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Recent Pollen Deposition in Miller's Bay, Lake Okoboji, Iowa

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Abstract: Proportional counts (200/sample) of pollen present in nine samples of surface sediments from a settling basin in Miller's Bay, Lake Okoboji, Iowa, are summarized. In order of decreasing abundance the types of pollen listed are Compositae, *Quercus*, Gramineae, *Pinus*, *Ulmus*, *Picea*, *Carya*, *Tilia*, *Juglans*, *Ostrya*, *Fraxinus*, *Betula*, *Salix*, *Acer negundo*, fern (spores), *Celtis*, *Myriophyllum*, *Sparganium*, *Typha*, *Alnus*, and *Potamogeton*. The period of "pollen rain" for *Tilia americana* was determined to be from June 27 to July 14 (in 1964). Pollen found in algal mats collected during this period contained 15 types of pollen, of which *Tilia* pollen was the most abundant.

INTRODUCTION

A recent study of sediments from the deep basin of West Lake Okoboji, Iowa, by Stoermer (11) has shown them to be of considerable magnitude. Core samples thirty feet in depth taken by that investigator were composed primarily of diatomaceous material and radiocarbon dating showed the thirty-foot level to be less than 4,000 years old. Since the present lake is post-Pleistocene in origin, it is probable that similar materials were deposited during several thousands of years prior to this date and, thus, there may be an additional layer of thirty or more feet of sediments below the base of the deepest core obtained so far.

Although not the subject of this presentation, a preliminary study by the authors of the cores used by Stoermer revealed the presence of considerable amounts of pollen in the sediments. Since one of the more complete pollen records for the post-Pleistocene period in this region may exist in these sediments, it is anticipated that cores extending downward to the original lake basin will be obtained and analyzed.

Certain preliminary studies appear essential to the larger program. Three aspects in particular which concern the production and dissemination of "modern" pollen should be considered:

(1) The compilation of a reference herbarium of pollen from the present flora of the region, with particular reference to the pollen of native and introduced trees.

(2) A record of pollen deposited recently in the surface layers of the lake sediments.

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(3) A comparison of the extent to which the so-called "pollen rain" of certain species correlates with the relative abundance of: (a) individuals of the species in existing vegetation and (b) its percentage occurrence in the recent sediments.

Much caution is advisable in interpretations derived from the last named activity as palynologists have become increasingly aware of the possible errors inherent in quantitative evaluations of pollen data. However, it has long been recognized that interpretations of past vegetation of a region through analysis of pollen in core samples may be strengthened through comparison of recent pollen deposits with existing vegetation. Thus the approach used herein, even though limited in scope, was considered worthwhile.

West Lake Okoboji is located in Dickinson County in northwestern Iowa. Its maximum depth is in excess of 40 meters, and the lake water is thermally stratified during summer and winter seasons. The shoreline has an irregular outline of approximately 29 km. Longest dimensions of the lake are 8.8 km (length) and 4.6 km (breadth). The glacial material of the surrounding terrain is of Late Wisconsin age and much of the cultivated land in the vicinity was originally prairie. The forest fringe along the lake shore has increased in extent in modern times, possibly due to protection from fire. More detailed descriptions of the lake with numerous citations are included in a study by Macbride (7) and in Stoermer's (11) thesis.

Materials and Methods

I. *Preparation of Reference Slides.*

Freshly collected pollen from more than 150 species of plants occurring commonly in Iowa was preserved in vials with glacial acetic acid. Because tree pollen has a special significance in palynology, an effort was made to collect pollen from as many tree species as possible. Collections were begun in early spring, 1964, and continued through the summer. The majority of the spring collections were made for the authors by Mr. Randall W. Shobe; the rest by the authors except for a series collected in August by Miss Phyllis Holst, Dr. Thomas Melchert, and Dr. Karl Holte.

Preparation of fresh pollen to resemble preparations of fossil pollen was accomplished by the acetolysis technique of Erdtman (3) as modified by Wilson and Goodman (13). These preparations were then stained in aqueous safranin, washed in distilled water, centrifuged, washed in Cellosolve, centrifuged again, and stored in Cellosolve until slides were made.

Slides were made by placing a drop of Cellosolve with its suspended pollen on a slide, warming slightly over an alcohol lamp to evaporate most of the liquid, and adding Diaphane as the permanent mounting medium. The materials were gently mixed on the slide with a toothpick before adding a pre-warmed cover slip. The slides were allowed to dry for several days on a warming pan.

II. *Preparation of Sediments for Pollen Analysis*

Since the presence of sand and silt particles, diatom frustules, algal remains, and various fragments of organic matter tend to obscure the presence of pollen in sediments, some process for removing them is necessary. It is fortunate that the walls of most pollen grains resist certain drastic treatments which may be utilized to eliminate most other components of sediments. Directions for the steps in the process used are these:

1. Break up sample into small particles and place in a copper beaker.
2. Completely cover with concentrated hydrofluoric acid and stir with a plastic rod. All procedures with hydrofluoric acid should be done under a fume hood. (Rubber gloves and a face mask should be worn).
3. Heat over a Bunsen burner and allow to boil 3-5 minutes.
4. Remove from burner and cool for several minutes, then fill the beaker with distilled water and let the sediments settle.
5. Decant and discard the supernatant fluid. Concentrate remainder of the sample by centrifugation in copper or plastic tubes; or, refill beaker with distilled water and let the sediments settle.
6. Place centrifuged or settled sample in a 250 ml glass beaker and add 3 times as much Schulze's solution. (Preparation: dissolve 20 grams of potassium chlorate in 200 ml of distilled water, stir, and heat until the crystals are dissolved; then add 400 ml of concentrated nitric acid.) Stir the sample and let stand for 12 hours in the solution.
7. Fill beaker with distilled water, stir, and let sediments settle.
8. Decant and centrifuge as in step 5.
9. Add a volume of 28% ammonium hydroxide twice of the remainder, stir, and let stand 2-3 hours.
10. Add distilled water, stir, and let settle; then, decant and centrifuge.
11. Wash with distilled water, centrifuge, and decant. Repeat until ammonia odor is gone.

12. Add stain and let stand at least 30 minutes.
13. Add distilled water, stir, centrifuge and decant supernatant fluid.
14. Add Cellosolve, stir, centrifuge, and decant.
15. Repeat step 14.
16. Store in labeled vials in Cellosolve, and make slides as with fresh pollen.

III. *Collections of Sediments*

Collections were made during the summer of 1964 and were limited to sediment samples from a part of Lake Okoboji known as Miller's Bay. Physiographic studies by Dr. Richard Bovbjerg and his students have shown that the deepest part of the bay lies close to the south shore near Hiawatha Point (Figure 1). Indications are that the bottom in this area serves as a "settling bowl" in which various sediments accumulate. The rest of the bay has a sloping sandy surface which is kept relatively clean by current actions.

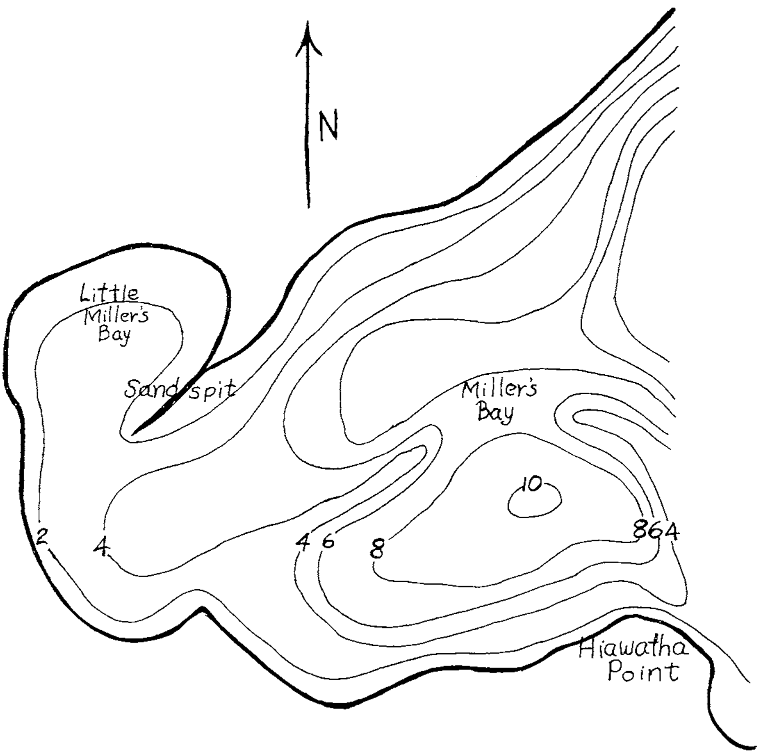

Figure 1. Map of Miller's Bay redrawn by permission from a portion of an unpublished map of Lake West Okoboji, Iowa, prepared by Dr. Richard Bovbjerg and Mr. J. R. Hall in 1962

(Contour interval = 2 meters; 1 cm. = 260 feet)

A crude technique was devised to sample the surface layer of sediments. A three foot length of 2 inch pipe was suspended by yoke in such a way that it could be dragged along the bottom sliding across the surface of the sediments without digging in deeply. This caused the easily disturbed ooze to form a dense cloud above the bottom. A plankton net was tied by a short line to the pulling rope just above the yoke. Thus, when the pipe was dragged across the bottom, the net passed through a continuous cloud of sediments. This apparatus was hauled across approximately one hundred meters of the bottom to obtain each sample. Hauling was done by hand from a boat with the most practical speed being determined by experience. Since "proportional" pollen counts rather than absolute counts were intended, this method of collecting gross samples is considered adequate. Nine samples were collected and analyzed for pollen.

IV. *Collection and Preparation of Pollen from Algal Mats.*

The annual appearance in Little Miller's Bay (Figure 1) of dense mats of green algae has been observed for many years. Commonly, the dominant components of these mats are species of *Rhizoclonium.* Growth begins in early spring close to the bottom and the mats do not become noticeable until they rise to the surface in late spring or early summer. The filaments become densely interwoven and trap bubbles of gas (mostly oxygen) which provide a "lifting" effect. *Rhizoclonium* filaments are not particularly slippery and, since they become firmly intertwined with rooted vegetation, they are not easily displaced laterally by wind action.

In the spring of 1964, however, growth conditions favored the development of species of *Spirogyra* to such an extent that growth of *Rhizoclonium* seemed to be partially inhibited. Dense, billowing "clouds" of *Spirogyra* filaments rose to the surface in late spring and early summer. Due, presumably, to the slippery nature of the filament surfaces, these "clouds" were not bound tightly to the rooted vegetation. They were easily displaced laterally by wind action and began floating about in the lake by early summer. Often they were washed ashore on windward beaches where their nuisance value was extreme.

Because of the probability that some pollen was trapped in the algal mats, it was decided to investigate whether or not useful information could be obtained from a preliminary investigation of this matter. On July 8, just after the peak period for release of *Tilia* pollen, portions of several *Spirogyra* mats were collected in Little Miller's Bay, within fifty meters of a shore where two large basswood trees were prominent in the forest fringe. The algae were drained of free water and allowed to air dry in a protected container for several days. In the "damp dry" condition the amount collected approximately filled a 500 ml beaker.

Maceration with HF, followed by treatment with Schulze's solution, ammonium hydroxide and acetolysis was accomplished following procedures noted above for sediments. The full treatment was deemed necessary to bring these pollen grains to the same level of chemical treatment as those in the sediments.

V. *Proportional Pollen Counts*

While recognizing that techniques for absolute pollen counts per unit of sediment may ultimately become standardized, the authors were of the opinion that the long established method of proportional counts would serve the exploratory purposes of this investigation.

Slide transects were made in sequence until a total of 200 identifiable pollen grains or fern spores were counted. Moss spores, fungus spores, algal cells, and unclassifiable single-celled objects, primarily eroded or collapsed pollen grains, were not counted. Generic identifications were made for tree pollen and several herbaceous plants. The pollen of grasses and composites were counted as members of the Gramineae and Compositae, respectively.

Problems with identification of pollen of fossil species or species not presently occurring in the surrounding vegetation did not arise, as the investigation dealt strictly with recent pollen of local origin.

VI. *Measurement of the Pollen "Rain" of Tilia*

Since *Tilia americana* L. was the only major tree species in which maturation of flowers and pollen release occurred during the summer session at Iowa Lakeside Laboratory, when the research was undertaken, plans were made to make a record of the time during which pollen of this tree was dispersed.

Slides smeared with vaseline were used to trap pollen from the air. They were suspended vertically at two locations, referred to below as (1) Hiawatha Point, and (2) Sandspit (Figure 1).

The site at Hiawatha Point was directly under a large basswood tree where it was assumed a maximum count would be obtained.

The "Sandspit" is a narrow ridge extending part way across Miller's Bay and serves to demarcate the area known as Little Miller's Bay. It has a sparse vegetation which includes several small willows. The closest basswood tree is at a distance of 180 meters across open water. Slides were suspended from willow branches at a height of four feet.

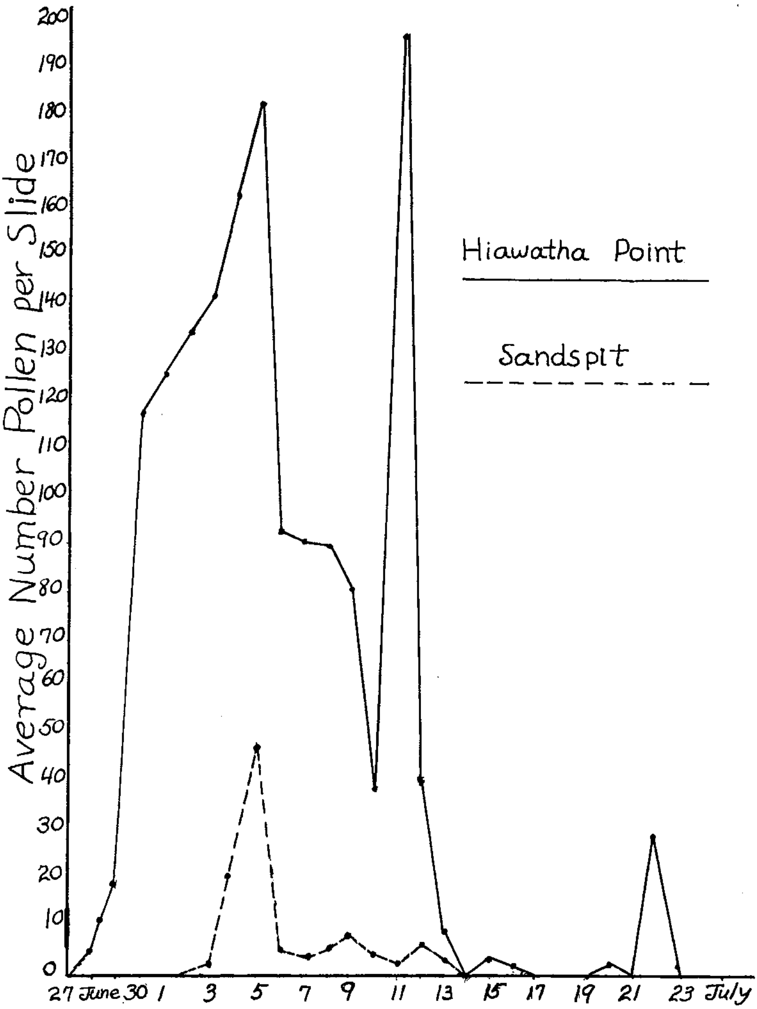

Figure 2. Period of "pollen rain" of *Tilia americana* in 1964
(Pollen grains encountered in ten transects per slide were counted and results from duplicate slides were averaged)

Slides were collected daily during the period from June 27, when the first release of *Tilia* pollen was observed, to July 14, when it was apparent that the flowering period was over. Collections were continued for an additional ten days, however, to determine if *Tilia* pollen remained common in the atmosphere.

Since the aim was to determine the rise, peak, and fall of the rate of dispersal of *Tilia* pollen, only *Tilia* pollen was counted. The slides were covered with 24 x 50 mm cover slips and counting was done at 100x. Ten traverses were made across each slide and the total count was recorded. Duplicate slides for each location were counted on each day, and the average of each pair of numbers is used (Figure 2) as an index of abundance for that date and location.

Results and Discussion

A. *Pollen in Recent Sediments*

Proportional counts of pollen present in nine samples of sediments from the "setting bowl" area of Miller's Bay, Lake Okoboji, are presented in Table 1. No attempt is made here to relate these figures to the actual abundance of individual species of plants found in the region. (To do this properly would be a massive task beyond the support capabilities of the present project.) However, certain general observations appear admissible.

The bur oak, *Quercus macrocarpa* Michx., is the most abundant species, and is recognized as being the dominant climax tree species in this area. Furthermore, selective cutting by resort owners has favored retention of this species and removal of others, to the extent that many local resorts exist in park-like stands of bur oak. Observations by the authors over a period of several years support the suggestion that oaks in this region produce large quantities of wind dispersed pollen each year. Davis and Goodlett (1) noted heavy production of pollen by some species of oak and, also, commented on the overrepresentation of oak pollen in the sediments of the Brownington (Vermone) pond. King and Kapp (5) also noted over-representation of oak pollen in samples from Northern Michigan. On these bases, the fact that oak pollen is more abundant than the pollen of other tree species in the sediments studied is not surprising. On the other hand, Erdtment (2) found oak pollen to be decidedly under-represented in southern Sweden while Potter and Rowley (8) found a similar under-representation of oak pollen in New Mexico.

Elms are abundant locally, and this is reflected by the relatively high percentage of their pollen in the sediments. Poplars and cottonwoods are common trees in the area but *Populus* pollen could not be identified with certainty in the sediments. Erdtman (2) has commented on the apparent absence in sediments of *Populus* pollen in an area where species in this genus are dominant members of the forest community. Sangster and Dale (9) reported on direct observations of the fate of *Populus* pollen in several habitats and described the rapid degradation of the grains which makes identification difficult or impossible. They also noted that *Populus* pollen was severely degraded by standard preparation techniques.

Table 1. Proportional Counts of Pollen in Recent Sediments from Miller's Bay, Lake Okoboji, Iowa

(Based on nine samples with 200 units counted per sample)

Genus or Family	Range of Occurrence in Nine Samples	Number of Samples with Zero Occurrence	Average Percent Occurrence
Compositae	60-97 in 200	.	38.9%
Quercus	30-57 in 200	..	21.1%
Chenopodium	14-23 in 200	..	9.1%
Gramineae	11-21 in 200	..	8.0%
Pinus	7-16 in 200	..	5.3%
Ulmus	4-12 in 200	.	4.9%
Picea	2-6 in 200	..	1.7%
Carya	2-4 in 200	..	1.3%
Tilia	0-5 in 200	1	1.3%
Juglans	0-4 in 200	1	1.0%
Ostrya	0-4 in 200	1	0.9%
Fraxinus	0-3 in 200	2	0.9%
Betula	0-4 in 200	2	0.8%
Salix	0-3 in 200	1	0.7%
Acer (A. negundo)	0-3 in 200	3	0.5%
Fern (spores)	0-3 in 200	3	0.4%
Celtis	0-2 in 200	4	0.3%
Myriophyllum	0-2 in 200	5	0.3%
Sparganium	0-2 in 200	4	0.3%
Typha	0-1 in 200	3	0.3%
Alnus	0-1 in 200	5	0.2%
Potamogeton	0-1 in 200	6	0.2%

Considering the abundance of willows along parts of the shoreline of Miller's Bay, the percentage of *Salix* pollen seems low. Also, the dense stands of box elder, *Acer negundo* L., which have taken over many neglected areas in the region, do not appear well represented by pollen in recent sediments.

The gymnosperms in the region are, for the most part, introduced species used as ornamentals and windbreaks. The most abundant of these are two pines, *Pinus nigra austriaca* (Hoess) A. & G. (the Austrian Pine) and *P. sylvestris* L. (the Scotch Pine) and two spruces, *Picea abies* (L.) Karst. (the Norway Spruce) and *P. pungens* Engelm. (the Colorado Blue Spruce). (Several other gymnosperms are widely planted in Iowa but these four appeared to be most common in the farmsteads of this area.)

It is generally considered difficult, if not impossible, to distinguish the pollen of species within these genera, and no attempt to do so was made.

It is worthy of note that gymnosperm pollen, particularly that of spruce, was collected repeatedly on the vaseline slides exposed to the atmosphere on the Sandspit and Hiawatha Point sites. These collections were made in July, several weeks after pollen release from the pines and spruces was completed. The tendency for certain gymnosperm pollens to remain airborne (or to be picked up from lodging places during windstorms) may account in some part for their overrepresentation in sediments. (See Vinje and Vinje (12), Davis and Goodlett (1), and Faegri and Iverson (4) for discussions of this general topic.)

The relatively high proportion of grass pollen is related to the fact that both cultivated and natural grasslands are common in the area. Composites are abundant in prairie areas, along roadsides and in neglected areas. Various species of *Chenopodium* are common weeds noted for an abundant production of pollen. *Sparganium* and *Typha* species occur locally in marshy areas and the submerged aquatics, *Potamogeton* spp. and *Myriopyhllum* spp. are common in some shallow areas of the lake. By including counts of several non-arboreal pollens the authors are following the lead of such workers as Lane (6) and Sears (10). It should be noted, also, that careful scrutiny of the slides used in this study revealed the presence of occasional pollen grains of other species, both arboreal and non-arboreal, than those listed. It was felt, however, that the sample size required to insure their inclusion in the counts would have been impracticably large for an exploratory study. Sears (10) has discussed the relative merits of high vs. low counts and questions the practicality of high counts except in cases where "masking effects. . . . at the site of sampling" are encountered.

B. *Pollen in Algal Mats*

Table 2 gives the actual counts of various types of pollen found to occur in the algal mats. These were collected on July 8, just a few days after the peak period for dispersal of *Tilia* pollen. The high percentage of *Tilia* pollen in the algal mats, in relation to that of *Quercus* and *Ulmus,* is taken to mean that pollen of the latter two was disseminated before the mats had developed extensively, and does not measure the true proportionality of pollen production by these trees.

Table 2. Pollen Recovered from an Algal Mat
(Total count of 200 grains from two slides)

Genus or family	Number counted	Genus or family	Number counted
Tilia	113	*Fraxinus*	2
Pinus	19	*Ostrya*	2
Gramineae	17	*Ulmus*	2
Quercus	16	*Carya*	1
Compositae	13	*Juglans*	1
Picea	7	*Potamogeton*	1
Chenopodium	3	*Typha*	1
Betula	2		

It is an intriguing speculation that pollen transported in those floating algal mats which disperse or sink in deeper areas of the lake, would be disproportionately represented in counts of pollen in the sediments. Those species which release pollen when the mats are fully formed would be favored over those which release pollen before the mats develop. This suggests further, that investigation of the pollen trapped in algal mats throughout an entire growing season may yield useful information as to the extent to which pollen is added to a lake each year.

C. *The "Pollen Rain" of Tilia*

Figure 2 is a graphic representation of the dispersal period for *Tilia* pollen in 1964. The first *Tilia* pollen collected on the vaseline-smeared slides appeared on June 28 at the Hiawatha lodge site (directly beneath a large bassewood tree). A continuing check begun several days previously revealed the first dehiscence of anthers occurred on June 27.

The fact that no *Tilia* pollen was collected at the sandspit site until July 3 is probably related to the fact that the period from June 28 to July 2 was a period of cold, damp weather, with several heavy rain showers—conditions generally unfavorable to a widespread dispersal of pollen.

The maximum count of *Tilia* pollen on the sandspit site occurred on July 5, and, since a similar but much larger peak was recorded on that date at the Hiawatha Lodge site, this date is used for the "real" peak of pollen dispersal for Tilia in this year. The period, June 27 to July 14, is considered to be the period of normal dispersal. The July 11 peak and the smaller peak on July 22 at the Hiawatha Lodge station represent times when pollen accumulated on leaves was secondarily dispersed by wind action, or washed off during violent rain storms on those dates.

Literature Cited

1. Davis, Margaret B. and Goodlett, J. C. 1960. Ecology 41:346-357.
2. Erdtman, G. 1943. An Introduction to Pollen Analysis. Chronica Botanica Co., Waltham, Mass.
3. ————. 1960. Svensk Botanisk Tidskrift 54:561-564.
4. Faegri, K. and Iversen, J. 1964. Textbook of Pollen Analysis. Hafner Publishing Co., New York.
5. King, James E. and Kapp, Ronald O. 1963. Can. Jour. Bot. 41:243-252.
6. Lane, George H. 1931. Ohio Jour. of Sci. 31:165-171.
7. Macbride, T. H. 1900. Iowa Geol. Surv. Rept., 1899. 10:185-239.
8. Potter, L. D. and Rowley, J. 1960. Botan. Gaz. 122:1-25.
9. Sangster, A. G. and Dale, H. M. 1964. Can. Jour. Bot. 39:35-43.
10. Sears, Paul B. 1963. Grana Palynologica 4:3, 424-427.
11. Stoermer, Eugene F. 1963. Unpublished Ph.D. Thesis. Library, Iowa State University of Science and Technology, Ames, Iowa.
12. Vinje, James M. and Vinje, Mary M. 1955. Amer. Midl. Nat. 54:418-432.
13. Wilson, L. R. and Goodman, G. J. 1963. Okla. Geol. Notes 23:167-171.