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SPECIAL PAPER

SYSTEMATICS OF THE ZYGNEMATACEAE (CHLOROPHYCEAE). III. TRANSEAU COLLECTION OF THE ZYGNEMATACEAE: AN OLD COLLECTION WITH MODERN USES[1]

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ABSTRACT

Edgar Nelson Transeau, botanist-ecologist-phycologist, accumulated a worldwide collection of algal specimens for the compilation of a monograph on the algal family Zygnemataceae, published in 1951. Following his death on January 26, 1960 this Collection remained at The Ohio State University, Columbus until 1978 when it was transferred to the University of Arizona, Tucson. A set of glycerine-preserved specimens on microscope slides is the major item of the Collection with the number of species represented as follows: *Spirogyra* (138), *Mougeotia* (52), *Zygnema* (45), *Zygnemopsis* (16), *Sirogonium* (9), *Debarya* (9), *Zygogonium* (4), *Mougeotiopsis* (1) and *Entransia* (1). All specimens of *Pleurodiscus, Sirocladium, Temnogametum* and *Temnogyra* are unidentified. With the Transeau Collection it was demonstrated that an old collection need not be an historical relic, but does have continued usefulness. Potential future use is a powerful justification for maintaining seemingly useless collections whose accumulation often represents the expenditure of untold time, effort and money on the part of many persons and institutions worldwide. Further, as man continues to alter his environment and species are destroyed, collections with long histories become increasingly more valuable. Specimens of the Transeau Collection were subjected to modern techniques, not available earlier, resulting in improved characterization of zygospore-wall structure by scanning electron microscopy and the determination of nuclear DNA by cytofluorometry.

THE DEATH of Dr. Edgar Nelson Transeau on January 26, 1960 left the phycological world with a collection of algal specimens and several kinds of written and illustrative material. These have never been described in a professional obituary. For the purpose of the present paper the sum of Transeau's materials will be referred to hereafter as the Transeau Collection or as the Collection. Over 1,450 microscope slides of algal specimens remain from his use during the compilation of a monograph titled *The Zygnemataceae,* published in 1951. In addition, the Transeau Collection contains eight notebooks with illustrations and data as well as the original plates used to illustrate the monograph. The quality of these plates exceeds those in the monograph and their greater size permits detailed study of zygospore wall ornamentation and other delicate features.

The publication of *The Zygnemataceae* represents the third and final phase of Transeau's productive career. Transeau was a botanist-ecologist-phycologist (Fig. 1, Table 1) with a primary interest in vascular plant ecology while at the same time he was an enthusiastic teacher of general botany. Of his 59 publications, 36 were on nonalgal subjects while only 12 of his 23 publications on algae dealt exclusively with the Zygnemataceae. His publications on the Zygnemataceae are listed following the literature cited section of the present paper.

According to Clarence E. Taft (pers. commun.) Transeau's studies on the Zygnemataceae began while he was on the faculty at Eastern Illinois Teachers College, and his initial contacts were with Frank Shipley Collins. Numerous specimens were secured by Transeau during his visits to phycological laboratories and herbaria in Europe during the mid-1920's.

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Fig. 1–3. E. N. Transeau and the Transeau Collection. **1.** (left). E. N. Transeau at The Ohio State University in 1932. **2.** (upper right). Slide cabinets with trays housing the Transeau Collection and eight volumes of notes used to compile *The Zygnemataceae* atop slide cabinets. **3.** (lower right). Four slides from the Transeau Collection with specimens of *Mougeotia decussata, Spirogyra denticulata, Zygogonium australe* and *Zygnema pectinatum* collected by J. D. Smith in 1878, John Blum in 1943, E. Stephens in 1921 and Frank S. Collins in 1904, respectively.

These contacts with phycologists throughout the world kept a continuous supply of specimens coming to his Collection. Specimens sent to Transeau from abroad and from fellow workers in the United States, along with those collected by him during forays into the field, nurtured the taxonomic studies that culminated in his monograph on the Zygnemataceae.

The Transeau Collection remained in the Department of Botany at The Ohio State University, Columbus following Transeau's death with maintenance and supervision provided by Dr. Clarence E. Taft. In May 1978 the Collection was transferred to the Department of Ecology and Evolutionary Biology at the University of Arizona, Tucson where the author has organized the Collection for use by himself and other interested investigators who can visit the University of Arizona. The present report, in addition to the historical account of Transeau's interest in the Zygnemataceae, is written to acquaint investigators with the scope of the Transeau Collection and to describe certain of its potential uses for future research.

MATERIALS IN THE COLLECTION—Glycerine-preserved specimens are the major item of the Transeau Collection (Fig. 2) with 265 species of nine genera identified as follows: *Spirogyra* (138 spp.), *Mougeotia* (52 spp.), *Zygnema* (45 spp.), *Zygnemopsis* (16 spp.), *Sirogonium* (9 spp.), *Debarya* (9 spp.), *Zygogonium* (4 spp.),

TABLE 1. *Brief biography of Edgar Nelson Transeau*

Born:	Williamsport, Pa., October 21, 1875
Died:	Columbus, O. January 26, 1960
1897	A.B., Franklin and Marshall College
1904	Ph.D., University of Michigan
1904–1906	Prof. of Biology, Alma College
1907–1915	Prof. of Botany, Eastern Illinois Teachers College
1915–1946	Prof. of Botany, Ohio State University
1924	President, Ecological Society of America
1940	President, Botanical Society of America
1950–1951	President, Phycological Society of America

Mougeotiopsis (1 sp.), and *Entransia* (1 sp.). All specimens of *Pleurodiscus, Sirocladium, Temnogametum,* and *Temnogyra* are unidentified, and the collection contains no specimens of *Hallasia.* Also 155 specimens belonging to 11 genera remain unidentified to the species level. These numbers compare with the total of 533 species belonging to the 13 genera described in *The Zygnemataceae.*

A species list with collection location to country or state within the United States is presented in Table 2. Twenty-four countries and 31 states in the United States are represented. The oldest specimen in the Collection is *Spirogyra neglecta* (Hassall) Kützing collected in Italy in 1852 by an unidentified collector. All data known for specimens are recorded on the slide labels with four examples illustrated in Fig. 3. These data are often incomplete with the collection location, collector or collection date missing. Yet these three kinds of data are known for at least one specimen for each of 265 species. With periodic addition of glycerine the Collection will last indefinitely.

USES FOR THE COLLECTION—Already the Collection has been used by the author in two major ways: 1) for the verification of identifications, and 2) as a source of research material for revision of the systematics of the Zygnemataceae. Figures 4 and 5 show two zygospores of living and preserved specimens that were used to assist in an identification, in this case for *Spirogyra jatobae* Transeau. The preserved specimen of this species in the Collection was collected originally by Francis Drouet (formerly of The Academy of Natural Sciences, Philadelphia, PA U.S.A.) in Jatoba, Brazil on October 3, 1933; the living specimen was sent to the author from near Seville, Spain where it was collected on July 4, 1978 by Vernon Proctor of Texas Tech University, Lubbock.

Identification of zygnematacean species is not possible unless zygospores are present. Even then an interpretation of ornamentation (or

TABLE 2. *Species list for the Transeau Collection. Glycerine-preserved specimens on microscope slides are present for 265 species from 31 states in the United States and 24 other countries. All binomials are listed exactly as they appear on slide labels*

Species	Collection location[a]
Spirogyra	
adnata	41
affinis	2
angolensis	—
aphanosculpta	—
aplanosporum	—
areolata	24
arta	—
articulata	—
bellis	6, 16, 18, 35, 40, 43, 52
biformis	—
borgeana	—
braziliensis	—
brunnea	32
calospora	5, 16
capensis	32
catenaeformis	16, 19, 55
catenparvula	—
chuniae	—
circumlineata	—
cleveana	—
collinsii	6, 16, 19
communis	16, 53
condensata	—
corrugata	1, 35
crassa	10, 16, 18, 36, 44, 53
crassiuscula	52
daedalia	42
daedaleoides	8
decimina	9, 16, 18, 19, 35, 43
denticulata	—
diluta	13, 16, 41
discoidea	52
dubia	20, 36, 44
ellipsospora	16, 18, 19, 25
emilianensis	16
farlowii	16, 17
fennica	37, 52
fluviatilis	7, 16
foveolata	18
goetzei	16
gracilis	16
gratiana	18
grevilleana	16, 53
groenlandica	16
hassallii	—
hatellensis	49
heeriana	—
hoena	12
hyalina	6, 20, 49
hymerae	9
inconstans	8, 16, 53
inflata	16, 34, 46, 49, 53
insignis	16, 40, 53
intorta	—
jatobae	35
juergensii	16, 45
jugalis	18
kaffarita	52
lagerheimii	—
lambertiana	14, 16

TABLE 2. *Continued*

Species	Collection location[a]
lamellosa	—
laxa	—
liana	37
lineata	48
longata	4, 6, 15, 16, 27
lutetiana	16
majuscula	16, 17, 18, 23, 24, 25, 31, 32, 35, 38, 39, 41, 53, 55
malmeana	35
manoramae	43
maravillosa	—
margaritata	24
maxima	18, 39, 50, 53
miamiana	6
minor	52
mirabilis	15, 37, 44, 53
narcissiana	—
natchita	19
neglecta	4, 16, 44, 50
nitida	5, 16
notabilis	29
oblata	—
occidentalis	24
olivascans	54
orbicularis	—
papulata	—
parvula	35
pellucida	40
perforans	6
plena	—
porangabae	35
porticalis	5, 10, 16, 53
pratensis	8, 16, 35
prescottii	16
princeps	35, 53
protecta	5, 16
pseudovarians	24
pulchrifigurata	—
punctata	16
punctulata	—
quadrata	5, 12, 16, 18, 33, 44, 52
quadrilaminata	6, 35, 49
quinina	15
rectangularis	16
rectispira	—
reflexa	—
reinhardii	—
reticulata	6, 8, 16, 19, 35
rhizobrachialis	35
rhizoides	—
rhizopus	35
rivularis	6, 11, 18
rugulosa	—
schmidtii	6, 29, 49
scrobiculata	—
setiformis	18, 26, 53
shangtungensis	37
silvicola	—
singularis	13, 29
smithii	6
spreeiana	16, 31, 52
submaxima	16, 35
subsala	18
supervarians	52
taftiana	29
tenuissima	16, 41, 46

TABLE 2. *Continued*

Species	Collection location[a]
teodoresii	6, 16
tetrapla	—
texensis	29
tsingtaoensis	37
turfosa	—
undulisepta	43
varians	5, 6, 14, 16, 24, 31, 36, 40, 42
variformis	—
veleta	—
ventricosa	—
verrucosa	—
visenda	19
weberi	16, 36
wollnyi	32
wrightiana	35
spp.	17, 18, 24, 25, 36, 49, 52
Zygnema	
areolata	25
azureum	9, 25
cannthiae	37
carinatum	25
carinthiacum	25, 37
catenatum	—
chalybeospermum	—
coerulum	—
collinsianum	19
condensatum	—
conspicum	30
corrugata	—
crassiusculum	—
cruciatum	3, 8, 16, 20, 37, 42
cyanosporum	—
cylindricum	12, 20, 24, 25, 52
cylindrosporum	—
czurdae	—
decussatum	—
excrassum	—
fanicum	—
frigidum	12, 25
giganteum	—
insigne	15, 16, 24
laetevirens	1, 19
lawtoneanum	25
melanosporum	24
micropunctatum	—
normani	25
operculum	25
ornatum	25
oveidana	6, 19
pawhuskae	25
pawneanum	25
pectinatum	16, 25
peliosporum	3, 4, 25, 36, 46
sinensis	37
spontaneum	52
stellinum	3, 6, 15, 16, 24, 41, 54
stephaniae	52
sterile	24
subtile	—
synadelphum	6, 12, 17, 24, 25, 37
tenue	15
vaucherii	24, 41
spp.	6, 18, 19, 25, 41

TABLE 2. *Continued*

Species	Collection location[a]
Mougeotia	
acadiana	6, 35
areolata	6
bicalyptra	—
caimani	—
calcarea	17, 19, 25, 35
capucina	1, 16, 22, 23, 28
celestis	6
cyanea	6, 17, 24, 25, 29
daytonae	6
decussata	15
drouetii	35
floridana	6
genuflexa	5, 18, 40, 53
globulispora	—
glyptosperma	41
gracilis	8
gracillima	6, 41
granulosa	—
intricatum	15
laetevirens	17, 22, 35, 47, 52, 53
lamellosa	41
macrospora	6
megaspora	53
miamiana	6
microspora	17
mirabilis	53
nummuloides	16
oblongata	6, 17
operculata	19
ovalis	—
parvula	6, 36, 46, 53
poinciana	6
prona	22
puchella	17
punctata	6
quadrangulata	6, 16
radicans	44
robusta	16, 25, 51
scalaris	6, 15, 16, 17, 53
seminoleana	6
sphaerocarpa	3, 17
sumatrana	—
tenuis	8, 10, 20
thylespora	6
transeaui	6
tubifera	23
tumidula	22
uberosperma	32, 52
varians	35
viridis	53
spp.	6, 19, 43
Sirogonium	
ceylanica	—
floridanum	6, 52
hui	37
illinoiense	25
melanosporum	—
sticticum	3, 6, 25, 29, 35, 52, 55
tenuius	25
ventersicum	32, 52
sp.	6
Debarya	
ackleyana	17
americana	17
costata	—
cruciata	25
decussata	—
glyptosperma	16, 41
reticulospora	—
smithii	3
sp.	16, 52
Zygnemopsis	
americana	17
columbiana	36
decussata	25, 36, 37
desmidioides	—
floridana	—
indica	—
iyengari	43
lamellata	—
minutum	17
pectinata	32, 52
sinensis	—
spiralis	—
splendens	—
stephensiae	52
transeauiana	—
wuchangensis	—
spp.	17, 52
Zygogonium	
anomalum	—
australe	52
ericetorum	6
stephensiae	52
spp.	13, 19
Entransia	
sp.	—
Mougeotiopsis	
fluitans	42
sp.	17
Pleurodiscus	
sp.	26
Temnogametum	
sp.	—
Temnogyra	
sp.	19
Sirocladium	
sp.	43

[a] The collection location key to states in the United States and to other countries is as follows: 1, Alabama; 2, Alaska; 3, California; 4, Colorado; 5, Connecticut; 6, Florida; 7, Hawaii; 8, Illinois; 9, Indiana; 10, Iowa; 11, Kansas; 12, Kentucky; 13, Louisiana; 14, Maine; 15, Maryland; 16, Massachusetts; 17, Michigan; 18, Minnesota; 19, Mississippi; 20, Missouri; 21, New Hampshire; 22, New York; 23, North Carolina; 24, Ohio; 25, Oklahoma; 26, Pennsylvania; 27, Rhode Island; 28, South Carolina; 29, Texas; 30, Virginia; 31, Washington; 32, Africa; 33, Austria; 34, Bohemia; 35, Brazil; 36, Canada; 37, China; 38, Denmark; 39, England; 40, Finland; 41, France; 42, Germany; 43, India; 44, Italy; 45, Japan; 46, Norway; 47, Paraguay; 48, Portugal; 49, Puerto Rico; 50, Romania; 51, Scotland; 52, South Africa; 53, Sweden; 54, Switzerland; 55, Uruguay.

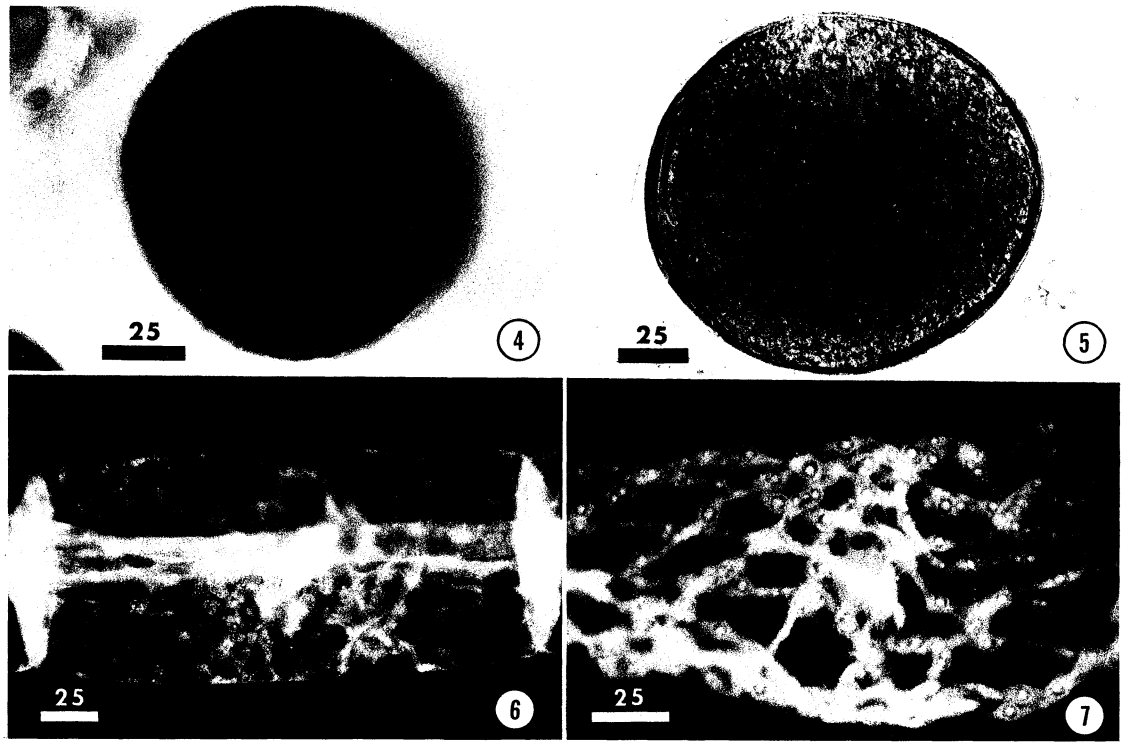

Fig. 4–7. *Spirogyra jatobae.* **4.** Zygospore from raw collection. **5.** Glycerine-preserved zygospore from Transeau Collection. **6.** Centrally located nucleus in living cell showing fluorescence following fluorochroming with BAO. **7.** Centrally located nucleus in a 48-yr-old, glycerine-preserved cell showing fluorescence following fluorochroming with BAO. Line scales in μm.

lack of it) for median wall layers of zygospores is required. Fortunately, zygospores are the best preserved feature of specimens in the Collection. Their use in verifying identifications is achieved by comparing zygospore length, width, shape, color and median wall ornamentation. Vegetative features of specimens are not only less useful, but also are mostly poorly preserved. Verification of identifications with specimens from the Collection is superior to the use of illustrations in *The Zygnemataceae.*

Historically, the light microscope has been used to interpret the ornamentation (or lack of it) on median walls of zygospores. But even Transeau (1951, p. 16) recognized the limitations of this instrument when he stated: "Some of the older species were described as having smooth median spore walls, although recent study of type specimens has shown them to be punctate. This circumstance is probably explained by the poor resolving power of the microscope lenses of the last century as compared with those available today." Now the arrival of the scanning electron microscope (SEM) provides a greatly improved method for interpreting zygospore-wall ornamentation, providing a unique demonstration of how new inventions enhance the value of something old.

Recently, Hoshaw (1980) demonstrated the use of SEM in revising the systematics of nine species of *Sirogonium.* He found the zygospore-wall ornamentation of six of the nine species to be at variance with earlier reports from light microscopy (Transeau, 1951). In the author's investigation, five of the nine species examined were from specimens in the Transeau Collection because living specimens were unavailable. Zygospore-wall ornamentation of living and preserved specimens appears similar when viewed by SEM as demonstrated for *Sirogonium melanosporum* (Randhawa) Transeau in Fig. 8 and 9. The ornamentation of this species, and others of *Sirogonium,* was examined using air-dried spores. These were prepared by the following procedure: removal of outer wall and outer median wall by means of No. 11 surgical blades using a stereomicroscope; transfer of spores, following wall removal, to specimen holders with attachment by double stick tape; air drying for 24 hr prior to gold-palladium coating (20–40 nm) in a Denton DV515 vacuum evaporator. Speci-

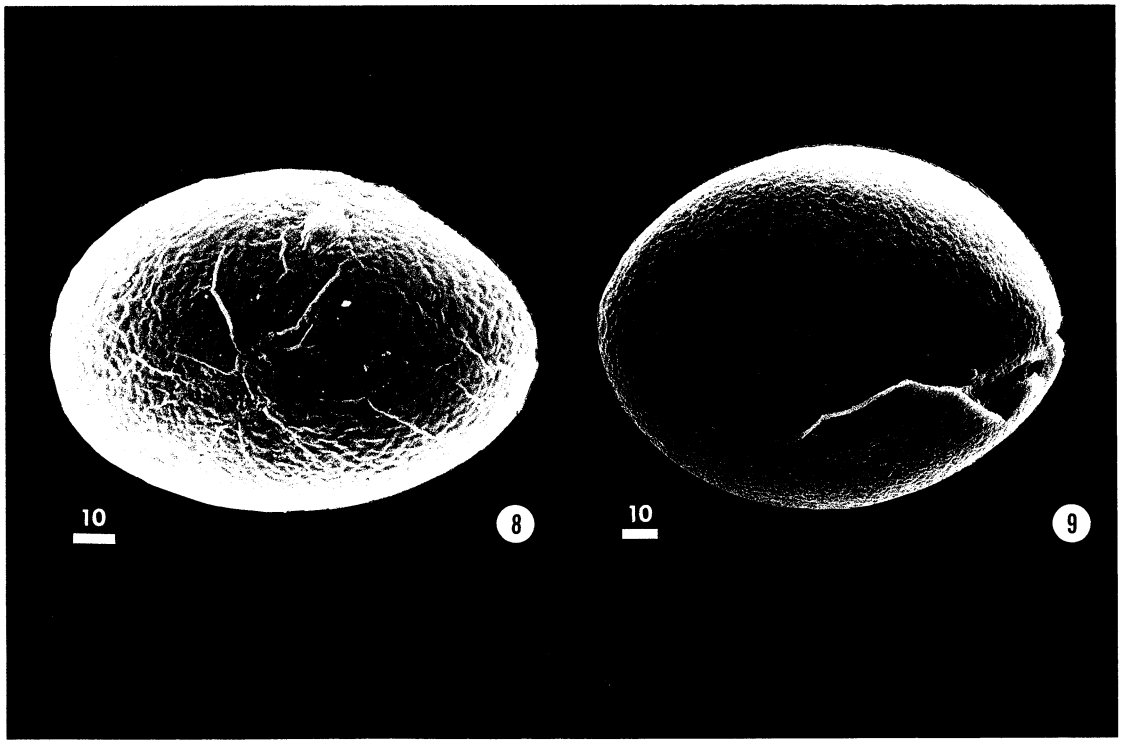

Fig. 8–9. *Sirogonium melanosporum.* **8.** Cultured zygospore (Hoshaw 716) showing median wall ornamentation. **9.** Glycerine-preserved zygospore from Transeau Collection showing median wall ornamentation. Line scales in μm.

mens were examined and photographed with an ETEC Autoscan electron microscope at 20 kv.

Vegetative cells of specimens in the Collection also may be useful in a revision of the systematics of the Zygnemataceae. An example is a use of these cells with their intact nuclei to measure nuclear DNA by cytofluorometry. Since chromosome counts are difficult or impossible for preserved specimens, measurement of nuclear DNA can serve as an indirect indicator of ploidy level. Transeau (1951, p. 9) has suggested polyploidy as a factor in speciation in the Zygnemataceae, and current investigations in our laboratory are directed toward elucidating the relationship of ploidy to speciation in the family. Figures 6 and 7 demonstrate that preserved nuclei as well as living nuclei of *Spirogyra jatobae* stain for DNA and fluoresce following fluorochroming with BAO [bis-(4-aminophenyl)-1,3,4,oxadiazole]. The 48-yr-old preserved cell shown in Fig. 7 exhibits a fluorescence brilliance of nuclear DNA equal to that of freshly cultured specimens. DNA measurements are made with a Leitz MPV photomultiplier.

Two potential uses of the Collection relate to studies on the occurrence and distribution of species and to studies of conjugation and its relation to natural environmental parameters. As an example, Table 3 shows the occurrence and distribution of four genera, *Spirogyra, Zygnema, Mougeotia,* and *Sirogonium* by continent. Such data could be used to answer questions of biogeography. Figure 10 shows time of most frequent conjugation, through the presence of zygospores on specific dates, for 105 species of *Spirogyra* in the Collection. From these data, coupled with collection locations, hypotheses may be constructed on the relation

TABLE 3. *Distribution of species for four genera in the Transeau Collection by continent*

Continent	Number of species			
	Spirogyra	*Zygnema*	*Mougeotia*	*Sirogonium*
Africa	13	3	2	3
Asia	10	5	1	1
Australia	1	0	0	0
Europe	24	5	12	0
North America	75	27	37	5
South America	15	0	5	1
Total	138	40	57	10

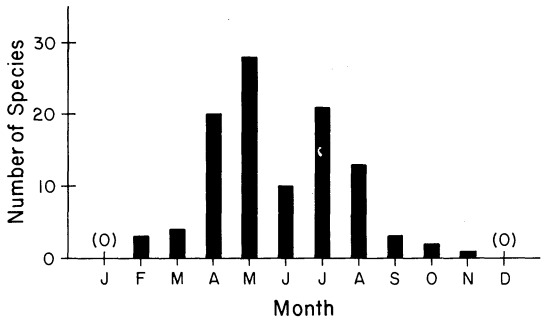

Fig. 10. Number of species of *Spirogyra* from the United States in the Transeau Collection with zygospores and the month of their collection.

of environmental parameters (e.g., photoperiod, temperature) to the timing of conjugation.

DISCUSSION AND CONCLUSIONS—Many types of materials are left behind when a botanist retires or dies. These include items such as living plants, preserved specimens, iconographs, books, and reprints. Without another person to care for or use these materials, they may be discarded or sold, resulting in a significant loss to the botanical community. Presently, there is no organized way to match materials with a new user. In the future, it would seem appropriate for botanical societies to volunteer as match-makers.

For algal materials there are culture collections which will accept living cultures and a few herbaria equipped to handle preserved specimens. But the time and effort of an interested individual is needed to insure the proper deposition and care of cultures and preserved specimens or of other algal materials following the death or inactivity of a phycologist. For example, the cultures of *Chlamydomonas* belonging to Gilbert M. Smith of Stanford University were sent by Robert M. Page, a mycologist, to the Culture Collection of Algae at Indiana University (now at The University of Texas) (Starr, 1978) soon after Smith's death. Hoshaw (1965) screened these cultures for sexuality and mating type inheritance so investigators would be aware of their potential usefulness. However, there is always uncertainty whether algal materials will be transferred to a location where they will receive this type of attention and be accessible for future use.

Collections of living and preserved specimens have potential usefulness far beyond the present. They are rarely too old or dusty or dry to be useful to an imaginative investigator. While about 1,800 public institutions maintain herbaria of vascular plants (Altschul, 1977), only an uncounted few maintain algae, especially freshwater specimens. Algal collections are mostly personal rather than institutional, making long-term maintenance a serious problem. The Transeau Collection provides an excellent example of a valuable collection of specimens without a plan for continued use following Transeau's death.

Why should seemingly useless collections receive expensive long-term maintenance? It should be obvious that collections like those of Transeau already represent the expenditure of untold time, effort, and money on the part of many persons and institutions throughout the world. It is impossible to imagine in the scientific climate of the 1980's that such a collection would be assembled again. Additionally, as habitats continue to be destroyed by man, collections from these habitats become increasingly more valuable.

The advent of new techniques or the application of those already known, but not yet used, may make possible the recording of new data from a collection. For the Transeau Collection it has been demonstrated by Hoshaw (1980) that the technique of SEM, unheard of during earlier detailed systematic studies of the Zygnemataceae, is a valuable tool for revising the systematics of this algal family. Also, the present paper relates how cytofluorometry may be used to determine the quantity of DNA in nuclei of preserved cells as a potential indirect measure of ploidy level. This technique should be applied to specimens of two or more preserved species in which size and number of

TABLE 4. *Number of slides of the five most prevalent species for four genera in the Transeau Collection*

Species	No. of slides	Species	No. of slides	Species	No. of slides	Species	No. of slides
Spirogyra		*Zygnema*		*Mougeotia*		*Sirogonium*	
majuscula	37	*synadelphum*	20	*laetevirens*	20	*sticticum*	25
bellis	21	*cruciatum*	18	*capucina*	17	*illinoiense*	7
quadrata	20	*peliosporum*	16	*calcarea*	14	*melanosporum*	6
reticulata	18	*cylindricum*	13	*cyanea*	12	*floridanum*	4
varians	17	*stellinum*	11	*scalaris*	11	*tenuis*	3

morphological features suggest ploidy has played a role in speciation. For example, three species of *Mougeotia*: *M. transeaui, M. floridana* and *M. poinciana* (Transeau, 1951, p. 104–105) are strongly suspect as being a polyploid series because they differ mostly in dimension of filaments and zygospores and in number of pyrenoids. Additionally, these three species have been collected in the same pond.

Most algal collections possess several types of potentially publishable data. Certain of these are recorded on labels or sometimes in accompanying record books. Unfortunately, data are incomplete on numerous slide labels of the Transeau Collection and no record book related directly to the slides exists today. This shortcoming has further impressed the author with the necessity of recording and maintaining data, which may not seem valuable at the moment, but may be used by others decades later.

Since the Transeau Collection was used primarily for the compilation of a monograph, data on slide labels remain as a source for biogeographic study. Perhaps, major differences in the number of slides for species in the Collection (Table 4) suggest an adaptive advantage of one species over another in nature. For example, the Collection contains 37 slides of *Spirogyra majuscula* Kützing while 38 species of the genus *Spirogyra* are represented by only a single slide. The author has experienced difficulty for two decades collecting specimens of *Sirogonium* other than *S. sticticum* (J. E. Smith) Kützing. Data for *Sirogonium* in Table 4 show 25 slides for *S. sticticum* and only 7 slides for the next most prevalent species, suggesting, at least, the greater occurrence of *S. sticticum.*

Unpublished ata from algal collections may be useful in constructing hypotheses for testing in the field or laboratory. As an example from the Transeau Collection, collection location and time may provide a clue to reproductive seasonality at specific latitudes. This is possible because knowing what species is present at a location requires evidence of reproductive activity in the form of zygospores, since these spores are needed for identification of any species. Therefore, data on the variability of conjugation time with latitude and altitude may enable an investigator to construct hypotheses on the effects of photoperiod and temperature on reproductive seasonality.

In the preceding paragraphs, I have demonstrated mostly with examples from the Transeau Collection why collections should be maintained in perpetuity. Such a plan will prevent a great loss of past human resources and allow for new inventions yet undiscovered and creative individuals to have their day with these collections.

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