

Some Observations on the Occurrence and Distribution of the Characeae of Indiana

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Various studies have considered the habitat of the Characeae usually in conjunction with a taxonomic presentation of the Characeae of other regions. A detailed report of this type was made by Robert Corillion (2) for France and occidental Europe, and was received while this study was in progress. It contains taxonomic, phytogeographical and phytosociological material with a large bibliography recommended for historical data. Several additional references are cited to supplement work on the North American Characeae: Anderson and Walker (1) Kiener (12), Prescott (15).

The Characeae are a group of the algae classed with the Chlorophyta or green algae, but are also ranked as a separate group. They are attached, aquatic plants with a rhizoidal system, central stem sometimes branching, with whorls of branchlets at stem nodes and are sexual with antheridia and oogonia on the branchlet nodes. Some species produce bulbils which are enlargements of the lower stem nodes and rhizoidal nodes and contain reserve starch. Three genera have been found in North America: Chara, Nitella and Tolypella.

In 1953, the author (4) published the third in a series of papers in which a taxonomic arrangement of the Characeae of Indiana was given. A distributional map of each species was included. An attempt had been made to obtain all specimens extant representing the bases of published reports as well as to collect widely over the state. Typic or co-typic specimens were studied whenever possible. Specimens were cited in detail so that the work could be expanded, repeated or confirmed.

Only a paragraph was included in the 1953 study giving a brief summary of the types of habitat, since the length of the paper was limited for publishing. The specimens cited in that paper constitute the basis of this report which gives a detailed discussion of occurrence and distribution. Many of the habitats have been revisited to observe changes and to further study the features.¹ There is an addition of one collection from Pokagon State Park display ponds, Steuben County, which yielded the first collection of Tolypella reported for the state, *Tolypella prolifera*. Another collection found there in a different pond proved to be another species of Tolypella, *Tolypella intricata* Leonh. (W. A. and F. K. Daily, collection 425, August, 1953). It is differentiated from *T. prolifera* chiefly by having divided sterile branchlets.

This study is limited to the occurrence and distribution of the Characeae of Indiana. Any comments concerning a broader area are based on my own study of specimens from the regions mentioned. Any correlation of the charophytes of this state with those found in the

¹The hospitality and aid of Dr. Murvel Garner and students at the Earlham College Biological Station, Dewart Lake, Indiana, is appreciated.

rest of North America must necessarily be tentative as wide areas have not been studied thoroughly or at all. Distributions based on published literature are misleading because of the differences among specialists concerning the concept of species.

Geographic Regions

Any understanding of plant distribution must depend on an understanding of the plant habitat, for the attached Characeae occur, just as higher plants, necessarily, in a suitable environment. Bodies of water over the world had their origins at different times during the history of the earth. Great cataclysms such as volcanic activity or glacial ravages changed the surface of the earth and often produced lake groups and drainage systems of different kinds. According to other reports, the development of the charophytic flora in different parts of the world often show species related to particular kinds of aquatic habitats even though many charophytes are ubiquitous.

In Indiana, aquatic habitats are interesting inasmuch as the Late Wisconsin glaciation had its borders within our state and as a result of this glacial period, about a thousand lakes were formed in the morainic northern area. It is in these lakes often connected with well developed drainage systems rich in calcium carbonate and to a lesser extent magnesium carbonate and other important minerals that the greatest expanse and variety of charophytic flora is found in Indiana. The pH varies in some representative lakes from 7.1 in the deep basins to around 8.3 at the surface. The habitat of charophytes is nearer the latter limit. For other chemical and physical data consult Will Scott (16), Evermann and Clark (6). Some streams studied would average a pH of about 7.5 (14).

Glacial drift spread over Indiana from the Wisconsin and other glaciations to a depth of as great as 500 ft. in some valleys. Sand, gravel, clay and occasional boulders with organic matter were tumbled together to form a productive, usually well-drained soil. Some predominantly clay areas are less well-drained. Sand and gravel were not uniformly deposited so that distribution of some species of the Characeae seems to be affected by the occurrence of different substrates in the aquatic habitats. Peat in bogs, marl deposits, silt from erosion and sedimentation of organic matter from the decay of plant material all seem to be important in the distribution of some of the species found in Indiana. Other species show a wide range of tolerance to various substrates.

Glaciation covered most of the remaining part of Indiana, so that only the central southern portion including the hilly, "Knobs Area" remained unglaciated. Some glacial material, moreover, was washed into this area by streams fed by melting glacial ice. The residual soils of the Knobs Area are comparatively acid where much leaching has removed the carbonates except where fresh erosion and springs bring carbonates from outcropped rock. Some artificial lakes in this area have a pH from 6.5 to 7.0 at the surface. In the central "Tipton Till" area of the state, soils and water are in general neutral to slightly

alkaline and are softer than in the lakes of the northern morainic area. However, they contain sufficient electrolytes to be very productive.

S. S. Visher (19) summarizes the geographic regions in Indiana as follows: "Northern Indiana was most recently, and most strikingly glaciated, Central Indiana was notably affected by an earlier ice sheet, but most of the glacial effects are less obvious. The core of Southern Indiana was not glaciated, and the rest was glaciated relatively long ago, with most of the effects not inconspicuous."

Climate

We owe the large number of permanent bodies of water in Indiana in part to the humidity of the region. It is unlike arid areas where the water evaporates to produce dry lake beds and temporary pools. The average rainfall here is about 39 inches a year. The leaching of soil because of heavier rainfall in the southern part of the state probably accounts for part of the distributional patterns shown by the Characeae in Indiana. Since this region is rough in topography, heavier rainfall is caused in the hills by clashes of cold and warm air drafts. In this way, temperature is also involved in producing types of habitats significant in charophytic distribution. It is thought that these conditions influenced the southern extension of the Pleistocene ice sheet (18). The temperature of the southwestern part of the state is about 5° F. higher than the northern part as an average with much greater differences in the extremes of summer and winter. Speaking of higher plants, C. C. Deam (5) states that there are an average of 158 growing days in the northern part of the state as compared with 188 in the southern part, so we seem to be in a transition area for both higher and aquatic plant life.

Light

Light intensity and length of day seem particularly important to the growth and reproduction of some of the Characeae (11). The amount of light available to charophytes is not the same as that available to terrestrial plants (except for a few emergent species) in that light must travel through water before reaching them. Clear water will reflect and absorb light and the disturbance of its surface causes a loss of even more light transmission. Anything such as plankton, silt or other suspended materials, cause less light to reach the submerged charophytes. Other factors such as thermocline and evaporation along with humidity affect the amount of suspended materials and thus the amount of light reaching the Characeae. The distribution of *Chara aspera* v. *Macounii* is undoubtedly affected by the light factor. It has been found in Indiana only in very shallow water on the edge of glacial lakes scoured of other vegetation by the action of ice and waves in winter. Here, undoubtedly this species finds more light and little competition from shading by other aquatic plants.

Another species, *Chara contraria*, seems to be tolerant to a rather wide range of light intensity, on the other hand. It has been found as an emergent plant at the shore and growing submerged to a depth of about 15 to 25 feet, about the limit of tolerance for charophytes here.

Therefore, the usual ecological concept of zonation of the Characeae in deeper water with emergent and floating vegetative zones approaching from shore is not supported by these observations. In fact, if one should make transects from shore to deep water around most of our lakes, one would find quite different vegetation at the same depth zone in different parts of a lake. Some areas might be devoid of vegetation depending on the age of the habitat, ecological requirements of the charophytes growing in the region, dispersal of charophytic reproductive bodies to the site, and the nature of the micro-habitat.

Biota, Gases, pH, Minerals

Even though a number of general factors have been recognized as influencing the natural habitat and the reciprocal influence of the environment on biota and the biota on environment, complex interrelationships among the factors can only be guessed at this time. For instance, experimental studies have shown that different ranges in the concentration of calcium carbonate seem optimal for the growth of the algae and, particularly, the Characeae, but the exact nature of its action has not been demonstrated. It may be important chiefly as a source of CO_2 , as a buffer to control pH, and possibly, it indicates only traces of minerals usually associated with it and which are not yet recognized as being important in the mineral nutrition of the Characeae.

Chara vulgaris is usually considered to be a common species, but is less common in this region than *C. contraria* and *C. globularis*. It occurs in rivers, spring-fed bogs with mud and peat bottoms, respectively, and is associated with lakes fed by springs. The occurrence of iron in the habitats where it is found suggests that iron or some associated mineral may be the chief factor influencing its distribution in this area. Stroede (17) considers this species mesotrophic for iron.

Organic Matter

The balance of organic matter on the substrate, depending on complex interrelationships between the growth, death and decay of various organisms and their activities, is important in the distribution of the Characeae. *Nitella tenuissima* var. *compacta* has been found in Indiana invariably attached to hummocks of soft peat in shallow waters of glacial lakes in northern Indiana. All charophytes of the state seem to need a little silt and sediment before appearing in a young habitat. Other species show an affiliation for organic matter to a lesser degree than *Nitella tenuissima*. In some unshaded areas of seepage ponds in southern Indiana which contained only partially decomposed leaves, no charophytes were found.

Physical Features of Lakes

The physical features of a lake influence the nature of the charophytic flora there. *The Guide to Indiana Lakes* (10) was consulted for acres in area, average and maximum depth and type of bottom. With this data recorded by species on McBee punch cards, some interesting correlations could be found. Since most lake bottoms are not uniform over their entire area with some part covered by a different

substrate than others or since an area may be a mixture of materials and have different types of deposits mentioned earlier, supplementary data were necessary in some instances from observation of the habitat to show associations of the Characeae to the kind of habitat.

The basins of lakes are important in distribution of the Characeae in several ways. Deep lakes are stratified in the summer, the boundary between thermocline and hypolimnion being about 27 feet deep in some. This is about the maximum depth to which the Characeae grow in this region, usually. If there are gradually sloping basins, a large charophytic flora is afforded a substrate in optimal light conditions. If the lake is steep-sided, such as part of Gentian Lake in Steuben County, the Characeae and many other submerged aquatics stop abruptly at about 15 to 25 feet in depth. South-facing slopes such as demonstrated at Gentian Lake receive more light than north-facing ones affecting growth of the Characeae even as an effect by north-facing and south-facing slopes has been noted for terrestrial vegetation. Maturation with attendant interrelated changes in a lake is influenced by the slope of the basin. Steep-sided lakes mature slower and this is partly due to less chance of shore vegetation piling up on the margin thus allowing more vegetation to grow there. This begins the filling of the lake at the margins and then reaches the boggy, marshy and finally terrestrial status.

The margin of a lake may influence the occurrence of the charophytes particularly on the north and east sides of our lakes. If the lake has a large surface area with much wave action, an irregular lake margin will supply protected coves where charophytes might grow. Otherwise, wave action might make these areas unsuitable for growth.

The drainage system affects the charophytic flora in a lake in that a lake with an inlet receives silt which may be deposited heavily on the bottom near it. Rheophiles or river-loving charophytes may occur on such silted areas. *Nitella flexilis* is one of these species, being found invariably on heavily silted bottoms of lakes or rivers. With also an outlet, stagnation is decreased in a lake, and there is some loss of suspended or dissolved materials.

Hills on the southwest side of lakes may protect them somewhat from the prevailing southwest wind which we have in Indiana. This reduces wave action and disturbs the lake bottom less, thus creating less surface reflection of light so that charophytes receive more light in protected water. Wave action as well as currents in streams and lakes influence the distribution of the Characeae. They are primarily inhabitants of quiet waters, but rivers do afford in the quiet ponded areas an acceptable habitat to a few charophytes such as *Nitella flexilis*, *Chara globularis*, *C. vulgaris*, *C. sejuncta*, *C. zeylanica*, *C. contraria* and *C. Braunii*.

The area drained about the habitat has some effect on it. If rich farmland surrounds the waters, the habitat will support certain species different from those in poorer farming conditions. Of course, there are species with a wide tolerance in mineral nutrition which might occur in rich and poor farming districts.

Habitat Changes

Our aquatic habitats are often changed, some in the short span of this work. These are more often wrought by man in this age than natural forces, as far as sudden changes are concerned, although the process of maturation usually moves relentlessly forward. Many of the lakes are apparently capable of supporting the same species for many years and are stable in this respect. For instance, I found most of the species growing in Lake Maxinkuckee as were found there during the Evermann and Clark (6) study over fifty years ago. Other sites revisited during the sixteen years of this study were found to be more or less stable. Ponds and river pools seem to provide a less stable habitat. However, due to draining, damming, dredging, dumping of sewage and treating with chemicals, many bodies of water are constantly changed.

Dispersal and Ecesis

Despite the suitability of a habitat, an oospore or some vegetative reproductive structure of the Characeae must be dispersed to the site before ecesis can take place. It seems that this is one of the most important factors in charophytic distribution. One is impressed with the randomness of dispersal when surveying the aquatic meadows of the shallow water of a lake. In bodies of water varying little in depth, and with little variation in bottom, shading, etc., one observes only scattered colonies of *Chara contraria*, a common species showing great tolerance to varying conditions in the habitat. The open areas show lack of dispersal there.

Long distance dispersal can be effected by birds apparently during migration. It has been reported that oospores can be carried in the digestive tract of birds unharmed. The vegetative reproductive structures can also be transported by birds and other animals by clinging to them and are capable of withstanding desiccation. The production of a large number of reproductive structures equipped to be transported unharmed and viable in a variety of habitats would greatly facilitate distributing the different species of charophytes widely. It is noteworthy that two dioecious species, *Nitella opaca* and *Chara aspera* v. *Macounii*, occurring in Indiana are not a significant part of the aquatic flora in this region. Although other factors influence their distribution, dioeciousness and randomness of fertilization undoubtedly also limit their occurrence. Fewer fertile oospores would be produced thus minimizing this type of dispersal. *Chara aspera* v. *Macounii* very often is entirely sterile in this region, so that conditions may not be optimum for production of oospores at all here.

After germination, the young plant may need conditions for growth not met by all habitats, so that this could be a limiting factor in the distribution of charophytes. Experimental studies might clarify this subject. If the species can compete successfully with other vegetation, it will succeed in a new habitat where a species with restricted needs might fail.

Distributional Analysis by Species

A brief distributional analysis for each species follows:

Chara aspera var. *Macounii* T. F. Allen has been found only in the glacial lake area in Kosciusko, Marshall and Steuben Counties from lakes having bottoms of different kinds including sand and gravel, marl and gravel, sand, marl, and muck. These lakes are classed as semi-hard lakes generally and usually have clear water. This species occurs on the ice-scoured bottom in shallow water where there is little competition and good light transmission.

This is a dioecious species often found without fruiting bodies in this area, so its distribution may be limited by this factor.

It is found north and west of Indiana, the lake region in this state being the southern limit of its distribution in this area. It may be a poor competitor in our vegetation because it is better adapted to colder climates. Its habit in shallow water here would subject it to average temperatures warmer than found farther north, so this area may be critical for this species.

Chara Braunii Gmel. has been collected very frequently over much of the state both in glaciated and unglaciated regions. The nature of the habitat ranges from sloughs to lakes of 2,618 acres in area, but shallow water on a sandy bottom seems preferred. Gravel, mud and marl bottoms also support its growth.

Although this seems to be a well-dispersed species in this area and the rest of North America, it usually comes from the well-lighted habitat and in some regions (Kiener, 12) seems characteristically a part of the flora of intermittent pools. Only one habitat here might be classed as intermittent or temporary.

Chara Brittonii T. F. Allen was unknown except for the type specimen collected in New Jersey until the collections from Indiana. It has been collected only in bog ponds here in LaPorte and Randolph Counties.

A collection deposited in my herbarium from Fish Lake, Berry County, Michigan, extends its rather limited known range. A study of this species and its range limits should be very interesting, since it is a very unique species being entirely ecorticate with two series of stipulodes at a stem node. Its small size and occurrence in shallow water along with young plants of other species may account for its being overlooked. It is probably much more common than indicated by the frequency of its collection.

Chara contraria A. Br. is the most frequently found charophyte in the state being found in glacial and unglaciated areas and covering large portions of young and old habitats with aquatic meadows. It is a prominent member of our gravel pit flora particularly and seems to grow there when other charophytes do not. It has been found on many types of bottom such as mud, muck, marl and muck, sand, clay. Types of habitat range from many lakes in the glacial lake region, bogs, oxbows of a river, excavated ponds, lake channels, river bayou, marl pit, gravel pits, river, river ponds, and drainage ditches. This species apparently has a wide range of tolerance to dissolved minerals, types of bottom

for anchorage and light intensity as mentioned earlier. It has been found growing emergent, submerged in shallow water and then into water up to about 25 feet deep.

It is an early arrival in a new habitat, appearing as soon as a small amount of silt or sediment has accumulated.

This species seems well distributed over North America judging from the specimens I have seen.

Chara delicatula Ag. has been reported only in the glacial lake region of the state in Marshall, Noble and Porter Counties. It was found in a variety of habitats: lake with marl bottom, on muck in the outlet of a lake, and large lakes with sand and muck bottoms. It grew in shallow as well as deep water.

This species does not compete very successfully with other aquatics and seems to occur in a few scattered areas over the North American continent. The fact that the antheridia may mature and be almost all gone by the time the oogonia are well developed may have a limiting effect on the distribution of this species.

Chara excelsa T. F. Allen is another species found infrequently in small quantities in the lake region of the state in Kosciusko and Steuben Counties. It does not compete well with other aquatics in this area.

Three large lakes of 233 to 2,618 acres, one of which had sand and two of which had marl bottoms were the only habitats where this was found. These were relatively deep lakes with a maximum depth of 56 to 68 feet.

It was associated each time of collection with *Chara contraria*.

Very little is known about the distribution of this species, the report from Indiana being the first since the original description. It has been found in Nebraska besides having been found originally in New York.

Chara globularis Thuill. is found very frequently in Indiana. It must have a wide range of tolerance to varying ecological conditions inasmuch as it has been collected from a variety of habitats. This species comes from small artificial ponds in clay areas, the largest natural lake in Indiana, Lake Wawasee, with an area of 2,618 acres and from shallow to deep lakes. It has occurred in strip coal mine ponds, a river, artificial small ponds, small to large lakes in unglaciated as well as glaciated regions, limestone quarry ponds, gravel pit ponds, swampy areas and a bog. A variety of bottoms included sand; gravel; marl; mud; clay; a mixture of shale, sandstone and coal; limestone; peat and silt. On rocky substrates a thin layer of sediment was necessary before charophyte growth began.

This species can be found from shallow to 15 to 20 feet of water; so it is tolerant to various intensities of light up to that limit as well as a variety of other conditions.

It is widespread in distribution over North America.

Chara hydropitys var. *septentrionalis* Nordst. is infrequently collected in the state and is not abundant. It comes from Jackson, Marshall, Morgan, Lake, Porter and Wayne Counties, so far, and is a characteristically shallow water to emergent form. As might be expected, it has

been found in sloughs, temporary ponds and the very shallow water of small lakes on sand, clay, peat, mud and gravel. It comes from glaciated and unglaciated regions showing a wide tolerance to different electrolytes.

Since there is more light penetration in shallow water and since this species may also be emergent, the habitat would be warmer than deeper waters, and may indicate a preference for warm habitats. It flourishes and develops fertile oospores under these conditions. Less competition would be met in the new habitat of a temporary pond or scoured edge of a lake, too.

It has a very light representation in my herbarium from North America, but from the specimens seen, it would seem that this species is reaching a critical zone in its distribution in the glacial lake region in Indiana, this being the northern boundary in this region. It has been found as far west as Kansas, east to New Jersey and south to South America with New York, the most northern occurrence.

Chara keukensis (T. F. Allen) Robinson is very similar in morphology and habit to the preceding species, and also seems tropical to subtropical in affinities. It has a very light representation in the herbarium from North America also. It would seem that this species is on the northern limits of its distribution in this region, too. It comes from locations both in and out of the glaciated area having been found in Jackson, Steuben, Cass, Lake and LaPorte Counties.

Chara Kieneri F. K. Daily is a peculiar species having been described by the author (3) in 1949 from specimens collected by Walter Kiener in Nebraska. It has been found in both glaciated and unglaciated regions of Indiana from Clay, Kosciusko, Lawrence, Newton and Steuben Counties. Habitats include artificial ponds, ponds in strip coal mines and lakes with 112 to 2,618 acres in area with wide variation in average depth. Bottoms ranged from sand, mud, gravel and marl to the shale, sandstone, coal and clay combination found in the strip mine pond. This species is never a very conspicuous part of the vegetation, and is not found in very shallow water.

The distribution records for the rest of North America, are meagre, but so far they come from as far west as Colorado and north into Canada. Indiana being on the southern limit of distribution. It might be interesting to mention that this species was found in the isolation of a mountain lake at 5,000 ft. in altitude in Colorado growing with the rare species, *N. opaca*. (i.e. rare in Indiana)

Chara sejuncta A. Br. has been found predominantly in the southern half of Indiana from Spencer, Brown, Clay, Dubois, Jackson, Jennings, Monroe, Orange, Washington and Sullivan Counties. It also covered large portions of the bottoms of some artificial lakes of Parke County, central Indiana. Glacial lakes in Marshall, Steuben and Porter Counties in northern Indiana had only scattered plants or small colonies. Artificial habitats with muck or mud bottoms seem typical for this species in this region. Underlying layers may be sand, gravel or clay. The type of habitat ranges from the Calumet River; to strip coal mine ponds; artificial lakes created by damming a stream; heavily silted highly

evolved glacial lakes with muck bottom, glacial lake outlets with muck sediment and seepage ponds.

From the specimens I have examined, it seems to occur from Missouri to the eastern part of the United States and from Ontario, Canada into South America, but the bulk of the collections come from the southeastern part of the United States, so the central part of Indiana appears to be approaching the critical zone for this species with northern occurrences in the lake region rare and the stand small.

Chara vulgaris Vaill. ex L. is usually considered a common species, but is less common in this region than *C. contraria* and *C. globularis*. It has been found in St. Joseph, Tippecanoe, Wayne, Carroll, Cass, Henry, LaGrange, Marion, Marshall, Putnam, Starke, Steuben, Kosciusko, Lake and Randolph Counties in glaciated regions chiefly in the northern half of the state.

This species quite often is associated with lakes and other bodies of water fed by springs or artesian wells indicating that mineral nutrition is important in distribution. Habitats include rivers, springs, artificial ponds, lakes, gravel pit ponds, marl pit ponds, and a bog pond fed by an artesian well. Substrates include gravel, mud, marl, clay, peat and sand.

This species is widely distributed over North America.

Chara zeylanica Willd. has four forms found in Indiana.

f. *Michauxii* (A. Br.) H. & J. Gr. has been found as a shallow water form in a variety of habitats widely scattered over the state in Clay, Harrison, Kosciusko, Marshall, Noble, Jefferson, and Whitley Counties. The habitats include lakes, gravel pit ponds, artificial ponds, rivers, limestone quarry and glacial lakes up to about 478 acres in area. The bottoms were predominantly calcareous including gravel, marl, limestone and mud in either glacial or calcareous regions, so the distribution of this form seems influenced by its being a calciphile.

The occurrence of this form as a rather insignificant part of the vegetation indicates that the environment and dispersal in Indiana are not ideal for it.

f. *Humboldtiana* (A. Br.) Zanev. also seems to be a calciphile being found on gravel and mud, gravel and muck. It has been found in two counties, Bartholomew and Kosciusko in the glaciated area of the state. This is also a shallow water form being found at the edge of a small lake (18 acres) and in some shallow artificial ponds.

f. *inconstans* (Kütz.) H. & J. Gr. has been found only once here in Bass Lake, Starke County, in shallow water and sand.

f. *macilentia* (A. Br.) F. K. Daily also comes predominantly from sand bottomed habitats in the glacial lake region with mud, muck and marl deposits. It has been found also in the Calumet River (sand) and a number of small to large lakes (up to 1,650 acres in area) in Kosciusko, Marshall, Steuben, Cass and Lake Counties.

This form is found more frequently than any other of this species in this state, but the species as a whole does not form a prominent part of the aquatic flora here. It is common in the southern part of the

United States especially in Florida. It is possible that the temperature in Indiana is too cool for the best growth of this species.

Nitella acuminata var. *subglomerata* A. Br. comes from two locations in Indiana and appears to be a southern species being found in Jackson and Sullivan Counties. One collection came from a shallow seepage pond with sandy bottom and the other collection came from an artificial lake covering an outcrop of bedrock from the Pennsylvanian system, Petersburg formation, according to Freeman (7). This formation contains limestone, shale and coal. The lake bed is listed as being gravel. Both areas would be poorer in electrolytes than lakes in the glacial lake region. The area of Shakamak Lake is 52 acres, with its five long narrow prongs resulting in much quieter water than if it were a round lake.

This variety of *Nitella acuminata* seems rather widely distributed over the United States apparently requiring quite a lot of light having been found in shallow ponds prevalently and less calcareous regions than the glacial lake region of Indiana. Representative collections from other regions substantiate these findings. Specimens sent by Walter Kiener from Nebraska were found often in rain pools of intermittent nature. From Kentucky, A. T. Hotchkiss (9) sent specimens from a sinkhole pond in a limestone region, Meade Co. and a pond from the Knobs area, Jefferson Co., possibly conforming to the pattern of occurrence.

Nitella flexilis (L.) Ag. var. *flexilis* and *N. flexilis* var. *subcapitata* (A. Br.) Crepin have been found in widely scattered locations over the state. They occur in Steuben, Kosciusko and Marshall Counties from the glaciated lake region, Marion County from the central region, and Brown County in the Knobs area in the southern part of the state. Although the underlying soil ranges from sand, mud, clay and marl with water from medium hard to soft, there is one feature displayed by all habitats which seems significant. They all had a fine textured silt rather heavily deposited on the bottom where this species was found. In a large lake, it was found near an inlet where silt had been deposited. It also seems adapted to living in subdued light. This would be necessary in a silt laden environment because of the suspension of silt in the water at least some of the time. The species will grow in shaded waters, too, and in rather deep locations.

Area and depth of the body of water is not significant in the distribution of this species because the habitat ranges in Indiana from the marshy at the outlet of Lake Maxinkuckee through river ponds, small lakes and finally the largest lake of Indiana, Lake Wawasee, covering 2,618 acres having a maximum depth of 68 feet. I usually consider *Nitella flexilis* as typically a rheophile or river dweller, though in Indiana so far it has been found more often in lakes but near the inlet of glacial lakes or in lakes which are dammed streams. Numerous specimens have been seen from North America, the species apparently being well distributed.

Nitella megacarpa T. F. Allen has been collected in three locations in Indiana all within the glacial lake district, Marshall, Porter and Starke Counties. The type of habitat is consistent in that these were

shallow lakes (4 to 6 foot average depth) poorly drained with muck or muck and sand bottoms. This would suggest fairly soft water. The area varied from one having only a few acres to a lake having 1,405 acres.

This species is not found often in Indiana and usually only a few plants constitute the collection. Very few specimens have been seen from the rest of the U. S., but the distribution seems to be in the southeastern United States.

Nitella opaca Ag. is rare in Indiana being collected only once in a drainage ditch at Elliott's Mills bog, Wayne County, Indiana. M. S. Markle (13) describes the habitat in the following manner, "It was necessary to blast through rock in order to get an outlet for the bog." The bog is in a depression in Niagara limestone. Hasslow (8) mentions the frequency with which this species was found on bedrock in Sweden. A habitat having bedrock with also water from the bog supplying acidity to act upon the bedrock would be scarce in this region, which may explain the rare occurrence of this species, since it seems to be adapted to this type habitat. In addition, it is dioecious and this hinders wide dispersal.

The occurrence of *N. opaca* in the rest of the United States seems scattered and infrequent judging from the specimens seen.

Nitella tenuissima var. *compacta* A. Br. is another species occurring entirely in the glacial lake area of the state in Kosciusko, Marshall and Steuben Counties. Area of the lakes varied from 5 to 2,618 acres. This species was found invariably in shallow water on muck or soft hummocks of peat, often partially buried in the soft organic substrate. The bottom was of various kinds including sand, gravel and marl.

This species seems rather widely distributed over the country.

Tolypella prolifera Leonh. and *Tolypella intricata* Leonh. The genus *Tolypella* had not been reported in the state until the work of the author. It has been found in evolved glacial lakes and ponds near them in the far northeastern area of the state in Kosciusko and Steuben Counties. Their occurrence only in quiet areas of the lakes and in artificial ponds is probably due to the fragileness of this genus. These plants would be easily broken off by wave action. They grow in the semi-hard water lakes and ponds. From the few collections made in other parts of North America which I have examined, it would seem that our lakes area is the southern limit of a genus having a northern distribution in North America.

Summary

Physical, chemical and biological factors influencing the occurrence and distribution of the Characeae of Indiana were discussed.

Analysis shows that the glacial lake area in Indiana is the southern border of distribution in this part of North America for the following species: *Tolypella prolifera*, *Tolypella intricata* and *Chara aspera* v. *Macounii*.

Indiana is at the northern border or is in a critical zone for northern distribution of several southerly and southeastern species:

Nitella megacarpa, *Chara hydropitys* v. *septentrionalis*, *Chara keukensis*, *Chara sejuncta* and *Chara zeylanica*.

Several species are widely distributed over North America and occur often in Indiana, these are: *Chara contraria*, *C. globularis*, *Chara vulgaris*, *Nitella flexilis* and *Chara Braunii*.

Other species known from scattered areas over North America occur in Indiana infrequently: *Nitella acuminata* v. *subglomerata*, *Nitella tenuissima* v. *compacta* and *Chara delicatula*.

One species, *Nitella opaca*, is a rare species for Indiana and seems scattered and infrequent over the rest of the United States.

Three other rare species *Chara Brittonii*, *Chara excelsa* and *Chara Kieneri* are little known being reported from Indiana the first time since the original reports.

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