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A pollen study of thirty-two species of grasses

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The *Butler University Botanical Studies* journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana's vegetation in past decades. Authors were Butler faculty, current and former master's degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler's first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal's publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor's degrees and 75 master's degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner , included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master's students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

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A STUDY OF POLLEN GRAINS OF THIRTY-TWO SPECIES OF GRASSES*

By FLORENCE GEISLER

Science Department of Indianapolis Public Schools

The study of fossil pollens from bogs and lake sediments shows that sometimes the percentage of grasses runs quite high. The presence of large amounts of grass pollens has usually been interpreted, often without justification, as proof of prairie invasion. It is certainly necessary to determine the genera of grasses which contributed the pollen before such a conclusion can be made. Keller (5) attempted this in his work on three Indiana bogs. Careful examination and measurements of the grass pollens found and comparison with size frequency of pollens from modern grasses forced him to the conclusion that the predominating pollen present in the bogs was that of *Calamagrostis canadensis* and not of prairie species. For that reason it has no diagnostic value as an indicator of a xerothermic period in northern Indiana.

In the present study an attempt is made to find some means of differentiating between various genera of grasses which are representative of ecological factors, with special emphasis on diagnostic differences between groups of typical prairie and typical aquatic grasses.

GENERAL CHARACTERISTICS OF GRASS POLLENS

Wodehouse (8) states that the pollen grains of the Gramineae are remarkably uniform throughout. The shape may be spheroidal, ovoidal, or ellipsoidal. The size range is from 32 microns to a little over 100 microns.

Erdtman (3), in summarizing the work of Firbas, divides grass pollens into two groups according to size, viz. the *wild grass type*, which ranges in size from 25 to 35 microns (the exception being 35 or 40 microns) and the *cultivated type*, whose pollens measure from 35 to 50 microns, with the modal peak at 40 microns. According to Wodehouse, the tribe Hordeae, which includes the most important

* A contribution in recognition of the 25th Anniversary of the Botany Department of Butler University.

cereal grasses such as wheat, barley, and rye, has large pollen grains. Included in this tribe are also Lolium, Agropyron, and Elymus. The grains of all these, except of Lolium, range in size from 33 to 47 microns, while those of the latter are only 28 to 33 microns. *Zea mays,* with its pollen grains of 90 to 100 microns, has the largest pollen grains of the grasses, but since it is restricted to cultivation in North America, it plays no part in pollen analyses of bog sediments.

The exine of grass pollens is thin and without distinguishing markings, but always slightly rough. Wodehouse likens it to "the stippled surface of an ordinary stucco wall." This feature is best observed in empty grains. The intine is thin and hyaline, the interior is packed with starch grains, and has a small hyaline body diametrically opposite the pore.

The most characteristic feature of the grass pollens is the single germ pore. This consists of a thickened rim of the exine and a small aperture covered by a delicate transparent membrane in the middle of which is a conspicuous thickening, called the operculum. In the case of ovoidal pollen grains the germ pore tends to be located in the larger end. The pore is circular in shape, or nearly so, although the margin may be irregular. The rim stains quite deeply. The elastic membrane covering the aperture varies from 2.3 to 9.1 microns according to Wodehouse (8). The larger grains usually have the larger aperture. The operculum at the center stains quite deeply. Sears (7) says, "the distinct central operculum may be absent in fossil material."

The round, smooth pollen grains of the grasses are adapted for pollination by wind. Insect pollinated grains are usually sticky, and are characterized by spines and furrows which enable them to cling better to the bodies of the insects. Pollen grains of the same and closely related species tend to be alike, provided the environmental features are uniform. For instance, the exine of willow, which is chiefly insect pollinated, is thick and furrowed, while that of poplar, which is wind pollinated, is thin and lacking in furrows. The size is consistent with wind pollination. According to Wodehouse (8) neither very large nor very small pollen grains are ever wind pollinated. The grass pollens fall into the intermediate class. The largest pollen grains, like the pumpkin, with grains about 200 microns in diameter, and the four-o'clock, with grains 180 microns in diameter, are so large they cannot float easily; and are insect pollinated. Small size seems to be a hindrance for pollen grains in leaving their anthers

or in separating from each other. Small floaters, like fungus spores, have a mechanism for throwing the spores clear of the plant and each other. Most plants lack this mechanism.

METHODS

The grasses included were selected from the following habitat groups:

I. AQUATIC. *Leersia oryzoides, Phragmites communis, Calamagrostis canadensis, Poa palustris, Glyceria septentrionalis, Zizania aquatica.*

II. WET LOWLAND. *Muhlenbergia racemosa, Phalaris arundinacea, Cinna latifolia, Spartina pectinata, Glyceria canadensis, Elymus villosus, Bromus kalmii, Elymus virginicus.*

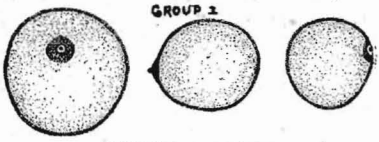
III. MESOPHYTIC. *Triodia flava, Poa autumnalis, Festuca elatior, Dactylis glomerata, Poa sylvestris, Bromus purgans.*

IV. PRAIRIE. *Koeleria cristata, Sporobolus asper, Sporobolus heterolepis, Buchloe dactyloides, Bouteloua curtipendula, Andropogon scoparius, A. furcatus, Stipa spartea.*

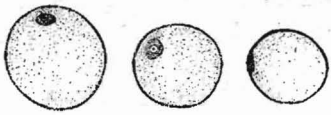
Samples of pollen grains studied were collected from labeled specimens in the herbarium, and by means of forceps and a needle were placed on a clean slide. The grains were obtained from two or more plants collected at different localities. The grains were covered with a drop of warm gelatin colored with gentian violet, and the cover glass was affixed. Care was taken to clean the needle and forceps each time to prevent mixing of the species. The slides were allowed to stand until the shrunken grains had resumed the normal shape, and the dye had penetrated.

Measurements of 50 or more pollen grains were taken of each species studied. It was at times impossible to obtain enough pollen grains from the dried material to make counts of 100; in such cases results are based on a count of 50. Measurements were also made of the aperture wherever the pore was visible. Measurements were made under the high power of a binocular microscope with a magnification of 645X. Ellipsoidal or ovoidal grains were measured across the larger diameter.

Drawings of the 32 species are shown in figure 1. In the drawings the smallest, the largest, and the intermediate sizes are shown.

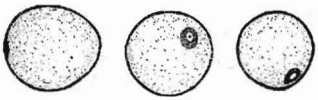


ZIZANIA AQUATICA



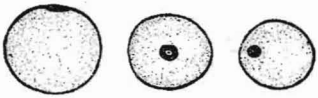
ELYMUS VILLOSUS

GLYCERIA SEPTENTRIONALIS

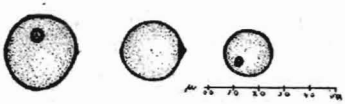


SPARTINA PECTINATA

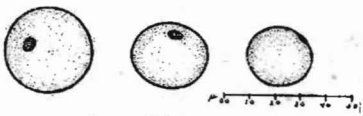
POA PALUSTRIS



GLYCERIA CANADENSIS



LEERSIA ORYZOIDES.

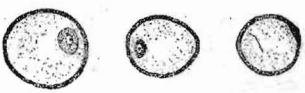


CINNA LATIFOLIA

CALAMAGROSTIS CANADENSIS

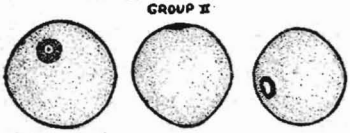
PHALARIS ARUNDINACEA

PHRAGMITES COMMUNIS



MUHLENBERGIA RACEMOSA

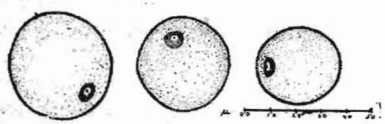
GROUP II



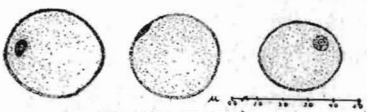
ELYMUS VIRGINICUS

GROUP III

BROMUS PURGANS

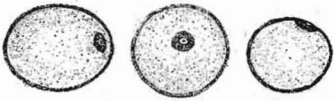


BROMUS KALMII

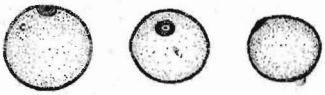


POA SYLVESTRIS

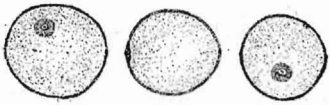
FESTUCA ELATIOR



STIPA SPARTEA

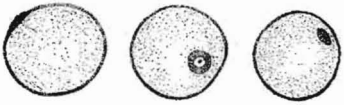


DACTYLIS GLOMERATA

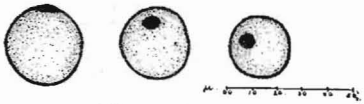


ANDROPOGON FURCATUS

POA AUTUMNALIS



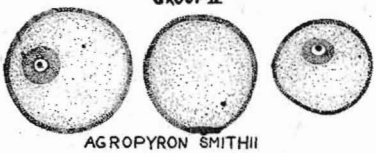
ANDROPOGON SCOPARIUS



TRIODIA FLAVA

GROUP IV

BOUTELOUA CURTIPENDULA

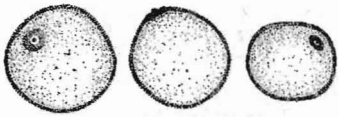


AGROPYRON SMITHII

BUCHLOE DACTYLOIDES

ELYMUS CANADENSIS

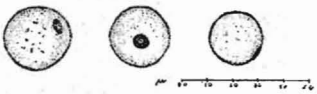
SPOROBOLUS HETEROLEPIS



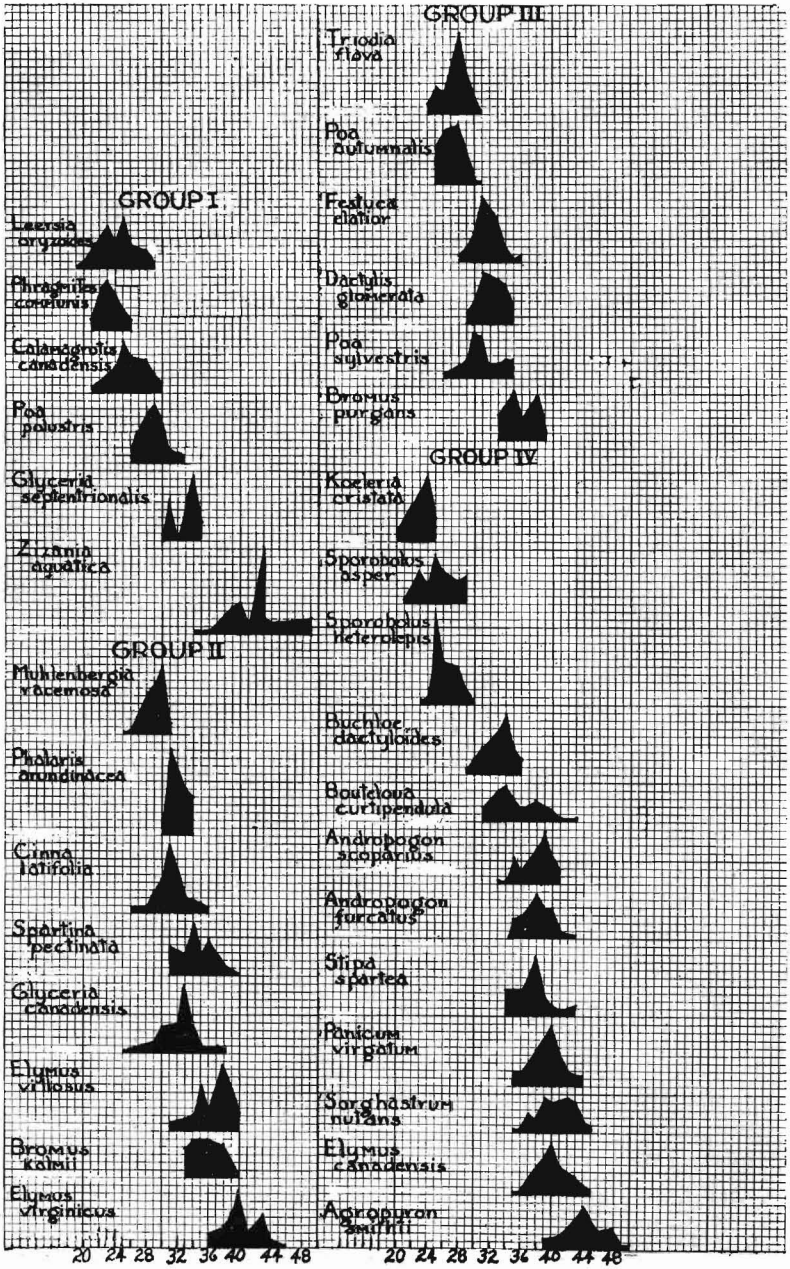
SORGHASTRUM NUTANS

SPOROBOLUS ASPER

PANICUM VIRGATUM



KOELERIA CRISTATA


GROUP I.
Leersia oryzoides
Phragmites communis
Calamagrostis canadensis
Poa palustris
Glyceria septentrionalis
Zizania aquatica
GROUP II
Muhlenbergia racemosa
Phalaris arundinacea
Cinna latifolia
Spartina pectinata
Glyceria canadensis
Elymus villosus
Bromus kalmii
Elymus virginicus
GROUP III
Tridia flava
Poa autumnalis
Festuca elatior
Dactylis glomerata
Poa sylvestris
Bromus purgans
GROUP IV
Koeleria cristata
Sporobolus asper
Sporobolus heterolepis
Buchloe dactyloides
Boutelova curtipendula
Andropogon scoparius
Andropogon furcatus
Stipa spartea
Panicum virgatum
Sorghastrum nutans
Elymus canadensis
Agropyron smithii
20 24 28 32 36 40 44 48
20 24 28 32 36 40 44 48

RESULTS

In the aquatic species (group I) the size range was 19-50 microns. If *Zizania aquatica* were excluded, the range would be 19-35 microns. This species has a pollen size range of 38-50 microns. The walls of the grains appeared thinner than those of prairie grasses of similar size.

The smallest pollen grains studied fell into group I, but there was considerable overlapping with group II. The modal peak was 25 microns (12%). In the 8 species of the wet lowland (group II), pollen grains ranged in size from 25-46 microns, with modal peak (15%) at 31 microns. The mesophytic group (gronp III) consisted of six species whose size range was 24-39 microns, with the modal peak (14.6%) at 31 microns. The 12 prairie species of group IV ranged in size from 21-50 microns, with modal peak at 30 microns (11%).

DISCUSSION

It has already been stated that the identification of the grass pollens is a very difficult problem, even if only separation of genera is involved. Lewis and Cocke (6) state, "Only a pollen expert would dare even to guess at the specific or even the generic names of all the grass pollen found."

Cain (1) in his study of 12 species of Pinus found that no readily diagnostic morphological characters could be discovered on basis of which to separate them, and so he sought a differentiation on the basis of size-frequency. In this study Cain found that certain of the species appear to be distinguishable by means of the range, shape, and mode of their size-frequency curve. Then he made a set of size-frequency curves for the three pine species of fossil pollen he was trying to identify. By matching these curves of the three fossil unknowns with the known modern pollen he thinks that he was able to identify two of the unknown, and to narrow his choice down between two species for the third unknown.

Size variation is no doubt a very satisfactory basis on which to classify biological forms, provided there is not too much overlapping of the sizes compared. This would fog, or perhaps even frustrate, a satisfactory differentiation between two species, or groups of species. Such a method also becomes more difficult to apply with increasing number of species involved. Study of grasses entering into a pollen analysis of bog sediments must necessarily include a large number of

species in order to cover the source of pollens from which contributions were made to a lake or bog. Since grasses represent almost the whole range of ecological situations, from extreme hydrophytism to extreme xerophytism, it seemed essential that four common habitat types be represented in the analysis by four groups of the most common and the most abundant species found in such habitats, as described previously. No attempt was made to determine the possible variation in size of pollen grains of the same species in different geographical locations. Cain (2) has shown that a variation exists in size of pollen grains of the same species of pine in different parts of the United States, and so there may very likely be the same condition prevailing in pollens of grasses. However, this would not likely eliminate the prime consideration in this problem, i. e. the similarity of pollen from Zizania and those of the dominant prairie grasses.

Separation on basis of pollen size of aquatic and wet lowland grass groups from the prairie grass group would be possible to a fair degree because of larger size of pollens of the prairie group if it were not for the intrusion of *Zizania aquatica* into the size group. Shape of its pollen and shape and characteristic of the pore are so closely the same as those of the Andropogons and Sorghastrum that this one species practically nullifies all attempts at a separation of aquatic and prairie groups.

The problem is also intensified by the habit of Zizania to grow in such profusion when shallowing water offers suitable habitat that it could contribute the major part of grass pollen at a given foot-level of a bog. Results of the present study gave no clue to a solution of the problem. However, the results indicate that if the peaks fall into the lower range of grass pollens, i. e. 19-39 microns, prairie conditions can hardly be associated.

SUMMARY

1. The pollen grains of 32 species of grasses were studied.

2. The grasses considered were divided into four groups, representing aquatic, wet lowland, mesophytic and prairie habitats.

3. Drawings were made of each species studied, and a size frequency curve was constructed.

4. Most of the species seem to have a single distinct high peak in the size-frequency, which, unfortunately, was identical for different species.

5. The modal peak for group I was 25 microns. The size range was 19-50 microns.

6. *Zizania aquatica* was the only member of group I with pollen size greater than 35 microns, and so overlaps with the prairie group. It seems to have a thinner cell wall than pollens of the same size from prairie species.

7. The modal peak for both groups II and III centered at 31 microns. Size range for group II was 25-46 microns and for group III it was 24-39 microns.

8. Size range for group IV was 21-50 microns, with a modal peak at 39 microns.

9. As a whole, the pollens of prairie grasses are markedly larger than those of other ecological groups, but since *Zizania aquatica* has pollen similar to that of the Andropogans and Sorghastrum it is practically impossible to separate prairie from aquatic grasses on basis of pollen size difference.

ACKNOWLEDGMENTS

Thanks is expressed to Dr. J. E. Potzger for suggesting the problem, for his helpful suggestions, and for critical reading of the manuscript. The writer is also grateful to Dr. Ray C. Friesner for loan of equipment from the Butler Botany Department to carry out this study.

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