THE PHOTOTROPIC PROPERTIES OF LACTUCA LUDOVICIANA (NUTT.) DC.
AND SILPHIUM LACINIATUM L.

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THE PHOTOTROPIC PROPERTIES OF LACTUCA LUDOVICIANA (NUTT.) DC. AND SILPHIUM LACINIATUM L.

THESIS

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CHAPTER I

INTRODUCTION

In order that the many metabolic activities of plants may be carried on to the most advantage, it is necessary that the vegetative organs be arranged in the most favorable relations with their environment. It is well agreed that this accomplishment is made possible chiefly through the property of irritability, the characteristic power of responding to external stimuli. Plant irritability is observed chiefly by the direction of growth and the orientation which the various organs assume. In most plants under natural conditions geotropic effects cause the primary root to grow downward and the main stem to grow upward, while phototropic effects cause the branches and leaves to be held in a more or less horizontal position.

This paper deals with certain phases of phototropic properties of two exceptional plants, the pertinent behavior of each being decidedly individualistic and in remarkable contrast to that of herbaceous plants in general. The prickly lettuce, Lactuca ludoviciana (Nutt.) DC. and the rosinweed, Silphium laciniatum L., two common Denton County, Texas, plants, have been selected for this study. These two plants commonly

assume what is known as the profile habit which gives them upon casual observance the appearance of having been flattened vertically. The edges or tips of their leaves tend to point in a seemingly north and south direction in order to expose the flat surfaces to the direct rays of the sun. The floral head of the prickly lettuce often points in a seemingly north or northwest direction. These facts furnish sufficient bases and interest for a technical investigation as to the accuracy of nature in setting up reliable compass phenomena in these two species of plants.

Review of Literature

Studies of various leaf movements on various plants had a comparatively early beginning. Little attention, however, has been given to the phototropic movements of the so-called compass plants which are merely mentioned in older publications.

The investigators are disagreed as to the real reason for naming these plants compass plants. The so-called compass plants are termed such by some writers and investigators because the leaves point in the four general directions, north, east, south, and west. They are termed compass plants by others because the edges of the leaves point north and south.

Stahl[1] (1881), who was the first to study the leaf movements of Lactuca scariola, found the leaves to be diaphototropic,

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[1] E. Stahl, "Uber sogenannte Kompasspflanzen," Jenaische Zeitschr. Naturwiss. XIV (1881), pp. 381-389.

so that they bring their laminae perpendicular to the rays of the sun. He was of the opinion that growth conditions are favorable only during the early morning and the late evening.

Bay[2] (1894) pointed out that the phenomenon of the north-south direction of Silphium laciniatum is often mentioned in early American literature.

Mayer[3] (1912) showed that the leaves of Lactuca scariola twist themselves in an effort to secure equal face illumination. This twisting or torsion is due at first to unequal illumination upon the two sides of each leaf. As a result of this unequal illumination two curvatures are produced at different points of the leaf base. These curvatures combine to produce the torsion.

Seybold[4] (1929) proved, by studying the movements of Lactuca scariola, that the leaves of plants rotating on a clinostat were still twisted. For some reason, however, he was unable to detect the north-south orientation of the leaves.

Dolk[5] (1930) made a thorough study of Lactuca scariola.

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[2]J. C. Bay, "On Compass-Plants and the Twisting of Leaves," Bot. Gaz. XIX (1894), pp. 251-252.

[3]A. Mayer, "Uber die Erkarung der Blattstellung von der sogenannten Kompasspflanzen," Jahrb. Wiss. Bot. X (1912), pp. 359-374.

[4]A. Seybold, "Untersuchungen uber die Transpirations-widerstande und uber die agyptisch-arabischer Wustenpflanzen," Planta IX (1929), pp. 270-314.

[5]Herman E. Dolk, "The Movements of the Leaves of the Compass-Plant, Lactuca Scariola," American Journal of Botany, XVIII (1931), pp. 195-204.

Most of the plants were dug out of the ground and grown in pots, while some of his experiments were carried out with plants growing in the open field.

Dolk found that the leaves of plants in the open field show that the direction of the torsions in the different leaves from two plants are fairly constant. This indicates that some internal factor plays a role in the movements of the leaves. The leaves of plants growing in the shade were not oriented but showed the same torsion to a different degree.

In order to determine the circumstances under which torsion appears, Dolk observed young leaves and pointed out that these are distinctly asymmetric with one half of a leaf growing faster than the other half. Due to an epinastic movement which starts in a direction perpendicular to the plane of the former curvature the two movements produce a torsion in the base. This torsion is disturbed by phototropic movements which tend to bring the laminae perpendicular to the light. Therefore, the leavew inserted at the east and west sides have small angles of insertion whereas those on the north and south have the largest.

Several experiments were carried out by Dolk to determine how far it is possible to change the direction of the leaves by changing the light conditions. These plants were grown between two screens so that they could receive only the light

from the north-south or from the east-west direction. In order to determine the reason why the light in the north-south direction is less effective than in the east-west direction, plant growth measurements were made in the morning and in the evening. The plants were found to grow twice as fast during the night as during the day. There was a distinct growth during the middle of the day, however. Dolk concluded that since the total amount of sunlight in the east-west direction is larger than the amount of sunlight in the north-south direction, the leaves assume the north-south direction in order to receive the maximum amount of sunlight.

Schanderl[6] (1932) sought to determine the factors which cause the so-called obligate compass plants to sometimes exhibit orientation other than north-south. Potted plants of Lactuca scariola were placed in artificial habitats. Schanderl found that the north-south position is not obligatory. He concluded that turgor differences and "radiations microclimate" cause the leaves to orientate.

The Problem

The literature just reviewed demonstrates the diversity in opinion among the few investigators as to their findings concerning the so-called "compass plants." There are very

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[6]Hugo Schanderl, "Okologische Untersuchungen an sogenannten Kompasspflanzen," Planta XVI (1932), pp. 709-762.

little experimental data to substantiate the phototropic properties of Silphium laciniatum and Lactuca ludoviciana. While others used artificial conditions principally, this paper uses only natural conditions in the open stand. Other investigators used Lactuca scariola to demonstrate the movement of leaves of the compass plant, while this problem has restricted itself to a thorough and extensive study of Lactuca ludoviciana with a less extensive study of Silphium laciniatum. Not only have the phototropic action of the leaves of Lactuca ludoviciana been studied, but also the phototropic action of the floral head. This investigation has for its aim the determination of the actual angular value of certain bodily organs of Lactuca ludoviciana and Silphium laciniatum under natural conditions, and an interpretation of these values in terms of the points of the compass.

CHAPTER II

FIELD WORK AND DATA

The Plants Used

Lactuca ludoviciana flourishes on the fine sandy loams, the clay loams, and to some extent on the clays of Denton County, Texas. It is found along highways, in fields, and in woodland areas.

A technical description of the plant as given by John K. Small is as follows:

> Lactuca Ludoviciana (Nutt.) DC. Biennial, glabrous. Stems erect, 4-15 dm. tall, paniculately branched above: leaves numerous; blades oblong-oblanceolate to oblong or oblong-lanceolate, 5-20 cm. long, acute or short-acuminate, sinuate-lobed or pinnatifid, spinulose along the margins as well as the midnerve beneath, clasping: peduncles with few scales: heads in close or open panicles: involucres 16-20 mm. high; inner bracts linear-lanceolate, scarious-margined: ligules yellow: achenes brown or black, the body obovate or oval, 4 mm. long, 3-ribbed, the beak fully as long as the body.[7]

The habitat of Silphium laciniatum is rather limited in that this plant is found mainly on virgin Denton stony clay. The surface material of this soil has been slightly altered by water erosion. This is to be expected since Denton stony clay occupies steep slopes and the crests of ridges. This is a prairie type soil usually too stony for farming. It is

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[7]John K. Small, Flora of the Southeastern United States, p. 1316.

valuable only for pasture land. Denton stony clay varies in color from a yellowish-brown to nearly black and varies in depth from two to eight inches. The sub soil is usually yellow while the surface soil is typically brown.

A technical description of this plant as given by John K. Small is as follows:

> Silphium laciniatum L. Stems stout, 1-3.5 m. tall, coarsely hispid. Leaves mainly basal; blades 1-4 dm. long, the segments lanceolate to linear, entire or pinnatifid, the dilated bases of the petioles often pinnatifid: heads showy: involucres 2-2.5 cm. high; bracts broadly lanceolate or ovate-lanceolate, 2.5-4 cm. long: ray-flowers numerous; ligules yellow, 3-5.5 cm. long: achenes oval to suborbicular, about 10 mm. long, narrowly winged, each with a shallow notch at the top.[6]

Field Work

The principal working paraphernalia consisted only of a Taylor Magnapole compass which indicates directions and measures angles in degrees. Zero degree on this compass is taken as north.

The field work was done during the summers of 1940 and 1941. The procedure consisted of s tudying various quadrats of the plants located in and near Denton, Texas, throughout the entire growing season. The compass was used in each study by holding it beneath, above, or to one side of each leaf or flower head studied.

The first work was done on the John Underwood farm, three

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[6] Ibid., p. 1242.

miles southwest of Denton. A total of three hundred fifteen young plants of Lactuca ludoviciana were used. The general direction of each flower head was determined by holding the compass directly beneath in such position that the stem of the head was parallel with the needle of the compass. Different groups of the three hundred fifteen plants were observed at various times during the day and various days during the latter part of July, 1940. A summary of the data obtained is shown in Table 1, page 13.

During the first week of August, 1940, the flower heads of fifteen plants of Lactuca ludoviciana were labeled and observed three times a day for seven consecutive days. The direction in degrees assumed by each flower head was determined by holding the compass in such position that the stem of the flower head was directly above the compass. The data obtained are given in Table 2, page 14.

The remainder of the field work was done during the summer of 1941. The first plants observed and checked were of the species Silphium laciniatum. One quadrat of these plants was studied extensively and thoroughly at this time. This quadrat is located about six miles west of Denton on the old Krum highway. The plants were young and exhibited only individual leaves as far as could be determined from their appearance above the ground. One hundred leaves were labeled with a number and the orientation of each leaf was determined

in degrees by holding the compass to one side of the vertical leaf and thus estimating the angle. Table 3, page 17, shows the results obtained by observing one hundred leaves at various times during the day for two consecutive days.

The first field work regarding the phototropic effects on the leaves of Lactuca ludoviciana for this year was done June 11, 1941, during the hours of ten and eleven in the morning. Twenty-five typical plants located in the open field were observed and measured. Since the leaves of this plant are twisted at the base in such manner as to place the leaves in a vertical position, the compass was held directly beneath the lower edge of each leaf. Thus, the angles of the leaves were not estimated, but were accurately measured in degrees. As in other phases of this investigation zero degree represents north. In Table 4, page 21, are recorded the directions of all the leaves of twenty-five plants of Lactuca ludoviciana.

The field work was completed June 16, 1941. The concluding observations and measurements were made as a check on previous work. A total of three hundred forty-five flower heads of Lactuca ludoviciana were observed. These plants were in three different quadrats located in different sections of Denton County. The data shown in Table 5, page 22 compare favorably with the results in Table 1.

Table 6, page 22, shows the angle of the northernmost

edge of each of fifty-six leaves of Silphium laciniatum. These plants were found in the same locality as were those observed in the former part of this investigation. Due to the limited number of these plants found growing during the summer of 1941, only a limited quantity of work could be done on Silphium laciniatum.

CHAPTER III

INTERPRETATIONS, SUMMARY, AND CONCLUSIONS

Discussion

In order to evaluate the accuracy of nature in revealing the points of the compass in living species of plants, a thorough s tudy was made of the angle of the floral heads and the leaves of Lactuca ludoviciana. A less extensive study was made of Silphium laciniatum.

According to the data in Table 1, two hundred eighteen of the flower heads of Lactuca ludoviciana point northwest, forty-two north, forty-one west, ten southwest, two northeast, and one east. These facts show that the flower heads generally point in the northwest direction. The plant from this standpoint then is not a true compass plant. However, the fact that the floral head so often points to the northwest signifies that nature is somewhat accurate, and that this direction might as well be relied upon as the true north position.

Observations made upon Table 2 indicate that there is no definite scheme of orientation of the flower heads during the day. This is not the case as is exhibited by the leaves of some plants. Of a possible one hundred five changes in direction between eight o'clock in the morning and noon, sixty remained unchanged, twenty-four bent toward the sun,

TABLE I

THE NUMBER OF FLOWER HEADS THAT POINTED IN EACH DIRECTION AT VARIOUS TIMES (LACTUCA LUDOVICIANA)

Direction Pointed	Date			
	July 15, 1940		July 27, 1940	
	7 A. M. (89)*	11:30 A. M. (95)	2 P. M. (76)	8 P. M. (60)
Northwest	60	58	55	45
North	7	13	17	5
Northeast	0	2	0	0
East	0	1	0	0
Southeast	0	1	1	1
South	0	2	0	1
Southwest	2	5	0	3
West	20	13	3	5

*The number in parentheses shows the number of the flower heads checked at that time.

TABLE 2

THE DIRECTION OF THE FLOWER HEAD OF EACH PLANT AT VARIOUS TIMES OF THE DAY FOR SEVEN CONSECUTIVE DAYS

Plants	Dates								
	Thursday			Friday			Saturday		
	8 A. M.	12 M.	7 P. M.	8 A. M.	12 M.	7 P. M.	8 A. M.	12 M.	8 P. M.
1	330	330	330	330	330	330	345	330	330
2	345	345	340	340	340	330	330	330	330
3	315	315	315	315	330	330	330	315	315
4	345	345	330	345	345	345	0	345	345
5	330	330	330	330	330	330	330	330	330
6	60	60	55	45	45	45	45	45	45
7	345	345	345	345	330	330	330	330	330
8	330	330	330	330	330	330	345	345	345
9	220	250	280	315	330	270	330	315	330
10	345	345	350	345	345	340	340	340	345
11	330	335	330	315	330	330	335	330	346
12	290	315	315	285	300	300	300	300	285
13	315	315	315	315	315	300	315	315	315
14	0	0	0	345	345	0	345	0	355
15	270	270	270	300	315	300	315	315	315

TABLE 2--Continued

Dates											
Sunday			Monday			Tuesday			Wednesday		
8 A. M.	12 M.	7 P. M.	8 A. M.	12 M.	7 P. M.	8 A. M.	12 M.	7 P. M.	8 A. M.	12 M.	7 P. M.
350	345	330	345	330	330	330	345	330	330	330	330
330	330	330	330	330	315	325	330	315	330	330	325
300	315	300	315	300	330	315	315	300	315	330	300
345	330	330	345	345	345	330	330	330	345	345	330
330	330	330	345	345	345	340	330	330	330	330	345
45	45	60	60	60	60	60	60	60	60	50	50
340	345	340	345	330	330	345	345	330	330	330	340
330	330	330	330	330	330	330	330	330	330	315	330
315	315	315	315	315	315	300	315	300	315	315	315
350	345	345	345	345	345	345	350	345	345	340	345
330	340	330	330	345	330	330	330	325	330	330	330
285	285	285	270	300	285	270	285	255	270	285	270
325	310	315	315	340	330	330	315	315	315	315	300
0	345	345	345	350	350	0	0	350	350	350	355
330	315	315	315	313	300	300	330	315	300	315	300

and twenty-one turned away from the sun. Of the same possible number of changes between noon and seven o'clock in the afternoon, sixty-two remained unchanged, thirty-two bent toward the sun, and eleven turned away from the sun. These facts show that fifty per cent do not orient themselves during the day, and about as many orient themselves away from as do toward the sun.

The leaves of Silphium laciniatum behave similarly to the leaves of Lactuca ludoviciana in that they do not orient themselves according to the position of the sun, but generally remain in the same position throughout the day. Table 3 illustrates this fact very clearly in terms of one hundred leaves observed three times a day for two consecutive days.

Of the one hundred fifty-six leaves of Silphium laciniatum observed and recorded in Table 3, sixty-six were oriented to a true north-south position, eighty-three pointed nearly to the north, and only the seven remaining ones varied as much as forty-five degrees either to the east or to the west. The angle of the edge of the leaf nearer the north was always measured since the leaves were in a true vertical position with respect to the surface of the earth. The data then shown in Tables 5 and 6 substantiate the fact that Silphium laciniatum is more nearly a compass plant than is Lactuca ludoviciana.

TABLE 3

THE DIRECTION IN DEGREES OF EACH LEAF OF EACH SILPHIUM LACINIATUM AT VARIOUS TIMES FOR TWO DAYS

Plant	Sunday			Monday		
	8 A. M.	12 M.	7 P. M.	8 A. M.	12 M.	7 P. M.
1	15	0	15	15	15	15
2	30	30	30	30	30	30
3	0	0	0	0	0	0
4	0	0	0	0	0	345
5	30	30	30	30	30	30
6	15	15	0	0	0	0
7	330	330	330	330	345	340
8	0	330	345	0	330	345
9	0	0	0	0	345	345
10	330	315	315	315	330	330
11	315	315	315	315	330	330
12	315	315	330	330	330	330
13	0	0	0	0	0	0
14	330	330	330	345	345	345
15	0	0	0	0	0	0
16	30	30	30	30	30	30
17	330	330	330	330	330	330
18	315	315	315	330	330	330
19	15	15	15	15	15	15
20	330	330	330	330	345	345
21	315	330	315	315	330	315
22	45	45	45	45	45	45
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	15	15	15
26	315	315	315	315	330	330
27	330	330	315	330	330	330
28	0	345	345	345	0	0
29	330	330	330	330	345	345
30	315	315	315	315	315	330
31	0	0	0	0	0	0
32	15	15	15	15	0	15
33	0	0	0	0	0	0

TABLE 3-- Continued

Plant	Sunday			Monday		
	8 A. M.	12 M.	7 P. M.	8 A. M.	12 M.	7 P. M.
34	15	15	15	30	30	30
35	0	0	0	0	0	0
36	0	0	15	15	0	0
37	0	0	0	15	0	0
38	15	15	15	15	15	15
39	330	330	330	330	345	345
40	15	15	15	30	30	30
41	0	0	0	0	15	15
42	45	45	45	45	45	45
43	330	330	330	330	330	330
44	15	15	15	30	30	30
45	315	315	315	315	330	330
46	45	45	45	45	40	45
47	0	0	0	0	0	0
48	15	0	0	15	0	0
49	0	0	0	0	0	0
50	0	0	15	15	0	0
51	0	0	0	0	0	0
52	0	0	0	0	0	0
53	0	0	0	0	0	0
54	45	45	45	45	45	45
55	330	330	330	330	330	315
56	330	330	330	330	330	315
57	330	330	330	330	330	330
58	0	0	0	0	0	0
59	0	330	330	330	330	330
60	0	0	0	0	0	0
61	30	30	30	30	15	15
62	0	0	0	0	0	345
63	0	0	15	15	15	15
64	15	15	15	30	30	15
65	15	15	15	15	15	0
66	0	0	0	0	0	0
67	0	0	0	0	0	0

TABLE 3--Continued

Plant	Sunday			Monday		
	8 A. M.	12 M.	7 P. M.	8 A. M.	12 M.	7 P. M.
68	0	0	15	15	0	0
69	0	0	0	0	345	345
70	345	345	330	345	330	330
71	0	0	345	345	345	345
72	0	0	0	15	0	0
73	0	0	0	0	0	0
74	15	15	15	15	15	15
75	0	0	0	15	0	0
76	0	0	0	15	15	0
77	330	330	330	345	345	345
78	300	300	300	300	300	300
79	330	330	330	345	345	345
80	0	0	0	0	0	0
81	0	0	0	0	0	0
82	330	330	330	345	345	345
83	30	30	30	30	30	30
84	0	0	0	15	0	0
85	45	45	45	45	45	45
86	345	345	345	345	345	345
87	0	0	0	15	0	0
88	15	15	15	15	15	15
89	0	0	0	0	0	0
90	30	30	30	30	30	30
91	330	330	330	330	330	330
92	15	15	15	30	30	30
93	0	0	0	0	0	0
94	0	0	0	0	345	0
95	330	330	330	345	345	345
96	0	0	0	0	345	345
97	45	45	45	45	45	45
98	0	0	0	0	0	0
99	30	30	30	30	30	30
100	0	0	0	0	0	0

Table 4 shows the position of all the leaves of twenty-five Lactuca ludoviciana plants located and studied in the open field in various quadrats. According to measurements these leaves point in all directions. This seems to be due to the whorled arrangement of the leaves and to the lack of their orientation in regard to sunlight. Of the six hundred twenty-three leaves of the twenty-five plants studied intensively, only thirty-nine point north and twenty-nine point south. Due to the fact that the leaves of a true compass plant orient themselves to a north-south position, and since the leaves of this plant point approximately equally in every direction, this species of Lactuca is seemingly not a true compass plant. The phototropic effects, however, are similar in that the leaves are vertical, but are unlike in regard to the direction of the leaves.

An inspection of Table 5 reveals the position of the flower heads of Lactuca ludoviciana plants in three different quadrats as determined during the summer of 1941. This further study was carried out in order to check on the similar previous study made during the summer of 1940. The data in this table check very favorably with those in Table 1. Evidently, the phototropic effects had not been altered in any way by environmental factors due to different seasons.

TABLE 4

THE NUMBER OF LEAVES ON EACH LACTUCA LUDOVICIANA THAT HAS EACH DIRECTION (ANGLE)

Direction of Leaf in Degrees	Plants																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
0	3	2	0	0	2	2	2	0	2	1	0	2	1	1	2	2	1	3	2	1	1	3	2	1	3
15	1	3	0	2	0	1	2	0	0	0	1	1	0	0	0	3	0	0	0	1	0	0	0	0	0
30	0	0	1	0	2	2	0	2	0	1	1	0	1	2	1	1	0	2	3	1	0	1	1	3	2
45	1	1	0	2	0	1	2	2	1	3	1	1	4	2	0	1	0	1	1	2	1	3	3	2	2
60	1	1	0	1	2	1	2	2	1	0	2	1	1	2	0	1	1	2	1	1	0	1	2	1	0
75	1	1	0	2	0	1	1	1	1	1	2	1	2	2	0	2	1	2	0	1	1	3	2	0	0
90	1	0	1	0	1	1	1	1	2	0	0	1	1	0	1	1	1	2	5	3	0	1	0	0	0
105	0	0	0	1	2	0	1	0	1	2	1	0	1	1	1	2	1	0	1	0	1	0	1	0	1
120	0	0	1	1	1	0	0	1	1	0	2	1	0	2	1	0	1	2	0	1	3	3	0	0	1
135	0	2	0	1	2	0	0	4	0	1	1	1	5	2	1	1	1	0	2	1	3	1	1	3	1
150	2	1	0	0	0	1	2	1	0	0	2	1	0	1	0	3	1	2	2	1	0	3	1	0	0
165	1	0	0	0	1	4	1	0	1	0	1	1	0	1	1	2	1	3	3	1	2	0	2	0	4
180	0	1	0	2	1	1	1	0	2	1	0	2	0	1	2	1	1	1	0	1	2	3	2	1	1
195	1	1	0	1	1	0	1	1	1	0	0	1	0	1	0	1	1	0	1	3	2	0	2	0	2
210	1	0	0	1	1	1	0	1	0	1	1	0	1	1	1	2	1	2	1	1	1	1	2	1	1
225	0	0	0	1	1	2	3	1	0	1	0	1	0	1	2	2	1	1	1	2	0	1	1	1	2
240	2	0	2	1	3	1	0	1	0	1	1	1	1	0	0	0	1	0	1	1	0	4	0	1	0
255	0	1	2	0	1	2	1	1	1	1	1	1	0	1	3	1	1	0	1	1	0	0	0	1	1
270	1	2	1	2	1	2	0	1	1	0	1	1	2	0	1	0	1	2	1	1	0	2	1	1	2
285	1	1	0	4	2	1	3	0	2	3	1	1	1	1	0	0	1	0	1	0	0	4	0	2	0
300	3	0	0	0	1	5	2	3	1	2	0	1	1	1	1	1	0	2	0	1	1	0	1	2	1
315	0	2	0	2	3	1	1	2	1	0	1	0	1	0	1	0	1	1	1	0	2	2	2	0	2
330	2	0	1	1	1	2	1	0	1	2	0	0	2	1	0	1	0	0	0	2	1	4	1	2	2
345	0	1	0	0	1	2	1	0	1	0	1	0	1	1	0	0	0	0	0	2	2	2	0	1	0

TABLE 5

THE NUMBER OF FLOWER HEADS IN QUADRATS ONE, TWO, AND THREE, THAT POINTED IN EACH DIRECTION (LACTUCA LUDOVICIANA)

Direction of Flower Head	Plants		
	Quadrat 1	Quadrat 2	Quadrat 3
0	13	8	11
15	2	4	0
30	5	6	1
45	2	6	1
60	2	5	2
75	3	4	0
90	2	4	0
105	0	4	0
120	1	2	6
135	1	0	3
150	1	2	1
165	3	0	2
180	3	0	7
195	1	1	0
210	3	2	7
225	1	4	10
240	2	0	7
255	3	2	8
270	9	4	13
285	5	5	14
300	9	5	23
315	6	10	20
330	15	5	11
345	6	6	10

TABLE 6

DIRECTION IN DEGREES OF A QUADRAT OF SILPHIUM LACINIATUM LEAVES

Directions	0	15	30	300	315	330	345	All Others
Number of Leaves	17	6	5	4	7	9	8	0

SUMMARY

1. A study of the so-called compass plants Lactuca ludoviciana and Silphium laciniatum was made with the aim of determining the phototropic effects on the leaves of both plants, and the flower heads of the former.

2. The plants used are typical of Denton County, Texas, and were observed in and near the city of Denton.

3. All the work was done under natural conditions and in the open field.

4. The work was extended through two growing seasons, the data of the second serving as a check on the first.

5. The positions of the leaves of both plants were determined in degrees by means of a compass.

6. The same procedure was used in determining the angular positions of the flower heads of Lactuca ludoviciana.

7. The recordings were made in the morning, at noon, and in the evening to determine whether the leaves or flower heads oriented themselves during the day.

8. Plants of all ages were used in this investigation in order to determine whether the phototropic properties are altered in any way by the age of the plant.

Conclusions

In that the leaves of the so-called compass plant Lactuca ludoviciana point in all directions rather than only

to the north and south, this plant is seemingly not a true compass plant. The leaves, however, are affected by phototropic conditions to the extent that they are twisted at the base and assume a vertical position with respect to the earth.

The floral heads of Lactuca ludoviciana, due to phototropic effects, generally point in a northwest direction. There is a more marked tendency on the part of the floral head to point north than do the leaves of the same plant.

Silphium laciniatum is seemingly a true compass plant in that the laminae of about fifty per cent of the leaves assume a true north-south position and less than five per cent assume a position which varies as much as forty-five degrees either to the east or to the west.

The leaves of both plants assume a vertical position to the earth presumably to acquire more light early in the morning and late in the afternoon.

BIBLIOGRAPHY

Britton, Nathaniel Lord, and Brown, Addison, Illustrated Flora of the United States, Canada, and the British Possessions, Vol. III, New York, Charles Scribner's Sons, 1898.

Dolk, Herman E., "Movements of the Leaves of the Compass-Plant Lactuca Scariola," American Journal of Botany, XVIII, 1931, pp. 195-204.

Holman, Richard M., and Robbins, Wilfred W., General Botany, New York, John Wiley & Sons, Inc., 1938.

House, Homer D., Wild Flowers, New York, Macmillan Co., 1935.

Hylander, Clarence J., The World of Plant Life, New York, Macmillan Co., 1939.

Loonsberry, Alice, and Rowan, Ellis, Southern Flowers and Trees, New York, Frederick A. Stokes Co., 1901.

Meyer, Bernard S., and Anderson, Donald B., Plant Physiology, New York, D. Van Nostrand Co., Inc., 1940.

Palladin, Vladimir I., and Livingston, Burton E., Plant Physiology, Philadelphia, P. Blakiston's Son & Co., 1926.

Peirce, George James, Physiology of Plants, New York, Henry Holt & Co., 1926.

Quinn, Vernon, Leaves Their Place in Life and Legends, New York, Frederick A. Stokes, 1937.

Schanderl, Hugo, "Okologische Untersuchungen an sogenannten Kompassflanzen," Zeitschw. Wiss. Biol. Abt. E. Planta 16(4): pp. 709-762, 1932.

Schulz, Ellen D., Texas Wild Flowers, Chicago, Laidlaw Brothers, 1928.

Small, John K., Flora of the Southeastern United States, New York, John K. Small, 1903.

Swingle, Deane B., A Textbook of Systematic Botany, New York, McGraw-Hill Book Co., 1928.

Thomas, Meirion, Plant Physiology, Philadelphia, P. Blakiston's Son & Co. Inc., 1935.

Vines, Sydney H., Textbook of Botany, New York, Macmillan Co., 1902.