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BOTANY

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INTRODUCTION

The genus *Nymphaea* in northeastern United States consists of three named entities. One of these, *N. tetragona* Georgi, is well characterized by its size, rhizome habit, leaf shape, receptacle shape, and number of flower parts. The other two species, *N. odorata* Ait. and *N. tuberosa* Paine, are separated with difficulty although authors have cited as many as twenty-five characters in which these taxa are said to differ. Table 1 presents the more important of these distinctions.

TABLE 1.—*Commonly cited distinguishing characteristics of two species of* NYMPHAEA

N. odorata Ait.	*N. tuberosa* Paine
Rhizome non-tuberous.	**Rhizome** bearing easily detached, tuber-like branches.
Leaves 15-25 cm in diam, usually red to dull, dark purple underneath.	**Leaves** 12-40 cm in diam, green underneath except often purplish at margin when young.
Petioles usually reddish-green to dark purplish-red.	**Petioles** green, often with several longitudinal brown stripes.
Flower open 7 a m to 1 p m, 7-12 (-15) cm broad, with prominent, sweet odor.	**Flower** open 8 a m to 3 p m, 10-23 cm broad, odorless or nearly so.
Sepals often purplish on back.	**Sepals** green on back.
Petals 23-32 (avg 27), the outer ovate to elliptic-lanceolate and with obtuse tips.	**Petals** more numerous, the outer obovate to spatulate and with broadly rounded tips.
Inner stamens with anthers broader than their filaments.	**Inner stamens** with anthers narrower than their filaments.
Carpels 13-25 (avg 17).	**Carpels** about 14.
Seeds very numerous, 2.3 mm long by 1.6 mm wide.	**Seeds** few (150 in large fruit), 4.4 mm long by 2.8 mm wide.
Aril exceeding the seed.	**Aril** shorter than the seed.

The genus has been monographed (Conard 1905) and discussions of variation in the *N. odorata-N. tuberosa* complex have been published by Conard (1916, 1917, 1918) who states in the last of these that "there is therefore in Iowa a type of waterlily of fairly wide distribution, combining characteristics of *Nymphaea odorata* and *N. tuberosa*, and variable in respect to certain of these characteristics."

The present study is an attempt to assess variability in this complex as the plants occur in the Itasca Park region of northcentral Minnesota.

Itasca State Park is located approximately 225 miles northwest of Minneapolis in northcentral Minnesota. Included within its boundaries are a great many lakes, ponds, sloughs, and bogs of various size and physical nature together with numerous interconnecting streams. Figure 1 shows the approximate location of the ten areas within which one or more plants were sampled as part of this study.

PROCEDURE

Beginning on July 4, the date on which *Nymphaea* plants were first seen in flower in the area, a series of observations and collections were made involving forty-one flowers from thirty-three plants located in ten different areas. As used here the term "plant" may be defined as a group of leaves and flowers obviously growing from the same rhizome and spatially isolated from similar groups. It was impossible to determine the exact limits of any plants, although such information would be valuable. Because spatial discontinuity was absent in the small "Bemidji Pond", the four flowers collected there are assumed to be from the same plant. Most plants had a single flower and averaged from 4-12 leaves except that fifty-seven leaves were selected at random from the plant in Bemidji Pond.

For each of the thirty-three plants the following data were obtained in the field.

[1]The field work upon which this paper is based was supported in part by the National Science Foundation and the University of Minnesota Biological Station at Lake Itasca during the summer of 1954. The author also wishes to acknowledge the support of the Iowa State College Industrial Science Research Institute during the spring of 1957 when this study was completed.
For their many suggestions and generous assistance during the course of the study, the author wishes to thank Dr. Thomas Morley, University of Minnesota, and Dr. R. W. Pohl, Iowa State College.

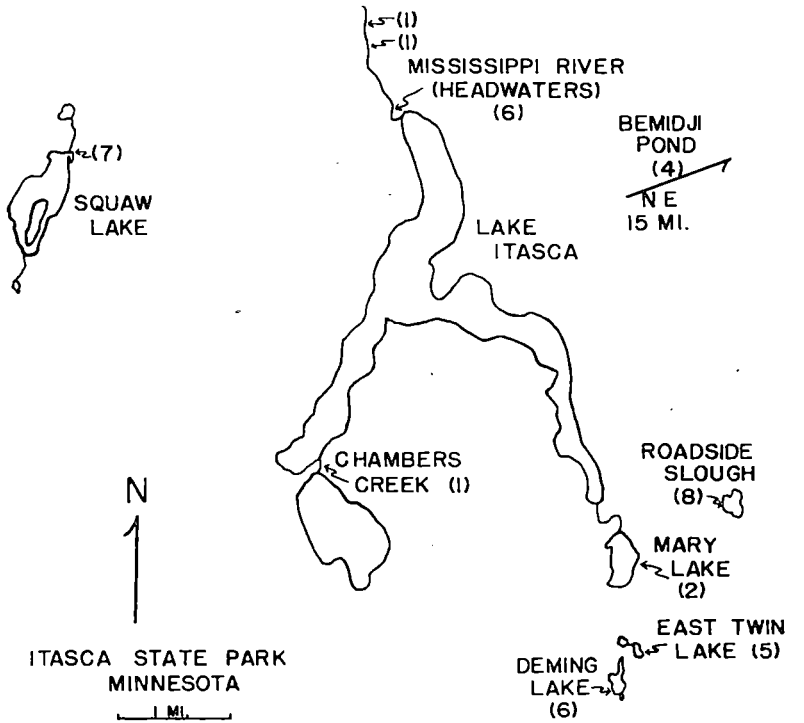

Figure 1. The approximate location of areas in which *Nymphaea* was studied and collected, 1954. Numbers in parentheses designate the number of flowers collected.

1. Maximum diameter of each leaf.

2. Coloration of the undersurface of each leaf, scored as 0 (green), 1 (light purple, especially toward the edges), or 2 (strong purple).

3. Presence or absence of brown stripes on the petiole, scored as 0 (striping absent), 1 (moderate), or 2 (strong).

4. Presence or absence of tubers. According to Conard (1905: 191) the 2-8 cm long tubers may develop from any part of the rhizome without observable order. When located, the tubers were found to be attached to the rhizome by a short, easily broken stalk a few mm in diameter. These factors combined with the physical problems

of finding the rhizome in the usual *Nymphaea* habitat made investigation for tubers one of the most difficult and inconclusive aspects of this study.

5. Flower diameter (only fully opened flowers were scored).
6. Sepal color, especially that of the outer surface.
7. Flower odor (only open flowers were scored).

After obtaining the above data, the author collected up to ten petals and at least as many stamens from each of thirty flowers, sampling insofar as possible the extent of variation in size and shape. An attempt was made to collect seed from these flowers at a later date on the assumption that the sampling done would not interfere with normal seed production. It was, however, not possible to recover the fruits except for two unmarked berries collected from a previously studied plant. The data on seed characteristics presented in this paper are based on these two berries together with one berry collected at the time the vegetative and floral variation of that plant was sampled.

In addition to the flowers treated as above, eleven complete flowers were collected. In all cases floral parts were laid out individually on newspaper and dried using artificial heat.

For complete flowers, the number of sepals, petals, staminodes, and stamens was determined after drying and for petals of all flower collections, the following measurements were made:

1. Length.
2. Width.
3. Distance from the widest part of the petal to the tip of the petal. This last measurement was then divided by the total length of the petal, the resultant decimal value times one hundred being an "index of shape." To facilitate comparisons between flowers, an "average shape index" was calculated for outer petals of each flower as follows:

a. For sample collections, the average was based on the 1-4 longest petals, variation in petal length in no case exceeding 5mm.

b. For complete collections, the average was based on the 5-7 longest petals including all those having the same length, the variation in petal length in no case exceeding 5mm. It should be noted that

the calculations in this and certain other sections are based on the assumption that the longer petals are the outer petals of the flower.

4. Shape of the apex was scored for each petal as rounded, intermediate, or obtuse using the illustrations in Gleason (1952: 151) as standards. For each of the eleven complete collections these data are presented as the percent of outer petals having an obtuse apex, the value being based on the 8-12 longest petals in the collection, including all those having the same length.

RESULTS

Leaf diameter: In all but a few instances, the diameter of leaves on any one plant varied from 5-15 cm. Where the variation was greater, it was usually due to the presence of one leaf of unusually small size. In general, variation was greatest on plants with leaves averaging 20 cm or more in diameter except that the least amount of variation recorded was from a plant having seven leaves the diameter of which varied between 23.3 and 26.6 cm. Figure 2 shows the distribution by diameter classes of the fifty-seven leaves from Bemidji Pond.

Within any one body of water, the average leaf diameter varied considerably from plant to plant but never as much as it varied from one body of water to another. These data are summarized in Table 2 and presented pictorially in Figure 3.

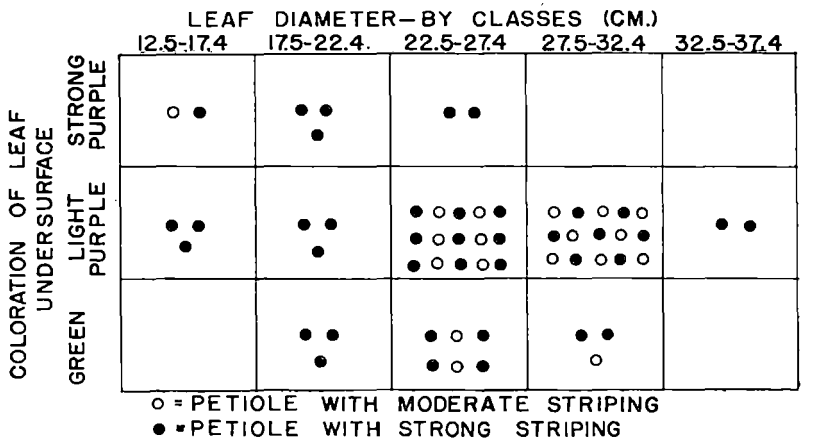

Figure 2. Characteristics of fifty-seven *Nymphaea* leaves, Bemidji Pond, 1954.

TABLE 2.—*Vegetative characteristics of* 33 *Nymphaea plants, Itasca Park,* 1954.

	COLORATION OF LEAF UNDERSURFACE									
	Green Brown petiole stripes				Purple Brown petiole stripes					
	Present Tubers		Absent Tubers		Present Tubers		Absent Tubers		Range in average leaf	Total number
Location of plant	Pres.	Abs.	Pres.	Abs.	Pres.	Abs.	Pres.	Abs.	diameter (cm)	of plants
Deming L.		4			1				15.4-23.9	5
Miss. R. (Headwaters)	1				3				15.2-24.8	4
Roadside Slough	3	2		2					19.3-28.6	7
East Twin L.	1	2				1			15.7-24.0	4
Squaw L.	1		1		2	1		2	8.1-21.0	7
Bemidji Pond*					1				25.0	1
Others	1			1	2	1			18.3-31.8	5
TOTALS	7	8	1	3	9	3	0	2	8.1-31.8	33

*Average based on 57 leaves selected at random throughout the pond.

Coloration of leaf undersurface: Although there is an apparent tendancy toward uniformity of coloration of the undersurface of leaves of any one plant, the exceptions are too numerous to permit generalizations. The same is true of the variation from plant to plant within the same area and from one area to another. Figure 2 shows the distribution of scores for the fifty-seven leaves from Bemidji Pond; Table 2 and Figure 3 present the averages of data for each of the plants studied.

Petiole stripes: Variation in this characteristic was slight or absent in many of the plants studied. Among plants growing in the same body of water, variation was inconsistent, being slight in most cases but not infrequently considerable. Figure 2 shows the distribution of scores for fifty-seven leaves from Bemidji Pond and the average data for individual plants are shown in Table 2 and Figure 3.

Tubers: While it was impossible to demonstrate conclusively that tubers were present or absent on many plants, it was always possible to collect tubers from at least one plant in each area studied. It was

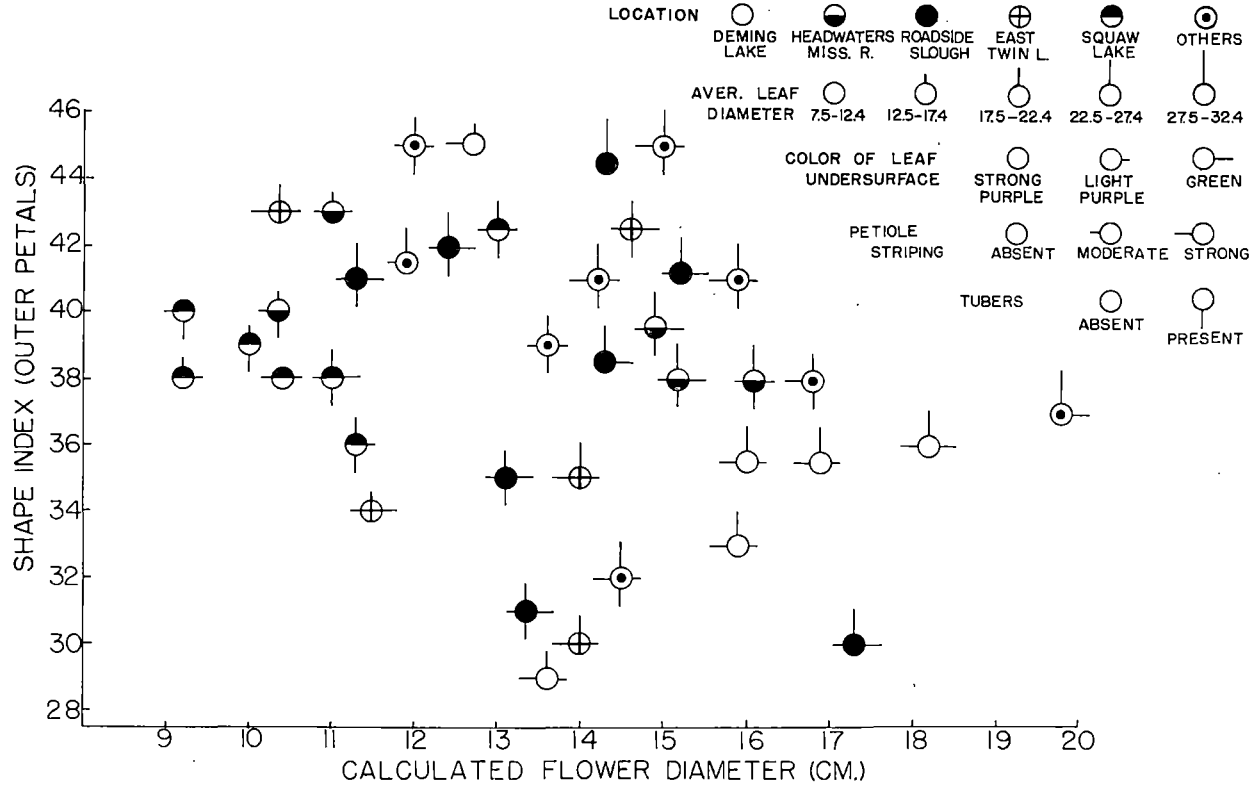

Figure 3. Scatter diagram showing the relationship between seven characteristics of forty *Nymphaea* flowers. Itasca Park region, 1954.

also possible to observe development of tubers in the vicinity of some plants on which tubers were not found. Table 2 and Figure 3 summarize the data.

Flower diameter: In order to develop a means whereby an investigator may more fully utilize available data, a regression equation was calculated using the following data obtained from each of twenty-five flowers.

1. Flower diameter as measured in the field.
2. Length of the longest petal after drying.

Generalizing from the more detailed equation calculated for the 95 percent confidence interval, it may be said that the flower diameter (fresh) is equal to 2.3 times the length of the longest petal (dry) ± 2 cm. Using 2.3 as a "flower diameter factor" it was found that the diameter of the forty-one flowers studied ranges between 9.2 and 19.8 cm (actual measured range for twenty-five flowers was 9.0-21.0 cm). The distribution of the values calculated for the forty-one flowers is presented in Figure 4.

Sepal color: For all flowers studied, the color of the outer surface of sepals was found to be green with no indication of a red or purple color. Inner surfaces were found to be uniform greenish-white.

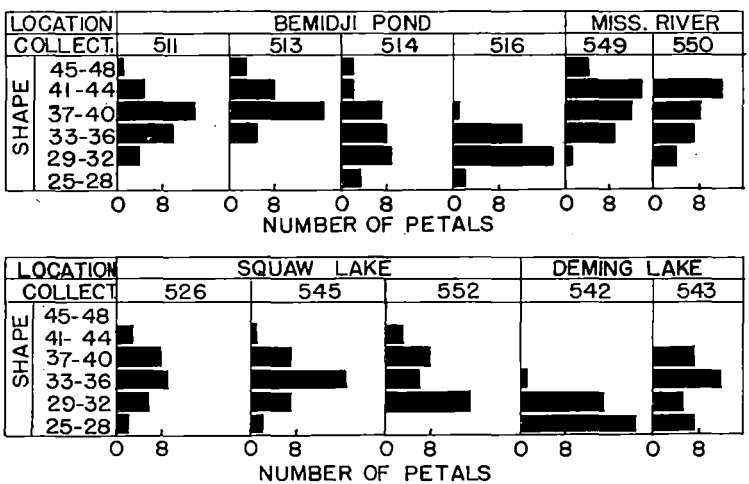

Figure 4. Characteristics of forty-one *Nymphaea* flowers. Itasca Park region, 1954.

Flower odor: Although the observations are totally subjective, odor for all flowers studied was scored as absent or indistinct. Some variation was noted but the author found it impossible to differentiate any distinct class values for this characteristic.

Number of sepals, petals, staminodes, and stamens: With rare exceptions, four sepals were present on each flower. Petal, staminode, and stamen number, however, varied considerably averaging, respectively, thirty-six, two, and seventy-eight for the eleven flowers collected complete. Individual data on these flowers are included in Table 3.

TABLE 3.—*Variation in eleven Nymphaea flowers, Itasca Park,* 1954.

Location of plant	Bemidji Pond				Miss. River		Squaw Lake			Deming Lake	
Collection No.	511	513	514	516	549	550	526	545	552	542	543
Calculated flower diameter (cm)	14.5	15.6	15.0	14.5	11.0	11.3	10.1	11.0	9.2	13.8	16.3
Petal No.	36	36	33	41	41	31	30	43	32	39	31
Stamen No.	114	83	103	87	70	83	60	65	82	77	80
Aver. shape index (outer petals)	41	41	45	32	43	40	38	38	40	29	36
Per cent outer petals obtuse	80	89	80	100	55	75	100	30	50	60	71

Petal shape: Within any one flower, the shape index value varied from petal to petal, gradually decreasing from the larger to the smaller petals except that where the staminode condition was approached the index value rose sharply. Figure 5 presents the distribution of shape index values by classes for individual petals of the eleven flowers collected complete. Figure 4 presents the distribution of average shape index of outer petals for all flowers studied. Additional information on variation in this characteristic may be obtained from Figure 3 where the average shape index of outer petals is used as the vertical axis. From these data it may be seen that while there is considerable similarity between the flowers of the same body of water, the total variation among the flowers from all bodies of water forms a rather complete continuum. In view of the wide variation in number of petals used to determine the average shape index of outer petals it should be noted that an analysis of variance (Snedecor 1946) showed that the sampling error was not significant.

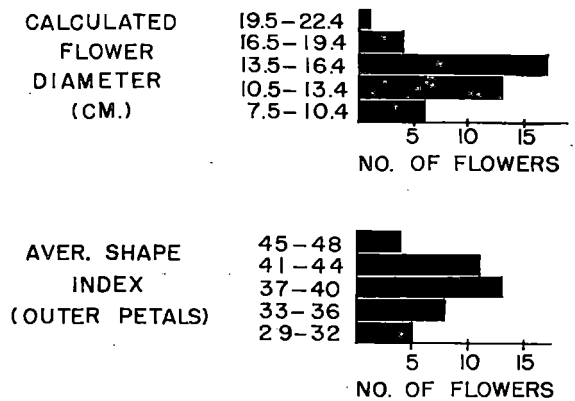

Figure 5. Distribution by classes of shape index values of individual petals of eleven *Nymphaea* flowers. Itasca Park region, 1954.

It is of special interest to note here the data on shape index available from sources other than the author's collections. These data are summarized in Table 4.

TABLE 4.—*Shape index values of outer petals of selected Nymphaea flowers.*

Source	No. of petals	Average shape index	Comment
Gleason, 1952	1	46	Illustration of **N. odorata**
Gleason, 1952	1	33	Illustration of **N. tuberosa**
Conard, 1917	2	42	Tracing, natural size; **N. tuberosa**
Conard, 1917	2	36	Tracing, natural size; **N. tuberosa**
Conard, 1918	1	36	Tracing, natural size; **N. tuberosa**
Conard, 1918	1	34	Tracing, natural size; **N. tuberosa**

Petal apex: No consistent pattern of variation in petal apex shape was evident in the eleven flowers for which the data are comparable. The most frequent pattern is that of outer petals having an obtuse apex; inner petals having a rounded apex. For the eleven flowers collected complete, the percent of outer petals having an obtuse apex is included in Table 4. For the flowers from which petal samples are small, the data are deemed insufficient to warrant presentation.

Anther width: filament width ratio: Examination of stamens collected has shown that in all flowers the inner stamens have anthers broader than their filaments. It should be noted, however, that the

width of inner filaments is not uniform, always being somewhat greater near the point of attachment. For this reason it may be well to qualify the above statement of relationship to exclude the lower one-third of the filament.

Seed characteristics: Data available from the three berries collected are presented in Table 5.

TABLE 5.—*Characteristics of seeds from three Nymphaea berries, Itasca Park,* 1954.

Collection number	Number of seeds	Seed length (average)	Seed width (average)
512A	447	3.32 mm	2.36 mm
512B	91	3.42 mm	2.59 mm
534	517	2.86 mm	2.02 mm

In addition to this table, certain other observations should be noted:

1. In all collections, the aril exceeded the length of the seed by at least 20 per cent.

2. In collection 512B the aril was frequently twice as long as the seed.

3. The berry of collection 512B was found to contain more aborted ovules than mature seeds.

CORRELATIONS

On the basis of average values, Figure 3 has been prepared to show the relationship between two floral characteristics, four vegetative characteristics, and site of collection. For purposes of clarity, some points have been adjusted slightly in preparation of the diagram.

While certain other methods of analysis reveal slight tendencies toward correlation of vegetative and floral characteristics, it is quite evident from Figure 3 that neither individual plants nor groups of plants can be separated from one another on the basis of the characteristics considered in this paper. Although it is probably an expression of general vigor, there is a positive correlation between flower diameter and leaf diameter but of all the other possible aspects of correlation, none are at all distinct. There is, however, in Figure 3 evidence of the previously mentioned tendency toward similarity among plants of distinct bodies of water. It should be emphasized, however, that these

data are based on averages and that for any one plant variation may be considerable (Figure 2). It should also be noted that this tendency is not unexpected; i.e., it is entirely possible that the plants in any one body of water are segments of one clone. Furthermore, in view of limitations on pollen dispersal, it is quite likely that a geographically isolated population of *Nymphaea* is also at least partially isolated biologically.

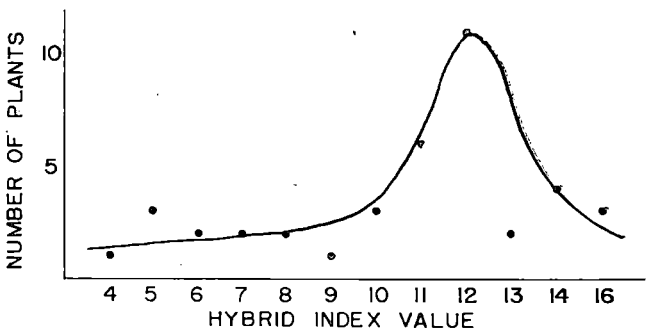

Figure 6. Generalized distribution curve of hybrid index values calculated for forty *Nymphaea* flowers. Itasca Park region, 1954.

TABLE 6.—*Assignment of hybrid index values to Nymphaea, Itasca Park*

	VALUE ASSIGNED				
	0	1	2	3	4
Tubers	Absent		Present		
Average leaf diam (cm)	7.5-12.4	12.5-17.4	17.5-22.4	22.5-27.4	27.5-32.4
Color of leaf undersurface	Strong purple		Light purple		Green
Brown petiole stripe	Absent	Moderate	Strong		
Calculated flower diam (cm)	7.5-10.4	10.5-13.4	13.5-16.4	16.5-19.4	19.5-22.4
Average shape index (outer petals)	45-48	41-44	37-40	33-36	29-32

Further evidence of the homogeneity of the Itasca Park populations *Nymphaea* is presented in Figure 6 which is a generalized distribution curve of hybrid index values (Anderson, 1936) calculated as shown in Table 6. It should be noted that each of the forty-one hybrid index values includes consideration of both floral and vegetative

characteristics with the result that in the five instances where it was possible to collect more than one flower per plant, the hybrid index value may vary, depending on which flower was used in the calculation. This variation is presented in Table 7.

TABLE 7.—*Variation in hybrid index values for Nymphaea plants having two or more flowers.*

Location of plant	Bemidji Pond				Roadside Slough		East Twin Lake		Miss. R. (Headwaters)		Deming Lake	
number	511	513	514	516	517	518	531	532	534	535	542	543
Hybrid index value	12	12	11	15	12	12	12	7	14	14	12	11

Although the data presented in Figure 6 do suggest the possibility of a bimodal population, the evidence is too limited to justify any conclusions. Introgression, apomixis, and similar phenomena are not excluded as possible explanations for the observed variation, but these studies must be extended considerably before any conclusions can be drawn.

CONCLUSIONS

1. To the extent that the data presented herein are indicative, the genus *Nymphaea* in the Itasca Park region consists of a single, highly variable taxon probably best considered as a form of *N. tuberosa.*

2. If it can be shown that both *N. odorata* and *N. tuberosa* occur in the region, these taxa must be defined on the basis of characteristics other than those discussed herein.

3. The data on which this paper is based are too limited to justify any attempt to explain the observable variation.

SUMMARY

Variation in the genus *Nymphaea* as it occurs in the Itasca State Park region of Minnesota has been investigated in a study involving forty-one flowers growing on thirty-three plants in ten different areas. Variation was found to be considerable, especially with respect to leaf diameter, coloration of leaf undersurface, degree of petiole striping, presence or absence of tubers, number of floral parts, flower diameter, gross petal shape, and shape of petal apex. Variation was absent with respect to sepal color, flower odor, and anther-width: filament-width

ratio. Data on seed characteristics were insufficient to justify conclusions on variation.

Attempts to correlate these variables revealed no consistent pattern except that, as might be expected, there is a tendency toward less variation among the plants of one body of water than among the plants of distinct bodies of water.

On the basis of the evidence presented it was concluded that in the Itasca Park region, *Nymphaea* consists of a single, highly variable taxon best considered as a form of *N. tuberosa*. The evidence also suggests that any attempt to separate two or more taxa in the *N. odorata-N. tuberosa* complex as it occurs in this region must be on the basis of characteristics other than those considered here.

LITERATURE CITED

ANDERSON, E. 1936. Hybridization in American Tradescantias. *Ann. Mo. Bot. Gard.* 23: 511-525.

CONARD, H. S. 1905. The waterlilies. *Carnegie Inst. Washington.* Publ. No. 4.

CONARD, H. S. 1916. The white waterlily of Iowa. *Proc. Iowa Acad. Sci.* 23: 621-623.

CONARD, H. S. 1917. The white waterlily of Clear Lake, Iowa. *Proc. Iowa Acad. Sci.* 24: 449-454.

CONARD, H. S. 1918. The white waterlily of McGregor. *Proc. Iowa Acad. Sci.* 25: 235-236.

GLEASON, H. A. 1952 The new Britton and Brown illustrated flora. Vol 2, *New York Botanical Garden.*

SNEDECOR, G. W. 1946. *Statistical methods.* Vol. 2, 4th ed., Ames, Iowa State College Press.