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A Study of the Variation of the Number of Ray Flowers of Certain Compositae

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A STUDY OF THE VARIATION OF THE NUMBER OF RAY FLOWERS OF CERTAIN COMPOSITAE.

BY WINFIELD DUDGEON.

The study of the variation of the ray flowers of *Rudbeckia hirta* (cone flower) was taken up during the Summer of 1906, at the suggestion of Dr. L. H. Pammel. The object of the study was to determine the amount of variation of the ray flowers, the variation for different localities, and any other facts that could be determined. Later, a study of *Rudbeckia triloba* and *Helianthus grosse-serratus* was taken up, with the same end in view, and that the different species might be compared.

In all, 5,885 heads were counted, with a distribution as follows:

TABLE No. 1.

DISTRIBUTION OF THE HEADS COUNTED.

Flower	No. Heads	Locality	Collected by	Date
Rudbeckia hirta	3,847	Total	.....	.....
	558	Ames, Ia.	E. R. Garner and writer	Aug., Sept.
	128	Center Point, Ia.	D. C. Snyder	Aug.
	3,161	8 miles southeast of Hedrick, Ia.	Writer	July, Aug.
Rudbeckia triloba	742	Ames, Ia.	Class in Evolution of Plants	Sept.
Helianthus grosse-serratus	1,296	Total	.....	.....
	125	Council Bluffs, Ia.	.....	Sept.
	1,171	Ames, Ia.	Class in Evolution of Plants	Sept., Oct.

All of the heads of *Rudbeckia hirta* were counted by the writer. The heads of *Rudbeckia triloba* and *Helianthus grosse-serratus* were counted by a class in Evolution of Plants, at Iowa State college. Some of the *Rudbeckia hirta* plants grew in a dry, light, sandy soil, in a closely cropped pasture. All of the other plants grew in from average to good conditions.

All of the heads were taken at random. No conscious selection was used. In nearly all cases, when a plant was taken, all of the

Rudbeckia hirta. Purple cone flower.

Helianthus grosse-serratus. Meadow sunflower.

flowers on it were counted. Only imperfect, and partially destroyed heads were discarded. Great care was taken in counting the rays, and in recording the counts, that no mistakes be made. Table No. 2 records the results of the counts.

TABLE No. 2.

CONDENSED TABLE FOR ALL THE VARIETIES STUDIED, SHOWING ALL OF THE MAGNITUDES AND THEIR CORRESPONDING FREQUENCIES.

Rays per head	Rudbeckia hirta				Rudb'kia triloba	Helianthus grosse-serratus		
	Ames	Center Point	Hedrick	Total	Ames	Council Bluffs	Ames	Total
2	.....	.....	1	1	.....	.....	.....	.....
3	.....	.....	1	1	.....	.....	.....	.....
4	.....	1	2	3	.....	.....	.....	.....
5	.....	.....	18	18	20	.....	.....	.....
6	1	4	19	24	83	.....	.....	.....
7	4	5	52	61	192	.....	1	1
8	45	1	576	622	306	.....	1	1
9	36	9	294	339	91	.....	13	13
10	42	9	249	300	32	2	27	29
11	53	21	233	307	11	6	65	71
12	87	23	340	450	4	16	124	140
13	230	47	1,050	1,327	1	34	320	354
14	43	5	192	240	2	23	215	238
15	12	3	59	74	.....	21	143	164
16	2	.....	35	37	.....	10	76	86
17	.....	.....	12	12	.....	7	51	58
18	1	.....	5	6	.....	4	41	45
19	.....	.....	9	9	.....	2	26	28
20	1	.....	1	2	.....	.....	25	25
21	.....	.....	4	4	.....	.....	35	35
22	.....	.....	4	4	.....	.....	7	7
23	.....	.....	3	3	.....	.....	.....	.....
24	.....	.....	.....	.....	.....	.....	.....	.....
25	.....	.....	1	1	.....	.....	1	1
26	.....	.....	.....	.....	.....	.....	.....	.....
27	1	.....	.....	1	.....	.....	.....	.....
28	.....	.....	1	1	.....	.....	.....	.....
Tot.	558	128	3,161	3,847	742	125	1,171	1,296

It will be seen by inspection of Table No. 2, and Plates I, II, III, and IV, that heads of *Rudbeckia hirta* containing 13 rays greatly predominate. The characteristic mode is at 13, with a very marked mode at 8, and smaller modes at 19 and 21-22. This very closely agrees with the results obtained by Lucas, '04 (Am. Nat., 38:427-429). He says that *Rudbeckia hirta* has a primary mode at 13, and secondary modes at 8 and 20-21. It is possible that a

larger number of variates in this study would have changed the secondary modes at 19 and 21-22 to a single mode at 20-21.

The *Rudbeckia hirta* heads from Ames do not have the mode at 19, and the mode at 8 is not so prominent. The heads from Center Point show a secondary mode at 7 only, but this irregularity is undoubtedly due to the small number of heads counted. The curve for the heads from Hedrick very closely resembles that for the total number of heads.

The curve for *Rudbeckia triloba* is very regular and smooth, with a mode at 8.

The curve for *Helianthus grosse-serratus* is somewhat irregular. The characteristic mode is at 13, with a small secondary mode at 21. It is probable that the secondary mode would disappear if more variates were counted. It does disappear if the classes are doubled, as is shown by Table No. 3 and Plate IX. In that

TABLE No. 3.

SHOWING THE COUNT FOR HELIANTHUS GROSSE-SERRATUS, WITH THE CLASSES DOUBLED.

Magnitudes....	7	8-9	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25
Frequencies...	1	14	100	494	402	144	73	60	7	1

case, the mode is at 12-13. The curve for the heads from Council Bluffs has but one mode, that at 13. So few heads came from there, though, that the curve has but little significance. Because nearly all of the *H. grosse-serratus* heads came from Ames, the curve for that place is very similar to the curve for the total number of heads, having a characteristic mode at 13, and a secondary mode at 21. By doubling the classes, this secondary mode may be made to disappear, also.

The formulae for the computation of all the constants were taken from "Statistical Methods with Special Reference to Biological Variation," by Davenport, '04. Great care has been taken that no mathematical errors enter into the work. To this end, all of the calculations were carried out to five decimal places, although only four are given in this paper. As far as possible, all the work was very carefully checked.

The following formulae have been used:

$$A = \frac{\Sigma(v \cdot f)}{n}$$

where A = the mean or average, Σ = sign of summation, V = the magnitude of any class, f = the frequency, or number of varieties in that class, and n = the total number of varieties.

$$\sigma = \sqrt{\frac{\Sigma (X^2 \cdot f)}{n}} \cdot \lambda$$

where σ = index of variability, or the amount the group as a whole varies from the mean, X = the amount of the deviation of any class from the mean, and λ = number of units in the class range. It is unity in all of these calculations.

$$C = \frac{\sigma}{A} \cdot 100\%$$

where C = coefficient of variability. The 100% is to get the result into more convenient form, and is entirely arbitrary.

$$E_A = \pm .6745 \cdot \frac{\sigma}{\sqrt{n}}$$

where E_A = the probable error of the mean.

$$E_D = \pm .6745 \cdot \frac{\sigma}{\sqrt{n}}$$

where E_σ = the probable error of the index of variability.

Tables 4, 5, and 6 show the constants as worked out for the various species and localities:

TABLE No. 4.

CONSTANTS FOR *Rudbeckia hirta*.

	Total	Ames	Center Point	Hedrick
n =	3847	558	128	3161
A =	11.3436	11.8889	11.5234	11.2401
D =	2.4379	2.0315	2.0765	2.5170
C =	21.4910%	17.0877%	18.0196%	22.3933%
E_A =	.0265	.0580	.1238	.0302
E_D =	.0187	.0410	.0875	.0214

TABLE No. 5.

CONSTANTS FOR *Rudbeckia triloba*.

	Ames
n =	742
A =	7.7345
σ =	1.2344
C =	15.9590%
E_A =	.0306
E_σ =	.0216

TABLE No. 6.

CONSTANTS FOR *Helianthus grosse-serratus*.

	Total	Council Bluffs	Ames
n =	1296	125	1171
A =	14.1937	13.9680	14.2178
σ =	2.4864	1.8371	2.5448
C =	17.5178%	13.1522%	17.8988%
E_A =	.0466	.1108	.0502
E_σ =	.0329	.0784	.0355

CONCLUSIONS.

From the foregoing, it is seen that there is quite a degree of uniformity of variation for plants of a given species, from different localities. Had the number of variates from each locality been larger, it is very probable that the variation for localities would have been still less.

Rudbeckia hirta and *R. triloba* are interesting when brought together in a study of this nature, because they are so closely related. In Gray's "Synoptical Flora of North America," Vol. I, Part II, 260-261, *R. hirta* and *R. triloba* are represented as very closely related to each other, and to *R. bicolor* and *R. subtomentosa.* It would be interesting to study the variation of these related species, presenting as they do, no marked structural differences. If the material were taken from the native habitats of the plants, many interesting facts might be brought out.

There is some indication of a tendency to the formation of two somewhat distinct species from *Rudbeckia hirta.* In the dry, unfavorable soil, the predominating number of rays was 8, while the predominating number in good soil was 13. In the poor soil, the plants were small, and many bore but a single head.

There also seems to be a tendency for the number of rays per head, of *Rudbeckia hirta,* to decrease, because the slope of the upper side of the frequency curve is steep, while the lower side is more gentle (Plate I).

The tendency seems to be for the number of rays per head, of *Rudbeckia triloba,* to decrease a little. It is probably almost stationary (Plate V).

The tendency seems to be for the number of rays per head, of *Helianthus grosse-serratus,* to increase. The lower side of the curve is quite steep, while the upper is a more gentle slope (Plate VI).

The results for *Rudbeckia hirta* in this study agree somewhat closely with those found by Lucas. Taking five groups, containing from 173 to 318 heads each, he found the means to be 14.188, 11.328, 11.868, 9.612, and 11.813. That all of his means are not very nearly 11.000, may be due to the small number of heads in each group. As has been indicated, the modes found in this study agree very closely with those indicated by him.

No account has been taken of the period of the flowering season that these heads were counted. Undoubtedly, heads blooming earlier would vary somewhat from those blooming later in the

season. Shull found such a variation in a white aster he studied to be quite marked (Amer. Nat., 36:111-152). The amount of variation, due to this cause, there would be in plants of this study cannot be told, for no record was kept for that purpose, but it would probably be considerable.

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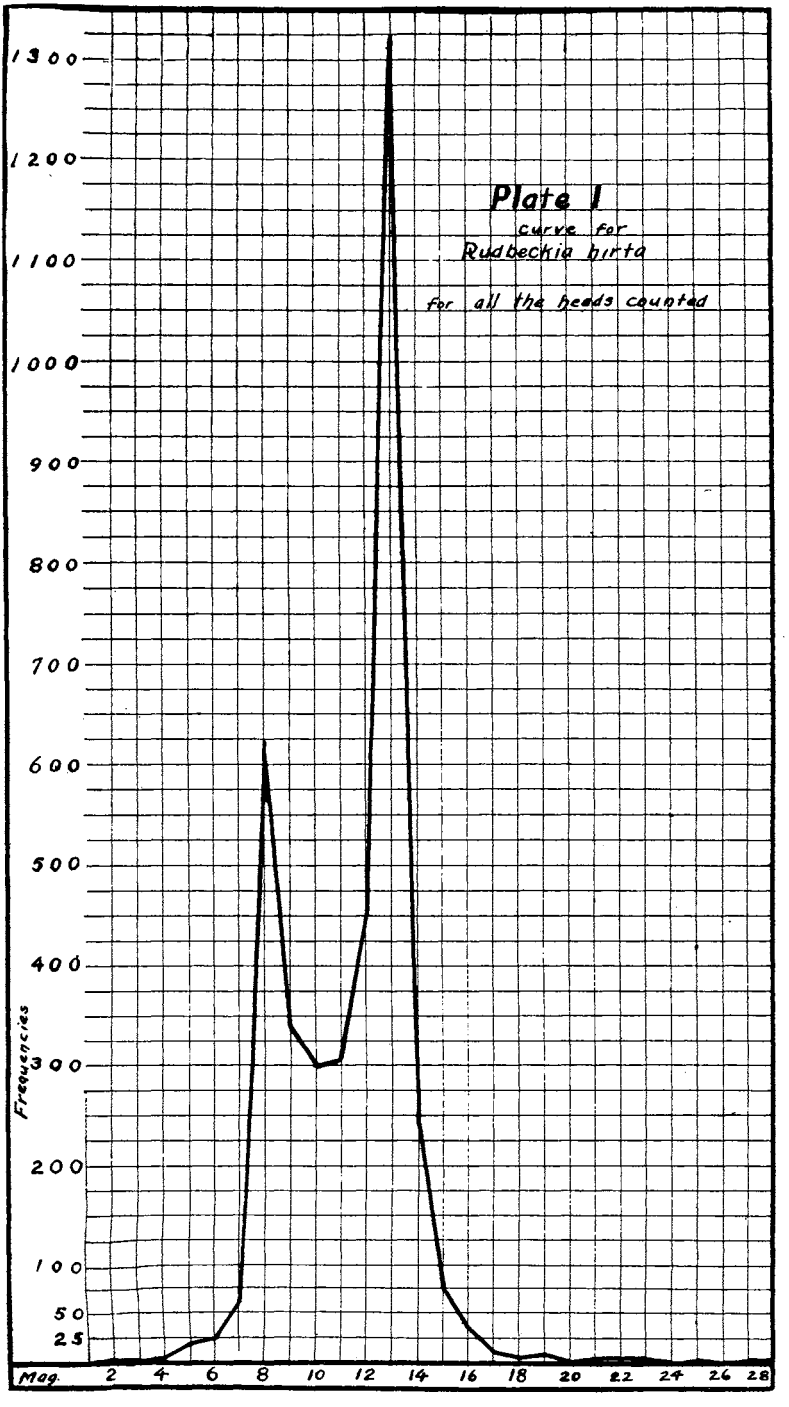
Plate I
curve for
Rudbeckia hirta
for all the heads counted
Frequencies
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
50
25
Mag.
2
4
6
8
10
12
14
16
18
20
22
24
26
28

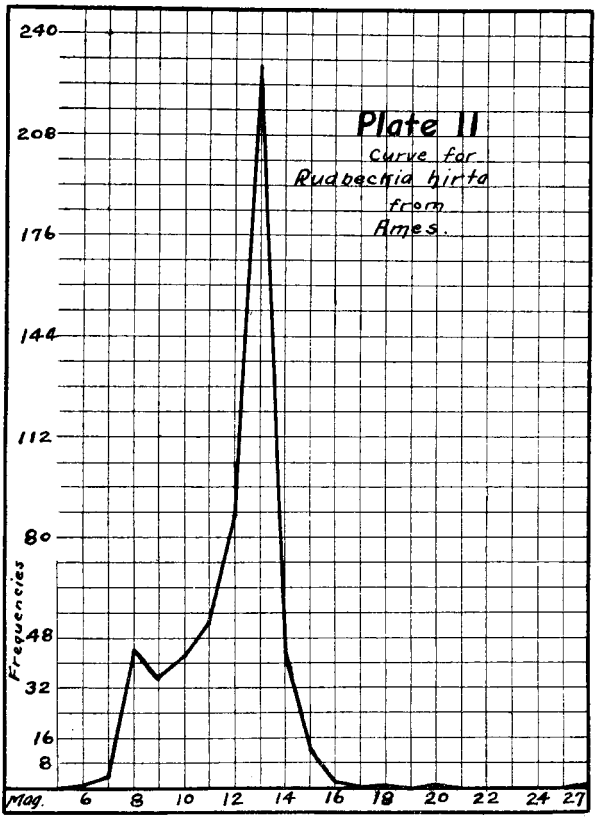
Plate II
Curve for
Rudbeckia hirta
from
Ames.
240
208
176
144
112
80
48
32
16
8
Frequencies
Mag.
6
8
10
12
14
16
18
20
22
24
27

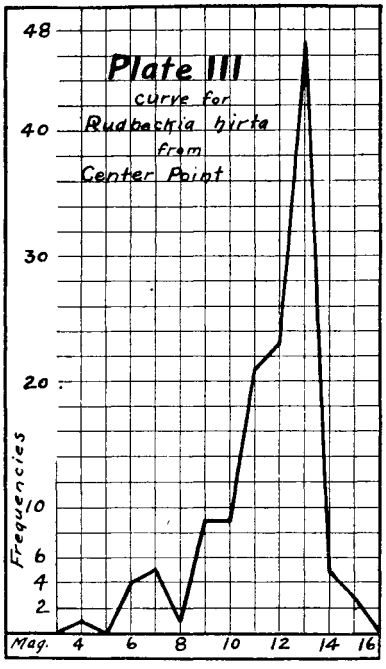
Plate III
curve for
Rudbeckia hirta
from
Center Point
Frequencies
48
40
30
20
10
6
4
2
Mag.
4
6
8
10
12
14
16

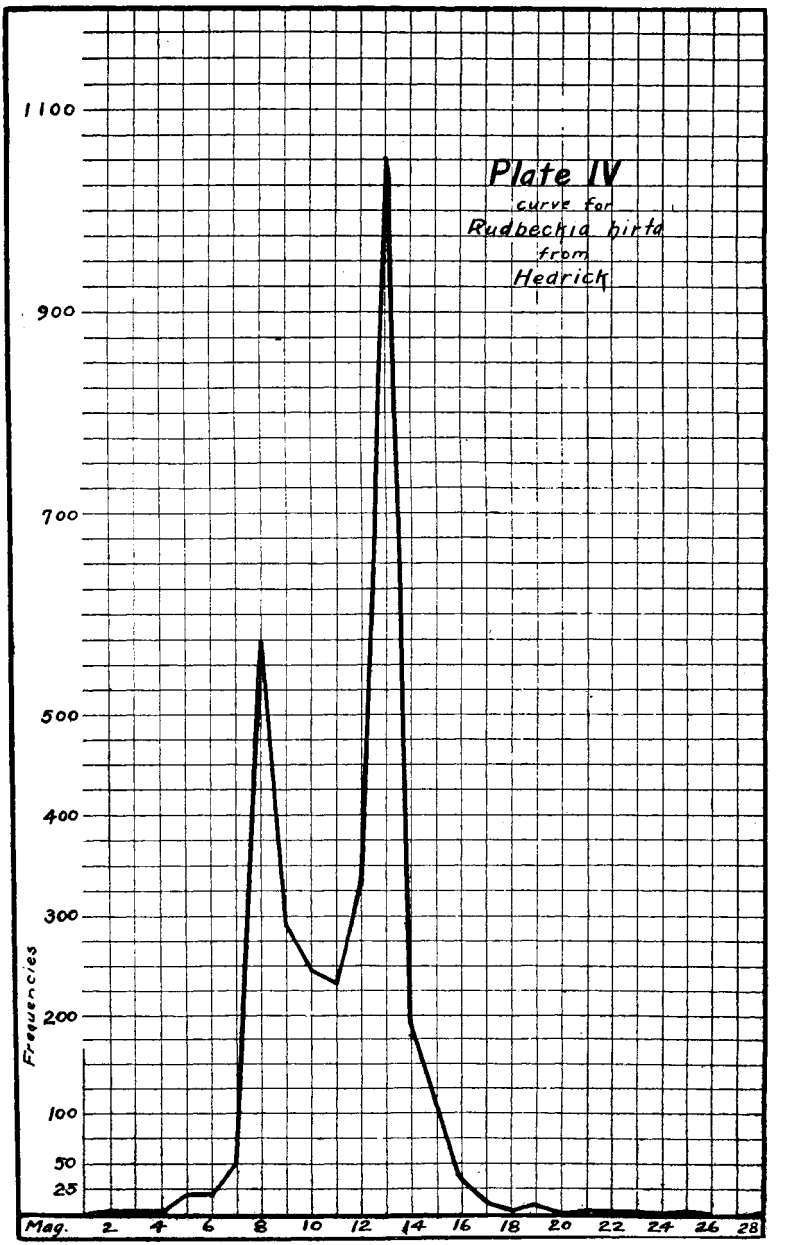
Plate IV
curve for
Rudbeckia hirta
from
Hedrick
1100
900
700
500
400
300
200
100
50
25
Frequencies
Mag.
2
4
6
8
10
12
14
16
18
20
22
24
26
28

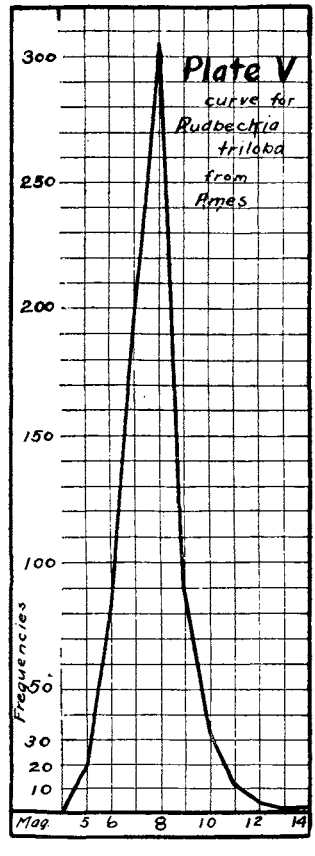
Plate V
curve for
Rudbeckia
triloba
from
Ames
300
250
200
150
100
50
30
20
10
Frequencies
Mag.
5
6
8
10
12
14

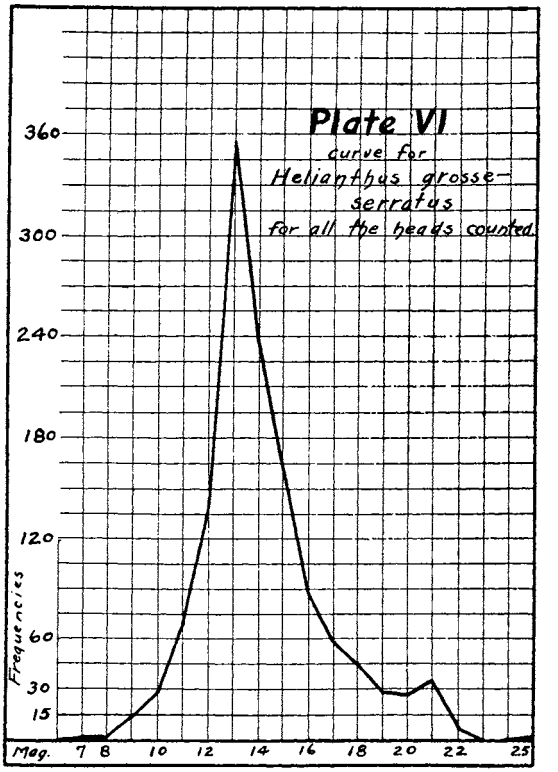
Plate VI.
curve for
Helianthus grosse-
serratus
for all the heads counted.
360
300
240
180
120
60
30
15
Frequencies
Mag. 7 8 10 12 14 16 18 20 22 25

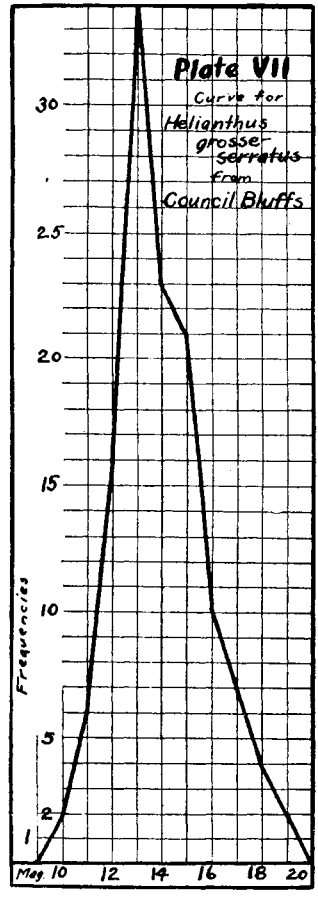
Plate VII
Curve for
Helianthus
grosse-
serratus
from
Council Bluffs
Frequencies
30
25
20
15
10
5
2
1
May 10
12
14
16
18
20

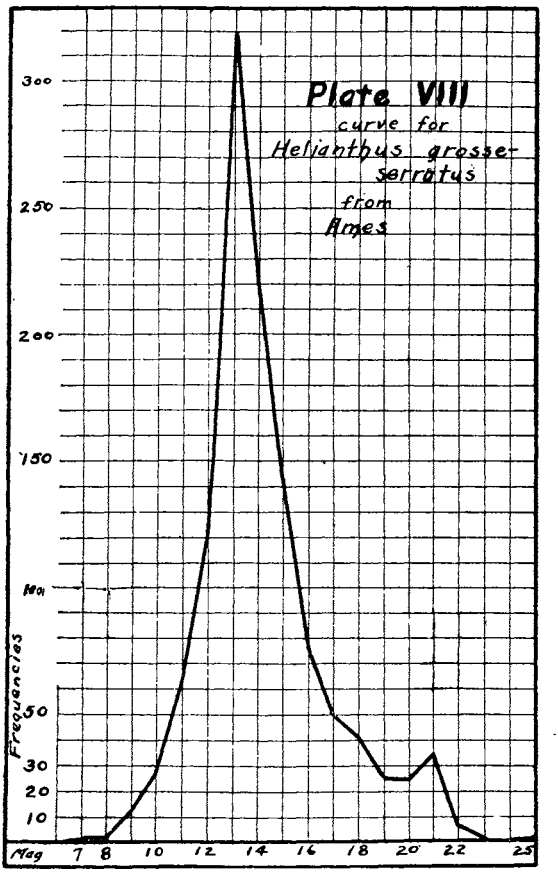
Plate VIII
curve for
Helianthus grosse-
serratus
from
Ames
300
250
200
150
100
50
30
20
10
Frequencies
Mag
7
8
10
12
14
16
18
20
22
25

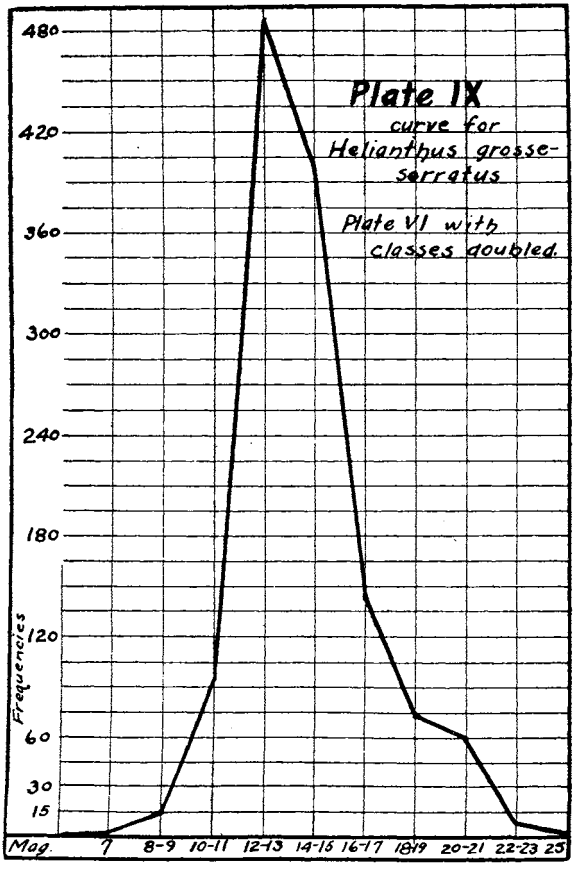
Plate IX
curve for
Helianthus grosse-
serratus
Plate VI with
classes doubled.
480
420
360
300
240
180
120
60
30
15
Frequencies
Mag.
7
8-9
10-11
12-13
14-15
16-17
18-19
20-21
22-23
25