rudolph *(Caloplaca)*, H. Sierk *(Leptogium)*, D. Swinscow *(Porina)*, W. Weber *(Acarospora)*, C. M. Wetmore *(Nephroma)*. Mr. W. D. Margadant of the Hunt Library kindly helped me with the Latin diagnoses.

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# Introduction

## GENERAL

Eastern North America has received more lichenological study than any other part of the continent. Such famous and productive workers as Edward Tuckerman, Henry Willey, Lincoln W. Riddle, R. Heber Howe, George K. Merrill, Charles A. Robbins, Alexander W. Evans, and Guy G. Nearing devoted much of their lives to the study of northeastern lichens. Yet with this exceptionally fine background of basic taxonomic knowledge, no recent workers studied this area using modern methods of floristic analysis and taxonomy until Gunnar Degelius visited the United States in 1939 and published two excellent papers, one dealing with the lichens of Maine (Degelius, 1940) and the other with the lichens of the Smoky Mountains of Tennessee (Degelius, 1941). In 1950, Hale wrote an account of the lichens of Aton Forest in northeastern Connecticut, and, in 1954, I. Mackenzie Lamb published a study of the lichens of Cape Breton Island, Nova Scotia. Both papers significantly added to our knowledge of the northeastern coast lichen vegetation. Culberson (1958a) reported on some lichens of North Carolina but dealt only with the pine-inhabiting vegetation.

This paper, then, is mainly designed to contribute to our knowledge of the eastern coastal plain vegetation, and, by so doing, to provide a link between the studies of the northern coastal regions and the Appalachians.

The principles which guided the research summarized here were that a vegetation cannot be adequately written without a thorough knowledge of the flora, and that a flora cannot be understood without a study of the ecological and phytogeographic factors which shaped it. In a study of this scope, it is impossible to answer all or even most of the questions asked concerning relationships and factors involved in the vegetational picture. It is my earnest hope that this study will point to the many taxonomic, ecologic, and phytogeographic problems still in need of clarification and solution, and will provide a stimulus for other workers to add to our knowledge in these and related fields.

## HISTORY

Long Island lichenology had its beginnings quite early in the history of American botany. Halsey (1823) published a list of lichens collected "in the vicinity of New York," but he did not state explicitly that he collected east of the East River, and there is some doubt as to whether he listed any Long Island specimens. Specimens which were collected in Brooklyn and Queens by George B. Brainerd and George D. Hulst during the 1860's may very well be the earliest from Long Island. Their collections, deposited in the Brooklyn Botanic Garden Herbarium, provide a good basis for reconstructing the probable state of the lichen vegetation of eastern New York City prior to urbanization (p. 275).

Among the other collectors of Long Island lichens during the late 19th century is Charles H. Peck, who collected all forms of plant life throughout New York State during his tenure as New York State Botanist. His collections are in the New York State Museum.

In 1899, S. E. Jelliffe published "The Flora of Long Island," which listed 54 lichen taxa from various parts of the island. G. S. Wood (1905) published additions to the lichen flora, adding 18 taxa to Jelliffe's list. In 1914, Wood published a list of lichens growing in the vicinity of New York City which included many species from Long Island.

The Cold Spring Harbor area was fairly well botanized, not only by Jelliffe and Wood, but also by A. J. Grout in 1900 and Stanley A. Cain in the 1930's in connection with the Long Island Biological Institute at Cold Spring Harbor. Since that time, however, no botanical field work has been done there. Some lichens collected by Stanley Cain as part of the "Flora of Cold Spring Harbor" are represented in the New York Botanical Garden Herbarium, but no specimens collected by Jelliffe or Wood were seen. Unfortunately, the complete collection of the Cold Spring Harbor flora which existed at one time (Cain, pers. comm.) could be located neither at the Biological Laboratories at Cold Spring Harbor itself nor elsewhere.

Roy Latham, one of the most versatile, thorough, and knowledgeable of the Long Island naturalists, began collecting lichens in 1908. He confined his collecting to eastern Long Island, especially around Orient Point, and rarely went as far west as Manorville. Latham's first concentrated effort was connected with his publication of the "Flora of the Town of Southold, Long Island . . ." in collaboration with S. H. Burnham (Burnham and Latham, 1914-25). The Farlow Herbarium includes many of these old Latham specimens which had been sent to Riddle, Hasse, or Merrill for identification. Since the early 1900's Latham has collected about 2000 lichen specimens, including many rare species. His is by far the most complete collection of lichens made on Long Island previous to these studies. Mr. Latham kindly provided his entire collection for my use. Approximately ⅔ of the collection are species of *Cladonia.*

The *Cladonia* specimens were almost all determined in duplicate by Alexander Evans, with whom Latham carried on an active correspondence until Dr. Evans' death in 1960. Many of Latham's collections represent the only specimens collected of some species rare on the island (p. 274). Mr. Latham continues to be active, and I have had the good fortune to accompany him on several collecting trips in eastern Long Island.

Raymond Torrey had a strong interest in lichens, especially of the New York City area, and made many collecting trips to Long Island particularly to study the *Cladoniae.* His interests were not confined to the genus *Cladonia,* however, as is evidenced by his paper on Long Island rock tripes (Torrey, 1933). The New York Botanical Garden

Herbarium contains Torrey's *Cladonia* collections. These specimens were all identified by Evans and prepared for the herbarium by John W. Thomson (Thomson, personal communication). It is surprising that no other genus of lichens is represented in the Torrey collections.

Although Babette Brown Coleman collected and published on some lichens from Montauk Point (Brown, 1948), no extensive collecting other than Latham's has been made in recent years.

(A complete list of Long Island collectors is presented in Appendix A.)

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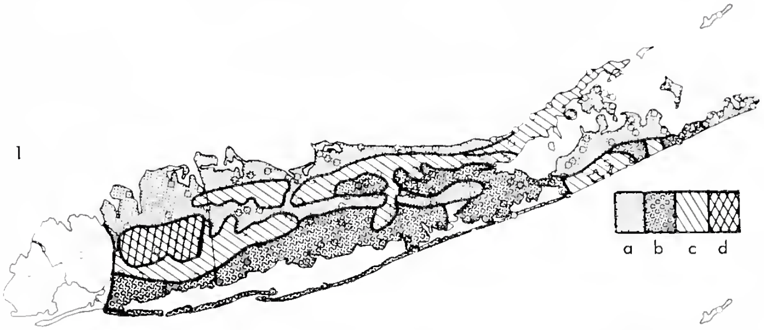

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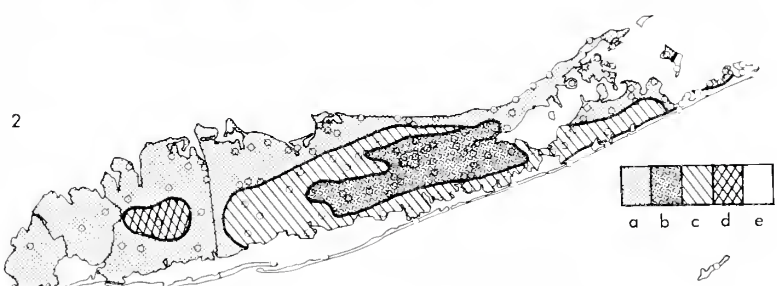

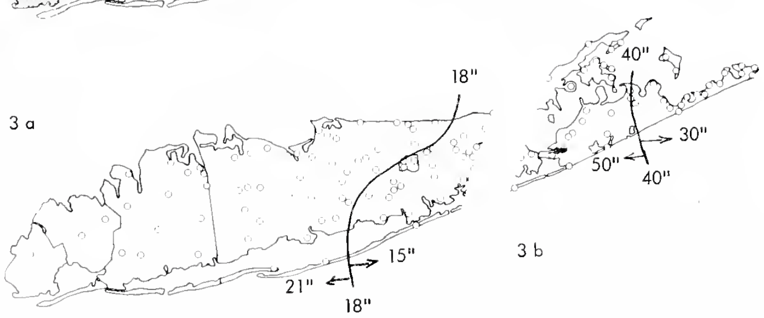

FIGURE 1. Soil types (after Cline, 1957). (a) excessively drained hilly soil (Plymouth-Haven Association), (b) excessively drained sandy soil (Colton-Adams Association), (c) Bridgehampton fine sandy loam, (d) well drained, prairie-type soil (Hempstead-Bridgehampton Association).

FIGURE 2. Original vegetation. (a) red oak forest, (b) pine-oak forest, and pine barrens, (c) scarlet-black oak forest, (d) Hempstead Plains grassland, (e) downs grassland and dune heath.

FIGURE 3. Precipitation. (a) Mean precipitation for growing season, May 1 to Sept. 30; (b) Mean annual precipitation.

# Description of Long Island

## GEOGRAPHY

Long Island makes up the eastern extension of the southern tip of New York State, lying just to the south of the Connecticut coast and separated from the mainland to the north by Long Island Sound and to the west by the East River and Manhattan Island. Long Island is 116 miles long and, at its broadest point, is 20 miles wide. There are several smaller islands just off the shores of Long Island, and these were visited and included in the study wherever possible. Included were Long Beach, Jones Beach, Fire Island, Westhampton Beach, Shelter Island, Gardiner's Island, and Fisher's Island; not included were Robins Island (a small island in Peconic Bay) or Plum Island, which is quarantined.

Long Island, the geographical unit, is subdivided into four political units: Kings, Queens, Nassau, and Suffolk Counties. Kings County (more widely known by its borough name — Brooklyn) and Queens County are part of New York City. Brooklyn is very populous and, except for one or two large parks and some swampy areas to the south, is covered to a large extent with brick, concrete, and asphalt. Queens is not quite so built up and still has many areas of more or less natural woods and swamps. Forest Park, in the center of one of the most populated parts of Queens, and Alley Pond Park, farther east, still show the magnificent red and black oaks *(Quercus rubra*[1] and *Q. velutina)* and tulip trees *(Liriodendron tulipifera)* which characterized the forests of that area prior to urbanization.

Nassau County is a classical example of suburbia. Extensive housing developments occupy its central portion and large estates are common on the north shore. Much of the area is still relatively undisturbed, especially on the larger tracts of privately owned property to the north.

The largest county in size and the smallest in population is Suffolk County. Although suburban developments are frequent along its western edge, the greater part of the area is made up of farmland and undeveloped pine barrens. Potatoes and cabbage are the chief crops produced. Resorts are common along the entire south shore.

## GEOLOGY

Prior to the Wisconsin glaciation the entire area which is now Long Island, except for the western corner, was under water and was covered by a number of marine sediments (MacClintock and Richards, 1936). Early Wisconsin glaciation (The Iowan-Tazewell complex) laid down two morainal ridges over this sediment. The first, the Ronkonkoma moraine, which runs through the center of the island eastward to Montauk Point and then off the coast to Martha's Vineyard and Nantucket

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[1] All phanerogamic nomenclature follows Fernald (1950) unless otherwise noted.

Island, probably resulted from the Farmdale advance (Flint, 1953). The second, caused by a readvance of the ice (the Iowan advance) after a slight withdrawal, formed the Harbor Hill moraine which extends eastward to Orient Point, then to Fisher's Island, and finally to Cape Cod. A third advance, the Tazewell, overrode the Harbor Hill moraine (Flint, 1953) and produced many of the major topographic features we now see on the north shore, such as the bluffs (figure 10), bays, and inlets (Nichols, 1958).

A broad outwash plain is associated with each moraine. It is especially extensive south of the Ronkonkoma moraine, where it forms a low, flat, sandy plain southward to the ocean. Wave action and ocean currents formed the off-shore barrier beaches, Fire Island being the longest.

Bedrock can be found only at the western edge of Long Island in Astoria (Queens).

The topography of Long Island is entirely glacial in origin. With the exception of the moraines mentioned above, the land is extremely flat. The highest point on the island is 428 feet above sea level at High Hill, near South Huntington. Kettle holes with associated bogs or lakes are scattered throughout the island (Fuller, 1914; Nichols, 1958).

The soils are formed on glacial parent material, and are more or less sandy, very well drained, and usually fairly acid (figure 1). The morainal areas are characterized by medium to moderately coarse textured glacial till (Plymouth-Haven association) often bearing large glacial erratics. Acid sandy-loams with fairly good moisture capacities (Bridgehampton associations) lie to the south of the moraines in most places. Very well-drained and very acid, coarse-textured gravel and sand of the glacial outwash (Colton and Adams associations) make up a large part of the southern edge of the island. In central Nassau County the soil morphology is much like that of a typical prairie (Hempstead-Bridgehampton association). The soil is well drained, highly acid, and with a dark-colored surface layer (Cline, 1957).

## CLIMATE

The precipitation over the greater part of the island is approximately 40 to 50 inches per year, or about 4 inches per month, except for the dry months of June and July (figure 3). Droughts are not uncommon in central Long Island. More than once a year, on the average, there is a "dry spell" (a period of at least 15 consecutive days, none of which receives 0.05 of an inch or more of precipitation). Approximately once every 2 years there is an "absolute drought" (15 consecutive days, none of which receives 0.01 of an inch of rain or more). East of Three Mile Harbor, the rainfall averages 30 to 40 inches per year. (Data and definitions kindly furnished by Brookhaven National Laboratory Meteorology Group.)

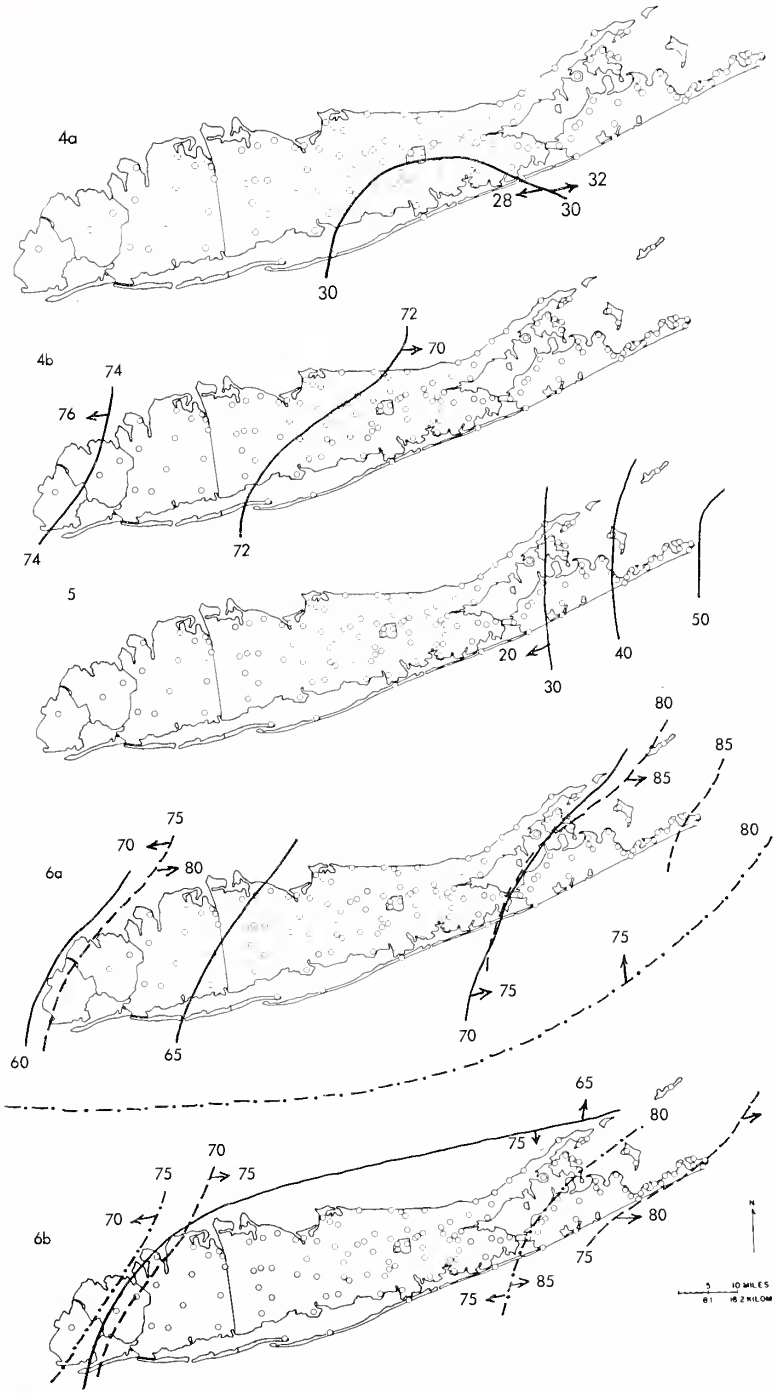

FIGURE 4. Temperature (Fahren.). (a) Aver. for Jan.; (b) Aver. for July.
FIGURE 5. Average annual number of days of dense fog.
FIGURE 6. Relative humidity. —·—·— 8:00 a.m., ——— noon, - - - - - - 8:00 p.m. (a) Aver. for July; (b) Aver. for Jan.

Temperatures on Long Island are rather mild, and differences are slight from one part of the island to another. On the average, the winter temperatures are about the same throughout the island, but are milder than farther inland due to the oceanic effect. Summer temperatures grade from warmest in the New York City area to coolest at the eastern half of the island (U.S.D.A., 1941) (figure 4). At Brookhaven National Laboratory, in central Long Island, the average recorded temperature was 65° F. between October 1 and September 30, and 40° F. between October 1 and April 30. Temperatures in that area rarely go below 10° F. or above 90° F.

Winds are quite brisk all over the island. In the central portions, over half the time winds are between 5.6 and 9 m/sec. (11 and 20 miles per hour), with winds over 11 m/sec. occurring 8 percent of the time. Montauk Point, on the eastern tip of the island, is well known for its high winds. Prevailing winds are from the southwest during the summer and the northwest during the winter.

Fog and mist are common phenomena on the eastern tip of Long Island, particularly in the Montauk area (figure 5). Depressions in the downs and between the dunes where fog can form create local pockets of extremely high humidity in the Montauk region (p. 32).

Almost every autumn, Long Island is subjected to violent storms which originate as hurricanes in the Caribbean and sweep up the east coast. Most of the storms do only minor wind damage to the plant communities, but occasionally severe storms cause extremely high tides, violent winds, heavy salt spray, and driving rains which do considerable damage along the coast and even farther inland, particularly on the eastern tip of the island. Roy Latham (in a letter) relates how the hurricanes of 1938 and 1944 completely flooded the beach at Orient Point (Long Beach) and swept away a great quantity of vegetation, including all but traces of the lichen flora. Tides rose 12 feet and even the corticolous lichens were washed into the ocean.

Trewartha (1961), in his modification of Köppen's classification of climatic regions, placed the Long Island area into his "Daf" category — indicating a humid, continental climate with warm summers.

In summary, the climate of Long Island is characterized by periodically droughty, warm summers and rainy, mild winters. In addition to the normally warm and droughty summers are the high winds and excessively drained soils, greatly increasing vegetational drought. The situation is somewhat alleviated locally by moist on-shore winds and fogs in the extreme eastern part of the island, where the rainfall is the least and the winds are the highest.

## VEGETATION TYPES

When one speaks of the "vegetation of Long Island," it must be understood that in many areas there are two vegetations to be discussed — that of the present, and that of the presettlement period. This is especially true in the New York City area and adjoining Nassau County, where urbanization virtually eliminated once important and conspicuous vegetation types and left only fragmentary remnants. For example, Forest Park, on the Brooklyn-Queens boundary, is the only surviving remnant of a forest described as having been "heavily wooded with large timber of an aspect similar to the timber of the Connecticut coasts" (Svenson, 1936). As late as 1917, Harper reported some remnant forests in the Queens area as constituting rich woods broken with streams and meadows. Some of the larger trees Harper listed as being most abundant were *Quercus velutina, Q. alba, Hicoria alba (Carya tomentosa),* and *Castanea dentata,* with *Quercus coccinea* being important in the drier woods and *Liriodendron tulipifera* being conspicuous in the rich woods.

Another excellent example of this massive vegetational obliteration can be seen in Nassau County, in the "Hempstead Plains" region. Originally, this area was a 16 mile long botanical oddity — a natural true prairie on Long Island. The land was not good for farming because of the dense, hard sod, but it was used extensively for pasture (Svenson, 1936). Hicks (1892) wrote a detailed account of the flora of the Hempstead Plains. The broad, unforested, gently rolling landscape provided a perfect situation for mass-produced housing. After the great expansion in suburban living just after World War II, many housing developments arose on the "plains" such as those in Levittown, Garden City, and Mineola. At this date, the only remnants of this fascinating vegetation type are found on fragments of the property adjoining some parts of the Meadowbrook Parkway and parts of Mitchell Air Force Base. It will later be pointed out that the lichen flora occurring on these fragments is amazingly rich for such a far western position on Long Island.

The original vegetation of Suffolk County, on the other hand, although fragmentary and relegated to parks in some areas to the west, remains in a more or less recognizable state (figure 2). Conard (1935) presented a vegetational analysis of the vegetation types of central Long Island, giving them phytosociological binomials. Among the most conspicuous communities are the well developed oak forests seen mostly on the north shore (Harper, 1917; Cain, 1936), the pine barrens which are well developed in central Long Island eastward to Riverhead (Harper, 1908; Britton, 1880), and the heathlike "downs" (as described by Taylor, 1923) which are very conspicuous in the Montauk area. Also important are the communities characteristic of the sand dunes (Brodo, 1961a), the *Chamaecyparis* bogs (Bicknell, 1908; Harper, 1907; Nichols, 1907; Taylor, 1916), the red maple swamps (Cain and Penfound, 1938), and the Hempstead Plains (Hicks, 1892; Harper, 1911, 1912; Cain, Nelson, and McLean, 1937).

More detailed breakdowns of the plant associations have been made by many authors (Miller and Young, 1874; Jelliffe, 1899; Taylor, 1915, 1922; Grier, 1925; Conard, 1935; Svenson, 1936; Brodo, 1961a). The names used in the following descriptions are those most widely accepted and used by the above authors and other naturalists in the area. The categories I used in a previous paper (Brodo 1961a), although well suited for describing central Long Island stands, had to be somewhat expanded to be of use in depicting the vegetation types throughout the entire island.

1. *Dune grass — Beach Heather — Shrub Savanna and Sand Plains* (formed on dune sand; excluding pine barren glades) (figures 7, 8). Dominant trees: *Pinus rigida, Prunus serotina* (both sparse and usually stunted). Dominant undergrowth and ground cover: *Ammophila breviligulata, Myrica pensylvanica, Prunus maritima, Arctostaphylos uva-ursi, Hudsonia tomentosa.* Soil: quartz dune sand with little or no organic matter. Light[2]: unlimited.

Most of the barrier beach on the south shore and a few small areas on the north shore are composed of long, rolling dunes, some still moving. The best developed dunes and their corresponding vegetation can be found along the entire length of Fire Island, and magnificent, huge, moving dunes can be seen in the Napeague-Promised Land area and on the western edge of Hither Hills State Park, facing Napeague Harbor. Trees are very sparse and occur mainly in boggy depressions between the dunes. More exposed trees are almost always dwarfed into a "krummholz" form.

Depressions and hollows between the dunes are termed "slacks" or "lows" by Salisbury (1952) for those with or without standing water,

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[2] Light: unlimited — almost entire area in open sunlight; excellent — at least ¼ the area in open sunlight, the rest in moderate shade; good — less than ¼ the area in open sunlight, the rest in moderate shade; fair — no open sunlight falling on ground, but some sunlight filtering through the trees; poor — tightly closed canopy with virtually no sunlight reaching the ground.

FIGURES 7-10. Vegetation types.

7. Sand dune vegetation on south shore dunes near Quogue, facing the ocean, consisting mainly of *Ammophila breviligulata, Hudsonia tomentosa*, and *Myrica pensylvanica.*

8. Sand dunes and sand plains at Napeague near Montauk. Ground cover is mainly *Arctostaphylos uva-ursi* and *Cladonia* (subgenus *Cladina*) spp. A few scattered scrub oaks (*Quercus ilicifolia*) and pine (*Pinus rigida*) can also be seen.

9. A portion of a sand plain community showing dune grass (*Ammophila breviligulata*), false heather (*Hudsonia tomentosa*), and the light colored *Cladoniae*, mainly *Cladonia submitis* and *C. boryi.*

10. North shore bluffs overlooking Long Island Sound (to the left of the picture). At the summit of the bluffs can be seen a portion of the red oak forest. The trees on the slope are mainly *Prunus serotina.*


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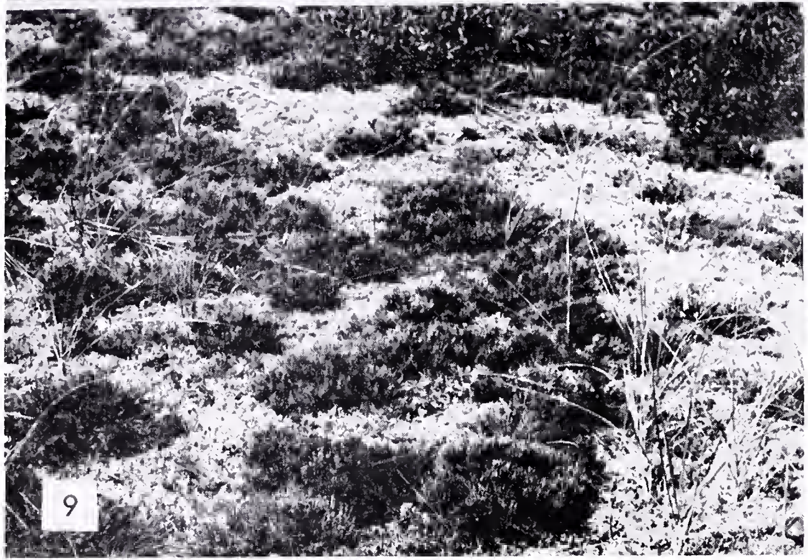
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respectively. They have local conditions of high moisture and cool temperatures due to their receiving runoff from surrounding dunes and persistent morning fogs, coupled with cool air drainage and protection from drying wind action. Salisbury (1952) also points out that such areas may be rich in soil nutrients (as compared with surrounding dunes) due to leaching and drainage into the hollows of minerals and some organic matter.

Dune grass *(Ammophila breviligulata)* is the most vigorous of the dune plants and is found throughout the area, with shrubs such as *Myrica pensylvanica, Prunus maritima,* and *Toxicodendron radicans* growing mainly on the lee sides of dunes. Bearberry *(Arctostaphylos uva-ursi)* and false heather *(Hudsonia tomentosa)* are often conspicuous on more exposed areas between the dunes (Brodo, 1961a). Conard (1935), whose *Ammophiletum breviligulatae, Hudsonietum tomentosi, Prunus maritima-Myrica carolinensis (M. pensylvanica)* association, and *Pinus rigida* scrub association all fit into this vegetation type, noted the close similarity of this community to the dune communities of Europe. Martin (1959) describes this vegetation type in detail, as it occurs in New Jersey (see especially his communities 1-2, 8-11, 15-18, 24-29, 44).

2. *Pine barrens* (part of continuum segment A in Brodo, 1961a). Dominant trees: *Pinus rigida, Quercus alba, Q. coccinea.* Dominant undergrowth: *Quercus ilicifolia, Gaylussacia baccata, Vaccinium angustifolium, V. vaccilans, Pteridium aquilinum.* Soil: dune sand or Colton and Adams sandy loam. Light: good to excellent.

The wide expanses of pitch pine *(Pinus rigida)* and scrub oak *(Quercus ilicifolia)* which are characteristic of most of central Long Island have existed for centuries virtually unchanged. George Washington wrote in his diary on April 22, 1790, a description of the area he saw as he rode from Patchogue to Coram and Setauket. He described the area as "too poor for cultivation, being low scrubby oak, not more than two feet high, intermixed with small and ill thriven pines" (Taylor, 1922).

Conard (1935) states that this basic community extends from Newfoundland (where it is fragmentary) south to Georgia and Texas, with *Pinus taeda* and *P. palustris* replacing *P. rigida* as the dominant. Both his *Pinetum rigidae* and *Quercetum ilicifoliae* communities can be placed here.

3. *Pine-oak forest* (continuum segments A and B in Brodo, 1961a) (figure 11). Dominant trees: *Quercus alba, Q. coccinea, Pinus rigida.* Dominant undergrowth: as in pine barrens, with *Q. ilicifolia* sparse except in glades. Soil: Bridgehampton sandy loam. Light: good.

This vegetation type is little more than an older, more mature pine barren. The three dominant trees are the same in both, but the order of abundance is different in the pine-oak forest with the appearance of

*Quercus velutina.* The soil is better developed with more organic matter, although the ground vegetation is essentially the same. The trees are generally older, taller, and straighter. Sparrow and Woodwell (1962) presented a good description of this vegetation type in their description of a radiation study area at Brookhaven National Laboratory in central Long Island. The *Quercetum velutinae* as described by Conrad (1935) belongs here and can also be applied to the scarlet-black oak woods discussed below.

4. *Scarlet-black oak forest* (continuum segment C in Brodo, 1961a) (figure 12). Dominant trees: *Quercus coccinea, Q. velutina, Q. alba.* Dominant undergrowth: as in pine-oak forest. Soil: Bridgehampton sandy loam. Light: good.

Again, we have a slightly older, more mature forest of basically the same structure as the previous vegetation types. *Pinus rigida* becomes relatively unimportant here with the increasing importance of *Quercus velutina.*

5. *Red oak forest* (continuum segment D in Brodo, 1961a). Dominant trees: *Quercus velutina, Q. rubra,* and locally, *Q. prinus.* Dominant undergrowth: *Viburnum acerifolium, Smilax glauca, Vaccinium* sp., *Parthenosissus quinquefolia.* Soil: Plymouth-Haven loam, generally with a good humus accumulation, on glacial till. Light: fair to poor.

The red oak forest extends all along the north shore and includes parts of the Sag Harbor region. It is this vegetation type which originally covered much of the New York City area and which was described by Harper (1917). Ground cover in the present stands is usually sparse, except in some local spots where *Smilax* species and *Rubus* species grow in dense thickets.

Conard's (1935) *Quercetum kalmietosum* and *Quercetum prini* both seem to fit best here. Where the soil is moist, *Fagus* begins to come and replace the oaks (Conard, 1935).

6. *Beech-oak forest.* Dominant trees: *Fagus grandifolia, Quercus rubra, Acer rubrum.* Dominant undergrowth: very sparse. Soil: Plymouth-Haven loam with much humus on till. Light: poor.

A few small, isolated areas near the eastern tip of Long Island bear remnants of some of the oldest vegetation on the North American east coast. These forests of old beech and oak trees can be found on Gardiner's Island, near Montauk Point, and on Shelter Island (Taylor, 1923).

7. *Downs.* Dominant trees: *Prunus serotina, Amelanchier intermedia.* Dominant undergrowth: *Myrica pensylvanica, Prunus maritima.* Dominant groundcover: *Andropogon scoparius.* Soil: Colton and Adams sandy loam. Light: unlimited.

Norman Taylor (1923) wrote a detailed account of the grasslands of the Montauk region. As far as records show, the area was always a grassland devoid of any substantial forest cover. *Prunus serotina* is the only conspicuous tree in the entire grassland area, and it is of very scattered occurrence. *Amelanchier intermedia* also occurs in a few groves. Shrubs are scattered throughout the area. Taylor (1923) stated that "wind is unquestionably the most important (factor) in maintaining the area as a grassland."

This community is called the *Andropogon scoparii* in Conard (1935).

8. *Hempstead Plains grassland.* Dominant tree: *Prunus serotina.* Dominant shrub: *Myrica pensylvanica.* Dominant ground cover: *Andropogon scoparius.* Soil: Hempstead-Bridgehampton sandy loam. Light: unlimited.

A great deal of work has been done on the vegetation of the Hempstead Plains (p. 9). It is considered by most workers to be a true "natural prairie," i.e., a stable grassland community. The long stretches of *Andropogon scoparius* are only occasionally broken by isolated black cherry trees or bayberry bushes. Wind was probably not an important factor in the development of the prairie here as it was with the very similar Montauk downs, since Hempstead Plains, in central Nassau County, is not an especially windy area. Hicks (1892) claimed that excessive drainage plus the thinness of the surface soil and general climate determined the character of the flora of the plains.

The soil is made up of tight, matted sod with sandy, eroded areas occurring wherever the sod had been broken. This dense sod, almost too hard to plow through and too dense to allow tree roots to penetrate, probably prevented subsequent forestation by local trees (Svenson, 1936).

Conard (1935) called this community the *Andropogon Hempsteadi.*

9. *Bogs.* Dominant trees: *Chamaecyparis thyoides, Acer rubrum, Nyssa sylvatica.* Dominant shrubs: *Vaccinium corymbosum, Toxicodendron vernix* (L.) Kuntze. Dominant ground cover: *Sphagnum* spp., *Vaccinium macrocarpon, V. oxycoccos, Woodwardia virginica.* Soil: wet, acid sand grading into acid peat. Light: excellent to poor, depending on canopy development.

FIGURES 11-14. Vegetation types.

11. Pine-oak forest at Brookhaven National Laboratory in central Long Island, dominated by *Pinus rigida, Quercus alba* and *Q. coccinea.*

12. Black oak forest near Manorville in central Long Island, with tall *Quercus velutina* and *Q. coccinea* and an undergrowth of *Vaccinium* spp.

13. A small gravel pit bog near the south shore at Eastport, surrounded by *Pinus rigida.* Lush stands of *Cladonia atlantica* were found here.

14. A sheltered inlet and gravel beach on Shelter Island (Ram Island Neck) which was the habitat of a collection of *Verrucaria microspora.*


11


12


13


14

White cedar swamps at one time were abundant all along the south shore at the heads of tidal streams and salt marshes (Harper, 1907; Nichols, 1907; Bichnell, 1908; Taylor, 1916). Heusser (1949), who presented the history of such an "estuarine bog" from the nearby New Jersey coast, stated that rising sea level, ditching (with the subsequent influx of brackish water), and fires caused the disappearance of the cedars in that area. Similar conditions probably occurred on the Long Island coast. In addition, with the spread of suburbanization, almost all the cedars in Nassau County were harvested and most of the swamps filled in to provide space for the ever-extending highways. Although there are still some fragmentary estuarine bogs in the Babylon area, the best developed bogs are those farther east and inland which were formed in glacial depressions and are surrounded by pine or pine-oak forests (figure 13). In the Manorville region, some bogs were extensively cultivated for cranberries, but few are still in use. The soil is very acid and provides a good habitat for bog plants such as *Vaccinium macrocarpon, V. oxycoccos, Drosera* spp., *Lycopodium* spp., *Sarracenia purpurea,* and *Utricularia* spp.

The white cedar swamps in various stages of development make up the *Chamaecypareum thyoidis, Chamaedaphnetum calyculatae,* and *Vaccinietum corymbosi* of Conard (1935). An otherwise similar community, but without white cedar, has been called the *Aceretum rubri* and is discussed next.

10. *Red maple swamp.* Dominant trees: *Acer rubrum, Nyssa sylvatica.* Dominant shrubs: *Clethra alnifolia, Viburnum dentatum, Vaccinium corymbosum.* Ground cover: sparse; *Osmunda* sp., *Sphagnum* spp. Light: fair to poor.

In wet areas not suited for white cedar, red maple swamps become established. They are common throughout the island. Cain and Penfound (1938) described and discussed this vegetation type in considerable detail, referring to it as the *Aceretum rubri* (including both the *Aceretum rubri* and the *Aceretum osmundaceum* of Conard [1935]).

It can easily be seen that vascular vegetation and soil type are strongly correlated (compare figures 1 and 2). The red oak forests are largely confined to the Plymouth-Haven soils, the pine-oak forests remain closely correlated with the Bridgehampton sandy loam, and the pine barrens are best developed on the Colton and Adams coarse sands. The Hempstead Plains grasslands are confined to the Hempstead-Bridgehampton soil association, which is considered to have been formed under grassland vegetation (Cline, 1957). The dune and down vegetation of the south shore occurs largely on windblown dune sand.

# Habitat Ecology

## GENERAL METHODS

*1. Collection data.* Many important ecological notes on particular species were gleaned from label data of individual collections. For very rare species, these were often the only data available other than my field notes. On my own collections, substrate was noted as accurately as possible for each specimen (e.g., the phorophyte species in the case of corticolous lichens). If the phorophyte species could not be determined in the field, I collected a portion of a branch or twig with the lichen for later identification. Height above ground was noted along with other parameters, such as exposure in relation to a body of water, a road, or a farm, if thought to be locally important. For each locality I recorded the general light conditions, the dominant tree layer, shrub layer, and ground cover.

Since collections are not unbiased, label data are of no use in statistical studies and only limited information can be gathered from this source concerning host specificity, vertical distribution, etc. Label data are of greatest use in determining where a species *can* occur, i.e., the substrate potential; and never where it *cannot* occur, i.e., the substrate limits. Label data may indicate trends and, where the number of collections is large and the ecological limits small, certain tentative conclusions may be drawn.

*2. Statistical studies.* There are many ecological phenomena which can be studied adequately only through the use of unbiased sampling and statistical analyses. Questions pertaining to substrate specificity, the range and frequency of species in different wooded stands, the effects of New York City on lichen distribution, and the vertical zonation of corticolous lichens were all approached statistically with the following methods.

Lichen sampling was carried out in two areas, one in central Long Island in 1959, and one on the north shore in 1961. Different sampling methods were employed in the two studies, but since both involved unbiased samples of small areas, the data should be comparable.

In the first case, 11 stands in central Long Island were sampled using a modification of the "random pairs" method of Cottam and Curtis (1949). The method has been fully described in previous papers (Brodo, 1961a; Culberson, 1955a; Hale, 1955a). Briefly, the method consisted of selecting pairs of trees at prearranged intervals along a randomly selected transect line until 20 pairs (40 trees) were examined. On each tree, two quadrats were studied, one from the ground level to a height of 30 cm, and another 40 cm high, centered at 1.3m (breast height). Each quadrat encircled the trunk. The stands sampled in the 1959 study ranged from pine barrens to red oak forests.

The second sampling study was done in 1961 in the red oak forests along the north shore. Twelve stands were sampled along an east-west

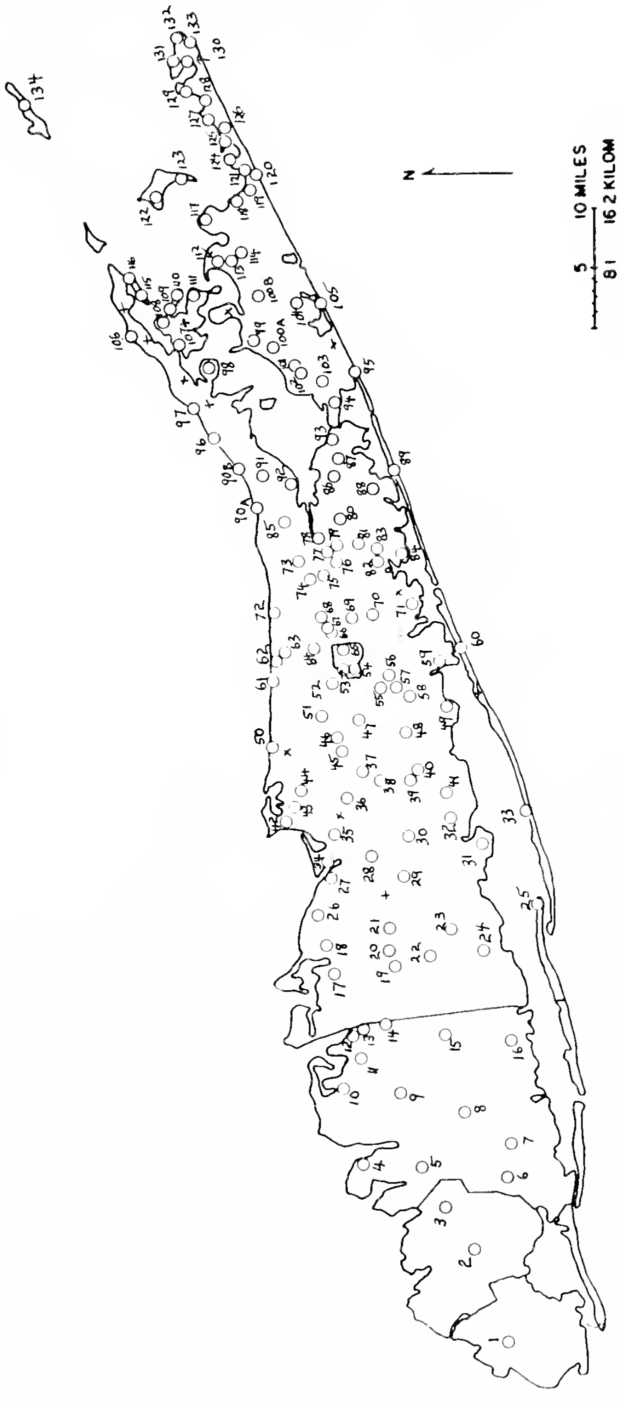

FIGURE 15. Collection localities.

transect starting at Forest Park in New York City and going eastward to Shoreham in central Long Island (figure 18).

For the purpose of this study it was desirable to limit the survey to red oak stands of fairly uniform composition. Due to the uneven topography of the morainal north shore, vegetation appeared very patchy and areas of more or less uniform tree composition were small. For this reason the random pairs method used in the previous study was unsuitable, since it covered too much territory and the vegetation within each sample would have been too diverse.

Instead, a spiral sampling technique was employed. The system simply consisted of choosing a point in the center of the area to be sampled and working in an ever-increasing spiral, examining all encountered trees until 50 had been studied. This, then, is essentially a 100 percent sample of a very small area. The selection of the starting point in each stand was made to center specifically in the greatest concentration of red oaks, regardless of the lichen population. This entirely non-random selection of stands is valid since it is not the tree vegetation which is under study, but rather the epiphytic vegetation of those trees. By selecting stands for a certain tree composition, the important variable of forest type is largely eliminated and the epiphytic vegetation within the stand can still be sampled in an unbiased manner.

On each tree, two cylindrical quadrats, delimited exactly as in the 1959 study, were examined. Neither dead trees nor any that were less than 10 cm in diameter at breast height (dbh) or inclined at an angle of more than 10° were considered. Data sheets were constructed to include about 25 common lichens, all of which could be identified in the field without question. The species and dbh of each tree as well as the presence in each quadrat of any listed lichen were recorded. Cover was not noted, but the direction of exposure of each species was recorded by noting its presence for each of eight compass points.

The lichens, as a rule, were easily identified in the field with a hand lens, although occasionally chemical tests were performed on the thalli with potassium hydroxide, *p*-phenylenediamine, or hypochlorite solution for confirmation. The phorophyte species were often more difficult to determine, perhaps owing to the apparent wide occurrence of hybridization in the area among members of the black oak group *(Quercus velutina, Q. rubra,* and *Q. coccinea).* If the tree under study was judged to be a hybrid, the two putative parent species were listed in place of a single species name (e.g., *Quercus rubra* X *coccinea*). Previously (Brodo, 1961a), these three members of the black oak group were considered collectively under the name of *Quercus velutina.* As will be pointed out later, the epiphytic lichen populations on the three species are very similar.

*3. Transplant experiments.* In an effort to clarify some of the ecological factors governing lichen distributions, some transplant experiments using corticolous lichens were carried out. The methods employed were fully described in a previous paper (Brodo, 1961b) but a brief account will be presented here, incuding a few modifications and improvements which were used in the latest experiments.

Using a steel punch (hereafter referred to as a "bark-borer") consisting of a hole-saw blade bevelled on the outside to a sharp cutting edge, and a holder (figure 19a, b), a bark disk bearing a portion of a lichen thallus could be removed from a tree with little injury to the lichen. The disk could then be transferred to a hole made in the bark of any other or the same tree using the same bark-borer. The death of the inner tissues of the bark disk was found to have no noticeable effect on the attached thalli. The cut edges of the lichens themselves also showed no degeneration and, in the case of the control disks, continued to grow after transplantation.

With continued use of the bark-borer, the blade tended to overlap at the point where the edges met (figure 19b). This resulted in uneven disk edges and occasionally prevented an easy removal of the disk from the tree. To prevent this, a wooden disk was made ⅜ inch thick, and cut so that it fitted snugly on the inside of the blade and against the holder. This disk effectively prevented the overlapping of the blade during the cutting operation and still left sufficient room inside so that no damage to the lichen thallus occurred.

Two methods of fastening the disk into its new position were tried, both employing grafting wax as an adhesive. The first (Brodo, 1961b) was to apply the wax to the back of the disk, and the second was to apply the wax to the inside of the hole receiving the disk. Due to the much larger number of disks lost in the second year run, it is recommended that the former technique be used.

The transplant experiments were used primarily to study vertical distribution and east-west distribution (New York City effects) and will be discussed further under those headings. In all cases, the lichens were examined at least twice after transplantation, first, after 4 months, and second, after 1 year.

In addition to the general methods described above, certain special techniques and procedures are discussed in their appropriate sections below. Results of individual studies are also discussed within the sections.

## SUBSTRATE

Although lichen thalli have usually been considered as neither saprophytic nor parasitic, it has long been known that certain lichens are more or less restricted to certain substrate groups. Keys to crustose lichens almost always make use of substrate early in the separation of groups of species on a gross level, such as the choice between "corticolous" and "saxicolous." The degree of substrate specificity, particularly of corticolous lichens, has been the subject of several studies (Hale, 1955a; Culberson, 1955a; Barkman, 1958; Brodo, 1959, 1961a).

In an earlier study of Long Island lichens (Brodo, 1961a), eight corticolous species were categorized according to their associations with each of three tree species, *Pinus rigida, Quercus alba, and Q. velutina* (including *Q. coccinea* and *Q. rubra*) in four segments of the pine to oak forest continuum. Various relationships were seen: (a) significant positive association of the lichen with the tree species over the entire continuum, (b) significant positive association in some segments, but not in all, (c) no significant positive or negative association with the tree in any segment, (d) significant negative association in some segments but not in others, and (e) significant negative association in all the continuum segments. The above relationships were interpreted as follows, respectively: (a) the lichen shows constant substrate specificity indicating possible substrate requirements, (b) the lichen shows some specificity for the tree but exhibits no clearcut requirement for it, (c) the lichen shows considerable flexibility in substrate requirements, varying in degree of association with any particular tree species as the bark characteristics such as texture, chemistry, and moisture relations change in the different stands, (d) the lichen shows some tolerance for the normally unfavorable substrate, but will occur more abundantly on other more favorable trees if they are available, and (e) the lichen has some sort of physical or physiological inability to inhabit the substrate.

The results of that study placed *Parmeliopsis placorodia* in category *a* with respect to *Pinus rigida; Graphis scripta* and *Lecanora caesiorubella* were in category *a* with *Quercus velutina* and in categories *e* and *d*, respectively, with *Quercus alba.* The other species, *Parmelia caperata, P. rudecta, P. subaurifera,* and *P. sulcata* had little difference in their associations with the two oak species, although all showed greater tendencies toward positive association with black oak (possibly due to bark stability). Thus, caution is necessary in interpreting association tendencies, since association values vary somewhat between stands and vegetation types (Brodo, 1959).

From field observation and collection data, a number of other lichens can be considered narrowly substrate-specific, although in the absence of unbiased sampling no quantitative statement can be made concerning them. Some of these species are listed below with their substrate placed in parentheses.

Corticolous: *Alectoria nidulifera (Pinus rigida), Cetraria fendleri (Pinus rigida), Leptorhaphis epidermidis (Betula populifolia), Lecidea anthracophilia (Pinus rigida), Lecidea scalaris (Pinus rigida), Trypethelium virens (Ilex* spp. and *Fagus grandifolia).*

Saxicolous: *Caloplaca citrina* (mortar and concrete), *C. feracissima* (concrete), *C. flavovirescens* (concrete), *Candelariella aurella* (concrete), *C. vitellina* (granite), *Lecanora dispersa* (concrete), *Lecidea erratica* (granite pebbles), *Rhizocarpon obscuratum* (granite), *Rinodina oreina* (granite), *Sarcogyne clavus* (granite).

Terricolous: *Baeomyces roseus* (eroded sandy loam), *Cladonia submitis* (acid sand), *C. boryi* (acid sand).

Lignicolous: *Chaenotheca phaeocephala* (white cedar stumps), *Lecidea aeruginosa* (planks), *Micarea prasina* (rotting wood).

The statistical studies cited on p. 20 attempted to clarify the basic factors involved in specificities by relying on the correlation of lichen presence with measurable bark characters. Some of these characters are listed and discussed below.

*1. Texture:* The external texture of the substrate can be important in trapping diaspores and protecting developing thalli, in providing entrance to other layers or tissues of the substrate, in capturing and retaining moisture and chemical substances, and in supporting other organisms which may remove potential lichen sites, or aid in any of the above. Different parts of a tree trunk may have different textures and consequently may bear entirely different lichen floras. For example, in fissured bark the rough fissures often bear hygrophytic species such as *Lepraria incana,* whereas adjoining plates support only hardy species such as the alga *Protococcus viridis* (see Barkman, 1958, p. 33). LeBlanc (1962) cites bark moisture capacity as causing the differences between the rich lichen flora of red oaks and the poor flora of beeches. It is probable, however, that the conspicuous differences in bark texture between the two trees were important in producing the different epiphytic vegetations.

Rough boulders normally bear more lichens than smooth ones, and some lichens undoubtedly have adapted to growing on very smooth surface in response to the competitive advantage of such an ability (e.g., *Lecidea erratica, Rhizocarpon obscuratum, Verrucaria microspora,* and *V. silicicola*).

*2. Moisture-holding capacities.* Many studies dealing with epiphytic vegetation, particularly cryptogamic vegetation, have included moisture capacity measurements of bark substances (Billings and Drew, 1938; Young, 1938; Hale, 1955a; Culberson, 1955a; Barkman, 1958; Brodo, 1959; LeBlanc, 1962). Barkman (1958) has reviewed this subject in detail.

Although the methods employed by the various workers varied somewhat, in general it was found that moisture capacities are greatest with soft, flaky barks, near the tree bases, on windward sides of tree trunks, and in humid areas. Except in a few cases, moisture capacity was expressed as the ratio of water absorbed to dry weight of the sample. LeBlanc pointed out that by using dry weight in the expression, barks with the same actual moisture capacity per unit of exposed surface may appear to have different moisture capacities if their densities are different. For example, bark sample *A* with a surface area of 10 $cm^2$ and weighing 10 grams may absorb 5 grams of water when submerged. Sample *B*, also with a surface area of 10 $cm^2$ (and of the same volume) but weighing 20 grams may also absorb 5 grams of water. Since sample *B* is twice as dense (and weighs twice as much as sample *A*, it appears to have only half the moisture capacity, when in reality the capacities are equal. LeBlanc (1962) attempted to correct for this error by expressing water gain on a "per unit surface area" basis. Unfortunately, it is extremely difficult to accurately measure surface area with any but the smoothest of bark types, and serious errors may thus be introduced into expressions derived in this way.

Barkman (1958) stated that moisture capacity is more meaningful if presented in terms of sample volume. This would be excellent to compare barks which are known to become totally and uniformly saturated with water. However, if only surface layers are wetted, as might well be the case with some of the hard-barked oaks, moisture capacity per unit volume is unusable.

The measurement of the rate at which a given bark sample returns to dry weight after being saturated (either by vapor or by liquid water) for any given period of time is, under uniform conditions of humidity, a direct function of its surface area, moisture capacity, and water binding capacity, all parameters of importance to epiphytes. Hale (1955a) and Billings and Drew (1938) presented some data on water loss and found that bark samples returned to approximately dry weight in about the same time for all trees studied, but that the initial rates were greatest in tree barks having the highest moisture capacity (expressed as a percent dry weight). Although these figures are important, they still do not reveal exactly how much water remains available to the epiphyte during this water loss. That is, a bark which absorbs four grams of water per unit surface area may lose water twice as fast during the first hour as a bark which absorbs one gram of water per unit area, but at the end of that hour the former still contains twice as much water as the latter and in a less strongly bound and hence more available state. Thus, it would seem that water loss rates alone could not be used as a substitute for some sort of a moisture capacity expression.

There seems to be no way to entirely overcome the density or the surface area problems. It is possible to introduce a correction factor into the dry weight expression to eliminate the density error, but the result is an expression in terms of volume and, as stated above, the samples would then have to be of the same volume or be proven to become uniformly saturated with water. The following example will illustrate this point.

| | *Sample A* | *Sample B* |
|---|---|---|
| Dry weight: | 5 gm | 3 gm |
| Volume: | 10 $\text{cm}^3$ | 10 $\text{cm}^3$ |
| Density: | 0.5 $\text{gm/cm}^3$ | 0.3 $\text{gm/cm}^3$ |
| Water absorbed: | 6 gm | 6 gm |
| Moisture capacity: | 6 gm/5 gm = 1.20 | 6 gm/3 gm = 2.00 |
| Density correction: | m.c × d =<br>1.20 × 0.5 = *0.60* | m.c × d =<br>2.00 × 0.3 = *0.60* |

TABLE 1a. Bark characters of some common Long Island phorophytes. Data on pH and moisture capacity were collected only for the most important trees. The column "number of observations" refers to the number of different trees sampled for each species. Only one bark sample from any individual tree was used.

Hydrogen ion concentration (pH) data were derived from surface scrapings made into a slurry with distilled water, equilibrated for 2 to 5 hours, and measured using a glass-electrode pH meter.

Moisture capacity was measured by immersing bark samples coated with wax on all cut surfaces into distilled water until they were saturated. Only samples 3.0 grams dry weight or more were used. Methods of weighing, deriving volume, and measuring surface area are all explained in the text. Observations of color, texture, hardness, etc. were made in the field.

| | *H-ion concentration (pH)* | | | | *Moisture capacity* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *percent water absorbed per unit:* | | | | | | | |
| | No. observations | minimum | maximum | median | No. observations | dry weight | volume | surface area | color | texture | primary periderm | hard or soft | exfoliation rate |
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. |
| *Pinus rigida* | 5 | 3.0 | 3.1 | 3.1 | 3 | 44 | 17 | 13 | black to dark brown | smooth, layered | — | S | very rapid |
| *Quercus rubra* | 5 | 2.8 | 3.6 | 3.4 | 4 | 32 | 26 | 17 | black to dark brown | very rough | — | H | — |
| *Q. coccinea* | 3 | 3.8 | 4.0 | 3.9 | 4 | 48 | 40 | 21 | grey to dark | rough to smooth | — | H | — |
| *Q. coccinea* X *rubra* | 1 | 4.0 | 4.0 | 4.0 | | | | | | | | | |
| *Quercus velutina* | 8 | 3.9 | 4.7 | 3.9 | 8 | 38 | 30 | 17 | dark brown to black | rough | — | H | — |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Q. alba* | 4 | 3.6 | 5.4 | 4.6 | 2 | 69 | 41 | 14 | light grey | smooth-layered | – | S | rapid |
| *Q. prinus* | — | — | — | — | — | — | — | — | black to dark brown | very rough to smooth | – | H | – |
| *Acer rubrum* | 3 | 4.3 | 4.7 | 4.4 | — | — | — | — | light grey | very smooth | ± | H | – |
| *Fagus grandifolia* | 4 | 4.6 | 4.9 | 4.8 | 2 | 58 | 49 | 14 | light to dark grey | very smooth | + | H | – |
| *Ulmus americana* | 4 | 5.1 | 6.9 | 6.1 | 2 | 120 | 61 | 21 | grey | rough | – | S | slow |
| *Ilex opaca* | 1 | 4.9 | 4.9 | 4.9 | — | — | — | — | light grey | very smooth | + | H | – |
| *Carya* sp. (with *Xanthoria*) | 1 | 6.3 | 6.3 | 6.3 | 1 | 76 | 42 | 10 | grey | rough to smooth | – | H | slow |
| *Populus grandidentata* | 1 | 3.9 | 3.9 | 3.9 | 1 | 55 | 46 | 21 | dark grey | smooth | ? | H | – |
| *Robinia pseudoacacia* | 1 | 5.1 | 5.1 | 5.1 | 1 | 66 | 21 | 13 | grey | very rough | – | S | slow |
| *Chamaecyparis thyoides* | — | — | — | — | — | — | — | — | brown | shredding | – | S | rapid |
| *Vaccinium corymbosum* | — | — | — | — | — | — | — | — | grey to brown | shredding | – | S | rapid |
| *Ilex verticilata* | — | — | — | — | — | — | — | — | light grey | smooth | + | ? | – |
| *Prunus serotina* | — | — | — | — | — | — | — | — | black | smooth to ridged | – | H | slow |
| *Juniperus virginiana* | — | — | — | — | — | — | — | — | grey to brown | shredding | – | S | rapid |

TABLE 1b. Trees ranked in order of their bark moisture capacity. The data are from table 1a. Number 1 has the highest moisture capacity, and number 7 has the lowest.

| With data from | | Dry weight | Volume | Surface area |
|---|---|---|---|---|
| MESIC | 1. | *Ulmus* | *Ulmus* | *Q. cocc.* |
| ↑ | 2. | *Q. alba* | *Fagus* | *Ulmus* |
| ↑ | 3. | *Fagus* | *Q. alba* | *Q. vel.* |
| ↕ | 4. | *Q. cocc.* | *Q. cocc.* | *Q. rubra* |
| ↓ | 5. | *Pinus* | *Q. vel.* | *Q. alba* |
| ↓ | 6. | *Q. vel.* | *Q. rubra* | *Fagus* |
| XERIC | 7. | *Q. rubra* | *Pinus* | *Pinus* |

TABLE 2. Sand and soil pH. All samples were from uniform surface material, mixed into a slurry with distilled water, equilibrated for about 15 minutes, and measured with glass-electrode pH meter. Only one sample from each source was studied.

| *General category* | *Specific source locality* | *pH* |
|---|---|---|
| Exposed, eroding ground, supporting *Baeomyces;* central Long Island | Yaphank | 4.3 |
| | Commack | 4.2 |
| | Riverhead | 4.1 |
| Beach sand from south shore | Fire Island (Bellport) | 4.5 |
| | Napeague Beach | 4.6 |
| Sand from central part of island | near Manorville | 4.2 |
| Sand from north shore beaches and dunes | Shoreham, beach sand behind very low dunes | 6.2 |
| | Rocky Point, top of high bluff, facing L. I. Sound | 6.1 |
| | Rocky Point, over crest of bluff, protected from full on-shore winds | 5.1 |
| | Rocky Point, on beach | 5.8 |
| Transplanted samples of beach sand | From: Fire Island (south shore); to: Bellport on Great South Bay; for one year | 4.5 |
| | From: Fire Island (south shore); to: Shoreham (north shore, on beach behind very low dunes); for one year. | 5.8 |

These final values represent grams water absorbed per unit volume, and are functions of moisture capacity which are comparable and give relative positions of the bark types. The principle is valid, but is replete with difficult problems, some of which were mentioned above. In addition, sample volumes are almost impossible to keep constant, since some bark types are thin (e.g., *Fagus grandifolia, Acer rubrum*) and others must be taken in thick slices (e.g., *Quercus rubra, Ulmus americana*). The measurement of volume is somewhat inaccurate in certain bark types, since bark samples often contain spaces which trap air in water displacement procedures. Inaccurate volume determinations, of course, make density figures of little practical value. Errors in volume measurement also decrease the value of moisture capacity expressions based on volume alone.

Despite the shortcomings of some of the methods discussed above, moisture capacity measurements were performed on bark samples from a number of common Long Island trees. The methods employed were essentially those of Culberson (1955a).

Bark samples were obtained with the use of the bark-borer used in the transplant studies (p. 19-20) wherever possible. This method provided samples of very similar size and volume except for the thin bark trees. Some bark types were not amenable to bark disk removal due to their instability and flaky nature (e.g., *Quercus alba* and *Pinus rigida*). Bark samples of these trees were collected without a borer and were cut down to approximate the surface area of the disks.

The samples remained unstudied for a year and a half and so were quite dry at the beginning of the observations. They were oven dried at 100° C. for a period of 20 hours to ensure uniform dessication. After cooling, the samples were weighed, coated with a layer of paraffin on all cut surfaces, and then reweighed to derive the weight of the wax. The volume of the wax on each sample was calculated with a knowledge of the wax's density.

Volume was measured by water displacement and was precise to 0.3 cc but volume measurements were somewhat exaggerated in certain bark types having large amounts of air retention, e.g., *Pinus rigida* bark. The exposed area was measured as follows: a small piece of aluminum foil was carefully fitted to the contours of a bark sample; the excess foil was then cut off at the limit of the exposed colonizable surface; the fitted foil piece was pressed flat, numbered, and weighed; the weights of the various foil replicates were then fitted on a standard curve constructed from the weights of foil samples of known surface area to find the surface areas of the bark samples. In this way very irregular, rough surface features of the bark samples could be accounted for in the surface area measurements.

Water absorption expressed as per unit dry weight, per unit volume, and per unit of colonizable surface is presented in table 1 along with the other bark features of the common Long Island trees.

In ranking the trees in order of bark moisture capacity, we can see that the method of expression is very important in the relative positions of the various species. Dry weight and volume expressions matched most closely, with *Pinus rigida* being a notable exception. Volume measurements of pine bark are complicated by considerable air retention between the bark plates during water displacement as noted above. This error would make the volume appear larger than it actually is and would thus effectively "lower" the moisture capacity expression based on volume. *Quercus rubra* appears more mesic than *Fagus* in the surface area expression, whereas the opposite is true with the dry weight and volume expressions. LeBlanc (1962) noted the same change in relative position of the two trees in his studies. One important difference in the area, dry weight, and volume sequences is in the relative position of *Quercus alba;* it appears relatively more xeric in the first and more mesic in the latter two. In view of the strong emphasis which has been placed on the difference in moisture capacities between black and white oaks in the past (see Hale, 1955a), it may be well to recheck these findings in other areas with larger samples. The sample size (1 to 8) in the data presented here was too small to warrant the formulation of strong conclusions pertaining to the relative positions of various trees with regard to their bark types.

*3. Stability.* The rapidity with which a given substrate surface is removed or changed in some way has a strong influence in determining which lichens will inhabit the surface. Only rapidly growing and maturing species can become established on unstable surfaces.

No species can colonize shifting sand as is found on sand dunes. Dune species usually become established on relatively less active dunes, on plant remains (Brodo, 1961a), or under the protection of trailing or low growing vascular species such as *Arctostaphylos uva-ursi* or *Hudsonia tomentosa.* The thalli may later become detached and continue development independently on the relatively stable sand surface. Where the sand is protected from strong wind action and becomes covered with an organic film, as in scrub oak thickets, certain species such as *Lecidea uliginosa, L. granulosa,* or *Cladonia cristatella* can become established and actually serve in binding the sand particles together (p. 42). Where the sand is even more stabilized, many more terrestrial species may gain foothold. *Baeomyces roseus* and *Pycnothelia papillaria* can apparently grow fast enough to grow over the eroding surfaces.

Rapidly sloughing bark severely limits the number of species which can inhabit a tree (Hale, 1952a; Barkman, 1958), and it is likely that this is one of the reasons for the relatively small number of species found on *Pinus rigida.* The best development of any species growing on pine occurs on the edges of the bark plates deep in the fissures where the bark is most stable. The poorest development is on the plate surfaces which lose outer flakes of bark almost continuously. The role of bark stability in limiting species coverage is made strikingly clear when the standing trunk of a dead pine appears close to a living tree. The stable bark of a dead tree is covered with lichens, whereas only spotty coverage is seen on the living bole, even though both trunks have equal light and are standing side by side. It is possible that the absence of a canopy may have some effect in changing the moisture relations (via increasing drainage) on the dead tree or in failing to contribute inhibitory organic material, but there are probably not as important as the stabilized substrate.

Pebbles and small stones often shift and roll with changes in weather, and thereby expose or cover lichens which may be growing on their surfaces. I first considered this problem in a study of the lichens of an old field at the American Museum of Natural History Biological Laboratory at Dix Hills, Long Island. Yearly observations of numerous pebbles indicated that *Lecidea erratica* develops very quickly on exposed stones (p. 42 to 43). Since these pebbles and stones undoubtedly shift or even turn over with frost action and heavy rains, rapid growth may be an important factor in the maintenance of populations of these species. Typical members of the exposed boulder communities such as *Parmelia arseneana* and *P. conspersa* have been found on some stabilized pebbles, adding strength to the supposition that the instability of pebbles may be a factor in eliminating these overshadowing but slowly growing species from competing for space with the small but rapidly developing *Lecideae.*

Small stones continuously roll and shift in the littoral zone of the shallow bays and inlets, and it is not surprising to find that the marine *Verrucariae (V. microspora* and *V. silicicola)* often are found growing on all sides of these pebbles, regardless of their position when collected.

*4. Chemical composition.* Bark chemistry as with bark moisture capacity has been studied by most epiphyte ecologists. Barkman (1958) again provides an excellent summary of the information published on the subject.

Of the many facets of bark chemistry, acidity has been the most widely studied. Great emphasis has been placed on bark acidity in explaining the distribution of some lichens (Billings and Drew, 1938; Hale, 1955a; Culberson, 1955a; Barkman, 1958; DuRietz, 1945 in Almborn, 1948). Barkman (1958) and Almborn (1948) have pointed out some of the oversimplifications to which some authors have fallen victim, but pH remains an important factor to be considered in epiphytic ecology.

The pH of bark samples of several of the common trees were measured. A few grams of bark material were obtained by slicing the surface layers from a bark sample and chopping them into a mealy consistency. Between five and seven ml of distilled water were added to each chopped bark sample, enough to form a thick slurry, and the mixture was allowed to equilibrate at room temperature (approximately 5 hours). Acidity was measured by using a glass electrode Beckman pH meter.

The acidity of soil samples was measured in a similar way. A soil slurry was formed using one part water and two parts soil (approximately

20 cc soil and 10 ml distilled water). The mixture was allowed to equilibrate (15 minutes) and pH was measured using the same apparatus as mentioned above. (The results of these measurements are given in tables 1a and 2.)

It would seem that acidity either affects the lichen vegetation directly or indirectly, or reflects a condition which does, because definite correlations can be seen between lichen presence and substrate pH. The very low pH of *Pinus rigida* bark could explain its poor and restricted flora, and the high pH of *Ulmus,* and *Robinia* provide clear associations with the so-called "nitrophytic" *(Xanthorion)* community. It is especially significant that a black oak once found bearing *Xanthoria* thalli had neutral bark, although this species of tree normally has very acid bark. That particular oak was growing in the center of a large Long Island duck farm, the atmosphere of which was very obviously filled with ammonia and other gaseous and fine particulate materials. Trees along farm roads exposed to farm dust have long been known to bear rich "coniophilous" communities (Barkman, 1958; Almborn, 1948). The very high moisture capacity of *Ulmus* may be a significant factor in the specificity of roadside species, although the oak mentioned above, which supported a rich *Xanthoria* community, had a low moisture capacity comparable with other oaks. The problem of separating nitrogen concentration from acidity in correlations of this kind has been discussed by both Almborn (1948) and Barkman (1958). Both authors point out the possibility of other factors being involved, especially phosphorous concentrations. For example, such typically "nitrophilous" species as *Caloplaca cerina, C. pyracea,* and *C. flavovirescens* are also found on turtle shell and bone, substrates known to be high in phosphorus. Since calcium concentrations are often high in alkaline substrates, calcium may be important in these specificities as well. Many so-called "nitrophilous" lichens, especially *Xanthoria parietina, X. fallax,* and *Physcia adscendens* are commonly found on mortar and concrete which have a high pH and calcium concentration, but are certainly not rich in nitrogen compounds.

The presence of *Cladonia submitis* and associated lichens on the south shore and inland and their absence on the north shore is strongly correlated with soil acidity. The south shore and inland sands are all distinctly acid, whereas the north shore sands are neutral (table 2). Exactly what is involved in this correlation is still not clear (p. 203). The eroding soil supporting *Baeomyces roseus* has the same pH as the dune sand and, therefore, acidity cannot explain the differences in the terrestrial communities of the two soil types. The higher moisture capacity and organic content of the eroded sandy loam are possibly the deciding factors in this case.

Other substrate minerals not studied here are undoubtedly important in lichen distributions. Although some data are available on the mineral contents of substrates (Barkman, 1958) and mineral nutrition of lichens

(Smith, 1960a, 1960b, etc.) the subject is still far from adequately understood. The extreme specificity of *Trypethelium virens* for several species of *Ilex* (Johnson, 1959) suggests the presence of some genetically controlled metabolite in that genus which is essential for the establishment or survival of the lichen. *Fagus grandifolia,* another common phorophyte for *Trypethelium virens,* would then also have to possess the ability to produce this substance or a substitute. There is some evidence that *Trypethelium* actually does utilize some bark material (Johnson, 1940). Fink (1913) suggested that other endophloedal crustose species also derive some nutritional benefit from their substrate. The fact that *Trypethelium virens* has been found in healthy condition on Long Island only on living trees, an observation also made by Johnson (1940), and the fact that all the host trees of this species have thin living bark, adds weight to the possibility that a specific class of metabolite is involved.

It is easy to imagine a lichen living on a nutrient-rich substrate making use of these nutrients, especially when all the mechanisms for their absorption are available and efficient (Smith, 1962). More work on substrate specificity is needed to clear up these important problems.

## CLIMATE

Atmospheric humidity is involved in the water budget of a lichen thallus to a greater degree than it is in the water budget of a rooted vascular plant in the same general habitat. This is due to a lichen's ability to pick up water vapor and use the absorbed moisture in photosynthesis and metabolism in a relatively short period of time, as compared with the green parts of vascular plants (p. 32). Thus, a habitat which might be dry for a terrestrial vascular plant due to excessive soil drainage, may not be dry to lichens if air humidity is high enough during part of the 24 hour cycle. It is the microclimate which one must measure in order to characterize the water budget in the ecological niche of a lichen. Unfortunately, to perform such measurements was beyond the scope of this work, although such studies would be extremely interesting and valuable.

Vertical and horizontal zonation (p. 34 to 35) and patterned distribution in bark fissures or on bark ridges are probably at least partly manifestations of different microclimates.

*1. Illumination and temperature.* Light intensity is a very complex factor, having both direct and indirect effects on microclimate. As Barkman (1958, p. 57) states ". . . it is often difficult to decide whether a given species is photophilous, thermophilous, or xerophilous," since strong light will raise the temperatures of both bark surfaces and the lichens themselves (especially if they are dark colored) and will, therefore, increase the evaporation rate, which in turn will increase drought conditions. The role of illumination in raising temperatures, and thus evaporation rates and drought, was an important consideration in Barkman's

(1958) summary of the causes of horizontal zonation (zonation according to direction of exposure) of epiphytes on tree trunks in Holland.

Lichens derive their principal nutrition from the photosynthesis products of their algal components, and so the lichen thallus is dependent upon light for survival. Since, in the lichens that have been studied, the net rates of photosynthesis per unit surface area are much lower than those of the leaves of higher plants (Smith, 1962), it is not surprising that most lichens are found in moderately or well-lighted habitats. Deeply shaded forests, dry or moist, are, in general, lichen poor. Lichens exposed to full sunlight, however, are often subject to extreme drought. Many species have developed adaptations, such as cortical pigment accumulation and cortical thickenings (Barkman, 1958) which cut down light intensity and transpiration.

Some Long Island lichens which seem to be distinctly photophilous are *Cetraria islandica* subsp. *crispa, Cladonia submitis, C. boryi, Xanthoria parietina, Parmelia sulcata, Usnea strigosa, Ramalina fastigiata, Pertusaria xanthodes,* and *Lecanora caesiorubella* subsp. *lathamii.* These species are most often found in well-illuminated habitats even though their general substrate types extend into more shaded areas. The first three species mentioned above are found almost exclusively on exposed sand plains and downs. *Xanthoria parietina* has long been known to be photophilous (Barkman, 1958). The remaining species occur most frequently in well-lighted but dry, mature pine-oak forests of central Long Island. This vegetation type can be thought of as a compromise habitat between optimum light and optimum moisture (Brodo, 1961a). In more humid localities, such as the Montauk region on the southern fluke of Long Island (figure 5), these species all reach their maximum development in completely exposed situations.

2. *Moisture.* Lichens are classically thought of as among the most drought-resistant plant types. Although it is true that many species can survive in habitats much too dry to support any but the most xeric of bryophytes, many lichens are clearly limited to rather moist environments and many others are very sensitive to changes in environmental moisture.

The role of moisture in the photosynthetic efficiency of lichens has been reviewed and summarized by Smith (1962). He points out that in the nonaquatic lichens which have been studied, photosynthetic efficiency is greatest at moisture contents below saturation. In nature, nonaquatic lichens are rarely saturated. Although most nonsorediose lichens absorb liquid water rapidly, they lose water almost as fast. Absorption of water vapor is a much slower process, but constantly humid areas are undoubtedly less droughty than dry, exposed areas with frequent rains (Barkman, 1958). This is especially the case since it has been shown that lichens can absorb water from nonsaturated air (Pavillard, 1939; Barkman, 1958). Thus, the misty thickets and shrubby groves of the depressions in the Montauk area are wet habitats, whereas just outside these groves on the exposed dunes, where constant strong winds make evaporation high, the habitat is extremely dry (Taylor, 1923; see also Salisbury, 1952). Ried (1960) pointed out that lichens are most seriously damaged when they are subjected to intermittent wet and dry periods. This may explain why some lichens that were thought to be drought resistant through laboratory experimentation actually appear sensitive to low moisture conditions when observed in the field. He suggested that it is the ability of various species to recover from a drought which might determine their distribution.

Moisture also has an important *indirect* influence on lichen growth. Inasmuch as microbial activity is highly dependent on moisture levels of various habitats, any lichen distribution dependent on the products of either fungal or bacterial growth or on the changes in the physical characters of substrates subjected to such activity would necessarily follow moisture changes as well.

Moisture comes to the corticolous lichen thallus from precipitation and from air humidity (both directly and through the wetted substratum), and rarely by inundation. In the tropics, moisture may be made available directly from the living tissue of the thin-barked trees (Imshaug, pers. comm.). The evaporation rate in any particular habitat and the moisture capacity of the substrate determines how efficiently and for how long this moisture is available to the lichen.

The availability of rain to epiphytic lichens is influenced by canopy type and canopy density mainly through their effect on the flow of water from the leaves and twigs down the branchlets and branches and finally down the trunk. This flow of water ("stemflow") is often a major route for the entrance of moisture to the forest interior (Kittredge, 1948) and is, of course, of major importance to corticolous plants. Stemflow is greatest with trees having ascending branches ("centripetal crown") as in *Acer* and *Fagus*, and is least with trees having drooping branches ("centrifugal crown") as in *Picea; Quercus* and *Pinus* are intermediate in this respect (Barkman, 1958; Geiger, 1965). It should also be borne in mind that precipitation which has passed through a canopy ("throughfall") is much richer in certain minerals and ions than unintercepted rain (Tamm, 1951).

In the pine-oak forest of Long Island, much of the rain reaches the bole directly through the loose canopy as well as by stemflow. In the dense, red oak forest, light rains never reach the ground or tree trunks, being evaporated directly from the canopy. Heavy rains filter down through the canopy, but only reach the bole via rain tracks (the channels of most liquid stem runoff) and general stemflow. However, once the rain has wet the ground and bark in a shaded forest, the precipitation is slowly converted to increased air humidity which slows evaporation from the wetted thalli and supplies additional moisture for a long period. The rain in a pine-oak forest, on the other hand, is quickly lost in the very well drained, sandy soils and dried from the bark with no substantial increase in the local humidity for more than a very short period of time.

It is, therefore, in the relatively open habitats that hygrophilous species occupy substrates with high moisture capacities (p. 51 to 54).

## VERTICAL DISTRIBUTION

The vertical zonation of corticolous epiphytes has intrigued many cryptogamic ecologists (Plitt, 1924; Billings and Drew, 1938; Hale, 1952a; Culberson, 1955a; Barkman, 1958; Brodo, 1959, 1961a, 1961b). Methods of study varied from detailed investigations of a few trees from base to crown (Plitt, 1924; Hale, 1952a) to studies of hundreds of trees only at basal and breast height quadrats (Hale, 1955a; Culberson, 1955a; Brodo, 1961a). Barkman (1958) made numerous observations concerning vertical zonation and thoroughly reviewed the previous work.

Several approaches were taken in the study of this phenomenon on Long Island: a statistical evaluation of species presence in breast height and basal quadrats, experimental transplant studies, and field observations of lichen communities.

As a result of the statistical investigations described previously, several common species could be characterized as to their vertical zonation affinities (table 3 and Brodo, 1961a. From an examination of the vertical distribution of certain common corticolous lichens in the pine-oak forests, as compared with the red oak forests (disregarding phorophyte species) (table 3), one can see that the frequencies in the basal quadrat in the former are consistently higher than those in the latter. This tendency of species normally dwelling at breast height to be confined to the basal area in dry pine oak woods is consistent with the statements made by several authors (Billings and Drew, 1938; Plitt, 1924; Potzger, 1939; Barkman, 1958) concerning vertical microclimatic gradients. That is, bark moisture is greater and evaporation is slower at tree bases, as opposed to microhabitats higher on the trunk. Barkman (1958) has pointed out how different moisture conditions in different vegetation types can influence epiphytic vertical distributions. He states that in moist woods typically base-dwelling communities sometimes cover entire trunks. On Long Island, this phenomenon is particularly striking with bog tree epiphytes. Within the humid, cool bogs, *Lobaria pulmonaria* and *Lobaria quercizans* grow at all levels, but just outside the bogs, in the drier oak forests, the same lichens are confined to tree bases.

Transplant experiments done in 1960-61 concerned with vertical distribution of *Lecanora caesiorubella* and *Cladonia chlorophaea* (Brodo, 1961b) showed that the *Lecanora* could survive when transplanted from breast height to the tree base, but that the *Cladonia*, upon being transferred from the base to breast height (1.3m), soon decayed. Lichen-frequency data bear out the supposition that the *Lecanora* is somewhat more facultative in its vertical distribution that is the *Cladonia* (table 3). Since the lichens were transferred on their original intact substrate to

TABLE 3. Vertical distribution of some corticolous lichens in red oak and pine-oak forests. Not all species listed were treated in the pine-oak forest data because some were absent or too infrequent, and some, due to recognition problems with sterile material, were not included in early sampling. Red oak forest data were collected from localities 7 to 11 in the north shore transect. The pine-oak forest data are from continuum segments A and B, in Brodo (1961a).

| | RED OAK FOREST | | | PINE-OAK FOREST | | |
|---|---|---|---|---|---|---|
| | Total frequency (percent of 300 trees) | Percent of total quadrat occurrences. Base | 1.3 m. | Total frequency (percent of 300 trees) | Percent of total quadrat occurrences. Base | 1.3 m. |
| *Cladonia chlorophaea* | 9 | 100 | 0 | 42 | 96 | 4 |
| *C. coniocraea* | 62 | 93 | 7 | | | |
| *Graphis scripta* | 10 | 22 | 78 | | | |
| *Hypogymnia physodes* | 3 | 37 | 63 | | | |
| *Lecanora caesiorubella* | 6 | 6 | 94 | | | |
| *L. chlarotera* | 5 | 25 | 75 | 11 | 33 | 67 |
| *Parmelia caperata* | 24 | 76 | 24 | 4 | 67 | 33 |
| *P. rudecta* | 24 | 69 | 31 | 3 | 86 | 14 |
| *P. saxatilis* | 14 | 57 | 43 | 11 | 60 | 40 |
| *P. sulcata* | 22 | 9 | 91 | 45 | 21 | 79 |
| *Pertusaria xanthodes* | 4 | 38 | 62 | | | |
| *Physcia millegrana* | 3 | 40 | 60 | 8 | 16 | 84 |
| *Ph. orbicularis* | 3 | 100 | 0 | 5 | 71 | 29 |

points on the same tree, the experiments also strongly indicated that it is microclimatic conditions, rather than bark surface features or differences in organic or inorganic nutrients on a vertical gradient, which largely determine where on a particular tree a lichen can survive. Since the degree of fungal-bacterial breakdown of bark appears to increase towards the tree base, it is possible that the microclimatic gradient may be operating through a biological link to influence the lichen.

In various local habitats not sampled in the statistical work, some noteworthy types of vertical zoning were observed. On the windward sides of trees growing close to bays and lakes, basal lichen communities often extend far up the trunk (see also Billings and Drew, 1938; Barkman, 1958). For example, *Parmelia rudecta*, *Parmelia caperata*, and *Physcia orbicularis*, all dominantly base-dwelling under normal conditions, were found growing high on the bay-facing side of an oak tree on Shelter Island. The lee side of the trunk had a normal basal zone.

Inclination of the phorophyte trunk greatly changes its moisture conditions and permits basal vegetation to grow much farther towards the crown (Barkman, 1958). A tree growing on a steep hillside essentially has the ground brought closer to the crown on the uphill side of the trunk, and this side, then, has a more "basal" epiphytic flora.

Crustose species are almost entirely confined to areas above the base, except for the normally basal epibryic and leprose crusts.

Although light has classically been cited as one of the main causes of vertical zonation of epiphytes (Plitt and Pessin, 1924; Barkman, 1958; Hale, 1952a, 1955a; etc.), light probably was not significantly involved in the results of the Long Island studies, since illumination does not seem to be a controlling factor in either forest type at the basal or 1.3m levels. In pine-oak forests, light appears to be abundant and uniform over most of the tree due to the low, loose canopy. In the shaded red oak forest, light appears to be uniformly low until one reaches the upper portions of the trunk and canopy far above the level examined. On the few felled or windblown trees that were examined, an obvious trend toward a greater number of crustose species at the treetops and a greater lichen cover in general points to a light effect. That photophilous *Usnea strigosa* is most abundant in forest glades, forest edges, and on treetops makes evident the fact that light is the controlling force in its vertical distribution.

Moisture, of course, is of major importance in all types of lichen distributions (p. 32-34). Vertical moisture gradients of many kinds have been reported, including evaporation rate (Plitt and Pessin, 1924; Potzger, 1939), bark moisture (Billings and Drew, 1938; Hale, 1952a), and relative humidity (Barkman, 1958). With the ground being a major water reservoir, it is evident that the farther one moves away from this reservoir, the drier the microclimate will be. The more humid an area, the less will be the difference between humidity at ground level and humidity at greater heights and, therefore, the less pronounced will be the vertical vegetational zonation which responds to this moisture gradient (Barkman, 1958, p. 39). This is indeed what is observed in the Long Island studies, and we can therefore conclude that moisture is probably a controlling factor in most cases.

Temperature and bark characteristics such as color, hardness, and porosity all have their effects on substrate moisture relations via evaporation rate or moisture capacities, and all show vertical changes. Since epiphytes are sensitive to moisture changes, it is easily seen how a vertical zonation of epiphytes can be influenced by these physical features of the substrate.

Organic and inorganic nutrients, having been either blown on to the bark surface, carried down by stemflow or throughfall (Tamm, 1951), or produced there by local microbial activity, are distributed along a vertical gradient and may play an important part in the distribution of certain species, particularly those that normally grow on the ground. The possible role of nutrient accumulation in the maintenance of established colonies of *Cladonia chlorophaea* has been disproven by transplant experiments (Brodo, 1961b) but its possible importance in the establishment of certain species cannot be eliminated. Since virtually no work has been done on the factors involved in the establishment of different species in nature, little can be said about this important aspect of lichen ecology at this time.

Certain bark characters such as hardness and rate of exfoliation have selective effects on certain lichens and certainly cause some vertical lichen zonation (p. 22; 29-30). Crustose species tend to be most abundant on the smooth, young bark at the top of the tree, possibly responding just as much to the physical bark feature itself as to the increased light at those levels. Hale (1950, 1952a) discusses the importance of bark texture in the maintenance of certain types of lichens according to their anchorage abilities. Some species have greater abilities to reinvade exfoliating bark than others and would cause vertical zonation along a bark-age gradient. One then might view a single tree trunk as demonstrating all stages of a corticolous succession with all stages in time frozen at different levels of the trunk.

## SUCCESSION

Both directional and nondirectional changes in species composition were seen within certain lichen communities (see Hanson and Churchill, 1961, for a fairly detailed discussion of ecological changes of different kinds). The tracing method used in the growth rate studies (see Brodo, 1965) provided a means for demonstrating the fluctuations in local lichen populations and the constant change in composition and coverage of lichen communities. Reports of no change in lichen communities in up to 50 years (A. L. Smith, 1921; Cooper, 1928) are to be viewed with some skepticism in the absence of precise measurements (as pointed out by Smith, 1962). Figure 16 presents one of the many examples of fluctuations which were observed. Here the thalli of *Parmelia sulcata* are shown to grow at one point, while in other places they fall away and allow the invasion and extension of *Physcia millegrana.*

When populations change in a directional fashion, succession can be said to be taking place (Hanson and Churchill, 1961). The changes described below may be truly successional or may be the first stages of a cyclic fluctuation. These changes were observed in the growth rate tracings of a community on *Quercus alba* in a moderately lighted oak woods (figure 17). The quadrat was at a height of one meter and was facing away from the prevailing wind direction.

1959: *Parmelia sulcata* — all thalli healthy, robust.
*Physcia millegrana* — all thalli healthy and vigorous; many very small thalli present.
*Lecanora caesiorubella* — one thallus, vigorous, with many large apothecia.
1961: *Parmelia sulcata* — some thalli showing evidence of decay; most healthy.
*Physcia millegrana* — all thalli healthy, vigorous.
*Lecanora caesiorubella* — vigorous; apothecia unchanged.
Dynamics:
a. *Lecanora caesiorubella* is being encroached upon and covered on all sides by *Physcia millegrana,* although both appear to be healthy.

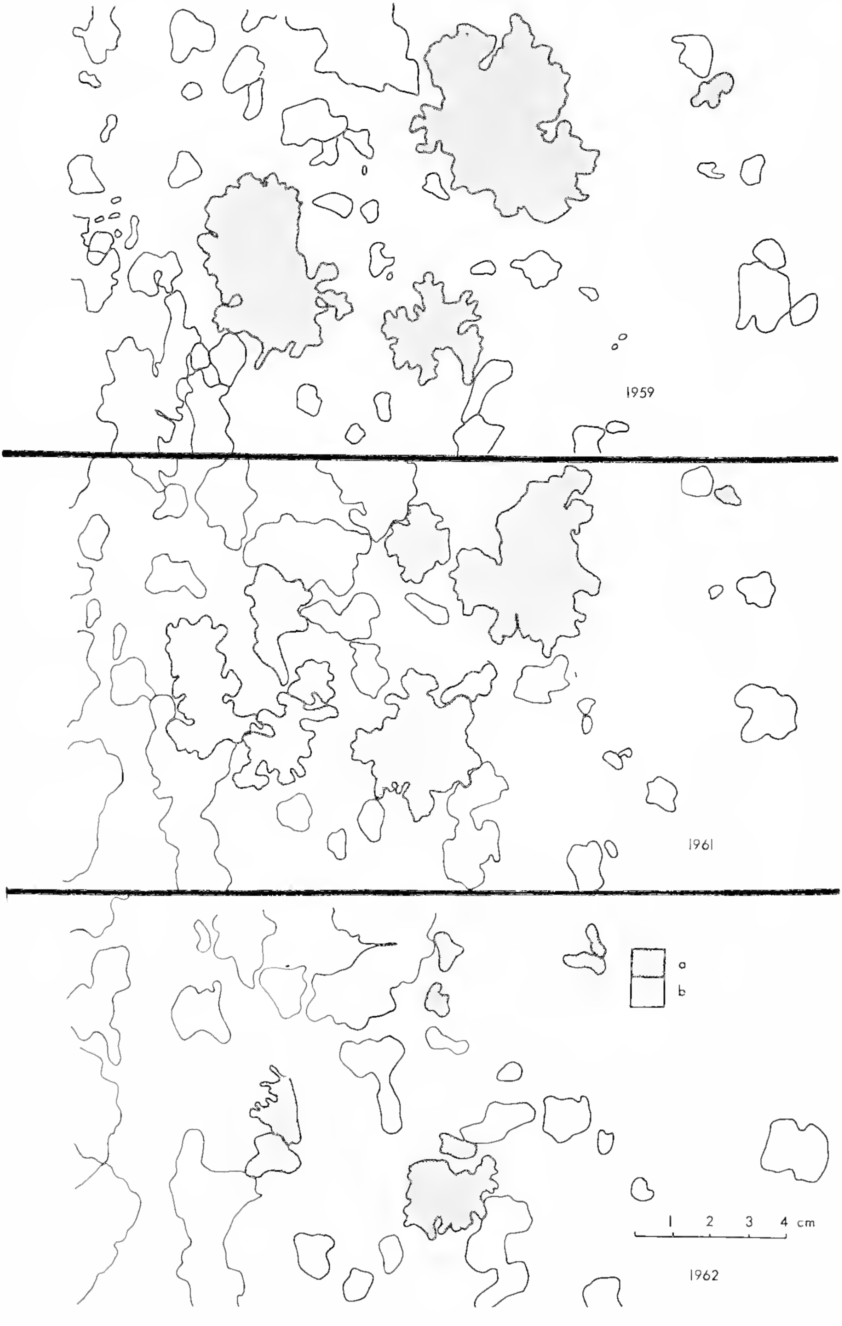

FIGURE 16. Population changes in a corticolous lichen community: nondirectional shifts. (a) *Parmelia sulcata*, (b) *Physica millegrana*.

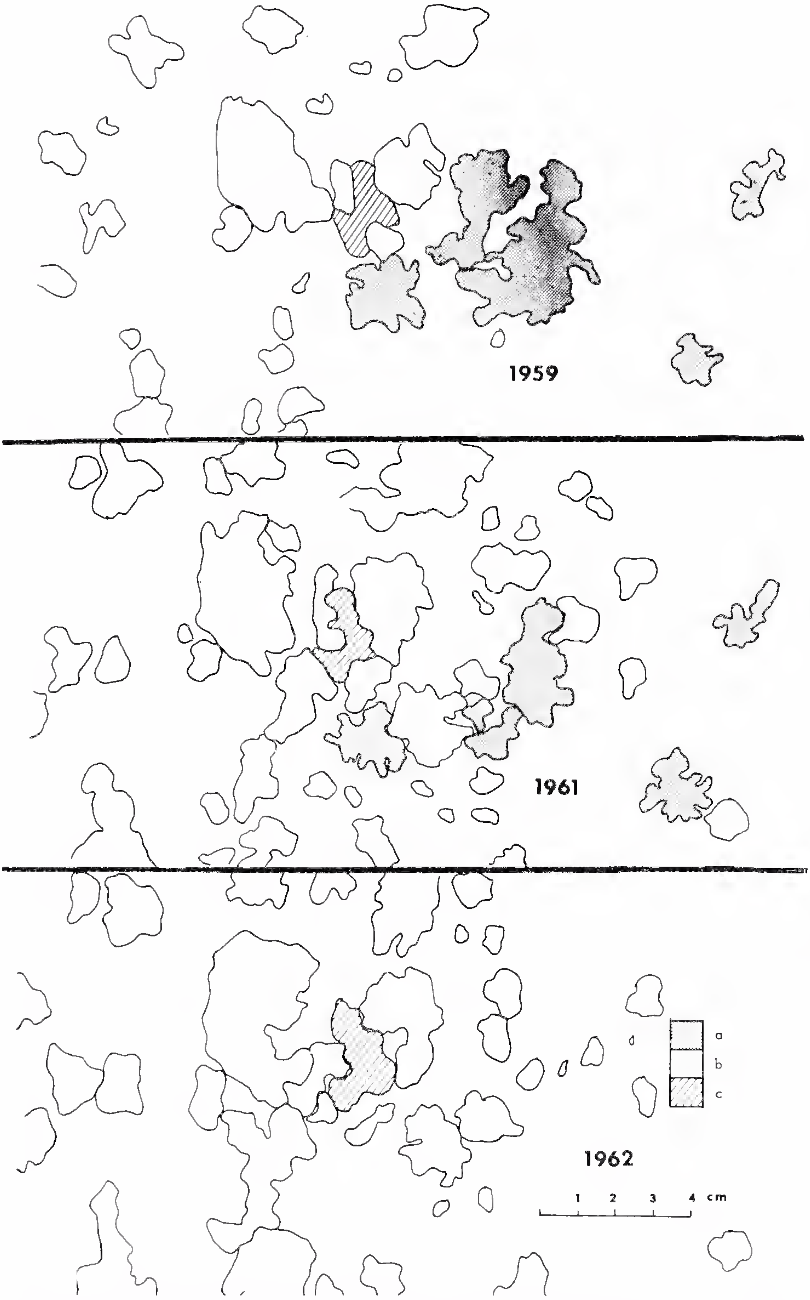

FIGURE 17. Population changes in a corticolous lichen community: directional shifts (succession) or a portion of a cyclic change. (a) *Parmelia sulcata,* (b) *Physcia millegrana,* (c) *Lecanora caesiorubella* subsp. *lathamii.*

b. Wherever *Parmelia sulcata* and *Physcia millegrana* are both healthy and are growing adjacent to one another, the *Parmelia* is growing over the *Physcia* with one exception in a very local area of a *Parmelia sulcata* thallus.

c. Wherever *Parmelia sulcata* appears to be dying, the *Physcia* is growing over the *Parmelia*.

d. Small regeneration lobes can also be seen in the dying areas of *Parmelia sulcata*.

1962: *Parmelia sulcata* — most thalli showing considerable decay.
*Physcia millegrana* — healthy, vigorous.
*Lecanora caesiorubella* — half the thallus whitened and decaying.

Dynamics:

*Physcia millegrana* was encroaching considerably on the *Lecanora*.

Succession occurs in response to a change in the environment of the site without a change in regional climate or a change in the organism. The rate is dependent on the organism's rate of growth and the environment's rate of change (Barkman, 1958). The sequence of the successional stages depends on the characteristics of the participating organisms, often both physical and chemical. Billings and Drew (1938) described a microsuccession of epiphytic bryophytes due to the aging of the bark substrate. Not only does bark change in time due to the tree's own activity, but, as Barkman (1958) points out, the epiphytes themselves alter the moisture capacity and acidity of the bark. The forest of which the tree is a part also changes in time, especially with reference to light and humidity.

With both corticolous and saxicolous lichens, the successional sequence is usually thought of as crustose to foliose to fruticose and/or bryophytes, i.e., according to the growth form, although Rudolph (1953a) has pointed out many exceptions to this scheme. The sequence described from the growth-rate tracings indeed fits into the more standard pattern. The one deviation involves poorly developed or depauperate specimens, in which case the succession may start to reverse. *Physcia millegrana* is normally overshadowed by *Parmelia sulcata*, except when the latter is in poor health, at which time the *Physcia* will overgrow the *Parmelia*. In areas recently subjected to air pollution, fruticose and foliose lichens are usually more severely damaged than crustose species, and succession can therefore be reversed, i.e., fruticose to foliose to leprose species. Barkman (1958) described such a reversal in Holland with *Lobaria* giving way to mosses which finally yield to *Pleurococcus*, where the species were found near industrial centers. This is thought to be due to the fact that the freer an organism is from its substrate surface, the more surface area it exposes to the polluted air and the more susceptible it is to air pollution. Thus, with increasing air toxicity, the larger foliose and fruticose lichens will be the first to go, then the smaller foliose species,

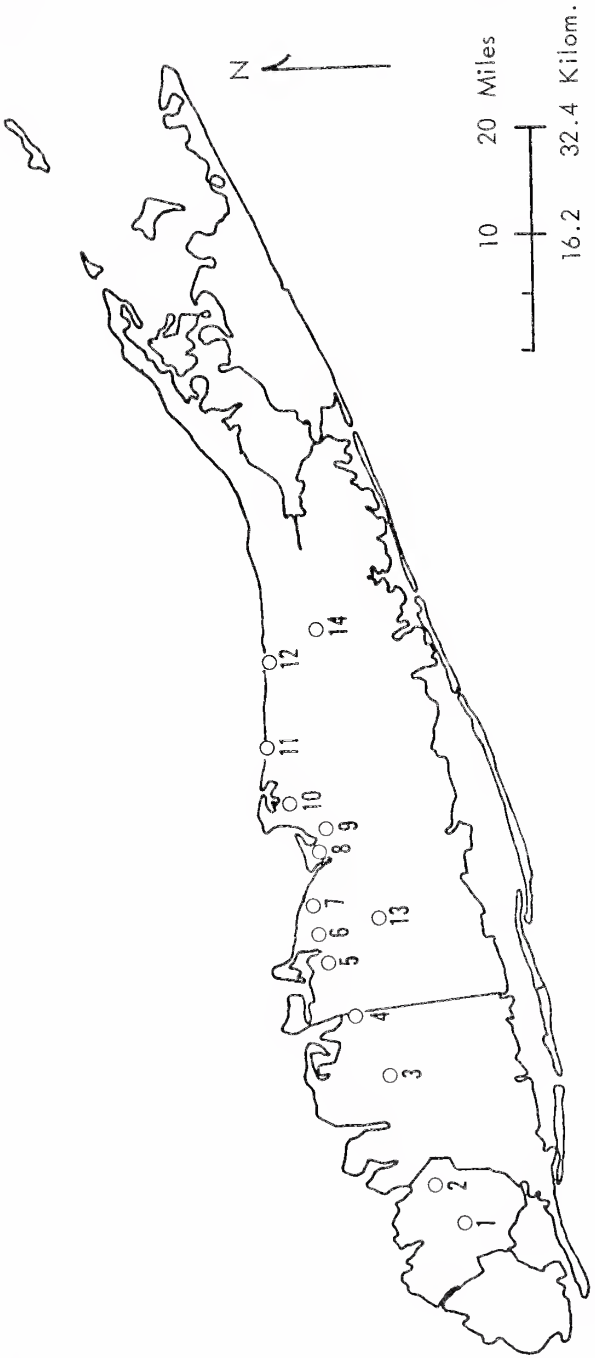

FIGURE 18. East-west transect and transplant localities. The central island localities used in Brodo (1961b) are numbers 1, 2, 3, 13, 14. The north shore, red oak forest localities used for the east-west transect studies are numbers 1 through 12. The 1961 north shore transplant experiment was set up in localities 1, 2, 4, 10, and 12.

and finally the leprose crusts and algae. In New York City, therefore, the algal communities covering the trees in the city parks can be considered to be in a disclimax stage maintained by air pollution.

Successional stages on boulders have not been studied on Long Island.

On the inland sand habitats, succession often proceeds from crusts such as *Lecidea uliginosa* or *L. granulosa,* to *Cladonia* spp., and finally to grasses and shrubs. On the windswept sand dunes of the south shore, however, the reverse is often observed. Dune grass *(Ammophila breviligulata)* gains a foothold, and upon its death and decay leaves a "stump" onto which some species of *Cladonia,* especially *C. boryi,* can become established. The clumps of *Cladonia* will close over the sand, more or less stabilizing the surface and will decompose and provide substrate for other plants (Brodo, 1961a). A similar but more nondirectional cyclic change was described by Watt (1947) working with a very similar community: *Calluna vulgaris, Arctostaphylos uva-ursi,* and *Cladonia sylvatica (Cladonia arbuscula).* In his scheme, the *Cladonia* stage can give way to bare soil, again upon which the phanerograms will become re-established. It is very possible that the same cyclic development may occur on the Long Island sand dunes, but I have not recorded any observations to that effect. Alvin (1960), in discussing lichens of an *Ammophila-Calluna* dune community (p. 60), considers sand stability and pH as prime factors in this succession with reproductive potential (soredia production) as possibly also important.

On eroding, sandy loam in the inland portions of the island, a type of cyclic change can be seen. *Baeomyces roseus* and/or *Pycnothelia papillaria* are the pioneers, effectively binding the soil particles together, providing a situation suitable for the invasion of many other species of *Cladonia* (particularly *C. strepsilis, C. subcariosa,* and *C. clavulifera*) which are followed by grasses and herbs. If the ground is disturbed and subjected to new erosion, the cycle will begin again.

I studied the role of lichens in a segment of old field succession over a period of 3 years at the American Museum of Natural History's Kalbfleisch Field Research Station on Long Island. Even in that comparatively short period, some interesting trends were observed.

The field under study (AP-5) was abandoned in 1954, and was thus 6 years old when these observations were first made. In 1960, the phanerogamic vegetation consisted of a mixture of annual and perennial weeds, with *Andropogon* becoming abundant by the third year of the observations. In general the trends were:

| *Vascular Plants:* | *Non-vascular Plants:* |
|---|---|
| Weeds sparse; light excellent | 1. Pebbles bare; soil exposed around weeds, except for some clumps of moss. |
| | 2. Pebbles covered with pycnidia of *Lecidea erratica,* some non-podetiate *Cladonia* squamules appear on moss clumps and, to a lesser extent, on the bare soil. |
| Grass becoming important; light diffuse | 3. Pebbles covered with pycnidia and small apothecia of *Lecidea erratica;* podetial initials seen on *Cladonia* thalli in moss clumps and, to a lesser extent, on the bare soil. |
| ↓ | 4. Pebbles covered with a mixture of pycnidia and mature apothecia of *Lecidia erratica;* podetia of *Cladonia cristatella* and *C. chlorophaea* well developed in moss clumps and on soil. |
| | 5. Rapid decline of all species, especially *Cladonia* spp. |
| Grass heavy; light very poor | 6. Disappearance of *Lecidea erratica* from pebbles. |

Portions of this succession were seen in various quadrats, and the entire successional picture is actually a composite of the many segments observed.

Robinson (1959), in a paper dealing with old field succession in North Carolina, also noted the importance of *Cladonia cristatella* and *C. grayi (C. chlorophaea)* in the 6-9 year old stage. He stated that the lichens attain their greatest dominance after the decomposition of much of the moss and grass vegetation. If the same sequence follows on Long Island, the observations at the Kalbfleisch Station could represent a minor primary succession within the overall successional pattern which could only be seen over a longer period of time.

Evans and Dahl (1955) noted that the most conspicuous lichen cover was in old field communities of mosses and perennial weeds ("Bryoid — Antennaria types") although some species, including *Cladonia cristatella* and *C. pyxidata,* attained importance in the "Poa - Aristida" community. The Bryoid-Antennaria community is well lighted, and becomes established on dry, unstable soil; whereas the Poa-Aristida community is slightly more shaded and is found on more stable soil.

Because of the common occurrence of ground fires in the pine areas of central Long Island, succession on burned ground and bark was studied in several areas. The types of pioneers on burned-over barrens depend on the extent of the fire. If even very limited areas are left unburned, a large number of species may be available for reinvasion. Fire can get very close to a lichen colony without destroying it. In southern New Jersey near Tuckerton, I studied an area which was burned over not more than 2 years previously. The fire swept through the area, charring almost the entire ground surface as well as many tree trunks. The fire apparently was windswept and very rapid, because on the lee sides of many trees charred bark extended to a height of about 4 feet, whereas on the windward sides of the same trees, many lichens appeared unharmed. On the soil, a similar situation was seen. Tiny areas untouched by the fire supported healthy colonies of several *Cladonia* species, particularly *Cladonia uncialis* and *C. subtenuis* although the fire had devastated areas only a few feet away. Small moss clumps, especially of *Leucobryum glaucum* or *Polytrichum* spp., seemed to provide protection for small lichen thallus fragments, and some reinvasion of the surrounding area probably originated from these clumps.

With a rich source of nearby species, succession seems to be rather haphazard with regard to pioneers, and is mainly dependent on which lichens have the best means of dispersal. Charred ground is soon covered by dust, then wind-blown soil and other plants, and is recolonized soon after the fire has gone. Charred bark, however, remains uncolonized for a long period except by certain specialized species.

Succession on an area almost totally destroyed by fire gives a better indication of a natural succession because invasion, with few exceptions, must occur from outside and the species "selection" is much greater. I studied such an area in Yaphank, Long Island, adjoining the Suffolk County Firematic Training Center. The fire had totally destroyed the ground cover and charred the ground over an area of about 50 acres or more. The trunks of pines were burned to a height of 10-12 feet and the oaks were charred to a lower height. Two similar areas were studied and yielded similar observations. One was in Centereach and the other near Selden. Prior to the last burn, all the areas were pine-oak barrens of approximately the same age.

In all the areas, I noted that lichens invaded the soil before they invaded the bark of burned trees. The uncontested pioneer was the ubiquitous *Cladonia cristatella*, followed closely by *C. bacillaris* and *C. chlorophaea*. All three species are extremely common on the island and all have very wide substrate tolerances. All three species are found on tree bark of many types, soil of many types, and even stones and gravel if they are present. *Cladonia caespiticia* was observed as an associated pioneer in the Yaphank and Centereach areas as well as on charred ground in two other incompletely burned areas. Sterile thalli of *Lecidea uliginosa* covered small patches of sand in the Selden locality.

No reinvasion of the charred oak bark was seen, but the burned pine bark supported a number of species of crustose lichens. *Lecanora subintricata,* a very minute, athalline crustose species, was collected on a completely charred and almost destroyed pine; *Lecidea anthracophila* was on moderately charred bark near the edge of the burn. Other species such as *Lecidea scalaris* and the foliose *Parmeliopsis placorodia* were on unburned bark just above charred material and probably were remains of a pre-existing population rather than a reinvading one. However, *Lecidea scalaris,* and sometimes *L. anthracophila,* have been collected on charred bark on numerous occasions and undoubtedly can reinvade recently burned over forests.

I did not study the long term effects on the terrestrial lichen flora after frequent burning. Buell and Cantlon (1953), however, observed an increase in the lichen cover with burning frequency over a period of years. Johnsen (1959) reported a slight increase in lichen cover with periodic burning, but declined to make a firm statement pending more complete data. Both the above studies were made in pine forests, the first in the pine-oak region of New Jersey, and the second in a pure stand of loblolly pine *(Pinus taeda)* in the North Carolina piedmont.

## SPECIES COMPOSITION WITHIN HABITATS

It has long been known to field botanists that certain plants tend to be found in association with certain other plants. It soon became convenient, therefore, to refer to these groups of species collectively as "communities" or "unions." With the growth of the field of phytosociology, hundreds of plant communities were examined, analyzed, and named. It is my opinion that the use of Latin epithets in naming biological communities of any kind implies an intricate predictable organization which does not exist. The principles underlying this opinion as they apply to lichen communities are listed below.

1. Each local lichen population has definite ecological requirements (i.e., a specific niche); for certain species these requirements are narrow, and for others they are broad.

2. Lichens with similar gross ecological requirements will tend to be found together more frequently than lichens with dissimilar ecological requirements. The more similar the gross requirements, the more frequently the occurrence of the two together. Since, according to the "ecological exclusion principle," no two species having exactly the same niche requirements can exist together, as the ecological requirements of two lichen populations approach identity, a higher and higher degree of competition will develop between them. One species, once present in a habitat, could successfully exclude an ecologically similar species by: (a) extremely rapid growth (preempting suitable available space), or (b) chemically or physically altering the habitat preventing the establishment of the ecologically similar species. This, of course, could be effective only if the establishment requirements of a species were different from

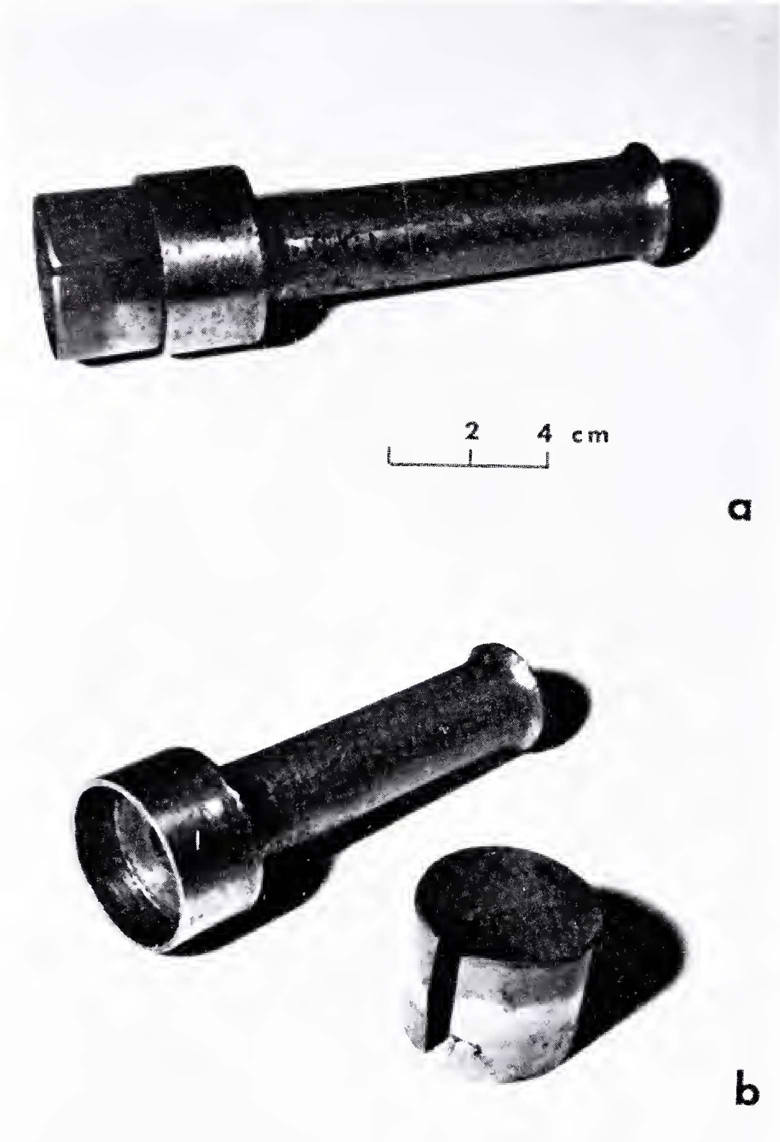

FIGURE 19. Bark-borer (a) Assembled, ready for use; (b) with blade removed to show additional features of the steel holder.

its survival requirements. Barkman (1958, p. 197) believes that the production of a growth inhibitor by *Opegrapha dubia* and *O. cinerea* prevent the two from occurring side by side, although they seem to have the same habitat requirements.

3. Any particular area or locality has a limited set of potential species available for colonization due to that locality's particular ecological and phytogeographic position. For example, a white cedar bog on Long Island does not have all the lichens in the world available for colonization (excluding the slim possibility of chance long distance dispersal). Only those species whose distributions include Long Island which had means to arrive at Long Island (as via coastal plain swamps), and which require or can tolerate a high moisture, low light, cool temperature environment such as is found in these bogs, could occur there. Thus, out of approximately 16,000 species known to science, we are left with about 30 which may be found in a Long Island bog. On any particular tree in the bog, such as a *Chamaecyparis*, the list is cut down even more (eliminating lichens which must grow on the ground, rotting wood, and vegetation or smooth bark, etc.) leaving only a dozen potentials. The chances are very high that some or all of these potential species will be on white cedars in that bog, their diaspores having arrived there and distributed themselves in a relatively random fashion.

4. The conditions in any particular habitat are not static, mainly due to aging of the substrate itself and to local changes in microclimatic conditions; consequently the community composition in these habitats is not static. Succession does not always occur with the same sequence of species or at the same rate. This often results in the establishment of mosaic communities of mixed development, making any phytosociological classification extremely difficult.

5. The composition of lichen communities varies from one habitat to another in an unbroken continuum along physical, chemical, or microclimatic gradients. Almborn (1948) cites an excellent example of such a continuum following an illumination gradient. The lichens involved were members of a community on *Fagus*.

The concept of "community" as used here should not be confused with the integrated biological system, consisting of lichens, bryophytes, microorganisms, vascular plants, and animals, of which it is a part. Strictly speaking, one can even think of each lichen thallus as a sort of "community" . . . an intimate, highly integrated association of algae and a fungus.

In conclusion then, we can consider a "lichen community" to be a group of species having similar gross ecological requirements and occupying a certain habitat together. This group of species is subject to directional and non-directional change with time resulting in a compositional continuum from one group to another.

If we decide that lichen communities should not receive Latin names, the problem of how to deal with communities still remains. One can "classify" a community according to its floristic composition, as do most phytosociologists, and merely refrain from giving it a specific name, or one can delimit communities according to their ecological affinities by classifying their habitats. The latter method is employed in this work.

Each method has its advantages and disadvantages, and a final choice depends mainly on the use of the ultimate product. Barkman (1958) in discussing epiphytic communities, ably outlines the advantages of using floristic criteria for vegetational analysis. He states that phorophytes cannot be used alone, since "1. the kind of host tree is not of direct influence, 2. its significance varies from one region to another, 3. other ecological factors are thus ignored and, last but not least, 4. any logical system should be classified upon the characters of the object to be classified, *in casu* upon the vegetation itself...." His arguments are well taken, and phorophytes alone are not used in the system outlined below. However, in my opinion, (1) phorophytes, as well as other lichen substrates, often seem to have a distinct influence on their lichen vegetation as is evidenced by the number of species which are wholly or partially substrate specific (p. 20-21), (2) the changes in substrates of certain communities from one area to another often give important clues pertaining to the causes of accompanying changes in vegetation, (3) ecological factors other than substrate can easily be included if needed, and (4) since lichen communities themselves are basically "unnatural," i.e., they are only fragments of true biological communities, the method of community classification one uses should depend on convenience and usefulness. The chief advantage of the classification of habitats over the floristic method described by Barkman is that the former does not eliminate any vegetational combination and, therefore, makes possible the classification of a total flora into communities; in the floristic method, representative associations are selected from the total flora, leaving many vegetational combinations not considered.

The first major division of the habitat classification which follows is by the various vegetation types (in their broadest concepts). The next division is by substrate; first the general substrate type is considered and then any other narrower substrate classification that seems pertinent. Occasionally a microclimatic division is made beyond that of the substrate.

Under each habitat are listed, in approximate order of importance, lichens which have a high probability of being found in that ecological situation. These species comprise the "lichen community." One must keep in mind that the species lists represent potential communities and not actual ones. Rarely will all of the species in any particular community occur together.

Bark characters for all the corticolous community phorophytes are summarized in table 1.

To aid the reader in locating specific habitats, an outline of the habitat types precedes the discussions.

- I. Upland Habitats
  - A. Corticolous
    - 1. *Pinus rigida*
    - 2. *Quercus alba*
    - 3. *Q. prinus*
    - 4. *Q. velutina* group
    - 5. *Fagus grandifolia*
    - 6. *Acer rubrum*
    - 7. *Ulmus americana*
  - B. Saxicolous
    - 1. Mortar and concrete
    - 2. Granite boulders
    - 3. Pebbles and small stones
  - C. Terricolous
    - 1. Mossy soil
    - 2. Sandy soil
  - D. Lignum
    - 1. Stable, dry lignum
    - 2. Unstable, highly decomposed lignum
- II. Bog and Swamp Habitats
  - A. Corticolous
    - 1. *Chamaecyparis thyoides*
    - 2. *Acer rubrum*
    - 3. *Ilex verticillata*
  - B. Terricolous
  - C. Lignicolous
- III. Maritime Habitats
  - A. Aerohaline stratum (salt mist zone)
    - 1. Corticolous
      - a. *Myrica pensylvanica — Prunus maritima*
      - b. *Prunus serotina*
      - c. *Juniperus virginiana*
      - d. *Ilex opaca*
    - 2. Saxicolous
      - a. Concrete and mortar
      - b. Granite boulders
    - 3. Terricolous
      - a. Stabilized sand
      - b. Dune sand
    - 4. Lignicolous
  - B. Hygrohaline stratum (salt spray and storm tide zone)
  - C. Hydrohaline stratum (littoral zone)

## I. UPLAND HABITATS

### A. Corticolous.

1. *Pinus rigida* (pitch pine).

Species: (a) base — *Cladonia bacillaris, C. incrassata, C. cristatella.* (b) breast height—*Parmeliopsis placordia, P. aleurites, Lecidea anthracophila, L. scalaris, Bacidia chlorococca.*

Comments: The best lichen development occurs on the edges of the bark plates, not on their surface (p. 28).

Species in the basal community, especially *Cladonia incrassata* and *C. parasitica,* are often found only on strongly decayed wood and on pine bases. The reasons may lie in the fact that both substrates are very acid (Barkman, 1958, p. 113) and usually moist. Pine needles and bark flakes often cluster at the bases of pines, forming thick piles of material which retain moisture long after all other material is dry. Thus, pine bases have a particularly high local humidity.

Pine bark species found at breast height are usually narrowly confined to pine alone, at least on Long Island, although pine-dwelling species which are found in bogs as well as pine forests often are collected on *Chamaecyparis thyoides* or even *Vaccinium corymbosum.*

2. *Quercus alba* (white oak).
   Species: (a) base — *Parmelia caperata, Physcia orbicularis, Cladonia coniocraea.* (b) breast height — *Parmelia caperata, P. rudecta, P. saxatilis, Physcia orbicularis, Parmelia subaurifera, Physcia millegrana.*

Comments: The relatively high moisture capacity and low acidity of the bark of *Quercus alba* renders it a unique habitat in the black oak and pine-filled forests of central Long Island (see also Hale, 1955a). However, its lichen vegetation does not vary much from that of black oaks, with a few important exceptions, notably among the *Physciae* which are rather common on white oaks and rare on black oaks. Distinctions between these two oaks are further developed under the discussion of the black oak group. LeBlanc's *Parmelia caperata, P. rudecta, P. saxatilis, Physcia millegrana,* and *Ph. orbicularis* unions (LeBlanc, 1963) resemble the Long Island white oak bark community at different points in the continuum of lichen composition.

3. *Quercus prinus* (chestnut oak).
   Species: (a) base — *Cladonia coniocraea, Parmelia rudecta.* (b) breast height — *Parmelia sulcata, P. rudecta, P. caperata.*

Comments: The very hard, impervious bark of *Quercus prinus* makes it a rigorous habitat for all but the most xeric of species, especially above the base. Its relationship with the lichen vegetation of other trees of the red oak forest will be discussed under the *Quercus velutina* group.

4. *Quercus velutina* group (black oak group) including *Q. velutina* (black oak), *Q. coccinea* (scarlet oak), *Q. rubra* (red oak), and all hybrids, especially *Q. coccinea X rubra.*
   Species: (a) base — *Cladonia coniocraea, C. chlorophaea, Parmelia caperata, P. rudecta, P. saxatilis.* (b) breast height (partial shade) — *Parmelia sulcata, P. rudecta, Bacidia chlorococca, Graphis scripta, Lecanora caesiorubella* subsp. *lathamii, Parmelia caperata, P. saxatilis.* (c) breast height (light good) — *Parmelia sulcata, Lecanora caesiorubella* subsp. *lathamii, Pertusaria xanthodes, Parmelia subaurifera, Lecanora chlarotera, Parmelia saxatilis, Usnea strigosa.*

Comments: Comparisons of the epiphytic lichen vegetation of members of the black oak group indicate that all species support very similar communities. Even the lichen vegetation on *Quercus alba* bears many resemblances to that of members of the black oak group.

Using data from the 1961 transect study of the red oak forests on the north shore (p. 17), the epiphytic lichen communities of the principal tree species were compared. Only those on relatively common trees could be compared statistically. Kulcsinski's coefficient of community proved to be the most useful statistical tool. Only stands 7 through 12

(Sunken Meadow to Shoreham) were used, since those stands west of Sunken Meadows were considered under the influence of the New York City atmospheric conditions. Where it seemed valuable and pertinent, the results of the red oak forests were compared with those of the pine-oak forests derived from data collected in 1959 in connection with the study of central Long Island (Brodo, 1961a). Continuum segments A and B taken together are considered as "pine-oak forest" for the purposes of these comparisons.

It is possible to compare the epiphytic lichen floras of a number of trees using lichen frequencies at 1.3m and at the base, as did Culberson (1955a), or by disregarding vertical position. The latter was done for the lichen communities on oaks in the red oak forest. The communities were then arranged in sequence, with the most similar closest together and those most dissimilar farthest apart. Vertical distribution was disregarded in this case since there were few differences between the basal and 1.3m vegetations of the trees, and the additional lichen species introduced by the combined values aided in the computations. The matrix of coefficient values with the ranked communities is presented in table 4.

The most striking aspect of the matrix is how high and how similar the values are. In Culberson's comparisons, the values ranged from 8 to 76, with only one pair of tree species having a coefficient over 70. In the Long Island study, all oaks, particularly *Quercus velutina, Q. coccinea,* and *Q. coccinea* X *rubra* were very similar in their epiphytic vegetation. Only *Quercus prinus* was distinctly apart from the others.

TABLE 4. Degree of similarity of the lichen vegetation growing on various species of oak in the red oak forest. Coefficients of association were based on the formula $C = \frac{2w}{a+b} \times 100$, where a=the number of lichen species on one tree, b=the number of lichen species on the compared tree, and w=the number of species found in common on both trees. A value of 100 indicates perfect association (i.e., identity, as far as lichen vegetation is concerned). A low value indicates relatively little similarity.

| | *Q. vel.* | *Q. cocc.* | *Q. cocc.* x *rubra* | *Q. alba* | *Q. rubra* | *Q. prinus* |
|---|---|---|---|---|---|---|
| *Quercus velutina* | ---- | 71 | 71 | 68 | 60 | 42 |
| *Q. coccinea* | ---- | ---- | 82 | 73 | 70 | 46 |
| *Q. coccinea* x *rubra* | ---- | ---- | ---- | 74 | 73 | 46 |
| *Q. alba* | ---- | ---- | ---- | ---- | 81 | 61 |
| *Q. rubra* | ---- | ---- | ---- | ---- | ---- | 66 |
| *Q. prinus* | ---- | ---- | ---- | ---- | ---- | ---- |

Even *Quercus alba* with its soft, porous bark, was almost indistinguishable in epiphytic vegetation from the black oaks.

These results agree well with what one finds in the actual red oak forest — a rather monotonous and sparse epiphytic flora throughout the stands, regardless of the phorophyte. However, in the pine-oak forest, a field worker is struck by a subtle but distinct difference between the white oak and black oak epiphytic communities. Analyzing the coefficient of association of *Q. alba* and *Q. velutina* communities in the pine-oak forest, as was done with the communities on oaks in the red oak forest, we arrive at a figure of 78, which indicates they are similar in their epiphytic flora. Considering the basal and breast height lichen frequencies separately, the coefficient of association values are 74 and 75 respectively, still not reflecting any differences between the trees. Using only the presence of the number of lichen species unweighted by the number of trees examined, rather than frequency, one arrives at a totally different and much more realistic picture (table 5b).

The reader may come to suppose that this is merely a technique of statistical juggling to find results which fit preconceived notions. However, the policy of looking for a statistical means of revealing some more or less apparent ecological phenomenon actually can throw a great deal of light on the real factors involved in this phenomenon. This is a good case in point. An unweighted species presence analysis of the breast height vegetation of *Quercus velutina* and *Q. alba* reveals that the two are not at all similar, whereas their basal communities are very much so. One can see that a few common and very frequent species can far outweigh a larger number of rarer, constant, and somewhat substrate specific

TABLE 5. Coefficients of association of lichen vegetation on different tree species at base and breast height quadrats. The coefficients were computed as in table 1.

a. RED OAK FOREST

| | *Base* | *Breast height* |
|---|---|---|
| *Quercus rubra — Q. alba* | 70 | 67 |
| *Q. velutina — Q. rubra* | 81 | 78 |
| *Q. velutina — Q. alba* | 83 | 74 |

b. PINE-OAK FOREST

| | *Base* | *Breast height* |
|---|---|---|
| *Q. velutina — Q. alba* | 83 | 57(60)[3] |

[3] Since the asymptote of the species sample curve for the *Quercus velutina* — breast height data under "pine-oak forest" was not as sharp as was seen with the other curves, an extrapolation from 45 to ca. 90 trees was made, which adds approximately 2 species to the *Q. velutina* flora. It can be assumed that one of the two is shared with *Q. alba* in the *Q. velutina-Q. alba* comparison, raising the coefficient from 57 to 60. (See full discussion in text.)

species. For example, three species of *Physcia* and two of *Pertusaria* were found only on *Q. alba* and never on *Q. velutina.*

But if unweighted species presence is accepted as being a more instructive test, it cannot be used in comparing two trees of different frequencies unless a test is made to establish the extent to which the sample size is affecting the number of epiphytic species observed. For example, if 50 white oaks and 25 black oaks were examined, one would normally expect many more epiphytic species on the former if, in a sample of 25 trees, the total lichen flora on that tree species is only barely represented. If it can be shown, however, that in this example, essentially all the epiphytic species on black oak were examined after a sample of 20 trees, and that the same was true of white oak, the two trees can be compared without regard for the sample size. Species-sample curves were constructed for each of the tree species and their lichen vegetation (both basal and breast height) in the red oak and pine-oak forests, and it was shown that with each tree species, the sample size (40 to 90 trees) was sufficiently large to allow direct comparisons with other trees.

Coefficients of association were then calculated for *Quercus velutina* and *Q. alba,* using the basal vegetation and the breast height vegetation. After testing sample size and species number for the oaks in the red oak forests, *Q. velutina* (including *Q. coccinea,* as in the pine-oak forest), *Q. rubra,* and *Q. alba* were found to be comparable on an unweighted species-presence basis (table 5).

Two very interesting things can be seen from the table of coefficients. First, the breast height communities of *Quercus alba* and *Q. velutina* show greater difference than their basal communities. Secondly, this difference appears much greater in the pine-oak forest than in the red oak forest.

Concerning the first point, it should be noted that the bark of *Quercus alba* is unlike that of *Q. velutina* in several respects, the most obvious being hardness, moisture capacity, and color. Bark hardness was not measured as was done by Culberson (1955a), but white oak bark is easily flaked off and gouged with a fingernail, and the bark of *Q. velutina* is sometimes difficult to cut into even with a sharpened steel knife. The average moisture capacity of *Q. alba* was found to be 69 percent (dry weight), 41 percent (volume), and 14 percent (area), and that of *Q. velutina* was found to be 38 percent (dry weight), 30 percent (volume) and 17 percent (area). (See p. 22-28 for a discussion of moisture capacity measurements.)

Hale (1955a) emphasized the differences in bark characters, particularly the moisture capacities, between *Q. alba* and *Q. velutina.* Color is more important than would at first be suspected. Heat absorption and thus, indirectly, evaporation rate must be influenced by bark color. All these factors add up to a characterization of black oak bark as a very dry habitat (hard, low moisture capacity, high evaporation rate) and white oak as a comparatively moist habitat (soft, high moisture capacity, low evaporation rate). Many authors (Barkman, 1958; Billings and Drew, 1938; Young, 1938; Brodo, 1959) have noted the great importance of the physical characteristics of bark on the distribution of epiphytes. This difference in moisture relations between *Q. velutina* and *Q. alba* would naturally be less important at the tree base where the microclimate is normally humid (Barkman, 1958; Billings and Drew, 1938) than at breast height where microclimate is variable and usually drier. The large number of species on *Quercus alba* may thus be related to the wetter microhabitat which can support a greater number of drought-sensitive species.

This difference between *Q. velutina* and *Q. alba* disappears in red oak forests, which are more moist and more shaded than pine-oak forests (Brodo, 1961a), and where the vertical zonation is in general not as distinct as in drier habitats. It should also be noted that many of the species which differentiated the two lichen communities in the well-lighted, pine-oak forest were photophilous species and therefore were absent in the shaded red oak forest.

The lichen community found on *Carya* spp., not included in the statistical studies, is very similar to that of the younger, smoother parts of the oak trunks, especially when well-lighted communities are compared.

Depending on the state of development and position in the community continuum (as reflected in the local dominant species), the following "unions" of LeBlanc (1963) can be referred to the community found on black oak on Long Island: *Bacidia chlorococca* union, *Graphis scripta* union, *Parmelia rudecta, P. saxatilis* and *P. sulcata* unions.

5. *Fagus grandifolia* (American beech).

   Species: *Trypethelium virens, Pyrenula nitida, Buellia curtisii, Graphis scripta, Phaeographis dendritica.*

Comments: The hard, smooth bark of *Fagus grandifolia* effectively limits the lichen community growing on it to crustose species, and the dense, shade-producing canopy restricts the community even further.

6. *Acer rubrum* (red maple).

   Species: *Hypogymnia physodes, Parmelia perforata, Pertusaria trachythallina, Parmelia subaurifera, Lecanora chlarotera, L. caesiorubella* subsp. *lathamii.*

Comments: The community on maple in upland habitats closely resembles that of other smooth, hard barked trees, especially *Quercus coccinea. Hypogymnia physodes,* however, is more abundant on maples than on oaks in oak forests.

7. *Ulmus americana* (American elm).

   Species: *Xanthoria parietina, X. fallax, Physcia millegrana, Ph. stellaris.*

Comments: Elms, especially as they occur along roadsides, have been studied a great deal in relation to their lichen flora. The neutral pH of the bark, no doubt, has a direct or indirect effect upon the epiphytic flora, because other neutral barked trees (e.g., *Populus deltoides, Robinia pseudoacacia*) have very similar floras. In the Braun-Blanquet system, this community would be included in the *Xanthorion parietinae* Alliance (Barkman, 1958). In LeBlanc's treatment of Canadian epiphytic communities (LeBlanc, 1963), the *Xanthoria fallax* union would most closely apply here.

B. Saxicolous.

1. Mortar and concrete. pH 7-10.8
   Species: (a) Full sun — *Caloplaca feracissima, Lecanora dispersa.* (b) Partial or full shade — *Caloplaca flavovirescens, Placynthium nigrum.*

Comments: Mortar and concrete, being highly alkaline and calcareous, are equivalent to limestone in their general characters and in their lichen vegetation. There is no natural occurrence of limestone on Long Island.

2. Granite boulders. Acidic, coarsely crystaline, very hard.
   Species: (a) Full sun — *Rinodina oreina, Lecanora cinerea, Parmelia arseneana, P. conspersa, P. stenophylla, Sarcogyne clavus.* (b) Partial or full shade — *Lecidea albocaerulescens, Lepraria zonata, Parmelia caperata, Lecanora cinerea, Buellia stigmaea.*

Comments: There is some species-overlap on the granite communities of well-illuminated and poorly-illuminated boulders, but a few species are absolutely restricted to one or the other (e.g., *Rinodina oreina* in the former and *Lecidea albocaerulescens* in the latter community).

3. Pebbles and small stones. Usually smooth, but not always; high in quartz. Found in fields, on roadbanks, or in other open areas.
   Species: *Lecidea erratica, L. coarctata, L. cyrtidia, Acarospora fuscata, Rhizocarpon obscuratum.*

Comments: Why these species develop on pebbles and not on boulders of similar hardness and chemistry is hard to determine. It is possible that the high mineral supply (derived from seepage and splashing from surrounding soil) or higher humidity (due to close proximity to ground) is involved. The lack of stability of small stones and pebbles is also probably a factor in limiting the kinds of lichens which can survive in this community (p. 29).

C. Terricolous.

1. Mossy soil. Gravelly, but relatively rich in organic matter; in oak woods of various development; pH not measured. Species: *Cladonia subtenuis, C. caespiticia, C. cristatella, C. bacillaris, C. pleurota, C. chlorophaea, C. furcata.*

Comments: This community is best developed in forest glades, or on moss-covered abandoned roads. It is almost always at least partially shaded.

2. Sandy soil. Little to no organic matter; pH 4.1-4.6.
   Species: (a) Unstable, eroded, sandy loam (roadbanks, fire breaks, etc.; subsoil or very fine sandy loam) — *Baeomyces roseus, Pycnothelia papillaria, Cladonia strepsilis.* (b) More or less stable but bare sandy loam (slightly more sandy than "2") —*Cladonia strepsilis, C. subcariosa, C. clavulifera, C. atlantica, C. chlorophaea, C. pleurota.* (c) Very sandy soil—Lecidea *uliginosa, L. granulosa, Cladonia cristatella, C. macilenta, C. atlantica, C. uncialis, Cetraria islandica.* (d) Dune sand — shifting, sometimes grass-covered — *Cladonia cristatella, C. boryi, C. uncialis, C. submitis, C. chlorophaea, C. furcata* (especially f. *racemosa*), *Cetraria islandica* subsp. *crispa.*

Comments: The sandy-soil communities as outlined above are largely arbitrary units derived from a continuum formed along a soil gradient from comparatively rich, sandy loam to almost pure quartz dune sand. Although a few species are more or less confined to one unit (e.g., *Baeomyces roseus* and *Pycnothelia papillaria*), most terricolous species can be found throughout most of the continuum.

D. Lignum.

1. Unstable, dry lignum (fences, planks, decorticate logs, decorticate branches and twigs).
   Species: *Lecidea aeruginosa, L. botryosa, Cladonia cristatella, C. bacillaris, Lecidea myriocarpoides, Bacidia chlorococca.*

Comments: This community occurs in both partially shaded and sunny habitats. A very frequent member of this community is the imperfect fungus *Coniosporium olivaceum* Link.

As logs and planks become heavily decomposed, the community composition changes, giving rise to the community listed below.

2. Unstable, highly decomposed lignum (rotting logs and stumps).
   Species: *Cladonia parasitica, C. incrassata, C. bacillaris, Micarea prasina.*

Comments: The characters of high acidity and moisture capacity seen in rotting wood have much in common with the bases of *Pinus rigida* and the similarities in community composition are obvious (p. 49). The community is best developed in swamps and bogs where wood decays quickly, but it also occurs in oak forests on heavily decomposed stumps.

## II. BOG AND SWAMP COMMUNITIES

A. Corticolous.

1. *Chamaecyparis thyoides* (swamp white cedar) — *Vaccinium corymbosum* (highbush blueberry).
   Species: *Parmelia hypotropa, Parmeliopsis ambigua, P. aleurites, Cetraria viridis, C. ciliaris, Hypogymnia physodes, Usnea trichodea, U. subfusca* sensu Motyka.

Comments: The corticolous lichen communities on these two woody bog plants are remarkably similar, especially in view of the fact that one is a conifer. Several members of the bog lichen community occur exclusively in bogs and only on these substrates (e.g., *Cetraria viridis, Parmeliopsis ambigua,* and *Usnea trichodea*). The relationship between the bog habitat and the bog lichen flora will be discussed later.

Several lichens commonly found on pine in pine forests are found on white cedar in bogs *(Lecidea anthracophila, Ochrolechia parella, Parmeliopsis aleurites). Cetraria ciliaris,* normally found on white cedars, was collected from *Betula populifolia* in two different maple swamps. The close similarity of *Betula* bark to that of conifer bark was noted by Barkman (1958), Skye (1958), and others.

2. *Acer rubrum* (red maple).
   Species: *Lobaria pulmonaria, L. quercizans, Parmelia rudecta, P. caperata, Pertusaria amara, Bacidia chlorococca.*

Comments: The smooth, hard bark of *Acer rubrum* undoubtedly has a great effect on its epiphytic lichen vegetation. The maple community is almost totally different from that on bog trees and shrubs with looser, more absorbent bark.

3. *Ilex verticillata* (black alder).
   Species: *Trypethelium virens, Graphis scripta, Lecanora caesiorubella* subsp. *lathamii, Pertusaria xanthodes.*

Comments: The affinities of this community to that of *Ilex opaca* have already been mentioned. The presence of the other species mentioned may well be due to the better light conditions in *Ilex verticillata* thickets. The dense shade produced by the canopy of *Ilex opaca* exclude all but the most shade tolerant of species.

B. Terricolous (acid boggy sand, edges of bogs).
   Species: *Cladonia calycantha, C. atlantica.*

Comments: This community also is well developed on dry, acid sand, especially as found in pine barrens.

C. Lignicolous (rotting logs).
   Species: *Cladonia parasitica, C. incrassata, C. didyma, C. vulcanica, C. santensis, C. beaumontii.*

Comments: The community on rotting wood in bogs is basically identical with that of drier forests except for the occasional presence of the four rare species mentioned last.

A marked geographic difference was seen in the community composition in disjunct localities of southern New Jersey and Cape Cod. The dominant species in the New Jersey bog-lignum community was *Cladonia santensis,* which covered large areas of dead wood and cedar stumps. *Cladonia vulcanica* was not collected there at all. On Cape Cod, *Cladonia vulcanica* was clearly dominant and *C. santensis* was not collected. The lignum community in Long Island bogs showed neither *C. vulcanica* nor

*C. santensis* as dominants; both are, in fact, very rare on the island. Instead *Cladonia incrassata* and *C. parasitica,* both common throughout the northeastern coastal plain, were most conspicuous.

## III. MARITIME HABITATS

Because maritime communities are so heavily influenced by their proximity to salt water, it is useful to classify them on the basis of their salt water exposure. Des Abbayes (1934) presented a detailed discussion of the zonation at the shoreline. Following Du Rietz (1925a in des Abbayes, 1934) he recognized three major divisions, (1) the *aerohaline stratum,* which is strictly terrestrial, receiving salt only as a fine mist suspended in the air and which is never wet with salt water, (2) the *hygrohaline stratum,* which receives salt water directly as salt spray, by immersion at very high tides, or at the high spring tides, and (3) the *hydrohaline stratum,* which is submerged with every high tide regardless of the season.

Boyce (1954) and Oosting and Billings (1942) measured the salt spray concentrations at various distances from the mean tide. The latter authors found that salt spray is greatest on the exposed side of the fore dune, less at the hind dune summits, still less at the lee side of the fore dune, and least at the lee side of the hind dune. Boyce reported salt concentrations of up to 2.2 mg salt $dm^2$/hr. at a distance of 270 m from mean tide, with a wind speed of 11 m/sec. His data show that salt concentrations closely depend on wind speeds, as well as distance from the salt source. On Long Island, wind speeds of 11 m/sec, are very common (p. 8) and so one can safely say that the aerohaline zone extends at least 270 m from the water, and probably much beyond.

Des Abbayes subdivided the hygrohaline stratum into three "echelons" based on the presence of certain indicator species. Since none of his indicator species, except for *Verrucaria microspora,* is present on Long Island, only the three major strata will be used in this community classification.

A. Aerohaline stratum (salt mist zone).

1. Corticolous.

a. *Myrica pensylvanica* (bayberry) — *Prunus maritima* (beach plum).

Species: (a) Exposed to full wind and salt-mist (fore dunes, bluff tops, beaches): (1) base — *Parmelia sulcata, P. hypotropa;* (2) breast height — *Rinodina milliaria, Lecidea varians, Parmelia hypotropa.* (b) Protected from full wind and salt mist (lee side of dune, groves of trees): (1) base — *Parmelia sulcata, P. livida;* (2) breast height — *Parmelia hypotropa, P. perforata, Lecidea varians, Ramalina fastigiata, Usnea strigosa.*

Comments: All the species listed are photophilous with high drought and salt resistance. It is evident, however, that wherever moisture is greatest in the dunes areas, the lichen vegetation is most luxuriant. This type of community is best seen in the Montauk Point area and behind the moving dunes at Promised Land. The lichen communities listed above occur on many shrubs along the shores, and almost unchanged on many of the dune and beach trees. (See discussions of black cherry and red cedar below.)

b. *Prunus serotina* (wild black cherry).
Species: *Parmelia sulcata, P. subaurifera, Buellia curtisii, B. stillingiana, Pertusaria xanthodes, Lecidea varians, Usnea strigosa.*

Comments: This community has many similarities with the shrub communities, and differs chiefly in the inclusion of several additional photophilous crusts.

c. *Juniperus virginiana* (red cedar).
Species:*Physcia millegrana, P. orbicularis, Ramalina willeyi, Parmelia hypotropa.*

Comments: This community is surprisingly "nitrophytic" (cf. p. 30) perhaps from the neutralizing effects of salt mist (see Barkman, 1958).

The absence of conspicuous crustose species is perhaps due to the instability of the substrate.

d. *Ilex opaca* (American holly).
Species: *Trypethelium virens, Phaeographis dendritica.*

Comments: This community is very similar to that on *Fagus grandifolia* and *Ilex verticillata,* which are the only other substrates for *Trypethelium virens.* The most striking similarity between the trees is that all three possess a very thin, hard outer bark with a living layer just beneath. This factor alone could not be the decisive one in determining the distribution of *Trypethelium,* however, since many other trees and shrubs have this character also (e.g., *Acer rubrum* and *Amelanchier intermedia*).

2. Saxicolous.

a. Concrete and mortar.
Species: *Xanthoria parietina, Caloplaca citrina.*

Comments: *Verrucaria muralis, V. nigrescens* and *Rinodina salina* occur as rare members of the community having only been found at Orient Point.

*Xanthoria parietina* and *Caloplaca citrina* are common aerohaline species, although both are also widely distributed far from salt water (p. 249 and 252).

*Lecanora dispersa* and *Candelariella aurella* are also found in the aerohaline stratum as facultative members of the community. The former is listed by des Abbayes (1934) as a typical member of the aerohaline stage community. Alvin (1961) noted *Catillaria chalybeia, Rinodina demissa (R. salina), Lecanora dispersa, Xanthoria parietina* and *Candelariella vitellina* (ecologically equivalent to *C. aurella*?) as comprising a community found on the bricks of a sea wall on the east coast of England. This community is remarkably similar to the one on Long Island except for the absence of *Caloplaca*.

b. Granite boulders.

Comments: No lichens were seen which were at all confined to the aerohaline granitic rocks, although several species normally found farther inland were found growing in the salt spray zone. *Parmelia caperata* and *Acarospora fuscata* are conspicuous species in this category. *Parmelia caperata* was listed by des Abbayes (1934) as common in the aerohaline stage.

3. Terricolous.

a. Stabilized sand (as on Orient Point).

Species: *Cladonia pyxidata, C. strepsilis.*

Comments: On Long Island, *Cladonia pyxidata* has only been collected on stabilized beach sand in the salt spray zone. It is interesting, from the standpoint of the possible salt-preference of this species, that I have seen it growing in luxuriant abundance on beach sand on the shore of Lake Erie (Point Pelee, Ontario). *Cladonia strepsilis* is clearly a facultative member of the aerohaline community.

b. Dune sand (as on Fire Island and at Napeague Beach — figure 9).

Species: *Cladonia submitis, C. boryi, C. uncialis, C. cristatella, Cetraria islandica, Cladonia chlorophaea.*

Comments: Since the community on dune sand extends essentially unchanged into inland localities, salt spray can be eliminated as important in defining its distribution. It is possible, in fact, that heavy salt spray such as would occur on an exposed fore dune may inhibit the community's development (p. 203).

A description of a coastal sand dune community is presented by Alvin (1960) in a study of lichen ecology of England's south coast at Dorset. He characterizes the dune lichen vegetation using a "cross-section" of a dune much as I did with a south shore Long Island dune (Brodo, 1961a). Although Alvin's dune system was more complicated (consisting of three ridges), his community is very similar structurally and even floristically to that of Long Island. Unbranched *Cladoniae* such as *C. coniocraea, C. chlorophaea,* and *C. macilenta* were closest to the ocean on relatively unstable sand, giving way to the shrubby *Cladinae (C. sylvatica, C. impexa, C. tenuis), C. furcata, C. uncialis,* and *Cornicularia aculeata* farther back in protected depressions behind the first main ridge. Finally appearing on the stable second ridge were *Lecidea (Biatora) uliginosa, Cladonia crispata,* and *C. squamosa.* With a few species replacements such as *Cetraria islandica* subsp. *crispa* for *Cornicularia aculeata* which in eastern America is much more northern, *Cladonia submitis* for the more northern and/or European *Cladinae,* and the North American endemic *C. atlantica* and *C. squamosa* (which is more mesic on Long Island), the dune community is essentially unchanged in structure.

This is but another example of closely related species in different geographic areas occupying similar niches in similar habitats to create remarkably similar communities.

4. Lignicolous (windswept stumps).

Species: *Lecanora laevis.*

Comments: Species occurring in the windswept areas of the island (on beaches and sand dunes) often are very well developed. *Lecanora laevis* is a good example, often covering old, hard, windswept stumps, especially at Orient Point.

B. Hygrohaline stratum (salt spray and storm tide zone) (saxicolous).

Species: *Bacidia umbrina, Acarospora fuscata.*

Comments: The species listed as "characteristic" of the hygrohaline community (which is almost non-existent on Long Island) are actually far from their normal habitats (farther inland) and seem to be displaying more of a tolerance for the zone than a preference for it.

C. Hydrohaline stratum (littoral zone) (saxicolous) (figure 14).

Species: *Verrucaria microspora, V. silicicola.*

Comments: The members of the hydrohaline community are found in no other habitats. Degelius (1940) reported *V. microspora* from the upper hydrohaline in Maine. *Verrucaria erichsenii,* which Degelius found abundant in the lower hygrohaline stratum was not found on Long Island.

# City Effect

No discussion of the lichen vegetation of a partially urban area would be complete without a consideration of the detrimental effects of city climate on lichen growth and diversity — the "city-effect." The city effect phenomenon has been so well documented in recent years that it has become one of the most well-known of lichen characteristics, even to persons knowing little else about these organisms. I studied the problem as it occurs on Long Island in some detail and published the results in a recent paper (Brodo, 1966). It is necessary here only to point out certain aspects peculiar to the Long Island situation, and to repeat the general conclusions.

Nearly the entire western third of Long Island is made up of a portion of New York City and its heavily-populated suburbs. It is not surprising, therefore, that a strong city effect can be demonstrated on the lichen flora. Unbiased sampling of the lichens of oak forests along the north shore, transplant experiments of foliose lichens along two east-west transects, and analyses of the distributions of many species all were made to determine the extent of this effect. The results of these three approaches gave slightly different types of information but basically corroborated each other.

The red-oak forest samples of epiphytic lichens showed that there is a gradual increase in number of species and number of individuals as one leaves the city center, and that different species "recover" at different rates. It also showed that there is little "vertical shift" in the tree bole vegetation; i.e., lichens normally found at breast height on trees in central Long Island do not gradually become more and more restricted to tree bases closer to the city, a phenomenon reported by several observers of city lichens in other parts of the world (Jones, 1952; Rydzak, 1958; Gilbert, 1965).

The results of controlled transplant experiments pointed out that the city environment is powerful enough to kill certain foliose lichens within a few months of exposure, and that with a year of exposure, the effect can be demonstrated as far as 40 miles from central Brooklyn.

Distribution maps of numerous species again indicate that the city effect is felt up to about 40 miles from Brooklyn, and that different species enter the improved flora at different points.

There have been a great many words written and many speculations made concerning the causes of the city effect. Air pollution is the factor most often given as the main element, but city-induced drought is also cited quite often and certainly must be considered. There is little doubt that lichens are very sensitive to air pollutants, ($SO_2$ is the material most often mentioned), and few would deny that the peculiar biology of lichens makes them particularly sensitive to changes in microclimate. Why some recent workers have attempted to attribute the entire effect to one or the other of the two elements is therefore puzzling (see Rydzak, 1958 and Gilbert, 1965).

The results of the studies on Long Island were compared with those of previous studies done in Europe, and a hypothesis was developed which, I believe, incorporates the two elements of city environment into a plausible explanation of the city effect. A detailed discussion of this hypothesis has been published. In general, however, it appears that both city-induced drought and air pollution affect the lichen flora of an urban area. Air pollution is carried to a much greater distance and is the chief factor in the reduction in species diversity over long distances. Drought is felt only locally, in and immediately around the most built-up portions of the city. On Long Island, the pollution effect is so strong that almost all lichens are killed well beyond the limit of the drought effect. The influence of drought is best demonstrated in the field by changes in the vertical distribution of corticolous species. This, then, explains why there is no vertical distribution shift on Long Island, while in other areas, where pollution is not as great and the drought and pollution affected lichens overlap, a vertical shift is noted close to the cities.

# Floristic Elements

## INTRODUCTION

In an area as small and geologically uniform as Long Island, historical factors cannot explain local distribution patterns, since ample time has been available for the uniform distribution of any plants which arrived on the island other than very recently introduced adventives. The migration routes by which these plants reached Long Island are of considerable interest, however, and it is worthwhile to examine some of the probable sequences of events which fashioned the lichen flora of Long Island as we see it today.

In attempting a floristic analysis of the lichen flora of Long Island, it has been necessary to analyze the major distribution patterns represented in eastern North America, and to view these patterns not only with regard to North American distributions in general, but also with certain aspects of worldwide distribution. There is a much greater need for a broad geographic perspective in dealing with distribution of lichens as compared with flowering plants since endemism on a species level is much more common in the latter (Ahti, 1964). Approximately 24 percent[4] of the lichens of Long Island are endemic to North America as compared with an estimated 65 percent of the vascular flora. (The vascular plant statistics were derived from an unbiased sample from Smith and Ogden's unpublished preliminary flora of Suffolk County, in conjuncton with comments on endemism in Fernald [1950].)

Many authors have contributed to our understanding of the floristic patterns to be seen in eastern North America. Good (1964) provides a general pattern of the major elements. The forest regions of the eastern deciduous forest as described and mapped by Braun (1950), although not delineated by floristic criteria, reveal some of the basic floristic features of eastern North America, particularly the strong influence of the Appalachian Mountains.

There have been few general treatments of lichen distribution in North America. Thomson (1963) in his monograph of *Physcia,* discussed American distribution patterns with an emphasis on extra-American relationships. Although his eight categories have limitations for the kind of floristic analysis I would like to attempt here, two of Thomson's categories are used in only slightly modified form. The phytogeographic system proposed by Hale (1961a) is very useful and many of his categories are retained essentially unaltered.

## THE CLASSIFICATION OF ELEMENTS

The floristic elements have been broadly classified according to general climate. An Arctic-Boreal, Temperate, and Tropical element can thus be recognized. The elements are each divided into two or more "sub-

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[4] Computed from a sample of 87 percent of the total lichen flora.

elements," and, in one case, further subdivided into geographical units. The limits of these categories are presented below and representatives of each in the Long Island lichen flora are listed in table 6.

*Element I: Arctic-Boreal.*

The Arctic-Boreal element is that element which has no climatic northern boundary. Since tree line would be a northern boundary for arctic corticolous species but not for arctic terricolous species, substrate was bypassed as a limiting criterion.

We can recognize two subelements within the Arctic-Boreal element. The *Arctic-alpine subelement* corresponds closely with Thomson's (1963) "circumboreal arctic-alpine" category. It is distinctly arctic in character, extending into temperate United States only in the alpine zones of some of the eastern and western mountains. With this circumscription, it is obvious that no member of this subelement could be present on Long Island. The members of the Arctic-Boreal element which do extend into boreal and temperate climates are grouped together as the *Boreal-temperate subelement* (figure 20). These species are generally very widespread due to their broad climatic tolerances and access to circumpolar migration routes.

*Element II: Temperate.*

In the Temperate element are included all species with relatively distinct northern and southern climatic limits, usually close to the northern and southern boundaries of the United States.

The temperate element can be divided into six subelements. The first is more or less intermediate between typically arctic and temperate distributions. This *North Temperate subelement* is not considered as arctic due to its relatively clear northern boundaries, but shows distinct boreal tendencies in many instances. It is best developed in northern United States and southern Canada, although it often extends southward to include most of continental United States (figure 21). The "circumboreal north temperate" category of Thomson (1963) corresponds to this subelement, which includes many of the more widely distributed common species.

Three important physiographic features of temperate eastern North America are the coastal plain, the Appalachian and Ozark mountain systems, and the Mississippi valley. The Appalachian Mountains form the core of the area occupied by the *Appalachian subelement*. Extensions and slight modifications of the basic Appalachian distribution permit us to recognize a number of "units" within this subelement. The *Appalachian unit* includes only species whose basic distribution is along the NE-SW mountain chain alone (figure 22). Extensions to include the Ozark Mountains, the Great Lakes region, and the southern Rocky Mountains define the *Appalachian-Ozark*, *Appalachian-Great Lakes*, and *Appalachian-Great Lakes-Rocky Mountains* units, respectively (figures 23-25).

Species confined to any or all three of the segments of the coastal plain (i.e., Gulf, southern Atlantic and northern Atlantic) are included in the *Coastal Plain subelement* (figure 26). This subelement often shows an extension into the Mississippi Valley.

A large number of eastern temperate species are not restricted to the Appalachian or coastal plain regions but are found throughout the eastern deciduous forest from the Mississippi Valley (or even farther west) to the Appalachians or the east coast. These species comprise the *East Temperate subelement* (figure 27). There sometimes is a distinct northern or southern concentration within the subelement (see maps of *Parmelia galbina* and *P. livida* in Culberson, 1961) but its division into two units is not warranted.

Often, there is a narrowly restricted concentration of records in the northeastern states, and it is difficult to decide whether the species belongs to an eastern segment of the North Temperate subelement, a northern segment of the East Temperate subelement, or a portion of an Appalachian-Great Lakes distribution. Any or all of these may be involved, of course, and there is no value in recognizing separate categories. "Northeast Temperate" species have arbitrarily been listed with the East Temperate subelement.

There are a number of wide-ranging species which are apparently relics of ancient and worldwide distributions, and which now are restricted in their distributions by their narrow climatic tolerances (see below). These species are grouped together into the *Oceanic subelement.* They are generally characterized in North America by having east coast-west coast disjunct distributions (figure 28). Other species with oceanic tendencies (e.g., *Lobaria quercizans, Collema subfurvum*) but which have well defined distributions in one of the subelements already described are considered only with the latter. In table 6 they are designated with asterisks.

The oceanic type of distribution (usually considered as an element in its own right) perhaps has been studied more than any other, especially in Europe (Degelius, 1935; Mitchell, 1961; Faegri, 1958). Degelius (1941) also made some observations on oceanic species in eastern North America.

The Oceanic subelement is characterized by its occupation of areas with high atmospheric humidity (although degrees of rainfall may differ from one place to another), and areas where temperature fluctuations are small from one season to another (i.e., having mild winters and cool summers). Though areas of this type are generally coastal, they need not be. A definite oceanic flora can be found in the Smoky Mountain region of Tennessee and North Carolina (Degelius, 1941). In the present study no distinction is made between "eu-oceanic" (strictly oceanic in distribution) and "suboceanic" (basically oceanic with a somewhat broader tolerance of other climates) as was done by Degelius (1935) since lichen distributional and ecological limits are still relatively poorly known within North America as compared with Europe.

FIGURE 20. Arctic-Boreal element: Boreal-Temperate subelement. *Cladonia alpestris* (after Ahti, 1961).

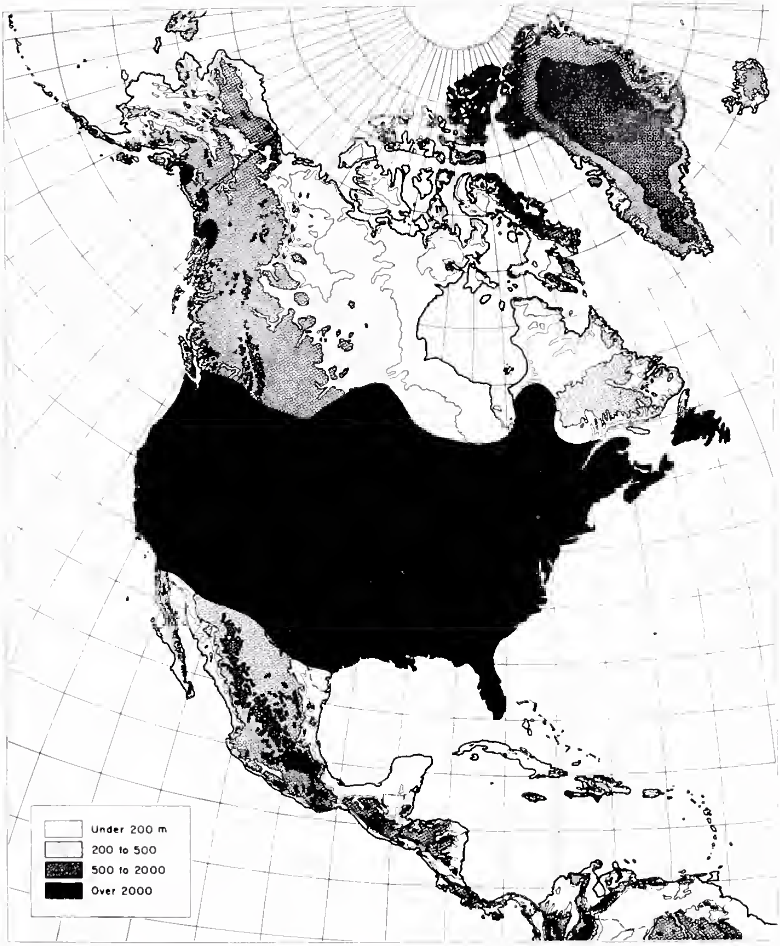

FIGURE 21. Temperate element; North Temperate subelement. *Physcia stellaris* (after Thomson, 1963).

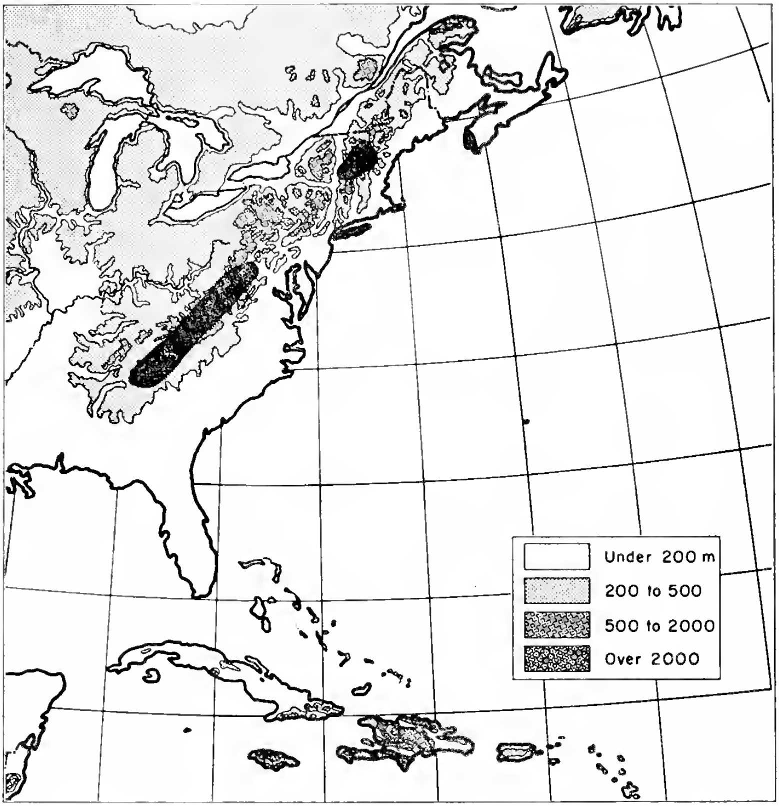

FIGURE 22. Temperate element; Appalachian subelement; Appalachian unit. *Parmelia appalachensis* (after Culberson, 1962).

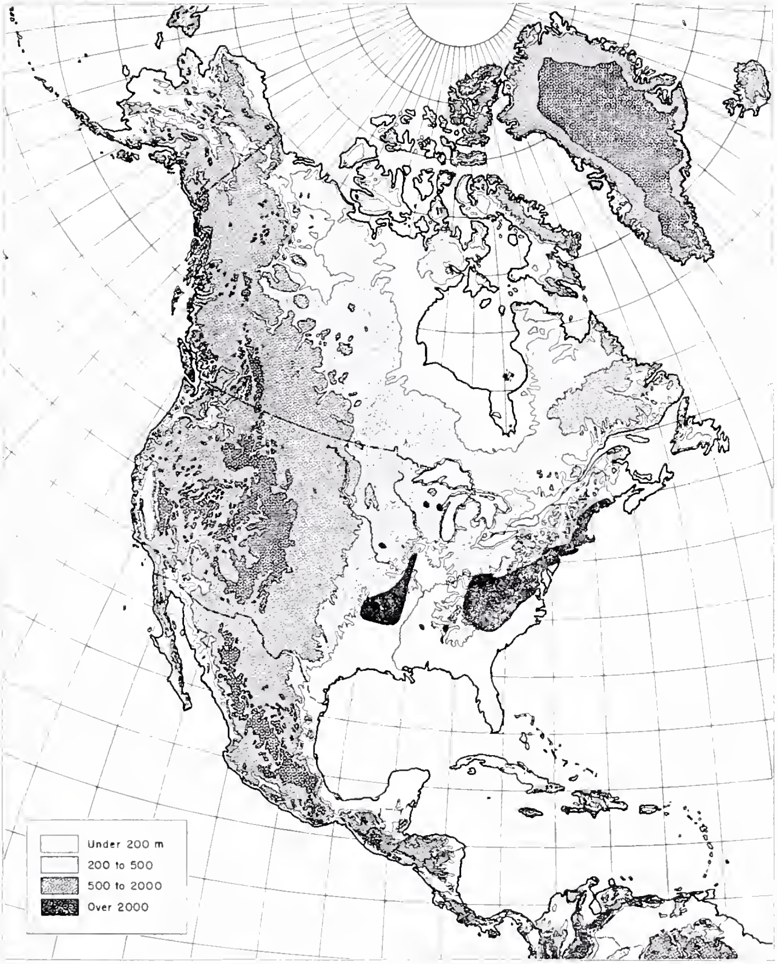

FIGURE 23. Temperate element; Appalachian subelement; Appalachian-Ozark unit. *Anzia colpodes* (after Hale, 1955c).

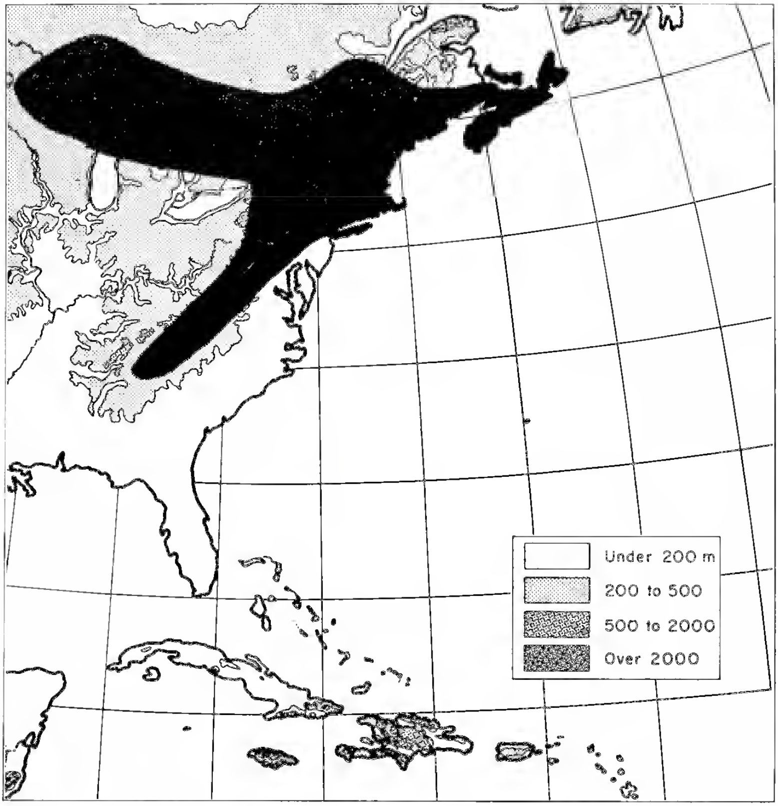

FIGURE 24. Temperate element; Appalachian subelement; Appalachian-Great Lakes unit. *Parmelia olivetorum* (after Culberson, 1958b).

FIGURE 25. Temperate element; Appalachian subelement; Appalachian-Great Lakes-Rocky Mountain unit. *Pseudevernia furfuracea* (after Hale, 1955c).

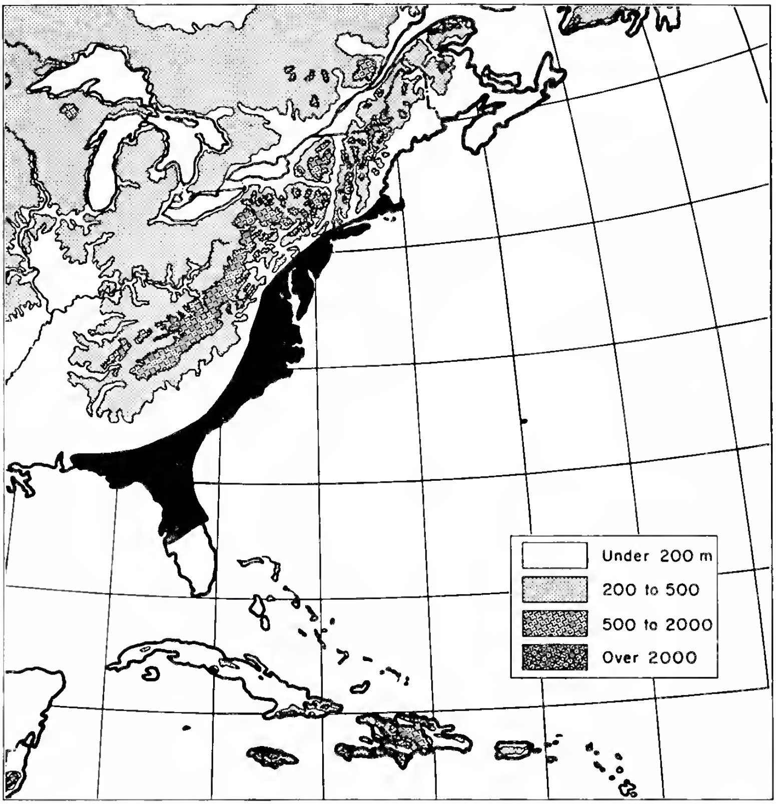

FIGURE 26. Temperate element; Coastal Plain subelement. *Ramalina willeyi* (after Howe, 1914).

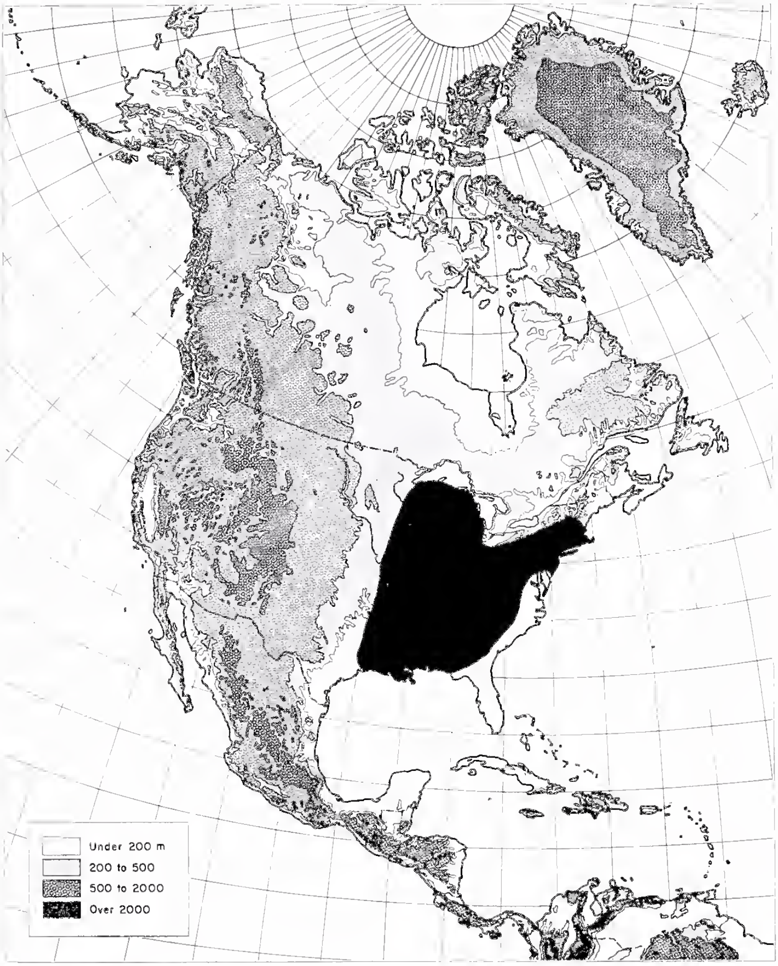

FIGURE 27. Temperate element; East Temperate subelement. *Parmelia aurulenta* (after Hale, 1958).

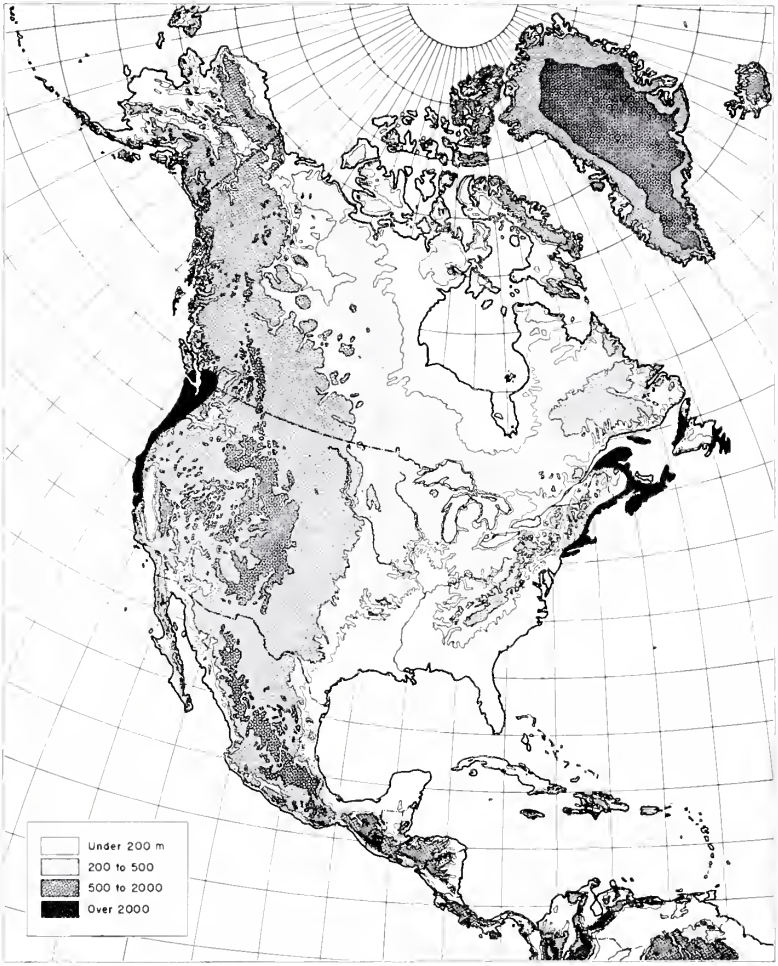

FIGURE 28. Temperate element; Oceanic subelement. *Nephroma laevigatum* (after Wetmore, 1960).

Members of the *Maritime subelement* are restricted by habitat availability to the temperate maritime zones along the coast. Compared to the maritime flora of Europe, this subelement is very poorly developed in eastern North America (see Degelius, 1940). Although the Maritime subelement theoretically includes species restricted to the sea coast by the presence of salt water, salt spray, or some associated marine influence, no aerohaline species from Long Island appear to fit into this category.

*Element III: Tropical.*

Species which show a basically tropical distribution are grouped into the *Tropical element.* Representatives in the western hemisphere are usually widespread in Central and/or South America and sometimes can be found in other tropical areas throughout the world as well. The element is manifest in eastern North America, centered in the Appalachian mountain system and on the coastal plain, and is thus conveniently divided into *Appalachian-Temperate* and *Coastal Plain subelements.* It is perhaps also proper to recognize an *Oceanic subelement,* although there appears to be only one example on Long Island.

## SUMMARY OF SIGNIFICANT FEATURES

Table 7 presents a summary of the categorization of the lichen flora into its phytogeographic elements and subelements, with figure 29 giving a graphic representation of some of the important facets of the major categories. The summary is based on table 6, which includes approximately 81 percent of the known Long Island lichen flora, all the species for which we have some good phytogeographic information.

Some observations which deserve special attention are:

1. The Arctic-Boreal element is represented by 21 percent of the flora, all but two species being partially or entirely circumboreal.
2. Many of the most common species on Long Island (see table 7) are members of the Arctic-Boreal element, e.g., *Cladonia chlorophaea, C. coniocraea, Parmelia sulcata* and *P. saxatilis.*
3. The Temperate element is most abundantly represented (71 percent of the flora).
4. All North American endemic species are in the Temperate element, mainly in the East Temperate (6 percent) Appalachian (7 percent) and Coastal Plain (8 percent) subelements. In all, 24 percent of the lichens of Long Island are endemic.
5. Of the sampled species with an East Asia-East America disjunct distribution (16 in all), by far the greatest number (38 percent) are found in the East Temperate subelement.
6. Considering its northern latitude, Long Island has a surprisingly good representation of tropical species (8 percent). Most members of the Tropical element are confined to the coastal plain in eastern North America.

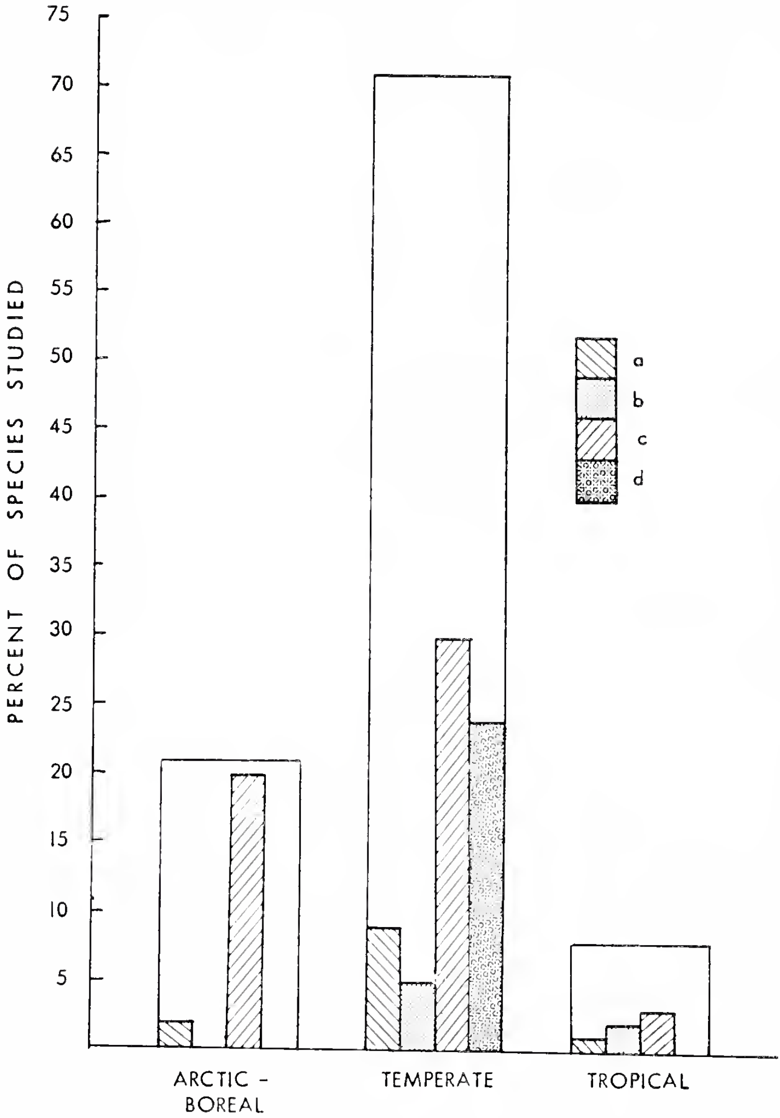

FIGURE 29. Phytogeographic affinities of the Long Island lichen flora. The three floristic elements are depicted on the abscissa. Percentages on the ordinate were derived from a sample of 209 species (81 percent of the total lichen flora). (a) Species also found in Europe alone, (b) species also found in Asia alone, (c) species also found in both Europe and Asia, (d) species endemic to North America.

7. Most of the species having amphiatlantic distributions (12 percent) are represented in the Temperate element (the East Temperate and North Temperate subelements).

## DISCUSSION

Braun's (1950) map of the forest regions and sections in eastern North America reveals that Long Island lies at the apex of three major forest types: the Oak-Chestnut region, with its origin in the Appalachian foothills and southeastern piedmont, and the Southeastern Evergreen forest region, which lies on the Gulf and Atlantic coastal plains. The Hemlock-White Pine-Northern Hardwoods region lies to the north but is separated from direct continuity with Long Island by an area of Oak-Chestnut forest in southern Connecticut.

The new vegetation map by Küchler (1964) shows a very similar pattern, but with the vegetation units more precisely delimited. For example, Küchler's map clearly shows the change from the oak-hickory-pine forest of the southeastern piedmont to the northeastern pine-oak forest of southern New Jersey, Long Island, and Cape Cod, and shows more clearly the differences between the Gulf coastal plain and the central- and northeastern coastal plain vegetation.

Thus, there are at present three unbroken biological "highways" along which species can migrate to Long Island from the south, and an almost uninterrupted conifer-hardwoods forest to the north which provides easy access for northern species. These migration routes have existed essentially unchanged for thousands of years.

The greater part of Long Island has only been available for colonization since late Pleistocene time after the last retreat of the Wisconsin ice in that area (ca. 15,000 to 20,000 years before the present). It is highly probable that a considerable portion of the northern continental shelf now under water was exposed as a coastal plain during and just after the last glacial maximum (Fogg, 1930; Nichols, 1958). As the Long Island area became ice free this extensive coastal plain would have provided an opportunity for unhindered plant immigrations from the south and west. Soon after, sea levels rose, due to the melting of the glaciers (Flint, 1957), flooding the Long Island Sound area separating Long Island from any closer connections it might have had with New Jersey and submerging much of the southeastern New England coast. Much of the submerged coastline north of Long Island reemerged with the up-doming of the area (Flint, 1957), but since Long Island was apparently on or just south of the "hinge line" it remained an island.

The high percentage of circumboreal species in the Boreal-Temperate and Northern Temperate subelements (95 percent and 77 percent, respectively) is not surprising in view of the extreme likelihood of late Tertiary and Pleistocene land bridges across parts of the arctic, allowing the free flow of plants from one continent to another (Fernald, 1931; Flint. 1957; Colinvaux, 1964). Graham (1964) cites evidence for North Atlantic migrations via the arctic islands during periods of temperate climate in the Cenozoic. Arctic species probably can still migrate via the northern islands in a circumpolar route (Li, 1952).

The theory of pre-Pleistocene continental drift is still very much alive and, if true, may explain many of the present day amphiatlantic lichen distributions (Dansereau, 1957; Good, 1964). Hultén (1958)

TABLE 6. Phytogeographic categories represented in the Long Island lichen flora. Aspects of each species' world-wide distribution are noted as follows: A=found in Asia; E=found in Europe; N=North American endemic; X=not endemic, but absent from Europe and Asia. Species with oceanic tendencies but which cannot be placed in the Oceanic subelement are indicated by asterisks (*). Details of the distribution of each species and/or references to published summaries or maps are presented in the annotated list.

New information concerning the world-wide distribution of a few of these species was incorporated into the following list too late to be included in the statistical summaries. There is no appreciable change in any of the summary percentages.

## I. ARCTIC-BOREAL ELEMENT

A. *Arctic-alpine subelement:* no representatives on Long Island

B. *Boreal-temperate subelement.*

| | |
|---|---|
| *Caloplaca pyracea* | AE |
| *Candelariella aurella* | AE |
| *C. vitellina* | AE |
| *Cetraria islandica* | AE |
| *Cladonia alpestris* | AE |
| *C. arbuscula* | AE |
| *C. cariosa* | AE |
| *C. carneola* | AE |
| *C. chlorophaea* | AE |
| *C. deformis* | AE |
| *C. fimbriata* | AE |
| *C. furcata* | AE |
| *C. mitis* | AE |
| *C. pleurota* | AE |
| *C. pyxidata* | AE |
| *C. rangiferina* | AE |
| *C. scabriuscula* | AE |
| *C. squamosa* | AE |
| *C. uncialis* | AE |
| *C. verticillata* | AE |
| *Dermatocarpon miniatum* | AE |
| *Diploschistes scruposus* | AE |
| *Hypogymnia physodes* | AE |
| *Lecanora cinerea* | AE |
| *L. dispersa* | AE |
| *L. rubina* | AE |
| *L. symmicta* | AE |
| *Lecidea macrocarpa* | AE |
| *Lecidea vernalis* | AE |
| *Parmelia saxatilis* | AE |
| *P. sulcata* | AE |
| *Parmeliopsis ambigua* | AE |
| *Peltigera aphthosa* | AE |
| *P. canina* | AE |
| *P. polydactyla* | AE |
| *P. praetextata* | AE |
| *Placynthium nigrum* | AE |
| *Rhizocarpon grande* | AE |
| *Rinodina oreina* | E |
| *Sarcogyne simplex* | AE |
| *Solorina saccata* | AE |
| *Verrucaria muralis* | AE |
| *Xanthoria fallax* | E |

## II. TEMPERATE ELEMENT

### A. *North Temperate subelement*

*Acarospora fuscata* AE
*Alectoria glabra* N
*Bacidia umbrina* E
*Buellia punctata* AE
*B. stillingiana* N
*B. turgescens* N
*Caloplaca aurantiaca* AE
*C. cerina* AE
*C. citrina* AE
*C. flavovirescens* AE
*Candelaria concolor* AE
*Catillaria glauconigrans* N
*Cetraria ciliaris* AE
*Chaenotheca phaeocephala* E
*Cladonia bacillaris* AE
*Cladonia coniocraea* AE
*C. conista* AE
*C. macilenta* AE
*C. multiformis* X
*C. nemoxyna* AE
*Evernia mesomorpha* AE
*Graphis scripta* AE
*Lecanora atra* AE
*L. hageni* AE
*L. muralis* AE
*L. varia* AE
*Lecidea aeruginosa* AE
*L. albocaerulescens* AE
*L. botryosa* AE
*L. coarctata* E
*L. granulosa* AE
*L. nylanderi* AE
*L. scalaris* AE
*L. uliginosa* AE
*L. viridescens* AE
*Lobaria pulmonaria** AE
*Micarea prasina* AE
*Parmelia caperata* AE
*P. conspersa* E
*P. reticulata* AE
*P. stenophylla* AE
*Pertusaria amara* E
*Physcia adscendens* AE
*Ph. aipolia* AE
*Ph. orbicularis* AE
*Ph. stellaris* AE
*Rinodina confragosa* AE
*R. milliaria* N
*Sarcogyne clavus* E
*Stereocaulon saxatile* E
*Usnea longissima* AE
*Verrucaria nigrescens* AE

### B. *East Temperate subelement*

*Bacidia atrogrisea* AE
*B. inundata* E
*B. schweinitzii* N
*Buellia curtisii* N
*B. polyspora* X
*Cladonia apodocarpa* N
*C. brevis* E
*C. caespiticia* AE
*C. capitata* AE
*C. caroliniana* N
*C. clavulifera* A
*Cladonia cristatella* N
*C. floerkeana* AE
*C. parasitica* AE
*C. strepsilis* AE
*C. subcariosa* AE
*C. subtenuis* X
*Dimerella diluta* AE
*D. lutea* AE
*Lecidea anthracophila* E
*L. cyrtidia* N
*L. erratica* E
*Leptogium corticola* E
*Leptogium cyanescens* AE
*Leptorhaphis epidermidis* E
*Micarea melaena* AE
*Parmelia aurulenta* A
*P. galbina* A
*P. livida* N
*P. perforata* E
*P. rudecta* A
*Parmeliopsis aleurites* AE
*Phaeographis dendritica* AE
*Physcia millegrana* N

*Physcia subtilis* N
*Ph. tribacoides* E
*Pycnothelia papillaria* E
*Pyxine sorediata* A
*Ramalina fastigiata* AE
*Trypethelium virens* N
*Usnea mutabilis* N
*U. strigosa* A

## C. *Appalachian subelement*

### 1. *Appalachian unit:*

*Buellia dialyta* N
*B. stigmaea* N
*Cladonia piedmontensis* N
*Haematomma* sp. N
*Parmelia appalachensis* N

### 2. *Appalachian-Ozark unit:*

*Anzia colpodes* X
*Caloplaca camptidia* N
*Parmelia hypotropa* AE

### 3. *Appalachian-Great Lakes unit:*

*Alectoria nidulifera* AE
*Anaptychia palmulata* A
*Bacidia chlorantha* N
*B. chlorococca* E
*Baeomyces roseus* AE
*Cetraria tuckermanii* N
*Collema subfurvum** AE
*Haematomma ochrophaeum* A
*Lobaria quercizans** N
*Parmelia olivetorum* AE
*P. subaurifera* AE
*Umbilicaria mammulata* N
*U. muhlenbergii* AE

### 4. *Appalachian-Great Lakes-Rocky Mountain unit:*

*Cetrari fendleri* N
*Cladonia mateocyatha* N
*Parmelia subrudecta* AE
*Parmeliopsis placorodia* N
*Pseudevernia furfuracea* E
*Umbilicaria papulosa* X

## D. *Coastal Plain subelement*

*Bacidia chlorosticta* N
*Cetraria viridis* N
*Cladonia atlantica* N
*C. beaumontii* N
*C. boryi* A
*C. evansii* N
*C. floridana* N
*C. incrassata* AE
*C. santensis* N
*C. simulata* N
*C. submitis* A
*Lecanora caesiorubella* subsp. *lathamii* N
*L. cupressi* N
*Melanotheca cruenta* N
*Parmelia michauxiana* N
*Pertusaria propinqua* N
*P. xanthodes* N
*Porina cestrensis* N
*Ramalina stenospora* N
*R. willeyi* N
*Usnea trichodea* A

## E. *Oceanic subelement*

*Cladonia terrae-novae* N[5]
*Nephroma laevigatum* AE
*Pertusaria velata* AE
*Xanthoria parietina* AE
*Xylographa opegraphella* N

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[5] This species was added to the Long Island list too late to be included in the various statistical summaries of phytogeographic affinities.

### F. *Maritime subelement*

| | |
|---|---|
| *Verrucaria microspora* | E |
| *Verrucaria silicicola* | N |

## III. TROPICAL ELEMENT

### A. *Coastal Plain subelement*

| | |
|---|---|
| *Cladonia calycantha* | AE |
| *C. didyma* | A |
| *C. vulcanica* | A |
| *Parmelia dilatata* | AE |
| *Pertusaria tuberculifera* | X |
| *Porina nucula* | E |
| *Ramalina complanata* | X |
| *Teloschistes flavicans* | AE |

### B. *Appalachian-Temperate subelement*

| | |
|---|---|
| *Anaptychia obscurata* | AE |
| *A. pseudospeciosa* | A |
| *Cladonia cylindrica* | A |
| *C. pityrea* | AE |
| *Pannaria lurida* | X |
| *Parmelia perlata* | AE |
| *P. plittii* | X |
| *Teloschistes chrysophthalmus* | E |

### C. *Oceanic subelement*

| | |
|---|---|
| *Cladonia carassensis* | AE |

---

suggested that amphiatlantic patterns are best explained by postulating eastern and western continental migrations from the Bering Strait region rather than trans-Atlantic migrations. Colinvaux (1964) has sketched the Pleistocene floristic activity over the Bering land bridge. Dahl (1950) considered present day American-European disjunct distributions of lichens and some other plants as having originated from arctic parental populations which survived the ice ages in unglaciated areas of the arctic. Among the Long Island lichens, 14 percent of the species have amphiatlantic distributions.

North Temperate and some Oceanic species possibly migrated across the northern regions during pre-, inter-, or post-glacial warm periods and later retreated southward with a cooling of the northern regions and the glacial advance, returning only as far north as the northern conifer-hardwoods with the disappearance of the ice. Potzger (1952) presented palynological evidence to suggest that the pine barrens of southern New Jersey served as a refugium for many boreal communities which were displaced southward by the Wisconsin glaciation. These northern plants survived the ice ages side by side with southern communities, only to migrate northward again with the retreat of the ice. Long Island, therefore, was in an excellent position to be invaded by many of these northern species. *Cladonia terrae-novae* probably derived its distribution pattern in this way (p. 201). Possibly some North Temperate species also were introduced from Eurasia into the North American flora during the post-glacial warm period and were eliminated from the northern boreal and arctic latitudes following the recent cooling in northern climate.

Fernald (1931) and Braun (1955) present evidence showing that the Appalachian and coastal plain floras originated from pantropic connections that invaded the Appalachians at a very early time. With the uplift of the area during the Tertiary, some species moved out onto the newly exposed coastal plain, leaving only fragmentary relics behind on the Appalachian plateaus. Much speciation appears to have occurred in the southern Appalachians during the long period of its isolation (Fernald, 1931), and the high percentage of endemics seen in the Appalachian and Coastal Plain subelements may date from this time.

During the Pleistocene glaciation, coastal plain species were restricted to regions south of the ice, although probably not very far south (Braun, 1955; Potzger, 1952). With the retreat of the ice, the northeastern coastal plain became available for colonization from the south. Fernald (1931) cited much botanical evidence to support his theory that there was a post-glacial period of relatively warm climate when the entire coastal plain was connected by a continuous land formation perhaps as far north as Newfoundland (see also Braun, 1955). If this was the case, there was an excellent route available for the migration of the new coastal plain species northward to Long Island and beyond (cf. above, and Fogg, 1930).

The East Temperate subelement had at least two origins: one, as an eastern segmentation of a north temperate distribution, and the other as a broadening Appalachian distribution. Those East Temperate species which originated from the north are likely to show an amphiatlantic

TABLE 7. Phytogeographic affinities of Long Island lichens. All percentages are percent of total sample (209 species, or 81 percent of total lichen flora).

| | Total of species | Percent of flora | In Europe, not Asia | | In Asia, not Europe | | Europe and Asia | | N. Amer. Endemic | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | # | % | # | % | # | % | # | % |
| I. ARCTIC | 43 | 21 | 2 | 1 | 0 | 0 | 41 | 20 | 0 | 0 |
| 1. Arctic-alpine | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2. Boreal-temperate | 43 | 21 | 2 | 1 | 0 | 0 | 41 | 20 | 0 | 0 |
| II. TEMPERATE | 149 | 71 | 19 | 9 | 11 | 5 | 63 | 30 | 50 | 24 |
| 1. N. Temperate | 52 | 25 | 7 | 3 | 0 | 0 | 39 | 19 | 5 | 2 |
| 2. E. Temperate | 44 | 21 | 9 | 4 | 6 | 3 | 13 | 6 | 12 | 6 |
| 3. Appalachian | 26 | 12 | 2 | 1 | 2 | 1 | 7 | 3 | 14 | 7 |
| 4. Coastal Plain | 21 | 10 | 0 | 0 | 3 | 1 | 1 | 1 | 17 | 8 |
| 5. Oceanic | 4 | 2 | 0 | 0 | 0 | 0 | 3 | 1 | 1 | 1 |
| 6. Maritime | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| III. TROPICAL | 17 | 8 | 3 | 1 | 4 | 2 | 6 | 3 | 0 | 0 |
| 1. Coastal Plain | 8 | 4 | 2 | 1 | 2 | 1 | 2 | 1 | 0 | 0 |
| 2. Appal.-temp. | 8 | 4 | 1 | 1 | 2 | 1 | 3 | 1 | 0 | 0 |
| 3. Oceanic | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| TOTALS: | 209 | 100 | 24 | 11 | 15 | 7 | 110 | 53 | 50 | 24 |

pattern, whereas those coming from the Appalachian center often are either North American endemics or show evidence of a widespread Tertiary (and East Asia disjunct) distribution (cf. below).

The historic relationships of the various elements, subelements, and units are summarized in figure 30.

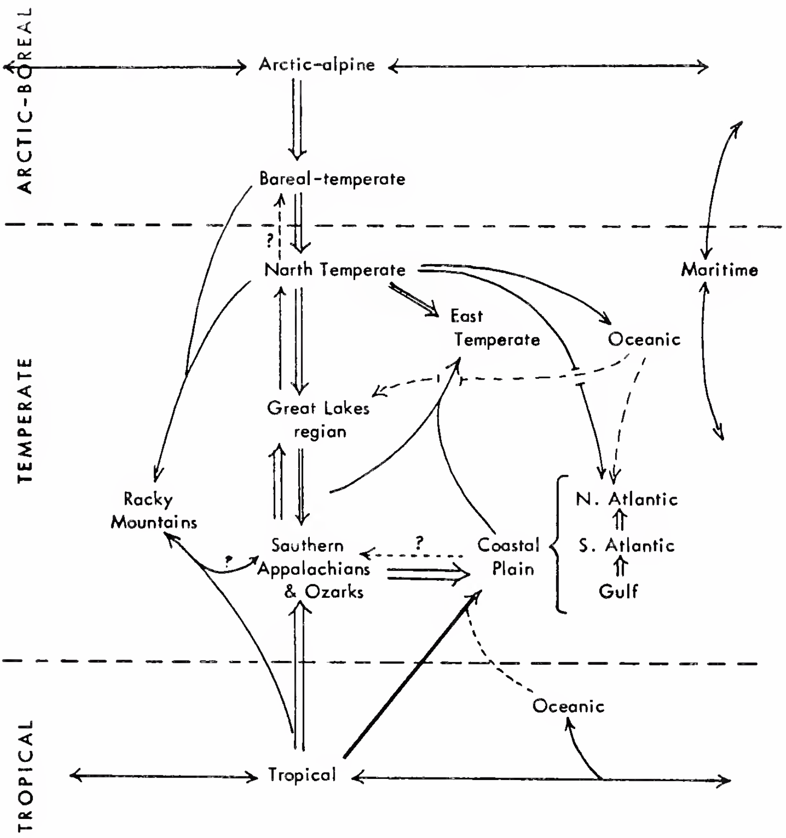

FIGURE 30. Historic relationships between floristic elements, subelements, and units in eastern America. Arrows indicate the general direction of the migration of species from one area (or category) to another. The categories have been placed in quasi-geographical positions relative to each other. Thickness of an arrow indicates the relative extent of the migration; a dotted line arrow refers to a slight connection. Tropical and Arctic-boreal elements indicate their worldwide affinities, whereas the Temperate element is relatively isolated except through its tropical or boreal connections.

The similarity between the floras of temperate eastern North America and eastern Asia have long been recognized and discussed (Li, 1952). This classical disjunct distribution pattern is clearly evident within the temperate element of Long Island lichens. Eight percent of the Long Island flora represents Eastern America-Eastern Asia disjuncts. Li (1952) states that Asian-Eastern Temperate floral similarities represent a relic distribution of a Tertiary flora which once covered the temperate to arctic northern hemisphere. The fragmentation of the flora was caused by many geological changes including mountain formations, continental submergence, climatic change, and glaciation (Li, 1952).

It is especially interesting to note that we see these disjunct patterns on a species level with lichens, whereas phanerogamic botanists rely on generic similarities (Fernald, 1931; Li, 1952). This sort of evidence can suggest extreme genetic stability and slow rate of evolution in many lichen fungi as compared with flowering plants (see also Thomson, 1963). In discussing amphitropic distributions, Raven (1963) points out that disjunct distributions on a species level, especially when involving autogamous organisms (as would be the case with lichens) probably are due to long distance dispersal, particularly by migrating birds, and not to any once continuous populations which became extinct in intervening areas. While this may be true of amphitropic distributions of flowering plants along bird migration pathways, it is hardly possible that the east Asia disjunct distributions of dozens of species in the eastern American lichen flora could have their origin by long distance dispersal, especially when this pattern is well known in other plants at higher taxonomic levels.

Degelius' wide experience with the European lichen flora permitted him to recognize a number of European-American vicariant pairs in his studies of the lichen flora of Maine (Degelius, 1940). He proposed a new category, "subvicarious species," to include species which do not entirely displace each other but instead show different frequency ratios in the different areas. He suggested various alternate possibilities for vicariant and subvicariant combinations as follows (1-4). Capital letters indicate the species is abundant, and small letters indicate it is rare. Alternatives 5-11 have been added and will be discussed below.

| *Alternative* | *N. America* | *Europe* | |
|---|---|---|---|
| 1. | A | B | (true vicariants) |
| 2. | A + b | B | (subvicariants) |
| 3. | A | a + B | |
| 4. | A + b | a + B | |
| 5. | a | b | (?) |
| 6. | a | B | (not vicariants) |
| 7. | A | b | |
| 8. | a + b | B | |
| 9. | A | a + b | |
| 10. | A + b | A | |
| 11. | A | A + b | |

In order to discuss these alternatives, we must first define "vicariant (or vicarious) species." Vicariants are disjunct, but closely related species which are similar morphologically and often ecologically. I think it is fair to say that most definitions implicitly or explicitly assume approximately equal abundance of the two vicarious populations. This would then immediately exclude alternatives 6 through 11, and especially 10 and 11 as vicariants.

Since Degelius almost certainly wanted to emphasize relative abundance rather than absolute abundance of vicarious pairs, alternative 5 is superfluous (being equivalent to alternative 1) and can be eliminated.

There are many other possible combinations which could be listed, of course, but they clearly do not represent vicariants.

European-American vicarious species found in the Long Island flora are listed in table 8. Degelius' use of *Parmelia (Pseudevernia) cladonia* and *P. furfuracea* as an example of alternative 2 is not applicable. *Pseudevernia cladonia* is relatively rare in North America, while *P. furfuracea* is more widespread and often common. The pair would, therefore, more closely fit into alternative 10 (assuming the North American and European chemical populations of *P. furfuracea* are basically con-

TABLE 8. European-American vicarious sub-generic taxa in the Long Island lichen flora. In the cases with asterisks, the parent or daughter populations have apparently continued to diverge and speciate, producing double-taxon vicariants. The problem, while slightly more complicated, is basically the same. Alternate No. 1 of Degelius (1940) refers to "true vicariants" with one species found exclusively in America and the other, equally abundant, found only in Europe. Alternative No. 2 refers to "sub-vicariants", with the European species represented in the American flora as a rare or very local plant in addition to the more abundant American species.

| America | Europe | Degelius (1940) Alternate Number |
|---|---|---|
| 1. *Cladonia subtenuis* | *C. tenuis* | 2 |
| 2. *C. terrae-novae* | *C. impexa* | 1 |
| 3. *Pseudevernia furfuracea* (lecanoric acid strain) | *P. furfuracea* (olivetoric and physodic acid strains)* | 1 |
| 4. *Lobaria quercizans* | *L. amplissima* | 2 |
| 5. *Umbilicaria papulosa* | *U. pustulata* | 2 |

specific) and should no longer be considered as vicariants.[6] It is interesting that alternatives 3 and 4 are entirely absent. Even Degelius (1940) could not give an example of No. 3, and his example of No. 4 *(Lecanora carpinea-L. pallida)* is no longer applicable in the light of recent studies (Imshaug and Brodo, 1966). A consideration of the origin of vicariants and their probable relative abundance is, therefore, of interest.

Vicariants originate from speciation of an isolated portion of a widespread population. The geographic separation of a parent and daughter species may occur either before or after the initiation of the new species. Löve (1955) makes a definite distinction between the two types of resulting vicariants. He regarded those species having arisen *after* geographic segmentation of a parent species as "true vicariads," and those species which arose within a parent population by some immediate genetic isolating mechanism (such as polyploidization) and *later* became separated from the parent population, as "false vicariads." Löve, after discussing the usefulness of the distinction, explains how, in flowering plants, cytological studies can establish what type of vicariism is involved in each particular case. Even if the distinction is useful, as it may well be in certain organisms, i.e., in lichen fungi which appear to be genetically "apomictic," the distinction cannot be made.

In any case, if either type of vicariism mentioned above occurs, it is evident that alternatives 2 and 3 should be more common than alternative 1 because of the low probability of entirely displacing a parent population (i.e., with the parent population becoming totally extinct in one area). It is therefore significant that two of the three examples of No. 1 cited by Degelius (1940) *(Lobaria quercizans-L. amplissima; Umbilicaria papulosa-U. pustulata)* now appear to be the more common alternative 2. (It should be pointed out, however, that the North American population of *Lobaria amplissima* is disjunct from that of *L. quercizans*, being known only from southern Mexico.)

It is therefore even more puzzling that there are no examples of alternative 3 in the lichen flora. One could hypothesize that all lichen vicariants are "true" vicariants (*sensu* Löve, 1955) and have come *from* Europe (suggesting an interesting way of analyzing a migratory direction) but this would be an unlikely conjecture since it is also possible that "false vicariism" is involved and in the opposite direction.

Alternative 4, which requires an original bidirectional migration or occasional long distance imports in one or both directions with the maintenance of an equilibrium ratio between the two species (see MacArthur and Wilson, 1963) appears to be least likely of all.

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[6] Hale (pers. comm.) informs me that *Pseudevernia cladonia* and *P. furfuracea* are not actually closely related, and that the former is locally common in some areas above 3000-4000 ft.

## SUMMARY

The affinities and possible origins of the various phytogeographic categories are presented schematically in figure 30. In general, there seems to have been two routes of worldwide distribution: arctic-boreal and tropical, with the Temperate element largely derived from one of these two origins. Long Island is approached from the north via the oak-chestnut forests which included parts of western Long Island before urbanization. The fragmentation of what probably once were continuous European-American boreal or temperate distributions gave rise to many examples of amphiatlantic patterns, including several vicarious pairs of species. Many northern species reached the island from the south, however, just after the last glacial maximum. Some of the temperate species which originated in southeastern United States reached Long Island via the Appalachian Mountain system, which partially empties out into northern New Jersey. The Atlantic coastal plain provided a coastal "highway" along which southern species, many of which originated in the southern Appalachians, could migrate northward to Long Island. These same two migration routes were used in the introduction of tropical species into the Long Island flora. Oceanic species, many of which had ancient origins and worldwide distributions, became isolated in various areas of eastern North America in late Tertiary and Quaternary times, such as in the humid and comparatively mild Smoky Mountains of the Appalachian system and along the northeastern coast including parts of eastern Long Island, Nantucket Island, Cape Cod, Newfoundland, and Nova Scotia.

# The Lichen Flora

## COLLECTIONS

In 138 Long Island localities, approximately 3,200 collections were made. An additional 290 collections in southern New Jersey, 200 on Nantucket Island, and 400 on Cape Cod provided information on mainland and island floristic connections with the Long Island lichen vegetation.

Floristic distribution maps often come under serious criticism because they are said to represent the perambulations of the collector rather than the distribution of the organisms. To overcome this short-occur. As a result, a map can be prepared to indicate species absence seen in a locality were collected no matter how common they are. In this way, a determination of where a species does not occur can be made almost as accurately as the determination of where the species does occur. As a result, a map can be prepared to indicate species absence as well as presence (Imshaug, 1957a). Of course, rare species will occasionally be missed and common ones will occasionally be forgotten, but, on the whole, an attempt at a complete-collection is a significant improvement over the more haphazard collecting methods of the past. This method was employed in all the Long Island, New Jersey, and Cape Cod localities.

The Long Island localities are listed below and are represented by numbered dots in figure 15. In the interests of brevity, localities are cited in the annotated catalog only by locality-number, in parentheses.

KINGS COUNTY: (1) Prospect Park (Brooklyn Botanic Gardens).

QUEENS COUNTY: (2) Forest Park, oak woods; (3) Alley Pond Park, oak woods and field.

NASSAU COUNTY: (4) Sands Point, shaded maple-oak woods and open field; (5) North Hills, dry slope above swamp; (6) Valley Stream, *Acer rubrum* swamp and oak clearing; (7) Rockville Centre, Hempstead Lake State Park; (8) East Meadow, "Hempstead Plains;" (9) Brookville, mature oak woods; (10) Glen Cove, mature red oak-beech woods; (11) Laurel Hollow; (12) Cold Spring Harbor, path and black oak woods; (13) Cold Spring Harbor, woods; (14) Syosset-South Huntington, young oak woods; (15) Bethpage, young oak woods, recently burned; (16) Massapequa-Seaford, black oak woods.

SUFFOLK COUNTY: (17) Centerport, red oak-chestnut oak woods and roadside. (18) Vernon Valley (near Northport), red oak woods; (19) South Huntington-Half Hollow, oak-hickory woods; (20) Dix Hills, oak woods and mossy slope; (21) Commack, mature oak woods; (22) Deer Park, oak woods and pine woods; (23) Deer Park, woods, swamp, and field; (24) near Babylon, pine-oak woods bordering acid bog; (25) Captree State Park, sand dunes; (26) near King's Park, red oak woods; (27) San Remo, beech-oak-ash woods; (28) Hauppauge, wet woods; (29) Central Islip, young oak woods; (30) Ronkonkoma, oak-pine woods; (31) Heckscher State Park south of E. Islip, oak-hickory woods; (32) Oakdale, young oak woods, and West Sayville, roadside; (33) Fire Island, Cherry Grove, Sunken Forest Preserve, *Ilex opaca* grove; (34) Missequogue, chestnut oak-red oak woods; (35) St. James, red oak-

FIGURES 31-81. Long Island distributions. Each open circle represents a locality where a collection of a complete set of lichen species was made, but where the species in question was absent. With the exception of figure 32 (see below), a black dot indicates that a specimen of the species was collected in that locality. Specimens collected by Latham, Brainerd, Hulst, and others are mapped whether or not they were recollected by me in the same locality. In some cases (e.g., the pre 1900 New York City collections), these old records are of considerable historic interest. All Brooklyn dots represent pre 1900 collections.

FIGURE 31. Localities of oceanic species. Included are the Long Island localities of *Cladonia terrae-novae, Collema subfurvum, Leptogium cyanescens, Lobaria pulmonaria, L. quercizans, Nephroma laevigatum,* and *Pertusaria velata. Xanthoria parietina* was excluded since its distribution appears in figure 84.

FIGURE 32. Bog and swamp localities.

FIGURES 33-41. Lichens found mainly in bogs and swamps.

FIGURES 42-52. Lichens found mainly in pine-oak forests. (42-47: with few or no localities east of Shinnecock; 48-52, with eastern extension; 42-45: pine specific; 46-47: oak specific.)

FIGURES 53-56. Lichens found mainly in morainal areas. (53-56: terricolous; 57-60: saxicolous; 61-63: corticolous)

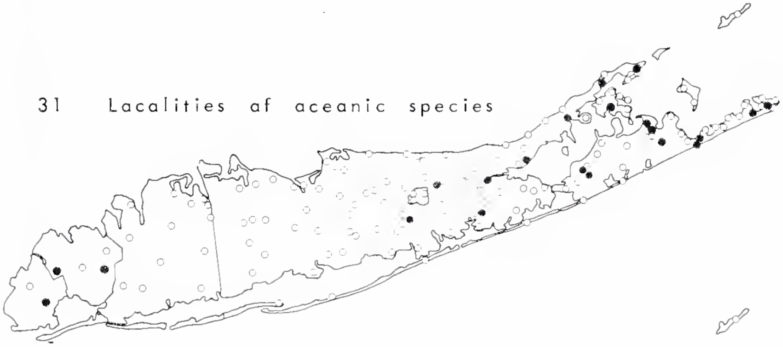
FIGURES 64-70. Lichens found mainly in the humid "fog belt" region. (69-70: fog belt species collected in New York City prior to 1870)

FIGURE 71. An avoidance of the red oak forest. *Physcia millegrana.*

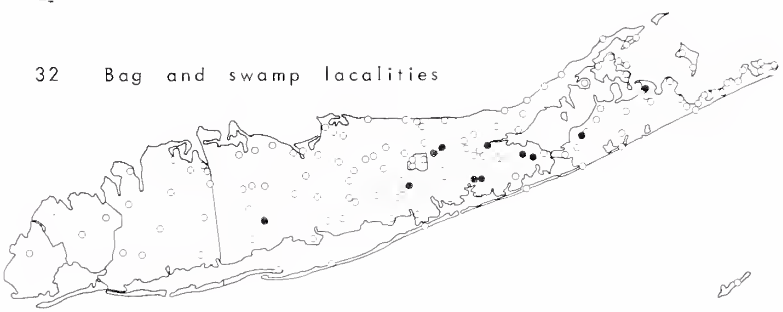
FIGURES 72-73. The scattered distribution of two terrestrial lichens.

FIGURES 74-76. Lichens found mainly on sand dunes and sand plains.

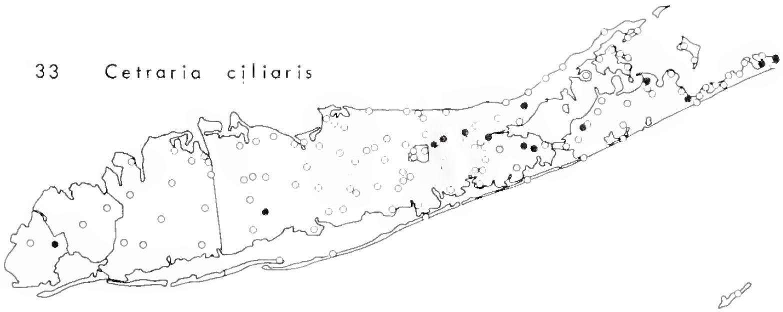
FIGURES 77-81. Lichens having a maritime distribution. (71-80: aerohaline; 81: hydrohaline.)



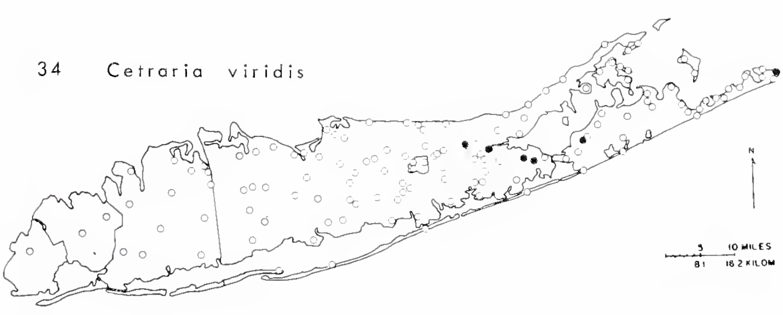
31 Lacalities af aceanic species



32 Bag and swamp lacalities

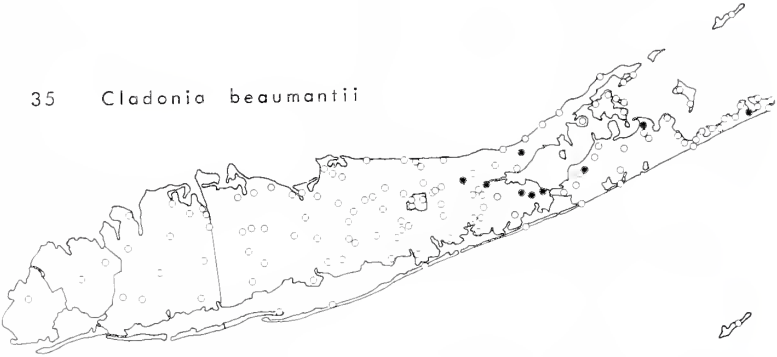


33 Cetraria ciliaris

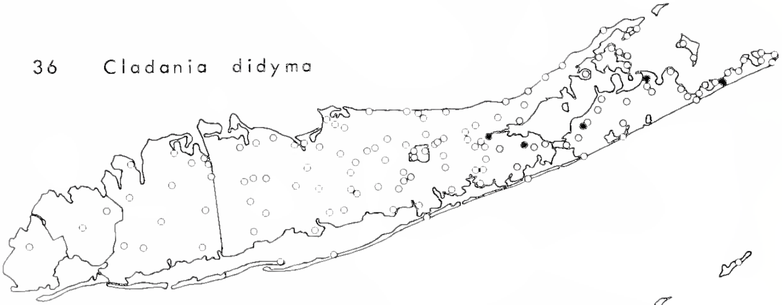


34 Cetraria viridis

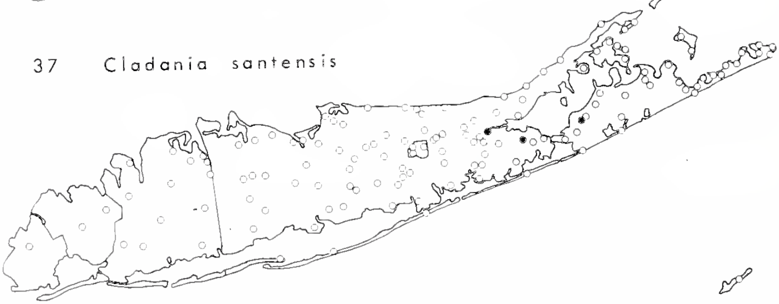
35 Cladonia beaumantii



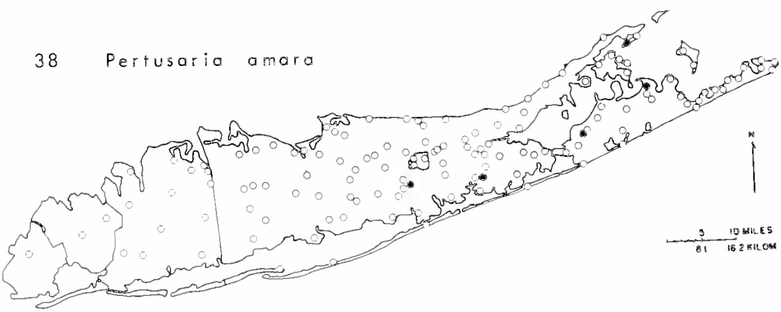
36 Cladania didyma

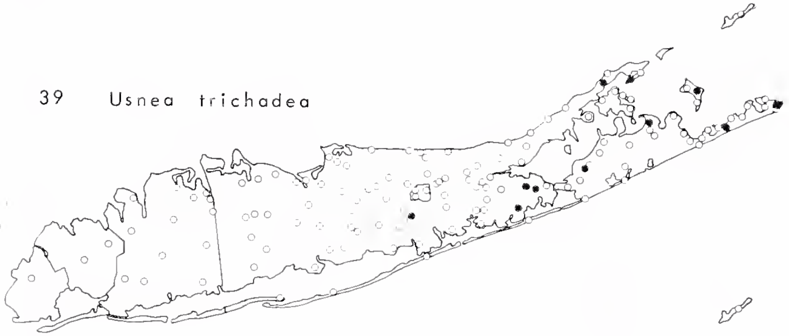


37 Cladania santensis

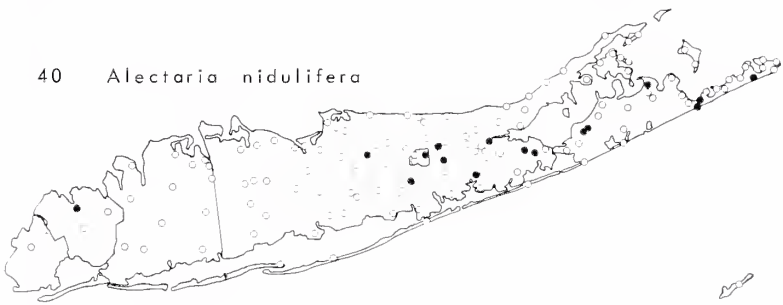


38 Pertusaria amara

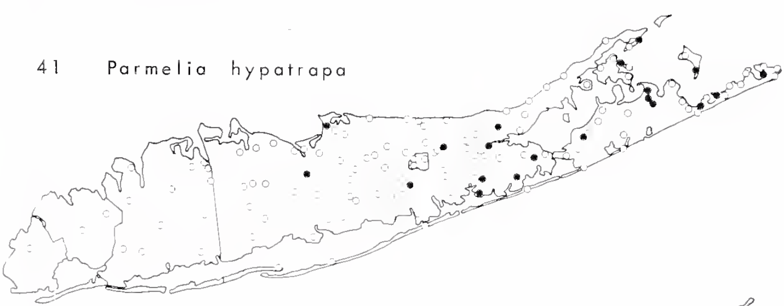




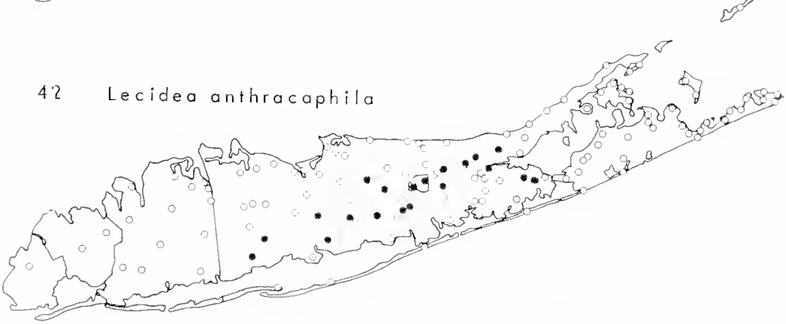
39 Usnea trichadea



40 Alectaria nidulifera

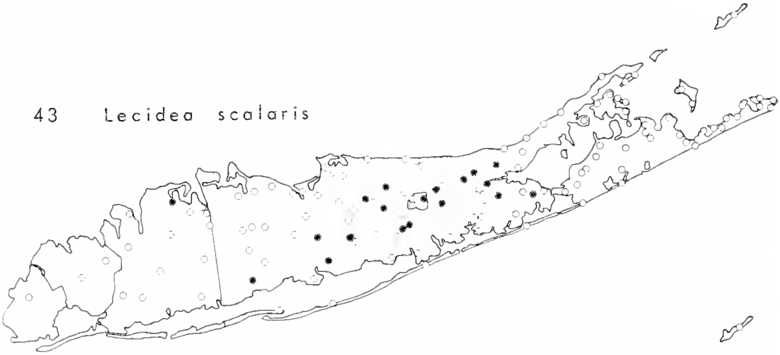


41 Parmelia hypatrapa

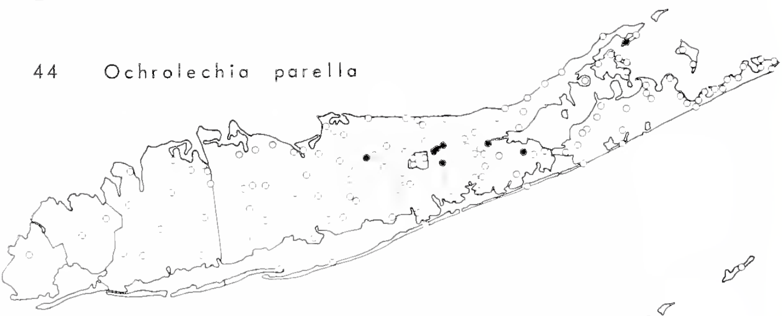


42 Lecidea anthracaphila

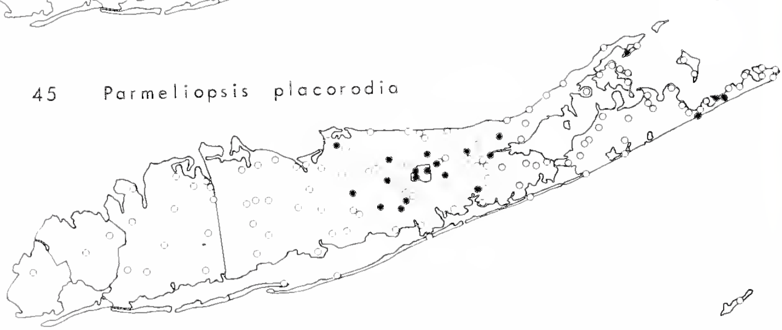
43 Lecidea scalaris



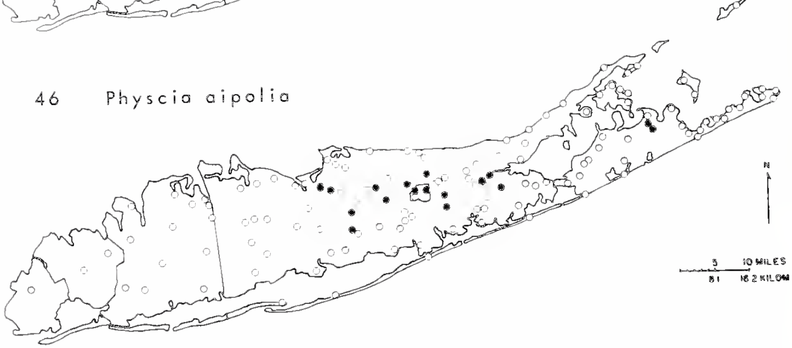
44 Ochrolechia parella



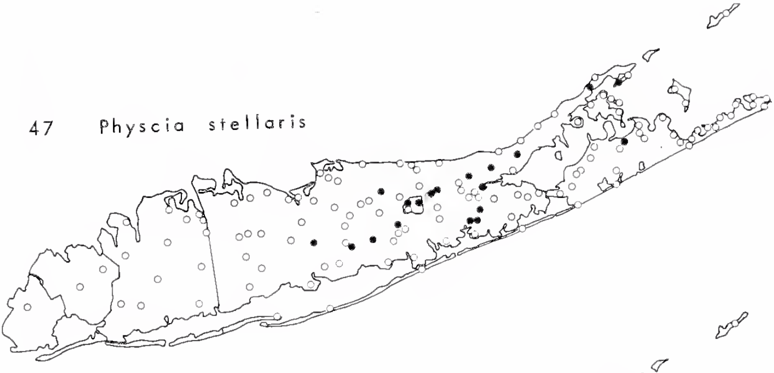
45 Parmeliopsis placorodia



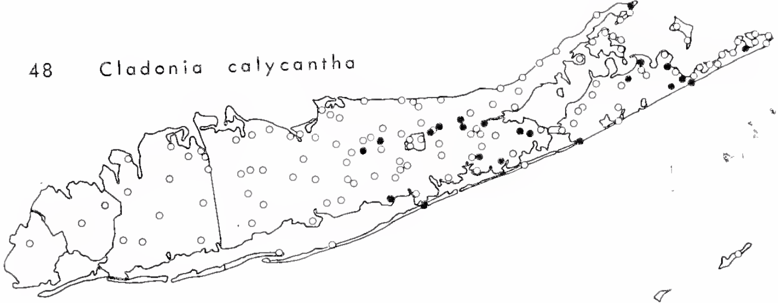
46 Physcia aipolia



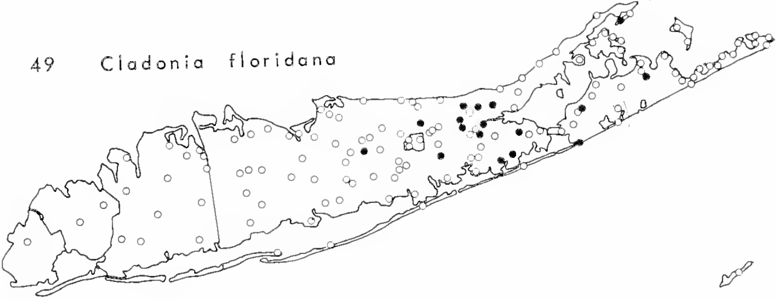
47 Physcia stellaris



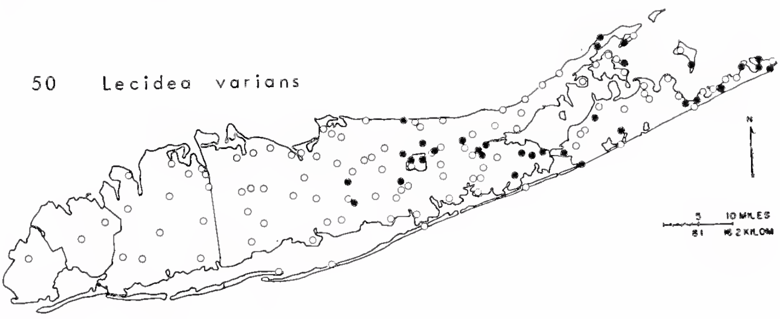
48 Cladonia calycantha



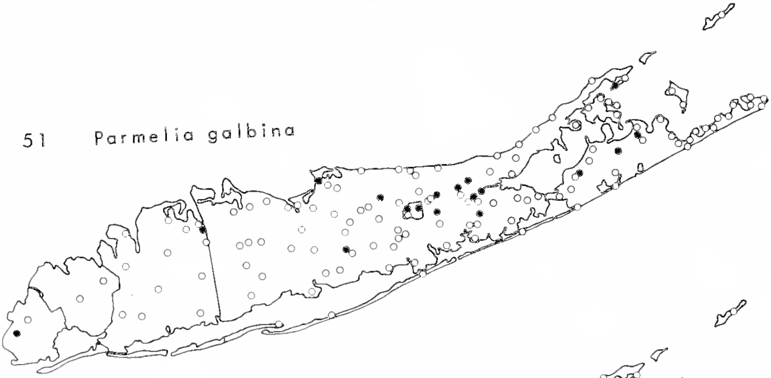
49 Cladonia floridana



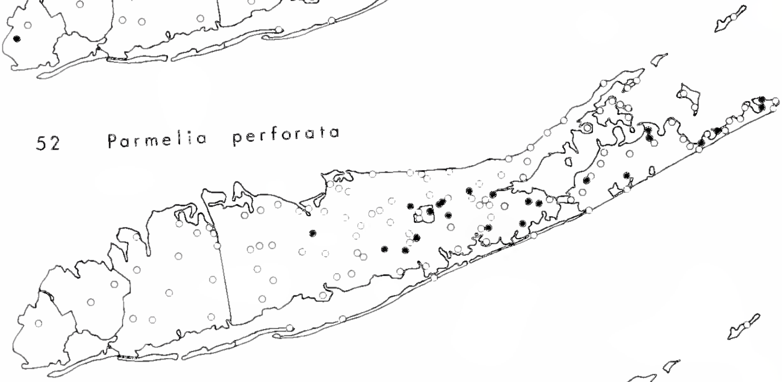
50 Lecidea varians



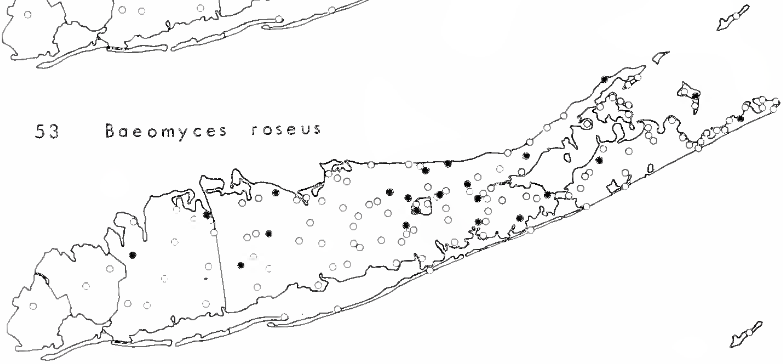
51 Parmelia galbina



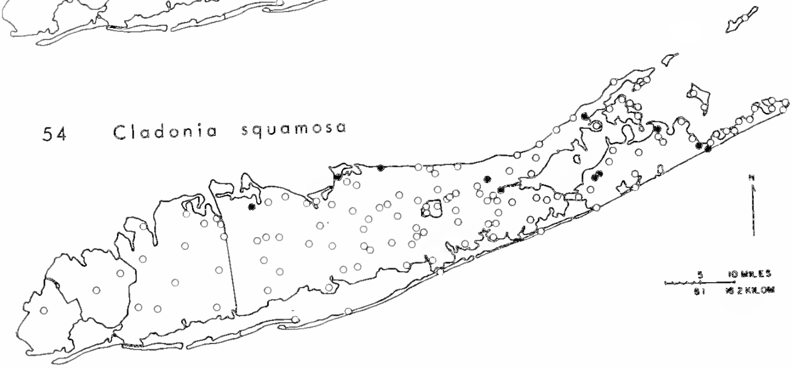
52 Parmelia perforata

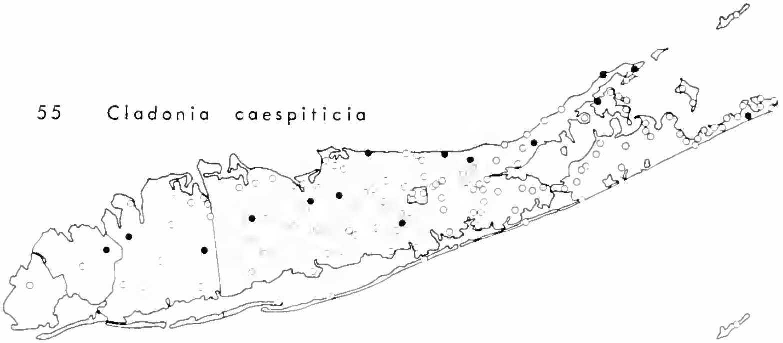


53 Baeomyces roseus

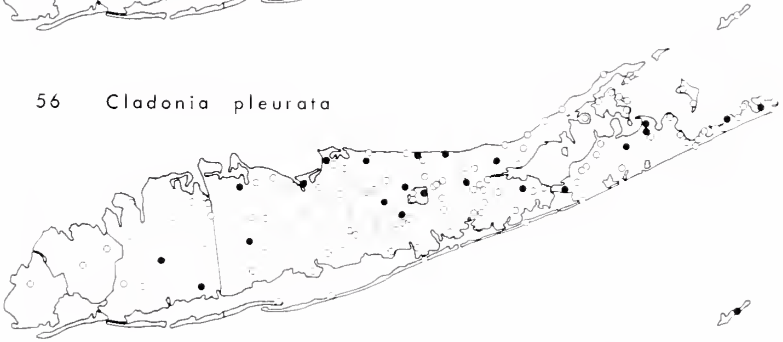


54 Cladonia squamosa

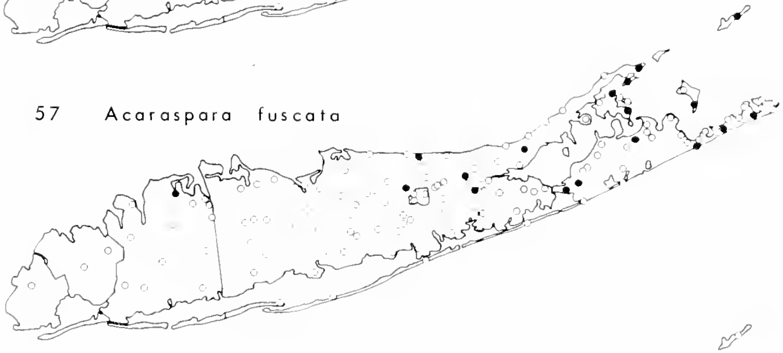




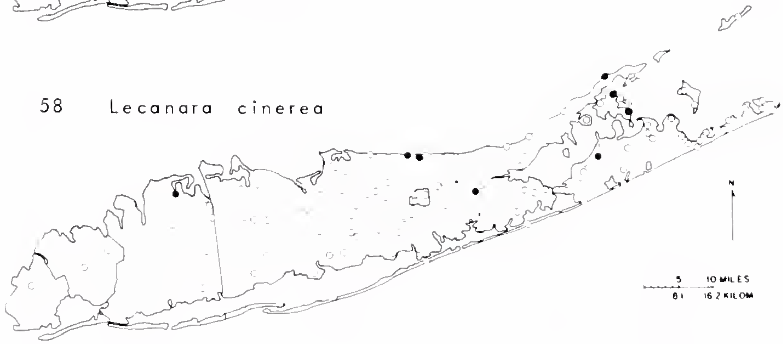
55 Cladonia caespiticia



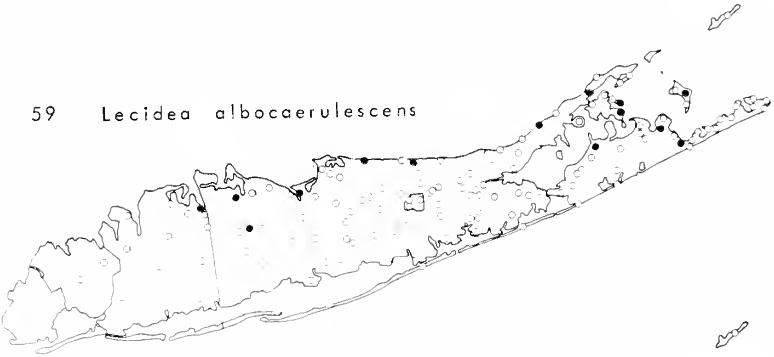
56 Cladonia pleurata



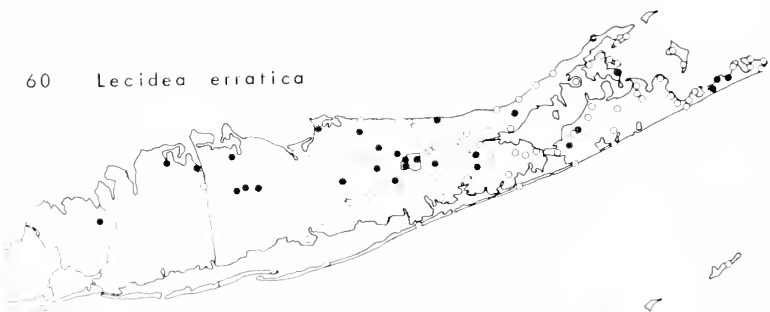
57 Acaraspara fuscata



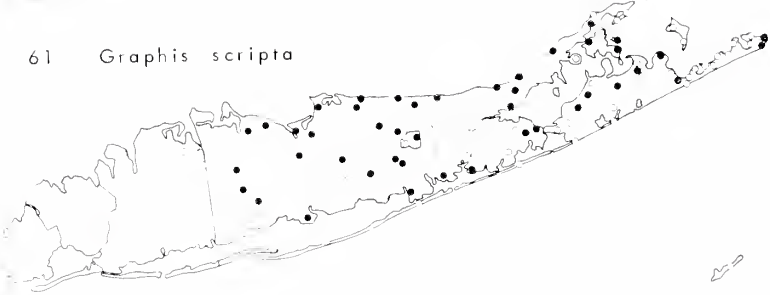
58 Lecanara cinerea



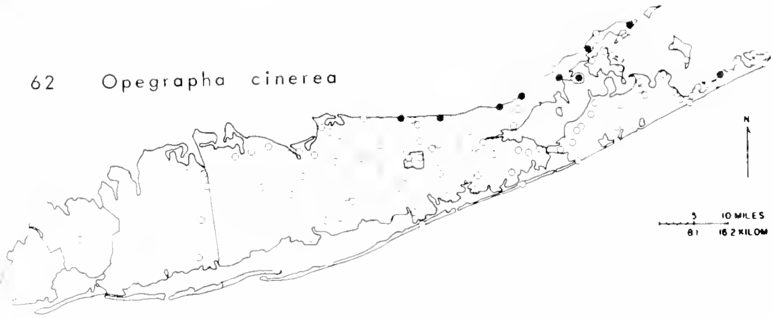
59 Lecidea albocaerulescens



60 Lecidea erratica

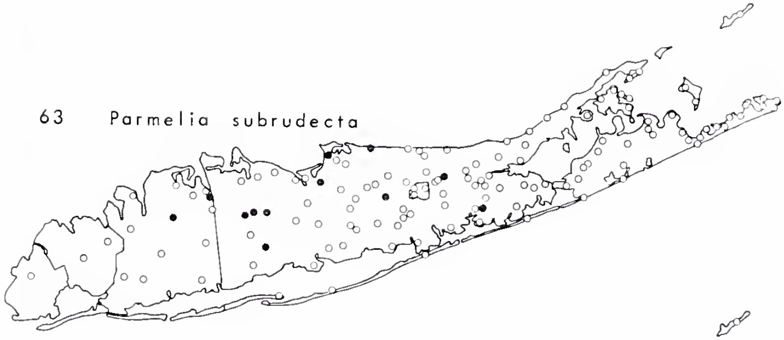


61 Graphis scripta

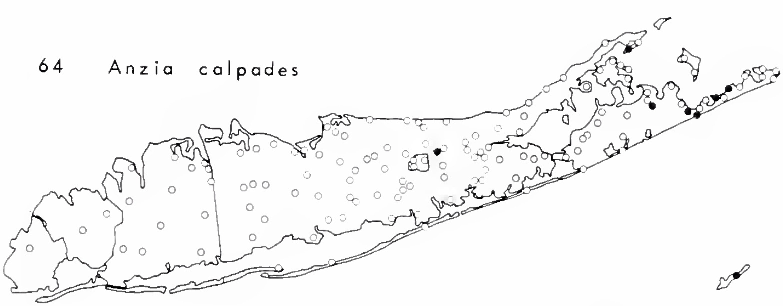


62 Opegrapha cinerea

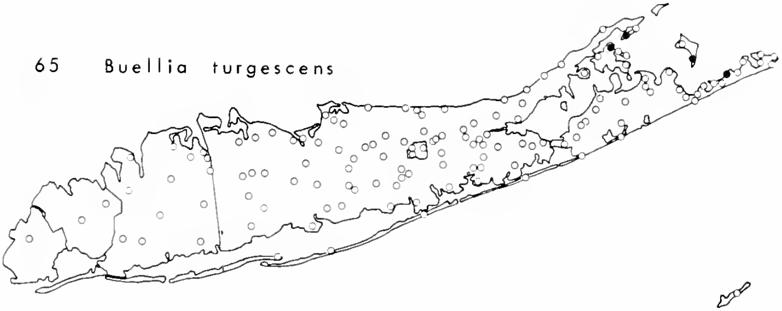
63 Parmelia subrudecta



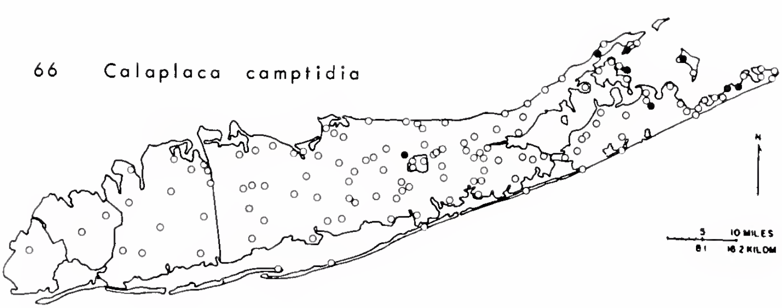
64 Anzia calpades



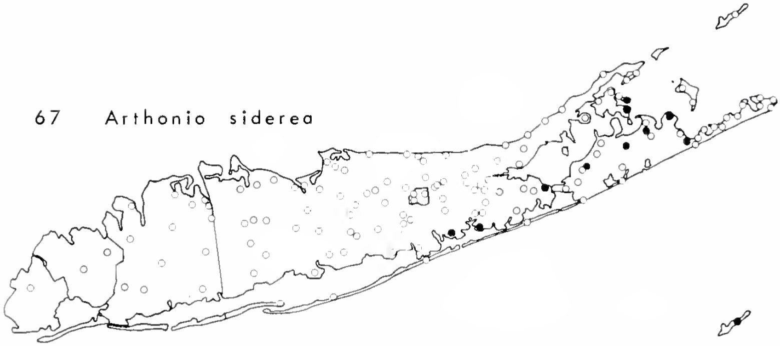
65 Buellia turgescens



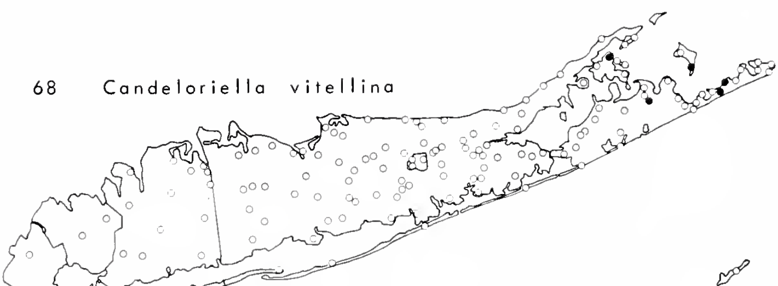
66 Calaplaca camptidia



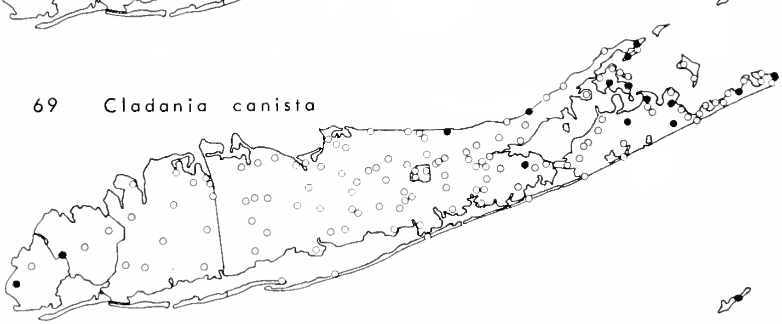
67 Arthonio siderea



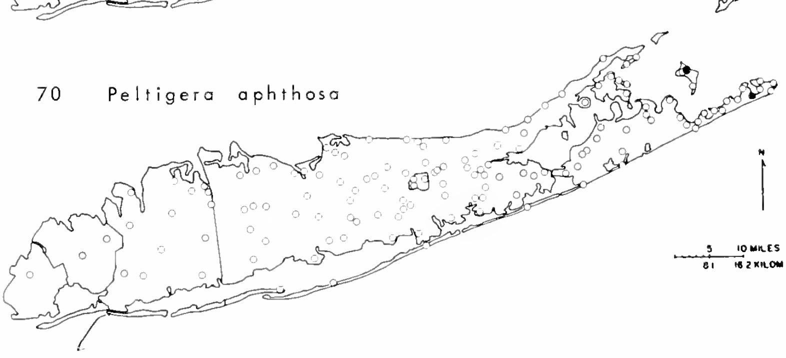
68 Candeloriella vitellina

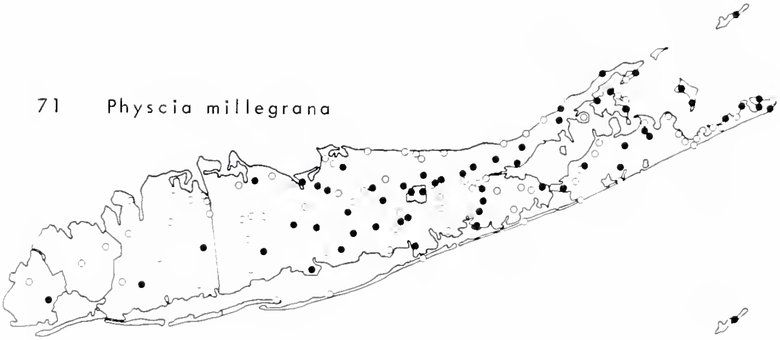


69 Cladania canista

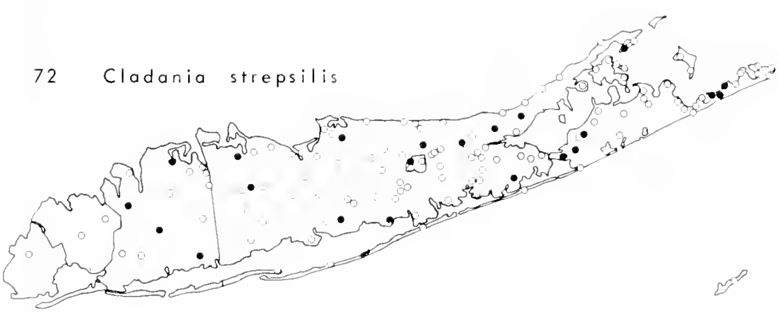


70 Peltigera aphthosa

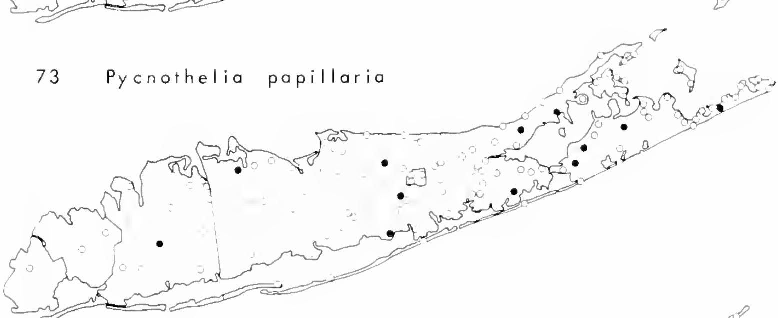




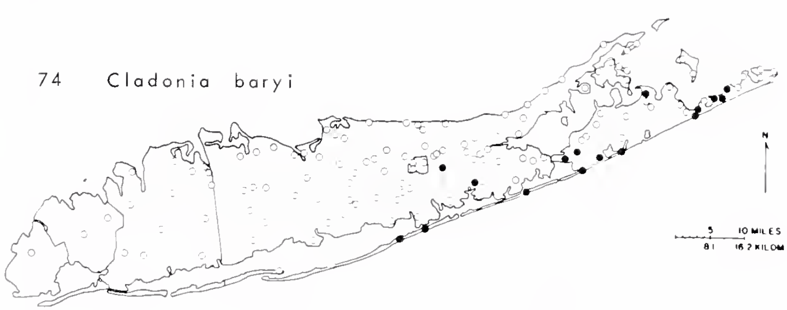
71 Physcia millegrana



72 Cladonia strepsilis

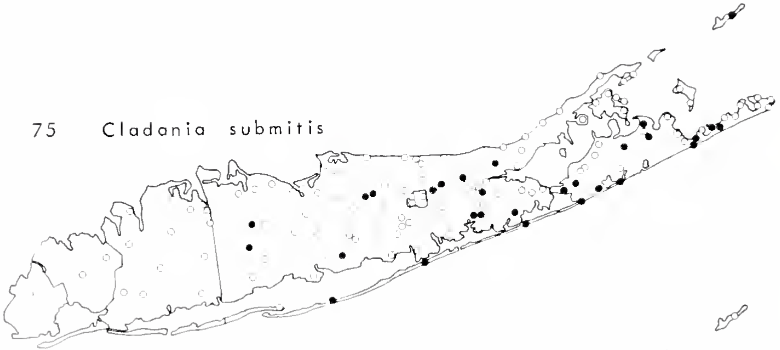


73 Pycnothelia papillaria

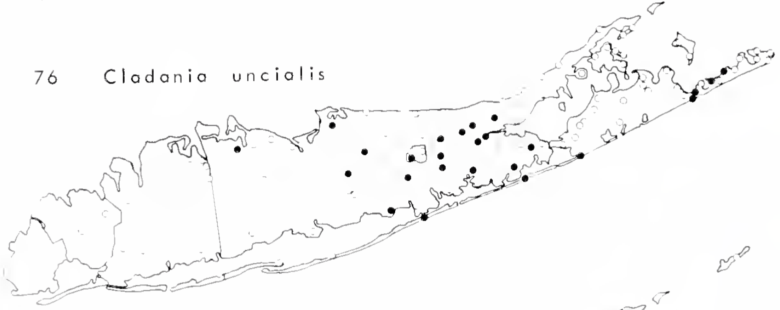


74 Cladonia baryi

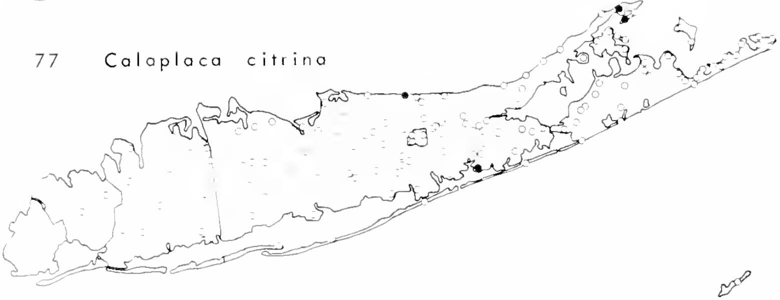
75 Cladonia submitis



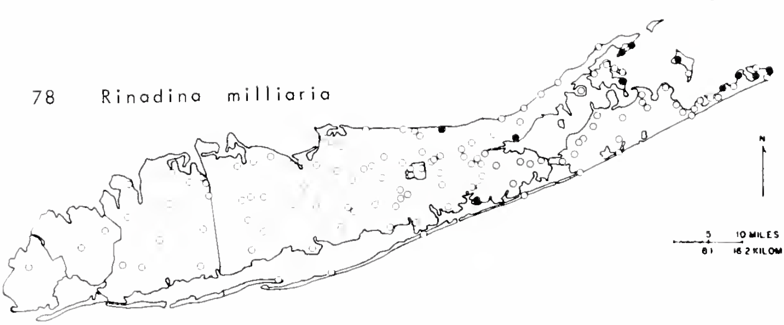
76 Cladonia uncialis

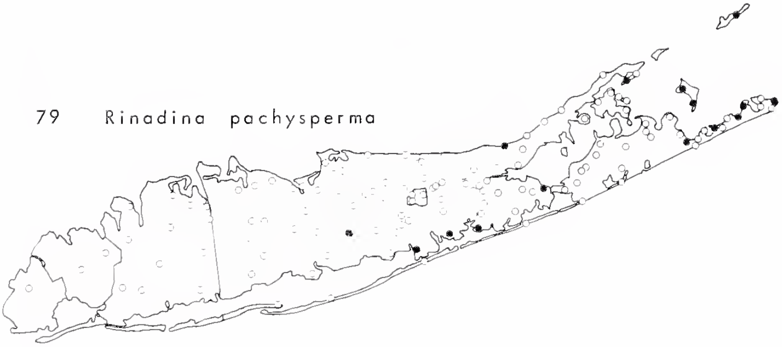


77 Caloplaca citrina

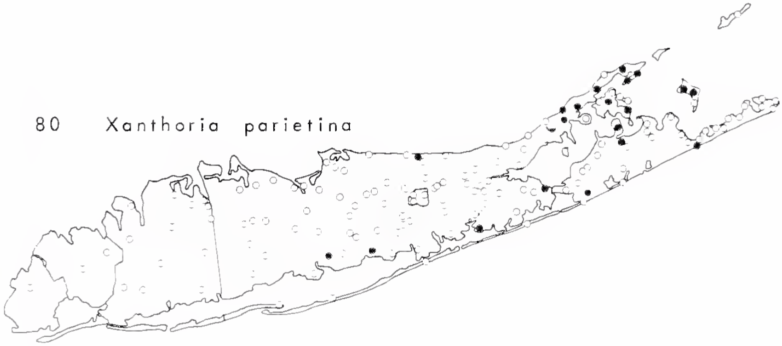


78 Rinadina milliaria





79 Rinadina pachysperma



80 Xanthoria parietina

81 Verrucaria silicicala

black oak woods; (35 - 36) Nesconset; (36) Centereach, pine-oak barrens burned over; (37) Selden, roadside; (38) Farmingville, young oak woods; (39) Patchogue, young oak woods; (40) Patchogue, open pine barren recently burned; (41) Sayville, wet oak-pine woods; (42) Old Field, dry oak woods; (43) East Setauket, red-scarlet oak woods; (44) Port Jefferson Station, dry oak woods; (45) Coram, mature oak woods; (46) Coram, burned over pine barren; (47) Middle Island, young oak-hickory woods; (48) Patchogue, field, young oak woods and maple swamp; (49) Bellport, open field; (S. of 49) Fire Island opposite Bellport, between dunes; (50) Miller Place - Mount Sinai, red oak-chestnut oak woods; (S. of 50) Miller Place, oak-hickory woods; (51) Middle Island, mature oak woods; (52) Upton, pine-oak woods; Ridge, oak and pine woods; (53) Upton, Brookhaven National Laboratory, roadside boulder, oak woods; (54) Upton, Brookhaven National Laboratory, pine woods and pine-oak woods; (55) Yaphank, oak woods, field and roadside elm; (56) Brookhaven, oak-pine woods and bog; (57) Yaphank, pine-scrub oak barren, burned over; (58) Brookhaven Station, pine barrens; (59) Shirley, oak woods; (60) Fire Island, S. of Shirley, sand dunes; (61) Shoreham, sand bluffs and black oak woods; (62) Shoreham-Wading River, shaded oak-hickory woods; (63) Wading River Station, old black oak woods; (64) Montauk Trail, young pine barren; (65) Upton, young black oak woods, oak-pine woods, pine woods and maple swamp; (66) Manorville, open, quaking bog and surrounding oak woods; (67) Manorville, black oak woods and mature oak woods; (68) Manorville, oak woods, mature oak woods; (69) Manorville, pine-oak woods; South Manor, pine barren; (70) South Manor, recently burned pine barren and young oak woods; (71) Center Moriches, black oak woods; (NE. of 71) Eastport, graveyard; (72) Wading River (Wildwood State Park), black oak woods and bluffs; (73) near Riverhead, pine-oak woods; (74) Calverton, oak-pine woods and maple swamp; (75) Calverton, pine-oak woods; (76) 2 mi. S. of Calverton, Bald Hill, pine woods; (77) Riverhead, black oak woods; (78) Riverhead, bogs and adjoining oak woods; (79) Riverhead, pine barren; (80) Quogue-Riverhead Rd., SW. of Flanders, oak-pine woods; (81) Riverhead, pine-oak woods; (82) Eastport, gravel pit bog; (83) Speonk, pine-oak barren, adjoining maple swamp and sphagnum bog; (84) Remsenburg, black oak woods; (85) Riverhead, pine barren and young pine-oak woods; (86) Flanders, *Chamaecyparis* bogs and pine barrens; (87) Hampton Bays, pine-oak woods and *Chamaecyparis* bog; (88) Quogue Station, oak woods; (89) Quogue, sand dunes; (90A) Northville, deep black oak woods; (90B) Mattituck, sand bluffs; (91) Laurel, oak-beech woods; (92) South Jamesport, oak woods; (93) Hampton Bays (Squiretown), young oak woods, and Canoe Place, roadside *Carya tomentosa;* (94) Shinnecock Hills; (95) Southampton, *Hudsonia*-dune area; (96) near Cutchogue bluffs; (97) Peconic, oak-hickory woods; (S. of 97) Peconic Station; (98) Southold or Laughing Waters, oak-hickory woods; (99) Noyack, oak-hickory woods; (99 - 111) North Haven; (100 A) Noyack, mature oak woods; (100 B) Sag Harbor, oak-hickory woods; (101) North Sea, open oak woods; (102) North Sea, *Chamaecyparis* bog and oak woods above bog; (103) Tuckahoe, open grassy field; (104) Bridgehampton, red maple swamp; (105) Sagaponack, sand dune; (106) East Marion, oak-cherry-locust woods and bluffs; (107) Shelter Island, Silver Beach, oak-hickory woods; (SE. of 107) Shelter Island, Rt. 114 and Smith St., roadside; (108) Shelter Island, Ram Island neck, cherry-locust woods; (109) Shelter Island, Ram Island Drive, red cedar thickets; (110) Shelter Island, Ram Island, oak-maple woods; (111) Shelter Island, N. of Nichols Point, open oak woods, beech-oak woods, beach area; (112) Northwest, oak-hickory woods, and Three Mile Harbor, oak woods, open fields and woody bog; (113) Orient Point, red cedar woods and shores; (116) Orient Beach State Park; (117) Springs, oak-hickory woods and oak woods; (118) Springs, roadside; (119) Amagansett, oak-hickory woods; (120) Napeague, dunes and sand flats and sand barrens; (121) Promised Land, sand barrens, oak grove, cherry grove; (122) Gardiner's Island, field and old oak woods; (123) Gardiner's Island, south end, grassland; (124) Napeague, sand dunes and pine barrens; (125) Hither Hills State Park, pine barrens and dunes; (126) Hither Hills State Park, exposed ridge and fresh pond; (127) Hither Hills State Park, mature oak woods and wooded sand bluffs; (128) Montauk, white oak-scarlet oak woods; (129) Montauk, grassy downs; (130) Montauk, low sand dunes; (131) Montauk Point, sand and ridges; (132) Montauk Point, woods; (133) Montauk, shaded *Ilex verticillata* thicket; (134) Fisher's Island.

It is evident from the map in figure 15 that comparatively few collections were made in western Long Island. In Brooklyn, Queens, and Nassau Counties, collecting areas were almost exclusively parks, preserves, or highway borders. Even in many parts of Suffolk County, particularly along its western edge and along the north shore, the only more or less natural areas available for study were on large private estates where the owners were kind enough to allow exploration of their property.

## ADDITIONAL SPECIMENS EXAMINED

Several herbaria known to have large or significant Long Island collections were visited, including the Brooklyn Botanic Garden (BKL) (Brainerd and Hulst collections), the New York Botanical Garden (NY) (Torrey *Cladonia* collections), the Farlow Herbarium (FH) (early Latham collections and some *Ramalina* material in the Howe collections), the New York State Museum (NYS) (earliest Latham collections, many reported in Burnham and Latham [1914], and Charles Peck collections), the Evans herbarium at the U.S. National Museum (US: Evans), the University of Michigan Herbarium (MICH) (Latham collections identified by Fink), the Missouri Botanical Garden (MO) (Latham collections identified by Dodge), and the Herbarium of the Staten Island Institute of Arts and Science (Staten Island) which contains several old and interesting Long Island specimens. A few specimens were also seen from the University of Tennessee herbarium (TENN) and the Cornell University herbarium (CUP). Latham's personal herbarium is given the designation: (Latham).

## TAXONOMY

*1. Species concept.* The problem of "what is a species," difficult as it is with any group of organisms, is compounded and confounded in lichens by the fact that two organisms are involved. In discussing lichens, there are two facets to the problem: (1) what do we mean by "lichen species" — the consortium, or merely the lichen fungal component, and (2) the common problem of where does one species end and another begin.

The first facet was solved, in theory, in 1950 when the International Code of Botanical Nomenclature added the statement "for nomenclatural purposes names given to lichens shall be considered as applying to their fungal components" (Lanjouw, 1961, Art. 13, Note 4). Culberson (1961a) seriously challenged that position and maintained, in a convincing series of arguments, that the name of a lichen should apply to the entire lichen thallus . . . fungus plus alga. His main arguments center around the fact that almost nothing is known about unlichenized lichen fungi and that the little that is known points to the fungi as being quite different in morphology, physiology, and ecology from the lichen as a whole. Since, theoretically, the classification and identification of an organism is based on its own morphology, etc., Culberson asks how one can apply a name to an organism based on the totally different morphology, physiology and chemistry of a thallus of which the organism in question is only a part.

Although his arguments are well taken, I still believe a lichen name should refer to the fungal component alone. To say that one can only classify an organism divorced from all other members of its biotic environment is not valid. Obligate parasitic fungi are studied only in relation with their host, and yet the taxonomy of parasitic fungi has not come to a halt because of it. If, perchance, it is found that a particular parasite looks different or has different reactions on different hosts, what may be thought to have been several host specific species at one time can be considered to be one species later with no particular difficulty. Why should it be any different with lichen fungi? I believe that very few different lichens will be found to have the same lichen fungus. Recently, Uyenco (1963) showed conclusively that the morphology of the *Coenogonium* lichen thallus, a lichen in which the alga is the dominant component, is due to the fungal component alone. She showed that the same lichen fungus, growing symbiotically with different species of algae in different regions, will produce identical lichen thalli. Thus, even thallus morphology can be interpreted as a fungus character.

To say that lichen chemistry cannot be used to characterize the fungal component of a lichen is to disregard the genetic basis for the ability to synthesize a lichen acid. The lichen fungus is involved in the production of the chemical, and in all probability at most derives certain essential chemical precursors from the alga (Hess, 1959). With a growing knowledge of the biochemical role of the alga in a lichen thallus, we will probably be able to establish a system in which the unlichenized fungus can produce characteristic substances in culture. Again we see that a thallus character, in this case chemistry, can be and probably is indicative of the genotype of the fungal component.

It therefore seems entirely proper to use thallus characters in characterizing a lichen fungus. It also seems proper to use the name of the fungal component of the thallus in routine references to the thallus as a whole. There is no need to allow lingual gymnastics to confuse and complicate the process of communication. If it is convenient to use a fungus name to refer to the thallus which it characterizes in nature, so be it. All those involved know what the name actually stands for, and there is no advantage to encumbering discussions with constant references to "*Parmelia sulcata* and its associated algae," rather than just "*Parmelia sulcata,*" the lichenized state being understood unless otherwise specified.

There still remains the problem of how broad or narrow a species we should recognize in lichenology. In the absence of evidence for heterothallism in lichen fungi, objective fertility "tests" as applied in phanerogamic systematics are not feasible, and so, more or less subjective analysis is the only means left for taxonomic decisions. It has been pointed out that regarding lichens as functional "apomicts" may have some merit, especially in speciation and phytogeographic considerations (John Beaman, pers. comm.).

I think it is fairly obvious that generalizations concerning the relative merits of specific characters cannot be made. The presence of soredia is sometimes important, sometimes unimportant; certain lichen substances are more important in some groups and less important in others. This problem is discussed in some detail by Imshaug and Brodo (1966) and will not be elaborated on here. Suffice to say that the more information we have about a species and its close relative, i.e., the distribution, morphology, chemistry, etc., the easier it is to decide whether it is a species, deserves only intraspecific rank, or does not warrant taxonomic recognition at all. Thus, for *Lecanora caesiorubella,* the rank of subspecies was selected for recognizable segments of the species based on a great deal of information of all kinds. With less complete information, chemical segregates may have been considered "strains" or perhaps full species. The recognition of some species here is tentative pending a more extensive and intensive investigation of their group. Such species-pairs as *Cladonia didyma* - *C. vulcanica,* and *C. squamosa* - *C. atlantica,* the *C. subcariosa* group, and others need more work, but until that time the narrow limits are recognized.

In all too many cases, there is a serious question as to the status of a particular taxon. If there is still relatively little information available on which to base a firm decision, the previous treatment which I consider most authoritative, is followed. The individual systematic problems of various taxa are discussed in detail in the annotated list.

2. *Ecological forms.* One of the most difficult tasks of the taxonomist is to determine the status of forms found in differing habitats and showing different morphological or chemical characters. For example, since both moisture and light are needed for assimilation, some sort of

morphological and physiological compromises must have been met by the lichens in their adaptations to particular niches. But has the change in ecology produced the changes in morphology, or does the morphological variant represent a genetically stable entity confined to one ecological habitat? Weber (1962) recently tried to answer this question in dealing with the ecological modifications of some crustose lichens in the southwestern United States. He stressed the need for extensive field experience and the examination of large numbers of specimens in making objective decisions.

In some cases, the situation is fairly clear. *Xanthoria parietina*, for example, has a tendency to lose (or fail to develop?) its anthraquinone pigment in highly shaded places (Thomson, 1949; Barkman, 1958). Thalli growing on concrete blocks at Orient Point appeared bright yellow-orange on the exposed upper surface of the block and equally vigorous but a pale yellowish-white on the shaded side of the block. The change in habitat from strongly insolated to shaded (or the accompanying changes of dry to humid, and salt-sprayed to protected) apparently influenced the quantitative chemical differences.

*Cladonia cristatella* presents a somewhat similar situation. When in shaded woods, this species is highly branched and squamulose with a very low concentration of yellow usnic acid. In open sunny habitats, the species is sparsely branched, almost without podetial squamules, and very yellow with a high concentration of usnic acid. Increased photosynthetic area is an advantage in shaded localities, with the increased transpiration from the increased surface area being insignificant in relation to the well-being of the thallus. In exposed areas, since light is not a limiting factor and moisture is, the extra surface area provided by numerous podetial squamules is not needed and, in fact, would be disadvantageous and so is selected against.

The production of extra pigment in highly illuminated habitats applies to melanin formation as well as usnic acid or parietin formation. Several species of *Cladonia*, particularly *C. furcata* and *C. atlantica*, show distinct and often intense browning when exposed to strong sun. *Cetraria islandica* subsp. *crispa* shows exactly the same response in the same situation. Quispel (1959) and Barkman (1958) suggest that lichen pigments in dry thalli may have a role in the protection of algae from high light intensities and Rao and LeBlanc (1965) presented light absorption data supporting this. It would therefore be logical to expect cortical pigments to be in higher concentration in open areas than in shaded areas.

The *Peltigera canina* group provides an example of a much more difficult problem. There is basic disagreement on the status of ecologically differing members of this group, particularly *P. canina* sens. str. and *P. rufescens*. A dry, open, eroded habitat is characteristic of *P. rufescens* whereas a more cool, moist, mossy habitat is typical for *P. canina*. Thomson (1950a) maintains that there are all gradations from one type to the other, and that *P. rufescens* is merely an ecological form.

Lindahl (1953) insists that the two are clearly separate species. He performed some transplant experiments with mature plants and found that the transplanted thalli did not survive well, and those that did survive did not develop into the type characteristic of the new locality. Lindahl's transplantations were, unfortunately, not controlled with thalli transplanted to similar habitats so that the failure of his plants to survive in the new environment is not significant in itself. The lack of morphological change in a mature plant is also to be expected since patterns of growth, once having reached a "point of no return" (Cantino, 1961), may be difficult if not impossible to alter. Transplantations of isidia or tiny squamules may prove to be valuable in determining the role of ecological conditions on the thallus forms.

*3. Infraspecific taxa.* The use of infraspecific categories in this paper is admittedly erratic. In general, varieties and forms are not considered and no new infraspecific taxa are described, although a few new combinations are made involving varieties. The few exceptions involve references to more clearly defined taxa which sometimes are considered as full species (such as *Rhizocarpon obscuratum* f. *reductum*) or thoroughly studied taxa which fit well into an infraspecific rank (such as *Lecanora caesiorubella* subsp. *lathamii*). The numerous varieties and forms described in *Cladonia* are not recognized, since the large majority are undoubtedly growth forms and ecological variants and the rest have been insufficiently studied.

*4. Keys and annotated list.* The arrangement of the flora into subclasses and orders follows Hale and Culberson (1966). The family concepts follow Hale (1961a) with the following exceptions: the Nephromaceae (after Wetmore, 1960), the Baeomycetaceae (after Räsänen, 1943), the Candelariaceae (after Hakulinen, 1954), and the Teloschistaceae and Physciaceae (after Nannfeldt, 1932). The arrangement of genera within the families follows Zahlbruckner (1926b). Species have been placed in alphabetical order within the genera except for *Cladonia,* which was arranged according to Mattick's (1940) (and in the case of the subgenus *Cladina*, Ahti's [1961]) treatment.

The keys have been somewhat expanded to include brief diagnoses of each species. In many cases, however, additional descriptive comments concerning certain important or confusing taxa have been included in the annotated list.

All generic and specific names are numbered consecutively in the order in which the names appear in the annotated list. The generic keys following the group keys are in the same order. References to the generic keys are made in the group keys using the genus numbers (in boldface type). All genera represented by only one species on Long Island do not appear in the generic keys. Instead, the species is keyed out in the group keys and is directly referred to its position in the annotated list by means of its species number (in lightface type), as are all species in the keys.

Author abbreviations follow Sayre, et al (1964).

In the annotated list, all specimens listed under "material seen" or elsewhere in the discussions which were collected by Imshaug or Brodo have been deposited in the Michigan State University Herbarium (MSC), unless otherwise noted. The locations of other specimens have been recorded using standard abbreviations (Lanjouw and Stafleu, 1964).

Comments on extra-Long Island, North American, and worldwide distributions were made to provide a framework for the floristic treatments presented in the section on Floristic Elements. No attempt was made to compile a complete listing of all known localities. Instead, a limited number of fairly reliable and, in most cases, modern treatments were consulted to provide information on the basic distribution patterns and affinities. Undoubtedly some of the records are based on old concepts or misidentifications and are incorrect; I hope that the errors are few.

Individual state and province records are presented where specific statements or maps of distributions are not available. Sources of the North American records, unless stated otherwise, are as follows: Nova Scotia (Lamb, 1950); Maine (Degelius, 1940; Davis, 1964a, b); Connecticut (Evans and Meyrowitz, 1926; Hale, 1950); Massachusetts (Ahmadjian, 1958; pers. coll.); New Jersey (pers. coll.); central New York (Brodo, 1959); North Carolina (Degelius, 1941; Culberson, 1958a); Tennessee (Degelius, 1941; Phillips, 1963); Alabama (McCullough, 1964); Arkansas, Missouri (Hale, 1957b); Oklahoma (Hale, 1957b; Thomson, 1961); Indiana (Fink and Fuson, 1919); Arizona (Darrow, 1950; Weber, 1963); New Mexico (Rudolph, 1953b); Michigan (Hedrick and Lowe, 1936; Thomson, 1951); Wisconsin (Hale, 1955a; Culberson, 1955a); Minnesota (Fink, 1910); Black Hills (Wetmore, 1965); Idaho (Hedrick, 1948); Washington (Howard, 1950); British Columbia (Weber and Shushan, 1959); Alaska (Cummings, 1910; Thomson, 1950b; Krog, 1962); Northern Saskatchewan (Thomson and Scotter, 1961); Manitoba (Thomson, 1953); Ontario (Thomson, 1955; Ahti, 1964); Quebec (Thomson, 1955); Baffin Island (Hale, 1954); Canadian archipelago and East Arctic (Thomson, 1960; Lynge, 1935, 1947).

Unless otherwise stated, European records are based on Grummann (1963), Poelt (1963), or Zahlbruckner (1922-40). Statements concerning circumboreal distributions are based on papers by Lynge (1928, 1938, 1940a, 1940b, 1940c), as well as the papers on the North American arctic cited above. Asian references are all presented directly in the distributional notes.

Species regarded as "endemic" are found only in North America, except for a few species also found in the West Indies.

## KEY TO GROUPS

1. Thallus crustose: attached to substrate at all points; lower cortex absent (if podetioid, see Group III; if squamulose, see Group II) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2

1. Thallus at least partially free from substrate . . . . . . . . . . . . . . . . . 3
   2. Thallus bearing ascocarps . . . . . . . . . . . . . . . . . . . . . . . . Group I
   2. Thallus lacking ascocarps . . . . . . . . . . . . . . . . . . . . . . . Group II
3. Thallus foliose: lobes flattened, usually broad, clearly dorsi-ventral, attached to substrate either directly or by means of rhizines, or rarely, only by a central umbilicus; lower cortex usually present; apothecia sessile or immersed, thallus never podetioid . . . . Group III
3. Thallus fruticose: lobes more or less terete, or less frequently, flattened; basally attached to substrate at one or several points; pendulous, caespitose, or podetioid . . . . . . . . . . . . . . . . . . . . . . Group IV

## GROUP I — CRUSTOSE LICHENS (FERTILE MATERIAL)

1. Phycobionts blue-green algae. Thallus dark brown to black, areolate to subsquamulose, isidiate, prothallus blue green or blue black; apothecia lecideine; saxicolous on concrete . . . . 37. *Placynthium nigrum*
1. Phycobionts green algae . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
   2. Ascocarps on short, hair-like stalks; hymenium disintegrating and spores forming a yellow- to deep-brown mazaedium. Spores brown (in water), spherical, ca. 1-1.5 μ in diameter . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16. *Chaenotheca phaeocephala*
   2. Ascocarp sessile or immersed; hymenium remaining intact . . . . 3
3. Ascocarp ± elongated; irregular or obling . . . . . . . . . . . . . . . . . . 4
3. Ascocarp disk-shaped, hemispherical or spherical (sometimes imbedded within a stroma) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8
   4. Spores nonseptate, hyaline, 3-4 x 7-13 μ. Lirellae dark brown to red brown or black, oblong or elongate, rarely branched, 0.2 x 0.35-0.55 mm . . . . . . . . . . . . . . . . 28. *Xylographa opegraphella*
   4. Spores 1 to 7 septate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5
5. Spores with cylindrical cells; ascocarp ascolocular . . . . . . . . . . . . . 6
5. Spores with lenticular cells; ascocarp ascohymenial . . . . . . . . . . . 7
   6. Ascocarp ± enclosed in a heavy carbonaceous stromatic wall . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **7.** *Opegrapha*
   6. Ascocarp without a carbonaceous stroma or excipuloid margin . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **4.** *Arthonia*
7. Spores hyaline, 5 to 7 septate, 32-48 x 6-9 μ; exciple not continuous below, but well developed laterally and projecting conspicuously above hymenium . . . . . . . . . . . . . . . . . . . . . . . . 29. *Graphis scripta*
7. Spores brown, 2 to 3 septate, 21-30 x 6-7 μ; exciple continuous below, shallow, i.e., not projecting appreciably above hymenium . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 30. *Phaeographis dendritica*
   8. Ascocarp spherical or flask shaped, with walls completely enclosing hymenium except for ostiole at apex; walls generally partly or entirely carbonaceous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9
   8. Ascocarp disk shaped or cup shaped, with exposed hymenium; or, hymenium enclosed within thalline tissue in a wart-like

structure as in *Pertusaria,* without carbonaceous walls of any kind . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16

9. Ascocarps clustered in stromatic verrucae, more than one per stroma . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10
9. Ascocarps single, scattered . . . . . . . . . . . . . . . . . . . . . . . . . . . 11
   10. Thallus, especially stromatic verrucae, covered with a rusty-red pigment which is KOH + purple. (Spores brown, 3-septate, but not seen in L.I. material). Very rare . . . . 23. *Melanotheca cruenta*
   10. Thallus brownish or olivaceous, smooth, KOH-; spores hyaline, 4 to 8 septate, 23-45 x 8-13 μ. Frequent on *Ilex* and *Fagus* . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 24. *Trypethelium virens*
11. Spores muriform, hyaline. Ascocarp ascolocular . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4. *Polyblastiopsis quercicola*
11. Spores non-septate or only transversely septate . . . . . . . . . . . . . . 12
   12. Ascocarp ascolocular . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13
   12. Ascocarp ascohymenial . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14
13. Spores ellipsoid or fusiform, straight, 15-21 x (4-)5-7 μ, 1 to 3 septate; on oak and beach plum . . . . . . . . . . . . . . . . **1.** *Arthopyrenia*
13. Spores acicular, curved or sigmoid, 20-30 x 3-4 μ, 1 to 3(-5) septate; on birch . . . . . . . . . . . . . . . . . . . . . . . . 3. *Leptorhaphis epidermidis*
   14. Spores brown, 3-septate, cells lenticular, 16-20(-25) x 10-13μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22. *Pyrenula nitida*
   14. Spores hyaline . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15
15. Spores nonseptate. Saxicolous . . . . . . . . . . . . . . . . . . . . **9.** *Verrucaria*
15. Spores 3 to 16 septate, cells cylindrical. Corticolous . . . . . **14.** *Porina*
   16. Spores more than 50 per ascus, 4 x 2 μ. Saxicolous . . . . . . . . . 17
   16. Spores (1-)8(-20) per ascus, usually larger than 4 x 2μ . . . . 18
17. Thallus epilithic, areolate to squamulose, brown; apothecia completely immersed in thallus . . . . . . . . . . . . . . . . . . . . 141. *Acarospora fuscata*
17. Thallus mostly endolithic; apothecia sessile with a lecideine margin . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **37.** *Sarcogyne*
   18. Spores muriform . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19
   18. Spores nonseptate or transversely septate . . . . . . . . . . . . . . . . 21
19. Corticolous. Thallus thin, hypophloedal; apothecia minute, punctiform, 0.1-0.2 mm across; spores hyaline, 32-46 (-55) x 10-23 (-27)μ. Rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11. *Arthothelium taediosum*
19. Not corticolous. Thallus well developed; apothecia usually larger than 0.2 mm; spores brown or sometimes hyaline . . . . . . . . . . . . . . . . . 20
   20. Apothecia deeply concave, imbedded in thick thalline verrucae resulting in a double margin (thalline and proper); spores without any gelatinous epispore ("halo"), 22-40 x 10-14 μ. Medulla C + red, KOH + yellow. Saxicolous or growing on *Cladonia.* Rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 31. *Diploschistes scruposus*
   20. Apothecia flat to convex with proper margin alone, imbedded in thalline verrucae or arising between them; spores with a gela-

tinous epispore ("halo"). Medulla C + red or C -, KOH + or -. Saxicolous. Common . . . . . . . . . . . . . . . . . . **31.** *Rhizocarpon*

21. Spores brown, uniseptate . . . . . . . . . . . . . . . . . . . . . . . . . . . 22
21. Spores hyaline . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 23
    22. Apothecia with thalline margin . . . . . . . . . . . . . . . **61.** *Rinodina*
    22. Apothecia without thalline margin . . . . . . . . . . . . . **60.** *Buellia*
23. Apothecia with thalline margin or enclosed in thalline verrucae . . 24
23. Apothecia without thalline margin . . . . . . . . . . . . . . . . . . . . . . . 31
    24. Spores vermiform or sigmoid, septate or nonseptate, length to width ratio 7-9:1, 45-62 x 5-8 μ. Thallus PD + orange and KOH + yellow (thamnolic acid) . . . . . . . . . . . . . . . . . . . . . . 173. *Haematomma ochrophaeum*
    24. Spores ellipsoid, oblong, or subspherical, length to width ratio ca. 1.5-3:1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 25
25. Spores over 40 μ long, nonseptate . . . . . . . . . . . . . . . . . . . . . . . 26
25. Spores under 30 μ long, nonseptate or septate . . . . . . . . . . . . . . . 28
    26. Apothecia usually imbedded in thalline verrucae, or, if lecanorine, then spores over 200 μ long . . . . . . . . . . . . . . . . . . . . . . . . 27
    26. Apothecia lecanorine; spores 40-68 μ long, 8 per ascus. Disks C + red . . . . . . . . . . . . . . . . . . . . . . . . . . . **43.** *Ochrolechia*
27. Spores all hyaline, KOH −; spore walls not radiately channelled. Common . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **39.** *Pertusaria*
27. Spores sometimes brownish, KOH + sordid violet, 125-190 x 30-45 μ; spore walls conspicuously channelled. Uncommon . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 151. *Melanaria macounii*
    28. Spores polarilocular. Disk KOH + red-violet or KOH − . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **57.** *Caloplaca*
    28. Spores nonseptate. Disk KOH- . . . . . . . . . . . . . . . . . . . . . . . 29
29. Apothecial disk and margin yellow. Saxicolous . . . **45.** *Candelariella*
29. Apothecial disk black, brown, pale reddish buff, or yellowish. Saxicolous or corticolous. (If disk is yellowish, then corticolous) . . . . . . 30
    30. Phycobiont *Trentepohlia;* apothecia immersed in thallus. Spores hyaline, ellipsoid, 11-16 x 5-8 μ. Saxicolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 152. *Ionaspis odora*
    30. Phycobiont *Trebouxia;* apothecia immersed in thallus or sessile . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **42.** *Lecanora*
31. Ascocarp ascolocular. Spores usually septate, hyaline, ellipsoid to fusiform . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **6.** *Micarea*
31. Ascocarp ascohymenial . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 32
    32. Spores septate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 33
    32. Spores nonseptate . . . . . . . . . . . . . . . . . . . . . . . . . **28.** *Lecidea*
33. Spores uniseptate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 34
33. Spores 3 or more septate, fusiform to acicular . . . . . . . . . **30.** *Bacidia*
    34. Spores polarilocular, 13-16 x 8-10 μ. Disks KOH + purple-red . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 227. *Caloplaca discolor*
    34. Spores not polarilocular . . . . . . . . . . . . . . . . . . . . . . . . . . . 35

35. Apothecia black, strongly convex to hemispherical; hypothecium dark brown; spores with cells of unequal size, 9-15 x 4-5 μ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .63. *Catillaria glauconigrans*

35. Apothecia pale pinkish yellow or orange, deeply concave to ± flat; hypothecium hyaline; spores with cells of equal size, 9-14 x 2-4 μ. Asci extremely narrow, almost linear, thin walled. . . . . . . . . . . . .36

  36. Apothecial disks pink-yellow (flesh colored), deeply concave. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .32. *Dimerella diluta*

  36. Apothecial disks pale orange to orange buff, flat. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .33. *Dimerella lutea*

## GROUP II — CRUSTOSE LICHENS (STERILE MATERIAL)

1. Terricolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .2

1. Saxicolous. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .5

1. Corticolous or lignicolous. . . . . . . . . . . . . . . . . . . . . . . . . . .15

  2. Thallus black to dark brown, minutely verrucose to granulose. Thallus KOH -, PD -, C -. . . . . . . . . . . . . .59. *Lecidea uliginosa*

  2. Thallus pale grey, grey-green, or white. . . . . . . . . . . . . . . . . .3

3. Thallus C + red, KOH -, PD -. . . . . . . . . . . . .54. *Lecidea granulosa*

3. Thallus C - . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .4

  4. Thallus PD + deep yellow (baeomycic acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .80. *Baeomyces roseus*

  4. Thallus PD -, KOH + yellow (atranorin) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .78. *Pycnothelia papillaria*

5. On calcareous rock or mortar. . . . . . . . . . . . . . . . . . . . . . . . . .6

5. On siliceous rock. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .7

  6. Thallus dark brown to black, isidiate, KOH -; phycobionts blue-green algae. Prothallus conspicuous, blue-green . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .37. *Placynthium nigrum*

  6. Thallus yellow or orange, KOH + dark purple; phycobionts green algae. Thallus granular to thickly areolate and only occasionally breaking into sorediate patches; margin of thallus diffuse . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .226. *Caloplaca citrina*

7. Thallus yellow or yellow-green, KOH - . . . . . . . . . . . . . . . . . . . . .8

7. Thallus white, grey, or brown (no yellowish tint) . . . . . . . . . . . . . .9

  8. Thallus margin effigurate; thallus yellow-green. Medulla C + red, usnic and gyrophoric acids present. . .245. *Rinodina oreina*

  8. Thalli small, scattered, areolate to subsquamulose, deep yellow. Medulla C -, usnic and gyrophoric acids absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .176. *Candelariella vitellina*

9. Medulla C + red . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .10

9. Medulla C - . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .12

  10. Thallus grey, smooth, with scattered patches of soredia. Medulla KOH - . . . . . . . . . . . . . . . . . . . . . . . . . .(unknown no. 1)[7]

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[7] These unidentified sterile crustose species have been deposited in herb. MSC for future reference.

10. Thallus grey to ashy, esorediate, verrucose to areolate. Medulla KOH + yellow to orange and PD + orange (stictic acid) . . . . 11

11. Thallus brown, verrucose. Medulla I + blue . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 74. *Rhizocarpon grande*

11. Thallus grey to ashy, areolate to verrucose. Medulla I - . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 75. *Rhizocarpon intermedium*

12. Thallus leprose to granular sorediate, marginate and often zoned. Thallus PD + red or yellow, KOH - or + yellow(?) (fumarprotocetraric or barbatolic acid present) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 260. *Lepraria zonata*

12. Thallus smooth to areolate or verrucose. Thallus medulla KOH + yellow or red (stictic or norstictic acid present) . . . . . . . . . 13

13. Thallus dark cincreous or sordid green-grey, verrucose to areolate. Stictic or norstictic acid present . . . . . . . . . . . 157. *Lecanora cinerea*

13. Thallus white to very pale grey or ashy, smooth to areolate . . . . . . 14

14. Prothallus white, often conspicuous. Stictic or norstictic acid present. Growing on stones or boulders in shaded woods . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 48. *Lecidea albocaerulescens*

14. Prothallus black, often conspicuous. Norstictic acid present. Growing on exposed boulders. Pycnoconidia short, straight, bacilliform, 4-6 x ca. 1 µ . . . . . . . . . . . . . 239. *Buellia stigmaea*

15. Thallus squamulose, margins entire. Undersurface of squamules sorediate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16
(also see *Cladonia* key)

15. Thallus continuous or diffuse (not squamulose) . . . . . . . . . . . . . . 17

16. Thallus PD + red (fumarprotocetraric acid), C -. Squamules dark green-brown to olivaceous, 0.5-0.75 (-1.0) mm broad . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 49. *Lecidea anthracophila*

16. Thallus PD -, C + red. Squamules pale olivaceous, 1.0 - 1.5 mm broad . . . . . . . . . . . . . . . . . . . . . . . . . . 58. *Lecidea scalaris*

17. Thallus leprose, sorediate, or coralloid-isidiate . . . . . . . . . . . . . . . 18

17. Thallus smooth, areolate, or verrucose . . . . . . . . . . . . . . . . . . . . . 32

18. Thallus orange, yellow, or yellowish green . . . . . . . . . . . . . . . 19

18. Thallus grey, grey-green, brown, olivaceous, or black . . . . . . . 21

19. Thallus dark yellow to orange, KOH + dark purple. Thallus smooth, becoming coarsely sorediate in patches . . . . . 227. *Caloplaca discolor*

19. Thallus yellow to yellowish green, KOH - . . . . . . . . . . . . . . . . . . . 20

20. Lignicolous, on decorticate *Chamaecyparis* stumps in bogs. Thallus diffuse, leprose, pale yellowish or whitish green . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16. *Chaenotheca phaeocephala*

20. Corticolous. Thallus leprose-granular, decp yellow . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 177. *Candelaria concolor*

21. Medulla KC + violet. Thallus dark cinereous to grey-green; verrucae erupting into white sorediate mounds . . . . . . . 143. *Pertusaria amara*

21. Medulla KC - or KC + red . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22

22. Thallus effuse, leprose, or coralloid-isidiate . . . . . . . . . . . . . . . 23

22. Thallus with ± distinct soralia at least at thallus margin, verrucose or ± continuous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 27
23. Thallus coralloid-isidiate; phycobiont *Trentepohlia* . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 27. *Porina nucula*
23. Thallus effuse, leprose, phycobionts Trebouxioid . . . . . . . . . . . . . . 24
24. Thallus bluish green or blue-grey, KOH + yellow (atranorin), PD -, or rarely, PD + red (fumarprotocetraric acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 259. *Lepraria incana*
24. Thallus whitish green or dark green to blackish green . . . . . . . 25
25. Thallus KOH + yellow and PD + orange (atranorin and stictic acid). Thallus pale to whitish green, with thick white prothalline mat . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 261. *Lepraria* sp.
25. Thallus KOH -, PD - . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 26
26. Thallus coarsely granular, pale green to brownish green. Lignicolous. Very rare . . . . . . . . . . . . . . . . . . . . 62. *Lecidea viridescens*
26. Thallus finely granular, dark green to blackish green. Mostly corticolous. Very common . . . . . . . . . . . 66. *Bacidia chlorococca*
27. Thallus composed of scattered verrucae or areoles, some bursting into soredia . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 28
27. Thallus ± continuous and smooth, at least at the margins . . . . . . 29
28. Medulla C + red . . . . . . . . . . . . . . . . . . 47. *Lecidea aeruginosa*
28. Medulla C - . . . . . . . . . . . . . . . . . . . . . . . . 50. *Lecidea botryosa*
29. Thallus KOH + deep yellow and PD + orange (thamnolic acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 30
29. Thallus KOH -, PD - . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 31
30. Thallus pale grey to white, with crowded hollow verrucae in the older portions, many of which burst revealing coarsely granular soredia often leaving the center of the thallus essentially leprose . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 174. *Haematomma* sp.
30. Thallus ashy or darker, with sorediate verrucae scattered evenly over the thallus . . . . . . . . . . . . . . . 147. *Pertusaria trachythallina*
31. Thallus greenish or brownish green with maculiform greenish or yellow-green soralia scattered over the thin thallus . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Cfr. *Opegrapha* sp.
31. Thallus grey or greenish-grey, bursting into scattered, granular-sorediate soralia. Hypophloedal; phycobiont *Trentepohlia* . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (unknown no. 6)[8]
32. Medulla KOH + yellow or red . . . . . . . . . . . . . . . . . . . . . . 33
32. Medulla KOH - . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 35
33. Medulla KOH + yellow. Thallus thick or thin, pale grey to dark ashy . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 34
33. Medulla KOH + red (norstictic acid). Thallus thin, smooth, becoming areolate or chinky, pale greenish grey to white; pycnoconidia 4-7 μ long, straight, bacilliform . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 235. *Buellia curtisii* or 240. *B. stillingiana*

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[8] *Ibid*

34. Medulla KOH + deep yellow and PD + orange (thamnolic acid). Thallus densely verrucose and rugose, pale grey . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 173. *Haematomma ochrophaeum*

34. Medulla KOH + yellow-orange, PD - (?), thamnolic acid and atranorin absent, (stictic acid present?) thallus very thin, smooth, greenish grey. Pycnoconidia short, straight, 4-5 x ca. 1 μ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (unknown no. 7)[9]

35. Thallus olivaceous to blackish green, well developed, rugose to verruculose; pycnidia common, brown, pycnoconidia 0.5 x 1.2 μ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 65. *Bacidia chlorantha*

35. Thallus very thin or hypophloedal, or, if thicker, ashy or pale greenish grey; pycnidia common, black; pycnoconidia over 4 μ long . . . . 36

36. Pycnidia ± clustered in small groups; pycnoconidia 4-5 x 1 μ, straight, bacilliform. On *Ilex* and *Fagus* . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 24. *Trypethelium virens*

36. Pycnidia scattered evenly over the thallus; pycnoconidia curved . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 37

37. Pycnoconidia reniform, short, broad, 5-7 x 3-4 μ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15. *Opegrapha rufescens*

37. Pycnoconidia sickle shaped, slender (1 μ broad) . . . . . . . . . . . . . 38

38. Pycnoconidia 10-15 μ long (measured end to end, in a straight line), very strongly curved . . . . . . . . . . . . 14. *Opegrapha cinerea*

38. Pycnoconidia 15-20 μ long (measured as above), slightly curved . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (unknown no. 5)[9]

## GROUP III — FOLIOSE LICHENS

1. Thallus composed of aggregations of squamules individually attached to the substrate at one edge; (0.5-) 1-3 (-5) mm long or broad . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **35.** *Cladonia*

1. Thallus centrally attached; squamules, if present, part of a broad thallus; thallus over 10 mm in diameter . . . . . . . . . . . . . . . . . . . . . . 2

2. Phycobionts blue-green algae . . . . . . . . . . . . . . . . . . . . . . . . . 3

2. Phycobionts green algae . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7

3. Thallus gelatinous when moistened . . . . . . . . . . . . . . . . . . . . . . 4

3. Thallus not gelatinous when moistened . . . . . . . . . . . . . . . . . . . . 5

4. Upper cortex absent; globular isidia present; thallus broad . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 34. *Collema subfurvum*

4. Upper cortex present, paraplectenchymatous; isidia absent or coralloid-cylindrical; thallus narrow lobed . . . . . . **21.** *Leptogium*

5. Thallus small, lobes 2-3 mm broad; apothecia scattered over the surface of thallus; spores nonseptate. Lower surface densely white or tan, tomentose . . . . . . . . . . . . . . . . . . . . . . . . . . 38. *Pannaria lurida*

5. Thallus large, lobes 3-30 mm broad; apothecia at tips of lobes; spores septate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6

6. Lower surface ecorticate, usually conspicuously veined; apothecia on upper surface of lobes; medulla KOH-. . . **27.** *Peltigera* (p.p.)

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[9] *Ibid*

6. Lower surface corticate, glabrous, without veins; apothecia on lower surface of lobes; medulla yellow, KOH + pink to red-violet (anthraquinone: nephromin) . . . 41. *Nephroma laevigatum*

7. Thallus bright yellow or orange . . . . . . . . . . . . . . . . . . . . . . . . . . . 8

7. Thallus brownish, grey, grey-green, or yellowish green . . . . . . . . . . 9

8. Upper cortex KOH + red-violet (anthraquinone: parietin) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **58.** *Xanthoria*

8. Upper cortex KOH- (pulvic acid derivative) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 177. *Candelaria concolor*

9. Thallus attached to the substrate by central umbilicus . . . . . . . . . . 10

9. Thallus attached to substrate directly, or by many fine rhizines . . . . 12

10. Thallus yellow-green. Ascocarps apothecia with orange disks, abundant . . . . . . . . . . . . . . . . . . . . . . . . . 165. *Lecanora rubina*

10. Thallus brown, with no yellow tint . . . . . . . . . . . . . . . . . . . . . 11

11. Ascocarps (usually present) perithecia; medulla C- . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21. *Dermatocarpon miniatum*

11. Ascocarps (if present) apothecia with black disks, medulla C + red . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **36.** *Umbilicaria*

12. Cephalodia abundant, scattered over the upper surface of thallus. Phycobiont *Coccomyxa*. Very rare; on soil . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 43. *Peltigera aphthosa*

12. Cephalodia absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13

13. Thallus inflated, hollow; lower surface corticate, brown to black, smooth, naked. Granular soredia in labriform soralia; medulla PD + red (monoacetyl-protocetraric acid), KC + red (physodic acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 203. *Hypogymnia physodes*

13. Thallus solid; lower surface rhizinate, tomentose, or ecorticate . . . . 14

14. Hypothallus present, composed of a thick mat of interwoven black hyphae. Medulla PD-, KOH-, KC- . . . 210. *Anzia colpodes*

14. Hypothallus lacking . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15

15. Lower surface feltlike or tomentose, without rhizines. Lobes broad, over 3 mm across . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16

15. Lower surface rhizinate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 17

16. Medulla PD-, C-. Apothecia common, immersed in depressions in lobes; spores brown, uniseptate, 4 per ascus; phycobiont *Coccomyxa* . . . . . . . . . . . . . . . . . . . . . . . . 42. *Solorina saccata*

16. Medulla PD + orange (stictic acid), or, C + red (gyrophoric acid). Apothecia, if present, sessile; spores hyaline, 3-septate, 8 per ascus; phycobiont *Trebouxia* . . . . . . . . . . . . . **24.** *Lobaria*

17. Thallus yellow or yellow-green . . . . . . . . . . . . . . . . . . . . . . . . 18

17. Thallus brown, grey, or grey-green . . . . . . . . . . . . . . . . . . . . . 20

18. Lower surface bright yellow; usnic acid absent. Thallus smooth or rugose; soredia and isidia absent; black pycnidia common along thallus margins, sometimes becoming partially laminal. Medulla PD-, KOH-, C-, KC- . . . . . . . . . . 209. *Cetraria viridis*

18. Lower surface not yellow; usnic acid present . . . . . . . . . . . . . 19

19. Thallus with lobes less than 1 mm broad; older portions covered with granular soredia; divaricatic acid present .................................................. 179. *Parmeliopsis ambigua*
19. Thallus with lobes broader than 1 mm; soredia present or absent; divaricatic acid absent ..................... **48.** *Parmelia* (p.p.)
    20. Medulla PD + orange, KOH + deep yellow (thamnolic acid) .. ................................ **47.** *Parmeliopsis* (p.p.)
    20. Medulla not having that combination of reactions (thamnolic acid absent) .......................................... 21
21. Lower surface white, pale buff, or yellow .................... 22
21. Lower surface light or dark brown, or black (although marginal areas may have broad, irregular, white blotches) ................. 26
    22. Thallus brown or olivaceous-brown. Medulla C + red ....... ............................. 199. *Parmelia subaurifera*
    22. Thallus grey or grey-green ............................ 23
23. Thallus lobes 3-7 mm broad ............................ 24
23. Thallus lobes 0.5-3 mm broad .......................... 25
    24. Pseudocyphellae on upper surface; medulla I- ............. ................................. **48.** *Parmelia* (p.p.)
    24. Pseudocyphellae absent; medulla I + blue ................ ............................. 208. *Cetraria tuckermanii*
25. Cortical hyphae parallel with surface ............ **64.** *Anaptychia*
25. Cortical hyphae perpendicular to surface ............ **63.** *Physcia*
    26. Rhizines black with white tips, very dense; lobes 1-2 mm broad ............................................ 27
    26. Rhizines uniform in color, sparse to dense; lobes 1-6 mm broad ............................................ 28
27. Medulla mustard yellow, KOH + dull red-brown; lobes pruinose, especially near tips, with granular marginal soredia ............ ................................. 248. *Pyxine sorediata*
27. Medulla red-orange (KOH + purple) or white (KOH-); lobes not pruinose; soredia marginal and laminal ..... 252. *Physcia orbicularis*
    28. Pycnidia, common, marginal; rhizines sparse ............. ................................. **51.** *Cetraria* (p.p.)
    28. Pycnidia rare, laminal; rhizines usually ± dense ........... ................................. **48.** *Parmelia* (p.p.)

## GROUP IV — FRUTICOSE LICHENS

1. Thallus having erect, terete or subterete podetia or pseudopodetia. Mostly terricolous, but sometimes corticolous or saxicolous ...... 2
1. Thallus not podetioid; erect and shrubby, or, more or less pendent. Corticolous or saxicolous .............................. 5
    2. Podetia or pseudopodetia hollow ...................... 3
    2. Podetioid structures solid ........................... 4
3. Primary thallus squamulose or soon absent; spores nonseptate ...... ........................................ **35.** *Cladonia*

3. Primary thallus crustose, persistent, white granular; spores uniseptate. Medulla KOH + yellow (atranorin) . . . . . 78. *Pycnothelia papillaria*
   4. Primary thallus consisting of white granules; podetia short, each one terminated by a large, pink apothecium. Podetia and thallus PD + yellow, KC- (baeomycic acid). On raw, eroding soil . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 80. *Baeomyces roseus*
   4. Primary thallus consisting of prong-like phyllocladia; pseudopodetia sterile or with brown apothecia. Medulla PD-, KC + red (lobaric acid). Saxicolous . . . . . . . . . . 79. *Stereocaulon saxatile*
5. Thallus composed of terete filaments . . . . . . . . . . . . . . . . . . . . . . . 6
5. Thallus composed of distinctly flattened or at least basally angular lobes or branches . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7
   6. Thallus dark brown; filaments having no central cartilaginous axis. Soralia present. Medulla PD + red (fumarprotocetraric acid. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **54.** *Alectoria*
   6. Thallus yellow-green to grey-green; filaments with a central, cartilaginous, elastic axis . . . . . . . . . . . . . . . . . . . . . . . . **56.** *Usnea*
7. Thallus light or dark brown, shrubby; terricolous. Marginal pycnidia abundant; pseudocyphellae linear, submarginal; . . . . . . . . . . . . . . . . . . . . . . . . 207. *Cetraria islandica* subsp. *crispa*
7. Thallus not brown; corticolous . . . . . . . . . . . . . . . . . . . . . . . . . . . 8
   8. Thallus yellow or orange. Cortex KOH + red-violet . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **59.** *Teloschistes*
   8. Thallus grey-green or yellow-green. Cortex K- or K + yellow . . . 9
9. Medulla C + red. Thallus isidiate, grey-green (usnic acid absent); clearly dorsi-ventral . . . . . . . . . . . . . . 204. *Pseudevernia furfuracea*
9. Medulla C-. Thallus not isidiate, yellow-green to grey-green (usnic acid present); upper and lower surfaces not distinguishable . . . . . . 10
   10. Thallus soft, flexible (without chondroid layer), sorediate. Medulla KOH-, PD- . . . . . . . . . . . . . . . . 211. *Evernia mesomorpha*
   10. Thallus stiff, (with chondroid layer), often caespitose, esorediate. Medulla KOH- or KOH + red . . . . . . . . . . . . . . . **55.** *Ramalina*

## 1. ARTHOPYRENIA

1. Spores ellipsoid to subfusiform, 15-17 x 5-7 μ, 1 to 3 septate, with cells usually unequal in size; pseudothecia 0.15-0.26 mm in diameter; paraphysoid threads persistent, distinct. Corticolous . . . 2. *A. pinicola*
1. Spores fusiform, 16-21 x 4-5(-7) μ, 1 to 3 septate, with cells equal in size; pseudothecia 0.15-0.25 mm in diameter; paraphysoid threads distinct and persistent. Corticolous . . . . . . . . . . . . . . . . . 1. *A. cerasi*

## 4. ARTHONIA

1. Phycobiont *Trebouxia*. Thallus whitish to yellowish green, granular to verrucose; ascocarps round; disks ashy grey to black, heavily pruinose; spores 3-septate, (14-)16-22 x 5-7 μ . . . . . . . . . . . . . . . 5. *A. caesia*
1. Phycobiont *Trentepohlia* . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
   2. Ascocarps jet black or bluish grey (even when moist) . . . . . . . 3

2. Ascocarps red-brown to dark brown or brownish black, turning a distinct red-brown when moistened . . . . . . . . . . . . . . . . . . . . 5

3. Hypothecium (fruit base) brown. Thallus scattered, granulose to disappearing; ascocarps punctiform; spores 3-septate ± clavate, 10-17 x 4-6 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6. *A.* cfr. *mediella*

3. Hypothecium (fruit base) hyaline or essentially absent . . . . . . . . . . 4

4. Spores (3-)5 septate, penultimate cells much shorter than other cells, 17-20 x 5-7 μ . . . . . . . . . . . . . . . . . . . . . . 9. *A. sexlocularis*

4. Spores 3-septate, all spore cells equal in size, 14-20 x (4-)5-7 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8. *A. punctiformis*

5. Spores 2 to 4 septate, hyaline, one end cell much larger than other cells; ascocarps epruinose; spores 14-20 x 5-7 μ . . . . . . 10. *A. siderea*

5. Spores constantly 3-septate, ashy brown, all cells equal in size; ascocarps heavily pruinose; spores 12-17 x 4-6 μ . . . . . . 7. *A. polymorpha*

## 6. MICAREA

1. Saxicolous. Thallus greenish or brownish grey, minutely verrucose to granulose; ascocarps less than 0.5 mm in diameter, buff to black; spores 3-septate, (8-)12-16 x (2-)3-4 μ . . . . 71. *Bacidia* cfr. *trisepta*

1. Lignicolous (on rotting wood) . . . . . . . . . . . . . . . . . . . . . . . . . . 2

2. Spores mostly uniseptate, sometimes nonseptate, 6.5-8.5 x 3.0-3.5 μ; thallus blackish green, minutely granulose; ascocarps very convex to hemispherical, brown to black . . . . . . . . 13. *M. prasina*

2. Spores 1 to 3 septate, 16-19 x 5-6 μ; thallus dark green to greenish black, smooth or verrucose to ± granulose; ascocarps very convex to hemispherical, pitch black . . . . . . . . . . 12. *M. melaena*

## 7. OPEGRAPHA

1. Thallus thin, continuous to scurfy or hypophloedal; spores 8 per ascus . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2

1. Thallus thin, becoming sorediate in maculiform yellow green soralia; spores 4 per ascus. Ascocarps short and broad, 0.5-0.65 x 0.11-0.4 mm, somewhat branches; spores 5 to 7 septate, 18-23 x 4-5 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Cfr. *Opegrapha* sp.

2. Spores 22-36 x 2-3 μ, 3 to 7 septate; ascocarps (0.25-)0.5-2 mm long, somewhat branched, pycnoconidia 9-15 x 1-2 μ, strongly curved or twisted . . . . . . . . . . . . . . . . . . . . . . . . 14. *O. cinerea*

2. Spores 19-24 x 3.5 μ, 1 to 3 septate; ascocarps up to 0.5 mm long, unbranched; pycnoconidia 5-7 x 1-2 μ, curved . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15. *O. rufescens*

## 9. VERRUCARIA

1. Spores 6-9 x 3-5 μ; perithecia 0.1-0.2 mm across; thallus very thin, filmy, sordid dark brown. On quartz pebbles in littoral zone . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 17. *V. microspora*

1. Spores 15-26 x 6-15 μ; perithecia 0.2-0.4 mm across . . . . . . . . . . . 2

2. On littoral quartz pebbles. Thallus smooth, extremely thin, continuous, black to dark brown; spores 16-25 x 6-10 μ . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20. *V. silicicola*

  2. On concrete and mortar . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3

3. Thallus thick, dark brown to brownish grey, dispersed verrucose, areolate to almost squamulose; exciple carbonaceous; spores 15-18 x 8-9 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19. *V. nigrescens*

3. Thallus thin, pale grey to whitish ash, areolate to chinky, the areoles being ± dispersed; exciple pale; spores 20-23(-26) x 10-14 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 18. *V. muralis*

### 14. PORINA

1. Perithecia, buff to tan, 0.2-0.3 mm across; spores 5 to 9 septate, 48-75 x 7-9 μ. Thallus effuse coralloid-isidiate; exciple pale . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 27. *P. nucula*

1. Perithecia black; spores less than 6.5 μ broad . . . . . . . . . . . . . . . . . 2

  2. Spores 3 to 7 septate, 30-42 x 5-6 μ; exciple pale; thallus greenish black, chinky to almost granulose, well developed . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 25. *P. cestrensis*

  2. Spores mostly 9 to 13 septate, 58-65 x 5-7 μ; exciple carbonaceous; thallus dark or light grey-green, diffuse, very thin, almost absent in places . . . . . . . . . . . . . . . . . . . . . . . . 26. *P. hibernica*

### 21. LEPTOGIUM

1. Thallus very thin, isidiate, the isidia cylindrical, becoming coralloid and subsquamulose; apothecia absent . . . . . . . . . . . 36. *L. cyanescens*

1. Thallus relatively thick, not isidiate or sorediate, but rugose and finely rugulose; apothecia common; margins smooth and entire; spores 20-23 x 9-12 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . 35. *L. corticola*

### 24. LOBARIA

1. Thallus olivaceous, pitted and reticulate, with soredia and sometimes isidia on the ridges and margins. Sterile on L.I. Medulla PD + orange and KOH + yellow (stictic acid), C-, KC + reddish (lobaric acid?) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 39. *L. pulmonaria*

1. Thallus grey to light green, smooth, without soredia or isidia. Usually fertile. Medulla PD-, KOH-, C + red . . . . . . . . . . . 40. *L. quercizans*

### 27. PELTIGERA

1. Phycobionts green algae, cephalodia scattered over thallus surface. Rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 43. *P. aphthosa*

1. Phycobionts blue-green algae; cephalodia absent . . . . . . . . . . . . . . 2

  2. Thallus surface glabrous (without tomentum). Spores acicular 75-103 x 4-5 μ . . . . . . . . . . . . . . . . . . . . . . . . . 45. *P. polydactyla*

  2. Thallus surface tomentose to some extent . . . . . . . . . . . . . . . . 3

3. Thallus producing minute regeneration squamules at edges and along wounds . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 46. *P. praetextata*

3. Thallus not producing regeneration squamules . . . . 44. (*P. canina*) 4

  4. Thallus with grey granular soredia produced in small, laminal, orbicular soralia . . . . . . . . . . . . . . . . . . . 44. *P. canina* var. *spuria*

  4. Thallus esorediate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5

5. Veins on lower surface white . . . . . . . . . . 44. *P. canina* var. *rufescens*
5. Veins brown to the edge of the thallus . . . 44. *P. canina* var. *ulorrhiza*

## 28. LECIDEA

1. On soil . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
1. On rock . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
1. On bark or old wood . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8
    2. Thallus green to greenish grey or greenish white, verrucose, becoming sorediate, C + red; apothecia 0.6-1.3 mm in diameter; hypothecium hyaline; spores 6-10 x 3-6 μ . . . . . . 54. *L. granulosa*
    2. Thallus dark olivaceous brown to black, granulose, C-; apothecia mostly 0.3-0.4 mm in diameter; hypothecium dark brown; spores (6-) 8-10 x 4-7 μ . . . . . . . . . . . . . . . . . . . . . . . . 59. *L. uliginosa*
3. Apothecia white pruinose with conspicuous dark grey rims. Thallus light grey to whitish grey, continuous to irregularly cracked, KOH + red (norstictic acid) or KOH + yellow (stictic acid); hypothecium dark brown or red-brown; spores (13-) 16-20 x 6-8 (-10) μ. Usually on shaded rocks . . . . . . . . . . . . . . . . . . . . . . . . 48. *L. albocaerulescens*
3. Apothecia black or brown, epruinose. Thallus KOH- . . . . . . . . . . . 4
    4. Apothecia 0.5-1.5 mm in diameter; disks black . . . . . . . . . . . . 5
    4. Apothecia less than 0.5 mm in diameter; disks black or brown . . . 6
5. Spores 16-18 x 8 μ . . . . . . . . . . . . . . . . . . . . . . . . 55. *L. macrocarpa*
5. Spores 7-12 x 3-6 μ . . . . . . . . . . . . . . . . . . . . . . . 52. *L.* cfr. *cyrtidia*
    6. Spores 11-20 x 7-10 μ; apothecial disks red-brown to dark brown to black; hypothecium yellowish to hyaline . . . . . 51. *L. coarctata*
    6. Spores 6-8 x 3-4 μ; apothecial disks black; hypothecium dark brown . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7
7. Epithecium and outer edge of exciple dark green to greenish black . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 53. *L. erratica*
7. Epithecium and outer edge of exciple reddish brown, not green (but hymenium may be pale olivaceous at times) . . . . . . . . 52. *L. cyrtidia*
    8. Thallus squamulose, composed of imbricate squamules. Apothecia rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9
    8. Thallus not squamulose . . . . . . . . . . . . . . . . . . . . . . . . . . . 10
9. Thallus C + red, PD- (lecanoric acid). Squamules mostly 0.5-1.0 mm across, yellowish- or olive-green . . . . . . . . . . . . . . 58. *L. scalaris*
9. Thallus C-, PD + red (fumarprotocetraric acid). Squamules mostly less than 0.5 mm across, olive- to brownish green to dark olivaceous brown . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 49. *L. anthracophila*
    10. Hypothecium dark brown or reddish brown . . . . . . . . . . . . . . 11
    10. Hypothecium hyaline . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12
11. Thallus thick verrucose-areolate, becoming sorediate, grey-green to brown; spores 6-12 x (2-) 3-5 μ . . . . . . . . . . . . . . . . 50. *L. botryosa*
11. Thallus not sorediate, very thin, dark green-black; spores 6-8 x 3-4 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 56. *L. myriocarpoides*
    12. Spores narrowly ellipsoid to fusiform, 11-19 x 3-5 μ . . . . . . . . 13

12. Spores ellipsoid to spherical, 5-10 x 3-7 µ. Apothecial disks red-brown to black . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14
13. Spores 15-19 x 4-5 µ, sometimes uniseptate; apothecia often strongly convex and hemispherical, disks flesh colored to darker brown . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 61. *L. vernalis*
13. Spores 11-13 x 3-4 µ, never uniseptate; apothecia ±convex but not hemispherical, disks yellow to pale orange . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (see 167. *Lecanora symmicta*)
14. Thallus yellow-green, areolate to chinky or somewhat granular, C + yellow-orange. Apothecia red-brown to dark brown, usually less than 0.3 mm across; spores 7-10x(4-)5-7 µ . . . 60. *L. varians*
14. Thallus grey-green to brownish green, granulose to sorediate, C + red or C- . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15
15. Spores subglobose, 5-6 x 3-6 µ. Soredia C- . . . . . . . . . 57. *L. nylanderi*
15. Spores ellipsoid or oval, 6-10 x 3-4 µ. Soredia C+red . . . . . . . . . . 16
16. Apothecial disks lead black, margins prominent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 47. *L. aeruginosa*
16. Apothecial disks black, margins absent . . . . . . 62. *L. viridescens*

## 30. BACIDIA

1. Spores narrowly ellipsoid or narrowly ovate; ratio of length to width not more than 7:1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
1. Spores acicular, very narrow, ratio of length to width usually more than 7:1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
2. Saxicolous. Apothecia minute, pale buff to black, convex, marginless; spores (8-)12-16 x (2-)3-4 µ; thallus coarsely granulose, light brownish grey to greenish grey . . . . . . . . 71. *B.* cfr. *trisepta*
2. Corticolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
3. Hypothecium dark brown; hymenium brownish; spores 16-20 x 5-6 µ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (see 12. *Micarea melaena*)
3. Hypothecium and hymenium hyaline; spores (19-)23-32 x 3-6 µ. Apothecia minute, black, convex, marginless . . 66. *Bacidia chlorococca*
4. Spores strongly curved and spiral shaped, 13-16 x 2-3 µ (measured end to end, in a straight line). Saxicolous. Rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 72. *B. umbrina*
4. Spores ± straight . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5
5. Saxicolous. Disks usually lighter than margins; epithecium dark greenish black to black; spores obscurely 3-septate, 19-28 x 1-2 µ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 69. *B. inundata*
5. Corticolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6
6. Hypothecium dark brown or red-brown . . . . . . . . . . . . . . . . . 7
6. Hypothecium pale, hyaline, yellowish, or very light brown . . . . 8
7. Apothecia small, 0.25-0.60 mm in diameter; spores obscurely 1 to 3 septate, 20-33 x 2-3 µ; phycobiont *Trebouxia* . . . . . 67. *B. chlorosticta*
7. Apothecia large, 0.75-1.25 mm in diameter; spores obscurely 6 to 9 septate, 35-55 x 3-4 µ; phycobiont *Trentepohlia* . . . 70. *B. schweinitzii*

8. Polysporous; thallus thick, coarsely granular to verrucose, dark green to olive; apothecia irregular, up to 1.25 mm in diameter, often clustered and crowded; margins raised, conspicuous. Spores 5 to 7 septate, 20-26 x 2-3 μ. . . . . . . . . . . . . . . . 65. *B. chlorantha*
8. Octosporous; thallus thin, greenish grey; apothecia smaller, round, not clustered; margins not raised . . . . . . . . . . . . . . . . . 9
9. Disks red-brown to black; margins concolorous or lighter, disappearing with age; epithecium reddish violet (intense in KOH); spores 7 to many septate, 39-68 x 4-6 μ. . . . . . . . . . . . . . . . . . 64. *B. atrogrisea*
9. Disks light buff to ± dark brown (never black); margins darker than disks; epithecium brown; spores obscurely 3 to 4 septate, 19-32 x 1-3 μ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 68. *B. intermedia*

## 31. RHIZOCARPON

1. Spores uniseptate, hyaline to slightly tinted, (11-)13-20 x (5-)6-10 μ. Thallus sordid greyish green to ashy, verrucose to minutely verruculose, KOH + red (norstictic acid) or KOH + yellow (stictic acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 73. *R. cinereovirens*
1. Spores muriform or submuriform, or thallus sterile . . . . . . . . . . . . . 2
2. Medulla C + red (gyrophoric acid?), KOH + yellow (stictic acid). Spores soon dark brown, many celled . . . . . . . . . . . . . . 3
2. Medulla C-, KOH + red or KOH-. Spores hyaline for a long time, then brown . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
3. Medulla I-. Thallus whitish to light ashy or brownish grey, subcontinuous to areolate, and finally verrucose; spores 26-38 x 10-15 μ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 75. *R. intermedium*
3. Medulla I + blue. Thallus dark brown or grey brown, verrucose with ± round, ± scattered verrucae; spores 25-29 x 10-13 μ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 74. *R. grande*
4. Medulla KOH + red (norstictic acid). Thallus ± smooth, thin; apothecia without any indication of a thalline margin; spores 20-27 x 10-13 μ. . . . . . . . . . . . . . . . . . . . . . . . . . 77. *R. plicatile*
4. Medulla KOH-. Thallus verrucose or areolate, almost squamulose in places; apothecia immersed in small areoles giving appearance of a thalline margin; spores 19-29(-32) x 8-16 μ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 76. *R. obscuratum*

## 35. CLADONIA

1. Primary thallus crustose, persistent, consisting of grey-green or grey to whitish verrucae or granules; spores uniseptate. Pseudopodetia usually under 0.75 mm tall, molariform to somewhat branched, often inflated. Pseudopodetia KOH + yellow and PD- (atranorin) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 78. *Pycnothelia papillaria*
1. Primary thallus squamulose or absent in mature plant; spores nonseptate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
2. Podetia forming a more or less complex branch system (shrubby); primary thallus disappearing in maturity . . . . . . . . . . . . . . . . . 3

2. Podetia simple or sparingly branched, or *absent*, primary thallus squamulose, persistent . . . . . . . . . . . . . . . . . . . . . . . . . . 16

3. Podetia corticate, except where cortex is replaced by soredia in the sorediate species . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4

3. Podetia ecorticate, esorediate (Subgenus CLADINA) . . . . . . . . . . 9

4. Podetia yellowish, usnic acid present (Subsection UNCIALES) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5

4. Podetia grey-green to brownish, usnic acid absent (Subsection CHASMARIAE) . . . . . . . . . . . . . . . . . . . . . . . . . 7

5. Cartilaginous cylinder forming an unbroken inner lining of the podetia, with tiny white granules resembling pruina; cortex smooth and shiny; podetia slender (dry habitats) or robust (moist habitats). Medulla UV + blue-white (squamatic acid) . . . . . . 126. *C. uncialis*

5. Cartilaginous cylinder more or less discontinuous or fibrous; cortex not smooth nor shiny. Medulla UV- (squamatic acid absent) . . . . 6

6. Podetia inflated, contorted, perforate; cartilaginous cylinder composed of loosely interwoven strands; medullary hyphae (as seen in podetial cross-sections) loose and anastomosing, (5-)6-8 μ in diameter . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 124. *C. boryi*

6. Podetia not inflated or perforate; cartilaginous cylinder composed of closely interwoven strands; medullary hyphae compact, 3-5 (-7) μ in diameter . . . . . . . . . . . . . . . . . . . . 125. *C. caroliniana*

7. Soredia present, especially at podetial tips; podetia usually sparsely branched . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8

7. Soredia absent; podetia intricately branched . . . . . . . 122. *C. furcata*

8. Soredia usually farinose, scattered in irregular patches over much of the podetium, gradually coalescing into a continuous sorediate area; squamules confined to the lower half or third of the podetium, or entirely absent . . . . . . . . . . . . . . . . . . 121. *C. farinacea*

8. Soredia granular, mostly confined to the tip of the podetium; squamules commonly covering entire podetium. Rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 120. *C. scabriuscula*

9. Branching more or less isotomic, distinct main stems absent or only exceptionally present; plants giving a rounded, tufted appearance. Thallus PD- . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10

9. Branching anisotomic, distinct main stems usually present . . . . . . . 11

10. Thallus yellowish, KOH- (usnic acid present, atranorin absent); tetra- to pentachotomies predominating, usually star shaped around an axillary hole . . . . . . . . . . . . . . . . . . . . 128. *C. alpestris*

10. Thallus grey, or, rarely, somewhat yellowish, KOH + yellow (usnic acid absent, atranorin present); di- or trichotomies predominating, axils generally closed. Surface appearing very rough, almost tomentose; algal layer not continuous . . . . 127. *C. evansii*

**11.** Thallus PD- . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12

**11.** Thallus PD + red (fumarprotocetraric acid) . . . . . . . . . . . . . . . . 14

12. Thallus KOH + yellow (atranorin). Thallus surface uneven,

appearing “tomentose”, algal layer very discontinuous, branching mostly dichotomous with trichotomies common. Very rare. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 130. *C. terrae-novae*

12. Thallus KOH- (atranorin absent) . . . . . . . . . . . . . . . . . . . . . . . 13

13. Branches very robust, often sprawling; axils broadly open; branching usually tetrachotomous with dichotomies rare; algal layer very smooth and compact, appearing almost corticate. Pseudonorangiformic acid present. Very common . . . . . . . . . . . . . . . . . . . . . . 133. *C. submitis*

13. Branches usually slender, always erect; axils often closed or only slightly open; branching usually trichotomous with dichotomies common; algal layer smooth or decomposed. Pseudonorangiformic acid absent. Very rare . . . . . . . . . . . . . . . . . . . . . . . . 134. *C. mitis*

14. Branching predominantly dichotomous, tri- and tetrachotomies rare; branchlets usually very slender, erect; axils infrequently open; main stems often indistinct; pycnidial jelly red . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 129. *C. subtenuis*

14. Branching predominantly tri- and tetrachotomous around widely open axils; branchlets robust, falcate; main stem always distinct; pycnidial jelly colorless . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15

15. Thallus blue-grey. Usnic acid absent, atranorin present . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 131. *C. rangiferina*

15. Thallus grey-green to yellowish grey. Usnic acid present, atranorin absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 132. *C. arbuscula*

16. Podetia and apothecia absent . . . . . . . . . . . . . . . . . . . . . . . . 17

16. Podetia and/or apothecia present . . . . . . . . . . . . . . . . . . . . . . 37

17. Medulla PD + red, orange, or yellow . . . . . . . . . . . . . . . . . . . . . 18

17. Medulla PD- . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 30

18. Medulla PD + red (fumarprotocetraric acid) . . . . . . . . . . . . . 19

18. Medulla PD + yellow or orange . . . . . . . . . . . . . . . . . . . . . . 24

19. Squamules sorediate on lower surface, broad, entire to broadly lobed . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20

19. Squamules esorediate on lower surface . . . . . . . . . . . . . . . . . . . . 21

20. Squamules large, over 1.0 mm broad, ascending . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 106. *C. coniocraea*

20. Squamules minute, 0.5-0.75(-1.0) broad, closely appressed . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 49. *Lecidea anthracophila*

21. Margins of squamules finely divided to ± granulose . . . . . . . . . . . 22

21. Margins of squamules entire to broadly crenate . . . . . . . . . . . . . . 23

22. Grayanic acid (or, very rarely, cryptochlorophaeic acid) present (in Long Island material) . . . . . . . . . . . . . . . 103. *C. chlorophaea*

22. Grayanic and cryptochlorophaeic acids absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 112. *C. caespiticia*

23. Atranorin present. Squamules strap-shaped; margins somewhat revolute . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 111. *C. apodocarpa*

23. Atranorin absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *C. calycantha*, *C. clavulifera*, *C. mateocyatha*, *C. pyxidata*

24. Medulla C + green . . . . . . . . . . . . . . . . . . . . . . . 93. *C. strepsilis*
24. Medulla C- . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 25
25. Medulla KOH + blood red (norstictic acid) . . . . . 96. *C. subcariosa*
25. Medulla KOH- or KOH + yellow . . . . . . . . . . . . . . . . . . . . . . . 26
26. Medulla KOH + deep yellow and PD + orange (thamnolic acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 27
26. Medulla KOH-, PD + yellow . . . . . . . . . . . . . . . . . . . . . . . . 29
27. Lower surface of squamules sorediate. Terricolous, corticolous, or lignicolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 83. *C. macilenta*
27. Lower surface of squamules esorediate. Lignicolous . . . . . . . . . . . 28
28. Margins of squamules granulose, sometimes reducing the primary thallus to a granular crust . . . . . . . . . . . . . . . . 113. *C. parasitica*
28. Margins of squamules finely divided, not granulose . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 84. *C. vulcanica*
29. Squamules entire or crenate. Squamatic and baeomycic acids absent, psoromic acid present . . . . . . . . . . . . . . . . . . . . . . . . . 98. *C. brevis*
29. Squamules finely divided. Squamatic and baeomycic acids present, psoromic acid absent . . . . . . . 116. *C. atlantica* or 117. *C. beaumontii*
30. Thallus C + red. Lower surface of squamules sorediate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 58. *Lecidea scalaris*
30. Thallus C- . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 31
31. Upper surface or lower surface of squamules yellow or yellowish (usnic acid present) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 32
31. Upper surface of squamules grey to grey-green, lower surface white (usnic acid absent or not detectable) . . . . . . . . . . . . . . . . . . . . . . 34
32. Lower surface of squamules sorediate. Squamatic acid present, barbatic acid absent . . . . . . . . . . . . . . . . . . . . 86. *C. incrassata*
32. Lower surface of squamules esorediate. Squamatic acid absent, barbatic acid present . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 33
33. Squamules very large, broadly crenate to strap shaped; lower surface yellowish. Didymic acid absent . . . . . . . . . . . . . . . . 92. *C. robbinsii*
33. Squamules small, usually finely divided; lower surface white. Didymic acid present . . . . . . . . . . . . . . . . . . . . . . . . . . . . 87. *C. cristatella*
34. Lower surface of squamules ± sorediate. Barbatic acid present, didymic and squamatic acids absent . . . . . . . . . . 82. *C. bacillaris*
34. Lower surface of squamules esorediate . . . . . . . . . . . . . . . . . . 35
35. Squamatic acid present, didymic acid absent . . . . . 115. *C. squamosa*
35. Squamatic acid absent, didymic acid present . . . . . . . . . . . . . . . . 36
36. On highly decayed wood in shaded bogs . . . . . . . . 85. *C. didyma*
36. On soil, dry tree bases, or dry lignum in exposed areas . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 87. *C. cristatella*
37. Apothecia essentially sessile on primary squamules or on very short decorticate podetia (less than 2 mm tall); squamules finely crenate; apothecia brown, flat to strongly convex. Squamules PD + red (fumarprotocetraric acid) . . . . . . . . . . . . . . . . . . . 112. *C. caespiticia*

37. Apothecia, when present, on ± well developed podetia at least partially corticate and over 2 mm tall; podetia often sterile . . . . . . . . . . 38
    38. Podetia without cups or tiers . . . . . . . . . . . . . . . . . . . . . . . . . . 39
    38. Podetia with more or less distinct cups or tiers . . . . . . . . . . . . 64
39. Podetia without soredia or granules, although in some cases somewhat ecorticate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 40
39. Podetia granular or with granular or farinose soredia . . . . . . . . . . 54
    40. Apothecia red; podetia and squamules yellowish green to grey-green (usnic acid present) . . . . . . . . . . . . . . . . . . . . . . . . . . . 41
    40. Apothecia brown, tan, or buff, or absent; podetia and squamules grey-green to olive-green or yellowish green (usnic + or −) . . . 42
41. Primary squamules covered on lower surface with granular or farinose soredia. Common on decaying stumps and logs. . . . . 86. *C. incrassata*
41. Primary squamules without soredia. Very common on many substrates. Podetia usually grey-green, squamulose on bark in the shade, and yellow-green without squamules on the ground in the sun . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 87. *C. cristatella*
    42. Podetia more or less abundantly branched. Podetia PD + red or orange . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 43
    42. Podetia usually simple, or, if branched, only once or twice near the summit. Podetia PD + or − . . . . . . . . . . . . . . . . . . . . . . 44
43. Podetia often growing in dense mats, 10-20 mm tall, often bearing brown apothecia; holes in axils often surrounded by proliferations, giving the appearance of rudimentary cups. Podetia KOH + lemon yellow, PD + red-orange or orange-yellow (thamnolic acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 118. *C. floridana*
43. Podetia not growing in dense mats, usually over 20 mm tall; apothecia rare; holes in axils never surrounded by proliferations. Podetia KOH- or brownish, PD + red (fumarprotocetraric acid) . . . 122. *C. furcata*
    44. Podetia PD + . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 45
    44. Podetia PD − . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 52
45. Podetia PD + red (fumarprotocetraric acid) . . . . . . . . . . . . . . . . 46
45. Podetia PD + yellow to orange . . . . . . . . . . . . . . . . . . . . . . . . . . 48
    46. Thallus yellowish green to grey-green; podetia 7-15 mm tall, minutely squamulose; apothecia minute, present or absent. Very rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 110. *C. simulata*
    46. Thallus dark or pale green-grey; podetia usually less than 10 mm tall, not squamulose; apothecia always present, large, at least equal to diameter of podetium. Common . . . . . . . . . . . . . . . . 47
47. Podetia usually grooved and twisted, often decorticate, often longitudinally split or striate; apothecia buff to light brown, two to three times the diameter of the podetium . . . . . . . . . . . . . . . 94. *C. capitata*
47. Podetia usually corticate, verrucose or areolate, not twisted or striate; apothecia dark or sometimes light brown, one to two times the diameter of the podetium . . . . . . . . . . . . . . . . . . . . . . 97. *C. clavulifera*

48. Medulla C + green, KOH- (strepsilin and baeomycic acid). Thallus and podetia olive green; podetia ± inflated. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 93. *C. strepsilis*

48. Medulla C-, KOH + or − (strepsilin absent). Thallus and podetia grey-green or brownish green; podetia usually slender. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 49

49. Podetia with perforate tips or axils, covered with large or small squamules or verrucae. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 50

49. Podetia not perforate, without squamules, or, slightly squamulose on lower half . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 51

50. Podetia KOH- (baeomycic acid present). Podetia commonly over 10 mm tall, slender, grey-green. . . . . . . . . . . 117. *C. beaumontii*

50. Podetia KOH + yellow (thamnolic acid present). Podetia usually under 10 mm tall, robust, pale grey to almost white. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 114. *C. santensis*

51. Medulla KOH + red (norstictic acid). . . . . . . . . . 96. *C. subcariosa*

51. Medulla KOH − (psoromic acid) . . . . . . . . . . . . . . . . 98. *C. brevis*

52. Thallus with a distinct yellow tint (usnic acid present) . . . . . . 53

52. Thallus without any hint of yellow (usnic acid absent). Thallus grey or brownish green; podetia commonly 10-15 mm tall, fissured. Atranorin present. Very rare. . . . . . . . . . . 95. *C. cariosa*

53. Primary squamules small (mostly less than 0.5 mm broad); podetia common; apothecia flat, reddish brown, abundant. Rare. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 91. *C. piedmontensis*

53. Primary squamules very large (1-4 mm broad); podetia rare, very short, arising from lateral edges of squamules; apothecia strongly convex, dark brown. Very rare. . . . . . . . . . . . . . . . 92. *C. robbinsii*

54. Podetia PD + . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 55

54. Podetia PD − . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 62

55. Podetia PD + yellow to deep yellow-orange, KOH + lemon yellow (thamnolic acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 56

55. Podetia PD + deep red, KOH − or + dingy brown (fumarprotocetraric acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 58

56. Apothecia brown to purple-brown, common. Podetia and margins of primary squamules covered with large corticate granules. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 113. *C. parasitica*

56. Apothecia red, but sometimes lacking. . . . . . . . . . . . . . . . . 57

57. Primary squamules esorediate; podetial soredia coarsely granular; podetia often decorticate and translucent with cartilaginous layer exposed. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 84. *C. vulcanica*

57. Primary squamules sorediate; podetial soredia farinose or, rarely, granular, covering podetium; podetia often decorticate turning brown to black, but opaque. . . . . . . . . . . . . . . . . . . . . . . 83. *C. macilenta*

58. Podetia short, rarely taller than 6 mm, with blunt apices, covered with coarsely granular soredia on the lower ½ to ⅔ of podetium,

and farinose soredia on the upper ½, ecorticate areas abundant. Grayanic acid present . . . . . . . . . . . . . . . . . . . . 108. *C. cylindrica*

58. Podetia usually much taller than 6 mm, apices sharply pointed, ± corticate at the base, corticate on upper parts. Grayanic acid absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 59

59. Podetia partially decorticate, the decorticate areas becoming pellucid and dark; granular soredia covering large portions of the podetia. Podetia often bent or contorted . . . . . . . . . . . . . . . . . 109. *C. pityrea*

59. Podetia corticate for the most part, or the cortex is replaced by granular or farinose soredia . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 60

60. Podetia unbranched, relatively stout, tapering ± abruptly to a sharp point, each podetium arising from the center of a primary squamule. Podetia and squamules with a vague yellowish green tint; farinose sorediate on upper half or more of podetium; squamules large, sometimes sorediate. Common and variable . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 106. *C. coniocraea*

60. Podetia commonly branched, long and slender, not arising from the center of primary squamules . . . . . . . . . . . . . . . . . . . . . . . . 61

61. Soredia usually farinose, scattered in irregular patches over much of the podetium, gradually coalescing into a continuous sorediate area; squamules confined to lower half or third of the podetium, or absent. Frequent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 121. *C. farinacea*

61. Soredia granular, mostly confined to tip of podetium; squamules commonly covering entire podetium. Rare . . . . . . . . 120. *C. scabriuscula*

62. Podetia corticate for most of length, some areas bursting into granular soredia; some granular soredia on lower surface of squamules near the margins; apothecia red. Usnic acid present or absent. Rare . . . . . . . . . . . . . . . . . . . . . . . . 81. *C. floerkeana*

62. Podetia mostly sorediate, often with many decorticate areas; apothecia red. Usnic acid absent . . . . . . . . . . . . . . . . . . . . . . 63

63. Podetia covered with granular soredia, or soredia becoming farinose on upper half; decorticate areas becoming translucent, then brown; primary squamules esorediate. On wood or bark. Rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 85. *C. didyma*

63. Podetia entirely covered with farinose soredia, occasionally with a small corticate area at the base; decorticate areas white, opaque; primary squamules usually having granular soredia on lower surface near the margins. On various substrates. Very common . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 82. *C. bacillaris*

64. Podetia without soredia or granules, but sometimes squamulose or minutely verrucose . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 65

64. Podetia sorediate or granular . . . . . . . . . . . . . . . . . . . . . . . . . 73

65. Cups opening into podetia . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 66

65. Cups closed by continuous membranes . . . . . . . . . . . . . . . . . . . . . 70

66. Podetia KOH + deep yellow (thamnolic acid) . . . . . . . . . . . . 67

66. Podetia KOH- . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 68

67. Cups very narrow, almost rudimentary, slightly perforated at tip. Rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 114. *C. santensis*

67. Cups broad, with extensive proliferations . . . . . . . 123. *C. carassensis*

68. Podetia PD + . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 69

68. Podetia PD − (squamatic acid present) . . . . . 115. *C. squamosa*

69. Podetia PD + yellow (baeomycic and squamatic acids present) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 116. *C. atlantica*

69. Podetia PD + red (fumarprotocetraric acid). Podetia and cups irregularly perforate and lacerate . . . . . . . . . . . . . . . . 119. *C. multiformis*

70. Podetia proliferating from center or edges of cups; cups shallow, flat, or slightly convex; podetia corticate . . . . . . . . . . . . . . . . . 71

70. Podetia simple, deeply goblet shaped, not proliferating, extensively decorticate. Inside of cup lined with small or large scattered areoles or flat squamules. Grayanic acid absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 102. *C. pyxidata*

71. Proliferations irregular, mostly from cup edges; cups abortive, ± squamulose; squamules large . . . . . . . . . . . . . . . 101. *C. mateocyatha*

71. Proliferations from center of cups, regular; cups well formed; podetia esquamulose . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 72

72. Cups gradually expanding from stalk; podetia usually completely corticate. On neutral soils . . . . . . . . . . . . . . . . 99. *C. verticillata*

72. Cups abruptly expanding from stalk; podetia with a ± continuous cortex becoming distinctly areolate or partially decorticate. On acid soils, especially in or near bogs . . . . . . . . 100. *C. calycantha*

73. Podetia distinctly yellowish green (usnic acid present or absent) . . . 74

73. Podetia grey-green or brownish (usnic acid absent). Apothecia brown . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 77

74. Podetia PD + orange and KOH + yellow (thamnolic acid); usnic acid absent. Podetia with narrow, shallow cups, corticate at base, soon becoming farinose sorediate and sorediate for most of length. (On Nantucket Island, not on Long Island) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . [*C. digitata* (L.) Hoffm.]

74. Podetia PD-, KOH-; usnic acid present . . . . . . . . . . . . . . . . . 75

75. Apothecia brown. Barbatic acid present, zeorin absent. Cups deep, goblet shaped, covered with farinose soredia . . . . . . . 90. *C. carneola*

75. Apothecia red. Barbatic acid absent, zeorin present . . . . . . . . . . . 76

76. Cups often elongate, somewhat split longitudinally; soredia farinose. Rare . . . . . . . . . . . . . . . . . . . . . . . . . 88. *C. deformis*

76. Cups goblet shaped, not split; soredia coarsely granular. Common . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 89. *C. pleurota*

77. Soredia coarsely granular, covering entire podetium. Podetia PD + red (fumarprotocetraric acid) or PD-; grayanic or, rarely, cryptochlorophaeic acid present . . . . . . . . . . . . . . . . . . 103. *C. chlorophaea*

77. Soredia farinose. Podetia PD + red (fumarprotocetraric acid) . . . 78

78. Cups shallow, deeply dentate, with short, spur-like branchlets

proliferating from edges giving a star-like appearance, or, infrequently, these proliferations are lacking. Homosekakaic acid present (but often difficult to demonstrate) . . . 107. *C. nemoxyna*

78. Cups usually deep, not proliferating from edges. Homosekakaic acid absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 79

79. Podetia slender, trumpet shaped; cups narrow; soredia covering entire podetium. Substance "H" absent . . . . . . . . . . . . . . . . 104. *C. fimbriata*

79. Podetia broad, goblet shaped; cups wide; soredia usually absent on lower half of podetium where there is a continuous cortex. Substance "H" present . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 105. *C. conista*

## 36. UMBILICARIA

1. Thallus pustulate; undersurface naked. Apothecia common; disks ± smooth, becoming somewhat gyrose with age with margins complete (leiodisc) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 137. *U. papulosa*
1. Thallus smooth; undersurface rhizinate or lamellate . . . . . . . . . . . . 2
    2. Undersurface with flat, reticulate lamellae; rhizines absent; apothecia common; disks very gyrose with margins lacking (actinodisc) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 136. *U. muhlenbergii*
    2. Undersurface densely rhizinate, with a mat of short black rhizines; apothecia not seen on L. I. material, rare elsewhere. (Disks concentrically gyrose with a ± complete proper margin [gyrodisc]) . . . . . . . . . . . . . . . . . . . . . . . . . 135. *U. mammulata*

## 37. SARCOGYNE

1. Apothecial disks rough, verrucose, carbonaceous; epithecium carbonaceous, thick, very uneven. Apothecia 0.3-1.0 mm across; hymenium (65-)100-120(-200) µ (including the black epithecium) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 140. *S. simplex*
1. Apothecial disks ± smooth, reddish black (especially when wet); epithecium thin, brown, granular. (Note: Occasionally some carboaceous material appears in epithecium, but always in very small amounts) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
    2. Apothecia 0.5-2.0 mm across; hymenium 85-120µ high; hypothecium usually yellowish or brownish. Common . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 138. *S. clavus*
    2. Apothecia less than 1 mm across; hymenium 60-85µ high; hypothecium hyaline. Rare . . . . . . . . . . . . . . . . . . . . 139. *S. privigna*

## 39. PERTUSARIA

1. Fruit warts smooth, or at least not servediate or granular . . . . . . . . 2
1. Fruit warts sorediate or granular . . . . . . . . . . . . . . . . . . . . . . . . 8
    2. Spores 8 per ascus (or, rarely, 4 per ascus) . . . . . . . . . . . . . . 3
    2. Spores 2 per ascus or 1 per ascus . . . . . . . . . . . . . . . . . . . . . . 5
3. Spores uniseriate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
3. Spores biseriate. Fruit warts smooth; ostioles prominent, depressed. Fruit warts PD + orange and KOH + red (norstictic acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 145. *P. propinqua*

4\. Thallus epiphloedal, thick; fruit warts crowded, over 1 mm across, eupertusariate, PD-, KOH-. . . . . . . . . . . . . 148. *P. tuberculifera*

4\. Thallus hypophloedal, thin; fruit warts scattered, under 1 mm across, ampliariate, PD-, KOH- (?) . . . . . . . . . . . . 142. *P. alpina*

5\. Apothecium lecanorine. Disk and thallus C + red. . . . 149. *P. velata*

5\. Apothecium not lecanorine; fruit warts with one or more ostioles. Fruit warts and thallus C-. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6

6\. Thallus grey, rarely yellowish; fruit warts eupertusariate, polycarpous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7

6\. Thallus yellowish green, rarely greyish; fruit warts ampliariate (or, infrequently, somewhat eupertusariate), monocarpus or dicarpous. Thallus UV + pink-orange; fruit warts PD ± orange and KOH + yellow (stictic acid) . . . . . . . . . . 150. *P. xanthodes*

7\. Fruit warts PD + red (fumarprotocetraric acid). Spores (85-)97-124(-138) x 35-45 μ, always hyaline, radial canals absent. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 146. *P. subpertusa*

7\. Fruit warts PD + orange and KOH + yellow (stictic acid). Spores 125-173 x 30-62 μ, hyaline to brownish, radial canals and transverse wall markings usually conspicuous . . . . . . . 151. *Melanaria macounii*

8\. Sorediate warts KC + violet. Thallus dark ashy. . . 143. *P. amara*

8\. Sorediate warts KC-. Thallus light or dark grey . . . . . . . . . . . 9

9\. Soredia PD + orange and KOH + yellow (thamnolic acid); spores 2 per ascus. . . . . . . . . . . . . . . . . . . . . . . . . . . 147. *P. trachythallina*

9\. Soredia PD-, KOH-; spores 1 per ascus . . . . . . . 10. (*P. multipuncta*)

10\. Thallus thin, smooth; fruit warts scattered, bases ± broad; spores 97-110 x 45-48 μ. . . . . . . . . . . . . . . 144. *P.* cfr. *multipuncta* (#1)

10\. Thallus thick, verrucose; fruit warts crowded, base constricted; spores 125-150 x (45-)55-70 μ. . . . 144. *P.* cfr. *multipuncta* (#2)

## 42. LECANORA

1\. Thallus becoming distinctly lobed at the margins, or subfoliose. Saxicolous. (Section PLACODIUM) . . . . . . . . . . . . . . . . . . . . . . . 2

1\. Thallus with margins not lobed or subfoliose . . . . . . . . . . . . . . . . . 3

2\. Thallus closely adnate, crustose; apothecia greenish or brownish, 0.5-1.5 mm in diameter. On calcareous substrates . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 164. *L. muralis*

2\. Thallus ascending, subfoliose to peltate; apothecia yellowish or orange, up to 2.5 mm in diameter. On granite. . . 165. *L. rubina*

3\. Apothecia immersed in thallus (especially in young condition); disks black; spores (12-)16-20 x 7-10 μ. Saxicolous (Section ASPICILIA) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4

3\. Apothecia sessile (Section LECANORA) . . . . . . . . . . . . . . . . . . . 5

4\. Thallus KOH-. Pycnoconidia (9-)10-14 x 1 μ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 154. *L. caesiocinerea*

4\. Thallus KOH + yellow (stictic) or KOH + red (norstictic). Pycnoconidia (10-)13-18 x 1 μ. . . . . . . . . . . . . . . 157. *L. cinerea*

5. Disks pitch black. Apothecia up to 2 mm across; epithecium tinted violet, especially in KOH; spores 12-16 x 7-9 μ. . . . . . . . . 153. *L. atra*
5. Disks yellowish to brown or dark brown (never black) . . . . . . . . . 6
    6. Spores 6-8 μ wide . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7
    6. Spores 2-6(-7) μ wide . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11
7. Disks heavily pruinose, C + orange; apothecia lavender. Apothecial sections KOH + blood red (norstictic acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 155. *L. caesiorubella* subsp. *lathamii*
7. Disks epruinose or very light pruinose, C-; apothecia brown. Apothecial sections KOH + yellow (atranorin alone) . . . . . . . . . . . . . . 8
    8. Amphithecium containing large, colorless crystals; epithecium inspersed with granules . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9
    8. Amphithecium without large, colorless crystals; epithecium not inspersed with granules . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10
9. Epithecium PD + red-orange with the production of small orange acicular crystals. Epithecial granules persistent in KOH; apothecial disk dark brown, epruinose, strongly convex; margin crenate, soon becoming thin and bead like; spores 12-14 x 7-8 μ. Very rare. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 160. *L. degelii*
9. Epithecium PD − or PD + yellow (with no crystals formed). Epithecial granules dissolve in KOH; apothecial disk yellow-brown to red-brown, often slightly pruinose, flat to convex; margin thick, smooth to crenate; spores 10-13 x 6-7 μ. Very common . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 156. *L. chlarotera*
    10. Thallus very thick, verrucose and chinky, neither granular nor sorediate; apothecia up to 2 mm in diameter, often twisted and "urn shaped"; disk reddish brown; apothecial cortex thick, 45-50 μ. On cedar stumps and old wood . . . . . . . . 163. *L. laevis*
    10. Thallus thinner, smooth to granular and sorediate; apothecia 0.5-1.0 mm, circular, closely adnate; disk deep mahogany brown; apothecial cortex 16-25 μ thick. On bark . . . . . 169. *Lecanora* sp.
11. Spores 5-7 x 2-4 μ. Apothecia minute, 0.2-0.4 mm in diameter. On old wood . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 166. *L. subintricata*
11. Spores 8-16 x 3-7 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12
    12. Saxicolous (on limestone and mortar). Thallus almost lacking; apothecia 0.25-0.50 mm in diameter; disks yellow-brown to olive-brown; margins white or ashy, usually persistent; spores 9-10 x 4-6 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 161. *L. dispersa*
    12. On bark, wood, or bone . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13
13. Disks yellow pruinose, lemon yellow when young, gradually turning red-brown. Thallus well developed, grey, very rough; spores 11-14 x 4-5 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 159. *L. cupressi*
13. Disks epruinose or lightly white pruinose, yellow to brown . . . . . . 14
    14. Apothecial margin cortex indistinct, not gelatinous; thallus granulose to sorediate, yellow-green; apothecia scattered or crowded; disks yellow to buff . . . . . . . . . . . . . . . . . . . . . . . . . . 16

14. Apothecial margin cortex distinct, gelatinous, thick; thallus essentially absent, or if present, not granular or sorediate; apothecia very crowded, abundant. . . . . . . . . . . . . . . . . . . . . . . . . . . . . .15

15. Apothecial sections KOH- (atranorin absent). Disks buff to very pale brown, lightly white pruinose; spores 10-13 x 3-5(-7) µ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .162. *L. hageni*

15. Apothecial sections KOH + yellow (atranorin present). Disks yellow-brown to dark brown, epruinose; spores 9-12 x 4-7 µ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .168. *L.* cfr. *varia*

16. Apothecial margins persistent, becoming thin and disappearing in age, soon becoming granulose; spores 10-16 x 3-5 µ. Atranorin absent. Frequent. . . . . . . . . . . . . . . . . . . . . . . . .158. *L. conizaea*

16. Apothecial margins absent in all but the youngest apothecia, smooth when present and hardly distinguishable from the disk; spores 11-13 x 3-4 µ. Thallus C-. Very rare. . . .167. *L. symmicta*

## 43. OCHROLECHIA

1. Thallus (cortex and medulla) C- and KC-. Disks often somewhat pruinose; spores 45-68 x 21-36 µ. Variolaric acid present in apothecial margin. Common; corticolous. . . . . . . . . . . . . . . . . . .170. *O. parella*

1. Thallus (cortex or medulla) C + red. . . . . . . . . . . . . . . . . . . . . . .2

2. Cortex of apothecial margin C + red; amphithecial medulla C-. Thallus thick, verrucose; spores 40-60 x 25-26 µ. Algae present in a layer (sometimes not continuous) below hypothecium; apothecial cortex relatively thin. Very rare; corticolous. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .171. *O. rosella*

2. Cortex of apothecial margin C-; amphithecial medulla C + red, stipe C-. Thallus thin, rimose to verrucose; spores 38-59 x 21-26 µ. Corticolous. . . . . . . . . . . . . . . . . . .172. *Ochrolechia* sp.

## 44. HAEMATOMMA

1. Thallus covered with sorediate verrucae towards the center, becoming smooth at the edges; thallus eventually becoming a granular sorediate crust, blue-grey to greenish grey; sterile. Thallus PD + orange and KOH + yellow (thamnolic acid) . . . . . . . . . .174. *H.* sp.

1. Thallus coarsely verrucose or almost granular, but not sorediate, whitish green to yellowish green; apothecial disks red-brown, common; spores (35-)45-62 x 5-8 µ. Thallus PD + orange and KOH + yellow (thamnolic acid) . . . . . . . . . . . . . . . . . .173. *H. ochrophaeum*

## 45. CANDELARIELLA

1. Octosporous; thallus appearing mostly black, or pale to dull yellow in small areas, granulose to verrucose or subsquamulose. On calcareous rock. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .175. *C. aurella*

1. Polysporous (spores about 20 per ascus); thallus yo'k- to greenish yellow, never darkening, granular-verrucose, with granules or subsquamulose verrucae becoming crowded into flattened or rounded patches. On granitic rocks. Often sterile. . . . . . . . . .176.*C. vitellina*

## 47. PARMELIOPSIS

1\. Thallus yellow-green, surface bursting into irregular laminal soralia which coalesce into a mass of granular soredia. Thallus PD-, KOH-, usnic and divaricatic acids present . . . . . . . . . . . . . . 179. *P. ambigua*

1\. Thallus grey-green or grey, esorediate. Thallus PD + orange and KOH + yellow (thamnolic acid); usnic and divaricatic acids absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2

  2\. Thallus isidiate, adnate; sterile . . . . . . . . . . . . . . 178. *P. aleurites*

  2\. Thallus not isidiate, often ascending; rarely sterile . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 180. *P. placorodia*

## 48. PARMELIA

1\. Thallus yellowish green (usnic acid present) . . . . . . . . . . . . . . . . . . 2

1\. Thallus greyish, olive-green, or brownish, no trace of yellow (usnic acid absent) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7

  2\. Soredia in punctiform soralia, or tiny verrucae scattered over upper surface of thallus; lobes broad, 4-6 mm, or rarely less. Medulla PD + orange, KOH-, KC + red (protocetraric and caperatic acids present). Corticolous or saxicolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 184. *P. caperata*

  2\. Soredia or tiny verrucae absent; lobes less than 4 mm broad. Medulla PD + yellow or orange, KOH + red. Saxicolous . . . . 3

3\. Isidia present. Stictic and norstictic acids present . . . . . . . . . . . . . . 4

3\. Isidia absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5

  4\. Lower surface of thallus black almost to edge . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 185. *P. conspersa*

  4\. Lower surface of thallus buff to brown throughout . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 193. *P. plittii*

5\. Lower surface pale brown to buff; thallus more or less ascending. Salacinic acid present . . . . . . . . . . . . . . . . . . . . . 198. *P. stenophylla*

5\. Lower surface black except very close to margins . . . . . . . . . . . . . . 6

  6\. Salacinic acid present . . . . . . . . . . . . . . . . . . 202. *P. tasmanica*

  6\. Stictic and norstictic acids present . . . . . . . . . . 182. *P. arseneana*

7\. Thallus olive-green (wet) or brown (dry), never grey. Irregular laminal soralia present. Medulla C + red . . . . . . . 199. *P. subaurifera*

7\. Thallus grey or grey-green . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8

  8\. Pseudocyphellae (white dots) scattered over upper surface . . . . 9

  8\. Pseudocyphellae absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12

9\. Medulla C-; protolichesterinic acid present. Soredia or isidia absent, lower surface black, becoming pale at margins. Very rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 181. *P. appalachensis*

9\. Medulla C + red, protolichesterinic acid absent . . . . . . . . . . . . . . 10

  10\. Isidia absent, soredia present . . . . . . . . . . . . . . . . . . . . . . . . 11

  10\. Isidia present, soredia absent. Very common . . . . 196. *P. rudecta*

11\. Soredia in punctiform soralia; lower surface pale brown. Frequent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 200. *P. subrudecta*

11. Soredia marginal; lower surface black. Very rare .......................................... 191. *P. olivetorum*

12. Marginal cilia present .................................. 13

12. Marginal cilia absent .................................. 17

13. Soredia absent .................................. 14

13. Soredia present .................................. 15

14. Medulla KC-, KOH + red, PD + yellow (norstictic acid present, stictic and protocetraric acids absent); cilia usually abundant; lower surface with a ± broad irregular white margin; apothecia distinctly perforate ...................... 192. *P. perforata*

14. Medulla KC + red, KOH-, PD + orange (protocetraric acid present, norstictic and stictic acids absent); cilia very sparse; lower surface of thallus uniformly black, lightening to brown at margin; apothecia not perforate .......... 190. *P. michauxiana*

15. Rhizines present to the thallus edge (hypotrachynoid); upper surface of thallus ± covered with reticulate cracks and/or tiny, irregular white areas (maculae); soredia marginal or laminal. Medulla PD + orange, KOH + red (salacinic acid present) ...... 195. *P. reticulata*

15. Rhizines absent from edge of thallus (amphigymnioid); reticulate cracks and maculae absent .................................. 16

16. Lower surface of thallus smooth, not rugulose, with a ± broad, irregular white margin; soredia apical or marginal. Medulla KOH + red, PD + orange (stictic + norstictic acids). Common .................................... 188. *P. hypotropa*

16. Lower surface of thallus rugulose, uniformly black or lightening slightly to brown at margin; soredia submarginal. Medulla KOH + yellow, PD + orange (stictic acid present, norstictic acid absent). Rare .................................. 193. *P. perlata*

17. Thallus with conspicuous reticulate ridges and depressions, especially on younger portions of the thallus. Medulla KOH + blood red (salacinic acid) .................................. 18

17. Thallus ± smooth, rugose or cracked, but without reticulate ridges and depressions. Medulla KOH + or KOH − ................ 19

18. Isidia present .......................... 197. *P. saxatilis*

18. Soredia present on ridges .................... 201. *P. sulcata*

19. Soredia present .................................. 20

19. Soredia absent .................................. 22

20. Medulla pale yellow; soredia laminal. Medulla PD- or PD + pale yellow, KOH + faintly yellow ......... 183. *P. aurulenta*

20. Medulla white; soredia marginal or laminal ............... 21

21. Medulla PD + orange, KOH-, KC + red (protocetraric acid). Surface of thallus smooth with no maculae; lobes mostly 3-4 mm broad, crenate .......................... 186. *P. dilatata*

21. Medulla PD + orange, KOH + red (salacinic acid). Surface of thallus with reticulate cracks and maculae (see couplet #15) ...................................... 195. *P. reticulata*

22. Medulla yellow, especially near the algal layer; chains of 2 to 4 moniliform cells scattered throughout the medulla. Medulla PD + orange, KOH + orange (unidentified substance) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 187. *P. galbina*
22. Medulla white throughout; moniliform cells absent . . . . . . . . 23
23. Medulla PD + orange-red, KOH-, KC + red. Rhizines simple, unbranched; medulla thick, cottony (see couplet #14) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 190. *P. michauxiana*
23. Medulla PD-, KOH + red-brown. Rhizines branched; medulla ± thin, not cottony . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 189. *P. livida*

## 51. CETRARIA

1. Terricolous. Thallus fruticose, dark brown, with broad or linear lobes ascending vertically, producing a caespitose growth form; pseudocyphellae mostly marginal, linear. Medulla PD- . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 207. *C. islandica* subsp. *crispa*
1. Corticolous. Thallus foliose, brown, grey, or yellowish; lobes often ascending but never linear and never caespitose . . . . . . . . . . . . . . 2
   2. Thallus grey, pitted; lower surface mostly white, sometimes mottled. Medulla I + blue . . . . . . . . . . . . . . 208. *C. tuckermanii*
   2. Thallus yellowish green or brownish green, never grey . . . . . . . 3
3. Lower surface yellow; upper surface greenish yellow . . . 209. *C. viridis*
3. Lower surface brown; upper surface brown or greenish brown . . . . 4
   4. Apothecia originating on upper surface; thallus small, appressed; lobes narrow, finely divided, 0.5-0.75 mm broad, never ciliate. Very rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 206. *C. fendleri*
   4. Apothecia originating on lower surface; thallus larger, ± ascending; lobes 1.5-4 mm broad, often conspicuously ciliate. Common in bogs. Medulla KC + red, UV + (in L. I. material) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 205. *C. ciliaris*

## 54. ALECTORIA

1. Thallus caespitose, wiry; soralia with isidia. Common . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 213. *A. nidulifera*
1. Thallus pendent, long; soralia without isidia. Very rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 212. *A. glabra*

## 55. RAMALINA

1. Lacinae subterete or angular, ± papillate. Medulla KOH + red and PD + yellow (salacinic acid). Spores straight, ellipsoid, 11-13 x (4-) 5-6 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 217. *R. willeyi*
1. Lacinae strongly flattened . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
   2. Lacinae with elliptical, delimited, marginal soralia containing farinose soredia. Medulla KOH- or KOH + red (norstictic acid [+ salacinic acid by chromatography]). On roadside trees in Cape Cod; not on Long Island . . . . . . . [*R. farinacea* (L.) Ach.]
   2. Lacinae esorediate, KOH-, PD- . . . . . . . . . . . . . . . . . . . . . . . . 3
3. Lacinae 3-8 mm broad, coarsely tuberculate-papillate. Very rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 214. *R.* cfr. *complanata*

3. Lacinae 1-3 mm broad, not tuberculate . . . . . . . . . . . . . . . . . . . . . . . 4
    4. Spores fusiform, straight or slightly curved, 18-24(-31) x 3-5 μ; lacinae strap shaped, with white striations (pseudocyphellae?) usually evident . . . . . . . . . . . . . . . . . . . . . . . 216. *R. stenospora*
    4. Spores ellipsoid, straight, 8-13 x 4-6 μ; lacinae strap shaped to broadened, often with numerous short proliferations along the margins; smooth, often with white punctiform pseudocyphellae, often subcanaliculate . . . . . . . . . . . . . . . . . . . . 215. *R. fastigiata*

## 56. USNEA

1. Medulla rusty red . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
1. Medulla white . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
    2. Thallus subpendent to pendent; branching irregular, often dichotomous, never strigose; isidiate-soralia present; apothecia rare. Norstictic, salacinic, etc., absent . . . . . . . . . . . 219. *U. mutabilis*
    2. Thallus erect, shrubby, strigose; branchlets short; isidia and soredia absent; apothecia common. Norstictic acid present in about 50 percent of the specimens seen . . . . . . . 220. *U. strigosa*
3. Thallus pendent, filaments exceedingly slender, never tuberculate or papillate; stramineous or yellow-green. Medulla PD- . . . . . . . . . . . . 4
3. Thallus erect or subpendent; filaments generally coarse, papillae and/or tuberculae present; dark ashy green, at least in older portions. Medulla PD + yellow or orange . . . . . . . . . . . . . . . . . . . . . . . . . . 5
    4. Branching by frequent dichotomies; perpendicular side branches infrequent; axis reddish brown; articulations with swollen joints conspicuous; cortex intact. Common in bogs . . . 221. *U. trichodea*
    4. Branching infrequently dichotomous; perpendicular side branches common and regularly spaced; axis white; articulations with swollen joints absent; cortex becoming farinose. Very rare . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 218. *U. longissima*
5. Medulla KOH- (or KOH ± very faint yellow). Filaments papillate and tuberculate; branches coarse; erect or subpendent; cortex very thick and chondroid; isidiate-soralia usually present; base rarely blackened. Protocetraric acid, or rarely, barbatic or fumarprotocetraric[10] acid present . . . . . . . . . . . . . . . . . . . . . . . . . . 222. *U. sp.*
5. Medulla KOH + deep yellow or red (often distinct only in the apothecial medulla) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6
    6. Isidiate-soralia present; medulla very lax; apothecia not seen. KOH + red or yellow (salacinic or stictic acids present). Cape Cod region, fairly common. Not on L. I. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . [*U.* cfr. *comosa* (Ach.) Ach.]
    6. Isidiate-soralia absent; medulla compact; apothecia common. KOH + red (norstictic acid). Filaments strigose, scrobiculate on young branches . . . . . . . . . . . . . . . . . . . . . . . 220. *U. strigosa*

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[10] The two specimens containing fumarprotocetraric acid were from Cape Cod *(Brodo 4161, 4338).*

## 57. CALOPLACA

1. Corticolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
1. Saxicolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6
    2. Apothecial margin containing few or no algae; thallus yellow (KOH + red-purple), thin, sorediate. Spores 13-17 x 8-10 μ; isthmi 5-7 μ long . . . . . . . . . . . . . . . . . . . . . . . . 227. *C. discolor*
    2. Apothecial margin containing a distinct algal layer; thallus esorediate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
3. Apothecial disk brown, KOH- (or vaguely pale violet), pruinose. Spores 13-19 x 7-10 μ; isthmi 3-6 μ long . . . . . . . . 224. *C. camptidia*
3. Apothecial disks orange or yellow, KOH + dark purple or red-purple, not pruinose . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
    4. Thallus pale yellow or cream colored, KOH + red-violet (often weakly), thin, smooth. Apothecial disks yolk yellow to yellow-orange; margins yellow; spores 11-13 x 4-6 μ; isthmi 3-4 μ long . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 223. *C. aurantiaca*
    4. Thallus grey-green, ashy, or dark bluish grey, KOH- . . . . . . . . 5
5. Amphithecium thick, ashy to blue-grey, entirely persistent; apothecial disks sordid yellow to yellow-orange; spores 12-16 x 7-8 μ; isthmi (4-)5-6 μ long . . . . . . . . . . . . . . . . . . . . . . . . . . . . 225. *C. cerina*
5. Amphithecium very thin, pale grey to ashy, soon disappearing and revealing an orange margin; apothecial disks dark orange to red-orange; spores 10-14 x 4-7 μ; isthmi 2-4(-5) μ long . . . 230. *C. pyracea*
    6. Spore isthmi less than 3.5 μ long; thallus minutely areolate, yellow, becoming black or ashy, disappearing. Apothecia 0.25-0.40 mm in diameter; disks dark orange to orange-brown; margin yellow to orange, often becoming leprose or granular; spores 12-17 x 7-9 μ . . . . . . . . . . . . . . . . . . . . . . . 228. *C. feracissima*
    6. Spore isthmi more than 3.5 μ long; thallus yellow, rarely darkening . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7
7. Thallus effuse granular or sorediate to subsquamulose or areolate. Apothecial disks orange; margin yellow, often sorediate; spores 9-13 x 5-7(-9) μ; isthmi 3.5-5 μ long; sometimes sterile . . . 226. *C. citrina*
7. Thallus smooth, rimose, areolate, squamulose, or disappearing . . . . 8
    8. Thallus conspicuous, squamulose; apothecial disks dark red-orange to orange-brown; margins dark orange; spores 11-17 x 5-7 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . 229. *C. flavovirescens*
    8. Thallus essentially absent, or with rare yellow squamules; apothecial disks orange with yellow-orange margins; spores 11-15 x 4-6 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . 223. *C. aurantiaca*

## 58. XANTHORIA

1. Thallus with granular soredia in labriform soralia; lobes very small and narrow, 0.2-1.0 mm broad; apothecia rare . . . . . . . 231. *X. fallax*
1. Thallus esorediate; lobes broad, (2-)3-4 mm broad, flat; apothecia common . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 232. *X. parietina*

## 59. TELOSCHISTES

1. Thallus very short, caespitose, yellowish to tan; lacinae flattened, ± striate, giving rise to short, irregularly shaped side branches ending in pointed cilia; soredia absent........233. *T. chrysophthalmus*
1. Thallus longer, dark yellow-orange; lacinae terete or ridged and angular; cilia absent; patches of soredia frequent throughout length.... ..................................234. *T. flavicans*

## 60. BUELLIA

1. Saxicolous......................................2
1. Corticolous or lignicolous...........................3
    2. Medulla KOH + red (norstictic acid). Thallus whitish grey, areolate; prothallus black, well developed. Apothecia mostly sessile or immersed between areoles..........239. *B. stigmaea*
    2. Medulla KOH-. Thallus dark ashy brown; verrucose; prothallus inconspicuous........................241. *B. turgescens*
3. Apothecial sections KOH + red (norstictic acid). Apothecia 0.5-1.5 mm in diameter...............................4
3. Apothecial sections KOH-. Apothecia less than 0.5 mm in diameter ..........................................5
    4. Exciple pallid within; grey stipe absent; spores 17-24 x 6-8 μ; hymenium 80-130 μ high, hyaline...........235. *B. curtisii*
    4. Exciple uniformly dark; grey, T-shaped stipe present; spores 11-17 x 6-8 μ; hymenium 55-75 μ, yellowish............. ..............................240. *B. stillingiana*
5. Spores 8 per ascus...................................6
5. Spores 12 to 16 per ascus. Exciple pale within....237. *B. polyspora*
    6. Thallus PD + red (fumarprotocetraric acid). Spores 19-23 x 8-9 μ; apothecial margin usually absent; disk hemispherical... ..................................236. *B. dialyta*
    6. Thallus PD-. Spores 9-11 x 6-7 μ; apothecial margin distinct, disappearing with age; disk flat to slightly convex......... ..................................238. *B. punctata*

## 61. RINODINA

1. Saxicolous......................................2
1. Corticolous .....................................4
    2. Thallus pale grey or brownish grey.....................3
    2. Thallus yellowish green. Thallus lobed at margins; spores 10-12 x 6-7 μ. Medulla C + red, PD-, KOH-...........245. *R. oreina*
3. On siliceous rock. Thallus verruculose to almost squamulose; spores 17-23 x 9-13 μ.........................243. *R. confragosa*
3. On concrete. Thallus areolate to minute verrucose; spores 10-16 x 6-8 μ...................................247. *R. salina*
    4. Spores 5-7(-8) x (8-)10-12(-15) μ; hypothecium dark brown. Apothecia less than 0.5 mm in diameter.......244. *R. milliaria*
    4. Spores over 15 μ long; hypothecium hyaline or yellowish......5

5. Thallus brownish green to olive, verrucose or granulose to smooth and ± squamulose; spores pachysporous (examined in water), 16-23 x 6-10 μ. . . . . . . . . . . . . . . . . . . . . . . . . . . . .246. *R. pachysperma*
5. Thallus thin, smooth, light grey-green; spores mostly pachysporous (examined in water), 17-24 x 9-11 μ. . . . . . . . . . . .242. *R. applanata*

## 63. PHYSCIA

1. Thallus deep green, olive-green, or brownish grey; upper cortex KOH- (atranorin absent) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
1. Thallus grey or grey-green; upper cortex KOH + yellow (atranorin present) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
    2. Thallus esorediate; lobes finely divided, becoming covered with small lobules; lower surface white to buff; rhizines tan to brown; medulla white. Very rare . . . . . . . . . .257. *Anaptychia palmulata*
    2. Thallus with greenish marginal or laminal soralia; lobes crenate to entire, never subsquamulose; lower surface black; rhizines black with white tips; medulla white (KOH-) or red-orange (KOH + purple). Common . . . . . . . . . .252. *Physcia orbicularis*
3. Medulla mustard yellow. Thallus with marginal granular soredia; lobes pruinose, 1-2 mm broad . . . . . . . . . . . . . .248. *Pyxine sorediata*
3. Medulla white . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
    4. Thallus sorediate or with granules resembling soredia . . . . . . . . 5
    4. Thallus esorediate. Apothecial disks very dark brown to black, somewhat pruinose . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10
5. Soredia in laminal soralia . . . . . . . . . . . . . . .255. *Physcia tribacoides*
5. Soredia (or granules) marginal or terminal . . . . . . . . . . . . . . . . . . 6
    6. Lobes helmet shaped, bursting into soredia. Lobes with long, white, marginal cilia . . . . . . . . . . . . . . . . . .249. *Ph. adscendens*
    6. Lobes ±flat, not helmet shaped . . . . . . . . . . . . . . . . . . . . . . . . 7
7. Lobes broad, (2-)3-4 mm, rounded; cortical hyphae parallel to surface . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8
7. Lobes narrow, 0.3-2 mm broad; cortical hyphae at right angles to surface . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9
    8. Lower surface white (KOH-), ± corticate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .258. *Anaptychia pseudospeciosa*
    8. Lower surface yellow (KOH + purple), ecorticate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .256. *Anaptychia obscurata*
9. Lobes 0.3-1.0(-1.5) mm broad; spores 16-19 x 6-9 μ; soredia (or granules) large, marginal, sometimes reducing thallus to a granular crust. Corticolous, or very rarely, saxicolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .251. *Physcia millegrana*
9. Lobes very narrow, 0.1-0.5 mm broad; spores 12-16 x 6-8 μ; soredia (or granules), marginal and apical, occasionally laminal. Saxicolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .254. *Ph. subtilis*
    10. Medulla KOH + yellow. White spots (maculae) present . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .250. *Ph. aipolia*
    10. Medulla KOH-. White spots absent . . . . . . . . . .253. *Ph. stellaris*

### 64. ANAPTYCHIA

1. Thallus esorediate, brownish; upper cortex KOH- (atranorin absent); lobes finely divided, becoming covered with small lobules . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 257. *A. palmulata*
1. Thallus sorediate, greyish; upper cortex KOH + yellow (atranorin present); lobes not finely divided . . . . . . . . . . . . . . . . . . . . . . . . . . 2
    2. Lower surface light to deep yellow, KOH + red-violet, not corticate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 256. *A. obscurata*
    2. Lower surface white, KOH-, ± corticate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 258. *A. pseudospeciosa*

### 65. LEPRARIA

1. Saxicolous. Thallus grey to dark ashy green; granules large, often forming a ± lobed, zonate thallus. Thallus PD + red, and KOH- (fumarprotocetraric acid), or rarely, PD + yellow (barbatolic acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 260. *L. zonata*
1. Corticolous or lignicolous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
    2. Thallus with a distinct bluish grey cast, a ± thin layer of dispersed granules with little or no prothallus. Thallus KOH + yellow and PD- (atranorin) or rarely, KOH + yellow and PD + red (fumarprotocetraric acid + atranorin) . . . . 259. *L. incana*
    2. Thallus pale green or sometimes yellowish green, thick masses of granules subtended by a thick, white, prothalline mat. Thallus KOH + yellow and PD + orange (atranorin + stictic acid) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 261. *L.* sp.

## ARTHOPYRENIACEAE

### 1. ARTHOPYRENIA Mass.

1. **Arthopyrenia cerasi** (Schrad.) Mass. Ricerch. Auton. Lich. 167. 1852. *Verrucaria cerasi* Schrad. Ann. d. Bot. 22:86. 1797.

Material seen — SUFFOLK COUNTY: *Brodo 2375* (123).

Fink (1935) reports *A. cerasi* from young oaks, but the Long Island material was on *Myrica pensylvanica*.

Distribution — Maryland, Iowa, California (Fink, 1935); Europe.

2. **Arthopyrenia pinicola** (Hepp) Mass. Symm. Lich. 118. 1855. *Pyrenula punctiformis* var. *cineropruinose* f. *pinicola* Hepp, Flecht. Europ. 106. 1853.

Material seen — SUFFOLK COUNTY: *Brodo 3176* (65).

Degelius (1941) discusses the synonomy and gives a detailed description of his specimens. The Long Island material fits his description very closely. It was collected on the base of a white oak (*Quercus alba*). I also found a specimen on *Ulmus americana* in central New York State (*Brodo VIII*, in herb. CAN).

Distribution — Tennessee; Europe.

NOTE: *Arthopyrenia halodytes* (Nyl.) Arn. (*A. sublitoralis* [Leight.] Arn.) not collected, but may be found on shells and barnacles if sought.

## 2. LEPTORHAPHIS Korb

3. **Leptorhaphis epidermidis** (Ach.) Th. Fr. Nova Acta Reg. Soc. Sci. Upsal. III. 3:373. 1861. (Lich. Arct. 273. 1860.) *Lichen epidermidis* Ach. Lich. Suec. Prodr. 16. 1798.

Material seen — SUFFOLK COUNTY: *Brodo 1015* (27), *1120* (78), *1395* (65), *1985* (91), *2455* (22), *2591* (97), *2773* (31), *3100* (122), *3817* (66).

All specimens of this species were found on the bark of *Betula populifolia.* It is similar to *Polyblastiopsis quercicola* in gross morphological features such as shape, size, and position of the perithecia, but their spores and substrates are quite different.

Distribution — Eastern United States (Fink, 1935); Connecticut, Michigan, Wisconsin, Arizona, Black Hills: Temperate element, East Temperate subelement; Europe.

## 3. POLYBLASTIOPSIS Zahlbr.

4. **Polyblastiopsis quercicola** sp. nov.

Material seen — SUFFOLK COUNTY: *Brodo 2651* (61), *2674* (108), *2788* (31).

*Thallus subtilissimus, hypophloedalis, albus; algae non visa. Pseudothecia nigra, diam. 0.15-0.25 mm, hemispherica, dispersa, superficialia, sed saepe ex parte thallo vel epidermide corticis tecta; ostioles conspicues saepe; parietes carbonisati, virides-nigres ut oblinentur, praecipuus in KOH. Filamentae paraphysoideae et asci immersi in substrato gelatinoso, dissoluto in KOH. Filamentae paraphysoideae persistentes, distinctae in KOH, ramosa et anastomosa copiose, 1.5-2.5 μ diam. Asci parietes ± subtiles in* $H_2O$*, sed perspicue crassi in KOH, praecipuus apice. Sporae octonae, irregulariter seriatae, murales vel submurales, septis transversis 3-6, septis longitudinalibus 1-2, hyalinibus; vagina episporis lucida, conspicua, levis in* $H_2O$*, ± irregularis in KOH; 16-27 x 7-10 μ. Pycnidia nigra, minutissima, dispersa. Pycnoconidia hyalina, non septata, elongata-cylindrica ad fusiforma, 7-9 x 1 μ. Ad corticem* Quercus alba.

Holotype: New York. Suffolk County: Shoreham. Saint Joseph's Villa, N. Country Road, black oak woods, *Brodo 2651*, July 7, 1961, on *Quercus alba*, 0 ft. and higher (MSC) (see figures 82, 83, 87d).

Thallus very thin, hypophloedal, appearing white; no algae evident. Pseudothecia black, 0.15-0.25 mm in diameter, hemispherical, scattered, superficial, but often partially covered by thallus and/or upper layers of bark; ostioles often conspicuous; walls carbonaceous, greenish black when smeared, especially in KOH. Paraphysiod threads and asci embedded in gelatinous material which dissolves in KOH; paraphysoid threads persistent, distinct in KOH, abundantly branched and anastomosing, 1.5-2.5 μ in diameter. Asci appearing ± thin walled when mounted in water, but clearly thick walled, especially at apex, when mounted in KOH. Spores 8 per ascus, irregularly arranged, muriform or submuriform, 3 to 6 transverse septa, 1 to 2 longitudinal septa, hyaline; hyaline epispore sheath conspicuous, smooth in a water mount, ± irregular in a KOH mount; 16-27 x 7-10 μ. Pycnidia black, extremely minute, scattered. Pycnoconidia hyaline, nonseptate, elongate-cylindrical to fusiform, 7-9 x 1 μ.

The specimens from Long Island, as well as some from New Jersey (*Brodo 3728, 3755*), were rather uniform in morphology. The thallus often covers several square centimeters, or even decimeters, on or near the bases of oaks. Pseudothecia vary little in size. Spores are 16-27 x 7-10 μ and always show the gelatinous epispore sheath. Pycnoconidia are 6-9 x 1.0-1.5 μ, hyaline and nonseptate. Algae (apparently *Trentepohlia*) were in very small amounts just below the pseudothecia of a few specimens.

The species differs from similar *P. fallaciosa* (Stizenb.) Zahlbr. in having larger spores and hyaline, nonseptate rather than brown, septate pycnoconidia, and from *P. lactea* (Mass.) Zahlbr. in having somewhat smaller spores and eight rather than four spores per ascus. *Polyblastiopsis fallax* (Nyl.) Fink, which is close to *P. quercicola* from the description in Fink (1935), appears to be a synonym of *Arthopyrenia fallax* (Nyl.) Arn.

The species was found on the bark of *Quercus alba* and *Q. stellata.* Similar species are almost always found on *Betula* or some other tree, and so the unusual substrate served as the source of the specific epithet.

Distribution — New Jersey (see above).

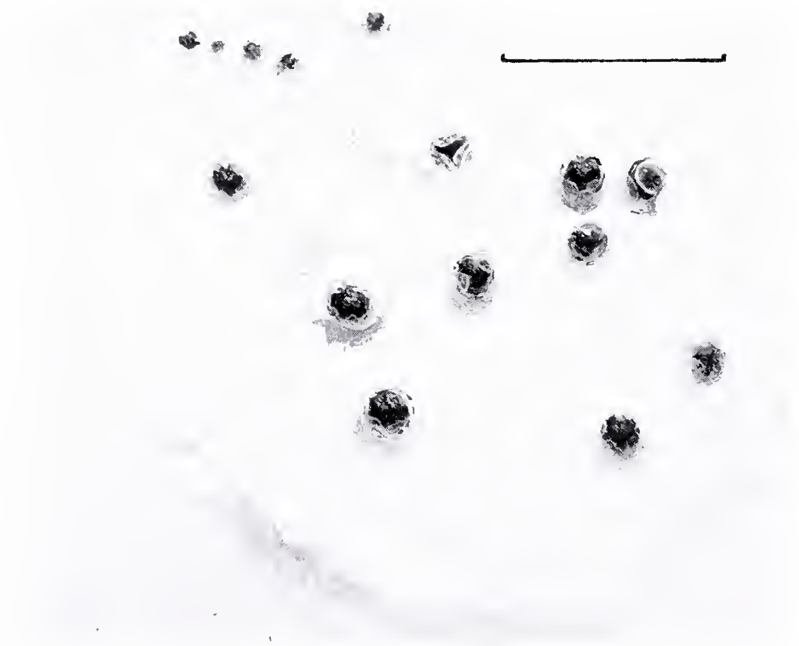

FIGURE 82. *Polyblastiopsis quercicola* (holotype). Scale equals 1 mm. Drawing by Brenda Carter Haas.

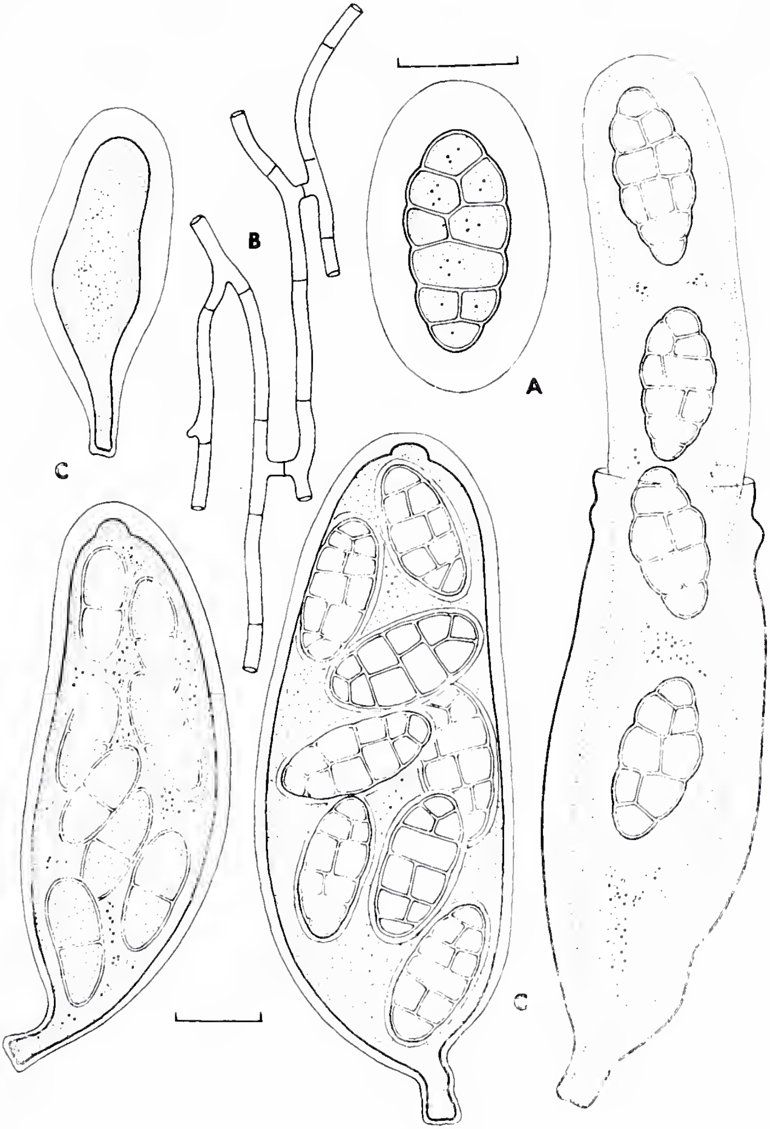

FIGURE 83. *Polyblastiopsis quercicola* (holotype). (a) ascospore, (b) paraphysoid threads, (c) developing and mature asci. Scales equal 10 µ. Drawings by G. Morgen-Jones, with the aid of a camera lucida apparatus, from material mounted in water.

## ARTHONIACEAE

### 4. ARTHONIA Ach.

5. **Arthonia caesia** (Flot.) Körb. Parerg. Lich. 269. 1861. *Coniangium caesium* Flot. in Körb. Syst. Lich. Germ. 295. 1855.

Material seen — SUFFOLK COUNTY: 19 specimens collected by Imshaug and/or Brodo.

Fink (1935) probably included this species in his concept of *A. impolita* (Ehrh.) Borr. (Syn. *A. pruinosa* Ach.). The two species are similar in their leprose thalli and small, dark, heavily blue-grey pruinose ascocarps, but may be separated as follows: *A. impolita*:[11] phycobiont *Trentepohlia*, fruit base hyaline, thallus reactions KOH yellow and KC red; *A. caesia:* phycobiont *Trebouxia*, fruit base yellow to red-brown, thallus reactions negative with KOH and KC.

The Long Island material was mostly fertile and agreed in all respects with European descriptions of the species.

The species is found on bark of all kinds in shaded or exposed woods, or on exposed downs. Under the right conditions, it apparently has a very rapid growth rate and was seen almost covering young twigs and branches in an oak forest in Laurel.

Distribution — Tennessee, Wisconsin, but probably common in eastern United States; Europe.

6. **Arthonia mediella** Nyl. Not. Soc. Faun. Fl. Fenn. Forhandl. 1:238. 1858-59.

Material seen — SUFFOLK COUNTY: *Brodo 795A* (90B).

The Long Island material agreed well with the description by Redinger (1937-38), and with a specimen from Finland (*Lang 347*, hb. MICH).

Redinger states that the species is corticolous, but the Long Island specimen was on old wood on an exposed bluff overlooking Long Island Sound.

Distribution — First North American record; Europe.

7. **Arthonia polymorpha** Ach. Syn. Lich.: 7. 1814.

Material seen — SUFFOLK COUNTY: *Brodo 1070* (98).

This species is similar to *A. siderea* in the color and stellate arrangement of the hysterothecia. It is, however, readily distinguished by its pruinose hysterothecia and pale brown spores with equal sized cells.

It was found on the bark of *Carya glabra*.

Distribution — Maryland, Florida, Louisiana, Illinois, Iowa, and California (Fink, 1935).

8. **Arthonia punctiformis** Ach. Kgl. Vet. Akad. Nya Handl. 130. 1808.

Material seen — SUFFOLK COUNTY: Imshaug *25742* (132). Orient, *Latham 782*, April 5, 1914, (Latham); Montauk, *Latham 3953*, April 6, 1927 (Latham); Greenport, *Latham 8608*, April 30, 1939 (Latham); Orient, *Latham 24178*, March 21, 1915 (Latham).

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[11] Based on Michigan material (MSC).

This species is similar to *A. radiata* (Pers.) Ach. in many respects, but the latter has larger ascocarps and an epiphloedal thallus, whereas the ascocarps of *A. punctiformis* are 0.1-0.2 mm across and its thallus is hypophloedal.

*Arthonia punctiformis* is found on bark of various kinds, and is rare on Long Island.

Distribution — Maine, Connecticut, Tennessee, Minnesota, Alaska; throughout the United States (Fink, 1935); Europe; Asia (Vainio, 1928).

9. **Arthonia sexlocularis** Zahlbr. Ann. Myc. 12: 336. 1914.

Material seen — SUFFOLK COUNTY: *Brodo 2818* (115).

This single specimen was found growing on the deeply-shaded base of *Celtis* sp. The distinctive spores agree perfectly with the description of Redinger (1937-38) based on European material.

Distribution — First North American record; Europe.

10. **Arthonia siderea** Degel. Ark. Bot. 30A(1): 14. 1940.

Material seen — SUFFOLK COUNTY: *Brodo 1182* (101), *1203* (101), *1515* (100B), *1862* (117), *1874* (117), *2306* (93), *2419* (113), *2606* (84), *2626* (71), *2686* (110), *2727* (111), *3247* (119); Orient; *Latham 8598A,* April 10, 1939 (Latham); Orient, *Latham 8600,* April 30, 1939 (Latham).

Although Degelius described this species as having "black apothecia," the hysterothecia actually range in color from red-brown to black. When moistened, the hysterothecia always appear a deep mahogany and never are black. The holotype, which Dr. Degelius kindly sent me, had hysterothecia which, although almost black when dry, also show the red-brown tint when wet. The Long Island material agrees in every respect with the holotype.

This species is probably more common than would be thought, judging from the number of times it has been reported. In Fink (1935), *A. siderea* easily keys out to *A. gregaria* (Weig.) Körb. which is now recognized as a synonym of *A. cinnabarina* (DC.) Wallr. (see discussion in Redinger, 1937-38). *Arthonia cinnabarina,* however, has rusty red, often powdery hysterothecia, which are KOH + red-violet. The hysterothecia of *A. siderea* are KOH-, smooth and often shiny. The spore type and ascocarp color clearly distinguish it from *A. radiata* (Pers.) Ach.

*Arthonia siderea* is found on the bark of black oaks well above the base, and is probably photophilous (figure 67).

Distribution — Maine; endemic.

### 5. ARTHOTHELIUM Mass.

11. **Arthothelium taediosum** (Nyl.) Müll. Arg. Flora 63: 287. 1880. *Arthonia taediosa* Nyl. Ann. Sci. Nat. Bot. IV. 3: 171. 1855.

Material seen — SUFFOLK COUNTY: *Brodo 3832* (66); Greenport, *Latham 8610,* April 16, 1938 (Latham); Greenport, *Latham 7206,* January 26, 1933 (MICH).

Two of the specimens from Long Island differ somewhat in spore size (32-37 x 10-17 μ in *Brodo 3832;* 34-46(-55) x 14-23(-27) μ in

*Latham 8610*), but the thallus and ascocarp characters agree perfectly. Except for the large spore sizes in the Latham specimen, the specimens fit the description of *A. taediosum* given by Redinger (1937-38) very well. Redinger's spore measurements are 24-30(-33) x 8-13 μ. The only other possible *Arthothelium* which could be considered for the Latham specimen would be *A. distendens* (Nyl.) Müll. Arg., and Nearing annotated the specimen with that name. After having examined a number of specimens of both species in the Fink herbarium (MICH) I feel there is little doubt that both Long Island specimens belong to *A. taediosum.* I could find no spores in *Latham 7206,* but the specimen was identified by Josiah Lowe as this species. The specimens of *A. distendens* had thicker thalli and much broader hysterothecia (up to 1 mm across). In the Long Island material, the ascocarps were punctiform to irregular, and 0.1-0.2 mm across.

*Arthothelium taediosum* was found on the smooth bark of red maple and oak on Long Island.

Distribution — Eastern United States, California (Fink, 1935); Connecticut; Europe (Redinger, 1937-38).

## 6. MICAREA Fr.

12. **Micarea melaena** (Nyl.) Hedl. Bih. Kgl. Svensk. Vet. Akad. Handl. afd. III, no. 3, 18: 82. 1892. *Lecidea melaena* Nyl. Bot. Not. 182. 1853.

Material seen — NASSAU COUNTY: *Brodo 1510* (14).

This species is considered in the genus *Bilimbia* in Fink (1935).

The Long Island specimen was found on a rotting stump.

Distribution — Eastern United States (Fink, 1935); Connecticut, Michigan; Temperate element, East Temperate subelement; Europe; Asia (Vainio, 1928).

13. **Micarea prasina** (Fr.) Körb. Syst. Lich. Germ. 399. 1855. *Biatora prasina* Fr. Stirp. Agri. Fems. 38. 1826.

var. **sordidescens** (Nyl.) comb. nov.

*Lecidea sordidescens* Nyl. Flora 57: 312. 1874.

Material seen — NASSAU COUNTY: *Brodo 1497* (9), *3497* (4). SUFFOLK COUNTY: *Brodo 1989* (51), *2578* (73).

The Long Island material would fall into the var. *sordidescens* (Nyl.) Lettau emend. Erichs. of *Catillaria prasina* (Fr.) Th. Fr. (Erichsen, 1957). This variety has a KOH + violet "epithecial" reaction. The spores are either mostly nonseptate or mostly uniseptate, but both types can always be found in a smear of the ascocarp. The species is treated in the genus *Catillaria* in Fink (1935).

*Micarea prasina* is found on rotten wood, but is rare on Long Island.

Distribution — Northern and eastern United States (Fink, 1935); Connecticut, Minnesota, Black Hills: Temperate element, North Temperate subelement; Europe; Asia (Vainio, 1928).

## OPEGRAPHACEAE

### OPEGRAPHA Ach.

14. **Opegrapha cinerea** Chev. Journ. Phys. Chim. Hist. Nat. 94: 41. 1822.

Material seen—SUFFOLK COUNTY: *Imshaug 25674* (72), *Brodo 59-221* (72), *785* (90A), *797* (90B), *1079* (98), *1755* (127), *2650* (61); Greenport, (collector unknown), April 1903 (FH).

This species is somewhat similar to *O. vulgata* (Ach.) Ach., which is distinguished by having (1) unbranched, shiny hysterothecia, (2) a greenish brown thallus, (3) spores 15-20 µ long, and (4) a specificity for coniferous bark (Redinger, 1937-38).

*Opegrapha cinerea* is found on the bark of smooth-barked broadleaf trees such as *Carya* sp. and *Quercus* sp. (which agrees with the habitat notes of Redinger, 1937-38). All the Long Island specimens were found within a half mile of the north shore (figure 62).

Distribution — Florida (Fink, 1935), the Smoky Mountains of Tennessee; Europe.

15. **Opegrapha rufescens** Pers. Neue Ann. Bot. 1:29. 1794.

Material seen — SUFFOLK COUNTY: Orient Point, *Latham,* June 5, 1911 (NYS).

Distribution — Florida (Fink, 1935); Europe.

## CALICIACEAE

### 8. CHAENOTHECA (Th. Fr.) Th. Fr.

16. **Chaenotheca phaeocephala** (Turn.) Th. Fr. Nova Acta Reg. Soc. Sci. Upsal. III, 3: 351. 1861. (Lich. Arct. 251. 1860). *Lichen phaeocephalus* Turn. Trans. Linn. Soc. Lond. 8: 260. 1807.

Material seen—SUFFOLK COUNTY: *Imshaug 25810* (86), *Brodo 2124* (102).

The spores of this species, normally brown, often become colorless in KOH.

*Chaenotheca phaeocephala* is rare on Long Island and is restricted to rotting stumps of *Chamaecyparis thyoides* in shaded bogs. It was collected once in southern New Jersey (*Brodo 3772*) and once on Cape Cod (*Brodo 4337*) in similar habitats and on the same substrate.

Distribution — New England and Minnesota (Fink, 1935); Michigan: Temperate element, North Temperate subelement(?); Europe.

## VERRUCARIACEAE

### 9. VERRUCARIA Schrad.

17. **Verrucaria microspora** Nyl. Ann. Sci. Nat. Bot. IV. 3: 175. 1855. *Verrucaria subsuperficialis* Fink in Hedr. Mycologia 25: 304, 1933.

Material seen — SUFFOLK COUNTY: Orient, *Latham,* 1925 (holotype of *V. subsuperficialis*) (MICH); Orient, *Latham,* 1927, (MICH, FH).

The holotype of *V. subsuperficialis* was compared with a specimen of *V. microspora* from Denmark, which was kindly sent to me by Dr. Degelius. The two specimens were identical in morphology and ecology, both having thin, membranous, dark brown thalli, small spores, and both having been found in the hydrohaline stratum (p. 61) on quartz pebbles.

Distribution — Maine: Temperate element, Maritime subelement; maritime Europe (Santesson, 1939; des Abbayes, 1934).

18. **Verrucaria muralis** Ach. Meth. Lich. 115. 1803.

Material seen — SUFFOLK COUNTY: *Brodo 2833* (115).

This species was found growing alongside *V. nigrescens* on mortar and brick in the aerohaline stratum at Orient Point. It differs from the latter species in having a white or ashy thallus, larger spores, and an entirely different type of perithecium. Its involucrellum is black, hemispherical, and is almost entirely external to the thallus; the exciple appears hyaline. The species fits the description in Zschacke (1933) fairly well. *Verrucaria muralis* is considered a synonym of *V. rupestris* Schrad. in Fink (1935), but the latter is considered quite different by Zschacke, with an endolithic, sometimes disappearing thallus. Zschacke states that *V. muralis* is found on sandstone and bricks.

Distribution — Arctic-boreal element(?); circumboreal.

19. **Verrucaria nigrescens** Pers. Ann. d. Bot. 15: 36. 1795.

Material seen — SUFFOLK COUNTY: *Brodo 2827* (115).

The Long Island specimen, together with one collected on Nantucket Island (Massachusetts) (*Brodo 3964 B*), agrees in most respects with descriptions by Zschacke (1933) and Fink (1935). However, the black medullary layer mentioned by Zschacke and others was not seen in all parts of the thalli, although it was conspicuous in the Nantucket specimen. Servit (1954) describes the spores of this species as 20-28 x 11 μ, but these measurements disagree with those of all previous authors.

Both the Long Island and Nantucket material were found on concrete, and both were either in or close to the aerohaline stratum (p. 59). It is a common lichen on calcareous rocks in Europe.

Distribution — Connecticut, Indiana, Black Hills, Washington, Manitoba: Temperate element, North Temperate subelement (see Fink, 1935); Europe; Asia (Zahlbruckner, 1930).

20. **Verrucaria silicicola** Fink in Hedr. Mycologia 25: 305. 1933.

Material seen — SUFFOLK COUNTY: *Brodo 2710* (111), *2826* (115); Three Mile Harbor, *Latham 32177*, April 16, 1951 (Latham); Orient, *Latham 36780*, April 14, 1950 (Latham); Three Mile Harbor, East Hampton, *Latham 36781*, April 19, 1949 (Latham); Shelter Island, *Latham 36785*, June 1, 1944 (Latham); Sag Harbor, *Latham 36786*, June 2, 1946 (Latham); Orient, *Latham* (Holotype) (MICH); East Hampton, *Latham 2647*, April 20, 1926 (MICH); East Hampton, *Latham 3995*, April 10, 1927 (MICH); East Hampton, *Latham 32177* (?? cf. above), April 11, 1953 (MO).

This species is similar in general external appearance to *V. microspora,* but the latter has much smaller perithecia and spores. Both species are found on pebbles and small stones in the hydrohaline stratum in the maritime region (figure 81).

Distribution — Long Island (Fink, 1935): Temperate element, Maritime subelement; endemic.

### 10. DERMATOCARPON Eschw.

21. **Dermatocarpon miniatum** (L.) Mann, Lich. Bohm. Obs. Dispos. 66. 1825. *Lichen miniatus* L. Sp. Pl. 1149. 1753.

Material seen — SUFFOLK COUNTY: Montauk, *Latham 22242,* May 6, 1926 (Latham). The specimen was found on a rock along railroad tracks.

Distribution — Massachusetts, Connecticut, Tennessee, Alabama, Oklahoma, Michigan, Ontario, Minnesota, Black Hills, Washington, British Columbia; arctic to temperate (Ahti, 1964): Temperate element, North Temperate subelement, but arctic in Asia (Lynge, 1928), Europe (Lynge, 1938), and Iceland (Lynge, 1940a).

## PYRENULACEAE

### 11. PYRENULA Ach.

22. **Pyrenula nitida** (Weig.) Ach. Syn. Lich. 125. 1814. *Sphaeria nitida* Weig. Obs. Bot. 45. 1772.

Material seen — SUFFOLK COUNTY: *Imshaug 25552* (52), *Brodo 59-250* (67), *850* (47), *978* (63), *1221* (100a), *1657* (88), *1787* (127), *2210* (61), *2304* (93), *2539* (73), *2610* (84), *3232* (35), *3320* (129); Napeague, *Latham 2835,* March 1, 1927 (Latham); Greenport, *Latham 3989,* April 1, 1927 (Latham).

*Pyrenula nitida* is the indicator species of a well-known and well-studied *Fagus* community in Europe (the *Pyrenuletum nitidae* Hill.). In both Europe and Long Island, the species is characteristic of smooth-barked trees, chiefly *Fagus* (and *Quercus* on Long Island), in moderately shaded woods (Barkman, 1958; Almborn, 1948). Its position in a *Fagus* community continuum seems to be governed by light availability (Almborn, 1948).

Distribution — Nova Scotia, Maine, Connecticut, Wisconsin, Minnesota; throughout the United States (Fink, 1935); Europe; Asia (Zahlbruckner, 1930).

### 12. MELANOTHECA Fee

23. **Melanotheca cruenta** (Mont.) Müll. Arg. Bot. Jahrb. 6: 397. 1885. *Trypethelium cruentum* Mont. Ann. Sci. Nat. II. 8: 537. 1837.

Material seen — SUFFOLK COUNTY: Gardiner's Island, *Latham,* May 23, 1923 (Latham).

A description and discussion of this species can be found in Johnson (1959).

The Long Island specimen extends the known range of *M. cruenta* slightly northward. This range extension is known for several other coastal plain species, among them *Cladonia santensis* and *Cladonia evansii*. The specimen was found on a tree trunk in rich woods.

Distribution — Along the coastal plain, New Jersey to Texas (Fink, 1935): Temperate element, Coastal Plain subelement; endemic.

### 13. TRYPETHELIUM Spreng.

24. **Trypethelium virens** Tuck. in W. Darl. Fl. Cestr. ed. 3, 453. 1853.

Material seen — SUFFOLK COUNTY: *Imshaug 25735* (132), *25743* (132), *25746* (132), *Brodo 59-194* (33), *2702* (111), *3070* (128), *3201* (33), *3211* (33), *3254* (119); Montauk, Point Woods, *Latham 3992*, April 7, 1927 (Latham); Orient, Latham Bros. woods, *Latham 3598C*, April 10, 1939 (Latham); Napeague, *Latham 28356A*, February 9, 1949 (MO).

The unusual specificity of this species for *Ilex* spp. and *Fagus grandifolia* was discussed on p. 31. One specimen (*Latham 8598C*) was collected from a black oak. Johnson (1959) lists a number of other substrates as well. *Trypethelium virens* is apparently skiophilous (or hygrophilous?) in holly groves, thickets, and beech forests; it is never found on well-illuminated trunks.

Distribution — *Trypethelium virens* shows an unusual North American distribution due to its dual substrate specificity. It has a typical coastal plain distribution from Louisiana through Florida to New England (Fink, 1935) following the range of *Ilex opaca*, as well as an Appalachian-Great Lakes distribution following the range of *Fagus grandifolia*.

Temperate element, Eastern Temperate subelement; endemic.

## PORINACEAE

### 14. PORINA Mull. Arg.

25. **Porina cestrensis** (Tuck. in W. Darl.) Müll. Arg. Flora 66: 338. 1883. *Verrucaria cestrensis* Tuck. in W. Darl. Fl. Cestr. ed. 3. 452. 1853.

Material seen — SUFFOLK COUNTY: Orient Point, *Latham 5*, March 22, 1910 (NYS).

The type material of this species (*Michener 204*, sub *Verrucaria cestrica*) was examined in the Farlow herbarium. A diagnosis of the holotype is presented in tabular form in the discussion of *P. hibernica* which follows.

Distribution — New England to Georgia, Alabama, and Tennessee (Fink, 1935): Temperate element, Coastal Plain subelement; endemic.

26. **Porina hibernica** P. James & Swins. in Swins. Lichenol. 2: 35. 1962.

Material seen — SUFFOLK COUNTY: *Brodo 1783 B* (127), *2598* (84), *3206* (33).

This species bears certain resemblances to two other *Porinae* from the New England area, *P. cestrensis* and *P. rhaphidosperma* Müll. Arg.

The table presented below points out some of the differences between them. The diagnoses of *P. centrensis* and *P. rhaphidosperma* are based on the type specimens. The values given in parentheses under *P. cestrensis* are measurements of other specimens which were studied.

| | *P. cestrensis* | *P. rhaphidosprema* | *P. hibernica* |
|---|---|---|---|
| Thallus | well developed; greenish black | ashy white to dirty green-grey; smooth to cracked, well developed | greenish to olivaceous; very thin, smooth or scurfy to almost absent |
| Perithecium | 0.15-0.25 mm | 0.20-0.35 mm | 0.20-0.35 mm |
| Exciple | hyaline | carbonaceous | carbonaceous |
| Spores: | 34-46 x 3-5 μ | | |
| size | (30-42 x 5-6 μ) | (63-)100-120 x 2-5 μ | 58-65 x 5-7 μ |
| shape | clavate, straight | acicular, flexuous | ± elongate-clavate to ± acicular, straight |
| septa | 5-8 | | |
| | (3-7 [-9]) | (9-)14-25 | (5-)9-13(-16) |
| cell size | irregular | equal | frequently irregular |

*Porina hibernica* was always associated with *P. nucula* on oaks in well shaded moist woods.

Distribution — First North American record; Ireland (Kilarney: type locality); oceanic(?).

27. **Porina nucula** Ach. Syn. Meth. Lich. 112. 1814.

Material seen — SUFFOLK COUNTY: *Brodo 1783 A* (127), *2598,* sterile (84), *3517* (33).

This species is one of the few *Porinae* having a pale, noncarbonaceous involucrellum.

The Long Island material was somewhat aberrant in that the perithecia were small and did not have the "plaques" or lamellae described by Swinscow (1962). Herbarium specimens of *Porina nucula* which I examined generally had a smooth to verrucose thallus, but the Long Island specimens had diffuse coralloid thalline outgrowths. These outgrowths appear like *Trentepohlia* filaments which have partially escaped lichenization. Swinscow (pers. corr.) said that these specimens were poorly developed but otherwise normal, and so, perhaps the condition is not as unusual as it first appears.

Its ecology is the same as that of *P. hibernica.*

Distribution — Gulf coastal plain (Fink, 1935): Tropical element (see Swinscow, 1962), Coastal Plain subelement; Europe (Swinscow, 1962).

## GRAPHIDACEAE

### 15. XYLOGRAPHA (Fr.) Fr.

28. **Xylographa opegraphella** Will. in Rothr. Proc. U.S. Nat. Mus. 7: 8. 1884.

Material seen — SUFFOLK COUNTY: Orient, *Latham 12,* May 1, 1914 (Latham); Orient, *Latham 1080,* April 1, 1915 (Latham).

Norstictic acid was demonstrated in KOH from the specimen with a well-developed thallus (*Latham 12*) and this substance undoubtedly is the basis of the KOH + red, PD + yellow reactions in the medulla of material examined by Lamb (1954). The other Long Island specimen (*Latham 1080*) had almost no thallus (but was identical in other respects to *Latham 12*) and norstictic acid could not be demonstrated in the very minute thalline particles which were present.

*Xylographa abietina* (Pers.) Zahlbr. differs from *X. opegraphella* in having broader spores and longer lirellae. An exsiccat collection of *X. abietina* (California Fungi no. 850) had spores 12-14 x 6-7 μ with lirellae up to a millimeter or more long. No norstictic acid could be found in the specimen, which had virtually no thallus.

*Xylographa opegraphella* is confined to old wood.

Distribution — New England coast (Fink, 1935), Nova Scotia; Alaska (Rothrock, 1884; Cummings, 1910): Temperate element, Oceanic subelement; endemic.

### 16. GRAPHIS Adans.

29. **Graphis scripta** (L.) Ach. Kgl. Vet. Akad. Nya Handl. 145. 1809. *Lichen scriptus* L. Sp. Pl. 1140. 1753.

Material seen — SUFFOLK COUNTY: 52 specimens collected by Imshaug and/or Brodo; 12 specimens collected by Latham (Latham).

The lirellae of this species are extremely variable in length, breadth, and degree of branching. Gross lirelline characters are therefore of little use in defining the species.

*Graphis scripta* is common on the bark of various deciduous trees, usually in partial shade, and is mainly associated with the red oak forest on the north shore (figure 61).

Distribution — Nova Scotia, Maine, Connecticut, Massachusetts, North Carolina, Tennessee, Michigan, Wisconsin, Indiana, Minnesota, Washington, Alaska: Temperate element, North Temperate subelement(?); Europe; Asia (Vainio, 1928; Zahlbruckner, 1930b).

### 17. PHAEOGRAPHIS Müll. Arg.

30. **Phaeographis dendritica** (Ach.) Müll. Arg. Flora 65: 382. 1882. *Opegrapha dendritica* Ach. Meth. Lich. 31. pl. 1, f. 10. 1803.

Material seen — NASSAU COUNTY: *Brodo 1509* (14), *546* (12), *554* (12). SUFFOLK COUNTY: 72 specimens collected by Imshaug and/or Brodo; 12 specimens collected by Latham (Latham); Greenport, *Latham 31919,* April 12, 1953 (MO).

The species is found on the bark of various deciduous trees in well-lighted or partially shaded woods.

Distribution — Eastern United States (Fink, 1935); Temperate element, East Temperate subelement; Europe; Asia (Zahlbruckner, 1930b).

## DIPLOSCHISTACEAE

### 18. DIPLOSCHISTES Norm.

31. **Diploschistes scruposus** (Schreb.) Norm. Nyt. Mag. Naturv. 7: 232. 1853. *Lichen scruposus* Schreb. Spic. Fl. Lips. 133. 1771.

var. **scruposus**

Material seen — SUFFOLK COUNTY: *Brodo 3847* (76); Orient, *Latham*, October 4, 1917 (Latham); Sag Harbor, *Latham*, May 10 1924 (Latham).

var. **parasiticus** (Sommerf.) Zahlbr. Cat. Lich. Univ. 2: 672. 1924.

*Lecanora scruposa* var. *parasitica* Sommerf. Suppl. Fl. Lapp. 100. 1826.

Material seen — SUFFOLK COUNTY: *Brodo 59-172* (100B).

All the specimens were on noncalcareous rock, except var. *parasiticus* which was collected on the sterile squamules of a species of *Cladonia*. *Diploschistes scruposus* was treated by Fink (1935) in the genus *Urceolaria*.

Distribution — Maine, Connecticut, Michigan, Oklahoma, Arizona, Black Hills, Washington, Manitoba, Baffin Island: Arctic-boreal element; circumboreal.

## GYALECTACEAE

### 19. DIMERELLA Trev.

32. **Dimerella diluta** (Pers.) Trev. Rend. Reale Ist. Lomb. Sci. 13: 65. 1880. *Peziza diluta* Pers. Syn. Meth. Fung. 668. 1801.

Material seen — SUFFOLK COUNTY: *Brodo 3200* (33).

Both this species and the one following were treated under the genus *Microphiale* by Fink (1935).

The Long Island specimen was found on the bark of an old oak in the dense shade of an *Ilex opaca* grove on Fire Island.

Distribution — Eastern United States (Fink, 1935); Maine, North Carolina, Black Hills, Saskatchewan: Temperate element, East Temperate subelement(?); Europe; Asia (Vainio, 1928).

33. **Dimerella lutea** (Dicks.) Trev. Rend. Reale Ist. Lomb. Sci. 13: 66. 1880. *Lichen luteus* Dicks, Fasc. Pl. Crypt. Brit. 1: 11, pl. 2, f. 6. 1785.

Material seen — SUFFOLK COUNTY: Orient, *Latham 1087*, May 3, 1914 (Latham).

A specimen of this species was also found on Cape Cod, (Massachusetts) in a bog (*Brodo 4323B*).

Distribution — Eastern United States, and Canada (Fink, 1910); Maine, North Carolina, Washington: Temperate element, East Temperate subelement(?); Europe; Asia (Vainio, 1928).

## COLLEMATACEAE

### 20. COLLEMA Wigg.

34. **Collema subfurvum** (Müll. Arg.) Degel. Bot. Not. 139. 1948. *Synechoblastus flaccidus* v. *subfurvus* Müll. Arg. Proc. Roy. Soc. Edinb. 11: 457. 1882.

Material seen — QUEENS COUNTY: Jamaica, *G. B. Brainerd*, 1866 (BKL); Jamaica, *G. B. Brainerd*, 1866, (BKL 031870). SUFFOLK COUNTY: Orient, *Latham 787A*, May 3, 1914 (Latham); Napeague, *Latham 2845*, March 1, 1927 (Latham); Montauk, *Latham 28309*, February 9, (Latham); Shelter Island, *Latham 36949*, May 4, 1943 (Latham).

*Collema subfurvum* differs from closely related *C. flaccidum* (Ach.) Ach. (Syn. *Synechoblastus rupestris* Trev.) in having globular rather than squamiform isidia, and in its corticolous rather than saxicolous substrate preference (Degelius, 1954). It is usually found on oak bark.

Distribution — New England, Smoky Mountains (Tennessee), Iowa, Illinois (Degelius, 1954): Temperate element, Appalachian subelement, Appalachian-Great Lakes unit; Europe (oceanic localities) and Asia (Degelius, 1954).

### 21. LEPTOGIUM S. Gray

35. **Leptogium corticola** (Tayl.) Tuck. in Lea, Cat. Pl. Cinc. 47. 1849. *Collema corticola* Tayl. J. Bot. 5: 195. 1847.

Material seen — SUFFOLK COUNTY: Montauk, *Latham 3993* (p.p.), April 6, 1927 (Latham).

Degelius (1940) discusses the nomenclatural problems pertaining to this species. The Long Island material agrees with the original description as well as Degelius' additions to it. Sierk (1964) presents a detailed discussion of the species.

Distribution — Temperate element, East Temperate subelement, Adriatic coast in Europe (map: Sierk, 1964).

36. **Leptogium cyanescens** (Ach.) Körb. Syst. Lich. Germ. 420. 1855. *Collema tremelloides* v. *cyanescens* Ach. Syn. Meth. Lich. 326. 1814. non *Lichen cyanescens* Pers. or *Parmelia cyanescens* Ach. (Degelius, 1935).

Material seen — QUEENS COUNTY: Jamaica, *G. B. Brainerd*, 1866? (BKL). SUFFOLK COUNTY: *Brodo 2126* (102); Orient, *Latham 787*, May 3, 1914, (Latham); Orient, *Latham 8199*, April 16, 1928 (Latham); Greenport, *Latham 8618*, June 1, 1931 (Latham); North Sea, *Latham 23333*, March 26, 1954 (Latham); Montauk, *Latham 28309A*, February 9, 1949 (Latham); Three Mile Harbor, *Ogden 5406*, May 11, 1954 (NYS).

This species was apparently included in *L. tremelloides* (L.) S. F. Gray by Fink (1935). *Leptogium tremelloides*, however, is strictly an

Old World species (Sierk, 1964). The confusing nomenclature of *L. cyanescens* has been clarified by Degelius (1935). The species' oceanic affinities are noted by Degelius (1935 and 1941). The distribution of *L. cyanescens* on Long Island (figure 31), showing a restriction to the foggy eastern tip, reflects these oceanic requirements. Sierk (1964) discusses its morphology, ecology, and distribution in detail.

On Long Island, the species is usually found on mossy tree bases.

Distribution — Temperate element, basically East Temperate subelement, with scattered occurrences in the Black Hills, western Canada and coastal Alaska, Europe, Asia (map: Sierk, 1964).

## PANNARIACEAE

### 22. PLACYNTHIUM S. Gray

In her recent North American monograph of the genus, Henssen (1963) placed *Placynthium* into the Peltigeraceae based on ascocarp development. Since Henssen's revision of the cyanophycean lichens and their families is still not complete, the older family concepts will be retained for the time being.

37. **Placynthium nigrum** (Huds.) S. Gray Nat. Arr. Brit. Pl. 395. 1821. *Lichen niger* Huds. Fl. Angl. ed. 2, 2: 524. 1778.

Material seen — SUFFOLK COUNTY: *Brodo 3921* (54).

Although *P. nigrum* is considered squamulose or even subfoliose by some authors, the Long Island material was all crustose, occasionally forming small subsquamulose areoles. Henssen (1963) presents a detailed account of the species' morphology and development.

This inconspicuous species is probably more abundant than the collection records show. It was found in a shaded woods on old concrete foundations.

Distribution — Arctic-boreal element (map: Henssen, 1963); Europe; Asia (Lynge, 1928).

### 23. PANNARIA Del.

38. **Pannaria lurida** (Mont.) Nyl. Mem. Soc. Sci. Nat. Cherb. 5: 109. 1857. *Collema luridum* Mont. Ann. Sci. Nat. II. 18: 236. 1842.

Material seen — SUFFOLK COUNTY: Montauk Woods north of Fresh Pond, *Latham 28322*, February 9, 1949 (Latham); Orient Point, *Latham 5*, April 4, 1910 (NYS). COUNTY UNKNOWN: Long Island (?), *Austin* (BKL 031953).

The species was found on oak and red cedar bark.

Distribution — Eastern United States (Fink, 1935): Tropical Element (Zahlbruckner, 1925), Appalachian-Temperate subelement.

## STICTACEAE

### LOBARIA Schreb.

39. **Lobaria pulmonaria** (L.) Hoffm. Deutschl. Fl. 2: 146. 1796. *Lichen pulmonarius* L. Sp. Pl. 1145. 1753.

Material seen — QUEENS COUNTY: Ridgewood, *G. B. Brainerd,* 1867 (BKL 031881). SUFFOLK COUNTY: *Brodo 887* (56), *1021* (112), *1045* (112), *2154* (102); 12 specimens collected by Latham (Latham).

Fink (1935) treated *L. pulmonaria* under the genus *Sticta.*

This species shows some variation in isidia and soredia production in various parts of its range. The Long Island specimens all have isidiate-soralia on the thallus margins and ridges, but they may be more common in some individuals than in others. The granular soredia are sometimes hard to see until most of the isidia have fallen away. The isidia vary from being short, almost like papillae, to elongate cylindrical, and finally coralloid.

The species is rare on Long Island. It is confined to tree bases in the oceanic areas of the eastern tip of the island and bog trees (especially *Acer rubrum*) outside this area.

Degelius (1935, p. 223) stated that *L. pulmonaria* favors an oceanic climate but is not restricted to an oceanic distribution.

Distribution — Nova Scotia, Maine, Connecticut, Tennessee, Michigan, Ontario, Indiana, Washington, British Columbia, Alaska: Temperate element, North Temperate subelement (Appalachian-Great Lakes: Hale, 1961a); Europe; Asia (Zahlbruckner, 1930; Magnusson, 1940).

40. **Lobaria quercizans** Michx. Fl. Bor-Amer. 2: 324. 1803.

Material seen — KINGS COUNTY: New Lots, (*Brainerd* ?), 1867 (BKL 031874). SUFFOLK COUNTY: *Brodo 1040* (112), *2145* (102), *2801* (102); Napeague, *Latham 2838,* March 1, 1927 (Latham); Napeague, *Latham 2837,* March 1, 1927 (Latham); Montauk, *Latham 28307,* February 9, 1949 (1945?) (Latham, MO); Riverhead, *Latham 36869,* May 16, 1960 (Latham); Montauk, *Latham 36884,* April 4, 1949 (Latham); Jamesport, *Latham 36948,* April 19, 1951 (Latham); (no locality), *Latham,* May 6, 1920 (Latham); Eastport, *Schrenk,* June 28, 1894 (MO).

*Lobaria quercizans* is the North American vicariad of *L. amplissima* (Scop.) Forss. (Degelius, 1940; Hale, 1957a), a well known European oceanic species (see Degelius, 1935). *Lobaria quercizans* was considered under the latter name in Fink (1935). The North American species also appears to have an oceanic distribution (Degelius 1941), and on Long Island is restricted to the fog belt and bogs. It often is found associated with *Lobaria pulmonaria.*

Distribution — Temperate element, Appalachian subelement, Appalachian-Great Lakes unit (map: Hale, 1957a); endemic.

## NEPHROMACEAE

### 25. NEPHROMA Ach.

41. **Nephroma laevigatum** Ach. Syn. Lich. 242. 1814. non auct.

Material seen — SUFFOLK COUNTY: Montauk, *Latham 36784,* May 6, 1929 (Latham).

A full discussion of the taxonomy and distribution of this species was presented by Wetmore (1960). Long Island is the southernmost locality for the species on the east coast. The specimen was found on rock.

Distribution — East and west coasts of North America: Temperate element, Oceanic subelement (Wetmore, 1960); oceanic regions of Europe (Degelius, 1935); Asia (Vainio, 1928).

## PELTIGERACEAE

### 26. SOLORINA Ach.

42. **Solorina saccata** (L.) Ach. Kgl. Vet. Akad. Nya Handl. 228. 1808. *Lichen saccatus* L. Fl. Suec. ed. 2, 419. 1755.

Material seen — SUFFOLK COUNTY: Montauk, *Latham 36883*, October 7, 1926 (Latham).

The specimen was collected on a rocky bank.

Distribution — Michigan, Ontario, Minnesota, Black Hills, Washington, Alaska, Manitoba, Quebec, Baffin Island: Arctic-boreal element; circumboreal.

### 27. PELTIGERA Willd.

43. **Peltigera aphthosa** (L.) Willd. Fl. Berol. Prodr. 347. 1787. *Lichen aphtosus* L. Sp. Pl. 1148. 1753.

var. **variolosa** (Mass.) Thoms. Trans. Wisc. Acad. Sci. 38: 253. 1947.

*Peltigera aphthosa* f. *variolosa* Mass. Sched. Crit. III: 64. 1856.

Material seen — KINGS COUNTY: New Lots, *G. B. Brainerd* (BKL 031888). SUFFOLK COUNTY: Gardiner's Island, *Latham* September 22, 1922 (Latham); Fisher's Island, *Latham*, June 24, 1929 (Latham); Montauk, *Latham*, May 17, 1942 (Latham).

The dark veins on the lower surface of this variety distinguish it from var. **aphthosa** (var. *typica* in Thomson, 1950a).

The material is from the ground in dry woods, and from a rock (figure 70).

Distribution — Arctic-boreal element, circumboreal (map: Thomson, 1950a).

44. **Peltigera canina** (L.) Willd. Fl. Berol. Prodr. 347. 1787. *Lichen caninus* L. Sp. Pl. 1149. 1753.

var. **rufescens** (Weiss) Mudd, Man. Brit. Lich. 82. 1861.

*Lichen caninus* var. *rufescens* Weiss, Pl. Crypt. Fl. Goet. 79. 1770.

Material seen — NASSAU COUNTY: Massapequa, *S. Cain 188*, July 7, 1935 (NY). SUFFOLK COUNTY: Devon, *Latham*, May 2, 1955 (Latham); Three Mile Harbor, *Latham 27207*, April 17, 1947 (Latham); Napeague, north of Fresh Pond, *Latham 8118*, April 6, 1938 (Latham); Three Mile Harbor, Hands Creek, *Latham 2646*, April 20, 1926 (Latham); Napeague, *Latham 36978*, May 3, 1947 (Latham).

Following Thomson (1950a), three varieties of this species can be recognized as occurring on Long Island.

The questionable taxonomic rank of var. *rufescens* is discussed on p. 110-111. On Long Island it is relatively rare, occurring mainly in dry woods on tree bases.

var. **spuria** (Ach.) Schaer. Lich. Helvet. Spicil. 6: 265. 1833.

*Lichen spurius* Ach. Lich. Suec. Prodr. 159. 1798.

Material seen — SUFFOLK COUNTY: *Brodo 59-280* (53), *2291* (87); Northwest, *Latham 26133,* April 10, 1947 (Latham).

Variety *spuria* has only been collected in its sorediate stage on Long Island. It has been clearly established that the sorediate form is a juvenile stage of var. *spuria* (Dahl, 1950). *Latham 26133* has both apothecia and soredia and appears similar to var. *rufescens,* which in turn is said to intergrade with var. *canina* (var. *albescens*) (Thomson, 1950a).

It was found on dry, sandy soil.

var. **ulorrhiza** (Flörke) Schaer. Enum. Crit. Lich. Europ. 20. 1850.

*Peltidea ulorrhiza* Flörke, Deutsch. Lich. no. 154. 1821.

Material seen — SUFFOLK COUNTY: Riverhead, *Latham,* November 1, 1913 (Latham).

The Latham specimen was found on the ground in a dry woods.

Distribution (of all varieties) — Arctic-boreal element; circumboreal (maps: Thomson, 1950a).

45. **Peltigera polydactyla** (Neck.) Hoffm. Desc. Adumbr. Pl. Lich. 1: 19, pl. 4, f. 1. 1790. *Lichen polydactylon* Neck. Meth. Musc. 85. 1771.

Material seen — QUEENS COUNTY: Jamaica, *G. B. Brainerd,* May 1866 (BKL 031889). SUFFOLK COUNTY: Montauk, *Latham,* May 12, 1920 (Latham).

*Peltigera polydactyla* is most closely related to *P. horizontalis* (Huds.) Baumg., from which it is distinguished by its vertically-oriented apothecia and its longer and narrower spores. Thomson (1950a) reports the spores of the latter species to be 24-45 x 3.5-6 μ.

The Long Island material, having broad, conspicuous veins on the lower thallus surface, represents var. *polydactyla* (var. *typica* of Thomson, 1950a).

Latham's specimen was found at the base of a tree in an oak woods.

Distribution — Arctic-boreal element (map: Thomson, 1950a), also Baffin Island, Manitoba; circumboreal.

46. **Peltigera praetextata** (Flörke in Somm.) Vain. Természetr. Fuzetek 22: 306. 1899. *Peltidea ulorrhiza* var. *praetextata* Flörke in Somm. Suppl. Fl. Lappon. 123. 1826.

Material seen — SUFFOLK COUNTY: *Brodo 1049* (112), *1254* (48), *2041* (45), *2133* (102), *2469* (23); Greenport, *Latham 53,* May 10, 1914 (Latham); Three Mile Harbor, *Latham,* November 21, 1926 (Latham); Riverhead, *Latham,* February 2, 1923 (Latham); 16 specimens collected by Latham (Latham).

This species is very similar to *P. canina* var. *rufescens* and seems to differ only in its ability to produce regeneration squamules on the thallus surface and margins. Experiments on the production of isidia (regeneration squamules) were performed by Thomson (1948) and Lindahl (1953) and resulted in two entirely opposite points of view regarding the taxonomic value of the structures. Thomson found that wounded thalli of *P. canina* var. *rufescens* regenerate on some lobes and not on others, whereas Lindahl found that no thalli of *P. canina* sens. str. regenerated and only *P. praetextata* showed regeneration. It is possible that Thomson was working with true *P. praetextata* "hidden" by its original lack of regeneration squamules (which Lindahl concedes may happen) and that true *P. canina sens. str.* would not produce regeneration even in the United States. It is also possible that only under certain conditions will species other than *praetextata* regenerate and these conditions were met in Wisconsin and not in Sweden, or that the America populations of *P. canina* differ in regeneration properties from the European populations, a difference which might be of taxonomic importance.

This entire problem, as it appears to me, is far from settled and should be investigated further. Until more work is done, however, the European concept of *P. praetextata* will be accepted.

The species is most frequently found growing on mossy tree bases in oak woods.

Distribution — Arctic-boreal element (map: Thomson, 1950a); Europe; Asia (Magnusson, 1940).

## LECIDEACEAE

### 28. LECIDEA Ach.

47. **Lecidea aeruginosa** Borr. in Hook. and Sowerb. Suppl. Engl. Bot. 1: tab. 2682. 1831. *Lecidea flexuosa* (Fr.) Nyl. Act. Soc. Linn. Bord. 21: 356. 1856.

Material seen — SUFFOLK COUNTY: *Imshaug 25834* (86), *Brodo 657* (79), *1157* (70), *1612* (69), *2213* (61), *2333* (44), *2548* (73), *2732* (111), *2964* (95), *3319* (129), *3336* (18), *2536* (49); Orient, *Latham 38174,* December 15, 1964 (Latham).

The separation of sterile material of *L. aeruginosa* from *L. botryosa* is discussed under the latter species. Laundon (1962) regarded *L. aeruginosa* (sub *L. flexuosa*) as synonomous with *L. granulosa.* On Long Island, however, except for spore size, the two are not at all similar either morphologically or ecologically. *Lecidea aeruginosa* has black or lead-colored plane apothecia, each with a thin hyaline hypothecium; *L. granulosa* has large, brown, irregularly convex to almost hemispherical apothecia, each with a thick opaque hypothecium. In addition, the former species is restricted to lignum and the latter is found only on sandy soil. I have examined material from the Black Hills of South Dakota, where both species occur on old wood, and still the fertile material of *L. aeruginosa* is easily distinguished from *L. granulosa.*

Distribution — Connecticut, Minnesota, Black Hills; throughout the United States (Fink, 1935): Temperate element, North Temperate subelement (?); Europe; Asia (Vainio, 1928).

48. **Lecidea albocaerulescens** (Wulf. in Jacq.) Ach. Meth. Lich. 52. 1803. *Lichen albocaerulescens* Wulf. in Jacq. Collect. Bot. 2: 184, f. 1. 1788.

Material seen — NASSAU COUNTY: *Brodo 549* (12). SUFFOLK COUNTY: *Brodo 2166* (99), *2434* (20), *2580* (96), *2689* (110), *2743* (111), *3019* (17), *3034* (50), *3037* (50), *3119* (34), *3272* (119), *3274* (119), *3411* (134), *3875* (62); Gardiner's Island, *Latham*, March 30, 1921 (Latham); Greenport, *Latham 3966*, April 1, 1927 (Latham); Greenport, *Latham 39*, May 10, 1914 (Latham); Three Mile Harbor, *Latham 32651*, May 25, 1954 (Latham).

This striking saxicolous species is easily identified in the field by its pruinose apothecia, dark apothecial margins, and smooth grey thallus. All but one specimen on Long Island were shown to contain stictic acid (both by paper chromatography and recrystallization in GAoT solution). The exception (*Brodo 549*) contained norstictic acid (red acicular crystals in KOH). This stictic-norstictic shift is a common phenomenon in lichen chemistry and can be seen in *Lecanora cinerea* and several species of *Parmelia*. Norstictic acid has never been reported for this species before.

*Lecidea albocaerulescens* is narrowly restricted to shaded granitic rocks and is only found in the poorly lighted, red oak forests of the north shore (figure 59).

Distribution — Connecticut, Tennessee, Michigan, Indiana, Oklahoma, Minnesota, Washington, Alaska; Eastern United States and Washington (Fink, 1935); Temperate element, North Temperate subelement; Europe; Asia (Lynge, 1928).

49. **Lecidea anthracophila** Nyl. Flora 48: 603. 1865.

Material seen — SUFFOLK COUNTY: 23 specimens collected by Imshaug and/or Brodo.

Fink (1935) lists this species with the genus *Psora*.

The PD + red constituent of *L. anthracophila* is apparently fumarprotocetraric acid but does not show exactly the same $R_f$ value as known fumarprotocetraric acid (as in *Cladonia subtenuis*) in paper chromatography (solvent: pyridine, ethyl acetate, and water). Fumarprotocetraric acid usually has an $R_f$ of approximately 0.30 to 0.45 and the *Lecidea anthracophila* material has an $R_f$ of approximately 0.40 to 0.55. In all other characters (color reaction with PD, fluorescence in UV before and after reaction with PD, etc.) it is identical to fumarprotocetraric acid.

The species is found only on fresh or charred bark of *Pinus rigida* (see page 49); figure 42). Fink (1935) reported it from old wood.

Distribution — Vermont, Massachusetts, New Jersey, and North Carolina (Fink, 1935): Temperate element, East Temperate subelement; Europe.

50. **Lecidea botryosa** (Fr.) Th. Fr. Lich. Scand. 1: 454. 1874. *Biatora botryosa* Fr. Kgl. Vet. Akad. Nya Handl. 268. 1822.

Material seen — NASSAU COUNTY: *Brodo 3494* (4). SUFFOLK COUNTY: *Imshaug 25633* (NW of 29), *25636a* (NW of 29), *Brodo 3202* (33).

When sterile, this species closely resembles *L. aeruginosa* which, however, is C + red. If apothecia are present, the hypothecial color (hyaline in *L. aeruginosa* and brown in *L. botryosa*) distinguishes the two.

The species is almost entirely restricted to old wood. It was found once (*Brodo 3494*) growing on the base of an old black oak in a shaded woods.

Distribution — Michigan, Arizona, Manitoba; Adirondack Mountains of New York, New Hampshire, with doubtful occurrences in the west coast (Lowe, 1939): Temperate element, North Temperate subelement; northern Europe, Asia (Lowe, 1939).

51. **Lecidea coarctata** (Turn. in Sm. and Sowerby) Nyl. Act. Soc. Linn. Bord. 21: 358. 1856. *Lichen coarctatus* Turn. in Sm. and Sowerby Engl. Bot. 8: pl. 534. 1799.

Material seen — QUEENS COUNTY: *Brodo 525* (3). SUFFOLK COUNTY: *Brodo 59-308* (54), *59-310* (54), *791* (90A), *2342* (44), *2688* (110), *1782* (127), *2531* (49), *2720* (111), *3901* (112); Orient, *Latham*, March 18, 1914 (Latham); Shelter Island, *Latham 22177*, October 26, 1944 (Latham); Montauk, *Latham 28127*, October 8. 1954 (Latham).

This is the only species, found on pebbles, which has small brown apothecia. The white, areolate, C + red thallus add to its distinctiveness. *Lecidea coarctata* is often associated with *L. erratica* and *Rhizocarpon obscuratum* on pebbles and small stones.

Distribution — Nova Scotia, Maine, Connecticut, Indiana, Minnesota, British Columbia; northern United States (Fink, 1935): Temperate element, North Temperate subelement; Europe.

52. **Lecidea cyrtidia** Tuck. Proc. Amer. Acad. Arts Sci. 12: 181. 1877.

Material seen — SUFFOLK COUNTY: *Brodo 1684* (88), *2330* (44), *2697* (110), *3078A* (128), *3120* (34), *3125* (34), *3287* (119), *3903* (112); Greenport, *Latham 3974*, April 1, 1927 (Latham); Shelter Island, *Latham 22177*, October 26, 1944 (Latham); Shelter Island, *Latham 22879A*, October 26, 1944 (Latham); Shelter Island, *Latham 22880*, October 26, 1944 (Latham); Shelter Island, *Latham 22880*, October 26, 1944 (Latham); *Latham 31015*, February 2, 1940 (Latham), Montauk Point, *Latham*, April 12, 1956 (Latham).

*Lecidea cyrtidia* is superficially very similar to *L. erratica*. However, the epithecium and the outer portions of the exciple are greenish black in the latter and brown in the former species. Magnusson (1952) described *L. nearingii* which, from its description, appears very similar to *L. cyrtidia*. *Lecidea nearingii* has a brown-black thallus, whereas *L. cyrtidia* has a pale to dark brownish-green thallus. The thalli of both species are thin and continuous. The distinctions are therefore very questionable from the published descriptions, but since the type of *L. nearingii* has not been examined no further conclusions can be made concerning its validity as a species.

One specimen had much larger apothecia than any of the others, but agreed in other respects with the descriptions of *L. cyrtidia.*

The species is common on pebbles and small stones in dry woods or fields.

Distribution — Eastern United States (Lowe, 1939): Temperate element, East Temperate subelement; endemic.

53. **Lecidea erratica** Körb. Parerg. Lich. 223. 1861.

var. **erratica**

Material seen — QUEENS COUNTY: *Brodo 524* (3). NASSAU COUNTY: *Brodo 545* (12), *3506* (10). SUFFOLK COUNTY: 32 specimens collected by Imshaug and/or Brodo; Shelter Island, *Latham 22879B,* October 26, 1944 (Latham); Shelter Island, *Latham 22883,* October 26, 1944 (Latham); Riverhead, *Latham 24271,* March 16, 1946 (Latham); Quogue, *Latham 28254* (Latham); Montauk Point, *Latham 29305,* May 6, 1949 (Latham); Orient, Brown Brothers Site, *Latham 29928,* November 4, 1951 (Latham); Riverhead, North River, *Latham 34271,* March 16, 1946 (Latham); East of Sag Harbor, *Latham,* October 19, 1945 (Latham).

var. **planetica** (Tuck.) Lowe, Lloydia 2: 279. 1939.

*Lecidea planetica.* Tuck. Syn. N. Am. Lich. 2: 131. 1888.

Material seen — SUFFOLK COUNTY: *Brodo 3012* (17).

Magnusson (1936) recognized several species as being closely related to *L. erratica*: *L. sylvicola* Flot., *L. cyrtidia* Tuck., *L. micytho* Tuck., and *L. planetica* Tuck. Lowe (1939) whose work is being followed here, treats *L. planetica* as a variety of *L. erratica* having a more well-developed thallus than the variety *erratica.* Lowe regards *L. micytho* as a yellowish form of var. *planetica.* The separations of *L. erratica* and *L. cyrtidia* have already been discussed under the latter species. *L. sylvicola* differs from *L. erratica* in having a greenish or greenish black hypothecium with a doubtfully distinguished pale bluish black exciple (Lowe, 1939) as opposed to a reddish brown to almost black hypothecium and an exciple greenish black externally and hyaline within.

This common species is found on pebbles in exposed fields and downs, and is particularly abundant in well-lighted areas on the Ronkonkoma moraine (figure 60). Some observations on its development have been presented on p. 43.

Distribution — Eastern United States west to Minnesota (Lowe, 1939): Temperate element, East Temperate subelement; Europe (ibid).

54. **Lecidea granulosa** (Ehrh.) Ach. Meth. Lich. 65. 1803. *Lichen granulosa* Ehrh. Pl. Crypt. Exs. 145. 1785.

Material seen — SUFFOLK COUNTY: *Imshaug 25644* (64), *25656* (64), *25788* (86); *Brodo 655* (79), *1900* (114), *1939* (85), *3372* (94), *3401* (75), *1404* (83); Shinnecock Hills, *Latham 7873,* February 14, 1938 (Latham); Southold, *Latham 7863,* February 11, 1938 (Latham); North Sea, *Latham 28128,* May 16, 1955 (Latham); Riverhead, *Peck,* September (NYS).

*Lecidea granulosa* is similar in some respects to *L. aeruginosa,* but the two are quite distinct on Long Island (see discussion under *L. aeruginosa*). It is known to grow on old wood as well as soil but is restricted on the island to sandy soil.

Distribution — Nova Scotia, Maine, Connecticut, North Carolina, Michigan, Minnesota, Arizona, Black Hills, Washington, Alaska, Saskatchewan; Northern United States (Fink, 1935): Temperate element, North Temperate subelement; Europe; Asia (Vainio, 1928).

55. **Lecidea macrocarpa** (DC. in Lam. & DC.) Steud. Nomencl. Bot. 245. 1824. *Patellaria macrocarpa* DC. in Lam. & DC. Fl. Franc. ed. 3 2: 347. 1805.

Material seen — SUFFOLK COUNTY: *Imshaug 25592* (52).

There has been much disagreement concerning the name of this species. Fink (1935) discussed it under the name *L. platycarpa* Ach., and Lowe (1939) following Vainio (1909, 1934) used *L. steriza* (Ach.) Vain. Clauzade and Rondon (1959) recently considered the species under the name *Lecidea contigua* (Hoffm.) Th. Fr. Most other workers have used *L. macrocarpa.*

The epithet "*macrocarpa*" was first used at the species level in the genus *Patellaria* by DeCandolle in 1805, which makes it the oldest available name. "*Steriza*" was only considered at the infraspecific level (*L. confluens* δ *L. steriza* Ach.) until Vainio raised it to a species in 1909. *Lecidea platycarpa* was not described until 1810 by Acharius. Vainio (1934) states that Theodor Fries used the name *contigua* incorrectly in referring Hoffman's *Verrucaria contigua* to the genus *Lecidea.* Fries' lichen was *L. macrocarpa* but Hoffman's name referred to a different species.

The Long Island specimen has a rather well-developed continuous to cracked and areolate thallus. It was found on a siliceous roadside pebble.

Distribution — Nova Scotia, Maine, Connecticut, Tennessee, Michigan, Minnesota, Idaho, Alaska, Saskatchewan, Baffin Island: Arctic-boreal element; circumboreal.

56. **Lecidea myriocarpoides** Nyl. Flora 48: 355. 1865.

Material seen — SUFFOLK COUNTY: *Brodo 2535* (49), *2362* (42), *3880* (62), *3892* (112).

This species was found only on well-illuminated, hard lignum.

Distribution — Eastern United States and California (Fink, 1935, Lowe, 1939); Europe.

57. **Lecidea nylanderi** (Anzi) Th. Fr. Lich. Scand. 1: 462. 1874. *Biatora nylanderi* Anzi, Cat. Lich. Sondr. 75. 1860.

Material seen — SUFFOLK COUNTY: *Brodo 1400* (65), *1953* (85), *2000* (51), *2549A* (73).

The very small, reddish brown apothecia and the subglobose to globose spores of this species easily distinguish it from other pine bark lichens. On Long Island it is limited to the bark of *Pinus rigida*. Culberson (1958a), studying the pine-inhabiting lichen vegetation of North Carolina, found *Lecidea nylanderi* only in the mountains of North Carolina. *Pinus rigida* is also found only in the mountains. This correlation may indicate a very high degree of substrate specificity, but since the specificity of the species was not indicated in that paper, and since other pines occur in the mountains, no such conclusion can be made. The species is found on *Pinus ponderosa* in the Black Hills of South Dakota and was also collected twice (*Brodo 4122, 4489*) on *Pinus rigida* in the Cape Cod region of Massachusetts.

Distribution — Adirondack Mountains of New York, Massachusetts, California, (Lowe, 1939); North Carolina, Wisconsin, Black Hills, Manitoba: Temperate element, North Temperate subelement; Europe; Asia (Vainio, 1928).

58. **Lecidea scalaris** (Ach.) Ach. Meth. Lich. 78. 1803. *Lichen scalaris* Ach. Kgl. Vet. Akad. Nya Handl. 127, tab. 5, f. 2. 1795.

Material seen — NASSAU COUNTY: *Brodo 3508* (10). SUFFOLK COUNTY: 19 specimens collected by Brodo and/or Imshaug.

As with *L. anthrocophila*, this species is treated under *Psora* by Fink (1935).

*Lecidea scalaris* has a high specificity for the bark of *Pinus rigida* but is not restricted to it (figure 43). Barkman (1958, p. 38) and Lowe (1939) state that the species is commonly found on burned wood, and this is certainly true on Long Island where it is often found on charred pine bark (see p. 45). *Acer saccharinum* and *Acer rubrum* were the preferred substrates in an area in central New York (Brodo, 1959). The reasons for these preferences are not clear, although all the substrates are highly acid. Ochsner (1928 in Barkman, 1958 p. 102) stated that *L. scalaris* is nitrophobus, but this is yet to be proven.

Distribution — Central New York, North Carolina, Arizona, Black Hills, Washington, Saskatchewan: Temperate element, North Temperate subelement (?); Europe; Asia (Lowe, 1939).

59. **Lecidea uliginosa** (Schrad.) Ach. Meth. Lich. 43. 1803. *Lichen uliginosus* Schrad. Spic. Fl. Germ. 1: 88. 1794.

Material seen — SUFFOLK COUNTY: 22 specimens collected by Imshaug and/or Brodo.

Laundon (1960) discusses in detail the similarities of this species with *Lecidea oligotropha* Laund. The latter is mainly characterized by its coarsely granulose to verruculose, pale brown to yellowish thallus. In contrast, *L. uliginosa* has a finely granular to almost leprose dark brown to black thallus. Only one North American specimen of *L. oligotropha* (from Minnesota) is cited by Laundon.

*Lecidea uliginosa* often forms conspicuous tar-like patches on partially stabilized sand. Closer examination will reveal tiny black apothecia scattered among the dark brown thalline granules. Alvin (1960) reported the species as occurring in dune communities in southern England, especially in the heath, ecologically very similar to some Long Island habitats.

Distribution — Nova Scotia, Connecticut, Michigan, Indiana, Minnesota, Black Hills; throughout United States (Fink, 1935); Temperate element, North Temperate subelement(?); Europe; Asia (Vainio, 1928).

60. **Lecidea varians** Ach. Syn. Meth. Lich. 38. 1814.

Material seen — SUFFOLK COUNTY: 37 specimens collected by Imshaug and/or Brodo; East Marion, *Latham 11* (*22249*), May 3, 1914 (Latham); Greenport, *Latham 3984,* April 1, 1927 (Latham); Orient, *Latham 70,* May 30, 1914 (Latham).

This species occurs on the bark of various trees from completely exposed dune areas to protected oak forests (figure 50).

Distribution — Nova Scotia, Connecticut, Michigan, Minnesota, Washington, Manitoba; throughout the United States (Fink, 1935); France (Acharius, 1814).

61. **Lecidea vernalis** (L.) Ach. Meth. Lich. 68. 1803. *Lichen vernalis* L. Syst. Nat. 3: 234. 1768.

Material seen — SUFFOLK COUNTY: *Imshaug 25752* (132), *Brodo 816* (55), *851* (47), *2649* (61); Greenport, *Latham 1998* (22247), February 27, 1927 (Latham); Greenport, *Latham 22254,* May 14, 1914 (Latham); Greenport, *Latham,* March 1, 1923 (Latham).

This species is distinguished by its strongly convex, pale apothecia and its fusiform, occasionally one-septate spores. It is not common on Long Island, but where it occurs, it often covers large portions of the tree trunk. It is found on the bark of various trees, particularly in rain tracks or in other equally moist or humid microhabitats. Outside of Long Island, the species is known to occur over moss.

Distribution — Nova Scotia, Connecticut, Michigan, Wisconsin, Minnesota, Arizona, Alaska, Manitoba, Baffin Island: Arctic-boreal element; circumboreal.

62. **Lecidea viridescens** (Schrad. in Gmel.) Ach. Meth. Lich. 62. 1803. *Lichen viridescens* Schrad. in Gmel. Syst. Nat. 2(2): 1361. 1791.

Material seen — SUFFOLK COUNTY: *Brodo 3016* (17).

This rare species was found growing over rotting wood. It somewhat resembles a *Lepraria* in its granulose, effuse thallus.

Distribution — Michigan, Minnesota, Arizona, Alaska; Eastern United States and California (Fink, 1935): Temperate element, North Temperate subelement; Europe; Asia (Vainio, 1928).

### 29. CATILLARIA (Ach.) Th. Fr.

63. **Catillaria glauconigrans** (Tuck.) Hasse, Bryol. 12:102. 1909. *Biatora glauconigrans* Tuck. Proc. Amer. Acad. Arts. Sci. 12: 179. 1877.

Material seen — SUFFOLK COUNTY: *Brodo 59-272* (53), *2549B* (73).

This species, rare on Long Island, was found only on pine bark. Nearing (1947) stated that it is an oak- and pine-dwelling lichen. It is therefore surprising and noteworthy that Thomson (1951) reported the species as growing on the bark of aspens (*Populus tremuloides*). This substrate usually bears a typically neutrophytic community of *Caloplaca* spp., *Physcia* spp., and *Xanthoria* spp., quite opposite from the communities on highly acid conifer bark.

Distribution — Massachusetts and California (Fink, 1935), New York (Nearing, 1947), Michigan, Arizona, Manitoba: Temperate element, North Temperate subelement; endemic.

### 30. BACIDIA De Not.

64. **Bacidia atrogrisea** (Del. in Hepp) Körb. Parerg. Lich. 133. 1860. *Biatora atrogrisea* Del. in Hepp, Flecht. Europ. 26. 1853.

Material seen — SUFFOLK COUNTY: Orient, *Latham 84B*, May 10, 1914 (Latham); Orient, *Latham 791*, April 5, 1914 (Latham); Orient, *Latham*, May 6, 1915, (Latham); Orient, *Latham*, April 10, 1921 (Latham).

Erichsen (1957) listed *B. atrogrisea* as a form of *B. endoleuca* (Nyl.) Kickx. Accepting this synonomy, *atrogrisea* must be regarded as the proper name for the species since it is older on the species level. Nylander was the first to use *endoleuca* as a species (*Lecidea endoleuca* Nyl. Acta Soc. Sci. Fenn. 7:460. 1863.)

*Bacidia luteola* (Schrad.) Mudd (syn. *B. rubella* [Hoffm.] Mass.) and *B. fuscorubella* (Hoffm.) Bausch. can sometimes be confused with *B. atrogrisea*. *Bacidia luteola* is distinguished by its uniformly pale to dark brown or reddish apothecia with no pruina, often becoming very convex to hemispherical. *Bacidia fuscorubella* differs in having red-brown to almost black apothecia, often with conspicuous white pruinose margins. Both these species have thicker thalli than *B. atrogrisea*. The Long Island material agrees very well with the Migula exsiccat, Krypt. Germ. no. 52.

The species is usually found on the bark of various coniferous trees. Thomson (1951) reported it from Michigan on *Thuja* bark.

Distribution — Connecticut, Michigan; Eastern United States (Fink, 1935): Temperate element, East Temperate subelement; Europe; Asia (Ikoma, 1957).

65. **Bacidia chlorantha** (Tuck.) Fink, Cont. U. S. Nat. Herb. 14: 91. 1910. *Biatora chlorantha* Tuck. Proc. Amer. Acad. Arts Sci. 1:252. 1847. (Syn. Lich. New Engl. 60. 1848.)

Material seen — NASSAU COUNTY: *Brodo 569* (11). SUFFOLK COUNTY: *Brodo 2001* (51), *2394* (113), *2647* (61), *3437* (sterile) (134), *3446* (134), *3831* (sterile) (66).

Lamb (1954) presented a description and a discussion of this species and Thomson (1951) compared it with *B. chlorococca*, with which it is sometimes confused. The Long Island material agrees well with Lamb's description of the specimens from Nova Scotia.

This species is often found sterile, but with many clusters of minute brown pycnidia containing pycnoconidia measuring 1.2 x 0.5 μ. It is found on the bark of various species of deciduous and coniferous trees.

Distribution — Nova Scotia, Connecticut, Smoky Mountains of North Carolina and Tennessee, Michigan; New England, New York, Ohio, Illinois, Minnesota (Fink, 1935): Temperate element, Appalachian subelement, Appalachian-Great Lakes unit; endemic.

66. **Bacidia chlorococca** (Graewe in Stizenb.) Lett. Hedw. 52: 131. 1912. *Lecidea chlorococca* Graewe in Stizenb. Nova Acta Acad. Leop. Carol. 34 (2): 24. 1867.

Material seen — NASSAU COUNTY: *Brodo 536* (16), *555* (12), *568* (11), *1308* (15). SUFFOLK COUNTY: 75 specimens collected by Imshaug and/or Brodo; Riverhead, *Latham,* May 1, 1960 (Latham).

Degelius (1940) described the spores of his material from Maine as slightly smaller than those of typical European specimens, although the specimens from Long Island fit the spore size of the European material well.

The species is found on a variety of substrates, including twigs and bark of coniferous and deciduous trees as well as old wood. It is found in exposed and shaded localities.

Distribution — Maine, central New York, North Carolina, Michigan, Wisconsin: Temperate element, Appalachian subelement, Appalachian-Great Lakes unit; Europe.

67. **Bacidia chlorosticta** (Tuck.) Schneid. Guide Study Lich. 109. 1898. *Lecidea chlorosticta* Tuck. Proc. Amer. Acad. Arts Sci. 5: 419. 1862.

Material seen — SUFFOLK COUNTY: *Brodo 2097* (78); Riverhead, *Latham 2380,* June 24, 1924 (Latham).

This rare species is distinctive in many ways. Its paraphyses appear to be branched, giving the apothecium an ascolocular appearance, but the olivaceous, minutely verruculose to subgranulose thallus, the large-celled Trebouxioid phycobiont, and the lack of thick-walled asci all are characteristic of *Bacidia* and not *Micarea.* The apothecia are small, lead black, and convex, with the margin disappearing. They are sessile or buried in the granular crust, or sometimes they become more or less stipitate. The hypothecium is dark brown, becoming sordid blackish violet below and olivaceous above in KOH. The margins are reddish violet in KOH.

The species is apparently restricted to *Chamaecyparis thyoides,* at least in the coastal plain region. Three specimens (*Brodo 3676, 3765, 3768*) were collected in southern New Jersey on white cedar in cedar bogs just as they were on Long Island.

Distribution — Connecticut; Massachusetts, South Carolina, Illinois (Fink, 1935); New Jersey (cf. above): Temperate element, Coastal Plain subelement; endemic.

68. **Bacidia intermedia** (Hepp in Stizenb.) Arn. Flora 54: 54. 1871. non Hampe in Mass. *Biatora anomala* var. *intermedia* Hepp in Stizenb. Nova Acta Acad. Leopold. — Carolin. 30 (3): 42. 1863.

Material seen — SUFFOLK COUNTY: *Brodo 3209* (33); Orient, *Latham 84,* May 10, 1914 (Latham).

It seems clear from published descriptions that the Long Island material belongs to what Tuckerman (1888, sub *Biatora*), Fink (1935), and Erichsen (1957) have called *Bacidia effusa* (Sm. in Sm. & Sowerby) Trev. However, there are a number of problems involved in the use of the name *B. effusa*. First, the epithet *effusa* cannot be used for any *Bacidia* since its basionym, *Lichen effusus* Sm. in Sm. & Sowerby (1808), is a later homonym of *Lichen effusus* Ach. (1798), a synonym of *Lecanora saligna* (Schrad.) Zahlbr. (see Recommendation 72A, Lanjouw, 1961). Secondly, *Lichen effusus* Sm. in Sm. & Sowerby is listed as a synonym of *Bacidia arceutina* (Ach.) "Arn." by Vainio (1922). The latter species as described by Vainio differ in many respects from the Long Island specimens. These Long Island specimens do fit Vainio's description of *Bacidia intermedia* ("Hepp") Arn. and they agree almost perfectly with the Rabenhorst exsiccat no. 509 (distributed as *Bacidia effusa*) cited by Vainio as typical *B. intermedia.* Still another name which must be considered is *Bacidia albescens* (Hepp) Zwack., which some authors (e.g., Arnold, 1884) considered as including *intermedia* as only a form with flatter, larger apothecia. Erichsen (1957) used all four names (*B. effusa, B. arceutina, B. intermedia* and *B. albescens*) as separate species distinguishing them as follows:

1. Apothecia at first light, darker in age, never black; spores mostly 20-50 μ long . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
1. Apothecia soon or from the beginning dark to black; spores mostly 40-60 μ long (but f. *brevispora* is 25-39 μ long) . . . . . . . . *B. arceutina*
    2. Apothecia whitish, flesh colored, or rose . . . . . . . . . . . . . . . . . . . 3
    2. Apothecia light brown, brick red, darker in age . . . . . . . . . *B. effusa*
3. Hymenium 50-60 μ high; spores 34-48 μ long[12]; apothecia remaining flat. 0-3-0.4(0.6) mm in diameter . . . . . . . . . . . . . . . . . *B. intermedia*
3. Hymenium 35-50 μ high; spores 20-33 μ long; apothecia first flat, then soon convex and marginless, 0.2-0.4 mm in diameter . . . . *B. albescens*

Fink (1935) did not use *B. intermedia.* He separated *B. arceutina, B. effusa* and *B. albescens* as follows:

1. Spores rarely more than 40 μ in length . . . . . . . . . . . . . . . . . . . . . . . 2
1. Spores rarely less than 40 μ in length (35-50 μ). Hypothecium yellowish; disks pale light brown to blackish . . . . . . . . . . . . . . . *B. arceutina*
    2. Hypothecium hyaline; apothecia not more than 0.5 mm across; disk light pink to pale reddish . . . . . . . . . . . . . . . . . . . . . . . *B. albescens*
    2. Hypothecium pale yellowish; apothecia small, 0.4-0.8 mm across; disk pale flesh colored to reddish brown . . . . . . . . . . . . . *B. effusa*

It appears that *Bacidia effusa* sensu Fink and Erichsen is probably synonymous with Vainio's *B. intermedia*, and *intermedia* is in all likelihood merely a form of *B. albescens.* Since I have not yet seen any authentic material of *B. albescens*, Vainio's interpretation is followed at this time. Unfortunately, the epithet *intermedia* on the species level (Arnold, 1871) is preempted by *Bacidia intermedia* Hampe in Mass. (1861), and

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[12] Based on Vainio (1922), which in turn is based on a single specimen.

therefore is invalid. Until further studies are done to determine the correct name for this taxon, however, *B. intermedia* (Hepp in Stizenb.) Arn. will be used.

Distribution — Massachusetts, Iowa, California (Fink, 1935, sub *B. effusa*); Europe; Asia (Vainio, 1928, sub *B. intermedia*).

69. **Bacidia inundata** (Fr.) Körb. Syst. Lich. Germ. 187. 1855. *Biatora inundata* Fr. Kgl. Vet. Akad. Nya Handl. 270. 1822.

Material seen — SUFFOLK COUNTY: *Brodo 761* (67), *3917* (54).

This species is usually found on siliceous rocks in or near a stream or brooks (Hale, 1950; Thomson, 1951), but the Long Island specimens were collected in comparatively dry habitats on concrete. One (no. *761*) was growing on a concrete foundation within a few feet of a swampy brook, and the other was collected in a shaded oak woods, on an old concrete foundation. However, Sandstede (1913) reported *B. inundata* from brick walls and Fink (1902) listed the species from limestone bluffs in Minnesota. Tuckerman (1888) stated that *B. inundata* is found "on various rocks, especially such as contain lime; as also on brick; . . ."

Distribution — Connecticut, Michigan, Minnesota, Indiana, Black Hills; East of Rocky Mountains (Fink, 1935): Temperate element, East Temperate subelement; Europe.

70. **Bacidia schweinitzii** (Tuck. in W. Darl.) Schneid. Guide Study Lich. 110. 1898. *Biatora schweinitzii* Tuck. in W. Darl. Fl. Cestr. ed. 3. 447. 1853.

Material seen — SUFFOLK COUNTY: *Brodo 2121* (102), *2157* (102); *2802* (102).

This species is unique among the *Bacidiae* in having *Trentepohlia* as a phycobiont rather than *Trebouxia*. Lamb (1954) discusses this fact and some other aspects of the history of the species.

*Bacidia schweinitzii* was found in only one locality, as a member of the *Acer rubrum*-bog community. It was also found in southern New Jersey (Burlington County, Atsion, *Brodo 3558*) on a roadside oak close to a bog.

Distribution — Nova Scotia, Maine, Connecticut, Tennessee, North Carolina, Oklahoma, Michigan, Indiana, Minnesota; eastern United States (Fink, 1935): Temperate element, East Temperate subelement; endemic.

71. **Bacidia** cfr. **trisepta** (Naegeli in Müll. Arg.) Zahlbr. in Engler-Prantl, Nat. Pflanzenf. 1(1):135. 1907. *Lecidea trisepta* Naegeli in Müll. Arg. Mem. Soc. Phys. Hist. Nat. Genève 16: 403. 1862.

Material seen — SUFFOLK COUNTY: *Brodo 2337* (44); Greenport, *Latham 38166A*, July 14, 1963 (Latham); Greenport, *Latham 38196A*, April 15, 1965 (Latham).

*Bacidia trisepta*, except for f. *saxicola* (Körb.) Lettau, is mainly known from lignum and bark. The ascocarps appeared to be ascolocular in the Long Island specimen. Since I have not examined the type and the

Long Island material was questionable, I will not transfer the species into *Micarea* where it might very well belong.

The specimens were all collected on shaded granitic rock.

Distribution — Massachusetts (Fink, 1935); Black Hills; Europe.

72. **Bacidia umbrina** (Ach.) Bausch, Verh. Nat. Ver. Carls. 4:103. 1869. *Lecidea umbrina* Ach. Lich. Univ. 183. 1810.

Material seen — SUFFOLK COUNTY: *Brodo 2738* (111).

The distinctive twisted and curved spores of this species easily separate it from all other *Bacidiae* on Long Island. Accurate measurements of the spore length were difficult due to the strong curvature of the spores, and the values appear to be somewhat lower than those reported by Hillman & Grummann (1957) or Erichsen (1957) (15-20 $\mu$ rather than 17-40 $\mu$ in length).

The ecology of the specimen found on Long Island was extremely unusual for the species. It was found in the hygrohaline stratum on a granite boulder above the littoral zone but well within the storm tidal level, and certainly exposed to salt spray in windy weather. Growing alongside the specimen was *Acarospora fuscata* (p. 61).

Distribution — Maine, Connecticut, Tennessee, Minnesota; northern United States (Fink, 1935): Temperate element, North Temperate subelement; Europe.

## 31. RHIZOCARPON Ram.

73. **Rhizocarpon cinereovirens** (Müll. Arg.) Vain. Acta Soc. Faun. Fl. Fenn. 53 (1): 336. 1922. *Patellaria cinereovirens* Müll. Arg. Flora 51: 49. 1868.

Material seen — SUFFOLK COUNTY: *Brodo 2173* (99), *3265* (119), *3899* (112).

The very lightly tinted or hyaline 1-septate spores of this species give it the appearance of a saxicolous *Catillaria* or a light-spored *Buellia* (especially *B. stigmaea*). However, gelatinous episporic sheaths are usually conspicuous, indicating its true position.

Runemark (1956) identified both norstictic and stictic acids from *R. cinereovirens* by chromatographic analysis. The presence of norstictic acid in the medulla, an unusual feature among the Catocarpons, was detected in two of the Long Island specimens. The third specimen (*Brodo 3899*) was KOH + yellow; chromatography showed the presence of stictic acid, but not norstictic acid. Unfortunately, the Long Island material was too scanty to enable a more thorough chemical analysis. However, the presence of stictic and norstictic acids together is by no means uncommon (cfr. *Parmelia conspersa, P. hypotropa*, etc.).

Distribution — Black Hills; Minnesota (Fink, 1935); Europe.

74. **Rhizocarpon grande** (Flörke in Flot.) Arn. Flora 54: 149. 1871. *Lecidea petraea* var. *fuscoatra* f. *grandis* Flörke in Flot. Flora 11: 690. 1828.

Material seen — SUFFOLK COUNTY: *Brodo 3850* (76).

*Rhizocarpon grande* was discussed at length by Degelius (1940, 1941). Degelius (1940) mentioned the KOH + yellow to testaceous reaction of the medulla as well as the C + red reaction. The substances responsible for these reactions were identified by Runemark (1956) as stictic and gyrophoric acids. Stictic acid was found in the Long Island specimen (paper chromatography), and the C + red reaction indicates that gyrophoric acid is probably present as well.

The specimen was found on an exposed granite boulder.

Distribution — Maine, Tennessee, Michigan, Minnesota, Idaho, Black Hills, Washington, Saskatchewan, Manitoba, Baffin Island: Arctic-boreal element; circumboreal.

75. **Rhizocarpon intermedium** Degel. Ark. Bot. 3OA (3): 43. 1941.

Material seen — SUFFOLK COUNTY: *Brodo 1903* (114), *2662a* (108), *3271* (119).

The Long Island specimen agreed perfectly with the type material (US). The type specimen contained stictic acid (by chromatography), as did the Long Island material (except one poorly-developed specimen). I also collected the species on Cape Cod (Massachusetts) (*Brodo 3947, 4201, 4207a*).

Distribution — Tennessee, Massachusetts (see above); endemic.

76. **Rhizocarpon obscuratum** (Ach.) Mass. Ricerch. Auton. Lich. 103. 1852. *Lecidea petraea* $\gamma$ *L. obscurata* Ach. Lich. Univ. 156. 1810.

Material seen — SUFFOLK COUNTY: *Imshaug 25599* (52), *Brodo 946* (53), *1753* (126), *1967* (91), *2340* (44), *2719a* (111), *2740* (111), *3078c* (128), *3285* (119), *3902* (112); Orient, *Latham 7413,* May 1, 1933 (Latham); Quogue, *Latham 28254B* (Latham); Shinnecock, *Latham 27288,* May 8, 1945 (Latham).

This species is apparently extremely variable, with many forms having been described for it (Erichsen [1957] included ten). Of the many forms, f. *reductum* (Th. Fr.) Eitn. seems to be most common on Long Island. This form is distinguished by a "more granulose thallus, smaller apothecia with thinner and disappearing margin, indistinctly papillated disk and submurale (not murale) spores" (Degelius, 1940). All Long Island specimens lacked any clearly positive chemical tests, although Runemark (1956) reported both stictic and gyrophoric acids from a specimen which he tested.

*Rhizocarpon orphninum* (Vain.) Zahlbr. is very similar to *R. obscuratum* but differs in having a KOH + violet or magenta reaction in the exciple and epithecium (Laundon, 1960).

*Rhizocarpon obscuratum* is common on pebbles and small stones and is often associated with *Lecidea erratica.*

Distribution — Maine, Minnesota (Fink, 1935); Nova Scotia, Connecticut, Tennessee, Saskatchewan; Greenland (Lynge, 1940c); Europe; Asia (Lynge, 1928)

77. **Rhizocarpon plicatile** (Leight.) A. L. Sm. Monogr. Brit. Lich. 2: 197. 1911. *Lecidea plicatilis* Leight. Ann. Mag. Nat. Hist. IV. 4: 201. 1869.

Material seen — SUFFOLK COUNTY: *Brodo 2336* (44), *3076* (128).

*Rhizocarpon plicatile* was found on well-illuminated or partially shaded boulders. I have collected specimens from the Adirondack Mountains of New York.

Distribution — Nova Scotia, Maine, northern New York (see above), North Carolina; Europe.

## STEREOCAULACEAE

### 32. PYCNOTHELIA (Ach.) Duf.

78. **Pycnothelia papillaria** (Ehrh.) Duf. Ann. Gen. Sci. Phys. Brux. 8: 5. 1817. *Lichen papillaria* Ehrh. Phytophyl. no. 100. 1780.

Material seen — NASSAU COUNTY: *Brodo 3345* (8); Plain Edge, *S. Cain 371, 372,* 1936, *Andropogonetum Hemsteadi* (NY). SUFFOLK COUNTY: *Brodo 59-177* (100B), *1177* (101), *1559* (103), *1682* (88), *1750* (126), *1752* (126), *1980* (91), *2015* (51), *2533* (49), *3005* (17), *841* (55); 16 specimens collected by Latham (Latham); Orient, *Booth,* August, 1877 (FH); Orient, *Latham 13,* V. 1914 (FH); Orient Point, *Latham,* 1927 (NY); Montauk Point, *R. H. Torrey,* 1933 (NY); Selden, *S. Cain 348, 359, 360,* 1936 (NY); Coram, *R. H. Torrey,* 1936 (NY); Calverton, *R. H. Torrey,* 1936 (NY); East of Calverton, *R. H. Torrey,* 1936 (NY); Route 112, north of Coram, *R. H. Torrey,* 1936 (NY).

The important characters which separate *Pycnothelia* from *Cladonia;* e.g. pseudopodetia rather than podetia (see Lamb, 1951), and septate spores rather than nonseptate spores, have for some reason been ignored in the recent past by most workers, with the notable exception of Watson (1953) and Mattick (1938). However, even Mattick (1940) later chose to regard *Pycnothelia* as part of *Cladonia* "for practical reasons." Hale and Culberson (1966) recognized the genus in their new checklist.

*Pycnothelia papillaria* seems to be narrowly restricted to well-illuminated localities on eroding sandy loam (p. 56; figure 73).

Distribution — Temperate element, East Temperate subelement: Europe (map: Sandstede, 1932).

### 33. STEREOCAULON Hoffm.

79. **Stereocaulon saxatile** Magn. Göteb. Kgl. Vet. Samh. Handl. IV. 30: 41. 1926.

Material seen — SUFFOLK COUNTY: *Brodo 3852* (76); (locality unknown), *Latham 38187* (No. 7), April 1924 (Latham).

Lobaric acid and atranorin were demonstrated by recrystallization in GAW and GAoT, respectively, in the Long Island and Cape Cod specimens. These chemical constituents were reported for this species by Lamb (1951) and Ramaut (1962).

The epithet *evolutoides* was published as a variety of *S. paschale* by Magnusson in 1926 and was first used on the species level by Frey in

1932. It is necessary, therefore, to refer to this species as *S. saxatile,* although most recent authors treat *saxatile* as a variety of *evolutoides.*

A specimen of this species in much better condition than the Long Island material was found on Cape Cod (East Dennis, *Brodo 4467*). Both specimens were growing on granite boulders, the former in partial shade and the latter in full sun.

Distribution — Nova Scotia, Massachusetts, Ontario, Saskatchewan: Temperate element, North Temperate subelement(?) (see Ahti, 1964); Europe. Listed as an "amphiatlantic, boreal" species by Lamb (1951).

## BAEOMYCETACEAE

### 34. BAEOMYCES Pers.

80. **Baeomyces roseus** Pers. Neue Ann. Bot. 1: 19. 1794.

Material seen — NASSAU COUNTY: *Brodo 59-114* (12), *2526* (5). SUFFOLK COUNTY: *Imshaug 25560* (52), *25583* (52), *25688* (72); *Brodo 59-179* (54), *830* (55), *836* (55), *975* (63), *1274* (31), *1223* (100A), *1686* (88), *1984* (91), *2003* (51), *2987* (26), *3081* (128), *3342* (76); 13 specimens collected by Latham (Latham); Wildwood State Park, *S. Smith 12669,* October 17, 1952 (NYS).

This species is usually found on eroding sandy loam, especially on the moraines (figure 53), and is often associated with *Pycnothelia papillaria.*

Distribution — Nova Scotia, Maine, Massachusetts, Connecticut, Tennessee; Appalachian-Great Lakes distribution (Hale, 1961a): Temperate element, Appalachian subelement, Appalachian-Great Lakes subelement (?); Europe, Asia (circumboreal: Sandstede, 1932).

## CLADONIACEAE

### 35. CLADONIA Wigg.

Subgenus *Cladonia*
Section CLAUSAE Körb
Subsection *Cocciferae* Del.
Series *Subglaucescentes* Vain.

81. **Cladonia floerkeana** (Fr.) Flörke, Clad. Comm. 99. 1828. *Cenomyce floerkeana* Fr. Lich. Suec. Exs. 82. 1824.

Material seen — SUFFOLK COUNTY: *Brodo 59-161* (83), *2076* (38), *2996* (17), *3426* (134); Southold, *Latham 7573* (+ *7581,* + *7588,* + *7590*), January 3, 1934 (Latham).

This species is found on the ground in open sandy or grassy fields.

Distribution — Vermont,[13] Massachusetts, Connecticut, New Jersey, Tennessee, Michigan: Temperate element, East Temperate subelement(?); Europe; Asia.

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[13] In addition to those locality references given on page 112, the following references pertain to *Cladonia*: Vermont (Evans, 1947), Connecticut (Evans, 1930, 1944), New Jersey (Evans, 1935), Tennessee (Mozingo, 1961), Michigan (Evans, unpublished key to the *Cladoniae* of Michigan). References to presence in Asia are based an Asahina (1950) unless otherwise stated.

82. **Cladonia bacillaris** (Ach.) Nyl. Bot. Sällsk. Faun. Fl. Fenn. Förh. 8: 179. 1866. *Baeomyces bacillaris* Ach. Meth. Lich. 329. 1803.

Material seen — KINGS COUNTY: New Lots, *G. B. Brainerd,* 1860's? (BKL 031984). NASSAU COUNTY: *Brodo 550A* (12), *1500* (9), *1506* (14). SUFFOLK COUNTY: 112 specimens collected by Imshaug and/or Brodo; 39 specimens collected by Latham (Latham); Orient, *Latham 209,* May 10, 1914 (FH); Barling Hollow (= Baiting Hollow?), *R. H. Torrey,* 1934 (NY); Holtsville, *R. H. Torrey,* 1936 (NY); Southold, *R. H. Torrey,* 1937 (NY); Wyandanch Club Game Reserve south of Smithtown, *R. H. Torrey,* 1937 (NY); E. of Greenport, *S. Smith 17855,* March 13, 1955 (NYS).

*Cladonia bacillaris* is one of the most common lichens on Long Island. The species is very variable, having numerous sterile and fertile forms. Red apothecia are present on approximately 50 percent of the specimens and appear either as conspicuous hemispherical terminal caps or mere dots of red at the podetial summits. The podetia either taper very gradually to a point, are almost entirely uniform in diameter, or are distinctly clavate.

The species is found on a variety of substrates, including soil, tree bases, and rotten wood, but it is found most frequently on wood.

Distribution — Vermont, Massachusetts, Connecticut, New Jersey, Michigan, Indiana, Minnesota, Oklahoma, Arizona, Black Hills, Washington, Alaska, Saskatchewan, Manitoba, Ontario: Temperate element, North Temperate subelement; Europe, Asia.

83. **Cladonia macilenta** Hoffm. Deutschl. Fl. 2: 126. 1796.

Material seen — SUFFOLK COUNTY: 16 specimens collected by Imshaug and/or Brodo; Montauk, Hither beach, *Latham 24001, 24023,* October 28, 1945 (Latham); Amagansett, *Latham 25991,* March 11, 1947 (Latham); Greenport, *Latham 27479,* April 30, 1950 (Latham); Flanders, *Latham 24775,* April 8, 1946 (Latham); Riverhead, *Latham 33321,* February 6, 1953 (Latham); East Marion, *Latham,* September 1, 1947 (Latham); Riverhead, *Latham,* May 16, 1960 (Latham); Orient, *Latham 215,* May 23, 1914 (FH); Orient, *Latham 209,* May 10, 1914 (FH).

*Cladonia macilenta* closely resembles *C. bacillaris,* the two being best separated by their chemistry: *C. macilenta* has thamnolic acid and *C. bacillaris* does not. Although *C. macilenta,* like *C. bacillaris,* is found on many different substrates, it is usually found on sandy soil.

Distribution — Vermont, Massachusetts, Connecticut, New Jersey, Tennessee, North Carolina, Michigan, Ontario, Minnesota, Black Hills, Washington, coastal Alaska: Temperate element, North Temperate subelement (?); Europe; Asia.

84. **Cladonia vulcanica** Zoll. Natur-et Geneeekundig Arch. Neêrl. Indie 1: 396. 1847.

Material seen — SUFFOLK COUNTY: *Imshaug 25821* (86), *25826* (86); *Brodo 2142* (102), *2150* (102); Northwest, *Latham*

*27458,* April 12, 1948 (Latham); Flanders, *Latham 24762,* April 8, 1946 (Latham); Riverhead, *Latham 32871,* April 18, 1955 (Latham); North Sea, *Latham 32317, 35349,* March 26, 1954 (Latham); Riverhead, *Latham,* May 2, 1957 (Latham); Riverhead, *Latham,* May 16, 1960 (Latham).

The presence of thamnolic acid in *C. vulcanica* distinguishes this species from the very similar *C. didyma.* Both species are found on rotting logs in bogs (figure 36). It is interesting that *C. vulcanica* was found to be abundant in the white cedar bogs of Cape Cod, but was never collected in my studies of similar bogs in southern New Jersey. Exactly the reverse was true of *C. didyma.*

Distribution — South America, and from New Jersey to Florida (Evans, 1952): Tropical element, Coastal Plain subelement; Asia.

85. **Cladonia didyma** (Fée) Vain. Acta Soc. Faun. Fl. Fenn. 4: 137. 1887. *Scyphophorous didymus* Fée, Essai Crypt. Ecorc. Off. 98 and 101, pl. 3, f. 13, 1824.

Material seen — SUFFOLK COUNTY: *Brodo 2106B* (86), *2132* (102); Montauk, Hither Beach, *Latham 24018,* October 28, 1945 (Latham); Riverhead, *Latham 29580,* August 7, 1950 (Latham); Riverhead, *Latham (36865)*?, May 16, 1960 (Latham); Northwest, *Latham 26436,* April 10, 1947 (Latham).

A discussion of some aspects of the ecology and taxonomy of this species can be found with the comments on *C. vulcanica.*

Distribution — Connecticut to Florida along the coast: Tropical element, Coastal Plain subelement; much of South America, Africa, Hawaii, Ceylon, Japan (map: Sandstede, 1932), but not listed from Japan by Asahina (1950).

### Series *Stramineoflavidae* Vain.

86. **Cladonia incrassata** Flörke, Clad. Comm. 21. 1828.

Material seen — NASSAU COUNTY: *Brodo 59-113* (12), *562* (13), *564* (11), *3512* (10). SUFFOLK COUNTY: 29 specimens collected by Imshaug and/or Brodo; 39 specimens collected by Latham (Latham).

This species is narrowly restricted to rotting wood and to pine bases. As in *Cladonia cristatella,* if podetia are produced, they are always capped by large red apothecia.

Distribution — Along the coast from Nova Scotia to Florida (Evans, 1952): Temperate element, Coastal Plain subelement; Europe; Asia.

87. **Cladonia cristatella** Tuck. Amer. Sci. 25: 428. 1858.

Material seen — KINGS COUNTY: Gowanus, *G. B. Brainerd,* (1866?), on ground (BKL). NASSAU COUNTY: *Brodo 538* (16), *544* (12), *1305* (15), *1504* (14), *3193* (6), *3347* (8), *3496* (4). SUFFOLK COUNTY: 93 specimens collected by Imshaug and/or Brodo; 61 specimens collected by Latham (Latham); Orient Point, *Latham,* November 6, 1911 (NYS); near Orient, *Latham 17,* 1914 (FH); near Orient, *Latham 27,* 1914 (FH); ?, *Latham 15,* 1914 (FH); Orient, *Latham 191,* May 20, 1914 (FH); East of Calverton, *R. H. Torrey,* 1936 (NY); Holtsville, *R. H. Torrey,* 1937 (NY); Pikes Beach, Westhampton, *R. H. Torrey,* 1936 (NY); Selden, *R. H. Torrey,* 1936 (NY); Selden, *S. Cain 349,* 1936 (NY); 2.3 miles SW of Riverhead, *S. Smith 11850, 11851, 11849,* August 14, 1952 (NYS).

*Cladonia cristatella* is common and widespread on Long Island, occurring on a variety of substrates in a multitude of forms (p. 110).

Distribution — Eastern United States (Sandstede, 1939): Temperate element, East Temperate subelement; endemic.

88. **Cladonia deformis** (L.) Hoffm. Deutschl. Fl. 2: 120. 1796. *Lichen deformis* L. Sp. Pl. 1152. 1753.

Material seen — SUFFOLK COUNTY: Montauk Point, *R. H. Torrey,* 1933 (NY).

This species, found only once on Long Island, is very similar to *C. pleurota,* differing in having farinose soredia and podetial cups which are often lacerate and have involute margins.

Distribution — Vermont, Massachusetts, Connecticut, Michigan, Ontario, Minnesota, Black Hills, Washington, Alaska, Saskatchewan, Manitoba, Canadian East Arctic: Arctic-boreal element; circumboreal.

89. **Cladonia pleurota** (Flörke) Schaer. Enum. Crit. Lich. Eur. 186. 1850. *Capitularia pleurota* Flörke, Mag. Ges. naturf. Freunde, Berlin 2: 218. 1808.

Material seen — NASSAU COUNTY: *Brodo 3344* (8); Massapequa, *S. Cain 35,* June 20, 1935 (NY). SUFFOLK COUNTY: 20 specimens collected by Imshaug and/or Brodo; Riverhead, *Latham 7707,* May 1, 1937 (Latham).

Sterile podetia of *C. pleurota* bear many resemblances to sterile *C. chlorophaea,* and the two are often found together on various types of soil. The yellow color of *C. pleurota* (due to usnic acid) distinguishes the two in the field. In addition, Long Island material of *C. chlorophaea* almost always can be shown to contain grayanic acid which is absent in *C. pleurota.* Its similarity to *C. deformis* has already been mentioned.

*Cladonia pleurota* grows well on eroded, sandy loam as well as on mossy soil and so has a broad distribution over both moraines (figure 56). It is also occasionally found on tree bases.

Distribution — Nova Scotia, Vermont, Massachusetts, Connecticut, New Jersey, Michigan, Ontario, Black Hills, Alaska, Manitoba, Canadian East Arctic: Arctic-boreal element; Europe; Asia; "hemiarctic" (Ahti, 1964).

### Subsection *Ochroleucae* Fr.

90. **Cladonia carneola** (Fr.) Fr. Lich. Eur. 233. 1831. *Cenomyce carneola* Fr. Sched. Crit. 4: 23. 1825.

Material seen — SUFFOLK COUNTY: *Brodo 2693* (110); Montauk, *R. H. Torrey,* 1933 (NY).

The presence of barbatic acid and farinose rather than granulose soredia are usually sufficient to separate sterile specimens of this rare species from the more common *C. pleurota.* Fertile material is easily distinguished, since the apothecia are brown rather than red.

*Cladonia carneola* is found on well-illuminated eroding soil.

Distribution — Black Hills, Washington, coastal Alaska, British Columbia, Saskatchewan, Manitoba: Arctic-boreal element; circumboreal (Sandstede, 1939; Ahti, 1964).

91. **Cladonia piedmontensis** Merr. Bryologist 27: 22. 1924.

Material seen — NASSAU COUNTY: *Brodo 3352* (8). SUFFOLK COUNTY: *Imshaug 25611* (116), *Brodo 2821* (115); Montauk Point, *R. H. Torrey,* 1933 (NY).

*Cladonia substraminea* Nyl. (p.p.) is listed as a synonym of *C. piedmontensis* by Fink (1935). It is also, in part, a synonym of *C. cristatella* f. *ochrocarpia* Tuck. (Evans, 1930; Fink, 1935). Until the type is examined and the true identity of *C. substraminea* is determined, the name *C. piedmontensis* will be used.

Distribution — Massachusetts and Connecticut southward to Alabama and Mexico (Evans, 1930): Temperate element, Appalachian subelement (?), Appalachian unit (?); endemic.

### Subsection *Foliosae* (Bagl. & Carest.) Vain.

92. **Cladonia robbinsii** Evans, Trans. Conn. Acad. Arts Sci. 35: 611. 1944.

Material seen — SUFFOLK COUNTY: Southold, *Latham 7550* (+ *7581*), January 20, 1934 (Latham); Orient, *Latham 8467,* May 5, 1939 (Latham); Orient, West Long Beach, *Latham 22304, 22309,* December 7, 1944 (Latham); Shinnecock Hills, *Latham 24964,* May 8, 1946 (Latham).

This species bears many similarities to closely related *C. strepsilis,* but differs from the latter in color (dark yellowish green as opposed to olive green) and in chemistry (usnic and barbatic acids present rather than baeomycic acid and strepsilin).

Distribution — Connecticut (Evans, 1944), Tennessee, Black Hills; endemic.

93. **Cladonia strepsilis** (Ach.) Vain. Act. Soc. Faun. Fl. Fenn. 10: 403. 1894. *Baeomyces strepsilis* Ach. Meth. Lich. Suppl. 52. 1803.

Material seen — NASSAU COUNTY: *Brodo 539* (16), *2527* (5), *3350* (8), *3515* (10). SUFFOLK COUNTY: 23 specimens collected by Imshaug and/or Brodo; 17 specimens collected by Latham (Latham); Orient Point, *Latham,* 1927 (NY); Shinnecock Hills, *R. H. Torrey,* 1933 (NY); Rt. 112 north of Coram, *R. H. Torrey,* 1936 (NY).

No other *Cladonia* on Long Island has strepsilin and the accompanying C + green medullary reaction.

This species is fairly common on waste soil and sandy roadbanks; it is occasionally found on mossy soil (figure 72).

Distribution — Eastern United States southward to Mexico (Sandstede, 1939): Temperate element, East Temperate subelement; Europe; Asia.

### Subsection *Podostelides* (Wallr.) Vain.

### Series *Helopodium* (Ach.) Vain.

94. **Cladonia capitata** (Michx.) Spreng. Syst. Veg., ed. 16, 4: 271. 1827. *Helopodium capitatum* Michx. Fl. Bor. Am. 2: 329. 1803.

Material seen — NASSAU COUNTY: Valley Stream, *E. A. Warner,* November 17, 1900 (BKL). SUFFOLK COUNTY: *Imshaug 25556* (52); *Brodo 59-127* (54), *59-188* (54), *59-206* (68), *615* (39), *710A* (65), *748* (53), *943* (59), *1359* (65), *1571* (65), *2167* (99), *2737* (111), *2742* (111), *2485* (23), *3069* (128); 25 specimens collected by Latham (Latham); Orient, *Latham 190,* July 4, 1914 (FH); Greenport, *Latham 5*, 1914 (FH); Coram, *R. H. Torrey*, 1936 (NY).

Fink (1935) listed this species under the name *Cladonia mitrula* Tuck. in W. Darl.

*Cladonia capitata* is most commonly found on tree bases in well-lighted oak forests, but sometimes is found on sandy soil.

Distribution — Eastern United States and Cuba (map: Sandstede, 1938): Temperate element, East Temperate subelement; Europe (Poelt, 1963); Asia.

95. **Cladonia cariosa** (Ach.) Spreng. Syst. Veg. ed. 16, 4: 272. 1827. *Lichen cariosus* Ach. Lich. Suec. Prodr. 198. 1798.

Material seen — SUFFOLK COUNTY: Montauk Point, *R. H. Torrey*, 1933 (NY).

Distribution — Vermont, Connecticut, Tennessee, Michigan, Ontario, Indiana, Minnesota, Black Hills, Arizona, Washington, Alaska, Saskatchewan, Manitoba, Baffin Island: Arctic-boreal element, circumboreal.

96. **Cladonia subcariosa** Nyl. Flora 59: 560. 1876.

Material seen — QUEENS COUNTY: *Brodo 520* (3). NASSAU COUNTY: *Brodo 3190* (6), *3348* (8). SUFFOLK COUNTY: *Imshaug 25619* (116), *25622* (116), *25624* (116), *25625* (116), *25629* (116); *Brodo 59-35* (53), *59-168* (82), *1797* (127), *2073* (38), *4227* (20); 11 specimens collected by Latham (Latham); Southold, *R. H. Torrey,* 1933 (NY); Montauk Point, *R. H. Torrey*, 1933 (NY); ?, *Latham* (*18*?), 1914 (FH).

One can consider *C. subcariosa* the central element of a group of closely related taxa called the *Cladonia subcariosa* group. Members of this group are morphologically almost indistinguishable, but show some differences in distribution and chemistry. Of this group, *C. subcariosa* contains norstictic acid, *C. clavulifera* contains fumarprotocetraric acid, *C. brevis* contains psoromic acid, and *C. polycarpia* contains atranorin. *Cladonia polycarpia,* which is not found on Long Island, is considered synonymous with *C. clavulifera* by Mattick (1940). In this paper, the first three species will be recognized although there is considerable question as to whether they are distinct (Mozingo, 1961). In view of the fact that these species differ little in their morphology, and their chemical components are closely "related" (all being $\beta$-orsellic acid depsides or depsidones with a substantial history of chemical shifting between closely related taxa) it might be better to consider them in an appropriate infraspecific rank. Pending further study of the morphology, chemistry, and phytogeography of members of the *C. subcariosa* complex, the various "microspecies" will be recognized.

*Cladonia subcariosa* is found in dry, sandy or grassy fields.

Distribution — Eastern United States (map: Sandstede, 1938): Temperate element, East Temperate subelement; Europe; Asia.

97. **Cladonia clavulifera** Vain. in Robb. Rhodora 26: 145. 1924.

Material seen — NASSAU COUNTY: *Brodo 2529* (5), *3498* (4), *3504* (10). SUFFOLK COUNTY: 18 specimens collected by Imshaug and/or Brodo; Southold, *Latham 7995* (+ *8004*), February 11, 1938 (Latham); Orient, Long Beach, *Latham 22288, 22291, 22299,* December 7, 1944 (Latham); Napeague, *Latham 22983* (= *22986*), February 20, 1941 (Latham); Amagansett, *Latham 25997,* March 11, 1947 (Latham); Noyack, *Latham 26518,* March 9, 1947 (Latham); Bridgehampton, *Latham 27050,* September 14, 1947 (Latham); North Sea, *Latham 28152,* May 16, 1955 (Latham); Orient Point, *Latham 2,* January 9, 1911 (NYS); near Orient, *Latham 13* (FH); (locality unknown) *Latham,* 1914 (FH); Montauk Point, *R. H. Torrey,* 1933 NY); Southold, *R. H. Torrey,* 1936 (NY); Pike's Beach, Westhampton, *R. H. Torrey,* 1936 (NY); Selden, *S. Cain 356, 347,* June 30, 1936 (NY).

This species is usually found on exposed, sandy ground.

Distribution — Maine, Mass., Connecticut, New Jersey, Maryland, Washington, D.C., Virginia (Sandstede, 1939); Vermont, Tennessee, Oklahoma: Temperate element, East Temperate subelement(?); Asia.

98. **Cladonia brevis** Sandst. Abhandl. Naturv. Ver. Bremen. 25: 192. 1922.

Material seen — SUFFOLK COUNTY: *Imshaug 25666* (64); *Brodo 1642* (69); Southold, *Latham 7883,* February 11, 1938 (Latham); Riverhead, *Peck* (NYS); Montauk Point, *R. H. Torrey,* 1933 (NY); East of Calverton, *R. H. Torrey* 1936 (NY); Airport near Westhampton, *R. H. Torrey,* 1936 (NY).

*Cladonia brevis,* like the other members of the *C. subcariosa* group (p. 185) is found on dry sandy soil.

Distribution — Maine, Massachusetts, Connecticut (Sandstede, 1938); Vermont, New Jersey, Tennessee, Manitoba: Temperate element, East Temperate subelement (?); Europe.

### Subsection *Thallostelides* Vain.

99. **Cladonia verticillata** (Hoffm.) Schaer. Lich. Helv. Spic. 31. 1823. *Cladonia pyxidata * C. verticillata* Hoffm. Deutschl. Fl. 2: 122. 1796.

Material seen — KINGS COUNTY: New Lots, *G. B. Brainerd,* (1866?) (BKL 031990); New Lots, *G. B. Brainerd,* (1866?) (BKL). SUFFOLK COUNTY: *Brodo 59-303* (53); Greenport, *Latham 23430*

April 12, 1945 (Latham); Northwest, Third station, *Latham 27447,* April 27, 1948 (Latham); Orient, *Latham 35337,* April 17, 1950 (Latham); Sag Harbor, *Latham,* September 15, 1941 (Latham); ? near Orient, *Latham 13* (FH).

The separation of this species from closely related *C. calycantha* is often very difficult. Such characters as smooth cup margins and gradually expanding cups usually attributed to *C. verticillata* are not always evident. The ecology of the two species, however, seems to be different with *C. verticillata* being found in open, sandy or grassy fields, especially on neutral soils, and *C. calycantha* being found mainly in boggy or acid sand localities, usually under pines (figure 48). The geographical distribution of the two species is basically different as well.

Distribution — Nova Scotia, Vermont, Massachusetts, Connecticut, New Jersey, Tennessee, Michigan, Ontario, Minnesota, Black Hills, Washington, Alaska, Saskatchewan, Manitoba, Canadian East Arctic; Arctic-boreal element; circumboreal.

100. **Cladonia calycantha** Nyl. Syn. Meth. Lich. 192. 1858.

Material seen — SUFFOLK COUNTY: *Imshaug 25856* (60); *Brodo 59-23* (83), *59-25* (83), *59-306* (68), *59-307* (68), *1129* (78), *2092* (83), *2287* (87), *2534* (49), *3396* (75), *3816* (66); 29 specimens collected by Latham (Latham); Napeague, *Latham 26024,* March 11, 1947 (US: Evans); Springs, *Latham 26432,* April 17, 1947 (US: Evans); Northwest, *Latham 26391,* April 17, 1947 (FH); Northwest Section 2, *Latham 27480,* April 21, 1948 (US: Evans); Airport near Westhampton, *R. H. Torrey,* 1936 (NY); Pike's Beach, Westhampton, *R. H. Torrey,* 1936 (NY); Sweezy Pond, 2.3 miles SW of Riverhead, *S. Smith 11855,* August 14, 1952 (NYS).

The relationship between this species and *C. verticillata* has been discussed with the latter.

Distribution — Newfoundland to Florida, South America, Australia (Sandstede, 1938): Tropical element, Coastal Plain subelement; Europe (Poelt, 1963); Asia.

101. **Cladonia mateocyatha** Robb. Rhodora 27: 50. 1925.

Material seen — NASSAU COUNTY: *Brodo 540* (16). SUFFOLK COUNTY: ?, *Latham 34,* 1914 (FH); Montauk Point, *R. H. Torrey,* 1933 (NY); between Commack and Kings Park, *R. H. Torrey,* 1937 (NY).

This species, very rare on Long Island, shows considerable morphological variability. Its smooth or cracked, completely corticate podetial surface, together with its irregularly proliferating cups, giving rise to contorted branches from both central and marginal areas, distinguish *C. mateocyatha* from other nonsorediate species.

This species is found on exposed soil.

Distribution — Massachusetts, Connecticut, Washington, D.C., West Virginia, New Mexico (Sandstede, 1939); Vermont, New Jersey, Tennessee, Michigan: Temperate element, Appalachian subelement, Appalachian-Great Lakes-Rocky Mountain unit (?); endemic.

102. **Cladonia pyxidata** (L.) Hoffm. Deutschl. Fl. 2: 121. 1796. *Lichen pyxidatus* L. Sp. Pl. 2: 1151. 1753.

Material seen — KINGS COUNTY: Gowanus, *G. B. Brainerd* (BKL) 031992). SUFFOLK COUNTY: *Imshaug 25628* (116), *25862* (60); *Brodo 2838* (115); 10 specimens collected by Latham (Latham); Montauk Point, *R. H. Torrey*, 1933 (NY).

The species is usually found on the ground in dry, sandy localities.

Distribution — Vermont, Massachusetts, Connecticut, New Jersey, Tennessee, Michigan, Ontario, Minnesota, Wisconsin, Black Hills, Arizona, Idaho, Washington, Alaska, British Columbia, Saskatchewan, Manitoba, Can. East Arctic, Baffin Island: Arctic-boreal element; circumboreal.

103. **Cladonia chlorophaea** (Flörke in Somm.) Spreng. Syst. Veg. ed. 16. 4: 273. 1827. *Cenomyce chlorophaea* Flörke in Somm. Suppl. Fl. Lapp. 130. 1826.

Material seen — COUNTY UNKNOWN: Fresh Pond, *Hulst*, 1890 (BKL 031986). QUEENS COUNTY: *Brodo 519* (3). NASSAU COUNTY: *Brodo 537* (16), *541* (12), *560* (13), *1306* (15), *3343* (8), *3507* (10); Oyster Bay, *L. P. le* ?, September 1889 (NY); Valley Stream, *Warner*, November 17, 1900 (BKL). SUFFOLK COUNTY: 109 specimens collected by Imshaug and/or Brodo; 70 specimens collected by Latham (Latham); (locality unknown), *Latham*, 1914 (FH); Orient, *Latham 185*, 1914 (FH); (locality unknown), *Latham*, 1914 (FH); Orient, *Latham 216*, May 23, 1914 (FH); Shinnecock Hills, *R. H. Torrey*, 1933 (NY); Holtsville, *R. H. Torrey*, 1936 (NY); Pikes Beach, Westhampton, *R. H. Torrey*, 1936 (NY) (PD + red); Pikes Beach, Westhampton, *R. H. Torrey*, 1936 (NY) (PD −); Suffolk County Airport near Westhampton, *R. H. Torrey*, 1936 (NY); Selden, *S. Cain 345*, June 30, 1936 (NY); Wyandanch Club Game Preserve south, *R. H. Torrey*, 1937 (NY); Horton's Beach, Southold, *S. Smith 11896*, *11897*, August 14, 1952 (NYS); Wildwood State Park near Riverhead, *S. Smith 12744*, October 17, 1952.

This species, one of the most abundant on Long Island, is extremely variable in morphology and ecology. Soredia range from almost farinose to granular and even appear corticate in some specimens; cups are either simple, goblet-shaped structures with smooth margins, or have many often large, marginal proliferations bearing large brown apothecia.

Fumarprotocetraric acid, as determined by a PD + red reaction on the podetia, was demonstrated in about 60 percent of the specimens. The presence of grayanic acid was determined by the microscopic examination of acetone extracts of the podetia, with supplementary recrystallization in GAW solution if necessary. It was found in all the Long Island specimens except one (*Brodo 1050* [112]) in which cryptochlorophaeic acid was demonstrated. In addition, 9 specimens of *C. chlorophaea* from southern New Jersey and 12 from Cape Cod were chemically examined. All of these also contained only grayanic acid except for one specimen (*Brodo 4387* from Cape Cod) which showed neither grayanic nor cryptochlorophaeic nor merochlorophaeic acids.

Fumarprotocetraric acid is regarded as an accessory substance in *C. chlorophaea* by most modern workers (see Evans, 1944). However, the presence or absence of the other substances mentioned above have been used by Evans, Asahina, and others as a basis for recognizing four species: *C. grayi* Merr. in Sandst. with grayanic acid; *C. cryptochlorophaea* Asah. with cryptochlorophaeic acid; *C. merochlorophaea* Asah. with merochlorophaeic acid; *C. chlorophaea* sens. str. with none of these chemicals. Several of these chemical segregates seem to have some geographic restrictions (grayanic acid strain is eastern; inactive strain is northern). The other strains are rather rare, and are poorly defined geographically. Until the full chemical story is known, at least in North America, it seems best to regard these segregates as chemical strains within *C. chlorophaea* sens. lat., although with further study at least a few may prove to be more logically considered as subspecies, or perhaps even species.

*Cladonia chlorophaea* is found on soil, lignum, or tree bases.

Distribution — Nova Scotia, Maine, Vermont, Massachusetts, Connecticut, New Jersey, Tennessee, Alabama, Florida, Michigan, Ontario, Indiana, Wisconsin, Minnesota, Oklahoma, Black Hills, Arizona, Washington, Alaska, British Columbia, Manitoba, Canadian East Arctic, Baffin Island: Arctic-boreal element; circumboreal.

[Note: Ahti's important treatment of the *C. chlorophaea* complex (Ahti, 1966) appeared after this paper was in proof, and therefore was not considered here.]

104. **Cladonia fimbriata** (L.) Fr. Lich. Eur. Ref. 222. 1831. *Lichen fimbriatus* L. Sp. Pl. 1152. 1753.

Material seen — SUFFOLK COUNTY: Riverhead, *Latham 7663B*, May 1, 1937 (Latham); Bridgehampton, *Latham 27043*, September 14, 1947 (Latham); North Sea, *Latham 32353*, April 26, 1954 (Latham); Riverhead, *Latham 33318*, June 1, 1923 (Latham); East Marion, *Latham*, May 3, 1914 (Latham).

*Cladonia fimbriata* varies from a very narrow-cupped condition very similar to *C. coniocraea* to a broader trumpet-shaped condition resembling *C. conista*. However, its podetia always show a distinct, deep, though often very narrow cup and rarely are as subulate as those of *C. coniocraea*, in which the podetial cups are flat or very shallow. *Cladonia fimbriata* also has much smaller podetial and basal squamules than the latter. In addition, the podetia of *C. fimbriata* never arise from the center of a primary squamule as do the podetia of *C. coniocraea*. *Cladonia conista*, with broad, goblet-shaped cups has its soredia confined to the upper third of the podetium and the inner surface of the cup and contains substance "H," whereas *C. fimbriata* has narrower podetia covered with soredia and does not contain substance H.

*Cladonia fimbriata* is found on the ground and on tree bases.

Distribution — Arctic-boreal element (Hale, 1954; Thomson, 1953, 1955): circumboreal.

105. **Cladonia conista** (Ach.) Robb. in Allen, Rhodora 32: 92. 1930. *Cenomyce fimbriata β-C. conista* Ach. Syn. Meth. Lich. 257. 1814.

Material seen — KINGS COUNTY: Gowanus, *G. B. Brainerd,* 1866 (BKL). QUEENS COUNTY: Cypress Hills, *Hulst,* 1890 (BKL 031991). SUFFOLK COUNTY: *Imshaug 25686* (72), *25750* (132); *Brodo 811* (90B), *1523* (100B), *2725* (111), *3086* (128); 10 specimens collected by Latham (Latham).

The presence of substance H in *C. conista* easily separates it from similar species which lack it, such as *C. fimbriata* (see above) and *C. chlorophaea.* In addition, the latter usually has distinctly granular soredia covering the entire podetium.

*Cladonia conista* grows on soil or tree bases (figure 69).

Distribution — Vermont, Massachusetts, Connecticut, New Jersey, Tennessee, Michigan, Black Hills: Temperate element, North Temperate subelement (?); Europe, Asia.

106. **Cladonia coniocraea** (Flörke) Spreng. em. Sandst. Syst. Veg. ed. 16. 4: 272. 1827. Sandstede, Abh. Naturw. Ver. Bremen 21: 373. 1912. *Cenomyce coniocraea* Flörke, Deutschl. Lich. 138. 1821.

Material seen — QUEENS COUNTY: *Brodo 526* (3). NASSAU COUNTY: 17 specimens collected by Brodo. SUFFOLK COUNTY: 83 specimens collected by Imshaug and/or Brodo; 47 specimens collected by Latham (Latham); Montauk Point, *R. H. Torrey,* 1933 (NY); Coram, *R. H. Torrey,* 1936 (NY); Greenport, *Latham 30938a,* May 30, 1952 (NYS).

This species is one of the most common and variable of the *Cladoniae. Cladonia coniocraea* is usually said to have abruptly tapering podetia entirely covered with farinose soredia except for a narrow basal zone. Long Island specimens, however, show every gradation from this "typical" form to a condition having almost entirely corticate podetia with patches of farinose or granular soredia scattered along their length. This latter form has generally been considered under the name *Cladonia ochrochlora* Flörke. Evans (1935) discussed the difference between these two species.

In general, five characters are fairly constant in *C. coniocraea*: (1) the podetia are sorediate, (2) the podetia are usually short, stout, and abruptly tapering to a sharp point, (3) the podetia arise from the center or near center of a primary squamule, (4) the primary squamules are broad, and (5) the podetial cortex and the soredia usually have a yellowish or yellow-olive cast (not due to usnic acid).

A great deal of variability can be seen in (1) the extent of podetial cortex, (2) the type of soredia (although the granular sorediate condition is very rare), (3) the presence of soredia on the primary squamules (from abundant to essentially absent), (4) the presence of cupped podetia (cf. *C. fimbriata,* p. 188), (5) the lobing of the primary squamules (entire to crenate), and (6) the degree of branching (podetia are almost always simple, but rarely have one, or at most, two simple branches). Apothecia, which are rare in this species, are brown and irregular, occurring at the edges of poorly developed cups or trays.

*Cladonia coniocraea* is usually found on mossy soil or tree bases and almost always in shaded situations. Its city-tolerance is discussed in Brodo (1966).

Distribution — Nova Scotia, Maine, Vermont, Massachusetts, Connecticut, New Jersey, Tennessee, Alabama, Ontario, Michigan, Wisconsin, Minnesota, Indiana, Oklahoma, Arizona, Washington, Alaska, British Columbia, Manitoba, Canadian East Arctic: Temperate element (?), North Temperate subelement; Europe, Asia.

107. **Cladonia nemoxyna** (Ach.) Arn. Lich. exs. no. 1495. 1890. *Baeomyces radiatus β. B. nemoxynus* Ach. Meth. Lich. 342. 1803.

Material seen — SUFFOLK COUNTY: *Brodo 2713* (111); Orient, Long Beach, *Latham 19*, April 15, 1914 (Latham); Montauk Point, *R. H. Torrey*, 1933 (NY); Southold, *R. H. Torrey*, 1936 (NY); 2.3 miles southwest of Riverhead, *S. Smith and Ogden, Smith 11853, 11854*, August 14, 1952 (NYS).

*Cladonia nemoxyna* may contain fumarprotocetraric acid; it always contains homosekikaic acid (Evans, 1944). All the Long Island specimens were PD + red and presumably contained fumarprotocetraric acid. The specimens of this species cited by Degelius (1940) from Maine also were PD + red. Specimens from Ontario (Ahti, 1964), the Great Lakes region, and the Black Hills are PD −. The presence of fumarprotocetraric acid, therefore, may prove to have geographic correlation, as do many other chemical populations of lichens (*Cladonia uncialis, C. chlorophaea, Lecanora caesiorubella*, etc.)

Homosekikaic acid is very difficult to demonstrate, apparently because it occurs in very minute concentrations. The directions for its recrystallization from GAoT solution as given by Evans (1943) should be followed carefully.

This species was found on eroding soil associated with *C. conista, C. farinacea*, and *C. cristatella*.

Distribution — Vermont, Massachusetts, Connecticut, New Jersey, Tennessee, Ontario, Michigan, Black Hills, Washington: Temperate element, North Temperate subelement; Europe; Asia.

108. **Cladonia cylindrica** (Evans) Evans, Rhodora 52: 116. 1950. *Cladonia borbonica* f. *cylindrica* Evans, Trans. Conn. Acad. Arts Sci. 30: 482. 1930.

Material seen — NASSAU COUNTY: *Brodo 1309* (15), *3500* (10). SUFFOLK COUNTY: *Brodo 711A* (65), *955* (35-36), *1012* (27), *1262* (29), *1700* (133), *2226* (28), *3909* (112); Greenport, Gull Pond, *Latham 29595*, January 20, 1951, dry soil in woods (Latham).

This lichen bears many similarities with *C. coniocraea*. Both have more or less short, servediate, usually sterile podetia, and both are PD +

red. However, *C. cylindrica* has a clear gradation of coarse granules at the podetial base to farinose soredia at its tip and contains grayanic acid, whereas *C. coniocraea* is entirely covered with farinose soredia and lacks grayanic acid.

*Cladonia cylindrica* is found on tree bases, usually in shaded woods.

Distribution — Vermont, Massachusetts, Connecticut, New Jersey, Michigan; West Virginia (Sandstede, 1939): Tropical element, Temperate-Appalachian subelement; Asia; circumtropic (Sandstede, 1939).

109. **Cladonia pityrea** (Flörke) Fr. Nov. Sched. Crit. 21. 1826. *Capitularia pityrea* Flörke, Ges. Naturf. Fr. Berlin Mag. 2: 135. 1808.

Material seen — QUEENS COUNTY: *Brodo 523* (3). SUFFOLK COUNTY: *Brodo 585* (92), *2747* (111), *3266* (119), *3323* (129); East Marion, *Latham 5,* May 3, 1914 (Latham); Greenport, *Latham 23428,* April 12, 1945 (Latham); Riverhead, *Latham 36811A*, May 1, 1960 (Latham); Riverhead, *Latham,* May 25, 1960 (Latham); Greenport, *Latham 7212* (?) (MICH); (locality unknown), *Latham,* 1914 (FH).

Almost all of the Long Island specimens of *C. pityrea* are identical with Connecticut material identified by Evans (in herb. FH) as *C. pityrea* var. *zwackii* Vain., and either form *subacuta* Vain. or form *squamulifera* Vain. The podetia were contorted and covered with coarse granules or granular soredia. In the type of form *squamulifera* (*Thaxter 35,* Trinidad, 1912-13, [FH]), the podetia were densely squamulose and granular servediate, not very contorted, and were not pellucid and dark in the decorticate areas. The podetial squamules were finely lobed and almost nonsorediate. In other words, the type of *f. squamulifera* does not seem to agree with Evans' identifications, and *f. squamulifera* sensu Evans is probably a kind of *f. subacuta* (especially since collections containing both forms in the same packet were common). The value of these infraspecific taxa is doubtful.

*Cladonia pityrea* has been collected on various substrates, including dry ground, tree bases, rocks, and wood.

Distribution — Vermont, Connecticut, New Jersey, Tennessee, Florida, Michigan; South America, West Indies, East Indies (Sandstede, 1939): Tropical element, Appalachian-Temperate subelement; Europe; Asia.

110. **Cladonia simulata** Robb. Rhodora 31: 105. 1929.

Material seen — SUFFOLK COUNTY: Northwest, *Latham 27200,* April 27, 1947 (US: Evans).

This species had been placed in the subsection Ochroleucae by Sandstede (1938) and Mattick (1940) on the basis of its resemblance to *C. piedmontensis*. Evans (1952), following Robbins, pointed out that the similarity of the species to *C. piedmontensis* is entirely superficial, and its chemistry (lack of usnic and presence of fumarprotocetraric acid) places it in the subsection Thallostelides, close to *C. pityrea.*

The specimen was growing on dry sand.

Distribution — Massachusetts, North Carolina, Georgia, Florida (Evans, 1952): Temperate element, Coastal Plain subelement; endemic.

### Section *PERVIAE* (Fr.) Matt.

### Subsection *Chasmariae* (Ach.) Flörke

### Series *Megaphyllae* Vain.

111. **Cladonia apodocarpa** Robb. Rhodora 27: 211. 1925.

Material seen — SUFFOLK COUNTY: Riverhead, *Latham 24794*, April 5, 1946 (US: Evans).

This species is the only nonpodetiate *Cladonia* on Long Island, containing both atranorin and fumarprotocetraric acid. Latham's specimen was from a dry woods.

Distribution — Northeastern states (Sandstede, 1939); Tennessee, Alabama: Temperate element, East Temperate subelement; endemic.

### Series *Microphyllae* Vain.

112. **Cladonia caespiticia** (Pers.) Flörke, Clad. Comm. 8. 1828. *Baeomyces caespiticus* Pers. Ann. d. Bot. 7: 155. 1794.

Material seen — QUEENS COUNTY: *Brodo 521* (3). NASSAU COUNTY: *Brodo 1310* (15), *2528* (5). SUFFOLK COUNTY: *Imshaug 25693* (72); *Brodo 2426* (20), *2755* (107), *3023* (50), *3864* (57), *3912* (36); Orient, *Latham 789*, March 3, 1914 (Latham); Montauk, *Latham 31892*, May 16, 1951 (Latham); Mattituck, *Latham 33140*, June 7, 1955 (Latham); East Marion, *Latham*, May 3, 1914 (Latham); Orient, *Latham 199*, May 15, 1914 (FH); (locality unknown), *Latham*, 1914 (FH); Barling Hollow (= Baiting Hollow?), *R. H. Torrey*, 1934 (NY); Wyandanch Club Game Preserve, south of Smithtown, *R. H. Torrey*, 1937 (NY).

This species is found on bare or mossy ground, often on charred ground, and less frequently on tree bases. It is almost always in shaded or partially shaded localities, particularly in the black and red oak forests (figure 55).

Distribution — Eastern United States (Sandstede, 1938): Temperate element, East Temperate subelement; Europe; Asia.

113. **Cladonia parasitica** (Hoffm.) Hoffm. Deutschl. Fl. 2: 127, 1795. *Lichen parasiticus* Hoffm. Enum. Lich. 39, tab. 8, fig. 5. 1784.

Material seen—NASSAU COUNTYs *Brodo 1505* (14), *1507* (14). SUFFOLK COUNTY: *Brodo 927* (59), *1273A* (21), *1293* (19), *1296* (19), *2100* (78), *2153* (102), *2456* (22), *2643* (71), *2975* (43), *2978* (43), *3041* (50), *3155* (65), *3878* (62). *3906* (112); 12 specimens collected by Latham (Latham); Shinnecock Hills, *R. H. Torrey*, 1933 (NY).

*Cladonia parasitica* is usually described as having granular soredia. On many specimens which I have seen, however, the so-called soredia appear to be corticate and, therefore, are actually granules.

The species has been called *C. delicata* (Ehrh.) Flörke by most authors.

This species is almost entirely confined to decaying logs and wood of various origins, but especially coniferous trees. It is usually found in shaded areas.

Distribution — Throughout eastern United States (Evans, 1930): Temperate element, East Temperate subelement; Europe; Asia.

114. **Cladonia santensis** Tuck. Amer. J. Sci. Arts II. 25: 427. 1858.

Material seen — SUFFOLK COUNTY: *Imshaug 25820* (86); Riverhead, Sweezy Pond, *Latham 32870*, April 18, 1955, (Latham); North Sea, *Latham 36939*, May 20, 1954 (Latham); Riverhead, *Latham*, May 1, 1960 (Latham).

This species can be recognized even in the field by its very pale, almost white color, and its contorted, bent, minutely squamulose podetia. Sterile material of *C. santensis* sometimes closely resembles sterile *C. parasitica,* which also contains thamnolic acid. The latter, however, has finely divided, "lacy," granulate primary squamules, whereas in *C. santensis* the squamules are thicker and not granular or sorediate.

Long Island is the northern limit of this species (figure 37). It was found to be abundant in cedar bogs in southern New Jersey.

Distribution — New Jersey to Florida (Evans, 1952): Temperate element, Coastal Plain subelement; endemic.

115. **Cladonia squamosa** (Scop.) Hoffm. Deutschl. Fl. 2: 125. 1796. *Lichen squamosus* Scop. Fl. Carn. ed. 2. 2: 368. 1772.

Material seen — SUFFOLK COUNTY: *Brodo 2164* (102), *2358* (42), *2569* (73), *2998* (17), *3001* (17), *3003* (17), *3035* (50); 10 specimens collected by Latham (Latham).

This species, which is uncommon on Long Island, is usually found on mossy ground, rocks, or woods in partially shaded black or red oak forests (figure 54). Its relationship to *C. atlantica* is discussed under the latter species.

Distribution — Nova Scotia, Maine, Vermont, Massachusetts, Connecticut, New Jersey, Tennessee, Alabama, Ontario, Michigan, Minnesota, Indiana, Washington, coastal Alaska, Baffin Island; "arctic to southern temperate" (Ahti, 1964): Arctic-boreal element; circumboreal.

116. **Cladonia atlantica** Evans, Trans. Conn. Acad. Arts Sci. 35: 573. 1944.

Material seen — NASSAU COUNTY: *Brodo 542* (12), *1312* (15), *3502* (10). SUFFOLK COUNTY: 59 specimens collected by Imshaug and/or Brodo; 66 specimens collected by Latham (Latham); West Suffolk Co. Airport near Westhampton, *R. H. Torrey* (NY); Baiting Hollow, *R. H. Torrey*, 1934 (NY); Holtsville, *R. H. Torrey*, 1936 (NY); Smithtown, *R. H. Torrey,* 1936 (NY); 2.3 miles SW of Riverhead, *S. Smith 11852, 11856, 11857*, August 14, 1952 (NYS); Horton's Beach, Southold, *S. Smith 11895*, August 14, 1952 (NYS); 1.3 miles W of Middle Island, *S. Smith 17717*, March 12, 1955 (NYS).

This species, which is very common throughout the sandy parts of the island, is very variable in its morphology. Podetia devoid of squamules commonly are found, as well as podetia entirely covered with small or large squamules. Apothecia seem to be more common on the squamulose forms.

The main difference between *C. atlantica* and *C. squamosa* (from which it was segregated by Evans) is in the production of baeomycic acid in the former. Evans (1944) discussed their differences and similarities in detail. The two species also differ in ecology and distribution. *Cladonia atlantica* grows on acid sand and lignum and is more or less photophilous. *Cladonia squamosa* is a species of partially shaded, mossy, rich soil habitats.

Distribution — Temperate element, Coastal Plain subelement (see Hale, 1961a); endemic.

117. **Cladonia beaumontii** (Tuck.) Vain. Acta Soc. Faun. Fl. Fenn. 10: 455. 1894. *Cladonia santensis* b. *beaumontii* Tuck. Syn. N. Amer. Lich. 1: 245. 1882.

Material seen — SUFFOLK COUNTY: *Brodo 2249* (87); 21 specimens collected by Latham (Latham).

This species is very closely related to *C. atlantica* which, however, always shows more or less distinct cups. In addition, *C. beaumontii* is usually more decorticate than *C. atlantica.*

*Cladonia beaumontii* is a lignum-inhabiting bog species (figure 35).

Distribution — Massachusetts, Connecticut, New York, North Carolina, Florida (Evans, 1950): Temperate element, Coastal Plain subelement; endemic.

118. **Cladonia floridana** Vain. in Sandst. Clad. Exsic. 1196. 1922.

Material seen — SUFFOLK COUNTY: *Imshaug 25638* (64), *25665* (64), *25827* (86); *Brodo 652* (79), *654* (79), *1151* (70), *1933* (85), *1948* (85), *3393* (75), *3404* (75); 23 specimens collected by Latham (Latham); Suffolk Co. Airport near Westhampton, *R. H. Torrey,* 1936 (NY); Rock Hill (near) S. of Calverton, *Latham 7822,* June 28, 1937 (NYS).

*Cladonia floridana* is found on exposed or partially shaded sand or, rarely, on wood (figure 19). Although it is almost entirely limited to the coastal plain, R. H. Torrey (in Smiley, 1940) reported its occurrence in Ellenville, N. Y. (Ulster County) in the Shawangunk Mountains at an elevation of 2,200 feet. This unlikely distribution is repeated by the heath *Corema conradii,* which is typically a coastal plain species but is also found at 1500 feet on Gertrude's Nose, also in the Shawangunk mountains.

Distribution — Cape Cod to Florida (Evans, 1952): Temperate element, Coastal Plain subelement; endemic.

119. **Cladonia multiformis** Merr. Bryologist 12: 1. 1909.

Material seen — SUFFOLK COUNTY: *Brodo 2703* (111); (locality unknown), *Latham 28,* 1914 (FH).

This very rare species was found on dry soil.

Distribution — Nova Scotia, Vermont, Connecticut, Ontario, Michigan, Black Hills, Washington, Saskatchewan, Manitoba: Temperate element, North Temperate subelement; Africa (des Abbayes, 1938).

120. **Cladonia scabriuscula** (Del. in Duby) Nyl. Compt. Rendu 83: 88. 1876. *Cenomyce scabriuscula* Del. in Duby, Bot. Gall. 632. 1830.

Material seen — KINGS COUNTY: New Lots, *G. B. Brainerd,* 1866 (BKL); New Lots, *G. B. Brainerd,* 1866 (BKL 031988). SUFFOLK COUNTY: *Imshaug 25736* (132); *Brodo 59-276* (54), *1807* (125), *2622* (84); near Orient, *Latham 2,* May 1914 (FH).

This species and its relationship to *C. farinacea* is discussed in detail with the latter. *Cladonia scabriuscula* sens. str. is very rare on Long Island. It is found on mossy ground and on tree bases, usually in the shade.

Distribution — Nova Scotia, Vermont, Massachusetts, Connecticut, Michigan, Ontario, Black Hills, coastal Alaska; arctic to southern temperate, with oceanic tendencies (Ahti, 1964): Arctic-boreal element (?); Europe; Asia.

121. **Cladonia farinacea** (Vain.) Evans, Rhodora 52: 95. 1950. *C. furcata* $\gamma$ *scabriuscula* f. *farinacea* Vain. Acta Soc. Faun. Fl. Fenn. 4: 339. 1887.

Material seen — KINGS COUNTY: New Lots, G. B. Brainerd, (with *Cladonia bacillaris*) (BKL 031984). SUFFOLK COUNTY: *Brodo 59-276* (54), *59-296* (54), *1833* (125), *2712* (111), *3412* (134), *3183* (72); 19 specimens collected by Latham (Latham).

After looking at many specimens of both *C. scabriuscula* and *C. farinacea* from several parts of the country, I am not at all convinced that the two are actually different species.

In *C. scabriuscula,* the podetia are typically tall, branched, covered with small or large squamules (often sorediate) and become granular sorediate towards their tips. The squamules are often very inconspicuous on the upper half of the podetium, and the granular soredia are often abundant over the greater part of the podetium.

The Long Island material of *C. scabriuscula* usually is short (less than 20 mm tall), squamulose, and irregularly sorediate with clumps of granular soredia.

*Cladonia farinacea* typically has tall podetia which are infrequently branched, farinose sorediate for most of their length, and almost devoid of podetial squamules.

Long Island *C. farinacea,* however, is rather short, often has granular soredia, and occasionally even shows some podetial squamules. Evans identified all of Latham's *C. scabriuscula* sens lat. as *C. farinacea,* including a specimen which I am calling *C. scabriuscula* sens. str. (*Latham 7522*). In other words, Evans' concept of *C. farinacea* was apparently very broad and allowed for considerable variation in the principal separating characters.

*Cladonia farinacea* is usually found in dry, exposed, grassy fields or on eroded ground. *Cladonia scabriuscula* is usually on richer soil in more shaded localities.

The distribution of the two species seem to be fairly distinct in most areas.

Distribution — Widely distributed in North America; in eastern part, south to North Carolina and west to Wisconsin (Evans, 1950); Punta Arenas, southern tip of Chile (type locality), Port Famine, Straits of Magellan (Evans, 1950); Asia.

122. **Cladonia furcata** (Huds.) Schrad. Spic. Fl. Germ. 107. 1794. *Lichen furcatus* Huds. Fl. Angl. 458. 1762.

Material seen — QUEENS COUNTY: Fresh Pond, *Hulst,* 1890, (BKL 031989). SUFFOLK COUNTY: *Imshaug 25613*[14] (116), *25618* (116); *Brodo 59-174* (100B), *1166* (70), *1814* (125), *2046* (45), *2613* (84), *2741* (111), *2746* (111), *3092* (126), *3185* (69), *3250* (119), *3365* (94), *3370*[14] (94), *3890* (112); 52 specimens collected by Latham, including *7870*[14] (Shinnecock Hills) (Latham); Northport, *Grout,* December 1900 (BKL 031987); ?, *Latham,* May 1914 (FH); Southold, *Latham 188,* October 4, 1914 (FH).

*Cladonia furcata* shows considerable morphological variation with various ecological situations. It is usually pale green and more or less squamulose in the shade on mossy banks, and is slender, distinctly browned, and essentially devoid of squamules in fully exposed localities (p. 110).

A small percentage of the northeastern material of *C. furcata* shows the presence of atranorin, including several specimens from Long Island (see above), one from Nantucket (*Brodo 4165*) and one from Cape Cod (*Brodo 4330*). These specimens which appear like *C. furcata* but differ chemically were called *C. subrangiformis* Sandst. by Evans (1954). Ahti (1962) examined the type of the latter and stated that it seems to be distinct from *C. furcata.* He believes the North American material with atranorin, however, is merely a chemical race of *C. furcata.*

*Cladonia furcata* is found on exposed or partially shaded, sandy or grassy ground and, rarely, is also found on wood or mossy boulders.

Distribution — From arctic regions southward into Mexico (Evans, 1930), but not reported by Hale (1954), Thomson (1953, 1955), or Ahti (1964): Arctic-boreal element (?); circumboreal.

123. **Cladonia carassensis** Vain. Acta Soc. Faun. Fl. Fenn. 4: 313. 1887.

Material seen — SUFFOLK COUNTY: Three Mile Harbor, *Latham 26432,* April 17, 1947 (Latham); Riverhead, *Latham 30565,* April 3, 1952 (Latham).

The Latham specimens were found on rotten wood and sandy soil in bogs and swamps. Evans (1950) discusses the species in detail.

Distribution — Massachusetts, Connecticut, Oregon, Haiti, Brazil, New Zealand (Evans, 1950): Tropical element, Oceanic subelement; eastern Europe (Evans, 1950); Asia (Asahina, 1950, sub *C. japonica* Vain.).

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[14] Contains atranorin, as demonstrated with GAoT.

### Subsection *Unciales* (Del.) Vain.

124. **Cladonia boryi** Tuck. Proc. Amer. Acad. Arts Sci. 1:246. 1847. (Syn. Lich. New Eng. 54. 1848.)

Material seen — NASSAU COUNTY: Meadowbrook Valley, Hempstead Plains, *Harper,* March 27, 1918 (NY). SUFFOLK COUNTY: 28 specimens collected by Imshaug and/or Brodo; 40 specimens collected by Latham (Latham); 16 specimens collected by R. H. Torrey, 1933-1937 (NY); Orient Point, (collector unknown), September 1870 (FH); Southampton, *Clute,* September 3-7, 1898 (NY); Wading River, *Peck,* September (NYS); Wading River, *Peck* (NYS); Orient, *Young* (BKL); Orient Point, *Latham,* December 8, 1909 (NYS); Orient, *Latham 1,* 1913 (FH); (locality unknown), *Latham 30,* 1914 (FH); Three Mile Harbor, *Latham 26412,* April 17, 1947 (FH); Tiana Beach, *S. Smith 28842,* August 4, 1959 (NYS); 3 miles south of Montauk Point, *Gillis 4928,* September 7, 1961 (MSC).

The external morphology of this species is very variable and one should mainly rely on the internal anatomy described in the key.

*Cladonia boryi* is strictly an exposed sand plain and sand dune species (figure 74).

Distribution — Nova Scotia, Massachusetts, Conneeticut, New Jersey: Temperate element, Coastal Plain subelement (?); Asia and Brazil (Vainio, 1887).

125. **Cladonia caroliniana** Tuck. Amer. J. Sci. Arts II. 25: 427. 1858.

Material seen — NASSAU COUNTY: *Brodo 3346* (8), *3349* (8); Plain Edge, *S. Cain 373,* August 3, 1936, *Andropogonetum Hempsteadii* (NY). SUFFOLK COUNTY: 25 specimens collected by Imshaug and/or Brodo; 38 specimens collected by Latham (Latham); Coram, *N. Taylor 1,* June 15, 1922 (NY); Selden, *S. Cain 358,* June 30, 1936 (NY); Coram, *R. H. Torrey* (2 specimens), 1936 (NY); Reeves Bay near Flanders, *R. H. Torrey,* 1937 (NY); Rt. 112 north of Coram, *R. H. Torrey* (2 specimens), 1936 (NY); Barling Hollow (Baiting Hollow ?), *R. H. Torrey,* 1937 (NY); Pikes Beach, Westhampton, *R. H. Torrey,* 1936 (NY); 1.3 miles W of Middle Island, *S. Smith 17716,* March 12, 1955 (NYS); Tiana Beach, *S. Smith 28443,* August 4, 1959 (NYS).

*Cladonia caroliniana,* like *C. uncialis,* is found on sandy or mossy soil in exposed or partially shaded localities (figure 76).

Distribution — Throughout eastern United States (Evans, 1952): Temperate element, East Temperate subelement; endemic.

126. **Cladonia uncialis** (L.) G. Web. in Wigg. Primit. Fl. Holsat. 90. 1780. *Lichen uncialis* L. Sp. Pl. 1153. 1753.

Material seen — QUEENS COUNTY: Ridgewood, *G. B. Brainerd,* (1866?) (BKL). NASSAU COUNTY: Meadow Brook Valley, Hempstead Plains, *Harper,* March 27, 1918 (NY). SUFFOLK COUNTY: 36 specimens collected by Imshaug and/or Brodo; 66 specimens collected by Latham (Latham); Orient, *Young* (BKL); Shinnecock Hills, *R. H. Torrey*, 1933 (NY); Montauk Point, *R. H. Torrey*, 1933 (NY); Airport near Westhampton, *R. H. Torrey*, 1936 (NY); Coram, *R. H. Torrey*, 1936 (NY); Selden, *S. Cain 351*, June 30, 1936 (NY).

*Cladonia uncialis* shows several growth forms, apparently in response to different ecological situations. In exposed areas on bare sand, the podetia are slender and crowded, forming tight, flattened cushions; in shaded localities on mossy soil or in protected spots where moisture is usually abundant, the podetia become broad, tall, and erect without forming distinct cushions. The smooth, somewhat pruinose podetial inner lining, however, is constant for the species.

The chemistry of the species is somewhat variable, with squamatic acid occurring in some geographic areas and not in others (Evans, 1944). On Long Island, all specimens have a medullary white UV fluorescence and all those extracted with acetone and tested with GE solution showed the presence of squamatic acid. A study of the material of *C. uncialis* in the Michigan State University herbarium revealed that the squamatic acid strain is found in the Appalachian Mountain range and along the northeast coast as far north as New Brunswick as well as in boreal and arctic Canada and Alaska. The squamatic negative strain seems to be confined to the Great Lakes region and northern New England. In Europe the squamatic strain is found in central portions of the continent and the inactive strain is mainly found in Scandinavia and Russia (Evans, 1944).

Distribution — Arctic regions south to Alabama (Evans, 1930): Arctic-boreal element; circumboreal.

### Subgenus *CLADINA* (Nyl.) Leight. em. Vain.

### Section BICORNUTAE Abb.

127. **Cladonia evansii** Abb. Lond. J. Bot. 76: 351. 1938.

Material seen — SUFFOLK COUNTY: Shinnecock, *Latham 33156*, April 30, 1926. (US: Evans, Latham).

Latham's specimen was first identified as *Cladonia impexa* f. *condensata* (Flörke) Sandst. by Evans, who noted the presence of usnic acid, perlatolic acid, and atranorin. Ahti and Thomson later studied the same specimen and called it *C. evansii* (Ahti, 1961). When I first came upon a duplicate of the specimen in the Latham herbarium, I referred it to *C. terrae-novae* Ahti, having demonstrated atranorin and what appeared to be usnic acid in GAoT solution. However, after seeing the Evans herbarium material which was much better developed, and after examining many specimens of both *C. terrae-novae*, which I collected on Cape Cod and Nantucket Island, and *C. evansii* from the Michigan State University herbarium, I also came to the conclusion that the Latham specimen must indeed be *C. evansii* with Long Island thus representing its northernmost locality. The differences between *C. evansii* and *C. terrae-novae* are discussed on p. 201.

Latham's specimen of *C. evansii* was found on dry sandy soil on an open hill.

Distribution — Southeastern United States and the West Indies (map: Ahti, 1961): Temperate element, Coastal Plain subelement; endemic.

### Section ALPESTRES Abb.

128. **Cladonia alpestris** (L.) Rabenh., Clad. Europ. 11. 1860. *Lichen rangiferinus* ($\gamma$) *alpestris* L. Sp. Pl. 1153. 1753.

Material seen — KINGS COUNTY: Forest Park, *Hulst,* November 30, 1890 (BKL 031993). QUEENS COUNTY: Ridgewood, *G. B. Brainerd,* (1866?) (BKL). SUFFOLK COUNTY: *Brodo 653* (79), *3887* (120); 12 specimens collected by Latham (Latham).

*Cladonia alpestris* at one time was probably fairly abundant throughout the eastern part of Long Island (Latham, 1949), even having occurred in the New York City area at one time. Latham (1949) gives an extensive account of the species' distribution and ecology on the island. I have only seen *C. alpestris* twice on Long Island. The first observation was in a pine barren area south of Riverhead and was represented by a tiny fragment of a thallus, possibly blown there from a larger colony nearby which I could not locate. Latham took me to his "Colony seven" (Latham, 1949) at Napeague Beach which, at one time, was "in excess of 300 feet in diameter" but at the time of our visit consisted of but a few plants scattered among low shrubs, bearberry and *Cladonia submitis.*

Distribution — (Figure 20) Arctic-boreal element, circumboreal (Ahti, 1961).

### Section TENUES Abb.

129. **Cladonia subtenuis** (Abb.) Evans. Trans. Conn. Acad. Arts Sci. 35: 536. 1944. *Cladonia tenuis* * *Cl. subtenuis* Abb. Bull. Soc. Sci: Bretagne 16: 108. 1939.

f. **subtenuis**

Material seen — KINGS COUNTY: Forest Park, *Hulst,* November 31 (sic), 1890 (BKL 031993). NASSAU COUNTY: Valley Stream, *Warner,* November 17, 1900 (BKL). SUFFOLK COUNTY: 95 specimens collected by Imshaug and/or Brodo; 92 specimens collected by Latham (Latham); East Point, *Taylor 32,* July 2 to 3, 1918 (BKL); Orient Point, *Dillman,* 1927 (NY); Calverton, *Latham 7869,* September 17, 1937 (NYS); 10 specimens collected by R. H. Torrey (NY); 1.3 miles W of Middle Island, *S. Smith 17715,* March 12, 1955 (NYS); Eastport (vicinity), *S. Smith 28512, 28511, 28510,* August 5, 1959 (NYS).

f. **cinerea** Ahti, Ann. Bot. Soc. [Zool. Bot. Fenn.] 'Vanamo' 32(1): 69. 1961.

Material seen — SUFFOLK COUNTY: Promised Land, *Latham 27630,* June 2, 1951 (Latham) (Holotype); Peconic, *Latham 23445,* April 11, 1945 (Latham).

Ahti (1961) presents a full discussion of f. *cinerea,* which differs from f. *subtenuis* only in lacking usnic acid.

If the thalli of *C. subtenuis* are fertile, which is rare, the branches are shorter, stouter, and more verrucose than sterile specimens.

*Cladonia subtenuis* and *C. arbuscula* are the two species in the Long Island *Cladinae* most difficult to separate. They have the same chemical constituents (fumarprotocetraric acid, usnic acid, and ursolic acid) and their morphologies overlap to a large degree.

Ahti (1961) separates the two largely as is shown in the following table:

| *C. subtenuis* | *C. arbuscula* |
|---|---|
| 1. branching mostly dichotomous | 1. branching mostly tri- and tetrachotomous |
| 2. axils mostly closed | 2. axils mostly open |
| 3. slender branches | 3. heavy, robust branches |
| 4. main branch often sub- to indistinct | 4. main branch robust and very distinct |
| 5. branchlets mostly erect | 5. branchlets mostly unilaterally falcate |
| 6. podetial surface smooth | 6. podetial surface ± warty |
| 7. pycnidial jelly red | 7. pycnidial jelly hyaline |

Upon examining specimens determined by Ahti as *C. subtenuis* and *C. arbuscula*, and after personally examining scores of specimens from Long Island and nearby Cape Cod and southern New Jersey, it appears that only a few of these characters approach constancy.

There are many specimens of *C. subtenuis* which are quite robust and have heavy main stems, unlike typical *subtenuis*. On occasional specimens, axils may commonly be open and sometimes may even show whorls of branchlets around the gaping hole, although this latter condition is very rare. The pycnidial jelly of specimens so closely approaching *C. arbuscula* should be examined. The jelly will be reddish or red-brown in *subtenuis* and colorless in *arbuscula*. This was done in some of the questionable, very robust specimens of *subtenuis* from Long Island, and helped establish the range of variation to be expected in this very variable species. Unfortunately, pycnidial jelly can only be examined from relatively fresh specimens (not more than a few years old).

*Cladonia subtenuis* is most characteristic of partially shaded oak or pine-oak forests but can also be found in open sand barrens associated with *C. submitis* and *C. boryi*.

Distribution — (*f. subtenuis*) — Eastern United States (map: Ahti, 1961): Temperate element, East Temperate subelement; British Guiana (map: Ahti, 1961).

(*f. cinerea*) — New England (Ahti, 1961).

130. **Cladonia terrae-novae** Ahti, Ann. Bot. Soc. 'Vanamo' 30(4): 11. 1959 (nomen nudum); Arch. Soc. 'Vanamo' 14: 131. 1960.

Material seen — SUFFOLK COUNTY: Montauk, *Latham 38016*, August 19, 1963 (Latham).

The rarity of this species on Long Island is difficult to understand in view of its abundance on Nantucket Island and Cape Cod and its presence in southern New Jersey. In all but a few cases it was collected in boggy heath or on bog hummocks.

The presence of atranorin along with usnic acid is usually sufficient to separate this species from all other *Cladinae* with anisotomic branching. Perlatolic acid is also present, but is sometimes difficult to demonstrate. Although the species shows considerable morphological variability, especially in the thickness of the podetia and density of the young branches, the rough "tomentose" appearance of the surface and very discontinuous algal layer is striking and characteristic. The thallus is always distinctly anisotomic (having one or more distinct main stems) and in this respect differs from the very rare usnic acid form of *Cladonia evansii* which has a similar thallus surface and also contains atranorin (p. 198).

*Cladonia terrae-novae* differs from its vicarious European parent species, *C. impexa* Harm., principally in the absence of atranorin in the latter, although Ahti (1961) asserts that there are good morphological differences between the two species as well.

An interesting phytogeographical parallel with the distribution of *C. terrae-novae* involves the tiny fern, *Schizaea pusilla*. The two species have their southernmost locality in the very same bog in southern New Jersey and are found growing there almost side by side. The fern has not yet been found on Long Island, but, like the lichen, reoccurs farther north (especially in Nova Scotia and Newfoundland) in great abundance.

Distribution — Along the Atlantic coast from Newfoundland to New Jersey (map: Ahti, 1961): Temperate element, Oceanic subelement.

## Section CLADINA

131. **Cladonia rangiferina** (L.) G. Web. in Wigg. Prim. Fl. Holsaticae 90. 1780. *Lichen rangiferinus* L. Sp. Pl. 1153. 1753.
subsp. *rangiferina* var. *rangiferina*.

Material seen — SUFFOLK COUNTY: *Brodo 1018* (82), *1447* (83); 25 specimens collected by Latham (Latham).

*Cladonia rangiferina*, like *C. alpestris*, is a rare member of the community on open sand-dunes and sand plains on Long Island, but is found abundantly in the Cape Cod region in the same community. Both species were previously more common on the island than they are now (p. 276).

Distribution — Throughout arctic, boreal, east temperate, and west montane North America (map: Ahti, 1961): Arctic-boreal element; circumboreal.

132. **Cladonia arbuscula** (Wallr.) Rabenh. Deutschl. Kryp. Fl. 2: 110. 1845. *Patellaria foliacea* var. m. *Arbuscula* Wallr. Fl. Crypt. Germ. 1: 425. 1831.

Material seen — SUFFOLK COUNTY: *Brodo 59-284* (82), *3242* (120); Calverton, *Latham 7547*, October 10, 1933 (Latham); Flanders, *Latham 24717* (Latham); Calverton, *R. H. Torrey* (with *C. subtenuis*), 1936 (NY).

The nomenclatural problems of this species, called *C. sylvatica* (L.) Hoffm. by most authors are discussed in detail by Ahti (1961).

The Long Island material of this species belongs to Ahti's subsp. *arbuscula*, chemical strain I (with fumarprotocetraric acid). The similarities between *C. arbuscula* and *C. subtenuis* are discussed under the latter species (p. 200).

*Cladonia arbuscula* was found associated with *C. submitis* and *Cetraria islandica* on sand dunes.

Distribution — (maps: Ahti, 1961). (sens. lat.) — Arctic-boreal element; circumboreal. (subsp. *arbuscula*, chemical strain I) — Eastern boreal and temperate North America; Temperate element, North Temperate subelement (?), but clearly boreal to arctic in Eurasia.

133. **Cladonia submitis** Evans, Rhodora 45: 435. 1943.

Material seen—KINGS COUNTY: Forest Park, *Hulst*, November 31 (sic), 1890 (BKL 031993). SUFFOLK COUNTY: 66 specimens collected by Imshaug and/or Brodo; 36 specimens collected by Latham (Latham); Southampton, *Clute*, September 3-7, 1898 (NY); East Point, *Taylor 32*, July 2-3, 1918 (BKL); Farmingville, *Davis*, August 1916 (Staten Island); Pike's Beach, Westhampton, *R. H. Torrey*, 1936 (NY); Holtsville, *R. H. Torrey*, 1936, (NY); Selden, *R. H. Torrey*, 1936 (NY); Route 112 north of Coram, *R. H. Torrey*, 1936 (NY); Reeves Bay near Flanders, *R. H. Torrey*, 1937 (NY); Riverhead, *S. Smith 28444, 28559, 28560*, August 7, 1959 (NYS); Selden, *S. Cain 353*, June 30, 1936 (NY); Noyack, *Latham 26423*, April 17, 1947 (FH).

Ahti (1961) reported that an isotype specimen of *C. submitis* that he examined appeared to be *C. mitis*. Upon checking the holotype specimen in the Evans herbarium I discovered that it was already annotated by Ahti (in 1961) and by Thomson (in 1962). Ahti marked it as pseudonorangiformic absent, but Thomson noted that with the help of Kurokawa, he found pseudonorangiformic acid in small amounts in the greater portion of the material. I attempted to recrystallize the crucial chemical myself, but met with no success. In this connection, it should be mentioned that the holotype material is not a typical example of *C. submitis* from a morphological point of view. Although some branchlets show the characteristic prongs and robust nature of the species, most of the material is rather slender. The Sandstede exsiccats nos. 1564 and 1565, both on the same sheet as the holotype and both annotated by Evans as being *C. submitis* and containing "C" (pseudonorangiformic acid), are much more representative of typical *C. submitis*.

*Cladonia submitis* seems to have two basic growth forms on Long Island: one is prostrate and sprawling and the other is erect and often tufted. The former is characteristc of the isolated thalli in open sand dune areas and exposed sand barrens; the upright form is usually seen in protected situations, between clumps of grass, in extensive colonies on the dunes, and in partially shaded localities. This latter form often appears very much like *C. arbuscula,* which, however, is PD + red and lacks pseudonorangiformic acid. The prostrate form has no parallel in the *Cladinae* and is easily identified in the field.

It is interesting, although puzzling, that *C. submitis* is very abundant in south shore dune habitats, but is entirely absent from very similar habitats on the north shore (figure 75). There are three observable factors correlating with its occurrence on the south shore: the presence of a continuous foredune between the community and ocean, the presence of *Pinus rigida* in the immediate areas, and the high acidity of the sand. These three factors are probably somewhat interrelated and may affect the *Cladonia* distribution directly or indirectly and act either independently or together.

It is known that salt mist and salt spray causes maritime substrates to become more alkaline than normal (Barkman, 1958). It is also known that *Pinus rigida* is intolerant of large quantities of salt spray (Boyce, 1954). Ahti (1961) stated that *Cladonia submitis* is intolerant to salt spray and is never found near the ocean.

All these facts seem to suggest strongly that the salt spray on the south shore, blocked to a large extent by the foredune, is not nearly as abundant as it is on the north shore where the only protection comes from low dunes and hollows (see Oostings and Billings, 1942). It is, therefore, the salt spray, rather than any directly observed factor such as sand pH or the accumulation of pine detritus, which very likely limits the distribution of *C. submitis.*

Distribution — Atlantic coastal plain (map: Ahti, 1961): Temperate element, Coastal Plain subelement; Japan (Ahti, 1961).

134. **Cladonia mitis** Sandst. Clad. exs. no. 55. 1918.

Material seen — SUFFOLK COUNTY: Orient, West Long Beach, *Latham 23437,* April 7, 1945 (Latham); Promised Land, *Latham 25473,* April 1, 1946 (Latham).

This species is extremely rare on Long Island. It is apparently a member of the community on exposed sand with other *Cladinae.*

Distribution — Throughout the arctic and boreal northern hemisphere (map: Ahti, 1961): Arctic-boreal element; circumboreal.

## UMBILICARIACEAE

### 36. UMBILICARIA Hoffm.

135. **Umbilicaria mammulata** (Ach.) Tuck. Proc. Amer. Acad. Arts Sci. 1: 261. 1847. *Gyrophora mammulata* Ach. Syn. Lich. 67. 1814.

Material seen — SUFFOLK COUNTY: *Brodo 3843* (76); Montauk, *Latham,* May 1920 (Latham); Plum Island, *Latham,* July 1931 (Latham).

Llano (1950) considered Tuckerman's transfer of *Gyrophora mammulata* Ach. to *Umbilicaria* invalid, since Tuckerman, not knowing the true identity of Acharius' species, was actually working with what is now known as *U. caroliniana* Tuck. Llano, therefore, proposed the new combination *U. mammulata* (Ach.) Llano and considered *U. mammulata* (Ach.) Tuck. *non* Llano as a synonym of *U. caroliniana.* Llano's transfer is not necessary, since, although Tuckerman was mistaken about the identity of his new combination, it was still validly published.

The species has often been considered under the names *Umbilicaria dillenii* Tuck. or *Gyrophora dillenii* (Tuck.) Müll. Arg.

Of the three *Umbilicariae* on Long Island, this species is the only one I saw growing in the field. It was found on exposed granitic boulders at the summit of a morainal hill south of Riverhead. Torrey (1933) also reported it from the Wading River region.

Distribution — Temperate element, Appalachian subelement, Appalachian-Great Lakes unit; endemic (map: Llano, 1950).

136. **Umbilicaria muhlenbergii** (Ach.) Tuck. Enum. N. Amer. Lich. 55. 1845. *Gyrophora muhlenbergii* Ach. Lich. Univ. 227. 1810.

Material seen — SUFFOLK COUNTY: Gardiner's Island, *Latham,* June 28, 1927 (Latham); Bald Hill, 3 miles S. of Calverton, *Latham,* July 1, 1937 (Latham); Yaphank, *Wm. Davis,* January 3, 1929 (Staten Island).

This species is treated in the genus *Actinogyra* by Llano (1950). It is found on boulders.

Distribution — Temperate element, Appalachian subelement, Appalachian-Great Lakes unit; Europe (Poelt, 1963); north temperate regions of Asia (map: Llano, 1950).

137. **Umbilicaria papulosa** (Ach.) Nyl. Mem. Soc. Sci. Nat. Cherb. 5: 107. 1857. *Gyrophora papulosa* Ach. Lich. Univ. 226. 1810.

Material seen — SUFFOLK COUNTY: Wading River, *Latham 2643,* July 20, 1926 (Latham).

Llano (1950) considered this species in the genus *Lasallia.*

The species apparently is unknown on Long Island outside the Wading River region. I have searched the area for *Umbilicariae* without success, but Latham (see above) and Raymond Torrey (1933) collected *U. papulosa* there.

On Cape Cod (Barnstable County, N of Woods Hole, *Brodo 3927, 3956*), I collected several specimens of this species. It was growing abundantly over almost all exposed and partially shaded boulders in the area, but was found nowhere else on the Cape.

Distribution — Temperate element, Appalachian subelement, Appalachian-Great Lakes-Rocky Mountain unit, with several west coast localities; Africa (map: Llano, 1950).

## ACAROSPORACEAE

### 37. SARCOGYNE Flot.

138. **Sarcogyne clavus** (Ram. in Lam. & DC.) Kremp. Denkschr. Kgl. Bayer. Bot. Ges. 4: 212. 1861. *Lichen clavus* Ram. in Lam. & DC. Fl. Franc. ed. 3, 2: 348. 1805.

Material seen — SUFFOLK COUNTY: *Brodo 779* (90A), *786* (90A), *1715* (133), *1803* (127), *2383* (123), *2705* (111), *2810* (106), *3354* (62), *3377* (94), *3306* (134), *3432* (134), *3848* (76); Orient, *Latham 22246,* May 3, 1914 (Latham); probably Montauk Point, *von Scheur,* July 22, 1895 (MO).

Fink (1935) treats this species in the genus *Biatorella.*

*Sarcogyne clavus* is found on exposed granitic boulders.

Distribution — Connecticut, New York, Alabama, and California (Magnusson, 1935); Minnesota, Black Hills: Temperate element, North Temperate subelement (?); Europe.

139. **Sarcogyne privigna** (Ach.) Mass. Geneac. Lich. 10. 1854. *Lecidea privigna* Ach. Meth. Lich. 49. 1803.

Material seen — SUFFOLK COUNTY: *Brodo 961* (S of 50).

The similarity of this species with *S. clavus* and *S. simplex* (as well as *S. pruinosa*) is discussed in some detail by Magnusson (1935). *Sarcogyne privigna* is similar to *S. clavus* in having a smooth, red-black apothecial disk, but differs from the latter in having small (less than 1 mm broad), concave, irregular apothecia with prominent margins.

Distribution — New Hampshire, Connecticut, and New Mexico (Magnusson, 1935); Black Hills; Europe.

140. **Sarcogyne simplex** (Dav.) Nyl. Mem. Soc. Sci. Nat. 2: 337. 1854. *Lichen simplex* Dav. Trans. Linn. Soc. Lond. 2: 283. 1793.

Material seen — SUFFOLK COUNTY: *Brodo 1907* (114), *3089* (128), *3255* (119); Orient, *Latham,* April 25, 1921 (Latham).

This species is the only *Sarcogyne* with small apothecia having rough disks. It was collected on exposed or partially shaded granitic boulders.

Distribution — Maine, Connecticut, Tennessee, Minnesota, Black Hills, Washington, Manitoba; Canadian archipelago (Thomson, 1960): Arctic-boreal element (?); circumboreal.

## 38. ACAROSPORA Mass.

141. **Acarospora fuscata** (Schrad.) Arn. Verhandl. Zool. -Bot. Ges. Wien 20: 528. 1870. *Lichen fuscatus* Schrad. Spicil. Fl. Germ. 83. 1794.

Material seen — NASSAU COUNTY: *Brodo 3513* (10). SUFFOLK COUNTY: *Imshaug 25561* (52); *Brodo 1556* (103), *1739* (126), *2373* (123), *2660* (108), *2736* (111), *3386* (94), *3449* (134), *3849* (76), *3883* (62); 16 specimens collected by Latham (Latham); Montauk, Hither Beach, *Latham 27289,* October 28, 1947 (MO).

Both Magnusson (1929) and Weber (1962) have commented on the extreme morphological variability of this species. The C + red reaction of the cortex is also somewhat variable, being strongly positive in some cases and almost negative in others.

*Acarospora fuscata* is found on granite boulders and pebbles in exposed or partially shaded localities (figure 57). In addition, one questionable specimen was collected on calcareous rock (*Latham 22332,* with *Lecanora dispersa*), and one was found growing on a storm-tide-washed boulder (hygrohaline zone) (*Brodo 2736*).

Distribution — Northern and middle states (Fink, 1935): Temperate element, North Temperate subelement; Europe; Asia (Magnusson, 1929).

## PERTUSARIACEAE

### 39. PERTUSARIA DC.

142. **Pertusaria alpina** Hepp in Ahles, Pertus. et Conotr. 12. 1860.

Material seen — SUFFOLK COUNTY: Orient, *Latham*, May 23, 1914 (Latham).

The Long Island specimen was compared with Cummings' exsiccats (Decades of North American Lichens no. 281 and Lichens Boreali-Americani no. 211), the former of which was cited by Erichsen (1941) as *P. alpina*. (These exsiccats are both mixtures of *P. pustulata*, which has 2 spores per ascus, and *P. alpina* which has 4 to 8 spores.) The Long Island specimens were morphologically and anatomically identical with these exsiccats, but the Cummings specimens contained stictic acid (by chromatography) and were K + yellow and PD + orange, whereas the Long Island specimen was K − or K+ yellowish and PD −. (The specimen was too scanty to extract for chromatography.) The ultraviolet fluorescence of the thallus (orange-pink) was the same in all the material, however.

The Latham specimen is on cedar lignum and not on bark, as is the case with the Cummings material.

Distribution — Nova Scotia, District of Columbia (Cummings' Decades no. 281), Michigan; Europe.

143. **Pertusaria amara** (Ach.) Nyl. Bull. Soc. Linn. Norm. II. 6: 288. 1872. *Variolaria amara* Ach. Kgl. Vet. -Akad. Nya Handl. 163. 1809.

Material seen — SUFFOLK COUNTY: *Brodo 890* (56), *902* (56), *1411* (83), *1417a* (83), *2806* (102), *3898* (112); Orient, Long Beach, *Latham 22338*, December 7, 1944 (Latham); Orient, *Latham 61*, May 10, 1914 (Latham).

This species is the only KC + violet *Pertusaria* on Long Island. It was always found sterile. *Pertusaria amara* grows on the bark of various trees, usually in or near bogs (figure 38).

Distribution — Nova Scotia, Quebec, Maine, Connecticut, the Smoky Mountains of Tennessee, North Carolina, Michigan, Wisconsin, Black Hills; Washington (Fink, 1935): Temperate element, North Temperate subelement; Europe.

144. **Pertusaria multipuncta** (Turn.) Nyl. Lich. Scand. 179. 1861. *Variolaria multipuncta* Turn. Trans. Linn. Soc. Lond. 9: 137. 1808.

Material seen — SUFFOLK COUNTY: *Brodo 857* (47); Greenport, *Latham 1983*, February 27, 1923 (Latham); Montauk, *Latham 3944* (sterile), April 7, 1927 (Latham); Greenport, *Latham 27287*, April 16, 1945 (Latham); Greenport, *Latham*, February 27, 1923 (Latham).

The *Pertusaria multipuncta* group seems to be a rather heterogeneous complex of KOH −, PD − taxa having one spore per ascus, and includes at least three populations having spore size ranges which do not overlap. Representatives of two of these populations are on Long Island and seem to be morphologically distinct as well (see key). This group certainly needs further study.

These specimens were found on the bark of various deciduous trees.

Distribution — No comment seems warranted until the taxonomy of the group is clarified.

145. **Pertusaria propinqua** Müll. Arg. Flora 67: 273. 1884.

Material seen — SUFFOLK COUNTY: *Brodo 3276* (119).

This species, though represented by only a single collection from Long Island, was found abundantly in the locality where it occurred.

The description of *P. rubescens Erichs.* (Erichsen, 1941) agrees very well with the Long Island material except for the lack of zoned spore walls in the former. The type specimen of *P. rubescens* is from a hickory in the New Jersey coastal town of "Sea Girton" (Sea Girt?). This exactly parallels the Long Island collection in a coastal oak-hickory woods on *Carya* cfr. *tomentosa*. Without having seen authentic material of *P. rubescens*, I am not listing it as a synonym.

Although *P. propinqua* was described from a specimen on granite, it appears to be identical with the original collection of *P. torquata* Müll. Arg., which was on bark. I saw the original material of both taxa (in herb. MICH). Since the species is poorly known, a short description of the Long Island material follows:

Thallus dark ashy grey, smooth to rugose, becoming thick and cracked; fruit warts smooth or rough, becoming distinctly constricted at the base in maturity, lighter in color than the thallus (appearing as if their top surfaces were rubbed), 1-2 mm in diameter; ostioles single to many, usually large, ashy to black, usually somewhat depressed; epithecium cinereous, turning violet in KOH; spores 8, irregularly arranged in the ascus, 89-96 x 40-41 μ; spore walls zoned. Medulla of fruit warts and thallus PD + yellow, KOH + deep blood red. Norstictic acid demonstrated in KOH.

Distribution — Temperate element, Coastal Plain subelement (Fink, 1935 sub *P. marginata* Nyl.); endemic.

146. **Pertusaria subpertusa** sp. nov.

Material seen — SUFFOLK COUNTY: *Brodo 1035* (112), *1436* (83), *1674* (88), *2163* (102), *2289* (87).

> *Thallus virido-cinerous, continuus, rimae acquirendus, rugosus, ultimus minutissime verrucosus; verrucae fructae plerumque disperses, (0.5-)0.65-1.10(-1.30) mm diam., leves, hemisphericales ad subplaniferes; colorae thallis, basibus perspicues constrictis; ostioles 3-7 per verruca fructus, obscures vel pallides, tantum depressiuscules, 0.05 ad 0.15 mm diam. Paraphyses tenuisimae (± 1 μ) ramiosissimae.*

*Asci 193-287 x 35-42 μ, parietis crassa. Sporae hyalinae, non septatae, 101-144(-161) x 35-45 μ, parietes 4-10 μ crassae, zonates et canaliculates, 2 vel rarissime, 1 per ascus. Epithecium obscurum, KOH + violaceum. Medulla verrucarum fructus et thalli PD + rubro-aurantiaca, KOH + luteus transeuns rubidus, C −, KC −. Materiae chemicae: acidum fumarprotocetraricum et acidum salacinicum. Corticola.*

Holotype: SUFFOLK COUNTY: Three Mile Harbor, on Old Northwest Road 0.7 miles from junction with Alewife Brook Road, *Brodo 1035*, July 12, 1960, on bark of *Acer rubrum* in bog (MSC) (figures 84, 85).

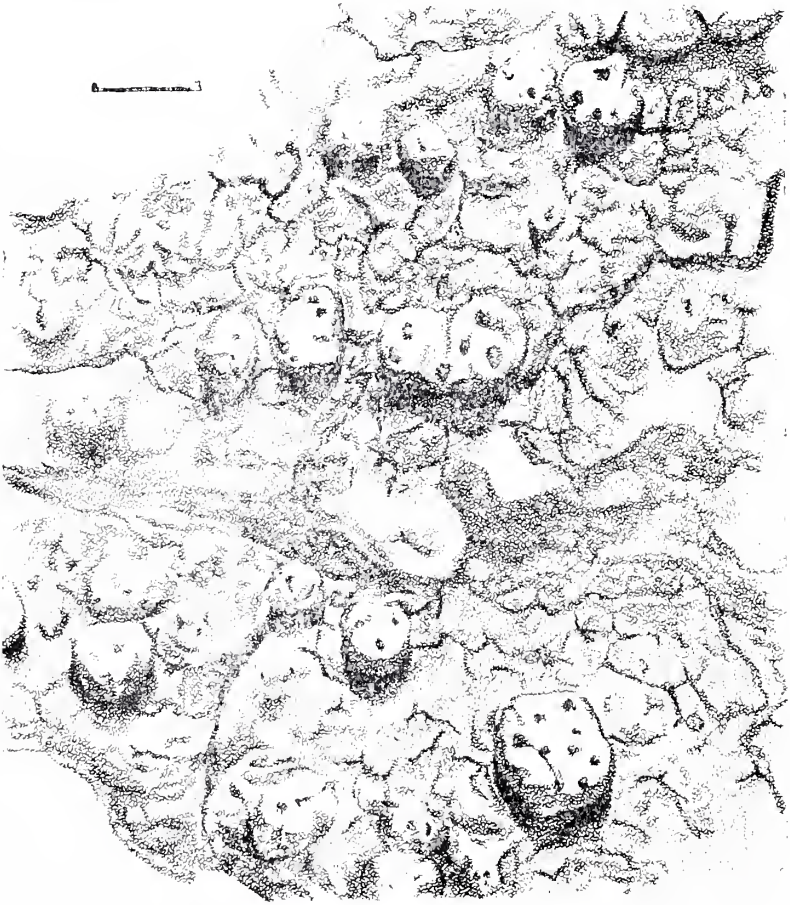

FIGURE 84. *Pertusaria subpertusa* (holotype). Scale equals 1 mm. Drawing by Brenda Carter Haas.

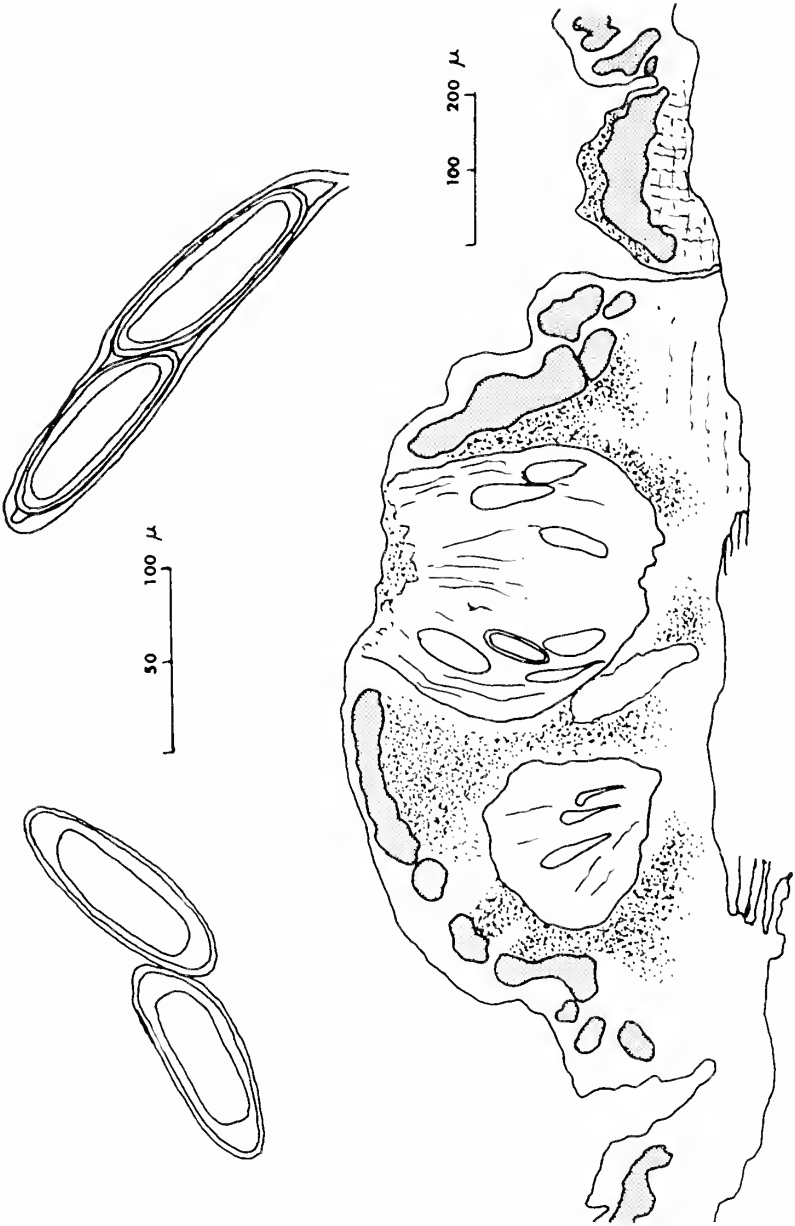

FIGURE 85. *Pertusaria subpertusa* (holotype). Spores and ascus mounted in water. Section of fruiting wart shows two apothecia, one in median view. Fine stippled shading indicates algal layer; coarse stippling indicates dark to opaque areas in the fungal tissue. Drawings made with the aid of a camera lucida apparatus.

Thallus grey to greenish grey, continuous, becoming cracked, rugose, and finally minutely verrucose; fruit warts mostly scattered, (0.5-)0.65 -1.10 (-1.30) mm in diameter, smooth, hemispherical to flattened, the same color as the thallus, distinctly constricted at the base; ostioles 3 to 7 per fruit wart, dark or pale, only slightly depressed, 0.05-0.15 mm in diameter. Paraphyses very slender (ca. 1 µ), much branched; asci thick-walled, 193-287 x 36-45 µ; spores hyaline, nonseptate, 101-144(-161) x 35-45 µ, walls 4-10 µ thick, zoned and channelled, 2 or, very rarely, 1 spore per ascus; epithecium dark, KOH + violet. Medulla of fruit warts and thallus PD + red-orange, KOH + yellow, becoming dark red, C −, KC −; fumarprotocetraric acid present. Corticolous.

The Long Island material is rather uniform in morphology, but does show some variation in the color of the ostioles (becoming pale in some specimens) and in the depth and breadth of the ostiole depressions (often becoming very deep and up to 0.20 mm broad in maturity).

The epithet "*subpertusa*" is used for this new species to emphasize its similarity in general appearance and spore type to *P. pertusa* (L.) Tuck. *Pertusaria pertusa* has larger spores (145-229 x 40-82 µ) and contains stictic acid. All other North American KOH + red *Pertusariae* have norstictic acid rather than salacinic acid and none, to my knowledge, contains fumarprotocetraric acid as well.

Of the four Long Island specimens, three were found growing on the bark of *Acer rubrum* in bogs or swamps and one was on *Quercus velutina* bark. I also collected a specimen in southern New Jersey (Atsion, *Brodo 3587*) on a black oak just outside a bog.

Distribution — New Jersey; endemic.

147. **Pertusaria trachythallina** Erichs. in Degel. Ark. Bot. 30A(1): 36. 1940.

Material seen — SUFFOLK COUNTY: 31 specimens collected by Imshaug and/or Brodo.

This species is discussed at length by Erichsen in his original description.

The species is found on the bark of various deciduous trees, usually at breast height. It can be considered a member of the black oak, breast height community, although it has also been found on *Quercus alba* and *Fagus grandifolia.*

Distribution — Maine; endemic.

148. **Pertusaria tuberculifera** Nyl. Act. Soc. Scien. Fenn. 7: 448. 1863.

Material seen — QUEENS COUNTY: Ridgewood, *G. B. Brainerd,* (1866?) (BKL 031906); Ridgewood, *G. B. Brainerd,* (1866?) (BKL). SUFFOLK COUNTY: 24 specimens collected by Imshaug and/or Brodo; Montauk, *Latham 27286,* April 17, 1946 (Latham); Springs, East Hampton, *Latham 28321,* February 9, 1949 (Latham).

*Pertusaria tuberculifera* belongs to Erichsen's subgenus *Eupertusaria* section *Insensibiles.* The material treated here was probably considered under the name *P. leioplaca* (Ach.) Lam. & DC. in Fink (1935) where *P. leioplaca* is described as having 4 to 8 spores. Erichsen (1935) regards *P. leioplaca* to be 4-spored alone, or rarely 2, 3, or 5-spored. The Long Island specimens are all dominantly 8-spored, with the 4 spore condition occurring frequently in the same apothecia. *Pertusaria tuberculifera* and *P. tetrathalamia* (Fée) Nyl. are often considered to be conspecific, but Erichsen (1936) pointed out that the latter has only four spores per ascus.

Since the species apparently is fairly common and yet poorly known, a more detailed description of the Long Island material may have some value:

Thallus dark ashy grey, continuous, smooth, becoming rugose and verrucose; fruit warts large, 1-3 mm in diameter, irregular, crowded, distinctly constricted at the base in maturity; spores 4 to 8, hyaline, (30-)34-40 x (55-)62-80(-97) μ, walls 6 μ thick, zoned, smooth. Medulla of fruit warts KOH −, PD −, KC −, C −. Thallus UV + orange fluorescence.

Distribution — South America (type locality), West Indies (Imshaug, 1957b), New Jersey (see above): Tropical element, Coastal Plain subelement (?).

149. **Pertusaria velata** (Turn.) Nyl. Lich. Scand. 179. 1861. *Parmelia velata* Turn. Trans. Linn. Soc. Lond. 9: 143. 1808.

Material seen — SUFFOLK COUNTY: *Brodo 1417B* (83), *2158* (102), *2138* (102), *3101* (122), *3278* (119); Riverhead, *Latham*, May 16, 1960 (Latham); Three Mile Harbor, East Hampton Twp., *Ogden 5405*, May 11, 1954 (NYS).

The C + red disks and thallus and the lecanorine apothecia of this species give it a superficial similarity with a species of *Ochrolechia*. However, the very large spores, one per ascus, easily refer it to *Pertusaria*.

*Pertusaria velata* is usually found in humid forests or bogs on the bark of deciduous trees. Almborn (1948) stated that the species is typical of the *Pyrenula nitida* society on *Fagus* and has an oceanic affinity. This would be borne out to some extent by its "oceanic" distribution on Long Island.

Distribution — Nova Scotia, Maine, Connecticut, Tennessee, North Carolina, Oklahoma, Michigan, Indiana, Iowa, Wisconsin, Minnesota, Black Hills, Washington, coastal Alaska, British Columbia: Temperate element, Oceanic subelement (?); Europe (oceanic), Asia, Africa, South America (Almborn, 1948).

150. **Pertusaria xanthodes** Müll. Arg. Flora 67: 286. 1884.

Material seen — SUFFOLK COUNTY: 80 specimens collected by Imshaug and/or Brodo; 10 specimens collected by Latham (Latham).

The Long Island material agrees well with Müller's type specimen from Texas, which I saw in Geneva. The thallus of the type was yellow, having ampliariate fruit warts, each with one pale, more or less depressed ostiole and containing one or two apothecia. There were 2 spores per ascus and walls were clearly zoned, often with one of the walls roughened on the inner surface.

This species is easily confused with certain forms of *Pertusaria pustulata* (Ach.) Duby, and was almost surely considered under this name in Fink (1935). *Pertusaria pustulata* is characterized by spores with thin, smooth, unzoned walls, and by dark ostioles. In addition, the epithecium of *P. pustulata* generally turns KOH + violet.

Since my material is rather variable, I will break down its description as follows:

*Constant characters:*

1. on bark
2. spores 2 per ascus
3. spores 30-45 x 70-120 μ
4. spore walls zoned, thick, rough
5. stictic acid present
6. UV fluorescence pink-orange

*Variable characters:*

1. ostiole color (pale or dark)
2. concentration of stictic acid
3. thickness of thallus
4. degree of density of fruit warts

*Almost constant characters:*

1. yellow color of thallus
2. ampliariate fruit warts
3. hypophloedal thallus

*Never seen:*

1. spore walls thin, smooth
2. epithecium KOH + violet

*Pertusaria xanthodes* is found on the bark of various species of deciduous trees, usually in well-lighted situations.

Distribution — Cape Cod (Massachusetts), New Jersey, Texas (type locality), West Indies (Imshaug, 1957b): Temperate element (?), Coastal Plain subelement; endemic.

### 40. MELANARIA Erichs.

151. **Melanaria macounii** Lamb, Ann. Rep. Nat. Mus. Can. 132: 286. 1954.

Material seen — SUFFOLK COUNTY: *Brodo 903* (56), *1858* (117), *2162* (102), *2804* (102), *3281* (119); Napeague, *Latham 2848*, March 1, 1927 (Latham).

*Melanaria macounii* resembles *Pertusaria pertusa* in many respects. Both have polycarpous, smooth, fruit warts of the same color as the thallus, both have two spores per ascus, and of approximately the same size range, and both contain stictic acid. In *M. macounii*, however, the spores are distinctly radiately channeled and often are brownish, turning sordid violet in KOH. (The hyaline spores, which predominate in the Long Island material, do not give this KOH reaction.)

The species is found on the bark of various deciduous trees in humid forests or bogs.

Distribution — Nova Scotia (type locality); Great Lakes region (seen in herb. MSC); endemic.

## LECANORACEAE

### 41. IONASPIS Th. Fr.

152. **Ionaspis odora** (Ach. in Schaer.) Th. Fr. Lich. Scand. 1: 273. 1871. *Gyalecta odora* Ach. in Schaer. Lich. Helv. Spic. 2: 80. 1826.

Material seen — SUFFOLK COUNTY: Shelter Island, *Latham 22881,* October 26, 1944 (Latham).

Latham's specimen agrees perfectly with the description of the species given by Magnusson (1933) in his monograph of the genus. Although Tuckerman (1882) cited a specimen of *I. odora* from New Hampshire, Magnusson (1933) stated that the species is "most likely not in North America." *Ionaspis lavata* Magn. was described from a Merrill collection from Mount Rainier, Washington. This species, however, differs from *I. odora* in having confluent, brownish apothecia, rather than scattered pale pink or yellow-brown apothecia. For some unknown reason, the type specimen of *I. lavata* is absent from its packet (in herb. FH) and I therefore have not seen it.

The species is listed under *Lecanora* by Fink (1935).

In addition to the reports of this species from the White Mountains of New Hampshire (Tuckerman, 1882), I collected a specimen from Cape Cod, Massachusetts (*Brodo 4399B*), on a granite boulder in partially shaded oak woods, a similar habitat to that of the Long Island collection. Magnusson (1933, p. 20), however, states its ecology as "on granitic stone on the banks in brooks and lakes at least part of the year wetted by water."

Distribution — New Hampshire (Tuckerman, 1882), Massachusetts (see above); Europe ("boreal-alpine species") (Magnusson, 1933).

### 42. LECANORA Ach.

153. **Lecanora atra** (Huds.) Ach. Lich. Univ. 344. 1810. *Lichen ater* Huds. Fl. Angl. 445. 1762.

Material seen — SUFFOLK COUNTY: Montauk, *Latham 24167,* May 4, 1926 (Latham).

The species is usually found on stone or tree bark, but is also known to occur on lignum on occasion (Hillman and Grummann, 1957; Erichsen, 1957).

Distribution — Alaska, Washington, Idaho, Quebec, Michigan, Minnesota, Black Hills, Arizona: Temperate element (?), North Temperate subelement, reported from European and Asian arctic by Lynge (1938, 1928).

154. **Lecanora caesiocinerea** Nyl. in Malbr. Bull. Soc. Amis Sci. Nat. Rouen 5: 320. 1869.

Material seen — NASSAU COUNTY: *Brodo 3505A* (10). SUFFOLK COUNTY: *Brodo 3871* (62).

The Long Island specimens of *L. caesiocinerea* agree well with Magnusson's description of this species (Magnusson, 1939) except that they have moniliform rather than submoniliform paraphyses and spores which are slightly smaller (15-20 μ long rather than over 20 μ long).

This species is very similar to *L. cinerea* and perhaps should be included there. It differs in the slightly shorter pycnoconidia, the KOH − thalline reaction, and the fewer apothecia. (See additional notes under *L. cinerea*.)

*Lecanora caesiocinerea* grows on exposed or partially shaded granitic boulders.

Distribution — Nantucket Island (Massachusetts) (*Brodo 4004*), Black Hills, Arizona; Europe.

155. **Lecanora caesiorubella** Ach. Lich. Univ. 366. 1810.
subsp. **lathamii** Imsh. & Brodo, Nova Hedw. 12:24. 1966.

Material seen — NASSAU COUNTY: *Brodo 559* (13). SUFFOLK COUNTY: 103 specimens collected by Imshaug and/or Brodo; 19 specimens collected by Latham (Latham); Eastport, Schrenk, June 26, 1894 (MO); Greenport, *Latham 18*, August 2, 1914 (FH); Greenport, *Latham 195*, March 20, 1914 (FH).

All the Long Island material of this species belongs to subspecies *lathamii*. Since a complete discussion of *L. caesiorubella* and other members of the *L. pallida* group has recently been published (Imshaug and Brodo, 1966), it suffices to say that this subspecies of *L. caesiorubella* is characterized by a C + orange-yellow disk and by the presence of protocetraric acid and norstictic acid in apothecial sections, the latter being more or less confined to the stipe.

This subspecies of *L. caesiorubella* is found on the bark of deciduous trees, usually in exposed areas.

Distribution (subspecies *lathamii*) — Nova Scotia to Texas: Temperate element, Coastal Plain subelement; endemic. The species as a whole has a tropical-temperate distribution (including South America, Africa) (Imshaug and Brodo, 1966).

156. **Lecanora chlarotera** Nyl. Bull. Soc. Linn. Norm. II. 6: 274. 1872.

Material seen — NASSAU COUNTY: Cold Spring, *Grout,* April 1, 1900 (BKL). SUFFOLK COUNTY: 83 specimens collected by Imshaug and/or Brodo; 14 specimens collected by Latham (Latham); Montauk Point, Easthampton Twp., northeast of Prospect Hill between Great Pond and Oyster Pond, *Ogden 5411*, May 12, 1954 (MSC).

This species is very common on Long Island, and it is extremely variable. The color of the disks, for example, varies from a pale yellow-brown to a dark chocolate brown; the margins are usually somewhat crenate, but sometimes are quite smooth and even; the epithecium is usually conspicuously granular but sometimes is almost without granules. Large, irregular, colorless crystals, however, always can be found in the amphithecium, particularly in the margins, and the epithecial granules and pigment always dissolve completely in KOH.

A number of corticolous species belonging to the *Lecanora subfusca* group have been reported from eastern or northern United States and, in an effort to show the differences between these species and *L. chlarotera,* a key to their separation follows.

This key is mainly based on the work of Magnusson (1932) to which I have added information which has been published since then, as well as some of my own observations.

1. Apothecial margin cortex 50-100 μ thick, strongly gelatinous. Exclusively on the bark of *Fagus* (see Lamb, 1954) (Nova Scotia, Maine) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *L. glabrata* Ach.
1. Apothecial margin cortex less developed, 8-35(-50) μ thick . . . . . . . . 2
    2. Cortex little developed, 8-15 μ thick, KOH −; crystals lacking in medulla. Epithecium inspersed with crystals, PD + red (see Degelius, 1941) (Maryland, West Virginia) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *L. cinereofusca* Magn.
    2. Cortex 20-35(-50) μ thick, inner portion distinctly delimited, KOH + strong yellow; medulla usually with heaps or clumps of crystals . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
3. Upper part of hymenium (epithecium) coarsely or finely granular . . . 5
3. Upper part of hymenium (epithecium) without granules, more or less reddish brown . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
    4. Apothecia thick, urn-like, margin coarsely crenulate (Maine, Michigan, Manitoba) . . . . . . . . . . . . . . . . . . . . . . . . . *L. subrugosa* Nyl.
    4. Apothecia thin, margin finely crenulate or smooth (Maine, New York, Connecticut, Tennessee, Michigan, Oklahoma, Manitoba, Quebec) . . . . . . . . . . . . . . . . . . . . . . . . . . *L. subfuscata* Magn.
5. On the bark of conifers . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6
5. On the bark of broadleaf trees . . . . . . . . . . . . . . . . . . . . . . . . . 7
    6. Thallus leprose or finely granular; epithecium PD −; disks dark red-brown; margins with a yellowish tint (Maine, Tennessee) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *L. pinastri* (Schaer.) Magn.
    6. Thallus smooth or rugose; epithecium PD + orange crystals. Spores (13-)17-20 x 8-13 μ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *L. insignis* Degel. (See discussion of *L. degelii.*)
7. Apothecial margin PD + red (substance unknown) (Connecticut, New York, Nova Scotia, Saskatchewan, Quebec) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *L. chlarona* (Ach.) Nyl.
7. Apothecial margin PD − or PD + pale yellow . . . . . . . . . . . . . . . . 8
    8. Epithecium PD + red, with the production of orange acicular crystals (substance unknown). Apothecial disks strongly convex; margins beaded and often discontinuous; spores 12-14 x 7-8 μ. (Long Island, North Carolina, and Tennessee) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *L. degelii* Schauer & Brodo (see p. 217).

8\. Epithecium PD −. Apothecial disks flat to somewhat convex; margins sometimes crenulate, but always continuous; spores 10-13 x 6-7 µ. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *L. chlarotera* Nyl.

*Lecanora chlarotera* is found on the bark of various deciduous trees throughout the island.

Distribution — North American distribution largely unknown, but undoubtedly common, at least in the east; coastal Massachusetts, New Jersey, Arizona; Europe.

157\. **Lecanora cinerea** (L.) Somm. Suppl. Fl. Lapp. 99. 1826. *Lichen cinereus* L. Mantissa 1:132. 1767.

Material seen — NASSAU COUNTY: *Brodo 3505B* (10). SUFFOLK COUNTY: *Brodo 1216* (100A), *2220* (61), *2664* (108), *2745* (111), *2808* (106), *3355* (62), *3419* (134), *3425* (134), *3433* (134), *3854* (76); Orient, *Latham 960*, April 19, 1924 (Latham); Shelter Island, *Latham 24374*, April 1, 1946 (Latham, MO).

There are two Long Island species of *Lecanora* in the section *Aspicilia*, *L. cinerea* and *L. caesiocinerea*, and they appear to be very closely related if, in fact, they are not conspecific.

In Europe, *L. cinerea* and *L. caesiocinerea* are separated easily by their differing reactions with KOH and by their pycnoconidia, which do not even come close to overlapping in length. *Lecanora cinerea* has a rapid KOH + yellow to red reaction (due to norstietic acid) and pycnoconidia 16 to 20µ long, whereas *L. caesiocinerea* has a KOH − (or dirty reddish brown) reaction and pycnoconidia 6 to 12µ long (Hillman and Grummann, 1957).

On Long Island, the situation is much more complicated. To begin with, instead of two, there are three divisions based on KOH reactions. KOH + red (norstictic acid), KOH + yellow (stictic acid), and KOH − Secondly, there are three size classes of pycnoconidia, each class correlated with a KOH reaction type. Thirdly, the three pycnoconidial size classes overlap, especially in the KOH positive groups. The KOH + red group on Long Island has pycnoconidia on the small side of the European scale, the KOH negative group has pycnoconidia on the large side of the scale, and the KOH + yellow group (the one for which there seems to be no European parallel), introduces an intermediate size range.

Since stictic acid and norstictic acid commonly shift within species, it is reasonable to presume that the stictic acid specimens represent North American chemical variants of the well known *L. cinerea*, which normally produces norstictic acid. The fact that their pycnoconidial sizes overlap considerably adds to the likelihood of the two variants being conspecific.

The KOH − material apparently is *L. caesiocinerea* with somewhat larger pycnoconidia than seen in European specimens.

*Lecanora cinerea* is found on exposed or partially shaded granitic rocks (figure 58).

Distribution — Nova Scotia, Maine, Michigan, Iowa, Minnesota, Arizona, Black Hills, Washington, Alaska, Arctic Canada; Arctic-boreal element; Europe; Asia (Zahlbruckner, 1930; Lynge, 1928).

158. **Lecanora conizaea** (Ach.) Nyl. Flora 55: 249. 1872. *Lecanora expallens* $\beta$. *L. conizaea* Ach. Lich. Univ. 374. 1810.

Material seen — QUEENS COUNTY: Ridgewood, *G. B. Brainerd,* (1866?) (BKL 031909). NASSAU COUNTY: Cold Spring, *Grout,* April 1, 1900 (BKL). SUFFOLK COUNTY: *Imshaug 25749* (132), *25770* C (121); *Brodo 1706* (133), *2374* (123), *2585* (97), *2831* (115); Orient, *Latham 100,* May 23, 1914 (Latham); Orient, *Latham 22257,* May 20, 1914 (Latham); Orient Point, *Latham,* April 11, 1910 (NYS).

This species is very similar to *Lecanora symmicta* (Ach.) Ach. in many respects. The thallus is whitish green to yellow-green, verruculose to granulose, the disks are yellow to buff or brown, and the spores are of the same size and shape. In *L. symmicta,* however, the apothecial margins which are at first smooth, pale, and usually transluscent, rapidly disappear with the apothecial disks becoming strongly convex. *Lecanora conizaea* has white or thallus-colored, smooth apothecial margins which soon become granulose-sorediate, and finally disappear, leaving the disks more or less flat or slightly convex. Some apothecia always show the typical granulose lecanorine margin.

*Lecanora conizaea* grows on the bark of various trees, usually in exposed habitats, especially near the ocean.

Distribution — Maine, Tennessee, North Carolina, Black Hills; Europe; Asia (Lynge, 1928).

159. **Lecanora cupressi** Tuck. in Nyl. Flora 55: 251. 1872.

Material seen — SUFFOLK COUNTY: Montauk, *Latham 3662,* April 28, 1926 (Latham).

The species was found only once, and was growing on wood of what seems to be *Juniperus.*

Distribution — Massachusetts to Florida and Louisiana (Fink, 1935): Temperate element, Coastal Plain subelement; endemic.

160. **Lecanora degelii** Schauer & Brodo, Nova Hedw. 11: 528. 1966.

Material seen — SUFFOLK COUNTY: Napeague, *Latham 2847,* March 1, 1927 (Latham).

The Latham specimen was compared with the type of *L. insignis* kindly sent to me by Dr. Degelius, and the two agreed in all respects except spore size and substrate type. The spores of the Long Island material, from oak bark, were smaller than those of the type from the bark of *Abies.*

Poelt and Schauer discovered a correlation between spore size and substrate in specimens of *L. insignis* collected recently by the latter in Austria. Small-spored specimens were from deciduous trees and larger spored specimens were from coniferous trees (Poelt, and Schauer, pers. comm.). Degelius' specimens from the Smoky Mountains showed the same correlation. The small-spored population was therefore described as a new species (Schauer and Brodo, 1966).

The beaded, almost disappearing margin and the production of PD + orange needles from the epithecium were both evident in the Long Island specimen. The species is very similar to *L. chlarotera,* but the larger spores and PD + epithecium of *L. degelii* easily distinguish the two.

Distribution — Smoky Mountains of Tennessee and North Carolina; Austria and Bavaria (Schauer and Brodo, 1966).

161. **Lecanora dispersa** (Pers.) Somm. Suppl. Fl. Lapp. 96. 1826. *Lichen dispersus* Pers. Neue Ann. Bot. 1: 27. 1794.

Material seen — KINGS COUNTY: *Brodo 4538* (1). NASSAU COUNTY: *Brodo 3194* (7). SUFFOLK COUNTY: *Brodo 2798* (84), *2839* (115); Orient, Long Beach, *Latham 22332,* December 7, 1944 (Latham).

The Long Island material of this species agreed with both American and European specimens examined at the Farlow herbarium. The apothecial margins of *L. dispersa* are usually described as pruinose or even powdery, but in my observations this is not always the case.

The species is similar to *L. hageni* in many respects, and is often included in that species. *Lecanora hageni,* however, generally shows a distinct, thick gelatinous apothecial margin cortex, whereas *L. dispersa* is essentially without a cortex of any kind. The latter seems to be confined to calcareous rock and mortar, and the former is most frequently found on bark. Both species are commonly found growing with species of *Caloplaca.*

On Long Island, *L. dispersa* was found only on mortar and brick. It has the distinction of being the only species found in the westernmost collection locality on the island . . . in the heart of thickly populated Brooklyn. It is well known in Europe as being a highly city-tolerant species (Erichsen, 1957).

Distribution — Michigan, Indiana, Minnesota, Black Hills, Arizona, Manitoba, Canadian archipelago: Arctic-boreal element; circumboreal.

162. **Lecanora hageni** (Ach.) Ach. Lich. Univ. 367. 1810. *Lichen hageni* Ach. Lich. Suec. Prodr. 57. 1798

Material seen — SUFFOLK COUNTY: *Brodo 3361* (S of 97).

The similarity of this species to *L. dispersa* has been discussed in connection with the latter. *Lecanora hageni* was collected only once, on a roadside *Ulmus* growing with *Xanthoria fallax* and *X. parietina.*

Distribution — Nova Scotia, Maine, Connecticut, Michigan, Indiana, Minnesota, Black Hills, Rocky Mountains (seen in herb. MSC), Washington, Alaska: Temperate element, North Temperate subelement; Europe; Asia (Magnusson, 1940).

163. **Lecanora laevis** Poelt, Ber. Bayer. Bot. Ges. 29: 64. 1952.

Material seen — SUFFOLK COUNTY: *Brodo 2829* (115); Orient, *Latham 57,* May 23, 1914 (Latham); Orient, *Latham 817,* October 29, 1916 (Latham); Orient, *Latham 7421,* June 5, 1933 (Latham); Orient, *Latham 7424* (*22245*), June 5, 1933 (Latham); Orient, Long Beach, *Latham 3940,* March 27, 1927 (Latham); Orient, *Latham,* March 3, 1915 (Latham); Orient Point, *Latham 6,* April 18, 1910 (NYS); Flanders, *S. Smith 34927,* August 1, 1962 (NYS).

*Lecanora laevis* bears an external resemblance to *L. allophana* (Ach.) Nyl. which, however, has a thick, gelatinous apothecial margin cortex and seems to be exclusively European. Both Lamb (1954) and Laundon (1958) have presented detailed descriptions of *L. laevis.* On Long Island it seems to be restricted to the aerohaline stratum on the eastern Long Island coastline.

Distribution — Nova Scotia; southern Europe and North Africa (Lamb, 1954); Ireland (Laundon, 1958).

164. **Lecanora muralis** (Schreb.) Rabenh. Deutschl. Krypt. Fl. 2: 42. 1845. *Lichen muralis* Schreb. Spic. Fl. Lips. 130. 1771.

Material seen — SUFFOLK COUNTY: Gardiner's Island, *Latham 36807,* May 23, 1923 (Latham).

This species, common on limestone outcrops in the northeast and elsewhere, probably was introduced into Long Island with a shipment of limestone building materials. It is found nowhere else on the island, probably due to the lack of naturally-occurring limestone.

Distribution — Connecticut, central New York, Michigan, Iowa, Minnesota, Oklahoma, Black Hills, Arizona, Idaho, Washington, Alaska: Temperate element, North Temperate subelement; Europe; Asia (Zahlbruckner, 1930; Magnusson, 1940).

165. **Lecanora rubina** (Vill.) Ach. Lich. Univ. 412. 1810. *Lichen rubinus* Vill. Hist. Pl. Dauph. 3: 977. 1789.

Material seen — SUFFOLK COUNTY: *Brodo 1804* (127), *3443* (134).

This species was found on exposed granitic boulders within ¼ mile of Long Island Sound.

Distribution — Connecticut, Ontario, Michigan, Iowa, Minnesota, Black Hills, Arizona, Idaho, Washington, Alaska, Northern Saskatchewan: Arctic-boreal element, circumboreal (Ahti, 1964).

166. **Lecanora subintricata** (Nyl.) Th. Fr. Lich. Scand. 1: 265. 1871. *Lecanora varia* var. *subintricata* Nyl. Flora 51: 478. 1868.

Material seen — SUFFOLK COUNTY: *Imshaug 25616 B* (116); *Brodo 795* (90B), *2600* (84), *3859* (57).

*Lecanora subintricata,* although listed by Hale and Culberson (1960), was not listed by Fink (1935) and has not been mentioned in any recent North American literature which I have seen. The Long Island material fits the European descriptions very well.

*Lecanora fuscidula* Degel. is a very similar species from Maine (Degelius, 1940). I examined the type specimen of *L. fuscidula* kindly sent to me by Dr. Degelius and found it to differ from *L. subintricata* chiefly in having a well-developed, gelatinous, apothecial margin cortex, about 16-20 μ thick. In addition, the thallus of *L. fuscidula* is scurfy, ashy, and evanescent, whereas that of *L. subintricata* is greenish and granulose, and usually is well developed.

As in Europe (see Hillman and Grummann, 1957) the Long Island *L. subintricata* was found on old wood and pine bark. It is often associated with *Lecidea aeruginosa.*

Distribution — Europe; Asia (Vainio, 1928).

167. **Lecanora symmicta** (Ach.) Ach. Syn. Lich. 340. 1814. *Lecanora varia θ. L. symmicta* Ach. Lich. Univ. 379. 1810.

Material seen — SUFFOLK COUNTY: *Brodo 59-261* (54).

*Lecanora symmicta* is very similar to *L. conizaea.* It is placed with *Lecanora* rather than in *Lecidea,* as is often done, due to its apparent close ties with the other members of the *Lecanora varia* group, many of which lose their margins in maturity.

*Lecanora symmicta* often resembles *Lecidea vernalis* in certain respects, but the latter has hemispherical apothecia in maturity, and larger spores (15-19 μ long).

Distribution — Maine, Connecticut, North Carolina, Tennessee, Michigan, Minnesota, Black Hills, Arizona, Washington, Manitoba; northeast Greenland (Lynge, 1940c): Arctic-boreal element (?); Europe; Asia (Vainio, 1928).

168. **Lecanora** cfr. **varia** (Ehrh.) Ach. Lich. Univ. 377. 1810. *Lichen varius* Ehrh. Pl. Crypt. Exs. no. 68. 1785.

Material seen — SUFFOLK COUNTY: Orient, Long Beach, *Latham 3917,* March 27, 1927 (Latham).

This specimen differs from all the other *Lecanorae* on Long Island, not only in morphology but also in substrate (on bone). Bruce Fink, to whom this specimen was sent for identification many years ago, called it *L. varia.* The fact that its apothecial margin has a well developed, gelatinous cortex puts it close to *L. varia.* The Long Island specimen, however, contains atranorin and is therefore KOH + yellow. Most authors regard *L. varia* as a KOH- species, although some (e.g., Hillmann and Grummann, 1957) regard *L. varia* as either KOH + or KOH −. The Long Island material also seems to be very close to *Lecanora sarcopsis* (Wahlenb. in Ach.) Röhl. (*L. effusa* [Pers.] Ach.) which, however, usually has an indistinct, ungelatinized apothecial cortex and slightly pruinose apothecial disks.

Distribution — Connecticut, North Carolina, Indiana, Iowa, Wisconsin, Minnesota, Black Hills, Arizona, Washington, Alaska: Temperate element, North Temperate subelement; Europe; Asia (Lynge, 1928).

169. **Lecanora** sp.

Material seen — SUFFOLK COUNTY: *Brodo 1189* (101).

This specimen is in the *L. subfusca* group, and closely resembles *L. subfuscata* Magn. except that it does not have large crystals in the amphithecium and has a light grey rather than a dark grey to cinereous thallus. The thallus is granulose to almost sorediate in spots and smooth at the edges.

The apothecial disks are deep mahogany brown, flat, 0.5-1.0 mm in diameter, with smooth to slightly crenulate margins. The epithecium is brownish (remaining so in KOH) and is not inspersed with granules (as in *L. chlarotera*). The amphithecium, although it does not have large, colorless crystals, is filled with smaller crystals. The apothecial cortex is 16-25 μ thick and appears to be paraplechtenchymatous. The medulla and cortex are PD + yellow and KOH + yellow. The spores are 9-13 x 6-7 μ. It was found on the bark of *Quercus alba* near the tree base.

## 43. OCHROLECHIA Mass.

170. **Ochrolechia parella** (L.) Mass. Ricerch. Auton. Lich. 32. 1852. *Lichen parellus* L. Mantissa 1: 132. 1767.

Material seen — SUFFOLK COUNTY: *Imshaug 25708* (68), *25853a* (86); *Brodo 59-252* (67), *1112* (78), *1619* (69), *2040* (45), *2096* (78), *2102* (78), *3809* (66); Riverhead, *Latham 7787A*, May 1 1937 (Latham); Riverhead, *Latham 36865*, May 16, 1960 (Latham); Riverhead, *Latham 36932*, May 16, 1960 (Latham); Bay View, *Latham 36953B*, October 8, 1960 (Latham); Orient, Long Beach, *Latham*, April 26, 1920 (Latham); Greenport, *Latham 200*, September 27, 1914 (FH); Eastport, *Schrenk 15*, June 24, 1894 (MICH).

*Ochrolechia parella*, the commonest species of *Ochrolechia* on Long Island, was also found in southern New Jersey and on Cape Cod. It is easily distinguished from the other species of *Ochrolechia* on Long Island by its C — thallus and its production of variolaric acid. This substance is most easily demonstrated by introducing KOH onto a water mount of apothecial sections and observing the thin, colorless needles, often in radiate clusters, which are produced in the epithecial and amphithecial regions.

Verseghy (1962) states that *O. parella* is strictly saxicolous, but the Long Island specimens, all corticolous, compared favorably in morphology and chemistry with the type of *O. parella* f. *striata* Vers. (leg. Szatala, Bulgaria, in herb. F). In Verseghy's monograph, my material keys down to *O. pallescens* (L.) Mass. (see discussion under *O. rosella*).

*Ochrolechia parella* is found on acid bark of both broad-leaf and coniferous trees, most frequently in bogs (figure 44). It has also been seen on old wood.

Distribution — North American distribution unclear; Asia (Zahlbruckner, 1930).

171. **Ochrolechia rosella** (Müll. Arg.) Vers. Beih. Nova Hedw. 1: 110. 1962. *Pertusaria pallescens* var. *rosella* Müll. Arg. Flora 62: 483. 1879.

Material seen — SUFFOLK COUNTY: *Brodo 2147* (102).

Verseghy (1962) published the combination *Ochrolechia rosella*, using *Pertusaria pallescens* var. *rosella* Müll. Arg. (from Asia) as her basionym. Tuckerman's combination, *Lecanora pallescens* v. *rosella,* was listed as a synonym, but Verseghy mistakenly gave its first date of publication as 1882 (Syn. N. Am. Lich. 1: 196) instead of 1872 (Gen. Lich. 125). Since Tuckerman's combination precedes that of Müller, and the epithet *rosella* is at the varietal level in both, it would seem that Verseghy's new combination should properly give Tuckerman's name as the basionym. Since it is possible that Müller's *rosella* and Tuckerman's *rosella* are different species, especially in view of the fact that Verseghy does not list Tuckerman's specimens in her notes on distribution and apparently did not see the Tuckerman material, it is difficult to defend considering Tuckerman's name as the true basionym of *O. rosella.* From Verseghy's description, except for the single spore measurement given, which is slightly large, it would appear that the Long Island material is *O. rosella* (Müll. Arg.) Vers.; that name will be used until the proper disposition of Tuckerman's name can be determined.

The Long Island specimen was identical (except for the lack of sterile rays of tissue in the apothecia) with the material filed under *Lecanora pallescens* v. *rosella* in the Tuckerman herbarium. To aid in future discussions of the species, a lectotype should be assigned for Tuckerman's epithet, since he did not cite any specimens in his original publication, and in 1882, only wrote "northern and middle states, *Muhlenberg,* etc." Fortunately, Grace Howard is soon to publish a North American monograph of *Ochrolechia* in which Tuckerman's var. *rosella* will be typified (Howard, pers. comm.).

This species has long been confused and misinterpreted in the literature. Although it has generally been considered as a variety of *O. pallescens* (L.) Mass., it actually is not similar to that species at all. *Ochrolechia pallescens* is apparently a relatively uncommon oceanic species of the British Isles and France and has a C − thallus and a C −, KC + red apothecial margin, with conspicuously pruinose apothecial disks. *Ochrolechia rosella,* according to the material in the Tuckerman herbarium, has a C + red reaction in the thallus and apothecial cortices. The apothecial disks are lightly or not at all pruinose, and sometimes show distinct "rays" of sterile tissue as described by Tuckerman (1872). It is a relatively common northeastern species and is possibly synonymous with a very similar western species, *O. oregonensis* Magn. These two taxa are closely related to *O. tartarea* (L.) Mass., which also has an intensely C + red reaction in the thallus and apothecial cortices. According to Verseghy (1962), *O. tartarea* is exclusively saxicolous.

The specimen from Long Island is very well developed. The thallus is light grey to whitish, and is rugose to thickly verrucose. Its cortex is C + red, but the medulla is C − (and also KOH − and PD −). The apothecia are 10-20(-25) mm in diameter and are urn shaped (i.e., with a narrow stipe and basal attachment). The apothecial disk is yellow-orange to orange-pink, lightly pruinose, and appears very rough. No sterile rays were evident. With both C and KC, the disk turns red.

The hymenium is about 200 μ thick, and the spores are hyaline, very thin walled, and measure 40-60 x 25-26 μ.

The Long Island specimen was collected in a bog on the bark of *Acer rubrum.*

Distribution — uncertain: Temperate element, "northern and middle states" (Tuckerman, 1882); Asia (Verseghy, 1962).

172. **Ochrolechia** sp.

Material seen — SUFFOLK COUNTY: Greenport, *Latham 793,* March 28, 1914 (Latham); Southold, *Latham 973,* March 10, 1922 (Latham).

This species has usually been called *O. pallescens* (L.) Mass., but *O. pallescens* is quite different in distribution, morphology, and chemistry (cf. above).

In Verseghy (1962), the material agrees fairly well with descriptions of both *O. harmandi* Vers. and *O. austroamericana* (Malme) Vers. However, *O. harmandi* is known only from Oceania and the Orient, and the thallus is stated to be not continuous. *Ochrolechia austroamericana,* while agreeing better in thallus morphology (continuous, rugose) and being more logical from a phytogeographic viewpoint (from South America), cannot be used for nomenclatural reasons. The name is a later homonym of *O. austroamericana* (Räs.) Räs. Verseghy created the new combination, apparently because the basionym of her taxon (*O. tartarea* var. *austroamericana* Malme, 1937) has priority over Räsänen's *O. pallescens* var. *austroamericana* Räs., 1939). Räsänen, however, raised his variety to species level in 1941. Since the Code of Botanical Nomenclature states that only epithets of equal rank have priority over each other, Räsänen's *O. austroamericana* clearly has priority over Verseghy's combination. Without having examined any authentic material of either *O. austroamericana* sensu Verseghy or *O. harmandi,* I decline from introducing a new name, since it may well be that such a common species already has a valid name.

This species, while usually showing distinctly pruinose disks, often lacks pruina altogether. The C reaction of the thallus and apothecial margin is confined to the medullary regions and is negative in the cortices, exactly opposite from the situation in *O. rosella.*

It was found on oak and maple bark.

Distribution — Cape Cod, southeastern United States, West Indies (seen in herb. MSC).

## 44. HAEMATOMMA Mass.

173. **Haematomma ochrophaeum** (Tuck.) Mass. Atti I. R. Istit. Veneto III. 5: 253. 1860. *Biatora ochrophaea* Tuck. Proc. Amer. Acad. Arts Sci. 1: 253. 1848.

Material seen — SUFFOLK COUNTY: *Brodo 2125* (102).

This species was collected a number of times in bogs on Cape Cod (*Brodo 4174, 4205, 4342, 4371*). Its morphology, especially the frequent lack of septation in its spores, is discussed by Lamb (1954). The species differs from *Haematomma* sp. in ecology as well as in morphology, being more characteristically found in bogs and swamps on bark and wood than in upland oak and pine forests.

Distribution — Nova Scotia, Maine, Massachusetts, New Hampshire, Vermont, New York, North Carolina, West Virginia, Michigan, Ontario, Quebec: Temperate element, Appalachian subelement, Appalachian-Great Lakes unit, Japan (Culberson, 1963b).

174. Cfr. **Haematomma** sp.

Material seen — SUFFOLK COUNTY: 42 specimens collected by Imshaug and/or Brodo; Orient, Long Beach, *Latham 22340*, December 7, 1944 (Latham); Montauk, Hither Woods, *Latham 27292*, April 17, 1946 (Latham).

The status of this material is far from clear. At first, it appeared to be identical with sterile material of *Haematomma elatinum* (Ach.) Mass. (see Culberson, 1963b). With further study, mainly at the suggestion of Culberson, it became clear that the soralia were entirely different (originating in irregular breaks in the thallus, distinct, and punctiform in *H. elatinum*, and in tiny, hollow, globular to vermiform verrucae in this material), although both can produce a granular sorediate crust in the older parts of the thallus. In addition, *H. elatinum* is generally found on coniferous bark, and *H.* sp. is found on deciduous bark.

*Pertusaria trachythallina* also contains thamnolic acid, and Imshaug (pers. comm.) pointed out that several specimens of that species show vermiform, hollow, sorediate verrucae. It seems odd, however, that no smooth, *Pertusaria*-like, sterile thallus has yet been found among this material, and that only a few of the dozens of fertile *Pertusaria* specimens show any tendency towards the production of hollow verrucae. The distinctive, often thick, white to yellowish, fibrous prothalline margin seen on almost every specimen of *Haematomma* sp. contrasts with the absent or, at most, very thin, white prothallus of *Pertusaria trachythallina*.

*Haematomma leprarioides* (Vain.) Vain., described from South America, is a similar species, usually found in the sterile condition. Its soredia are farinose, however, and are produced in distinct punctiform soralia not associated with verrucae.

With what we now know about this species, it could as well be placed in *Pertusaria* as in *Haematomma*, and the only reason for choosing the latter is its superficial similarity to *H. elatinum*.

Distribution — Maine, North Carolina, Virginia (Culberson, 1963b); Massachusetts (Cape Cod), New Jersey: Temperate element, Appalachian subelement, Appalachian unit (?); Europe.

## CANDELARIACEAE

### 45. CANDELARIELLA Mull. Arg.

175. **Candelariella aurella** (Hoffm.) Zahlbr. Cat. Lich. Univ. 5: 790. 1928. *Verrucaria aurella* Hoffm. Deutch. Fl. 2: 197. 1796.

Material seen — SUFFOLK COUNTY: *Brodo 2799* (84), *2840* (115).

From the descriptions given by Hakulinen (1954), these specimens represent var. *aurella.*

This species commonly grows in association with species of *Caloplaca* on mortar in exposed situations.

Distribution — Michigan, Indiana, Iowa, Kansas, Minnesota, Black Hills, California, Washington, Quebec, Canadian archipelago: Arctic-boreal element (?); arctic and temperate Europe (Hakulinen, 1954); Asia (Magnusson, 1940).

176. **Candelaria vitellina** (Ehrh.) Müll. Arg. Bull. Herb. Boiss. 2: 47. 1894. *Lichen vitellinus* Ehrh. Pl. Crypt. Exs. no. 155. 1785.

Material seen — SUFFOLK COUNTY: *Brodo 1802* (127), *1912* (114), *2368* (123), *2671* (108), *3441* (134).

*Candelariella vitellina* was usually found sterile in the Long Island localities, although the few fertile specimens showed typical polysporous asci. Most of the Long Island specimens best fit the description of var. *assericola* Räs. as given by Hakulinen (1954), the thallus being granular-verruculose, with the granules or verrucules becoming crowded into flattened or rounded patches sometimes becoming almost subsquamulose. Many grade into what is better referred to as var. *vitellina* with the thalline granules and verrucae more dispersed. For this reason, no segregation of the Long Island material into varieties was attempted.

On Long Island, the species is found on exposed granitic boulders associated with *Sarcogyne* spp. and *Rinodina oreina* (figure 68).

Distribution — Maine, Connecticut, Michigan, Indiana, Wisconsin, Minnesota, Black Hills, Arizona, Washington, northern Saskatchewan, Manitoba, Baffin Island: Arctic-boreal element; circumboreal.

### 46. CANDELARIA Mass.

177. **Candelariella concolor** (Dicks.) B. Stein in Cohn, Kryptog.-Fl. Schlesien 2(2):84. 1879.

var. **concolor**

Material seen — KINGS COUNTY: New Lots, *Brainerd* (?) with *Physcia millegrana*) (BKL 032039).

var. **effusa** (Tuck.) Burnh. Bryologist 25: 73. 1922.

*Theloschistes concolor* var. *effuse* Tuck. Syn. N. Amer. Lich. 1: 52. 1882.

Material seen — SUFFOLK COUNTY: *Imshaug 25581* (52); *Brodo 59-242* (67), *669* (77), *2424* (118), *2499* (67), *2776* (31), *3146* (65).

With the exception of the New Lots specimen cited above (var. *concolor*), all the Long Island material of this species showed virtually no foliose lobes. It was found growing on the bark of various broadleaf trees, usually at the base or around raintracks.

Distribution — Massachusetts, Connecticut, central New York, Arkansas, Missouri, Michigan, Indiana, Wisconsin, Minnesota, Black

Hills, Arizona, Washington: Temperate element, North Temperate subelement; Europe; Asia (Zahlbruckner, 1930).

## PARMELIACEAE

### 47. PARMELIOPSIS (Stizenb.) Nyl.

178. **Parmeliopsis aleurites** (Ach.) Nyl. Syn. Lich. 2:54. 1863. *Lichen aleurites* Ach. Lich. Suec. Prodr. 117. 1798.

Material seen — NASSAU COUNTY: *Brodo 547* (12), *3509* (10). SUFFOLK COUNTY: 37 specimens collected by Imshaug and/or Brodo; North Sea, *Latham 36933c*, May 20, 1954 (Latham).

*Parmeliopsis aleurites* is found on the bark of various tree species, especially *Pinus rigida* and *Chamaecyparis thyoides*, but also oaks, and is occasionally found on lignum. It is most frequent in well-lighted oak and pine forests.

Distribution — Maine, Connecticut, Massachusetts, New Jersey, North Carolina (mountains and piedmont), Tennessee, Alabama, Michigan, Minnesota, Black Hills, Arizona, boreal Ontario: Temperate element, East Temperate subelement; Europe; Asia (Vainio, 1928).

179. **Parmeliopsis ambigua** (Wulf. in Jacq.) Nyl. Syn. Lich. 2: 54. 1863. *Lichen ambiguus* Wulf. in Jacq. Coll. Bot. 4: 239. 1790.

Material seen — SUFFOLK COUNTY: *Imshaug 25806* (86), *25812* (86); *Brodo 1108* (78), *2270* (87).

Both usnic and divaricatic acids were demonstrated in the Long Island material, making it *P. ambigua* sens. str. (or "chemical race A" in the treatment by Culberson [1955c]).

*Parmeliopsis ambigua* was usually found on *Chamaecyparis* (occasionally on *Pinus*) in bogs. As with the other species of *Parmeliopsis*, this one seems to have a strong specificity for conifers throughout its range. It is found abundantly on pine on the coastal plain of North Carolina (Culberson, 1958a), on white cedars farther north, and on spruce and fir in boreal forests.

Distribution — Nova Scotia, Maine, Connecticut, New Jersey, Alabama, Michigan, Wisconsin, Black Hills, Arizona, Washington, Alaska, northern Saskatchewan, Manitoba, Baffin Island, arctic Ontario: Arctic-boreal element; circumboreal.

180. **Parmeliopsis placorodia** (Ach.) Nyl. Syn. Lich. 2: 55. 1863. *Parmelia placorodia* Ach. Syn. Lich. 196. 1814.

Material seen — 24 specimens collected by Imshaug and/or Brodo; Orient, *Latham*, April 1, 1920, on *Juniperus* (Latham); Manorville, *Latham 7767*, May 20, 1937 (Latham); Riverhead, *Latham 8196*, March 9, 1938 (Latham); Napeague, *Latham 8624*, June 11, 1938 (Latham); Napeague, *Latham 25985*, March 11, 1947 (Latham); Napeague, *Latham 34095*, April 1, 1956 (Latham).

This species is the most conspicuous foliose member of the pine bark community (figure 45). In some pine forests the ascending, often subfruticose, finely-divided and abundantly fruiting thalli of *P. placorodia* can be seen on almost every pine tree, especially dead ones where the loose bark has ceased to slough off (pp. 28-29).

The substrate specificity of this species has been discussed in detail by Culberson (1955c). *Parmeliopsis placorodia* is almost exclusively a *Pinus*-dwelling species, but in various parts of the country can grow on various species within the genus. In the east, the substrate is *P. rigida,* in the Great Lakes Region it is *P. banksiana,* and in the west it is *P. ponderosa* (Culberson, 1961b). On Long Island, *Parmeliopsis placorodia* has also been collected on *Chamaecyparis* (twice), *Vaccinium corymbosum* (once, cf. p. 50) and on *Quercus coccinea-velutina* (twice) (not hybrid; p. 19). Rare occurrences on fence rails and shingles have been noted as well.

Distribution — Northeastern United States (map: Culberson, 1955c), Black Hills, Arizona, Ontario: Temperate element, Appalachian subelement, Appalachian-Great Lakes-Rocky Mountain unit; endemic.

### 48. PARMELIA Ach.

181. **Parmelia appalachensis** W. Culb., Nova Hedw. 4(3-4): 571. 1962.

Material seen — *Brodo 59-270* (53).

This species has long been included in the complex of pseudocyphellate *Parmeliae* collectively called *P. bolliana* Müll. Arg. (see Culberson and Culberson, 1956). In his description of the new species, Culberson (1962) indicated how it can be separated from the very similar *P. frondifera* Merr. I have seen and collected much material of *P. frondifera* in central New York (Madison County, Bridgeport) where it always has abundant apothecia and an entirely pale undersurface with numerous pale buff rhizines. The Long Island specimen has a pitch black undersurface becoming pale tan only at the margins, and is covered with black or dark brown rhizines. It is essentially identical with an isotype of *P. appalachensis* (Hale, Lich. Amer. Exs. 63 [MSC]). The lobules so characteristic of *P. appalachensis* are not well developed on the Long Island specimen but are distinctly present.

The Long Island specimen was collected on the mossy base of a *Quercus alba* in an oak woods.

Distribution — Nova Scotia south to North Carolina (figure 27): Temperate element, Appalachian subelement, Appalachian unit (map: Culberson, 1962).

182. **Parmelia arseneana** Gyeln. Ann. Mycol. 36: 269. 1938.

Material seen — SUFFOLK COUNTY: *Brodo 3025* (50), *3853* (76), *3870* (62); Orient, *Latham 942B,* April 25, 1921 (Latham).

This species has been variously treated by different authors. It mainly comprises what Hale (1955b) called *Parmelia conspersa,* chemical strain no. 1.

It is found on granitic boulders.

Distribution — Uncertain.

183. **Parmelia aurulenta** Tuck. Amer. J. Sci. Arts. II. 25: 424. 1858.

Material seen — KINGS COUNTY: Gowanus, *G. B. Brainerd,* (1866?) (BKL 031946 or 031947). NASSAU COUNTY: *Brodo 3493* (4). SUFFOLK COUNTY: *Brodo 59-263* (53), *859* (47), *1364* (65), *1586* (65), *2325* (44), *2495* (67), *3305* (129), *3330* (18), *3916* (54); Orient, *Latham,* April 11, 1910 (NYS).

This species is not common on Long Island. It is most frequently found on the bark of *Quercus alba,* often at the base.

Distribution — Throughout eastern United States except for southeast coast (figure 27): Temperate element, East Temperate subelement (map: Hale, 1958); China, South Africa, India (Hale, pers. comm.).

184. **Parmelia caperata** (L.) Ach. Meth. Lich. 216. 1803. *Lichen caperatus* L. Sp. Pl. 1147. 1753.

Material seen — QUEENS COUNTY: Ridgewood, *G. B. Brainerd,* (BKL 031948); Cypress Hill, *Hulst,* 1890 (BKL 031949); Richmond Hill, *Hulst,* 1890 (BKL 031850). NASSAU COUNTY: *Brodo 534* (16). SUFFOLK COUNTY: 96 specimens collected by Imshaug and/or Brodo; 17 specimens collected by Latham (Latham).

*Parmelia caperata,* one of the most common species on Long Island, was used in various ecological and experimental studies.

Often, soredia are scarcely produced at all or are in minute, almost isidiate heaps of granules scattered over the thallus surface. The lobes are almost always broad and rounded, but on rare occasions they become laciniate.

*Parmelia caperata* is most common on tree bases of almost any species of tree on Long Island. It is also found with fair frequency on exposed, partially shaded, or shaded boulders, even in the salt spray zone near the coast (p. 60).

Distribution — Nova Scotia, Maine, Massachusetts, New Jersey, North Carolina, Tennessee, Alabama, Arkansas, Missouri, Oklahoma, Indiana, Michigan, Ontario, Wisconsin, Minnesota, Black Hills, Arizona, Washington, Manitoba: Temperate element, North Temperate subelement; Europe; Asia (Asahina, 1952).

185. **Parmelia conspersa** (Ach.) Ach. Meth. Lich. 205. 1803. *Lichen conspersus* Ach. Lich. Suec. Prodr. 118. 1789.

Material seen — SUFFOLK COUNTY: *Imshaug 25602* (SW. of 106); *Brodo 1908* (114), *2379* (123), *2655* (108), *2709* (111), *3018* (17), *3024* (50), *3029* (50), *3381* (94), *3421* (134), *3444* (134), *3846* (76); Orient, *Latham 942A,* April 25, 1921 (Latham); Shelter Island, *Latham 22929,* October 14, 1949 (Latham).

This species is the isidiate member of the *Xanthoparmeliae* which was considered under the name *P. isidiata* (Anzi) Gyeln. by Hale (1955b, 1956a) and later (Hale, 1961a) as *P. lusitana* Nyl. Hale (1964) discusses the systematics of this and related taxa in great detail. It is distinct from *P. plittii* Gyeln. in the color of its undersurface: black to very dark brown in *P. conspersa* and pale brown to buff in *P. plittii.* All of the Long Island material of both species contained both norstictic and stictic acids.

*Parmelia conspersa* is found on exposed granitic boulders, as are most of the other *Xanthoparmeliae*. Several members of this group are often found growing together, even intermingling thalli, and one must be very careful in order to get an unmixed collection.

Distribution — Eastern North America, southern Canada, Black Hills, Oregon, California (map: Hale, 1964): Temperate element, North Temperate subelement; Europe.

186. **Parmelia dilatata** Vain. Acta Soc. Faun. Fl. Fenn. 7(7): 33. 1890.

Material seen — SUFFOLK COUNTY: *Brodo 1760* (127), *1869* (117).

This species is distinctive since few other marginally sorediate *Parmeliae* contain protocetraric acid. It generally has been mentioned in the literature under the name *Parmelia robusta* Degel. Hale (1965b) discusses its nomenclatural problems.

*Parmelia dilatata* is usually a very broad, vigorous plant. Both Long Island specimens, however, were small lobed (3-4 mm broad). They were found on *Quercus velutina* in the fog belt region of the island's south fluke.

Distribution — South Carolina, Georgia, Florida, tropic and subtropic regions (Hale, 1959a): Tropical element, Coastal Plain subelement; Europe, Asia (Hale, 1965b).

187. **Parmelia galbina** Ach. Syn. Meth. Lich. 195. 1814.

Material seen — KINGS COUNTY: Gowanus, *G. B. Brainerd,* (1866?) (BKL). NASSAU COUNTY: Cold Spring, *Grout,* April 1, 1900 (BKL). SUFFOLK COUNTY: 22 specimens collected by Imshaug and/or Brodo; Orient, *Latham 3,* May 2, 1914 (Latham).

Culberson (1961c) in his study of the *Parmelia quercina* group, presented an excellent description and discussion of this species including a photograph of the characteristic moniliform cells of the medulla.

The species is clearly a member of the breast height community on *Quercus velutina* (figure 51).

Distribution — Temperate element, East Temperate subelement, Japan (map: Culberson, 1961c).

188. **Parmelia hypotropa** Nyl. Syn. Lich. 1: 378. 1860.

Material seen — SUFFOLK COUNTY: 26 specimens collected by Imshaug and/or Brodo; 15 specimens collected by Latham (Latham); Orient Point, *Latham,* October 11, 1909 (NYS); Orient Point, *Latham,* April 18, 1910 (NYS); Orient Point, *Latham,* April 25, 1910 (NYS); Orient Point, *Latham 15,* April 4, 1910, April 11, 1910, April 4 and 18, 1910 (Note: three packets) (NYS, MICH); Orient, *Latham 3926,* March 27, 1927 (NYS?).

*Parmelia hypotropa* can be confused with several closely related *Amphigymniae,* especially *P. perlata* and *P. perforata,* or even with

*P. reticulata* (subgenus *Hypotrachyna*). The table below summarizes the distinctions between these species.

| | *P. hypotropa* | *P. perforata* | *P. perlata* | *P. reticulata* |
|---|---|---|---|---|
| 1. soredia | marginal | absent | submarginal | marginal and sometimes submarginal |
| 2. irregular white margin on undersurface | usually conspicuous; rarely scanty | as in *P. hypotropa* | absent | absent |
| 3. revolute margins | absent | absent | present | absent |
| 4. undersurface | smooth | smooth | minutely rugulose | smooth |
| 5. uppersurface | occasionally with scattered white maculae | uniform or occasionally with scattered white maculae | uniform | with conspicuous reticulate cracks or maculae, esp. on older portions |
| 6. Chemistry, other than atranorin | norstictic and stictic acids | norstictic alone | stictic alone | salacinic acid alone |
| 7. cilia | > 1 mm; conspicuous | > 1 mm; conspicuous | < 1 mm; inconspicuous | < 1 mm; inconspicuous |
| 8. apothecia | not seen (rare) | common; perforate | not seen (rare) | not seen (rare) |
| 9. abundance | common | common | very rare | infrequent |

*Parmelia hypotropa* is a photophilous species, being most commonly collected on the bark or twigs of various trees in exposed areas, especially where the humidity is maintained at a fairly high level. It is best developed on trees in the oceanic dune areas of the island's south fluke, especially in hollows and on the lee sides of the dunes, but frequently occurs on exposed bog trees as well (figure 41). It occasionally is found in oak forests.

Distribution — Mainly Ozark and southern Appalachian Mountains (Hale, 1961a), but also California and Mexico (Hale, 1965b): Temperate element, Appalachian subelement, Appalachian-Ozark unit; Europe, Africa, Asia (Hale, 1965b).

189. **Parmelia livida** Tayl. Lond. J. Bot. 6: 171. 1847.

Material seen — NASSAU COUNTY: *Brodo 556* (13), *558* (13); Massapequa, *S. Cain 39, 40,* June 20, 1935 (NY). SUFFOLK COUNTY:

39 specimens collected by Imshaug and/or Brodo; Northwest, *Latham 26136C,* April 17, 1947 (Latham); Northwest, *Latham 26136,* April 10, 1947 (MO). (Note: specimen numbers and dates are as on the original labels except for the segregate designation "C" in the preceding specimen.)

This species has been discussed in detail by Culberson (1961c). It is outwardly very similar to *P. galbina,* from which it can be separated by its uniformly white medulla, PD − and KOH + red-brown reactions, and its lack of medullary moniliform cells. Hale (pers. comm.) also draws attention to the difference in the rhizines of the two species: branched in *P. livida* and simple in *P. galbina.*

*Parmelia livida* grows on the bark of various species of trees, usually at breast height, in oak forests.

Distribution — Throughout southeastern United States, northward along the east coast to New Hampshire (map: Culberson, 1961c): Temperate element, East Temperate subelement; endemic.

190. **Parmelia michauxiana** Zahlbr. Cat. Lich. Univ. 6: 244. 1929. *Parmelia epiclada* Hale, Bryologist 62: 125. 1959.

var. **michauxiana**

Material seen — SUFFOLK COUNTY: *Brodo 59-216* (68), *620* (39), *1191* (101), *1421* (83), *1522* (100B), *1784* (127), *1883* (117), *1901b* (114), *2222* (61), *3249* (119), *3256* (119), *3262* (119), *3907* (112); Orient, *Latham,* April 25, 1921 (Latham); Napeague, *Latham 8121,* November 6, 1938 (Latham); Northwest, *Latham 26135B,* April 10, 1947 (Latham).

var. **laciniata** (Hale) comb. nov.

*Parmelia epiclada* var. *laciniata* Hale, Bryologist, 62: 126. 1959.

Material seen — SUFFOLK COUNTY: *Brodo 1191* (101).

Although this species is considered to be a member of the subgenus *Hypotrachyna,* it has many characteristics in common with certain species in *Amphigymnia.* For example, its lobes are often very broad (up to 5 mm across) and bear sparse but distinct black marginal cilia. On rare occasions, specimens will be encountered having very narrow lobes (mostly 1-2.5 mm broad) curled inward and ascending. These specimens can be called var. *laciniata.* Apothecia are commonly present but are never perforate. Protocetraric acid and atranorin are always present and the medulla is conspicously thick and very cottony. This combination of characters is usually sufficient to separate it from any similar species on Long Island.

*Parmelia michauxiana* is a member of the breast height community on oak.

Distribution — Temperate element, Coastal Plain subelement (see Hale, 1959b); endemic.

191. **Parmelia olivetorum** Nyl. Not. Sallsk. Faun. Fl. Fenn. Forhandl., n. ser. 8: 180. 1866.

Material seen — SUFFOLK COUNTY: Fisher's Island, *Latham,* June 24, 1929, (Latham); Montauk, *Latham 36782,* July 5, 1931 (Latham).

This species must be extremely rare on the island, since, although I made a special effort to find specimens in the two localities listed above, I never saw a trace.

Among the taxonomic problems involved in this species is the controversy concerning the logic in recognizing species solely on the basis of chemical differences. *Parmelia olivetorum* contains atranorin and olivetoric acid, and closely related *P. cetrarioides* contains atranorin and perlatolic acid (Culberson, 1962). Culberson (1958b) discussed these chemical populations in detail, presenting maps of their distribution. The two populations both have Appalachian-Great Lakes distributions, although *P. olivetorum* seems to have more northern tendencies (Culberson, 1958b). Nomenclaturally, whether one considers the two as synonymous or as distinct species, the name which must be used for the Long Island material (which contains olivetoric acid) is *P. olivetorum.*

Latham's specimens were found on rock.

Distribution — Temperate element, Appalachian subelement, Appalachian-Great Lakes unit (map: Culberson, 1958b); Europe; Asia (ibid).

192. **Parmelia perforata** (Wulf. in Jacq.) Ach. Meth. Lich. 217. 1803. *Lichen perforatus* Wulf. in Jacq. Coll. Bot. 1: 116, pl. 3. 1786.

Material seen — QUEENS COUNTY: Ridgewood, *G. B. Brainerd,* (1866?) (BKL 031952); Ridgewood, *G. B. Brainerd,* (BKL). NASSAU COUNTY: Cold Spring, *Grout,* April 1, 1900 (BKL); Cold Spring, *Harris,* April 28, 1904 (MICH). SUFFOLK COUNTY: 35 specimens collected by Imshaug and/or Brodo; 16 specimens collected by Latham (Latham); Eastport, *Schrenk,* June 24, 1894 (MICH); Sayville, *Lloyd, 135,* December 2, 1896 (NY); Yaphank, *Davis,* June 3, 1929 (STATEN ISLAND); Flanders, *Latham 7232,* February 3, 1933 (MICH).

All the specimens collected on Long Island showed the presence of norstictic acid. Until recently, it was believed that *P. perforata* was characterized by containing salacinic acid and could be separated on this basis from *P. hypotropoides* Will., which contains norstictic acid (Hale, 1957c). However, Hale (pers. comm.) more recently concluded that specimens earlier determined as *P. perforata* are *P. cetrata* Ach., and that *P. hypotropoides* is synonymous with *P. perforata. Parmelia erecta* Berry is also a synonym of *P. perforata.*

*Parmelia perforata* is remarkably similar to *P. hypotropa* in many respects, and the two are undoubtedly closely related (p. 229).

*Parmelia perforata* occurs mainly in pine-oak forests and bogs, and like *P. hypotropa,* is found on exposed trees and shrubs in the humid oceanic habitats in eastern Long Island (figure 52).

Distribution — Temperate element, East Temperate subelement (map: Hale, 1957c); Ireland, Madagascar (Hale, 1965b).

193. **Parmelia perlata** (Huds.) Ach. Meth. Lich. 216. 1803. *Lichen perlatus* Huds. Fl. Angl. 448. 1762.

Material seen — SUFFOLK COUNTY: Orient Point, *Latham,* April 18, 1910 (NYS); Orient Point, *Latham,* April 25, 1910 (Note: mixed with *P. hypotropa*) (NYS).

An excellent description of this species and a discussion of its nomenclature has been provided by Hale (1961b). *Parmelia perlata* is compared with more common, similar species in the discussion of *P. hypotropa.* Its occurrence on Long Island extends the known range of *P. perlata* northward from the southern Appalachians.

Distribution — Unglaciated southern Appalachians (Hale, 1961b): Tropical element, Appalachian-Temperate subelement; South America, Mexico, Japan, and Australia (ibid).

194. **Parmelia plittii** Gyeln. Fedde. Repert. 29: 287/415. 1931.

Material seen — SUFFOLK COUNTY: *Brodo 878* (47), *1805* (127), *3879* (62); Shelter Island, *Latham 22929A,* October 14, 1949 (Latham).

*Parmelia plittii* is separated from *P. conspersa* mainly by the color of the thallus undersurface (see under *P. conspersa*). Hale (1964) also points out that *P. plittii* never shows the loosely-attached form which is often found in *P. conspersa.* The ecology as well as the distribution of the two species on Long Island appear to be identical.

Distribution — Widespread in tropical America, and in Africa, Appalachians-Great Lakes region (map: Hale, 1964): Tropical element, Appalachian-Temperate subelement.

195. **Parmelia reticulata** Tayl. in Mack. Fl. Hibern. 2: 148. 1836.

Material seen — KINGS COUNTY: Ridgewood, *G. B. Brainerd,* (1866?) (BKL 031954). SUFFOLK COUNTY: *Brodo 1765 A* (127), *2136* (102), *3264* (119).

The reticulate cracks which seem to first appear as white reticulate maculae are not always very conspicuous. They are usually best developed on the older portions of the thallus. The black rhizines are often long at the margins and extend out from under the thallus, giving the appearance of marginal cilia. Under these conditions, *P. reticulata* bears several resemblances to *P. hypotropa,* and their separation is summarized under the latter species.

Of the three Long Island collections, two were on *Quercus velutina* in oak woods and one was on *Acer rubrum* in a white cedar bog. All three specimens, however, were found in the humid and oceanic south fluke region of the island.

Distribution — North Carolina, Tennessee, Alabama, Arkansas, Missouri, Oklahoma, Arizona; Great Lakes region (seen in herb. MICH); western United States (Hale, pers. comm.); "cosmopolitan" (Hale, 1961a): Temperate element (?), North Temperate subelement (?); Europe, Asia, Africa, Australia (Zahlbruckner, 1930).

196. **Parmelia rudecta** Ach. Syn. Meth. Lich. 197. 1814.

Material seen — SUFFOLK COUNTY: 84 specimens collected by Imshaug and/or Brodo; 14 specimens collected by Latham (Latham); Orient, *Young* (BKL); Orient Point, *Latham*, April 11, 1910 (NYS); Southold, (*Davis?*), Sept. 5, 1912 (STATEN ISLAND).

This very common species shows a great deal of variation in the extent of isidial production. A few specimens were almost completely devoid of isidia, but the great majority showed the typical coralloid form or the somewhat flattened type described by Culberson (1962).

The ecological limits of *P. rudecta* are broad. It is found on a variety of phorophyte species and commonly grows on the base as well as at breast height. It is abundant throughout the island except for its sharply delimited distribution at the Nassau-Suffolk County border which presumably is due to the city-effect.

Distribution — Throughout eastern United States (map: Culberson & Culberson, 1956): Temperate element, East Temperate element; China, Argentina (Culberson, 1962); Japan, Africa (Hale, 1965a).

197. **Parmelia saxatilis** (L.) Ach. Meth. Lich. 204. 1803. *Lichen saxatilis* L. Sp. Pl. 1142. 1753.

Material seen — COUNTY UNKNOWN: Long Island, *Austin* (BKL 031946). NASSAU COUNTY: *Brodo 533* (16), *543* (12), *565* (11), *1512* (14). SUFFOLK COUNTY: 81 specimens collected by Imshaug and/or Brodo; 10 specimens collected by Latham (Latham).

Due to its abundance, *P. saxatilis* was used in a number of ecological studies (Brodo, 1961a). The species has a significant specificity for *Quercus velutina* (including *Q. coccinea*: see p. 21) in pine-oak and in scarlet-black oak forests. It is most conspicuous in the latter vegetation type, as is the very closely related *P. sulcata* (table 9). Although the two species are almost always found in the same oak stand they are often present in widely different quantities. In two typical oak stands in central Long Island, *P. sulcata* outnumbered the thalli of *P. saxatilis* by a large margin in one stand, and was essentially absent from another stand in which *P. saxatilis* was very abundant. The principle of non-overlapping niches of closely related species may play a part in this curious distribution (Brodo, 1961a).

*Parmelia saxatilis*, besides being found on various trees, also grows on boulders and on rare occasions, even on soil.

Distribution — Throughout temperate, arctic, and boreal North America, including northern Saskatchewan, Manitoba, arctic Ontario, Canadian east arctic, and Baffin Island: Arctic-boreal element; circumboreal.

198. **Parmelia stenophylla** (Ach.) Heug. Correspondzbl. Naturf. Verein. Riga 8: 109. 1855. *Parmelia conspersa β. P. stenophylla* Ach. Meth. Lich. 206. 1803.

Material seen — KINGS COUNTY: Gowanus, *G. B. Brainerd* (1866?) (BKL 031951). SUFFOLK COUNTY: *Imshaug 25691* (72);

*Brodo 2667* (108); Northwest, *Latham,* April 10, 1947 (Latham); Shelter Island, *Latham 24375,* April 1, 1941 (Latham).

The circumscription of *Parmelia stenophylla* is still not clear (see discussion under *P. tasmanica*). The Long Island specimens having no isidia and a pale lower surface all contain salacinic acid and are more or less loosely attached. They represent the most "typical" of the *P. stenophylla* populations.

*Parmelia stenophylla* is found on exposed or partially shaded granitic boulders throughout the morainal regions of the island.

Distribution — Throughout United States, southern Canada, and a few arctic localities (map: Hale, 1955b): Temperate element (?), North Temperate subelement; Europe; Asia (Magnusson, 1940).

199. **Parmelia subaurifera** Nyl. Flora 66: 22. 1873.

Material seen — SUFFOLK COUNTY: 65 specimens collected by Imshaug and/or Brodo; Greenport, *Latham,* January 26, 1923 (Latham); East Marion, *Latham 27,* May 3, 1914 (Latham); Orient, *Latham 3928,* March 27, 1927 (Latham); Orient, *Latham 7454,* June 5, 1933 (Latham); Orient, *Latham 8584,* April 30, 1939 (Latham); Northwest, *Latham 27214,* April 17, 1947 (Latham); Riverhead, *Latham 36889,* May 25, 1960 (Latham).

*Parmelia subaurifera* is the only *Melanoparmelia* on Long Island. It grows on various types of tree bark in a variety of vegetation types. One specimen was found growing on an exposed boulder in the Montauk area.

Distribution — Nova Scotia, Maine, Massachusetts, Connecticut, New Jersey, Tennessee, Michigan, Ontario, Wisconsin: Temperate element, Appalachian subelement, Appalachian-Great Lakes unit; Europe, Asia (Vainio, 1928).

200. **Parmelia subrudecta** Nyl. Flora 69: 320. 1886.

Material seen — NASSAU COUNTY: *Brodo 561* (13), *1496* (9). SUFFOLK COUNTY: *Brodo 868* (47), *1288* (21), *1292* (19), *1440* (83), *2197* (20), *2350* (42), *2478* (23), *3039* (50), *3109* (68), *3221* (35), *3237* (35).

This species, long considered under the name *P. borreri* (Turn. ex. Sm. in Sm. & Sowerby) Turn. or *P. dubia* (Wulf. in Jacq.) Schaer. (see Culberson, 1962 and Hale, 1959b), is properly *P. subrudecta. Parmelia borreri* has a black undersurface and contains gyrophoric acid, whereas *P. subrudecta* has a pale undersurface and contains lecanoric acid (Hale, 1965a).

*Parmelia subrudecta* seems to have a strong affinity for the mature red oak forests of the morainal regions (figure 63). It is found on the bark of various deciduous trees in shaded woods.

Distribution — Throughout the Appalachian mountains and the Great Lakes region, Arkansas, New Mexico, Colorado, California, Mexico (map: Hale, 1965a); Arizona: Temperate element, Appalachian subelement, Appalachian-Great Lakes-Rocky Mountains unit; Europe, South Africa, and Australia (Hale, 1965a); eastern Asia (Culberson, 1962).

201. **Parmelia sulcata** Tayl. in Mack. Fl. Hibern. 2: 145. 1836.

Material seen — QUEENS COUNTY: Ridgewood, *G. B. Brainerd* (?) (BKL 031956). NASSAU COUNTY: *Brodo 535* (16), *1315* (15). SUFFOLK COUNTY: 83 specimens collected by Imshaug and/or Brodo; Riverhead, *Latham*, May 1, 1960 (Latham); Riverhead, *Latham*, May 16, 1960 (Latham); Greenport, *Latham*, May 12, 1960 (Latham); Orient, *Latham 696*, March 30, 1914 (Latham); Orient, *Latham 8583*, April 30, 1939 (Latham); Northwest, *Latham 26136D*, April 17, 1947 (Latham); Orient Point, *Latham*, April 18, 1910 (NYS).

The ecology of *Parmelia sulcata* has been discussed with *P. saxatilis*, which it closely resembles both morphologically and ecologically. *Parmelia sulcata* also shows a significant association with *Quercus velutina*, especially in the pine-oak forests (Brodo, 1961a).

Distribution — Nova Scotia, Maine, Massachusetts, Connecticut, New Jersey, North Carolina, Michigan, Ontario, Wisconsin, Minnesota, Black Hills, Arizona, Washington, Alaska, British Columbia, Saskatchewan, Manitoba, Quebec, Baffin Island: Arctic-boreal element; circumboreal; listed as having an Appalachian-Great Lakes-Rocky Mountain distribution by Hale (1961a).

202. **Parmelia tasmanica** Hook. and Tayl. Lond. J. Bot. 3: 644. 1844.

Material seen — SUFFOLK COUNTY: *Brodo 1906* (114), *2369* (123), *3080* (128); Southold, Janning's Woods, *Latham 63868* (36868), July 4, 1933 (Latham).

Members of the *Parmelia stenophylla* group having a black lower surface and salacinic acid can be referred to this species. It was previously designated, at least in part, as *P. conspersa*, chemical strain no. 2, by Hale (1955b). Degree of adnation, formerly considered by Hale (1955b, 1956a) to be an important differentiating criterion, appears to be unreliable. Loosely attached specimens, which by former standards would have all been called *P. stenophylla* and expected to show a pale lower surface, now are found to have black lower surfaces in some specimens and pale lower surfaces in others. Abandoning degree of adnation as a prime character, the taxa can be separated on the basis of lower surface color alone, and this has been done with many of the specimens annotated by Hale in the Michigan State University Herbarium. Whether or not these taxa should be recognized at the species level is a matter for future discussion and investigation.

The species is strictly saxicolous, usually on exposed boulders.

Distribution — Eastern United States, Japan, Australia, Europe (Hale, pers. comm.).

## 49. HYPOGYMNIA Nyl.

By virtue of their hollow thalli, complete lack of rhizines, and distinct chemistry (Krog, 1951), members of the well-defined subgenus

*Hypogymnia* of the genus *Parmelia* seem to be sufficiently distinct to be considered together as a separate genus.

203. **Hypogymnia physodes** (L.) Nyl. Lich. Paris 39. 1896. *Lichen physodes* L. Sp. Pl. 1144. 1753.

Material seen — SUFFOLK COUNTY: 46 specimens collected by Imshaug and/or Brodo; 10 specimens collected by Latham (Latham).

*Hypogymnia physodes* is a common species on Long Island and, as with most common species, shows a great deal of morphological variation. The lobes can be long and slender, or rather short, broad, and fan shaped. The soredia occur in abundant labriform soralia bursting from the tips of hollow lobes, or soredia are almost entirely absent. It is interesting to note that when the lobes are narrow, soralia appear to be abundant, whereas in broad-lobed forms, the soralia are very scanty.

*Hypogymnia physodes* was found on the bark of various deciduous and coniferous trees in oak woods, open areas, and swamps. Although the species was common, it was never found fertile.

Distribution — Nova Scotia, Maine, Massachusetts, Connecticut, New Jersey, North Carolina, Smoky Mountains, Michigan, Ontario, Minnesota, Black Hills, Arizona, Idaho, Washington, British Columbia, Alaska, Saskatchewan, Manitoba, Baffin Island: Arctic-boreal element; circumboreal.

## 50. PSEUDEVERNIA Zopf

204. **Pseudevernia furfuracea** (L.) Zopf, Beih. Bot. Centralbl. 14: 124. 1903. *Lichen furfuraceus* L. Sp. Pl. 1146. 1753.

Material seen — SUFFOLK COUNTY: *Brodo 2135* (102).

*Pseudevernia furfuracea* is generally thought of as a northern or high altitude species (one of the few temperate species of this genus) found very commonly in spruce-fir forests on conifers. It was, therefore, significant that this species was found growing on a dead *Chamaecyparis thyoides* in the cedar bog having the most "northern" and oceanic flora. In this same bog, I collected such other rare (on Long Island) oceanic and/or northern species as *Lobaria pulmonaria, L. quercizans, Leptogium cyanescens,* and *Pertusaria amara. Pseudevernia furfuracea* was also collected once near Woods Hole on Cape Cod (*Brodo 3926*) and once on Nantucket Island (*Brodo 4071*), both on *Pinus rigida* in oceanic pine-oak forests.

Hale (1955c) discussed some of the morphological variation of this species, as well as commenting on its chemistry, especially as the species occurs in North America. Hale (1956b) later discussed, in greater detail, its chemical variations throughout the world, particularly in Europe.

Distribution — Temperate element, Appalachian subelement, Appalachian-Great Lakes-Rocky Mountain unit (map: Hale, 1955c); Europe, North Africa (ibid).

## 51. CETRARIA Ach.

205. **Cetraria ciliaris** Ach. Lich. Univ. 508. 1810.

Material seen — KINGS COUNTY: East New York, *G. B. Brainerd*, (1866?) (BKL 031917). SUFFOLK COUNTY: *Imshaug 25796* (86), *25818* (86), *25829* (86); *Brodo 1067* (130), *1098* (78), *2094* (78), *2137* (102), *2271* (87), *2493* (23), *3132* (68), *3837* (66); 16 specimens collected by Latham (Latham).

*Cetraria ciliaris* has been the subject of a detailed population study (Hale, 1963). Hale discussed the local and geographic distributions of the three chemical races known within the species: the KC + red, C − alectoronic acid strain, the C + red olivetoric acid strain, and KC −, C − protolichesteric acid strain.

The two most common strains (olivetoric and alectoronic) are both represented on Long Island. Only 2 of the 10 specimens I collected contained olivetoric acid, and none of Latham's 16 specimens were of that strain. Hale (1963) demonstrated that the distribution of the two strains shows no correlation with substrate, microclimate, or other environmental factors. Their distribution in the Appalachians and in North America in general shows extensive overlapping and there is no basis for giving them taxonomic recognition.

The ecology of *C. ciliaris* on Long Island is almost precisely as noted by Hale (1963). It is usually found on *Pinus rigida* and *Chamaecyparis thyoides* in typical photophilous conifer lichen communities, but on Long Island it is almost entirely restricted to bog and swamp situations (figure 33). It is occasionally found on *Prunus maritima* in the dune community.

Distribution — Appalachian-Great Lakes-Rocky Mountain distribution with west coast population of the protolichesteric acid strain (map: Hale, 1963): Temperate element, North Temperate subelement (?) (Ahti, 1964); Europe (Ahlner, 1940); Asia (Vainio, 1928).

206. **Cetraria fendleri** (Nyl.) Tuck. Gen. Lich. 280. 1872. *Platsyma fendleri* Nyl. Syn. Lich. 1: 309. 1860.

Material seen — SUFFOLK COUNTY: Manorville, *Latham 7767a*, May 28, 1937 (Latham); Napeague, *Latham 25986*, March 11, 1947 (NYS).

This species is apparently very rare on Long Island, although I collected it in southern New Jersey (*Brodo 3698*), Nantucket (*Brodo 4112*), and Cape Cod (*Brodo 4191, 4312*). Latham's comment on his no. *25986*, "fairly common on pine bark, trunk and twigs in barren sandy grounds . . . ," must have pertained to a very local population in that area.

*Cetraria fendleri* is a typical member of the photophilous community on pine twigs, along with *Parmeliopsis placorodia*. Interestingly, it has an almost identical North American distribution. Culberson (1961b) also has commented on the ecological and phytogeographic similarities of these two species.

In North Carolina, *Cetraria fendleri* is an abundant pine-bark lichen occurring most abundantly in the Piedmont region (Culberson, 1958).

Distribution — Temperate element, Appalachian subelement, Appalachian-Great Lakes-Rocky Mountain unit (Culberson, 1961b); endemic.

207. **Cetraria islandica** (L.) Ach. Meth. Lich. 293. 1803. *Lichen islandicus* L. Sp. Pl. 1145. 1753.

subsp. **crispa** (Ach.) Cromb. Grevillea 12: 73. 1884. *Cetraria islandica* $\gamma$ *C. crispa* Ach. Lich. Univ. 513. 1810.

Material seen — NASSAU COUNTY: *Brodo 3351* (8); Plain Edge, *S. Cain,* August 3, 1936 (NY). SUFFOLK COUNTY: 16 specimens collected by Imshaug and/or Brodo; 63 specimens collected by Latham (Latham); Southampton, *Clute,* September 3 to 7, 1898 (NY); Montauk, *Copeland 2090,* June 7, 1941 (MSC).

*Cetraria islandica* is a widely distributed circumboreal species which includes a number of morphological and chemical variants. Imshaug (1957) presented a detailed discussion of these variants and their taxonomic status. Following Imshaug's argument, the Long Island material — having only marginal pseudocyphellae and showing a PD − reaction in the medulla — can be referred to subspecies *crispa.* On the species level, this taxon would be *C. ericetorum* Opiz (Ahti, 1964).

Roy Latham became particularly interested in this species and published a series of five papers on its Long Island distribution (Latham, 1945, 1946, 1947, 1948). In these papers, he noted the various stations where the lichen grew, the condition and extent of each colony, and its history as to hurricane or fire damage. After much field work, he concluded that, although *C. islandica* is commonly found on exposed hilltops and beaches, the species is found just as often ". . . in flat woodlands, locally remote from hilltops and exposed beaches . . ." (Latham, 1947).

My own field experience bears out Latham's observations. *Cetraria islandica* is found as a conspicuous member of the communities on sand dunes and grassy "downs" (p. 60), along with *Cladonia submitis* and *C. boryi.* It is interesting to note that it still can be found in surprising abundance in central Nassau County, along the Meadowbrook Parkway on the remains of the Hempstead Plains, just as it was in 1936 in nearby Plain Edge (cf. above) prior to the suburbanization of the area.

Distribution — Nova Scotia, Maine, Massachusetts, Connecticut, Michigan, Ontario, Minnesota, Rocky Mountains (Imshaug, 1957a), Washington, Alaska, Saskatchewan, Manitoba, Canadian archipelago, Quebec, Baffin Island: Arctic-boreal element; circumboreal.

208. **Cetraria tuckermanii** Oakes in Tuck. Amer. J. Sci. Arts 45: 48. 1843.

Material seen — QUEENS COUNTY: Jamaica, *G. B. Brainerd,* (1866?) (BKL 031916). SUFFOLK COUNTY: North Sea, *Latham 36933,* May 20, 1954 (Latham).

The nomenclature of this species had long been a source of confusion until Imshaug (1954) clarified the identities of various members of the group. *Cetraria tuckermanii* Herre as treated by Fink (1935) should be called *C. herrei* Imsh. (a species of the west coast); Fink's *C. lacunosa* Ach., at least in part, is actually *C. tuckermanii* Oakes in Tuck.

On Long Island, the species is very rare. I found it only once in southern New Jersey (*Brodo 3597*). Where it occurs, it is apparently a member of the bog community on *Chamaecyparis* with other bog *Cetrariae* (e.g., *C. ciliaris, C. viridis*).

Distribution — Temperate element, Appalachian subelement, Appalachian-Great Lakes unit (Hale, 1961a); endemic.

209. **Cetraria viridis** Schwein. in Halsey, Ann. Lyc. Nat. Hist. N. Y. 1: 16. 1824.

Material seen — SUFFOLK COUNTY: *Imshaug 25789* (86), *25801* (86), *25828* (86), *25849* (86); *Brodo 1094* (78), *2127* (102), *2241* (87); Flanders, *Latham*, May 31, 1925 (Latham); Calverton, *Latham*, May 1, 1960 (Latham); Riverhead, *Latham*, May 25, 1960 (Latham); Riverhead, *Latham*, June 17, 1960 (Latham); Riverhead, *Latham 2369*, June 22, 1924 (Latham); Montauk Point, *Latham 36972*, September 15, 1949 (Latham).

*Cetraria viridis* has usually been considered as a synonym of *C. juniperina* (L.) Ach. (see Fink, 1935). However, the dark yellow-green to almost grey-green upper surface of *C. viridis*, together with its small, finely divided almost lacy margins and its restricted east coast distribution, all serve to distinguish it from the pure yellow (sometimes dark yellow) more broadly lobed, more northern *C. juniperina* sens. str.

In the northeastern coastal plain, *C. viridis* is narrowly restricted to *Chamaecyparis* bogs on the white cedar trees themselves (figure 34), or, more rarely, on *Pinus rigida* or *Vaccinium corymbosum* (p. 50). I have collected it in bogs on *Chamaecyparis* in New Jersey (*Brodo 3672, 3791*) and Cape Cod (*Brodo 4348*).

Distribution — Massachusetts, New Jersey: Temperate element, Coastal Plain subelement; endemic.

## 52. ANZIA Stizenb.

210. **Anzia colpodes** (Ach.) Stizenb. Flora 45: 243. 1862. *Lichen colpodes* Ach. Lich. Suec. Prodr. 124. 1798.

Material seen — SUFFOLK COUNTY: *Brodo 1772* (127), *1830* (125), *1898* (114), *2496* (67), *3282* (119); Orient Point, *Latham*, April 18, 1910 (NYS); Orient, *Latham*, May 3, 1914 (Latham); Napeague, *Latham 8120* (Latham); Napeague, *Latham 8122B*, November 6, 1938 (Latham).

With its thick, highly branched, black hypothallus, *Anzia colpodes* can hardly be confused with any other species on Long Island. Superficially, however, it sometimes gives the appearance of being a form of *Hypogymnia physodes*. It is treated in the genus *Parmelia* by Fink (1935).

*Anzia colpodes* was collected almost exclusively in humid, oceanic oak and oak-pine forests of the eastern tip of Long Island (figure 64), as well as on Nantucket Island (*Brodo 4128*) and Cape Cod (*Brodo 4285, 4290*). It was always found on *Quercus velutina*, usually at breast height, although a few of Latham's specimens were from *Juniperus virginiana*.

Distribution — Eastern United States, especially in southern Appalachian and Ozark Mountains (map: Hale, 1955c): Temperate element, Appalachian subelement, Appalachian-Ozark unit (figure 23); Tasmania (Wilson, 1893 in Wetmore, 1963).

## USNEACEAE

### 53. EVERNIA Ach.

211. **Evernia mesomorpha** Nyl. Lich. Scand. 74. 1861.

Material seen — SUFFOLK COUNTY: *Brodo 692 B* (81), *2095* (78).

This species, included under *Evernia prunastri* (L.) Ach. var. *thamnodes* Flot. by Fink (1935), is characterized by relatively soft, flexible, highly irregular and angular, sorediate lacinae. It is very rare on Long Island, occurring on trees and shrubs in cedar bogs. It was also found on pines (*Pinus rigida*) in a pine-oak forest on Nantucket Island (*Brodo 4076*), and on open downs and in forests on Cape Cod (*Brodo 4175, 4314, 4495*).

Distribution — Nova Scotia, Maine, Massachusetts, Connecticut, Michigan, Black Hills, Saskatchewan, Manitoba, Ontario: Temperate element, North Temperate subelement (?); listed as having an Appalachian-Great Lakes distribution by Hale (1961a); Europe (Poelt, 1963); Asia (Zahlbruckner, 1930).

### 54. ALECTORIA Ach.

212. **Alectoria glabra** Mot. Fragm. Fl. Geobot. 6(3): 448. 1960.

Material seen — SUFFOLK COUNTY: Patchogue, *Latham*, June 11, 1921 (Latham).

The Long Island specimen was compared with an isotype of *A. glabra* (herb. US) and the two specimens agreed in all characteristics except, perhaps, the general color, which was somewhat paler in the type. Both showed the abundant non-isidiate soralia and the PD + red reaction. *Alectoria americana* Motyka, which is the more common North American member of the *A. jubata*-complex, is PD — and lacks soredia entirely. These species are discussed more thoroughly by Motyka (1964).

*Alectoria glabra* was most likely considered under the name *A. jubata* (L.) Ach. in Fink's (1935) flora.

There is some question as to whether the Latham specimen of *A. glabra* actually was collected on Long Island. It is possible that it was collected elsewhere in North America, was sent to Latham on exchange, and somehow became mislabeled (as was the case with a few specimens from the Pacific northwest area). Until this basically northern species is collected again on Long Island, or in the Cape Cod region which has a more northern flora, its presence on Long Island must remain questionable.

Distribution — Washington (type locality), Rocky Mountains from British Columbia to Colorado, Ontario and Newfoundland (Motyka, 1964): Temperate element, North Temperate subelement; endemic.

213. **Alectoria nidulifera** Norrl. in Nyl. Flora 58: 8. 1875.

Material seen — QUEENS COUNTY: Jamaica, *G. B. Brainerd*, 1866 (BKL). SUFFOLK COUNTY: 17 specimens collected by Imshaug and/or Brodo; 11 specimens collected by Latham (Latham).

This species, which Fink (1935) probably considered under the name *A. chalybeiformis* (L.) Röhl., is a frequent member of the pine bark community. It is found in open pine barrens, pine forests, and bogs, mostly on *Pinus rigida* and *Chamaecyparis thyoides* (figure 40). Occasionally it is collected from dead twigs or tangled stumps of *Hudsonia tomentosa* close to the ground in open sand barrens.

Motyka (1964) gives a detailed description of the species and points out a number of differences between the American and European populations.

Distribution — Quebec, northeastern United States south to Virginia (Motyka, 1964); Nova Scotia, Maine, Massachusetts, Connecticut, North Carolina, Tennessee, Michigan, Wisconsin, Arizona, British Columbia, Saskatchewan, Ontario: Temperate element, Appalachian subelement, Appalachian-Great Lakes unit (Hale, 1961a); Europe (Motyka, 1964); Asia (Vainio, 1928).

## 55. RAMALINA Ach.

214. **Ramalina complanata** (Sw. in Ach.) Ach. Lich. Univ. 599. 1810. *Lichen complanatus* Sw. in Ach. Kgl. Vet. Akad. Nya Handl. 290. 1797.

Material seen — Orient, *Latham*, April 20, 1920 (Latham).

The specimen upon which this record is based is sterile and poorly developed. In view of the species' normally southern or tropical distribution, such a record will have to be viewed with some skepticism, at least until more material is collected in the area.

Material of *R. complanata* from the Howe collection at the Farlow Herbarium was compared with Latham's collection. Except for its being sterile, Latham's material agreed well with a specimen from Corpus Christi, Texas (*Howe 2553*), as well as one from Lake Ngunga, British East Africa (*Howe 1786, S. M. Allen*, August 27, 1909). All had broad, heavy, stiff, more or less striate and rimose lacinae with conspicuous white pseudocyphellae or tuberculae, and all had PD −, KOH − medullary reactions.

The species was described from Jamaica, and according to Howe (1914) it is "common in the Austral Zone." If the Long Island specimen is correctly identified, it would not be the first example of a tropical species which has migrated up the Atlantic coastal plain as far north as Long Island (see *Cladonia evansii*). The Latham specimen was found on *Juniperus*.

Distribution — Florida, Texas, West Indies: Tropical element, Coastal Plain subelement (map: Howe, 1914); East Africa (above).

215. **Ramalina fastigiata** (Lilj.) Ach. Lich. Univ. 603. 1810. *Lichen calcaris* var. *fastigiata* Lilj. Utkast Svensk. Fl. 426. 1792.

Material seen — SUFFOLK COUNTY: *Imshaug 25766* (121); *Brodo 692A* (81), *1024* (112), *1727A* (131), *1732* (131), *1816* (125), *1956* (85), *2962A* (95), *3307* (129); Orient, *Latham,* April 20, 1920 (Latham); Orient, *Latham 42,* May 23, 1914 (Latham); Sag Harbor, *Britton 213,* July 17, 1898 (NY); Sag Harbor, *Britton*, July 13, 1897 (NY).

*Ramalina fastigiata* is a variable species characterized by its small, straight ellipsoid spores, and broad, usually short, often somewhat channeled lacinae. Magnusson apparently believed the species should be greatly subdivided, and he had annotated specimens from many American herbaria with unpublished names such as *R. americana* and *R. confusa* Magn. I have studied material annotated by Magnusson as *americana, confusa,* and *fastigiata,* and can find no constant character or combination of characters to warrant the recognition of more than one species.

The species occurs in the oceanic eastern tip of Long Island, mainly in the exposed lee dune and down communities or in well-lighted forests growing on various deciduous trees and shrubs.

Distribution — Throughout eastern United States (map: Howe, 1914): Temperate element, East Temperate subelement; Europe; Asia (Zahlbruckner, 1930; Vainio, 1928).

216. **Ramalina stenospora** Müll. Arg. Flora 60: 477. 1877.

Material seen — SUFFOLK COUNTY: Orient, *Latham,* October 1, 1914 (Latham); Orient, *Latham,* April 18, 1923 (Latham); Orient Point, *Latham,* November 26, 1909 (NYS); Orient, *Latham 742,* October 5, 1918 (NYS); Southampton, *Morgan* (*Howe 1677*) September 15, 1909 (FH: Howe); Southampton, *Carnegie* (*Howe 2659*), June 22, 1913 (FH: Howe); Southampton, *Carnegie* (Howe, Lich. Nov. Angl. 64), August 20, 1914 (FH: Howe, MSC).

Although *R. stenospora* has been collected in eastern Long Island a number of times, I myself have never seen it in the field. It is basically a southern species closely related to *R. montagnei* De Not., which has distinctly terete or subterete rather than strap-shaped lacinae. Howe (1914) reported *R. montagnei* from Jamaica, Cuba, Louisiana, and Florida. I have also seen a specimen from the Bahama Islands.

*Ramalina stenospora* appears to be a member of the community on coastal *Juniperus virginiana,* along with *R. willeyi.*

Distribution — West Indies, Gulf and Atlantic coasts north to Massachusetts (map: Howe, 1914): Temperate element, Coastal Plain subelement; endemic.

217. **Ramalina willeyi** R. H. Howe, Bryol. 17: 36. 1914.

Material seen — SUFFOLK COUNTY: *Imshaug 25764* (121); *Brodo 2834* (115), *2962B* (95); Orient, *Latham*, April 20, 1920 (Latham); Napeague, *Latham*, November 6, 1938 (Latham); Orient, *Latham 7436*, June 5, 1933 (Latham); Orient, *Latham 8576*, June 5, 1933 (Latham); Orient, *Latham 8585*, April 30, 1939 (Latham); Montauk, Hither Beach, *Latham 24010*, October 28, 1945 (Latham); Orient Point, *Latham*, December 20, 1909 (NYS); Orient Point, *Latham*, May 2, 1910 (NYS); Promised Land, *Latham*, January 21, 1947 (NYS).

*Ramalina willeyi*, with its subterete lacinae and KOH + red medullary reaction, is easily identified. Although the type could not be found in the Howe herbarium, an isotope from the Willey herbarium at the Smithsonian was examined by Hale, who reports (pers. comm.) that the KOH + constituent is salacinic acid. Howe (1914) seemed to regard the species as basically KOH −, helping to distinguish it from the West Indian species *R. attenuata*, which he said was KOH +. However, he stated that he had seen specimens of *R. willeyi* with a distinct coloration in KOH. All the Long Island specimens contain salacinic acid. One specimen from Cape Cod (*Brodo 4378*), tentatively identified as *R. willeyi*, contains protocetraric acid (by chromatography). A KOH − Florida specimen (in herb MSC), annotated by Magnusson as *R. willeyi*, had the flattened lacinae and slightly curved spores of *R. complanata*. It would, therefore, seem that salacinic acid is almost a constant component of the species, with protocetraric acid being a rare alternate.

*Ramalina willeyi* is a member of the aerohaline community on *Juniperus virginiana*. The species was found to be more luxuriant and more common on Nantucket Island and on Cape Cod.

Distribution — All along the Gulf and Atlantic coasts north to Cape Cod (map: Howe, 1914): Temperate element, Coastal Plain subelement; endemic.

## 56. USNEA P. Br. *ex* Adans.

218. **Usnea longissima** Ach. Lich. Univ. 626. 1810.

Material seen — SUFFOLK COUNTY: Napeague, *Latham*, May 30, 1922 (Latham); Northwest, *Latham*, May 18, 1949 (Latham).

This species, like *Alectoria glabra*, is characteristic of the spruce-fir forests of the north. I did not collect it anywhere on Cape Cod or Nantucket Island, where other species of *Usnea* were abundant, nor in any of the localities on Long Island having "northern" floras. However, according to the specimens cited by Motyka (1936-38) in his monograph, the species has a distribution which could conceivably include Long Island. It is also quite possible that the specimens, like some others in the Latham collection, were mislabeled.

Distribution — Nova Scotia, Michigan, Ontario, Minnesota, Washington, Alaska: Temperate element, North Temperate subelement (Ahti, 1964); Europe; Asia (Asahina, 1956).

219. **Usnea mutabilis** Stirt. Scot. Natural. 6: 107. 1881.

Material seen — Orient, *Latham,* May 23, 1914 (Latham); Orient, *Latham 8612B,* April 30, 1925 (Latham); Orient, *Latham 8613,* April 30, 1925 (Latham).

The densely isidiate branches and red medulla of this species quickly separate it from all other Long Island *Usneae.* Fink (1935) included *U. mutabilis* as a synonym of *U. florida,* an entirely different species.

*Usnea mutabilis,* having been collected on Long Island only by Roy Latham, is one of the rarest of the Long Island lichens, and may in fact be "extinct" on the island at the present time (cf. p. 276). All three Latham collections came from Orient prior to the 1938 hurricane which devastated so much of that area and washed away so many rare species of lichens (p. 276; Latham, 1945). On nearby Nantucket Island and Cape Cod, the species still grows luxuriantly in some localities, particularly in pine-oak forests and bogs on pines or other trees.

Distribution — Throughout eastern United States, especially in the south (Motyka, 1936-38): Temperate element, East Temperate subelement; endemic.

220. **Usnea strigosa** (Ach.) A. Eaton, Man. Bot. ed. 5, 431. 1829. *Usnea florida* $\gamma$. *U. strigosa* Ach. Meth. Lich. 310, pl. 6, f. 3. 1803.

Material seen — (Medulla red) QUEENS COUNTY: Ridgewood, *G. B. Brainerd,* 1866 (BKL 031932). SUFFOLK COUNTY: 39 specimens collected by Imshaug and/or Brodo; 19 specimens collected by Latham (Latham); Riverhead, *Peck* (NYS); Sayville, *Lloyd 137,* December 2, 1896 (NY).

(Medulla white) QUEENS COUNTY: Ridgewood, *G. B. Brainerd,* 1866 (BKL). SUFFOLK COUNTY: 15 specimens collected by Imshaug and/or Brodo; Mattituck, *Latham,* July 4, 1914 (Latham); Montauk, *Latham,* May 6, 1920 (Latham); Montauk, *Latham,* April 17, 1934 (Latham); Shelter Island, Swamp N. of — (?), *Latham 22221,* October 26, 1944 (Latham); Riverhead, *Latham 36871B, 36871C,* May 16, 1960 (Latham); Three Mile Harbor, *Latham 34091B,* April 17, 1947 (Latham); Quogue, *Latham 34313,* September 2, 1950 (Latham).

Of all the difficult groups in the difficult genus *Usnea,* the *U. barbata* group is certainly one of the most challenging. Hale (1962) recently pointed out that *U. strigosa* is made up of a number of chemical strains, among them, a norstictic acid positive strain and a norstictic-less strain, with red medullary color having no taxonomic value. Henry Imshaug and I, working independently from Hale, arrived at precisely the same conclusions.

Of the 50 specimens of *U. strigosa* having a red medulla that we chromatogrammed, 30 (60 percent) contained norstictic acid, and 20

(40 percent) lacked norstictic acid. All specimens with a white medulla that were tested (19) contained norstictic acid. The psoromic acid strain reported by Hale (1962) was not represented at all. Two Latham specimens (Montauk, April 17, 1934; Montauk, May 6, 1920) contained salacinic acid and would be referable to either the *U. arizonica* Motyka population or perhaps to the population represented by the type of *U. subfusca* Stirt. (which is also a member of the *strigosa* complex) (see Hale, 1962).

Thus circumscribed, *U. strigosa* becomes fairly easy to identify, being a shrubby, densely strigose species. The number of apothecia (none to many), color of the medulla (pure white to dark rusty red with all intermediates), and the presence of norstictic acid all are variable. It should be noted that the concentration of norstictic acid varies within the thallus as well. In the white medulla form a clear KOH + red reaction often could be seen only in the medulla of the apothecia, with the medulla of the filaments being perfectly negative with KOH, or at best, pale yellow.

In *U. strigosa*, we once again see the norstictic — psoromic (— salacinic) shift which occurs so often in closely related lichens.

*Usnea strigosa* is fairly common in well-lighted oak woods, bogs, lee dune thickets, etc., throughout eastern Long Island. It occurs exclusively on deciduous trees and shrubs.

Distribution — Throughout eastern United States (map: Hale, 1962): Temperate element, East Temperate subelement; Asia (Zahlbruckner, 1930).

221. **Usnea trichodea** Ach. Meth. Lich. 312. p. 8, f. 1. 1803.

Material seen — SUFFOLK COUNTY: *Imshaug 25802* (86), *25811* (86); *Brodo 897* (56), *1026* (112), *1028* (112), *1038* (112), *1666* (88), *2159* (102), *2161* (102), *2247A* (87); 13 specimens collected by Latham (Latham); Orient, *Young* (BKL); Orient, *Latham*, December 20, 1909 (NYS); Brookhaven, *Ames*, May 1910 (NYS).

The long, very slender, articulated filaments of *U. trichodea* are a common feature of the corticolous bog lichen communities on all species of trees (figure 39).

Distribution — Nova Scotia (type locality), east coast south to Florida and Texas (see Motyka, 1936-38), coastal British Columbia (Weber and Shushan, 1959): Temperate element, Coastal Plain subelement (?); Asia (Zahlbruckner, 1930). Asahina (1956) states that *U. hossei* Vain. f. *subtrichodea* Asahina from Japan has often been confused with *U. trichodea*, and Zahlbruckner's report from China may represent a misidentification. The B.C. report is from the Queen Charlotte Islands, known for many Asian disjuncts, and may also represent *U. hossei*. I have not examined the specimen.

222. **Usnea** sp. (*Usnea subfusca* sensu Mot.)

Material seen — SUFFOLK COUNTY: *Imshaug 25800* (86), *25822* (86); *Brodo 1820* (125) (?), *2104* (86), *2106A* (86), *2107* (86), *2134* (102), *2247B* (87), *2262* (87), *2269* (87), *2803* (102); Northwest, *Latham 27209*, April 18, 1947 (Latham); Montauk, SW of — (?), Fort Pond, *Latham 34082*, July 8, 1957 (Latham); Riverhead, North Swamp, *Latham 36877*, May 25, 1960 (Latham); Riverhead, *Latham 36946*, June 17, 1960 (Latham).

Most Long Island specimens of this species were identified by Herre as *U. subfusca* Stirt. (often as var. *halei* Herre) and, indeed, they agree in most respects with the description of *U. subfusca* given by Motyka (1936-38) in his monograph. However, as Hale (1962) pointed out, Stirton's specimen of *U. subfusca* (which I have also examined both morphologically and chemically) contains salacinic acid and has the strigose habit of a member of the *Usnea strigosa* complex. This leaves the species referred to by Motyka as *U. subfusca* without a name. Since there are several species cited (or even described as new) by Motyka which seem to be close to his *U. subfusca*, it is probable that one of these names could be applied here, and so no *nomen novum* is provided at this time. A likely candidate is *U. merrillii* Motyka, and Herre even annotated some specimens of this species under that name. However, the exsiccats cited by Motyka as *U. merrillii* (Merrill, Lich. 64, 99, and 130), which I examined at the University of Michigan herbarium were different from one another, and, in one case (no. 99), was a mixed collection. Confirmation must await an examination of the holotype of this and other suspect species.

The Long Island material is very variable in many respects. Although its general aspect is dark ashy green to olivaceous, it sometimes becomes stramineous toward the younger branchlets and is often mottled yellowish and grey-green in younger portions. Branching is loose, with irregular side branches and common dichotomies, although the end shoots frequently have few or no side branches. Papillae and sometimes small tubercles usually cover the main branches, but sometimes they are sparse. Isidiate soralia are generally conspicuous (rarely absent) on the younger portions of the thallus. Apothecia, which are very infrequent, are heavily pruinose, small (1.5-3 mm) and have long marginal "cilia" 1-3 times the diameter of the disk. The cortex, however, is always thick and chondroid, and the medulla is always white and thin.

Chromatographic analysis showed that protocetraric acid is present in all specimens except for one Long Island collection (*Brodo 2247B*), which contains barbatic acid, and two Cape Cod collections (*Brodo 4161, 4338*) which showed the presence of fumarprotocetraric acid.

The species is found in well-lighted areas of bogs and swamps, being rare elsewhere. It occurs on all types of trees, especially *Chamaecyparis thyoides*, and thus is usually associated with *Usnea trichodea.*

Distribution — Probably widespread in east temperate North America.

## TELOSCHISTACEAE

### 57. CALOPLACA Th. Fr.

223. **Caloplaca aurantiaca** (Lightf.) Th. Fr. Nova Acta Reg. Soc. Sci. Upsal. III. 3: 219. 1861. (Lich. Arct. 119. 1860). *Lichen aurantiacus* Lightf. Fl. Scot. 2: 810. 1777.

Material seen — SUFFOLK COUNTY. *Brodo 3311* (129), *3439* (134).

Both Long Island specimens assigned to this species proved to be difficult to identify. In the case of *Brodo 3311,* found on a windswept *Carya* on the Montauk downs, the thallus was very thin and almost devoid of the yellow tint characteristic of the species. In the case of *Brodo 3439,* the substrate (concrete) did not agree with Rudolph's (1955) view that the species is found only on wood and bark. The spore, thallus, and apothecial characters of the latter specimen seem to fit the descriptions of *C. aurantiaca* very well, and other modern authors (Erichsen, 1957; Hillmann & Grummann, 1957; Bertsch, 1964) state that the species can be saxicolous.

Distribution — Nova Scotia, Connecticut, Oklahoma, Wisconsin, Arizona, Idaho, Washington: Temperate element, North Temperate subelement; Europe; Asia (Zahlbruckner, 1930, and others).

224. **Caloplaca camptidia** (Tuck.) Zahlbr. Cat. Lich. Univ. 7: 83. 1930. *Lecanora camptidia* Tuck. Proc. Amer. Acad. Arts Sci. 5: 403. 1862.

Material seen — SUFFOLK COUNTY: *Imshaug 25595* (52); *Brodo 1765B* (127), *1769A* (127), *1897* (114), *2683B* (110), *3085B* (128), *3095* (122), *3103B* (122); Orient, *Latham,* May 3, 1914 (Latham); Greenport, *Latham 22259,* March 29, 1914 (Latham); Orient Point, *Latham 6,* November 21, 1910 (NYS).

This is the only *Caloplaca* on Long Island entirely without anthraquinone pigments. Superficially, it looks much like a *Lecanora* with pruinose, reddish brown apothecia. Its hyaline polarilocular spores, however, clearly identify it as a *Caloplaca.*

*Caloplaca camptidia* is found only on oak bark, and it is an occasional member of the breast height communities on oak (figure 66).

Distribution — Oklahoma, Appalachians (Rudolph, 1955): Temperate element, Appalachian subelement, Appalachian-Ozark unit (?); West Indies (Tuckerman, 1872); endemic.

225. **Caloplaca cerina** (Ehrh. in Hoffm.) Th. Fr. Nova Acta Reg. Soc. Sci. Upsal. III. 3: 218. 1861 (Lich. Arct. 118. 1860). *Lichen cerinus* Ehrh. in Hoffm. Pl. Lich. 2: 62, pl. 21, f. 13, 1789.

Material seen — SUFFOLK COUNTY: *Brodo 3311* (129); Three Mile Harbor, East Hampton, *Latham 2644,* April 20, 1926 (MICH).

As stated by Rudolph (1955), the relationship between *C. cerina* and the very similar *C. pyracea* is not always clear and it appears, at least on Long Island, that the two are very difficult to separate. Typically, *C. cerina* has a prominent, persistent, blue-grey, pseudothalline margin (referred to as the "amphithecium" by Rudolph, 1955). In *C. pyracea,* the pseudothalline margin almost always is entirely lacking in the mature apothecia. Sometimes, however, this grey margin will begin to disappear in *C. cerina* or will be relatively persistent in *C. pyracea.* (Imshaug, 1957c, gives a discussion on the relationship between the amphithecium and the pseudothalline margin.) In these cases, one must rely more heavily on disk color (which actually reflects a difference in the anthraquinone complements of the two species; Burgess, in press). *Caloplaca cerina* has dusky yellow to yellow-orange disks, whereas *C. pyracea* has orange to red-orange disks. Rudolph (1955) states that there is a difference in hypothecial height, but I have not been able to verify this in the material I have studied.

Although *C. cerina* is a very rare species on Long Island, it is widely distributed on a variety of "calcareous" or "nitrogenous" substrates (cf. p. 30). One specimen (*Latham 2644*) was collected on a turtle shell and the other found on an exposed *Carya* on the Montauk downs.

Distribution — Connecticut, Michigan, Indiana, Wisconsin, Arizona, New Mexico, Black Hills, Washington, Saskatchewan, Manitoba: Temperate element (?), North Temperate subelement; Europe; Asia (Zahlbruckner, 1930).

226. **Caloplaca citrina** (Hoffm.) Th. Fr. Nova Acta Reg. Soc. Sci. Upsal. III. 3: 218. 1861 (Lich. Arct. 118. 1860). *Verrucaria citrina* Hoffm. Deutschl. Fl. 2: 198. 1796.

Material seen — SUFFOLK COUNTY: *Imshaug 25605* (E of 106); *Brodo 2501* (61), *2800* (84), *2828A* (115), *2828B* (115), *2841* (115); near Orient (Narrows), *Latham,* (no date) (Latham).

*Caloplaca citrina* is recognized by its yellow-orange, granular sorediate thallus. The thallus, however, can vary from almost an entirely effuse-subareolate condition to one which is sterile, thick, and areolate with mere traces of granular soredia. The more abundantly sorediate specimens had many small apothecia with margins commonly becoming sorediate.

The species apparently is narrowly restricted to concrete and mortar substrates and is a member of the aerohaline community (p. 59). On Long Island, it is confined to the coastline (figure 77) although the species as a whole is continental.

Distribution — South Carolina, Kansas, Iowa, Missouri, Minnesota (Rudolph, 1955); Connecticut, Michigan, Black Hills, Washington: Temperate element, North Temperate subelement; Europe; Asia (Zahlbruckner, 1930).

227. **Caloplaca discolor** (Will. in Tuck.) Fink, Lich. Fl. U. S. 357. 1935. *Placodium ferrugineum* var. *discolor* Will. in Tuck. Syn. N. Amer. Lich. 1: 178. 1882.

Material seen — SUFFOLK COUNTY: *Brodo 1762* (127); Orient Point, *Latham*, April 18, 1910 (NYS); Orient, *Latham 22261*, March 20, 1921 (Latham); Orient, *Latham 22262*, May 23, 1914 (Latham); Orient, *Latham 1082* (22265), May 20, 1916 (Latham).

*Caloplaca discolor* was placed in the genus *Blastenia* by Rudolph (1955) because of its frequently alga-less margin. Intermediates are common, however, and would seem to indicate that the species should be retained in *Caloplaca*.

The species was found on the bark of oak and red cedar near the eastern tip of Long Island.

Distribution — Massachusetts, Michigan, Black Hills; endemic.

228. **Caloplaca feracissima** Magn. Bot. Not. 2: 189. 1953.

Material seen — SUFFOLK COUNTY: *Brodo 59-36* (53), *1825* (125), *3919* (54).

This species, described from a specimen on concrete from Wisconsin, was found to be comparatively common on inland concrete substrates on Long Island, although only three specimens were collected. Concrete and mortar closer to the coast commonly had *C. citrina* in its place. The dark orange to orange-brown apothecia usually subtended by a trace of black prothallus, the yellowish, almost totally absent thallus, and the narrow spore isthmi combine to make this species rather distinctive and easily identified.

I have seen specimens from Michigan and central New York State, and it is apparently much more common than indicated by the few reports. Since it grows well on concrete sidewalks and foundations, even close to industrial centers, it will almost surely become more abundant in the future.

Distribution — Central New York, Michigan, Wisconsin (type locality); endemic.

229. **Caloplaca flavovirescens** (Wulf.) Dalla Torre & Sarnth. Flecht. Tirol 180. 1902. *Lichen flavovirescens* Wulf. Schrift. Ges. nat. Freunde Berl. 8: 122. 1787.

Material seen — SUFFOLK COUNTY: *Brodo 2824* (66), *3918* (54), *3920* (54); Orient, *Latham 2873* (*22264*), February 7, 1926 (Latham).

This species was found on partially shaded or exposed concrete. Roy Latham's specimen from bone (above) was not entirely typical of the species in that it had a very inconspicuous thallus.

Distribution — Nova Scotia, Oklahoma, Arizona, Black Hills, Saskatchewan; "cosmopolitan" according to Rudolph (1955): Temperate element, North Temperate subelement; Europe; Asia (Zahlbruckner, 1930).

230. **Caloplaca pyracea** (Ach.) Th. Fr. Kgl. Svensk. Vet. Akad. Handl. 7(2): 25. 1867. *Parmelia cerina* var. *pyracea* Ach. Meth. Lich. 176. 1803.

Material seen — SUFFOLK COUNTY: *Brodo 2963* (95); Orient, *Latham*, May 27, 1914 (Latham); Greenport, *Latham 50*, May 10, 1914 (Latham); Orient Point, *Latham*, April 4, 1910 (NYS); Orient, *Latham 3939*, March 27, 1927 (MICH); Three Mile Harbor, East Hampton, *Latham 2644* (p.p.), April 20, 1926 (MICH).

*Caloplaca pyracea* is the common corticolous *Caloplaca* on Long Island. As mentioned before (p. 248), it is easily confused with *C. cerina*.

Distribution — Nova Scotia, Maine, Connecticut, Michigan, Indiana, Arizona, Black Hills, Washington, Baffin Island: Arctic-boreal element; northeast Greenland (Lynge, 1940); Europe; Asia (Zahlbruckner, 1930).

## 58. XANTHORIA (Fr.) Th. Fr.

231. **Xanthoria fallax** (Hepp in Arn.) Arn. Verh. Zool. Bot. Ges. Wien 30: 121. 1880. *Physcia fallax* Hepp in Arn. Flora 41: 307. 1858.

Material seen — QUEENS COUNTY: W. Flushing, (*Brainerd*?) (BKL); W. Flushing *G. B. Brainerd* (BKL 032033); West Flushing, (*Brainerd*?), April 12, 1868 (BKL 032034). SUFFOLK COUNTY: *Imshaug 25640* (64); *Brodo 884* (55), *1071* (98), *2118* (84), *2592* (97), *2701* (SE of 107), *2825* (115), *3097* (122), *3197* (32), *3359* (S of 97), *3362* (62); Orient, Long Beach, *Latham 7425*, May 31, 1940 (Latham); Montauk Point, *Latham 24172*, May 4, 1926 (Latham); Orient Point, *Latham*, January 3, 1910, (NYS); Orient Point, *Latham 8*, January 9, 1911 (NYS).

This small-lobed species is often confused with *X. candelaria* (L.) Arn. The soredia of *X. fallax* are produced on the *undersurface* as well as the edges of more or less hood-like lobes, whereas the soredia or granules of *X. candelaria* are produced only on the edges of the lobes which are never hood-like. Thompson (1949) also discusses these differences.

*Xanthoria fallax* is a rather common member of the community on roadside elms. It was found once on concrete (*Brodo 2825*) at Orient Point. In the past, this species must have been common in the New York City area (see citations above).

Distribution — Ontario (leg. LeBlanc), Michigan (seen in herb. MSC); Wisconsin, Oklahoma, Arizona, Black Hills, Saskatchewan, Canadian archipelago: Arctic-boreal element; Europe.

232. **Xanthoria parietina** (L.) Beltr. Lich. Bassan. 102. 1858. *Lichen parietinus* L. Sp. Pl. 1143. 1753.

Material seen — KINGS COUNTY: Flatbush, (*Brainerd*?) 1866 (BKL). SUFFOLK COUNTY: 16 specimens collected by Imshaug and/or Brodo; 10 specimens collected by Latham (Latham); Greenport, *Peck* (NYS); Greenport, *Peck*, Sept. (NYS); Orient, *Young* (BKL); E. Patchogue, collector unknown, September 8, 1912 (Staten Island); Sag Harbor, *Britton 212*, July 17, 1898 (NY); Sag Harbor, *Britton 211*, July 17, 1898 (NY).

This conspicuous species, although usually very easily identified, occasionally shows small-lobed, richly fruiting forms which resemble *X. polycarpa* (Ehrh.) Rieb. The latter species, however, is rarely found along the coast (never on Long Island) where *X. parietina* is most common. In addition, *X. polycarpa* never shows any tendency towards broad lobes or lack of apothecia, and typically has very narrow, finely-divided lobes almost obscured by apothecia. *Xanthoria parietina* almost always shows some broadened lobes.

*Xanthoria parietina* is a well known and often cited example of a "nitrophilous" or "neutrophytic" species, and, with its associated species with similar requirements, makes up the well known *Xanthorion parietinae* alliance discussed in full by Barkman (1958) and also by des Abbayes (1951). Barkman (1958) does not consider the community halophytic, despite its maritime affinities, although he notes that it is "favored by salt impregnation." He prefers to call it "nitrophytic" or "nitrophilous" and "subneutrophytic." The observations of Maas Gesteranus (1955) of *X. parietina* growing well on the windblown edges of salt lakes in Kenya, Africa, might point to the importance of sodium, high pH, or some other minerals to the species.

Both Barkman (1958) and Almborn (1948) note that the community develops best on the road-facing sides of trees along dusty roads, especially where nitrogen-rich dust may be blown on the substrata and thallus, although Almborn prefers to view with skepticism the theory that nitrogen concentration is the chief causal factor involved in this distribution. On Long Island, *X. parietina* was also most commonly found on the road-facing side of roadside trees. Although elms seemed to be the most suitable substrate, it was also collected on roadside oaks and maples.

Des Abbayes (1934) noted *X. parietina* in the upper hygrohaline (salt spray) zone of his maritime rock community. On Long Island, its distribution is more or less maritime, often being found very close to the coast (figure 80 and p. 59).

Distribution — On northeastern, Pacific and Gulf coasts (map: Hale, 1955c): Temperate element, Oceanic subelement(?) Hale, 1961a); Europe, in lowlands extending far inland and up to an altitude of about 1500 m (Maas Gesteranus, 1955); Asia (Vainio, 1928, Zahlbruckner, 1930).

## 59. TELOSCHISTES Norm.

233. **Teloschistes chrysophthalmus** (L.) Beltr. Lich. Bassan. 109. 1858. *Lichen chrysophthalmos* (sic) L. Mantissa Pl. 2: 311. 1771.

Material seen — COUNTY UNKNOWN: Long Island, N. Y., *Lloyd* (L. I. *133*) (NY); Long Island, *G. B. Brainerd* (NYS). SUFFOLK COUNTY: Orient, *Latham*, May 20, 1914 (Latham); Greenport, *Peck 151*, Sept. (NYS); Greenport, *Peck* (NYS); Moriches, (*Brainerd*?) (BKL 032035); Sayville, *Lloyd* (L. I. *138*), December 3, 1896 (NY);

Sag Harbor, *Britton* 210, July 17, 1898 (NY); Sag Harbor, on Judge Daly's place, *Britton,* July 13, 1897 (NY).

*Teloschistes chrysophthalmus* probably was a member of the coastal tree community. Along with *T. flavicans,* this species has apparently disappeared from Long Island. The hurricane of 1938 (see Latham, 1945) was probably an important factor in cutting down the population size to a point below the level at which the species could maintain themselves without reinvasion. Since Long Island appears to be the northern limits for both species, reinvasion was very unlikely.

Distribution — Widely distributed in the warm areas of the world (Zahlbruckner, 1931); "Mexican element," Texas to Minnesota in Great Plains and in New England (Hale, 1961a): Tropical element, Appalachian-Temperate subelement; Europe.

234. **Teloschistes flavicans** (Sw.) Norm. Nytt. Mag. Naturvid. 7: 229. 1853. *Lichen flavicans* Sw. Nov. Gen. Sp. Pl. 147. 1788.

Material seen — SUFFOLK COUNTY: Orient point, *Latham* (CUP); Orient Point, *Latham 19,* April 9, 1910 (NYS).

This species was apparently a member of the aerohaline *Juniperus* community (Latham, pers. comm.).

Distribution — "Mexican element," coastal areas of Texas and the Carolinas (Hale, 1961a); Florida, California (Rudolph, 1955), Connecticut: Tropical element, Coastal Plain subelement (?); Europe (Poelt, 1963); Asia (Zahlbruckner, 1930).

## PHYSCIACEAE

### 60. BUELLIA De Not.

235. **Buellia curtisii** (Tuck.) Imsh. in Brodo, comb. nov. *Gyrostomum curtisii* Tuck. Amer. J. Arts Sci. II, 25: 430. 1858.

Material seen — SUFFOLK COUNTY: 72 specimens collected by Imshaug and/or Brodo; 10 specimens collected by Latham (Latham).

This combination was first used in a thesis by Imshaug (1951, and 1952 [abstract]). Neither usage, however, constituted valid publication. Culberson (1953) did mention the new combination, but since he did not cite the basionym, his usage also does not constitute valid publication.

This species, the most common corticolous *Buellia* on Long Island, is superficially identical with *B. stillingiana.* The two species have very thin, more or less continuous, greenish grey thalli with pitch black apothecia. Both contain norstictic acid and both are found on a variety of deciduous trees, usually smooth-barked species, and usually at breast height. The differences between the two species lie in their apothecial and spore characters (key, p. 144).

Distribution — Southeastern United States, especially along the coastal plain, north to Connecticut (map: Imshaug, 1951): Temperate element, East Temperate subelement (?); endemic.

236. **Buellia dialyta** (Nyl.) Tuck. Gen. Lich. 187. 1872. *Lecidea dialyta* Nyl. Flora 52: 123. 1869.

Material seen — SUFFOLK COUNTY: *Brodo 1282* (21), *2460* (22).

*Buellia dialyta,* a relatively rare species on Long Island and elsewhere, is unusual in having a PD + red thallus reaction (due to fumarprotocetraric acid). Its thallus is usually very thin and scanty (Imshaug, 1951) but the Long Island material showed fairly well-developed thalli, white to pale ashy, at first thin but becoming thick and somewhat rugose and almost granulose.

The species was found once on the bark of *Quercus velutina* and once on the top surface of a rotting log.

Distribution — Maine, Vermont, New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, Tennessee, California (type locality, but the type may well have been mislabelled) (Imshaug, 1951): Temperate element, Appalachian subelement, Appalachian unit; endemic.

237. **Buellia polyspora** (Will. in Tuck.) Vain. Acta Soc. Faun. Fl. Fenn. 7 (1): 171. 1890. *Buellia myriocarpa* var. *polyspora* Will. in Tuck. Syn. N. Amer. Lich. 2: 97. 1888.

Material seen — COUNTY UNKNOWN: Long Island, *Latham,* 1914 (MSC). SUFFOLK COUNTY: 60 specimens collected by Imshaug and/or Brodo; Orient, *Latham 20,* April 5, 1914 (Latham).

*Buellia polyspora* differs from *B. punctata* sens. str. in several ways, in addition to having 12 to 24 spores per ascus rather than 8. The exciple in *B. polyspora* is almost hyaline within (as in *B. curtisii*), whereas in *B. punctata,* the exciple is solid dark brown to black. In addition, *B. polyspora* is only found on the bark of deciduous trees, whereas *B. punctata* is found on a variety of substrates including lignum and the bark of conifers.

On Long Island, *B. polyspora* shows a limited eastern distribution, possibly reflecting extreme intolerance to air pollution, but more likely indicating its preference for the well lighted, open woods and shrubby downs most common in that part of the island.

Distribution — Throughout eastern United States (Imshaug, 1951): Temperate element, East Temperate subelement; Brazil (Wainio, 1890).

238. **Buellia punctata** (Hoffm.) Mass. Ricerch. Auton. Lich. 81, f. 165. 1852. *Verrucaria punctata* Hoffm. Deutschl. Fl. 2: 192. 1796.

Material seen — COUNTY UNKNOWN: Long Island, N. Y., *Latham,* 1914 (CUP). SUFFOLK COUNTY: *Imshaug 25582* (52), *25616A* (116), *25770E* (121); Orient, *Latham 62,* May 23, 1914 (Latham); Orient, *Latham 3941,* April 20, 1927 (Latham); Orient, Long Beach, *Latham 22333,* December 7, 1944 (Latham); Orient Point, *Latham,* 1911 (CUP).

The relationship between this species and *B. polyspora* has already been discussed. *Buellia punctata* is very rare on Long Island, being found on bark (often conifer bark) and on old wood. The species was also collected on pine bark in Cape Cod.

Distribution — Throughout United States and southern Canada, and on the west and north coasts of Alaska, but absent from all other parts of high boreal and arctic Canada (map: Imshaug, 1951): Temperate element (?), North Temperate subelement; Europe; Asia (Zahlbruckner, 1930).

239. **Buellia stigmaea** Tuck. Syn. N. Amer. Lich. 2: 90. 1888.

Material seen — SUFFOLK COUNTY: *Brodo 2672* (108), *2807* (106), *3079* (128), *3881* (62).

This species is very similar in general appearance and chemical reactions to *Rhizocarpon cinereovirens* which, however, has a greenish epithecium and apothecial margin, and has very lightly tinted, slightly larger spores, each usually showing a conspicuous gelatinous sheath or "halo."

*Buellia stigmaea* has a smooth, whitish grey thallus which becomes irregularly cracked and areolate, allowing a conspicuous black prothallus to show through between the areoles as well as beyond the thallus edge. In contrast, *Rhizocarpon cinereovirens* has a dirty grey-green to whitish grey thallus which is minutely areolate to almost granulose and lacks a black prothallus.

Distribution — Appalachians, Missouri (north of Ozarks) (map: Imshaug, 1951); Alaska (Imshaug, pers. comm.)?: Temperate element, Appalachian subelement, Appalachian unit (?); endemic.

240. **Buellia stillingiana** J. Stein. Oest. Bot. Zeitschr. 68: 144. 1919.

Material seen — NASSAU COUNTY: Cold Spring, *Grout*, April 1, 1900 (BKL). SUFFOLK COUNTY: 37 specimens collected by Imshaug and/or Brodo; Greenport, *Latham*, May 12, 1960 (Latham); Orient, *Latham 736*, March 10, 1915 (Latham); Orient, *Latham 737*, May 3, 1915 (Latham); Orient, *Latham 22331A*, December 7, 1944 (Latham); Eastport, *Schrenk*, June 26, 1894 (MO).

This species, long confused with *B. parasema* (Ach.) De Not., is actually quite distinctive. It differs from *B. parasema* in lacking oil droplets in the hymenium and in having a "T"-shaped, grey apothecial stipe, with a more or less uniformly brown-black exciple rather than an exciple which is pale brown to pale olivaceous within (Imshaug, 1951; Lamb, 1954). The similarities between *B. stillingiana* and *B. curtisii* are discussed with the latter.

*Buellia stillingiana* is a common inhabitant of smooth-barked deciduous trees, especially in well-lighted situations.

Distribution — Throughout eastern United States, and in Pacific Northwest (map: Imshaug, 1951); absent in Black Hills: Temperate element, North Temperate subelement (?); endemic.

241. **Buellia turgescens** Tuck. Gen. Lich. 185. 1872.

Material seen — SUFFOLK COUNTY: *Brodo 1806* (127), *2371* (123), *2673* (108), *3423* (134); Orient, *Latham*, May 15, 1920 (Latham); Orient, Long Beach factory site, *Latham 22337*, December 7, 1944 (Latham).

This distinctive saxicolous species has a thick, brownish grey verrucose to granulose thallus with very small apothecia (less than 0.5 mm in diameter) either partially sunken into the verrucae and appearing aspicilioid, or, more commonly, sessile and prominent.

It grows on exposed or partially shaded granite boulders, and, on one occasion, was found by Latham on a brick (figure 65). Lignicolous specimens are known from Massachusetts (Imshaug, 1951).

Distribution — Maine, Massachusetts, Connecticut, New York, Ohio, Iowa, Kansas, Minnesota, California, Washington (Imshaug, 1951): Temperate element, North Temperate subelement; endemic.

### 61. RINODINA (Ach.) S. Gray

242. **Rinodina applanata** Magn. Bot. Not. 43. 1947.

Material seen — SUFFOLK COUNTY: *Brodo 3077b* (128).

This species, described from Louisiana, was found only once on Long Island (on oak bark) and probably is rare throughout its range. It is characterized by its thin, grey thallus and uniformly thick-walled spores with spherical lumina (pachyspores; figure 90c).

Distribution — Louisiana (type locality), Oklahoma; endemic.

243. **Rinodina confragosa** (Ach.) Körb. Syst. Lich. Germ. 125. 1855. *Parmelia confragosa* Ach. Meth. Lich. Suppl. 33. 1803.

Material seen — SUFFOLK COUNTY: *Brodo 2662b* (108), *3048* (50).

*Rinodina confragosa* is a rare member of the community found on shaded boulders, occurring there with *Rhizocarpon intermedium* and *Buellia stigmaea*. Its small apothecia (0.5-1.0 mm in diameter) are flat to slightly concave. The apothecial disks are brown and are bounded by a prominent rim which is smooth or becoming crenulate. The spores are conspicuously mischoblastiomorphic (see Imshaug, 1957c).

Distribution — Massachusetts, New Jersey, Louisiana, Illinois, Minnesota, Oregon, California (Fink, 1935); Michigan, Arizona, Black Hills, Washington, Alaska: Temperate element, North Temperate subelement; Europe; Asia, Africa (Fink, 1910).

244. **Rinodina milliaria** Tuck. Proc. Amer. Acad. Arts Sci. 12: 175. 1877.

Material seen — SUFFOLK COUNTY: *Imshaug 25615* (116), *25627* (116), *25680* (72), *25687* (72), *25753b* (132); *Brodo* 594 (92), *1064* (130), *1792* (127), *2607* (84), *2726* (111), *2830* (115), *3108* (122), *3317* (129); Orient, Long Beach, *Latham 22*, April 16, 1914 (Latham); Orient, Long Beach, *Latham 22335*, December 7, 1944 (Latham); Orient, Long Beach, *Latham 22355aB*, December 1, 1944 (Latham); Orient, Long Beach, *Latham 22339B*, December 7, 1944 (Latham); Orient, Brown's Hills, *Latham 23057*, March 18, 1945 (Latham); Orient, *Latham 36804*, April 10, 1956 (Latham); Southold, *Latham 36952B*, October 10, 1960 (Latham).

As pointed out by Magnusson (1947), the apothecia of this species often lose much of their lecanorine margins, and this, together with the black hypothecium, often give specimens the appearance of a *Buellia*. However, on every thallus there are always some apothecia showing a typical grey or greenish margin.

The spores are normally uniseptate, 8-15 x 5-7 µ, but one specimen (*Imshaug 25753b*), showed some unusual spores mixed in with the normal ones. These aberrant spores were 3-septate and slightly curved, and measured 15-20 x 5-7 µ.

*Rinodina milliaria* was found often on bark and wood, especially in windswept and salt-sprayed areas. Its distribution (figure 78) reflects its coastal tendencies on Long Island. Although it appears almost maritime on Long Island, the species has been reported from as far west as Manitoba.

Distribution — New England, New York, Pennsylvania (Fink, 1935); Maine, Wisconsin (Magnusson, 1947); Manitoba: Temperate element, North Temperate subelement; endemic (?).

245. **Rinodina oreina** (Ach.) Mass. Ricerch. Auton. Lich. 16, f. 24. 1852. *Lecanora straminea β. L. oreina* Ach. Lich. Univ. 433. 1810.

Material seen — SUFFOLK COUNTY: *Brodo 1801* (127), *1892* (114), *2364* (123), *2659* (108), *2675* (108), *2734* (111), *2816* (106), *3321* (129), *3447* (134), *3851* (76).

All the Long Island material of this species showed a PD −, C + red thallus reaction and thus belongs to "Chemical Strain II" of Hale (1952b). The specimens tested microchemically contained gyrophoric acid.

*Rinodina oreina* was found growing on exposed granite boulders in eastern Long Island, especially near the bays and ocean.

Distribution — Throughout United States, boreal and arctic Canada (map: Hale, 1952b): Arctic-boreal element; Europe. The gyrophoric acid strain, by itself, has a North Temperate distribution (see Hale, 1952b).

246. **Rinodina pachysperma** Magn. Bot. Not. 193. 1953.

Material seen — SUFFOLK COUNTY: 16 specimens collected by Imshaug and/or Brodo; Orient, North Locust, *Latham 17*, April 6, 1914 (Latham); Shelter Island, collector unknown, October 10, 1910 (FH).

The Long Island material was compared with the type specimen from Wisconsin (in herb. J. Thomson). The spore and apothecial characters agreed, but most of the eastern specimens had a smoother thallus, frequently in flat areoles which sometimes partially lift off the surface and appear subsquamulose. The type specimen has a well-developed, minutely areolate thallus, but showed the same olive-green to dark green color. Tendencies toward intergradation were seen, however, and no really significant differences could be found.

There are a few characters which appeared to be constant and conspicuous which deserve special mention. The apothecia often show both proper and thalline margins in macroscopic view. The spores were variable in shape, often slightly curved, rounded at one end and pointed at the other, or merely ellipsoid.

The species was collected on the bark of various deciduous trees, usually close to the coast (figure 79).

Distribution — Wisconsin (type locality), Black Hills; endemic.

247. **Rinodina salina** Degel. Uppsala Univ. Arsskr. 192. 1939 (nom. nud.); Ark. Bot. 30A (1): 55. 1940.

Material seen — SUFFOLK COUNTY: *Brodo 2828A* (115); Orient, *Latham 2873* (*22264*), February 7, 1926 (Latham) (with *Caloplaca flavovirescens*).

Degelius (1939) pointed out that the name *Rinodina demissa* Arn., under which this plant has generally been considered, cannot be used since the basionym, *Zeora metabolica β. demissa* Flörke, is based on an entirely different taxon, *Buellia ambigua* (Ach.) Malme.

*Rinodina salina*, a well-known maritime lichen in Europe, was first reported from North America by Räsänen (1933) (as *R. demissa*), from New Brunswick, Canada, and then by Degelius (1940) from Prince's Point in Maine, where it was found "on maritime rocks in the middle-hygrohaline." The original description notes the thallus as brownish to dark ashy. A specimen seen at the U.S. National Museum showed a distinct brownish tint. The Long Island specimens had no brown tint at all; they were whitish to ashy, becoming sordid ashy.

As in Europe and Maine, the Long Island specimens were in the maritime zone, specifically, the aerohaline zone. Both specimens were on calcareous substrates (concrete and bone) and were associated with species of *Caloplaca*.

Distribution — New Brunswick, Maine (see above), Black Hills (a very odd record in view of its ecology); Europe.

### 62. PYXINE Fr.

248. **Pyxine sorediata** (Ach.) Mont. in Sagra, Hist. Cuba 8: 188. pl. 7, f. 4. 1838-42. *Lecidea sorediata* Ach. Syn. Lich. 54. 1814.

Material seen — SUFFOLK COUNTY: *Brodo 59-255* (67), *869* (47), *1886* (114), *2056* (45), *2494* (67), *3895* (112).

Imshaug (1957c) has thoroughly discussed this species as it occurs in North America. None of the Long Island material had apothecia. *Pyxine sorediata* was found mostly at breast height on oaks in pine-oak forests.

Distribution — Throughout eastern United States (map: Imshaug, 1957c): Temperate element, East Temperate subelement; eastern Asia (ibid).

### 63. PHYSCIA (Schreb.) DC.

249. **Physcia adscendens** (Th. Fr.) Oliv. Fl. Lich. Orne 1: 79. 1882. *Physcia stellaris* var. *adscendens* Th. Fr. Lich. Scand. 1: 138. 1871.

Material seen — SUFFOLK COUNTY: *Brodo 59-330* (53), *2117* (93), *2120* (NE. of 71); Orient Point, *Latham 30*, April 18, 1910 (NYS).

This species was listed and discussed by Fink (1935) under *Physcia hispida* (Schreb.) Frege, a name which cannot be used due to its uncertain meaning (Thomson, 1963).

*Physcia adscendens* is relatively rare on Long Island. As is usual for the species, it occurs as a member of the communities on roadside poplars and elms or calcareous rocks (the *Xanthorion parietinae* alliance as recognized in Europe).

Distribution — Throughout northern and western United States and southern Canada (map: Thomson, 1963): Temperate element, North Temperate subelement, Europe, Asia (ibid).

250. **Physcia aipolia** (Ehrh. in Humb.) Hampe in Fürnr. Naturh. Topogr. Regensburg 2: 249. 1839. *Lichen aipolius* Ehrh. in Humb. Fl. Friburg. Spec. 19. 1793.

Material seen — SUFFOLK COUNTY: 21 specimens collected by Imshaug and/or Brodo.

The white spots characteristic of this species can best be termed maculae, rather than pseudocyphellae as they are sometimes called. In the latter, the upper cortex must be broken, allowing medullary hyphae to reach the surface. This is not the case in *P. aipolia*, where the spots appear to be tiny discontinuities in the algal layer beneath a continuous upper cortex.

*Physcia aipolia* is a member of the community on well-lighted black oaks and is usually found in open pine-oak forests (figure 46).

Distribution — Throughout the United States, southern Canada, and coastal Alaska (map: Thomson, 1963): Temperate element, North Temperate subelement, Europe, Asia (ibid).

251. **Physcia millegrana** Degel. Ark. Bot. 30A(1): 56. 1940.

Material seen — KINGS COUNTY: New Lots, (*Brainerd* ?) (BKL 032039). NASSAU COUNTY: *Brodo 1307* (15), *3195* (7). SUFFOLK COUNTY: 64 specimens collected by Imshaug and/or Brodo; Greenport, *Latham*, June 26, 1960 (Latham); Orient, *Latham 68*, May 23, 1914 (Latham); Orient, *Latham 7453*, June 5, 1933 (Latham); Orient, Long Beach, *Latham 8586*, April 25, 1939 (Latham); Greenport, *Latham 36928*, June 26, 1960 (Latham); Orient, *Latham 36936*, September 10, 1960 (Latham).

This very common species was for years considered to be the same as the European *P. tribacia* (Ach.) Nyl. (see Fink, 1935). The two are separated on the basis of their lower cortices: paraplectenchymatous in *P. millegrana*, and not paraplectenchymatous in *P. tribacia*. The only North American record of *P. tribacia* is from the Northwest Territories (Thomson, 1963).

The thallus varies from having flat, very finely-dissected lobes with very sparse marginal granules to a form having densely granular lobe margins, often piling up in the thallus center and almost giving the appearance of a granular crust.

The species usually is found on the bark of a variety of deciduous trees, especially in well-lighted forests (figure 71). It was found occasionally on the bark of *Juniperus virginiana* (which often supports neutrophytic communities), and once on a granite boulder (*Brodo 3096*). When the species grows on rock, it can be confused with *P. subtilis.* The separation of the two is discussed with the latter species.

Distribution — Eastern United States south to North Carolina and Texas, California (introduced) (map: Thomson, 1963): Temperate element, East Temperate subelement, endemic (ibid).

252. **Physcia orbicularis** (Neck.) Pötsch in Pötsch & Schiederm. Syst. Aufzähl. Samenlos. Pfl. 247. 1872. *Lichen orbicularis* Neck. Meth. Musc. 88. 1771.

Material seen — NASSAU COUNTY: *Brodo 1313* (15), *1501* (9), *1502* (14). SUFFOLK COUNTY: 52 specimens collected by Imshaug and/or Brodo; Orient, Long Beach, *Latham,* April 16, 1933 (Latham); Orient, *Latham,* April 15, 1914 (Latham); Orient, *Latham 892,* February 1, 1920 (Latham); Manorville, *Latham 8622,* May 20, 193(8)? (Latham); Montauk, *Latham 31912,* January 5, 1953 (Latham); Orient Point, *Latham 8,* January 9, 1911 (NYS).

There are two common forms of *P. orbicularis* in North America, one with a white medulla (f. *orbicularis*), and one with on orange-red medulla (f. *rubropulchra* Degel.). Both forms are represented on Long Island, with the latter being much more abundant. Forma *rubropulchra* appears to be restricted to North America but corresponds to f. *Hueana* (Harm.) Erichs. in Europe, which has a yellow-orange medulla with soredia of the same color (Degelius, 1940). A critical study of the anthraquinone pigments involved in these vicarious forms might prove very interesting in light of some of the recent data regarding the systematic and biogenetic importance of pairs of closely "related" depsides and depsidones in closely related taxa (see Runemark, 1956; C. Culberson 1963, 1964; Imshaug and Brodo, 1966).

Bruce Fink (1935) apparently referred to f. *orbicularis* as *P. virella* (Ach.) Flag., and to f. *rubropulchra* as "*P. endochrysea* (Hampe) Nyl." (*P. endochrysea* (Nyl.) Hampe in Krempelh.). His *P. endochrysea* may have also included some *P. endococcinea* (Körb.) Th. Fr. (a saxicolous non-sorediate species), since Fink lists *P. obscura* f. *endococcinea* as a synonym of *P. endochrysea* and Zahlbruckner (1931) lists the former as a synonym of *P. endococcinea.*

Tuckerman (1882) regarded *P. obscura* var. *endochrysea* Nyl. as synonymous with his *P. obscura* var. *erythrocardia* Tuck. Thomson (1963), who I assume saw Tuckerman's type, refers var. *erythrocardia* to *P. ciliata* (as f. *erythrocardia* [Tuck.] Thoms.). Degelius (1941) regarded "*P. endochrysea* Krempelh." as questionably synonymous with *P. ciliata* var. *erythrocardia.* Hale and Culberson (1960) listed *P. endochrysea* as a synonym of *P. orbicularis* f. *rubropulchra.*

Thus, the epithet *endochrysea* has been used for at least three North American species which have forms with a red medulla (*P. orbicularis, P. endococcinea,* and *P. ciliata*). Although the epithet *endochrysea* is of no nomenclatural importance as far as these species are concerned, it would be well for its identity to be established. Thomson (1963) did not mention the epithet at all, and so a final solution to the problem must await an examination of the type.

*Physcia orbicularis* is found most often on shaded tree bases, but is also found at other vertical positions on a variety of trees. It has also been collected on cement foundations.

Distribution — Throughout United States and adjacent Canada, especially in east (map: Thomson, 1963): Temperate element, North Temperate subelement, Europe, Asia (ibid). Forma *orbicularis,* as in species; forma *rubropulchra*: East Temperate, endemic (ibid).

253. **Physcia stellaris** (L.) Nyl. Act. Soc. Linn. Bordeaux 21: 307. 1856. *Lichen stellaris* L. Sp. Pl. 1144. 1753.

Material seen — SUFFOLK COUNTY: 26 specimens collected by Imshaug and/or Brodo; Orient, Long Beach, *Latham 27219,* May 15, 1947 (Latham); Orient, Long Beach, *Latham 22330,* December 7, 1944 (Latham); Orient Point, *Latham 26,* April 18, 1910 (NYS); Orient Point, *Latham,* May 2, 1910 (NYS); Greenport, *Peck* (NYS); Sag Harbor, *Britton 211,* July 17, 1898 (NY).

This species was found on the bark of several species of deciduous trees, mainly in well-lighted forests (figure 47). It also occurs on the bark of *Juniperus virginiana.*

Distribution — Throughout United States, southern Canada, coastal Alaska, central Mexico (map: Thomson, 1963): Temperate element, North Temperate subelement, Europe, Asia (ibid).

254. **Physcia subtilis** Degel. Ark. Bot. 30A(3): 72. 1941.

Material seen — SUFFOLK COUNTY: *Brodo 2370* (123), *2654* (108), *3356* (62), *3431* (134).

*Physcia subtilis,* a saxicolous species, is similar in some respects to *P. millegrana,* although the latter rarely occurs on rock. Some of their differences are outlined below:

| | *Physcia subtilis* | *Physcia millegrana* |
|---|---|---|
| Lobe width | 0.1-0.5 mm | 0.3-1.0(-1.5) mm |
| Soredia (granular) | marginal and apical | only marginal |
| KOH reaction of medulla | + (yellow) | — |
| Anatomy | paraplectenchymatous throughout | medulla not paraplectenchymatous |

Degelius (1941) and Thomson (1963) give the lobe size as no broader than 0.2 mm, but the Long Island material becomes at least twice that broad in a few cases.

*Physcia subtilis* was found on granitic rocks.

Distribution — Eastern United States, single localities in Arizona and Washington (map: Thomson, 1963): Temperate element, East Temperate subelement (?); endemic.

255. **Physcia tribacoides** Nyl. Flora 52: 322. 1869.

Material seen — SUFFOLK COUNTY: *Imshaug 25578* (52); *Brodo 2498* (67), *3904* (112); Orient, *Latham 949B*, May 10, 1923 (Latham).

This species was relatively rare on Long Island, where it was found on bases of *Quercus velutina* and *Q. alba* in oak forests and once on *Juniperus*.

Distribution — Eastern United States, and a single locality in California (map: Thomson, 1963): Temperate element, East Temperate subelement; rare in Europe (ibid).

## 64. ANAPTYCHIA Korb.

256. **Anaptychia obscurata** (Nyl.) Vain. Acta Soc. Faun. Fl. Fenn. 7(1): 137. 1890. *Physcia obscurata* Nyl. Ann. Sci. Nat. Bot. IV, 19: 310. 1863.

Material seen — SUFFOLK COUNTY: *Brodo 3908* (112); Orient, *Latham*, March 21, 1915 (Latham); Orient, *Latham 949*, May 10, 1923 (Latham).

This species has been treated in some North American literature as *A. heterochroa* Vain. and *A. servediifera* (Müll. Arg.) Du Rietz and Lynge in Lynge. Kurokawa (1962) discusses the nomenclature and morphology of *A. obscurata* in great detail. In addition, Degelius (1941) presents a thorough treatment of the separation of this species (sub *A. servediifera*) from the often confusing *A. pseudospeciosa* (sub *A. speciosa*).

The yellow anthraquinone pigment on the lower surface of *A. obscurata* varies in concentration from one part of the species' range to another, but all three Long Island specimens show a distinct dark yellow color which was clearly KOH + red-purple.

The species is rare on Long Island and is found on mossy tree bases.

Distribution — ". . . widely distributed in tropical and temperate zones around the world," eastern North America (Kurokawa, 1962): Tropical element, Appalachian-Temperate subelement; Europe, Asia, Africa (ibid).

257. **Anaptychia palmulata** (Michx.) Vain. Természetr. Füzeteck 22: 299. 1899. *Psoroma palmulata* Michx. Fl. Bor. Amer. 2: 321. 1803.

Material seen — KINGS COUNTY: New Lots, (*Brainerd*?) (BKL 032038).

Fink (1935) probably treated this species under the name *A. aquila* (Ach.) Mass. The latter is a synonym of *A. fusca* (Huds.) Vain., a European species (Kurokawa, 1962). *Anaptychia palmulata* is discussed in detail by Kurokawa (1962).

Distribution — Appalachian Mountains and Great Lakes region (map: Hale, 1956c, sub. *A. palmatula*): Temperate element, Appalachian subelement, Appalachian-Great Lakes unit; Asia (Kurokawa, 1962).

258. **Anaptychia pseudospeciosa** Kurok. J. Jap. Bot. 34: 176. 1959.

Material seen — SUFFOLK COUNTY: *Brodo 1390* (65).

This species was segregated from *A. speciosa* (Wulf.) Mass. by Kurokawa (1959, 1962) on the basis of the former's smaller spores and sorediate apothecial margin. (*A. speciosa* has spores over 30 μ long and has a smooth, crenulate, apothecial margin.) Sterile specimens of the inactive form (without salacinic acid) are virtually identical to European *A. speciosa*, and there is growing doubt that the two are distinct. The Long Island specimen was without salacinic acid. It was found on *Quercus alba* close to the base.

Distribution — Tropical and subtropical areas throughout the world (Kurokawa, 1962), eastern United States (Kurokawa, 1959): Tropical element, Appalachian-Temperate subelement; Africa, Asia (Kurokawa, 1962).

## 65. LEPRARIA Ach.

259. **Lepraria incana** (L.) Ach. Lich. Suec. Prodr. 7. 1798. *Byssus incana* L. Sp. Pl. 1169. 1753.

Material seen — NASSAU COUNTY: *Brodo 551* (12). SUFFOLK COUNTY: *Brodo 964* (S. of 50), *3826* (66).

Laundon (1962) gave a short discussion on the correct status of the genera *Crocynia* and *Lepraria* and noted that *Crocynia aeruginosa* Hue is a synonym of *L. incana.*

The presence of easily identifiable depsides and depsidones in the *Lepraria* complex promises to help clear up some of the taxonomic problems in the group. Although the three species of *Lepraria* on Long Island can be identified by their gross morphology alone, they can also be separated by their chemical constituents. By chromatographic analysis all specimens of *L. incana* were found to contain atranorin, and one from southern New Jersey (*Brodo 3546*) also contained fumarprotocetraric acid. The chemistry of the latter specimen was carefully rechecked to avoid the possibility of a contaminant.

*Lepraria incana* was found on tree bark in shaded habitats.

Distribution — New Jersey, but probably is more widely distributed.

260. **Lepraria zonata** sp. nov. *Crocynia zonata* Near. Lichen Book 354. 1947 (nom. nud.).

Material seen — NASSAU COUNTY: *Brodo 3514* (10). SUFFOLK COUNTY: *Imshaug 25601* (SW of 106); *Brodo 3844* (76), *3869* (62) (HOLOTYPE), *3876* (62).

This species was first mentioned in the literature by Nearing (1947), who presents a thorough description in English and states that the name is "current in the New York area" but has an "obscure origin." Since it appears to be a good species easily recognized by morphology and chemistry, a Latin description is provided here to make the name valid.

*Thallus crustaceus, omnis granulatus sed conspicuus segregatus et marginibus lobatusculis, series irregulariter areolatus; granulae 50-100 μ diam., sine ascocarpi. Materiae chemicae: acidum fumarprotocetraricum et atranorin. Saxicola.*

Thallus crustaceous, entirely granular, but clearly delimited and somewhat lobed at edges, becoming irregularly areolate; granules 50 to 100 μ in diameter; without ascocarps. Thallus contains fumarprotocetraric acid and atranorin (by chromatographic analysis).

Holotype: NEW YORK, Suffolk County: Wading River: *Brodo 3869,* August 11, 1962, vertical surface of partially shaded boulder (MSC) (figure 86).

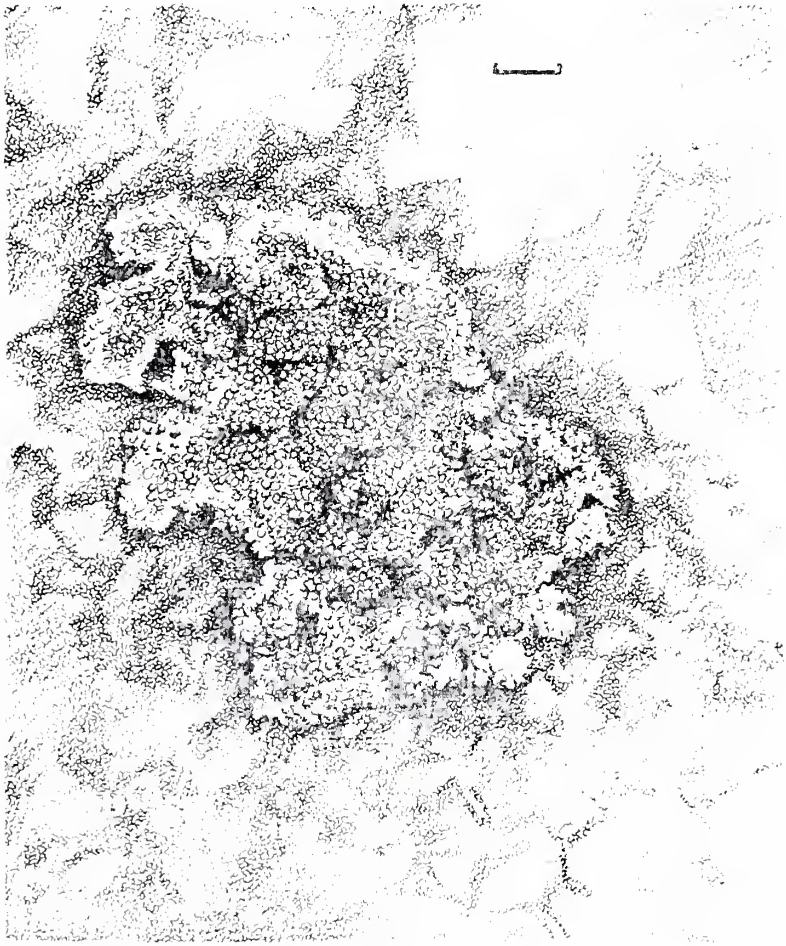

FIGURE 86. *Lepraria zonata* (holotype). Scale equals 1 mm. Drawing by Brenda Carter Haas.

Some specimens show the delimited, lobed, thallus edges more clearly than others, but none are entirely effuse. The Long Island specimens all contained fumarprotocetraric acid and atranorin except one (*Brodo 3514*), which showed only barbatolic acid.

This species is found on partially shaded granite boulders.

Distribution — Northeastern states (Nearing, 1947), Massachusetts (Cape Cod) (*Brodo 4162*).

261. **Lepraria** sp.

Material seen — NASSAU COUNTY: *Brodo 3499* (4). SUFFOLK COUNTY: *Brodo 591* (92), *2620* (84).

This species is often found in herbaria under *Crocynia membranacea* (Dicks.) Zahlbr. and apparently is quite common. The Long Island species differs from true *Lepraria membranacea* in forming thick, leprose mats, never membranous, subsquamulose sheets. The two apparently differ also in chemistry, although too few reliable specimens of *L. membranacea* have been examined to permit generalization.

Culberson (1963a) reported a leprose, pale green crust growing on greenhouse pots in Paris which produced stictic acid and atranorin. There is a very good chance that this as yet unidentified species from the United States may be the same as the one from Europe. There is obviously a great need for a thorough investigation of the North American *Leprariae*, especially one done with a careful eye for thallus chemistry.

On Long Island, the species is found on moist, shaded tree bases.

Distribution — Unclear, but probably widely distributed.

# General Discussions

## DISTRIBUTION OF LICHENS ON LONG ISLAND

In summarizing Long Island distributions of the various lichens, a number of patterns were seen to recur. The patterns correlated with various factors, among them substrate (tree, rock, or soil) distribution, vegetation types, climatic gradients such as the fog belt, the moraines, the coastal maritime zones, and city effects.

1. *Substrate.* Substrate distribution will define a species' distribution limits according to the substrate specificity of that species. A substrate specific species may be secondarily limited by climatic or other factors within the range of the substrate, but cannot occur outside the substrate range. Thus, a species completely or strongly confined to pine will not extend beyond the limits of the distribution of pine. Such is the case with *Parmeliopsis placorodia, Lecidea scalaris,* and *L. anthracophila,* all of whose distributions are limited to the pine forests which in turn reflect the natural distribution of *Pinus rigida* on Long Island (figures 45, 43, 42). There are several species closely associated with oaks, but they are limited by light and/or moisture conditions and so do not follow the full oak distribution. *Graphis scripta,* for example, is only found in the red oak forest where the shade and humidity is greater than in the pine-oak forest (Brodo, 1961a) (figure 61). The opposite is true of *Parmelia perforata, P. galbina, Physcia stellaris, Ph. aipolia, Ph. millegrana* (figures 52, 51, 47, 46, 71). Culberson (1955b), while pointing out that certain species in the Wisconsin lichen flora (e.g., *Candelaria concolor,* and *Parmelia aurulenta*) are apparently restricted in their distribution by their substrate preferences, maintains that most species showing clear-cut differences in north-south distribution in Wisconsin are responding to climatic differences and not substrate distributions.

Certain species confined to bog habitats are only found on *Chamaecyparis thyoides* and *Vaccinium corymbosum.* Whether these species (such as *Cetraria ciliaris, C. viridis,* and *Usnea trichodea*) are restricted to the bogs because these substrates are only found there, or whether the climate of the bog is the determining factor is still unclear, but the problem might be solved at least partially by a transplant experiment such as was described on p. 20.

Certain obligatory saxicolous species have distributions reflecting the positions of the two terminal moraines which laid down large numbers of granitic boulders (erratics) and large pebbles and stones (p. 6).

There are three major types of parent soil material represented on Long Island: hilly glacial till, sandy loam, and sand. Over these there have been local accumulations of alluvium, beach sands, and organic matter. The three parent materials are distinct enough to influence the distributions of several terricolous species, and yet have enough characteristics in common (e.g., sandy texture, excessive drainage, and low pH) to permit certain lichens with broader ecological limits to inhabit almost any part of the island having exposed glacial parent material.

*Baeomyces roseus, Cladonia squamosa, C. caespiticia,* and *C. pleurota* (figures 53, 54, 55, 56) are mainly confined to the hilly glacial till on which the Plymouth-Haven soil association has been formed, with occasional occurrences on the sandy loams of the Bridgehampton association. *Cladonia strepsilis* and *Pycnothelia papillaria* (figures 72, 73) are found throughout the island on soils of various types exposed by natural or man-made erosion. *Cladonia boryi, C. submitis,* and *C. uncialis* are fairly restricted to the Colton and Adams sandy soil association (figures 74, 75, 76).

This sand dune — sand plain community, although abundant on the dunes of the south shore, is entirely absent from those on the north shore, even though the sand texture is the same and many of the associated vascular dune plants are the same. The reason may relate to the relative salt spray deposition in the two areas (p. 203).

2. *Climate.* *a. Temperature:* The differences in temperature over Long Island, as indicated by published synoptic temperature maps, are too slight to influence lichen distribution directly. The indirect effects, e.g., with regard to moisture, are, however, of considerable importance.

The warm temperatures of the city, in combination with its relatively severe fluctuations in humidity, possibly contribute to the poor lichen flora in western Long Island. Rydzak (1958) believes drought to be the main or entire cause of "lichen deserts" in towns.

The relatively cool summer temperatures and mild winter temperatures of eastern Long Island, in combination with the very high humidity of that region, contribute towards the creation of a distinctly "oceanic" aspect to the lichen vegetation in that area. Faegri (1958) stressed the importance of considering both temperature and relative humidity in an area suspected of being oceanic (see discussion below under "humidity"). Bog habitats also have this combination of cool temperatures and high humidity, and thus provide conditions suitable for the establishment of oceanic and northern species west of the highly humid cool areas in the Montauk region (figure 31).

*b. Precipitation:* Precipitation differences in eastern and western Long Island are also small, and it is unlikely that rainfall or snowfall has an appreciable direct effect on lichen distributions on Long Island as a whole. The secondary effects of rainfall, e.g., in raising the air humidity in certain forest types more than in others, can and probably does have an effect in some distributions.

*c. Humidity:* Previous workers who have studied coastal lichen vegetation (Barkman, 1958; Almborn, 1948; Degelius, 1935; Mitchell, 1961) have all pointed out the importance of air humidity on the distribution of lichens. They particularly cite fog frequency as being an important factor. Degelius (1935) considers hygric factors as the most important in determining the distribution of oceanic species.

A map showing the numbers of days on Long Island with dense fog (figure 5) strikingly reflects the distribution of many lichens (figures 64-70). The south fluke (fork) of Long Island has a much greater species richness than any part of the north fluke except, perhaps, for intensely collected Orient Point. Such oceanic species as *Leptogium cyanescens, Nephroma laevigatum, Lobaria quercizans,* and *L. pulmonaria* all show distributions more or less restricted to the fog belt (figures 5 and 31).

*d. Salt Spray:* The maritime coastal distributions illustrated by *Caloplaca citrina, Rinodina milliaria, R. pachysperma,* and *Xanthoria parietina* (figures 77, 78, 79, 80) are curious in that the four have rather different distributions outside of Long Island. It would seem that all four have a high degree of salt tolerance and no salt requirement.

3. *Vegetation type.* An understanding of the distribution of lichens on Long Island depends on a knowledge of the vegetation types in which certain lichens are most likely to be found. That is, one would like to know which lichens are "characteristic" of certain vegetation types. In the Braun-Blanquet system, a characteristic species can be defined by its degree of "fidelity" (see Phillips, 1959). Involved in the analysis of fidelity is an intimate knowledge of coverage, sociability, frequency, and presence derived by time-honored methods of plot studies within given stands.

For the purposes of this study it seems best to use collection data as a source of information concerning the distribution of lichens in various vegetation types, considering each locality to be a "stand" in the Braun-Blanquet usage. In these collections, all vegetation types have been represented and each locality essentially has a complete species list. Since, however, within a given locality each species was only collected once (p. 91) and without any notation of its abundance, cover, sociability, or frequency, only "presence" (the percent of the stands of a particular vegetation type having any particular lichen) could be calculated, and the Braun-Blanquet system could not be used unaltered. Knowing the total number of localities in which each species was collected and the number of collections in each vegetation type, I could calculate the percentage of its occurrence in each category, calling this value the vegetation type - total locality value or VTL value. For example, *Bacidia chlorococca* was collected in 58 different localities on Long Island. Four of these were dune localities. Since there are 22 dune localities on Long Island, the presence value of *B. chlorococca* in dune localities is 4/22 or 23 percent. Since there are 58 specimens of *B. chlorococca* representing 58 localities, the VTL value of the species in dune localities is 4/58 or 7 percent.

If a species has a relatively high VTL value in the same vegetation type for which it has a high presence value, it can be called "faithful" in much the same context as fidelity is used in the Braun-Blanquet system. In practice, faithful species were selected by a nonmathematical system of examining the VTL and presence values (table 9) and selecting those species which showed particularly high values in only one (or sometimes two adjacent) vegetation types. ("High values" were considered to be a minimum of 20 percent presence plus 20 percent VTL value.) As in the Braun-Blanquet system, faithful species often are relatively uncommon (Phillips, 1959).

In table 9, presence and VTL values were calculated for all species that occurred in 10 or more of the 135 stands studied in Suffolk County. Nassau County localities were excluded because of the possibility of disturbance due to the proximity of New York City. All species known to be bog-inhabiting were considered, whether or not they occurred in ten stands, since there were only eight bogs studied.

In order to make the numbers of the various vegetation types more directly comparable, some categories were considered together. It seemed valuable, however, to separate the white cedar swamp localities from the maple swamps. Roadside trees, cherry-locust stands, beech climax forests, all of which were very infrequent, and a few localities which were inadequately described for classification were excluded.

Table 9 clearly shows that most species do not have a narrow restriction to a single vegetation type, but rather are distributed more broadly along a continuum with a moderate peak in one (or sometimes two) categories. A number of species bridge the gap evenly between two categories (e.g., *Cladonia clavulifera* between downs and pine-oak forests, *Cladonia capitata, Parmeliopsis placorodia, Pertusaria trachythallina,* and *Physcia stellaris* between pine-oak and scarlet-black oak forests, and *Pertusaria tuberculifera* between scarlet-black and red oak forests. In a previous paper (Brodo, 1961a), I discussed in detail the distribution of some common Long Island lichens along a pine-oak to red oak forest continuum.

Within each vegetation type the following species may be thought of as more or less "characteristic" as defined, from the Braun-Blanquet school, by Phillips (1959). Each species listed below is given a fidelity rating based on Phillips' definitions of the Braun-Blanquet fidelity categories. Category 5 is made up of species occurring almost exclusively in one vegetation type; category 4 comprises species having both presence and VTL values in one vegetation type more than twice those in any other; category 3 comprises all other faithful species (p. 269).

**Dunes, downs, and sand plains:**

| | |
|---|---|
| *Acarospora fuscata* | (4) |
| *Cetraria islandica* subsp. *crispa* | (3) |
| *Cladonia boryi* | (4) |
| *C. clavulifera* | (3) |
| *C. furcata* | (4) |
| *C. strepsilis* | (4) |

**Scarlet-black oak forest:**

| | |
|---|---|
| *Buellia stillingiana* | (3) |
| *Lecanora caesiorubella* subsp. *lathamii* | (3) |
| *Parmelia subaurifera* | (3) |
| *Parmeliopsis placorodia* | (3) |
| *Pertusaria trachythallina* | (3) |
| *P. tuberculifera* | (3) |
| *Physcia stellaris* | (3) |
| *Pyrenula nitida* | (4) |

**White cedar swamp:**

| | |
|---|---|
| *Alectoria nidulifera* | (3) |
| *Cetraria ciliaris* | (4) |
| *C. viridis* | (5) |
| *Usnea trichodea* | (4) |

**Pine barrens, pine-oak forest:**

| | |
|---|---|
| *Bacidia chlorococca* | (3) |
| *Cladonia atlantica* | (4) |
| *C. clavulifera* | (3) |
| *C. subtenuis* | (3) |
| *Lecidea anthrocophila* | (3) |
| *L. scalaris* | (3) |
| *L. uliginosa* | (4) |
| *Parmelia galbina* | (3) |
| *Parmeliopsis placorodia* | (3) |
| *Pertusaria trachythallina* | (3) |
| *Physcia aipolia* | (4?) |
| *Ph. stellaris* | (3) |

**Red oak forest:**

| | |
|---|---|
| *Cladonia coniocraea* | (3) |
| *Graphis scripta* | (3) |
| *Lecidea albocaerulescens* | (5) |
| *Pertusaria tuberculifera* | (3) |

**Maple swamp:**

(no faithful species)

Since the different vegetation types occupy different portions of the island, distribution patterns of characteristic species and others close to this designation reflect their specificities in maps of their distribution on Long Island. Distribution maps of some of these species are presented in figures 33 to 63 and 74 to 81.

a. *Dunes, downs, and sand plains.* Distributions of lichens strongly associated with dunes and sand plains are mapped in figures 74 to 76. *Cladonia submitis* and *C. uncialis* also occur in open sandy or grassy areas within the scarlet-black oak forest localities.

b. *Pine barrens and pine-oak forests.* Those species more or less restricted to the pine forests of central Long Island appear to be either pine specific (figures 42 to 45) or confined to well-illuminated oaks (figures 46 to 47 and p. 267). The two terricolous lichens characteristic of this vegetation type (*Cladonia calycantha* and *C. floridana*, figures 48, 49) are rather narrowly confined to very acid sand in open, well-lighted localities such as would be found in pine forests. *Lecidea varians, Parmelia galbina,* and *P. perforata* (figures 50 to 52), although basically pine-oak forest species, extend eastward in well-illuminated mixed oak and pine stands within the mature oak forest region.

c. *Morainal (scarlet-black oak and red oak forests).* Two vegetation types lie along the glacial moraines: the red oak forest and the scarlet-black oak forest. Gravelly, sandy loam and the presence of many boulders and stones characterize both vegetation types, and consequently many terricolous and saxicolous species are distributed along one or both of the moraines. Figures 53 to 56 include the terricolous species, figures 57

TABLE 9. Distribution of some common lichens in various vegetation types on Long Island. "Presence" indicates the percentage of localities of any particular vegetation type having a particular species. The "VTL value" indicates the percentage of specimens of a particular species in any particular vegetation type out of the total number of specimens of that species (assuming one specimen per locality). "Fidelity" is based on values of more than 20 percent in *both* presence and VTL in any one of two vegetation types, when those values appear to be significantly higher than other vegetation types. (See p. 269 for a more complete discussion of these terms.) The number in parentheses below the name of each vegetation type indicates the number of localities of that vegetation type out of a total of 135.

| | | PRESENCE | | | | | | | VEGETATION TYPE — TOTAL LOCALITY (VTL) VALUE | | | | | | | FIDELITY | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total no. of collections | Dunes, sand plains, downs (22) | Pine barrens pine-oak forest (28) | Scarlet-black oak forest (28) | Red oak forest (35) | White cedar swamp (4) | Maple swamp (11) | Extra (7) | Dunes, sand plains, downs | Pine barrens pine-oak forest | Scarlet-black oak forest | Red oak forest | White cedar swamp | Maple swamp | Extra | Dunes, sand plains, downs | Pine barrens pine-oak forest | Scarlet-black oak forest | Red oak forest | White cedar swamp | Maple swamp |
| Acarospora fuscata | 10 | 23 | 7 | 0 | 3 | 0 | 0 | | 50 | 20 | 0 | 10 | 0 | 0 | 20 | + | | | | | |
| Alectoria nidulifera | 11 | 5 | 11 | 4 | 0 | 100 | 18 | | 9 | 27 | 9 | 0 | 36 | 0 | 9 | | | | | + | |
| Arthonia caesia | 15 | 5 | 18 | 14 | 6 | 0 | 9 | | 7 | 33 | 27 | 13 | 0 | 7 | 13 | | | | | | |
| siderea | 10 | 0 | 0 | 14 | 14 | 0 | 0 | | 0 | 0 | 40 | 50 | 0 | 0 | 10 | | | | | | |
| Bacidia chlorococca | 58 | 18 | 70 | 43 | 49 | 25 | 27 | | 7 | 35 | 21 | 29 | 2 | 5 | 2 | | + | | | | |
| Baeomyces roseus | 14 | 0 | 11 | 18 | 14 | 0 | 0 | | 0 | 21 | 36 | 36 | 0 | 0 | 7 | | | | | | |
| Buellia curtisii | 44 | 9 | 18 | 39 | 46 | 50 | 18 | | 5 | 11 | 25 | 36 | 5 | 5 | 14 | | | | | | |
| polyspora | 41 | 27 | 39 | 32 | 23 | 25 | 9 | | 15 | 27 | 22 | 20 | 2 | 2 | 12 | | | | | | |
| stillingiana | 30 | 5 | 29 | 39 | 14 | 25 | 36 | | 3 | 27 | 37 | 17 | 3 | 13 | 0 | | | + | | | |
| Cetraria ciliaris | 8 | 5 | 0 | 0 | 0 | 100 | 27 | | 13 | 0 | 0 | 0 | 50 | 37 | 0 | | | | | + | |
| islandica | 11 | 23 | 4 | 0 | 9 | 25 | 9 | | 45 | 9 | 0 | 27 | 9 | 9 | 0 | + | | | | | |
| viridis | 4 | 0 | 0 | 0 | 0 | 100 | 0 | | 0 | 0 | 0 | 0 | 100 | 0 | 0 | | | | | + | |
| Cladonia atlantica | 39 | 9 | 61 | 29 | 17 | 50 | 27 | | 5 | 44 | 21 | 15 | 5 | 8 | 3 | | + | | | | |
| bacillaris | 67 | 32 | 79 | 64 | 40 | 75 | 9 | | 10 | 33 | 27 | 21 | 4 | 1 | 3 | | | | | | |
| boryi | 16 | 64 | 4 | 0 | 0 | 0 | 9 | | 88 | 6 | 0 | 0 | 0 | 6 | 0 | + | | | | | |
| capitata | 11 | 0 | 14 | 18 | 3 | 0 | 0 | | 0 | 36 | 45 | 9 | 0 | 0 | 9 | | | | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cladonia caroliniana | 19 | 32 | 14 | 14 | 6 | 0 | 9 | 37 | 21 | 21 | 11 | 0 | 5 | 5 | | | | |
| chlorophaea | 85 | 55 | 93 | 64 | 71 | 25 | 9 | 14 | 31 | 21 | 29 | 1 | 1 | 2 | | | | |
| clavulifera | 16 | 23 | 21 | 7 | 9 | 0 | 0 | 31 | 37 | 13 | 19 | 0 | 0 | 0 | <-+-> | | | |
| coniocraea | 62 | 9 | 36 | 64 | 77 | 25 | 9 | 3 | 16 | 29 | 44 | 2 | 2 | 5 | | | | +? |
| cristatella | 78 | 55 | 93 | 64 | 51 | 25 | 9 | 15 | 33 | 23 | 23 | 1 | 1 | 3 | | | | |
| furcata | 12 | 23 | 7 | 7 | 6 | 0 | 0 | 42 | 17 | 17 | 17 | 0 | 0 | 8 | + | | | |
| incrassata | 27 | 5 | 18 | 18 | 23 | 75 | 45 | 4 | 19 | 19 | 30 | 11 | 19 | 0 | | | | |
| macilenta | 14 | 5 | 7 | 14 | 14 | 50 | 0 | 7 | 14 | 29 | 36 | 14 | 0 | 0 | | | | |
| parasitica | 12 | 0 | 4 | 7 | 20 | 50 | 0 | 0 | 8 | 17 | 58 | 17 | 0 | 0 | | | | |
| pleurota | 19 | 9 | 21 | 7 | 26 | 0 | 0 | 11 | 32 | 11 | 47 | 0 | 0 | 0 | | | | |
| strepsilis | 19 | 32 | 14 | 7 | 11 | 0 | 0 | 33 | 21 | 11 | 21 | 0 | 0 | 0 | + | | | |
| submitis | 29 | 59 | 25 | 21 | 6 | 0 | 9 | 45 | 24 | 21 | 7 | 0 | 3 | 0 | + | | | |
| subtenuis | 43 | 45 | 57 | 18 | 20 | 25 | 27 | 23 | 37 | 12 | 16 | 2 | 7 | 2 | | + | | |
| uncialis | 25 | 32 | 32 | 21 | 6 | 0 | 9 | 28 | 36 | 24 | 8 | 0 | 4 | 0 | | | | |
| Graphis scripta | 44 | 0 | 14 | 46 | 66 | 0 | 0 | 0 | 9 | 30 | 52 | 0 | 0 | 9 | | | | + |
| Haematomma sp. | 40 | 5 | 21 | 46 | 34 | 50 | 18 | 3 | 15 | 33 | 30 | 5 | 5 | 10 | | | | |
| Hypogymnia physodes | 42 | 23 | 46 | 36 | 20 | 75 | 36 | 12 | 31 | 24 | 17 | 7 | 10 | 0 | | | | |
| Lecanora caesiorubella | 83 | 41 | 57 | 100 | 49 | 50 | 55 | 11 | 19 | 34 | 20 | 2 | 7 | 6 | | | + | |
| chlarotera | 64 | 27 | 43 | 71 | 46 | 25 | 27 | 9 | 19 | 31 | 25 | 2 | 5 | 9 | | | | |
| Lecidea aeruginosa | 12 | 14 | 14 | 0 | 9 | 25 | 0 | 25 | 33 | 0 | 25 | 8 | 0 | 8 | | | | |
| albocaerulescens | 11 | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 0 | 0 | 82 | 0 | 0 | 18 | | | | + |
| anthracophila | 23 | 0 | 43 | 29 | 0 | 25 | 0 | 0 | 52 | 35 | 0 | 4 | 0 | 9 | | + | | |
| erratica | 26 | 9 | 21 | 46 | 23 | 0 | 0 | 8 | 23 | 21 | 31 | 0 | 0 | 8 | | | | |
| scalaris | 18 | 0 | 36 | 25 | 0 | 0 | 0 | 0 | 56 | 39 | 0 | 0 | 0 | 6 | | + | | |
| uliginosa | 19 | 14 | 39 | 7 | 9 | 0 | 0 | 16 | 58 | 11 | 16 | 0 | 0 | 0 | | + | | |
| varians | 31 | 36 | 25 | 25 | 14 | 25 | 18 | 26 | 23 | 23 | 16 | 3 | 6 | 3 | | | | |
| Parmelia caperata | 83 | 27 | 57 | 86 | 77 | 50 | 27 | 7 | 19 | 29 | 33 | 2 | 4 | 6 | | | | |
| conspersa | 10 | 5 | 4 | 4 | 11 | 0 | 0 | 10 | 10 | 10 | 40 | 0 | 0 | 30 | | | | |
| galbina | 16 | 0 | 25 | 18 | 11 | 0 | 0 | 0 | 44 | 31 | 25 | 0 | 0 | 0 | | + | | |
| hypotropa | 20 | 27 | 14 | 18 | 9 | 50 | 0 | 30 | 20 | 25 | 15 | 10 | 0 | 0 | | | | |
| livida | 31 | 5 | 36 | 32 | 14 | 50 | 36 | 3 | 32 | 29 | 16 | 6 | 13 | 0 | | | | |
| michauxiana | 11 | 0 | 4 | 14 | 14 | 0 | 0 | 0 | 9 | 36 | 45 | 0 | 9 | 0 | | | | |

| | PRESENCE | | | | | | | | VEGETATION TYPE — TOTAL LOCALITY (VTL) VALUE | | | | | | | FIDELITY | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total no. of collections | Dunes, sand plains, downs (22) | Pine barrens pine-oak forest (28) | Scarlet-black oak forest (28) | Red oak forest (35) | White cedar swamp (4) | Maple swamp (11) | Extra (7) | Dunes, sand plains, downs | Pine barrens pine-oak forest | Scarlet-black oak forest | Red oak forest | White cedar swamp | Maple swamp | Extra | Dunes, sand plains, downs | Pine barrens pine-oak forest | Scarlet-black oak forest | Red oak forest | White cedar swamp | Maple swamp |
| Parmelia perforata | 28 | 18 | 25 | 18 | 6 | 75 | 64 | | 14 | 25 | 18 | 7 | 11 | 25 | 0 | | | | | | |
| rudecta | 75 | 23 | 43 | 71 | 74 | 25 | 55 | | 7 | 16 | 27 | 35 | 1 | 8 | 7 | | | | | | |
| saxatilis | 69 | 14 | 39 | 71 | 60 | 50 | 73 | | 4 | 16 | 29 | 30 | 3 | 12 | 6 | | | | | | |
| subaurifera | 60 | 14 | 46 | 75 | 40 | 50 | 18 | | 5 | 22 | 35 | 23 | 3 | 3 | 8 | | | + | | | |
| subrudecta | 10 | 0 | 0 | 7 | 17 | 0 | 18 | | 0 | 0 | 20 | 60 | 0 | 20 | 0 | | | | | | |
| sulcata | 74 | 32 | 68 | 71 | 60 | 25 | 27 | | 9 | 26 | 27 | 28 | 1 | 4 | 4 | | | | | | |
| Parmeliopsis aleurites | 26 | 0 | 36 | 25 | 11 | 100 | 9 | | 0 | 38 | 27 | 15 | 15 | 4 | 0 | | | | | | |
| placorodia | 19 | 5 | 25 | 21 | 3 | 25 | 18 | | 5 | 37 | 32 | 5 | 5 | 11 | 5 | | <-+-> | | | | |
| Pertusaria trachythallina | 25 | 0 | 39 | 43 | 6 | 0 | 0 | | 0 | 44 | 48 | 8 | 0 | 0 | 0 | | <-+-> | | | | |
| tuberculifera | 22 | 5 | 4 | 29 | 31 | 0 | 0 | | 5 | 5 | 36 | 50 | 0 | 0 | 5 | | | <-+-> | | | |
| xanthodes | 59 | 23 | 50 | 54 | 49 | 25 | 27 | | 8 | 24 | 25 | 29 | 2 | 5 | 7 | | | | | | |
| Phaeographis dendritica | 52 | 18 | 29 | 54 | 49 | 25 | 27 | | 8 | 15 | 29 | 33 | 2 | 6 | 8 | | | | | | |
| Physcia aipolia | 17 | 0 | 32 | 18 | 6 | 0 | 0 | | 0 | 53 | 29 | 12 | 0 | 0 | 6 | | | | | | |
| millegrana | 57 | 27 | 57 | 54 | 31 | 0 | 9 | | 11 | 28 | 26 | 19 | 0 | 2 | 14 | | | | | | |
| orbicularis | 58 | 27 | 29 | 71 | 46 | 0 | 27 | | 10 | 14 | 34 | 28 | 0 | 5 | 9 | | | | | | |
| stellaris | 17 | 0 | 29 | 29 | 0 | 0 | 0 | | 0 | 47 | 47 | 0 | 0 | 6 | 0 | | <-+-> | | | | |
| Pycnothelia papillaria | 11 | 14 | 0 | 18 | 9 | 0 | 0 | | 27 | 0 | 36 | 27 | 0 | 0 | 9 | | | | | | |
| Pyrenula nitida | 13 | 0 | 7 | 25 | 9 | 0 | 0 | | 0 | 15 | 54 | 23 | 0 | 0 | 8 | | | + | | | |
| Rinodina milliaria | 11 | 18 | 0 | 7 | 9 | 0 | 0 | | 36 | 0 | 18 | 27 | 0 | 0 | 18 | | | | | | |
| pachysperma | 14 | 14 | 4 | 18 | 11 | 0 | 0 | | 21 | 7 | 36 | 29 | 0 | 0 | 7 | | | | | | |
| Usnea strigosa<br>(red medulla) | 22 | 18 | 18 | 18 | 6 | 50 | 36 | | 18 | 23 | 23 | 9 | 9 | 18 | 0 | | | | | | |
| strigosa<br>(white medulla) | 8 | 0 | 11 | 11 | 6 | 0 | 0 | | 0 | 38 | 38 | 25 | 0 | 0 | 0 | | | | | | |
| trichodea | 7 | 5 | 0 | 4 | 0 | 75 | 18 | | 14 | 0 | 14 | 0 | 43 | 29 | 0 | | | | | + | |

to 60 include saxicolous species, and figures 61 to 63 comprise corticolous species. For more detailed ecological notes, the reader should consult the species discussions in the annotated list.

d. *Bogs and swamps.* The cool, humid climate of a bog, together with its very acid soil (or water) make it a unique habitat with a rather unique lichen vegetation. Maps of the typical bog and swamp distributions should be compared with the distribution map of the bog and swamp localities (figure 32).

Several of the corticolous bog species (figures 33, 34, 39) are confined to phorophytes which themselves are confined to bogs. In these cases it is difficult to separate substrate influence from climatic influence in determining the causes of bog specificity (p. 267). Climatic effects probably play a large role in the distribution of the lignicolous bog lichens (figures 35 to 37) as well as those bog-limited species also found growing on trees outside the bogs (such as *Pertusaria amara* on *Acer rubrum,* figure 38, and *Alectoria nidulifera* on *Pinus rigida,* figure 40).

*Parmelia hypotropa* (figure 41) shows a pattern which combines bog and swamp localities with humid maritime localities, a distribution shared by *Parmelia perforata* (figure 52) and *Ramalina fastigiata.*

e. *Maritime.* Maritime species are restricted to within a mile of the shore (figures 77 to 81) and are within the aerohaline, the hygrohaline, or the hydrohaline strata of the shore (p. 58). Their distributions are probably influenced by salt water or spray, high winds, high illumination, or some combination of these factors.

## FLORISTIC CHANGES

It is obvious to all students of Long Island natural history that the flora and fauna of the island have significantly changed during the past 50 to 75 years and are still changing. One need only list the lichens collected in the Brooklyn-Queens area prior to 1900 to see a striking example of these changes. Most of the following species were collected by G. B. Brainerd and George Hulst in 1860's.

*Alectoria nidulifera*
*Anaptychia palmulata*
*Candelaria concolor*
*Cetraria ciliaris*
*C. tuckermanii*
*Cladonia alpestris*
*C. bacillaris*
*C. capitata*
*C. chlorophaea*
*C. conista*
*C. cristatella*
*C. farinacea*
*C. furcata*
*C. pyxidata*
*Cladonia scabriuscula*
*C. submitis*
*C. subtenuis*
*C. uncialis*
*C. verticillata*
*Collema subfurvum*
*Graphis scripta*
*Haematomma* sp.
*Lecanora conizaea*
*Leptogium cyanescens*
*Lobaria pulmonaria*
*L. quercizans*
*Pannaria lurida*
*Parmelia aurulenta*
*Parmelia caperata*
*P. galbina*
*P. perforata*
*P. reticulata*
*P. stenophylla* (?)
*P. sulcata*
*Peltigera aphthosa*
*P. polydactyla*
*Pertusaria tuberculifera*
*Physcia millegrana*
*Usnea strigosa*
*Xanthoria fallax*
*X. parietina*

Eastern Long Island has also seen some alterations in the flora, but here the cause has mainly been the great hurricanes of 1938 and 1944. Roy Latham (in letter, May 29, 1960), describing the effects of these hurricanes on Long Beach at Orient Point wrote "Salt water flooded all of this beach which was exposed to gales and rolling waves and the beach was swept as clean as a new house floor. In places the water was four to six feet in depth and washed the bark lichens from the low cedar trunks and wrenched the branch-growing species away. All traces of Usneas and Ramalinas disappeared in the storm. I don't think these two species have appeared there since. The Cladonias showed a fair comeback in two years, but not in the abundance or large growth of the old days. I know that *alpestris* has not returned, and I don't believe *rangiferina,* [or] *sylvatica* [*arbuscula*] may have returned. After the second hurricane of 1944, the beach was again washed by high flood tides and left about the same condition as in 1938." Latham also mentioned local building projects and farm clearance as having removed the last stations of a few of the rarer species.

It is not only this generation, however, which has seen the gradual disappearance of lichens. Willey (1892, p. 3), reflecting on his 30 years of collecting in New Bedford, Massachusetts, wrote "Of late years, the clearing of forests, the quarrying of ledges, and the breaking up of boulders, have tended to the destruction of Lichens. The largest of the cypresses (*Chamaecyparis thyoides*) have gone to the migratory steam sawmill; the beeches went to the plane factory; and the hollies, once abundant, were converted into knick-knacks, so that few of any size remain; while the rocks and boulders exist only in the foundations of houses and factories.

Of the total lichen flora, 47 species, most representing Latham material, have not been collected in the course of my own field work. Of these, 24 are represented by only one specimen. Several of the remaining 23 species, perhaps, are actually becoming extinct on the island. Some mislabelling is involved in the Latham collection, and a few of the "rare" specimens from Latham's herbarium may actually represent material sent to Latham on exchange (especially from northwestern United States) which became misplaced and then mislabelled.

Some of the species which I did not find, together with some collected more frequently in the past than during this study are listed below, followed in each case respectively by the number of old and recent collections.

*Caloplaca pyracea* (5-0)
*Cladonia beaumontii* (21-1)
*C. alpestris* (14-2)
*C. rangiferina* (25-2)
*Collema subfurvum* (6-0)
*Lobaria pulmonaria* (13-4)
*Peltigera praetextata* (19-5)
*Ramalina stenospora* (7-0)
*R. willeyi* (9-3)
*Teloschistes chrysophthalmus* (9-0)
*T. flavicans* (2-0)
*Umbilicaria muhlenbergii* (3-0)
*Verrucaria silicicola* (9-2)

Special efforts were made to locate all these species, particularly the two *Teloschistes,* the *Umbilicaria, Cladonia rangiferina,* and *C. alpestris.* It is interesting to observe that for most of these species Long Island represents the outer edge of their natural distribution. It is the southern limit or near-limit, compared with areas of similar altitude, for *Cladonia alpestris, Caloplaca pyracea,* and *Umbilicaria muhlenbergii;* it is the northern, or close to the northern limit, for *Ramalina stenospora, Teloschistes chrysophthalmus,* and *T. flavicans.* The drainage and filling of local bogs and cutting of humid forests (particularly affecting the populations of oceanic species such as *Lobaria pulmonaria* and *Collema subfurvum*), hurricanes, building projects, and environmental pollution undoubtedly all took their toll. Once an outlying population is cut down by any of these factors, its chances of re-expansion are much slimmer than those of species lying well within their normal or potential range. The main reasons seem to be that these marginal populations are not living under optimum conditions for reproduction, and the chances of reinvasion are small due to low population levels in neighboring areas.

There were 70 species that were collected only in my own field work. The great majority of these are crustose species and were probably overlooked by previous collectors. It would be foolish to attempt a general analysis to find which, if any, of the 70 species might have actually become established on the island within the last 50 years. It is possible to state, however, that *Lecanora muralis* is apparently an adventive on Long Island, probably having been brought in on limestone building materials from some area to the north or west where both limestone and the species are abundant.

# Summary and Conclusions

## HABITAT ECOLOGY AND LICHEN COMMUNITIES

1. Substrate factors, including texture, moisture-holding capacity, stability, and chemical composition are important in defining lichen distributions and community composition.

2. The relationship between climatic factors (especially rate of fluctuation and degree of atmospheric humidity) and available light are also important.

3. If some of the characteristics of a substrate are altered by natural or unnatural means, the lichen communities inhabiting the substrate also will become altered. In this way, two substrates of basically unrelated origin may bear similar floras if the substrate characteristics converge and become close to identical.

4. Certain aspects of substrate characterizations, especially bark moisture capacity, were discussed in detail. No method for expressing moisture capacity now in usage appears to be entirely satisfactory.

5. The actual factors involved in producing communities commonly called "neutrophilic," "nitrophilic," or "coniophilic" need much more investigation and clarification before the terms can be used in a meaningful way. In most cases, it is similarly difficult to distinguish between "skiophilous" and "hygrophilous" tendencies in lichens. The terms should be considered as merely suggestive, and not necessarily reflecting absolute ecological requirements.

6. The results of transplant experiments used in the study of vertical lichen distribution on tree trunks suggest that with some species (e.g., *Cladonia chlorophaea*) microclimate is the limiting factor, and in others (e.g., *Lecanora caesiorubella*), it is some aspect of the substrate, or competition, that is limiting. The technique of transplanting bark disks bearing lichen thalli promises to be important in studies of lichen ecology.

7. The lichens of red oak forests were sampled in an east-west transect, and the data subjected to statistical analysis. From these results, certain observations were made concerning species composition in oak forests. These were compared with the results of an earlier sampling of oak and pine-oak forests in central Long Island, and conclusions were drawn pertaining to the differences in lichen flora seen in the two vegetation types.

8. Continua were described with communities on tree trunks (following bark age and/or vertical position gradients), and with terricolous communities (following soil type gradients).

9. Lichen successions involving corticolous, terricolous, and saxicolous species were observed and described. A detailed description of a primary old field succession was presented. Nondirectional or cyclic changes involving corticolous and dune-inhabiting communities were also described.

10. Lichen communities were considered to be groups of species living under similar conditions due to similarities in their habitat requirements and tolerances and with relatively little species interaction.

## LICHEN DISTRIBUTIONS

1. The distribution of some lichens on Long Island is heavily influenced by their substrate specificity, and of others, by climatic requirements.

2. Most species on Long Island are more or less confined to a particular segment of the forest continuum, usually including more than one vegetation type.

3. Certain vegetation types have "characteristic" lichen species, just as they have characteristic flowering plants. These characteristic lichens were listed and discussed.

4. Based on a sample of 81 percent of the total lichen flora, 21 percent of the species have an Arctic-boreal distribution, 71 percent are Temperate, and 8 percent are Tropical. In addition, 24 percent of the species are endemic to North America, 53 percent are circumboreal, 11 percent are found in Europe and not in Asia (almost all of which are amphiatlantic), and 7 percent are found in Asia and not in Europe (almost all of which have the classic Eastern Asia-Eastern United States disjunct pattern).

5. Origins of the various distributional types were suggested, and possible migration routes to Long Island were outlined.

6. The "fog belt" in the Montauk region, together with *Chamaecyparis* bogs, have a large number of oceanic and boreal species. Most of the coastal plain species are closely restricted to bogs, sand dunes and sand plains, and salt spray habitats, and many follow the limits of the pine-oak forest. East Temperate and North Temperate species are commonly centered in the red oak forests along the north shore.

## THE CITY EFFECT

1. A detailed study of the influence of the New York City atmosphere on Long Island lichen distribution was carried out using collection methods, statistical analyses of forest samples, and transplant experiments.

2. A city influences lichen distribution both through its induced drought conditions and its production of toxic atmospheric materials, presumably $SO_2$ for the most part. Pollution affects the lichens at greater distances from the town centers than does city-induced drought. These conclusions were stated as tentative, pending direct measurements of both humidity and pollution levels in conjunction with lichen growth.

3. It was suggested that on Long Island the pollution effect is so strong that most corticolous lichens are killed at a distance beyond which the drought effect can influence their vertical distribution.

## THE LICHEN FLORA

1. Despite its comparatively small size, Long Island shows a surprising diversity in its vegetation, both phanerogamic and cryptogamic.

2. Including only material personally investigated, 261 species in 65 genera and 28 families were cataloged. Literature records were excluded from the list because of the high frequency of misidentifications and recent reinterpretations of many species.

3. Three names were introduced as new to science: *Polyblastiopsis quercicola, Pertusaria subpertusa,* and *Lepraria zonata.* The *Lepraria* had a previous but invalid description.

4. The following are documented for the first time from North America, and have been listed in the latest North American checklist (Hale and Culberson, 1966):

*Arthonia mediella*
*A. sexlocularis*
*Ochrolechia parella*
*Pertusaria tuberculifera*
*Porina hibernica*

5. The following names from the Long Island lichen flora are not included in the North American checklist (ibid):

*Bacidia "intermedia"*
*Ionaspis odora*
*Lecanora degelii*
*Lecidea aeruginosa*
*Pseudevernia furfuracea*
*Stereocaulon saxatile*

# Appendix A

## LONG ISLAND COLLECTORS

| *Name* | *Approx. dates* | *Herbarium* | *Approx. localities* |
|---|---|---|---|
| Alexander, E. J. | 1926 | | Bellmore,<br>High Hill Beach |
| Ames, F. H. | May 1910 | NYS | Brookhaven |
| Austin, Maud G. | ? | BKL | "Long Island" |
| Booth, M. A. | 1877 | FH | Orient |
| Brainerd, George B. | 1860-1866 | BKL | New York City and vicinity |
| Britton, E. G. | 1897-1898 | NY | Sag Harbor |
| Brodo, Irwin M. | 1959-present | NYS, MSC | Throughout Long Island |
| Cain, Stanley A. | 1930's | NY | Selden,<br>"Cold Spring Harbor"<br>Massapequa |
| Carnegie, T. M. | 1913-1914 | FH: Howe | Southampton |
| Clute, Willard N. | 1898 | NY | Southampton |
| Copeland, Joseph J. | 1940's | MSC | Montauk region |
| Culberson, W. L. | 1950's | FH | Riverhead region |
| Davis, William | 1912-1929 | Staten Island | Yaphank, Farmingville, Wading River |
| Dillman, George | 1927 | NY: Torrey | Orient Pt. |
| Gillis, W. T. | 1961 | MSC | Montauk |
| Grier, N. M. | | | "Cold Spring Harbor" |
| Grout, A. J. | 1900 | BKL | Cold Spring Harbor and vicinity |
| Harper, R. M. | 1918 | NY | Meadowbrook Valley;<br>Hempstead Pl. |
| Harris, A. E. G. | 1904 | MICH | Cold Spring |
| Hulst, George D. | 1890 | BKL | New York City |
| Imshaug, H. A. | 1960 | MSC | Eastern Long Island |
| Latham, Roy | 1908-present | CUP, NYS, FH, MO, MICH, LATHAM, MSC | Eastern Long Island |
| Lloyd, F. E. | 1896 | NY | Sayville |
| Morgan, D. P. J. M. | 1909 | FH: Howe | Southampton |

| *Name* | *Approx. dates* | *Herbarium* | *Approx. localities* |
|---|---|---|---|
| Ogden, Eugene C. | 1950-present | NYS | Eastern Long Island |
| Peck, Charles H. | 1860's-1914 | NYS | Throughout Long Island |
| Schrenk, Hermann | 1894 | MO | Eastport |
| Schrenk, Joseph | ? | NY | College Pt., Jamaica |
| Smith, Stanley J. | 1950's-present | NYS | Eastern Long Island |
| Taylor, Norman | 1918-1922 | BKL | East Point, Coram |
| Torrey, Raymond | 1930's | NY | Throughout Long Island |
| Von Scheur | 1895 | MO | Montauk Point |
| Warner, E. A. | 1900 | BKL | Valley Stream |
| Young, Alfred R. | ? | BKL | Orient |

# Appendix B

## GLOSSARY

### I. MORPHOLOGICAL AND ECOLOGICAL TERMS

The emphasis in this portion of the glossary is on morphological terminology as used in lichenology and with definitions designed to aid experienced observers as well as individuals with little or no background in mycology or lichenology. No attempt was made to include all ecological terminology, since most terms were defined or explained in the text when they were used. Some ecological terms of special importance in the identification of lichens were included, however. Chemical terminology is treated in part II of this glossary.

*Acicular.* Needle-shaped, i.e., slender and pointed at both ends.

*Adnate.* Closely attached to a surface, with few or no ascending parts.

*Amphigymnioid.* In foliose lichens, lacking rhizines close to the edges of the lower surface although having rhizines in the center, as in the subgenus *Amphigymnia* of the genus *Parmelia.*

*Amphithecium.* The portion of a lecanorine apothecium external to the proper exciple (figure 87A), usually containing algae; the thalline margin.

*Ampliariate.* In *Pertusaria*, pertaining to fruit warts which are broadest at the base, as in the subgenus *Ampliaria.*

*Anisotomic branching.* In *Cladonia*, especially the subgenus *Cladina*, unequal branching which results in a more or less distinct main axis from which smaller, more slender branches arise.

*Apical.* At the apex or tip of a stalk or lobe.

*Apothecium.* A disk- or cup-shaped ascocarp (figure 87).

*Areolate.* Broken up into small, irregular, usually angular patches (areoles), often appearing tile-like.

*Articulated.* Divided into short or long segments and having conspicuous joints.

*Ascocarp.* The fruiting body of an Ascomycete; the structure which bears the asci which in turn contain the ascospores.

*Ascohymenial.* Pertaining to a type of ascocarp having true paraphyses and unitunicate asci; characteristic of the subclass *Ascomycetidae.*

*Ascolocular.* Pertaining to a type of ascocarp in which the asci (generally bitunicate) arise within a uniform stromatic mass and are separated in maturity, not by true paraphyses, but by paraphysoid threads; characteristic of members of the subclass *Loculoascomycetidae.*

*Ascospore.* A spore produced in an ascus.

*Ascus (asci).* The sac-like structure in Ascomycetes in which the ascospores are formed.

*Aspicilioid.* Having apothecia sunken into the thallus so that the apothecial disk is level with the thallus surface or slightly depressed; as in the section *Aspicilia* of the genus *Lecanora.*

*Axil.* In *Cladonia* thalli, the point at which two or more branches or a branch and the main axis meet.

*Axis.* (a) The main trunk or stem of an abundantly branching thallus. (b) In *Usnea*, the cartilaginous (chondroid) central core running through the thallus filaments.

*Bacilliform.* Rod-shaped and generally very small.

*Biseriate.* Spores in two rows within the ascus.

*Branching (di-, tri-, tetrachotomy).* In *Cladonia,* especially *Cladina,* refers to the number of equal branches coming off at any one axil (two, three, and four respectively).

*Caespitose.* Tufted; shrubby.

*Calcareous rock.* Rock containing lime and producing vigorous bubbling ($CO_2$) upon application of a strong acid.

*Canals.* In some *Pertusaria* spores, fine lines or channels on or within the outer or inner spore walls, and communicating with the spore lumen.

*Capitate.* Having a rounded or "head-like" shape, usually referring to a type of soralium.

*Carbonaceous.* Opaque black, and usually brittle.

*Cartilaginous.* Referring to tissues which are transluscent and somewhat stiff; chondroid.

*Cephalodium (cephalodia).* A small gall-like growth occurring in large numbers within the tissues or on the surfaces of some lichens; generally containing blue-green algae.

*Channelled.* Referring to spore wall markings in *Pertusaria* (see *canals*).

*Chinky.* Minutely and irregularly cracked.

*Chondroid.* See *Cartilaginous.*

*Cilia.* Hair-like thalline appendages; occurring at the thallus or apothecial margins of many foliose and fruticose lichens.

*Cinereous.* Grey-ashy in color.

*Clavate.* Club-shaped; i.e., broader at one end than the other.

*Continuous.* Thallus unbroken, or broken very little, by cracks.

*Coralloid.* (a) Having or being composed of small, minutely branched cylindrical outgrowths. (b) A type of isidium having this form.

*Cortex.* The outer protective layers of a lichen thallus or apothecium; completely fungal in composition; often cellular in appearance (paraplectenchymatous), but may have other forms as well (figure 87A).

*Corticolous.* Growing on bark.

*Crenate.* Having a margin with rounded teeth or minute lobes.

*Crenulate.* Finely crenate.

*Crustose.* A thallus type which is generally in contact with the substratum at all points and lacks a lower cortex; cannot be removed intact from its substrate without removing a portion of the substrate as well.

*Cyanophyceaen.* Pertaining to blue-green algae.

*Decorticate.* Having had a cortex which has now fallen away or decomposed.

*Dicarpous.* With two ascocarps; usually refers to two apothecia per fruit wart in species of *Pertusaria.*

*Dichotomy.* See *Branching.*

*Disk.* The flat, concave, or convex surface of an apothecium; usually pigmented in a characteristic way.

*Dispersed.* Pertaining to a thallus which consists of scattered small areoles or granules.

*Dorsi-ventral.* With recognizable upper and lower surfaces.

*Ecorticate.* Never having had a cortex.

*Effigurate.* Referring to the lobed margin of a thick, basically crustose thallus.

*Effuse.* Pertaining to a thallus having no distinguishable boundaries.

*Ellipsoid.* Oval to elongate-oval in outline.

*Endolithic.* Growing "within" a rock, i.e., under and around the rock crystals, often with little or no thallus visible on the outer rock surface.

*Epilithic.* Growing on a rock surface with little or no penetration between and under the rock particles.

*Epiphloedal.* In corticolous lichens, a thallus having little or no penetration below the outermost bark layer (figure 88B).

*Epispore.* A transparent gelatinous covering, often irregular in thickness, surrounding the ascospores of many lichens; often called a "halo."

*Epithecium.* The uppermost portion of the hymenium formed by the expanded tips of paraphyses; usually pigmented and sometimes inspersed with tiny granules.

*Eupertusariate.* In *Pertusaria,* pertaining to fruit warts which are more or less constricted at the base, as in the subgenus *Eupertusaria* of Erichsen.

*Exciple.* (a) An area in an apothecium external to and below the hypothecium, forming the apothecial margin in lecideine apothecia (figure 87B) and internal to the amphithecium in lecanorine apothecia (figure 87A). The "proper exciple" of Fink (1935). Note: Fink considered only the area lateral to the hymenium as the exciple, with the portion below the hymenium being called the "hypothecium." The hypothecium as used here refers only to the subhymenial tissue above the exciple, (the "subhymenium" of Degelius [1954]). (b) The inner wall of a perithecium, generally circular in cross-section; can be hyaline, pigmented, or carbonaceous (figure 87C).

*Excipuloid tissue.* Tissue forming the walls or margins of ascolocular ascocarps (especially in *Micarea* and *Arthonia*) similar in appearance and position to the true exciple of lecideine apothecia.

*Falcate.* Bending in one direction; sickle-shaped.

*Farinose soredia.* Very fine, powdery soredia.

*Flexuous.* Bending in alternate directions, i.e., "zig zag."

*Foliose.* Pertaining to a more or less "leafy" lichen thallus, distinctly dorsi-ventral, and varying in its attachment to the substrate from almost completely adnate to umbilicate.

*Fruit wart.* In *Pertusaria,* a thalline wart (verruca) which contains one or more apothecia.

*Fruticose.* Pertaining to a lichen thallus which is podetioid, pendent, or shrubby.

*Fusiform.* Narrow, tapering toward both ends, usually with pointed ends; spindle-shaped.

*Glabrous.* (a) Having a more or less smooth, shiny surface. (b) With no trace of tomentum.

*Globose.* Nearly spherical.

*Granular.* (a) Having granules or granule-like particles. (b) Pertaining to soredia, composed of particles large enough to be easily distinguished under a dissecting microscope, presenting a coarse appearance, not powdery as in farinose soredia.

*Granule.* (a) In thalli, a spherical or nearly spherical corticate particle. (b) Pertaining to chemical materials, any small regular or irregular particle, opaque or hyaline, found associated with various lichen tissues.

*Gyrose.* Having a folded or ridged surface; referring to apothecia, particularly in *Umbilicaria,* which show the invasion of concentric or radiating rows of sterile excipular tissue into the hymenium.

*Halophytic.* Growing in habitats having high salt concentrations.

*Hyaline.* Colorless.

*Hygrophilous.* Generally associated with moisture (usually high atmospheric humidity).

*Hymenium.* The fertile layer of an ascocarp, consisting of asci and paraphyses, or paraphysoid threads) (figure 87).

*Hypha (hyphae).* A fungal filament.

*Hypophloedal.* In corticolous lichens, in which most or all of the thalline tissue is below one or more layers of cork (figure 88A).

*Hypothecium.* The tissue just below the hymenium but above the exciple (figure 87); often difficult to distinguish from the exciple, of which some authors consider it a part (see *exciple*).

*Hypothallus.* A special differentiated hyphal tissue on the lower surface of some lichens, e.g., *Anzia.*

*Hypotrachynoid.* Having rhizines growing over the entire lower thallus surface, as in the subgenus *Hypotrachyna* of the genus *Parmelia.*

*Hysterothecium.* An elongate to linear ascocarp seen in some members of the Loculoascomycetidae, e.g., *Opegrapha.*

*Imbricate.* Pertaining to scales or squamules which overlap in a shingle-like fashion.

*Inflated.* Swollen and hollow.

*Involucrellum.* The exposed covering or cap external to the excipulum present on many perithecia; usually black and carbonaceous, but in some species, may be colorless or even contain algae (figure 87C).

*Involute.* With margins rolled inward.

*Isidium* (*isidia*). A minute, cylindrical, or coralloid thalline outgrowth which is corticate and contains algae; apparently functions as a vegetative reproductive body.

*Isotomic branching.* Branching into sub-branches of equal size, resulting in a thallus having no distinguishable main axis.

*Isthmus* (*isthmi*). The narrow canal between the two locules of a polarilocular spore (figure 90A).

*Labriform.* (a) Lip-shaped. (b) Pertaining to soralia, generally formed by an involute thallus margin or a bursting hollow thallus lobe, sorediate on the lower or inside (i.e., exposed) surface, as in *Hypogymnia physodes.*

*Lacinia* (*laciniae*). A long, slender thallus lobe, as in *Pseudevernia* and *Ramalina.*

*Laciniate.* Having elongated, narrow lobes.

*Lamellate.* In thin plates or sheets.

*Laminal.* On the flat, usually upper surface of a thallus.

*Lax.* Loose; not compact.

*Lecanorine.* Pertaining to an apothecium having a distinct amphithecium, usually containing algae, as in the genus *Lecanora* (figure 87A).

*Lecideine.* Pertaining to an apothecium in which there is no distinguishable amphithecium and, therefore, in which the exciple forms the apothecial margin (i.e., the proper margin), as in the genus *Lecidea* (figure 87B).

*Lenticular.* Shaped like a double convex lens.

*Leprose.* Composed almost entirely of loosely organized granules or soredia.

*Lignicolous.* Growing on bare wood (lignum), as on a decorticate log or a wooden fence.

*Lirella* (*lirellae*). An elongate to linear apothecium, often branched, as in *Graphis.*

*Lumen* (*lumina*). A cell cavity, occupied by the protoplast.

*Macula* (*maculae*). A very small white spot or blotch on the surface of a thallus, not associated with any break in the cortex, but simply representing a locally decolorized or alga-less area.

*Maculiform.* (a) Like a spot. (b) Referring to a type of small, rounded, laminal soralium.

*Maritime.* Having some association with the ocean.

*Mazaedium.* A mass of ascospores and paraphyses formed by the disintegration of the asci of a special type of ascocarp, as in *Chaenotheca.*

*Medulla.* The internal region in a thallus or lecanorine apothecium which is generally composed of loosely packed hyphae (figure 87A).

*Mischoblastiomorphic.* Pertaining to a spore with two funnel-shaped

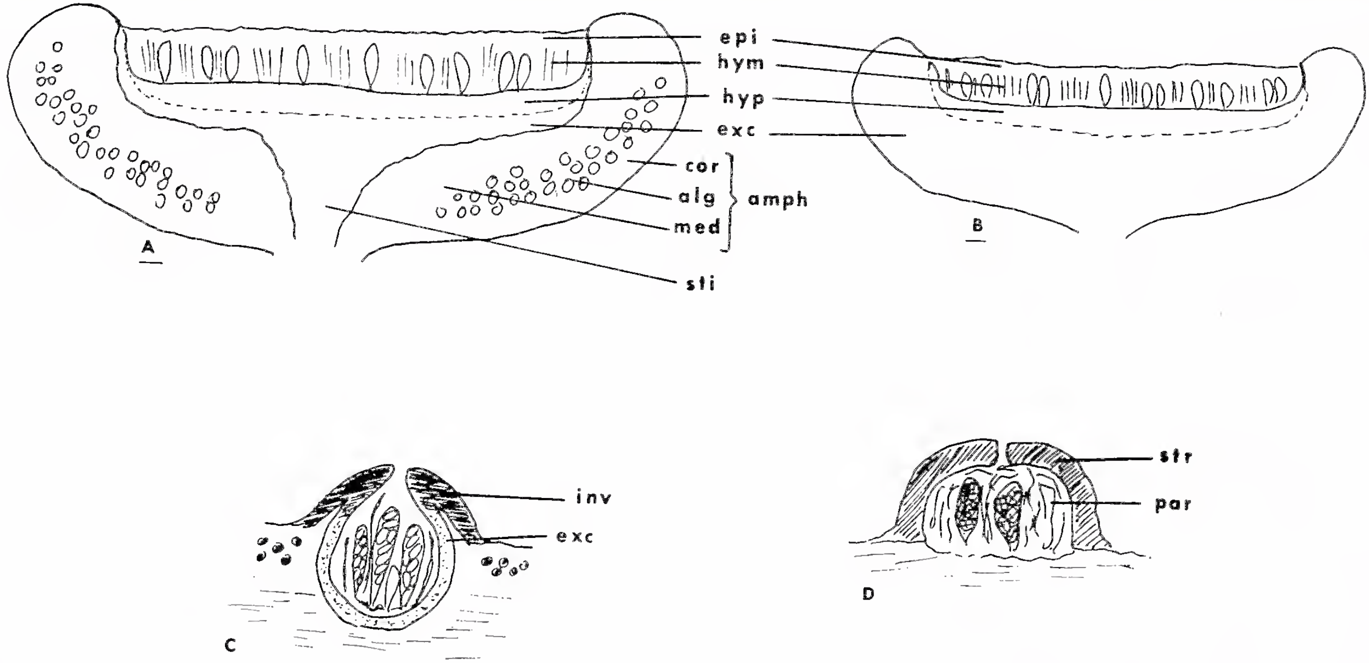

FIGURE 87. Ascocarps. (a) Lecanorine apothecium, as in *Lecanora* spp.; (b) lecideine apothecium, as in *Lecidea* spp.; (c) perithecium, as in *Porina hibernica;* (d) pseudothecium, as in *Polyblastiopsis quercicola. alg,* algal layer; *amph,* amphithecium; *cor,* cortex; *epi,* epithecium; *exc,* exciple; *hym,* hymenium; *hyp,* hypothecium; *inv,* involucrellum; *med,* medulla; *par,* paraphysoid threads; *sti,* stipe; *str,* stroma.

locules (the two locules appearing like an hourglass in section) (figure 90B).

*Molariform.* Shaped like a short, blunt tooth.

*Moniliform cells.* Globose hyphal cells joined together in a bead-like chain.

*Monocarpous.* Containing one apothecium.

*Murale.* Muriform.

*Muriform.* Having both longitudinal and transverse septa, with the cells thus appearing like a brick wall (figure 90D).

*Naked.* (a) Pertaining to a thallus without rhizines on the lower surface. (b) Epruinose.

*Neutrophytic.* Growing on a substrate having a pH close to 7 (i.e., substrates which are neither distinctly acid nor basic).

*Nitrophilous.* Showing a close association with substrates rich in nitrogen compounds.

*Nitrophobous.* Showing a distinct disassociation with substrates rich in nitrogen compounds.

*Nitrophytic.* Showing a tendency towards being nitrophilous.

*Nostoc.* A genus of blue-green algae found in many lichens; producing bead-like chains or filaments when free living, but, when lichenized, may be single- or few-celled (figure 89C).

*Octosporous.* Having eight spores per ascus.

*Orbicular.* Circular in outline.

*Ostiole.* The small, round, apical pore in various types of perithecia, pseudothecia, and even fruit warts of *Pertusaria.*

*Pachyspore.* An ascospore with uniformly thickened walls and spherical lumina (figure 90C).

*Papilla (papillae).* A small, generally conical, thalline outgrowth, having an unbroken cortical covering.

*Paraphysis (paraphyses).* A sterile hypha, sometimes branched, associated with asci in the hymenium of a member of the Ascomycetidae.

*Paraphysoid threads (or filaments).* The remains of stromatic tissue found between the asci in ascolocular ascrocarps; often is highly branched and anastomosing.

*Paraplectenchymatous.* Pertaining to fungal tissue which appears cellular in section due to short cells and a highly branched, irregularly oriented hyphal system.

*Pellucid.* Almost transparent.

*Peltate.* Attached at the center of the lower surface.

*Pendulose.* Pendent; hanging down, with little or no horizontal or erect growth.

*Perithecium.* A flask-shaped ascocarp characteristic of members of the Sphaeriales (figure 87C); may he sessile, or, more commonly, sunken partially or completely into the thallus tissue.

*Phorophyte.* The tree or shrub upon which a corticolous lichen is growing.

*Phycobiont.* The algal component (symbiont) in a lichen thallus.

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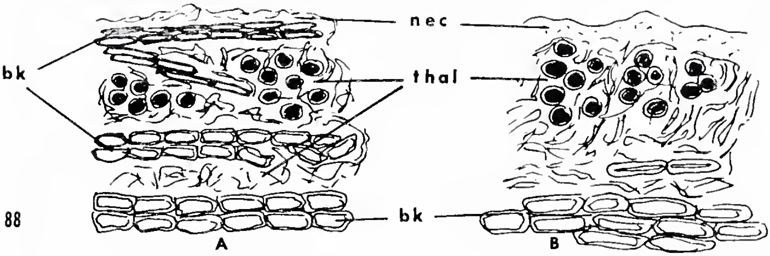

FIGURE 88. Thallus types. (a) Hypophloedal; (b) epiphloedal. *bk*, bark; *nec*, necrotic layer of thallus; *thal*, living thallus tissue.

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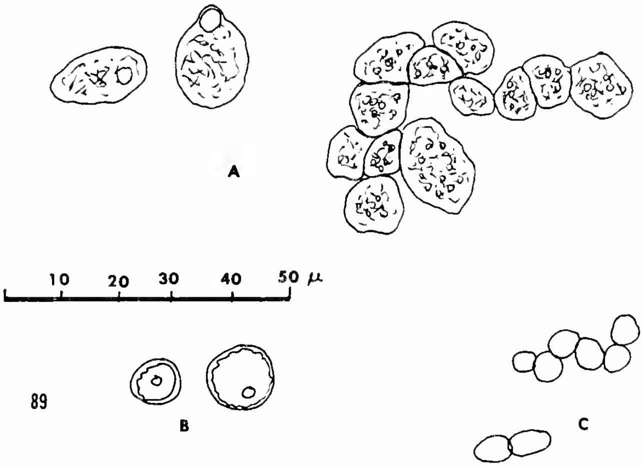

FIGURE 89. Lichen phycobionts (camera lucida drawings). (a) *Trentepohlia* (from *Graphis scripta*); (b) *Trebouxia* (from *Cladonia* sp.); (c) *Nostoc*, (from *Leptogium cyanescens*).

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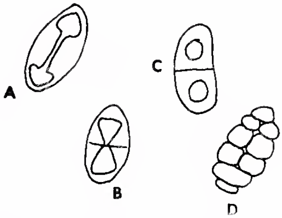

FIGURE 90. Some ascospore types. (a) Polarilocular; (b) mischoblastiomorphic; (c) pachysporous; (d) muriform.

*Phyllocladium* (*phyllocladia*). A minute, often lobed or scale-like outgrowth of the pseudopodetia of some members of the genus *Stereocaulon*.

*Platysmoid.* A tissue which consists of "densely agglutinated thick-walled hyphae with very narrow lumina . . ." (Dahl, 1952, p. 129), as in the subgenus *Platysma* of the genus *Cetraria.*

*Podetioid.* Having the general appearance of a podetium.

*Podetium.* A stalk formed by a vertical extension of apothecial tissues (usually the hypothecium and stipe); the stalk usually becomes secondarily invested with an algal layer and cortex (as in *Cladonia*) and can be either short and unbranched, or quite tall and highly branched.

*Polarilocular.* Pertaining to spores having two lumina separated by a relatively thick septum through which a narrow canal or isthmus passes (figure 90A), characteristic of members of the Teloschistaceae.

*Polycarpous.* Two or more apotheeia per fruit wart (in *Pertusaria*).

*Polysporous.* More than eight spores per ascus.

*Primary squamule.* The scale-like component of the primary thallus of a *Cladonia* species.

*Primary thallus.* The thallus of a *Cladonia* species exclusive of the podetia; generally composed of leafy scales or squamules, but sometimes (as in the subgenus *Cladina*) composed of a granular crust.

*Proper margin.* See *exciple.*

*Prothallus.* The non-assimilative lower portion of a lichen thallus seen around the outer edge of many crustose species as a white or pigmented margin, and often visible as a mat between the areoles or granules of other crustose species.

*Pruinose.* Having a frosted appearance (usually white or grey).

*Pseudocyphella* (*pseudocyphellae*). A tiny white dot or pore seen in large numbers on the upper and sometimes the lower thallus surfaces of many foliose species; caused by a break in the cortex and the extension of medullary hyphae to the surface.

*Pseudopodetium* (*pseudopodetia*). A podetioid stalk formed by a vertical extension or growth of thalline tissues; like true podetia, they can be simple (as in *Pycnothelia*) or highly branched (as in *Stereocaulon*).

*Pseudothalline margin.* A margin of thalline origin external to the amphithecium in lecanorine apothecia, and external to exciple in lecideine apothecia.

*Pseudothecium* (*pseudothecia*). The ascocarp of a member of the Loculoascomycetidae which appears superficially like a perithecium figure 87D).

*Punctiform.* Dot-like and very minute.

*Pustulate.* Having large and small blister-like protuberances over the thallus surface, each blister on the upper surface having a corresponding depression or pit on the lower surface.

*Pycnidial jelly.* A gelatinous substance found in the pycnidial cavity of some species of *Cladonia.*

*Pycnidium (pycnidia).* A globular or flask-shaped body, usually very small, in which pycnoconidia are formed; often closely resembling a perithecium in external appearance; the "spermagonium" of many authors.

*Pycnoconidium (pycnoconidia).* A small, spore-like body formed in a pycnidium; apparently can act as a conidium (an asexual spore) in some species and a spermatium (a type of male gamete) in others; it is what has been called a microconidium.

*Reniform.* Kidney-shaped.

*Reticulate.* Having a net-like appearance due to cracks, pigmentation, ridges, etc.

*Revolute.* Pertaining to margins which are rolled backward or downward.

*Rhizine (rhizinae).* A purely hyphal extension of the lower cortex, which generally serves to attach a foliose thallus to its substrate; of various lengths, thicknesses, colors, and degrees of branching.

*Rimose.* Having a minutely cracked appearance.

*Rugose.* Having a wrinkled surface.

*Rugulose.* Having a minutely wrinkled surface.

*Saxicolous.* Growing on rock, stone, pebbles, concrete, or brick.

*Scrobiculate.* Having a pitted appearance.

*Scurfy.* Having a fine powdery or scaly surface (not synonomous with *sorediate*).

*Septum (septa).* A crosswall in a hypha or spore.

*Sessile.* Without a stalk of any kind.

*Sigmoid.* Shaped like an "S."

*Siliceous rocks.* Rock composed mainly of silicon compounds, producing no bubbles upon application of a strong acid. Quartz and granite are examples.

*Simple.* Unbranched.

*Skiophilous.* Showing a strong association with shaded habitats.

*Soralium (soralia).* A body or area in which soredia are produced; can be in many forms.

*Sordid.* (a) Dark. (b) Appearing "dirty."

*Soredium.* A vegetative reproductive body of a lichen consisting of a few algal cells entwined and surrounded by a layer of fungal hyphae; entirely ecorticate; generally produced in localized masses called soralia, or covering large diffuse areas of a thallus.

*Spore.* A single- or few-celled reproductive body capable of giving rise to a new plant; as used here, refers specifically to an ascospore.

*Squamiform.* Scale- or squamule-shaped.

*Squamule.* A small, scale-like lobe or areole, generally at least partially ascending.

*Stipe.* In apothecia, the central stalk-like extension of the exciple downward and into the thallus.

*Stipitate.* Raised on a stalk or stipe.

*Stramineous.* Straw-colored.

*Stroma.* A closely-packed mass of hyphae, often carbonaceous, which is generally associated with reproductive structures.

*Striate.* Having a longitudinally striped, grooved, or ridged appearance.

*Strigose.* Bearing dense, short, hair-like projections or branches.

*Sub-* (a) Partially. (b) Incompletely. (c) Approaching. (d) Under.

*Subcanaliculate.* With shallow channels or furrows.

*Subfoliose.* Pertaining to a crustose species with marginal lobes, showing some tendency towards becoming ascending.

*Substrate.* The material upon which a lichen is growing or to which it is attached.

*Subulate.* Elongate, and gradually tapering to a point.

*Terete.* Circular in cross section.

*Terricolous.* Growing on soil or sand.

*Tetrachotomy.* See *branching.*

*Thalline.* Pertaining to the lichen thallus; similar to the thallus in appearance or structure.

*Thalline margin.* See *amphithecium.*

*Thallus.* In lichens, the vegetative plant body consisting of both algal and fungal components.

*Tier.* A platform-like expansion on the podetia of several species of *Cladonia* (e.g., *Cladonia verticillata*) at which point one or more new branches arise.

*Tomentose.* Covered with fine "hair"; having a downy or woolly appearance.

*Trebouxia.* A genus of single-celled green algae. Its distinctive, single, disk-shaped chloroplast almost fills the cell, and has a lobed or crenate margin. It is the most common green phycobiont in lichens (figure 89B)

*Trebouxioid.* Appearing similar to *Trebouxia.*

*Trentepohlia.* A genus of filamentous green algae found in many crustose lichens; when lichenized, the alga often produces only very short filaments or is single-celled. The orange-red pigmented globules, common in the cells of unlichenized individuals, are more infrequent or absent in lichenized individuals (figure 89A)

*Trichotomy.* See *branching.*

*Truncate.* More or less square or blunt at the base.

*Tubercle.* A minute, wart-like, thalline protuberance in which the cortex is generally broken at the apex.

*Umbilicus.* A solitary, short, thick, stem-like, purely hyphal attachment organ present on various foliose and subfoliose lichens, especially species of *Umbilicaria.*

*Uniseriate.* Spores occurring in one row within the ascus.

*Vein.* In lichens, broad or narrow ridges or thickenings, often pigmented, on the lower surface of some species of *Peltigera.*

*Vermiform.* Shaped like a worm; i.e., elongate, curved, more or less rounded.

*Verruca (verrucae).* A conspicuous wart-like thalline protuberance.

*Verruculose.* Covered with minute verrucae.

## II. CHEMICAL TERMS

All lichen substances mentioned in the keys or discussions are listed here together with their reactions with standard color test reagents and notes on their identification using recrystallization techniques.

By way of introduction to this portion of the glossary, a few comments on general methods for the color "spot" tests and microchemical crystallization are presented. Although chromatography was used extensively in some parts of the study, the techniques and data are too extensive to be presented here. For this information, Imshaug and Brodo (1966) or Hale (1961a) should be consulted.

1. *Color tests.* Reagents (KOH, Chlorox, iodine) should be stored in small jars or bottles. Since alcoholic solutions of PD are very unstable, and soon after preparation are unusable, small quantities of fresh PD should be prepared as needed (see glossary entry under *PD*).

All reagents should be applied to the thalli using a capillary pipette (such as a melting point tube) and *never* with the dropper from a reagent bottle. The pipettes can be drawn to a fine point for even better control of the reagent. Allow the reagent to pass into the pipette by capillary action, and merely touch the tube to the lichen material to empty a tiny but adequate amount on the area to be tested. Results should be observed under a dissecting microscope. KOH and PD colors are permanent and will often darken with time, but C and KC reactions are temporary and ephemeral.

For medullary reaction tests, expose a small portion of the medulla by cutting away the cortex with a razor blade. Reagents may be applied to any undamaged portion of the cortex for cortical tests. Tested portions of the thalli should always be discarded.

2. *Crystal tests.* Many lichen substances can be extracted from the intact lichen thallus (or apothecium) and recrystallized into a characteristic and recognizable form. The recrystallization reagents are generally one of the following: G.E., G.A.W., G.A.oT., G.A.An., G.W.Py (see glossary below for preparation formulas).

An extraction is made as follows: A small portion of the thallus or a few apothecia are placed in the center of a perfectly clean microscope slide which is placed on a slide warming table set at 60°C. Acetone is deposited on the lichen material drop by drop (allowing each drop to evaporate before applying the next) until 5 to 10 drops have been added. Lichen substances, if present, will appear as a residue ring around the lichen material. An alcohol lamp or microflame bunsen burner can be used instead of a slide warming table, but open flames should be used with caution because of the inflammability of acetone.

The lichen material is now discarded (or, if scarce, saved for morphological studies). The residue is generally scraped together, using a clean razor blade. A small drop of the proper reagent is placed on the residue and a clean cover glass carefully lowered into place. The slide is once again warmed for about one minute on the warming table. If a flame is used, special care must be taken so as to prevent the material from boiling. The slide is then allowed to cool.

Some crystals appear almost immediately (e.g., atranorin), and some take much longer (e.g., salacinic acid). Because all the reagents are made with glycerine, the slides may be left overnight or longer, if necessary, and they will not dry out. Crystals should be observed with a compound microscope.

*Alectoronic acid.* An orsellic acid depsidone; PD −, KOH −, KC + red, C −; in G.A.W.: colorless, radiating, irregular lamellae.

*Anthraquinone.* A bright red, orange, or yellow pigment found in many lichenized and some unlichenized fungi; turns a deep red or purple upon application of KOH.

*Atranorin.* A $\beta$-orsellic acid depside found in many lichens; PD − or + faint yellow (depending on concentration), KOH + yellow, KC −, C−; in G.A.oT. solution: yellow, straight or curved, usually highly branched, very slender needles; in G.E.: colorless, straight, blade-shaped crystals.

*Baeomycic acid.* A $\beta$-orsellic acid depside; PD + lemon yellow, KOH −, KC −, C−; in G.A. An.: yellow, thick needles often with frayed ends, often slow in forming.

*Barbatic acid.* A $\beta$-orsellic acid depside; PD −, KOH −, KC + orange, C −; in G.E. solution: colorless, short, prismatic crystals; in G.W.Py.: colorless, narrow, rectangular lamellae, often appearing as if the ends are broken off.

*Barbatolic acid.* A rare lichen substance; PD + yellow, KOH + yellow, KC + red, C −.

*C.* Undiluted household bleach (sodium hypochlorite solution); deteriorates rapidly and therefore must be poured fresh every few days.

*Caperatic acid.* A fatty acid; PD −, KOH −, KC −, C −; in G.E.: irregular, "warty," subglobular clumps of colorless crystals.

*Cryptochlorophaeic acid.* A lichen acid; PD −, KOH −, KC + red, C −; in G.A.W.: colorless, extremely slender, abundantly branched, curved or curled needles.

*Didymic acid.* A dibenzofurane compound known from several species of *Cladonia;* PD −, KOH −, KC −, K −; in G.A.W.: colorless, slender needles, slightly or strongly curled or hooked at the ends; in small clusters.

*Divaricatic acid.* An orsellic acid depside; PD −, KOH −, KC −, C −; in G.E. or G.A.W.: colorless or pale yellow straight or slightly curved needles, producing conspicuous perpendicular branches; often in radiate clusters.

*Fumarprotocetraric acid.* A β-orsellic acid depsidone; PD+ red, KOH− (or + dingy brown), KC−, C−; cannot be dependably demonstrated by crystal tests.

*G.A.An.* Glycerin — 95 percent ethanol — aniline, 2:2:1

*G.A.oT.* Glycerin — 95 percent ethanol — o-toluidine, 2:2:1

*G.A.W.* Glycerin — 95 percent ethanol — water, 1:1:1

*G.E.* Glycerin — glacial acetic acid, 1:1

*Grayanic acid.* A lichen acid found in a few species of *Cladonia*; PD−, KOH−, KC−, C−; in untreated acetone extract residue: colorless, very long, straight needles, sometimes becoming blade-shaped; in G.A.W.: colorless, slender, straight and unbranched needles sometimes occurring in clusters.

*G.W.Py.* Glycerin — water — pyridine, 1:3:1

*Gyrophoric acid.* An orsellic acid depside; PD−, KOH−, KC+ red, C+ red; in G.A.W. solution: colorless, small, granule-like clusters of crystals.

*Homosekikaic acid.* An orsellic acid depside found only in *Cladonia nemoxyna* (on Long Island); PD−, KOH−, KC−, C−; in G.A.oT. solution (after scraping acetone extract together and applying the solution to the underside of a cover slip): oily yellow masses in which are formed yellow, irregular, very thin lamellae.

*I.* A 1 percent solution of iodine in 10 percent potassium iodide, or an alcoholic solution made by dissolving a few crystals of iodine in 10 ml of 70 percent ethanol. Iodine tests should normally be done with sectioned material under magnification.

*Imbricaric acid.* An orsellic acid depside. PD−, KOH−, KC−, C−; microchemical methods cannot distinguish this substance from similar perlatolic acid (Culberson, 1958b).

*KC.* A reagent combination used in color tests. The area to be tested is moistened with KOH, after which C is applied. A positive reaction (usually a rose or orange color) is usually very fleeting, and must be observed carefully under magnification.

*KOH (K).* A 10-20 percent solution of potassium hydroxide.

*KOH + $K_2CO_3$ ($K^2$).* 5 percent KOH — 20 percent $K_2CO_3$, 1:1

*Lobaric acid.* An orsellic acid depsidone; PD−, KOH−, KC+ red, C−; in G.A.W.: colorless crystals, fanning out in curved radiate clusters; difficult to distinguish from some other substances, especially lecanoric acid.

*Merochlorophaeic acid.* A rare lichen acid: PD−, KOH+ wine red (?), KC−, C−; in G.E. solution: colorless, narrow lamellae with oblique ends, radiating out from a common point.

*Monoacetyl-protocetraric acid.* A β-orsellic acid depsidone; PD+ red-orange, KOH−, KC ?, C ?. The crystal forms in G.E. (colorless, flat, and blade-like) are difficult to distinguish from crystals produced by atranorin. It is best identified using chromatography (Imshaug and Brodo, 1966).

*Norstictic acid.* A $\beta$-orsellic acid depsidone; PD + yellow, KOH + yellow becoming blood red, KC −, C −; in KOH or KOH + $K_2CO_3$: orange or red, short, acicular crystals, clustered or solitary; in G.A.oT.: yellow, very thin, square or rectangular or sometimes irregular lamellae, often overlapping in small clusters.

*Olivetoric acid.* An orsellic acid depside; PD −, KOH −, KC + red, C + red; in G.A.W.: colorless, long, very slender, curved needles.

*Parietin.* A yellow or orange anthraquinone pigment commonly found in members of the Teloschistaceae.

*PD.* A freshly prepared, very dilute solution of para-phenylenediamine in 95 percent ethanol. It is best prepared on a glass depression microscope slide by adding a drop or two of the alcohol to a very small quantity of the chemical (enough to cover the tip of a dissecting needle). For larger quantities of PD, equivalent proportions of the reagents should be used. The material is extremely toxic and can easily stain the table surface, clothing, and herbarium packets and so should be handled and applied with care.

*Perlatolic acid.* An orsellic acid depside; PD−, KOH−, KC−, C−; in G.A.W. (after concentrating the acetone extract residue): colorless, branched, slightly curved or straight, long needles.

*Physodic acid.* An orsellic acid depsidone; PD −, KOH −, KC + red, C −; in G.A.W.: colorless, short, curved and branching crystals.

*Protocetraric acid.* A $\beta$-orsellic acid depsidone; PD + red-orange, KOH −, KC + red, C −; in G.A.oT.: yellow, irregular, granule-like crystals.

*Protolichesterinic acid.* A lactonic acid; PD −, KOH −, KC −, C −; in G.E.: colorless, square or rectangular, thin lamellae; best seen in polarized light.

*Pseudonorangiformic acid.* A lichen acid found only in *Cladonia submitis;* PD −, KOH −, KC −, C −; in G.E.: colorless crystals, falcate or arborescent, or in circular, curled clusters; crystalizes very slowly.

*Psoromic acid.* A $\beta$-orsellic acid depsidone; PD + deep yellow, KOH −, KC −, C −; in G.E.: colorless, feather-like fascicles of slender curved needles.

*Pulvic acid derivative.* A yellow, KOH − pigment such as is found in *Candelaria.*

*Salacinic acid.* A $\beta$-orsellic acid depsidone; PD + yellow, KOH + yellow slowly turning blood red, KC −, C −; in KOH + $K_2CO_3$: dark red curved needles in tightly-bound fascicles resembling sheaves of wheat; often very slow in forming, especially when the concentration is low; in G.A.oT.: yellow, small, boat-shaped (fusiform) crystals, often in small clusters.

*Squamatic acid.* A $\beta$-orsellic acid depside; PD −, KOH −, KC −, C −; brightly fluorescent (blue-white) in ultraviolet light; in G.E.: colorless, short prisms, resembling rice grains, sometimes in small clusters, but usually solitary.

*Stictic acid.* A β-orsellic acid depsidone; often found in conjunction with norstictic acid, either in the same thallus, or, in a corresponding and closely related species; PD + pale orange, KOH + deep yellow, KC −, C −; in G.A.oT: very pale yellow, small, thin, hexagonal lamellae.

*Strepsilin.* A dibenzofurane present only in *Cladonia strepsilis*; PD −, KOH −, KC + green, C + green.

*Substance H.* A lichen substance found in *Cladonia conista;* PD −, KOH −, KC −, C −; in an untreated acetone extract allowed to dry on the slide: long, colorless needles, parallel at the center but irregularly radiating at the periphery of the residue.

*Thamnolic acid.* A β-orsellic acid depside; PD + orange, KOH + deep yellow, KC −, C −; in G.A.An.: yellowish, straight, slender needles grouped into fascicles like sheaves of wheat.

*Usnic acid.* A yellow dibenzofurane pigment; one of the most common lichen substances; PD −, KOH −, KC + yellow or orange (faint), C −; in G.E.: yellow, narrow, flat needles, sometimes broadening into lamellae, often clustered.

*UV.* Ultraviolet light.

*Variolaric acid.* A lichen substance found in some species of *Ochrolechia* (diagnostic test on p. 221).

*Zeorin.* A triterpenoid substance (aliphatic); PD −, KOH −, KC −, C −; in G.A.An. or G.A.oT.: colorless, double pyramid crystals, often showing a conspicuous equatorial expansion.

# Appendix C

## CHECKLIST OF THE LICHENS OF LONG ISLAND

Class ASCOMYCETES

Subclass LOCULOASCOMYCETIDAE

Order Pleosporales
Arthopyreniaceae
*Arthopyrenia cerasi* (Schrad.) Mass.
*A. pinicola* (Hepp) Mass.
*Leptorhaphis epidermidis* (Ach.) Th. Fr.
*Polyblastiopsis quercicola* Brodo

Order Myrangiales
Arthoniaceae
*Arthonia caesia* (Flot.) Körb.
*A. mediella* Nyl.
*A. polymorpha* Ach.
*A. punctiformis* Ach.
*A. sexlocularis* Zahlbr.
*A. siderea* Degel.
*Arthothelium taediosum* (Nyl.) Müll. Arg.
*Micarea melaena* (Nyl.) Hedl.
*M. prasina* (Fr.) Körb.

Order Hysteriales
Opegraphaceae
*Opegrapha cinerea* Chev.
*O. rufescens* Pers.

Subclass ASCOMYCETIDAE

Order Caliciales
Caliciaceae
*Chaenotheca phaeocephala* (Turn.) Th. Fr.

Order Sphaeriales
Verrucariaceae
*Verrucaria microspora* Nyl.
*V. muralis* Ach.
*V. nigrescens* Pers.
*V. silicicola* Fink in Hedr.
*Dermatocarpon miniatum* (L.) Mann
Pyrenulaceae
*Pyrenula nitida* (Weig.) Ach.
*Melanotheca cruenta* (Mont.) Müll. Arg.
*Trypethelium virens* Tuck. in W. Darl.
Porinaceae
*Porina cestrensis* (Tuck. in W. Darl.) Müll. Arg.
*P. hibernica* P. James & Swins. in Swins.
*P. nucula* Ach.

Order Lecanorales
Graphidaceae
*Xylographa opegraphella* Will. in Rothr.
*Graphis scripta* (L.) Ach.
*Phaeographis dendritica* (Ach.) Müll. Arg.
Diploschistaceae
*Diploschistes scruposus* (Schreb.) Norm.
Gyalectaceae
*Dimerella diluta* (Pers.) Trev.
*D. lutea* (Dicks.) Trev.
Collemataceae
*Collema subfurvum* (Müll. Arg.) Degel.
*Leptogium corticola* (Tayl.) Tuck. in Lea
*L. cyanescens* (Ach.) Körb.
Pannariaceae
*Placynthium nigrum* (Huds.) S. Gray
*Pannaria lurida* (Mont.) Nyl.
Stictaceae
*Lobaria pulmonaria* (L.) Hoffm.
*L. quercizans* Michx.
Nephromaceae
*Nephroma laevigatum* Ach.
Peltigeraceae
*Solorina saccata* (L.) Ach.
*Peltigera aphthosa* (L.) Willd.
*P. canina* (L.) Willd.
*P. polydactyla* (Neck.) Hoffm.
*P. praetextata* (Flörke in Somm.) Vain.
Lecideaceae
*Lecidea aeruginosa* Borr. in Hook. & Sowerby
*L. albocaerulescens* (Wulf. in Jacq.) Ach.
*L. anthracophila* Nyl.
*L. botryosa* (Fr.) Th. Fr.

*L. coarctata* (Turn. in Sm. & Sowerby) Nyl.
*L. cyrtidia* Tuck.
*L. erratica* Körb.
*L. granulosa* (Ehrh.) Ach.
*L. macrocarpa* (DC. in Lam. & DC.) Steud.
*L. myriocarpoides* Nyl.
*L. nylanderi* (Anzi) Th. Fr.
*L. scalaris* (Ach.) Ach.
*L. uliginosa* (Schrad.) Ach.
*L. varians* Ach.
*L. vernalis* (L.) Ach.
*L. viridescens* (Schrad. in Gmel.) Ach.
*Catillaria glauconigrans* (Tuck.) Hasse
*Bacidia atrogrisea* (Del. in Hepp) Körb.
*B. chlorantha* (Tuck.) Fink
*B. chlorococca* (Graewe in Stizenb.) Lett.
*B. chlorosticta* (Tuck.) Schneid.
*B. intermedia* (Hepp in Stizenb.) Arn.
*B. inundata* (Fr.) Körb.
*B. schweinitzii* (Tuck. in W. Darl.) Schneid.
*B. trisepta* (Naegeli in Müll. Arg.) Zahlbr.
*B. umbrina* (Ach.) Bausch.
*Rhizocarpon cinereovirens* (Müll. Arg.) Vain.
*R. grande* (Flörke in Flot.) Arn.
*R. intermedium* Degel.
*R. obscuratum* (Ach.) Mass.
*R. plicatile* (Leight.) A.L. Sm.

Stereocaulaceae

*Pycnothelia papillaria* (Ehrh.) Duf.
*Stereocaulon saxatile* Magn.

Baeomycetaceae

*Baeomyces roseus* Pers.

Cladoniaceae

*Cladonia alpestris* (L.) Rabenh.
*C. apodocarpa* Robb.
*C. arbuscula* (Wallr.) Rabenh.
*C. atlantica* Evans
*C. bacillaris* (Ach.) Nyl.
*C. beaumontii* (Tuck.) Vain.
*C. boryi* Tuck.
*C. brevis* Sandst.
*C. caespiticia* (Pers.) Flörke
*C. calycantha* Nyl.
*C. capitata* (Michx.) Spreng.
*C. carassensis* Vain.
*C. cariosa* (Ach.) Spreng.
*C. carneola* (Fr.) Fr.
*C. caroliniana* Tuck.
*C. chlorophaea* (Flörke in Somm.) Spreng.
*C. clavulifera* Vain.
*C. coniocraea* (Flörke) Spreng. em. Sandst.
*C. conista* (Ach.) Robb.
*C. cristatella* Tuck.
*C. cylindrica* (Evans) Evans
*C. deformis* (L.) Hoffm.
*C. didyma* (Fée) Vain.
*C. evansii* Abb.
*C. farinacea* (Vain.) Evans
*C. fimbriata* (L.) Fr.
*C. floerkeana* (Fr.) Flörke
*C. floridana* Vain.
*C. furcata* (Huds.) Schrad.
*C. incrassata* Flörke
*C. macilenta* Hoffm.
*C. mateocyatha* Robb.
*C. mitis* Sandst.
*C. multiformis* Merr.
*C. nemoxyna* (Ach.) Arn.
*C. parasitica* (Hoffm.) Hoffm.
*C. piedmontensis* Merr.
*C. pityrea* (Flörke) Fr.
*C. pleurota* (Flörke) Schaer.
*C. pyxidata* (L.) Hoffm.
*C. rangiferina* (L.) G.Web. in Wigg.
*C. robbinsii* Evans
*C. santensis* Tuck.
*C. scabriuscula* (Del. in Duby) Nyl.
*C. simulata* Robb.
*C. squamosa* (Scop.) Hoffm.
*C. strepsilis* (Ach.) Vain.
*C. subcariosa* Nyl.
*C. submitis* Evans
*C. subtenuis* (Abb.) Evans
*C. terrae-novae* Ahti
*C. uncialis* (L.) G.Web.
*C. verticillata* (Hoffm.) Schaer.
*C. vulcanica* Zoll.

Umbilicariaceae

*Umbilicaria mammulata* (Ach.) Tuck.
*U. muhlenbergii* (Ach.) Tuck.
*U. papulosa* (Ach.) Nyl.

Acarosporaceae

*Sarcogyne clavus* (Ram. in Lam. & DC.) Kremp.
*S. privigna* (Ach.) Mass.
*S. simplex* (Dav.) Nyl.
*Acarospora fuscata* (Schrad.) Arn.

Pertusariaceae

*Pertusaria alpina* Hepp
*P. amara* (Ach.) Nyl.
*P. multipuncta* (Turn.) Nyl.
*P. propinqua* Müll. Arg.
*P. subpertusa* Brodo
*P. trachythallina* Erichs. in Degel.
*P. tuberculifera* Nyl.
*P. velata* (Turn.) Nyl.
*P. xanthodes* Müll. Arg.
*Melanaria macounii* Lamb

Lecanoraceae

*Ionaspis odora* (Ach. in Schaer.) Th. Fr.
*Lecanora atra* (Huds.) Ach.
*L. caesiocinerea* Nyl.
*L. caesiorubella* Ach.
*L. chlarotera* Nyl.
*L. cinerea* (L.) Somm.
*L. conizaea* (Ach.) Nyl.
*L. cupressi* Tuck.
*L. degelii* Schauer & Brodo
*L. dispersa* (Pers.)
*L. hageni* (Ach.) Ach.
*L. laevis* Poelt
*L. muralis* (Schreb.) Rabenh.
*L. rubina* (Vill.) Ach.
*L. subintricata* (Nyl.) Th. Fr.
*L. symmicta* (Ach.) Ach.
*L.* cfr. *varia* (Ehrh.) Ach.
*L.* sp.
*Ochrolechia parella* (L.) Mass.
*O. rosella* (Müll. Arg.) Vers.
*O.* sp.
*Haematomma ochrophaeum* (Tuck.) Mass.
*H.* sp.

Candelariaceae

*Candelariella aurella* (Hoffm.) Zahlbr.
*C. vitellina* (Ehrh.) Müll. Arg.
*Candelaria concolor* (Dicks.) B.Stein in Cohn

Parmeliaceae

*Parmeliopsis aleurites* (Ach.) Nyl.
*P. ambigua* (Wulf. in Jacq.) Nyl.
*P. placorodia* (Ach.) Nyl.
*Parmelia appalachensis* W. Culb.
*P. arseneana* Gyeln.
*P. aurulenta* Tuck.
*P. caperata* (L.) Ach.
*P. conspersa* (Ach.) Ach.
*P. dilatata* Vain.
*P. galbina* Ach.
*P. hypotropa* Nyl.
*P. livida* Tayl.
*P. michauxiana* Zahlbr.
*P. olivetorum* Nyl.
*P. perforata* (Wulf. in Jacq.) Ach.
*P. perlata* (Huds.) Ach.
*P. plittii* Gyeln.
*P. reticulata* Tayl. in Mack.
*P. rudecta* Ach.
*P. saxatilis* (L.) Ach.
*P. stenophylla* (Ach.) Heug.
*P. subaurifera* Nyl.
*P. subrudecta* Nyl.
*P. sulcata* Tayl. in Mack.
*P. tasmanica* Hook. & Tayl.
*Hypogymnia physodes* (L.) Nyl.
*Pseudevernia furfuracea* (L.) Zopf
*Cetraria ciliaris* Ach.
*C. fendleri* (Nyl.) Tuck.
*C. islandica* (L.) Ach.
*C. tuckermanii* Oakes in Tuck.
*C. viridis* Schwein.
*Anzia colpodes* (Ach.) Stizenb.

Usneaceae

*Evernia mesomorpha* Nyl.
*Alectoria glabra* Mot.
*A. nidulifera* Norrl. in Nyl.
*Ramalina complanata* (Sw. in Ach.) Ach.
*R. fastigiata* (Lilj.) Ach.
*R. stenospora* Müll. Arg.
*R. willeyi* R.H. Howe
*Usnea longissima* Ach.
*U. mutabilis* Stirt.
*U. strigosa* (Ach.) A. Eaton
*U. trichodea* Ach.
*U.* sp.

Teloschistaceae

*Caloplaca aurantiaca* (Lightf.) Th. Fr.
*C. camptidia* (Tuck.) Zahlbr.
*C. cerina* (Ehrh. in Hoffm.) Th. Fr.
*C. citrina* (Hoffm.) Th. Fr.
*C. discolor* (Will. in Tuck.) Fink
*C. feracissima* Magn.

*C. flavovirescens* (Wulf.) Dalla Torre & Sarnth.
*C. pyracea* (Ach.) Th. Fr.
*Xanthoria fallax* (Hepp in Arn.) Arn.
*X. parietina* (L.) Beltr.
*Teloschistes chrysophthalmus* (L.) Beltr.
*T. flavicans* (Sw.) Norm.

Physciaceae

*Buellia curtisii* (Tuck.) Imsh. in Brodo
*B. dialyta* (Nyl.) Tuck.
*B. polyspora* (Will. in Tuck.) Vain.
*B. punctata* (Hoffm.) Mass.
*B. stigmaea* Tuck.
*B. stillingiana* J. Stein
*B. turgescens* Tuck.
*Rinodina applanata* Magn.
*R. confragosa* (Ach.) Körb.
*R. milliaria* Tuck.
*R. oreina* (Ach.) Mass.
*R. pachysperma* Magn.
*R. salina* Degel.
*Pyxine sorediata* (Ach.) Mont. in Sagra
*Physcia adscendens* (Th. Fr.) Oliv.
*P. aipolia* (Ehrh. in Humb.) Hampe in Fürnr.
*P. millegrana* Degel.
*P. orbicularis* (Neck.) Pötsch in Pötsch & Scheiderm.
*P. stellaris* (L.) Nyl.
*P. subtilis* Degel.
*P. tribacoides* Nyl.
*Anaptychia obscurata* (Nyl.) Vain.
*A. palmulata* (Michx.) Vain.
*A. pseudospeciosa* Kurok.

Class FUNGI IMPERFECTI

*Lepraria incana* (L.) Ach.
*L. zonata* Brodo
*L.* sp.

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