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A Study Of Ecotypes In Vernonia Gigantea Gigantea (Compositae)

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A STUDY OF ECOTYPES IN VERNONIA GIGANTEA GIGANTEA (COMPOSITAE)

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ABSTRACT: *Vernonia gigantea* (Walt.) Trel. ssp. *gigantea* is distributed throughout the Eastern United States. It ranges from eastern Texas to northern Florida and northward to southeastern Nebraska and southern New York. *Vernonia gigantea* ssp. *gigantea* exhibits weak correlation with a latitudinal gradient. Reciprocal transplant experiments were carried out using cloned pairs of plants from different areas of the taxon's range to determine if this correlation is due to genetic differences or to environmental factors. Differences in flowering response between northern and southern populations were noted in the garden transplants. An experimental crossing program was carried out among individuals from different localities in order to determine whether reproductive isolating mechanisms existed among populations.

The genus *Vernonia* contains about 1,000 species and occurs on all but the European continent. There are approximately 20 species of *Vernonia* in the United States, most of which grow east of the one-hundredth meridian. *Vernonia gigantea* ssp. *gigantea* (hereafter referred to as *V. gigantea)* occurs from northern Florida to eastern Texas northward to New York and southeastern Nebraska. It is distributed across 12° of latitude and would be subjected to different environmental factors in various parts of its range.

One objective of this study was to determine the pattern of morphological variation along a north-south transect and to carry out reciprocal transplant experiments to determine if this variation is due to genetic differences or to environmental modification. Additionally, possible differences in flowering response among populations were determined.

METHODS AND MATERIALS

Morphological measurements were made on population samples (which normally consisted of 25 plants each in full flower) collected along a north-south geographical transect (Table 1). The following nine characteristics were scored or measured for each plant of every sample: (1) number of flowers per head; (2) mid-cauline leaf width; (3) mid-cauline leaf length; (4) inner bract width; (5) pappus color; (6) involucre length; (7) involucre width; (8) stem glaucousness; and (9) pubescence.

To determine the effects of northern and southern environments on plants from different localities, clones of *Vernonia gigantea* were secured by dividing the underground perennial rootstocks. One member of each clonal pair was planted in a transplant garden at Athens, Georgia and the other in a

TABLE 1. Source of Specimens for Morphological Analysis

Taxon	Collection or Accession Number[1]	Locality
Vernonia gigantea ssp. *gigantea*	U112	Hale County, Alabama
	U125	Clay County, Georgia
	U9	Harrison County, Indiana
	U12	Lawrence County, Indiana
	U13	Owen County, Indiana
	U15	Fountain County, Indiana
	U7	Larue County, Kentucky
	15899	Warren County, Kentucky
	F4	Union County, Mississippi
	15200	Jasper County, Mississippi
	U1	Coffee County, Tennessee
	U2	Sumner County, Tennessee

garden at Osage, Iowa. The dates of first floret anthesis were recorded, and at the end of the growing season plants were harvested, pressed, dried, and scored.

Plants from the different localities throughout most of the taxon's range were transplanted to a greenhouse for crossing experiments. The transplants were intercrossed in the combinations shown in Table 2. All taxa were found to be self-sterile, so that the crosses could be made by rubbing the heads of the inflorescences together daily for the duration of anthesis. Five weeks were allowed for the maturation of seed, and four to six months were required to produce flowering hybrids. Fertility of the parental plants and hybrids was measured by differential staining of mature pollen in 1% aniline blue in lactophenol for 24 hours. At least 200 grains from each plant were scored. Those which stained dark blue were considered to be fertile, whereas those that stained lightly or not at all were judged infertile.

Meiosis was examined in the parents and in at least one hybrid from all but one cross. Buds were fixed for approximately 20 min. in Carnoy's

[1]Collectors: U indicates Urbatsch; F indicates Faust; no letter indicates collection number or accession number of Jones.

TABLE 2. Reciprocal F_1 Crosses Made with *Vernonia gigantea* from Different Localities

Source of Parental Plants	Cytogenetical Observations	Pollen Stainability	
		Number of Plants Examined	Mean
Baldwin Co., Ala. X	n=17II, N	14	98.6
Jackson Co., Ark.	n=17II, N	8	88.9
Lawrence Co., Ark. X	n-17II, N	11	98.8
Warren Co., Ohio	n=17II, N	11	97.8
Lawrence Co., Ark. X	n=17II, N	6	97.9
Owen Co., Ind.		1	98.5
Gwinnett Co., Ga. X		9	97.7
Warren Co., Ohio		6	98.2
Sumner Co., Tenn. X	n=17II, N	13	99.2
Hardin Co., Ky.		10	99.2
Sumner Co., Tenn. X	n=17II, N	13	94.3
Lawrence Co., Ind.	n=17II, N	13	97.5
Sumner Co., Tenn. X	n=17II, N	10	99.6
Fountain Co., Ind.		12	99.3
Lawrence Co., Ind. X		9	99.3
Maries Co., No.	n-17II, N	8	99.4
Cape Giradeau Co., Mo. X	n=17II, N	11	97.8
Warren Co., Ohio	n=17II, N	13	97.7

solution (4 parts chloroform: 3 parts ethanol:1 part acetic acid) and then squashed in aceto-carmine.

RESULTS

Analysis of morphological characteristics of the field-collected samples showed that differences in leaf width and leaf length existed among the populations (Fig. 1). Southern populations have narrower and shorter leaves than northern populations. The transplant studies revealed that three of eleven clonal pairs grown in Iowa had considerably wider leaves than their counterparts grown in Georgia, six of eleven pairs in Iowa had slightly wider leaves, and in two cases the clonal pairs grown in Iowa had slightly narrower

[1]N = meiosis appeared normal

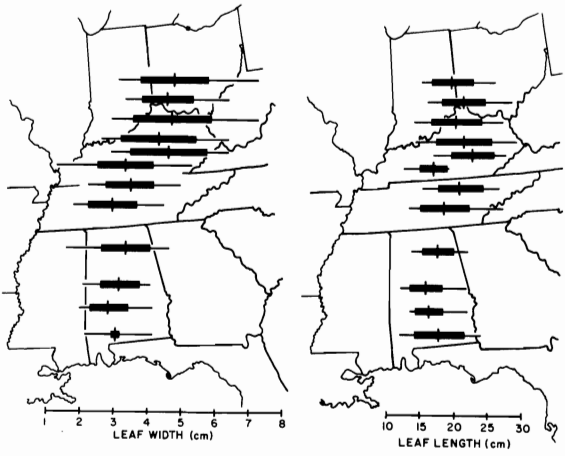

Figure 1

Comparison of leaf width and leaf length in *Vernonia gigantea* along a geographical transect. The vertical line represents the mean; the horizontal line represents the range; the horizontal bar represents ± one standard deviation from the mean. Values were obtained from measurements made on 25 individuals from population samples listed in Table 1.

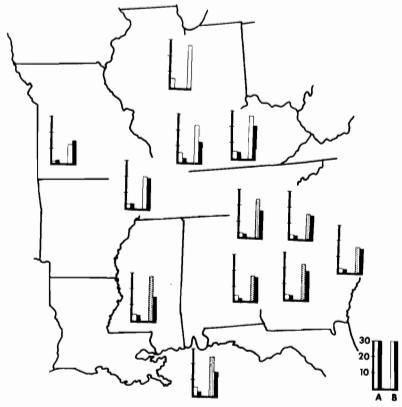

Figure 2

The variation in two morphological characteristics between clonal pairs grown in Iowa and Georgia transplant gardens. The ordinate scale for leaf width (A) and leaf length (B) is in centimeters. Black bars represent the clonal member grown in Georgia; white bars represent the clonal member grown in Iowa. Stippled bars indicate plants which did not flower in the Iowa transplant garden. Missing bars indicate plant parts missing at collection time. The graphs are placed on the map at positions corresponding to the collection site.

leaves than those grown in Georgia (Fig. 2). Analysis of differences in leaf length revealed that six of eleven clones grown in Iowa had considerably longer leaves, four of eleven had slightly longer leaves, and one had shorter leaves as compared with their clonal members grown in Georgia. One plant could not be scored since it had been stripped of its leaves.

Initial flowering dates and the daylength at these dates for each member of each clonal pair are compared with the growing period of the respective collection site in Table 3. Daylength determinations at the transplant sites at the time of anthesis were made using United States Naval Observatory Sunrise-Sunset Tables. The approximate lengths of the growing period at each collection site were determined from Visher (1954). Clones from northern collection sites flowered as much as six weeks earlier in the Georgia transplant garden than those from southern collection sites. Plants from southern collection sites grown in Iowa developed buds which had not flowered at the time the plants were harvested (October 1, 1969). Plants from northern collection sites reached anthesis throughout the middle of September in Iowa.

The results of the hybridization experiments suggested that breeding barriers probably do not exist between populations of *Vernonia gigantea* since all crosses attempted produced vigorous, F_1 hybrids. Pollen stainability in all hybrids was greater than 88% and no chromosomal aberrations were observed in the meiotic figures of the hybrids examined (Table 2).

DISCUSSION

The *Vernonia gigantea* clones used in this experiment were distributed over 10° (31° to 41°) latitude and, consequently, grew in habitats differing in daylengths, length of growing period, temperature extremes, edaphic factors, and undoubtedly in a multitude of other parameters.

The earlier flowering times of northern ramets in the southern transplant garden and the non-flowering of southern ramets in the northern transplant garden suggest that ecotypic differences exist within *Vernonia gigantea* in this regard. The data suggest that this flowering phenomenon is not due solely to photoperiodism. For example, the Maries County, Missouri collection began flowering in Iowa when the daylength was 11 hr. 58 min. while its counterpart in Georgia commenced blooming when the daylength was 13 hr. 57 min. Correlation of the flowering response of the clones with the growing period of their respective collection sites suggests that ecotypes are probably adapted to different lengths of growing seasons. Although the times of spring activity in the transplants were not recorded, it seems evident that the northern populations are adapted to a shorter growing period while the southern ones require more time to reach maturity.

It has been demonstrated by McMillan (1965, 1967) that southern populations of *Andropogon* are adapted to late maturity and a long frost-free

Table III. A Comparison of Growing Period at Collection Site with Date and Daylength at Times of Initial Flowering for *Vernonia gigantea* Grown in Iowa and Georgia Transplant Gardens

Collection Number*	Collection Site	Degrees Latitude	Growing Period[1]		Date of Initial Flowering		Daylength at Initial Flowering	
					Iowa	Georgia	Iowa	Georgia
U15	Fountain County, Indiana	41	158	ca.	10/10	7/6	10 hr 27 min	14 hr 20 min
U12	Lawrence County, Indiana	39	158	ca.	9/10	7/26	11 hr 58 min	13 hr 59 min
U53	Maries County, Missouri	38	173	ca.	9/10	7/27	11 hr 58 min	13 hr 57 min
U5	Hardin County, Kentucky	38	188	ca.	9/10	7/6	11 hr 58 min	14 hr 20 min
15909	Chatooga County, Georgia	34.5	188		Buds[2]	8/21	----------	13 hr 12 min
15734-1	Gwinnett County, Georgia	34	204		Buds	8/26	----------	13 hr 05 min
15347-1	Gwinnett County, Georgia	34	204		Buds	8/22	----------	13 hr 12 min
15347-3	Gwinnett County, Georgia	34	204		Buds	8/22	----------	13 hr 12 min
15347-4	Gwinnett County, Georgia	34	204		Buds	8/22	----------	13 hr 12 min
U60	New Madrid County, Missouri	37	204		Buds	8/17	----------	13 hr 22 min
2283	Forrest County, Mississippi	31	255		Buds	8/26	----------	13 hr 05 min
1	Baldwin County, Alabama	31	255		Buds	8/15	----------	13 hr 25 min
	Athens, Georgia Transplant Garden	34	204					
	Osage, Iowa Transplant Garden	41.5	143					

* Collectors: U indicates Urbatsch; no letter indicates collection or accession number of Jones.

[1] Length of growing season is defined as the average number of days in which temperature is above 28° F. (Visher, 1954).

[2] Buds at the time of harvest, October 1, 1969.

period, while northern populations have an earlier maturity. McMillan (1965, 1967) further reported that the region south of a line extending from Virginia westward across the Texas panhandle is one with a daily mean temperature never dropping below 35° F. Directly north of this line is a very narrow band in which two late winter and early spring months are required for the daily mean temperature to rise to 35° F. North of this narrow band is a broad belt in which the daily mean temperature reaches 35° F. in late spring over a relatively short period. The data suggest that this steep climatic gradient appears significant in the geographic separation of northern, early-maturing ecotypes from southern, later-maturing ones in *Vernonia gigantea.* If, in fact, these ecotypes exist, there must be strong selection for them since they are maintained in the absence of reproductive barriers. Although experimental evidence is lacking, the seeds of *V. gigantea* can be fairly easily dispersed by wind currents, and since the plants are obligate out-crossers ample opportunity for gene exchange is expected among populations. The evidence suggests that ecotypic differentiation may account, in part, for the widespread distribution of this taxon. A more comprehensive study, including the growth of plants in controlled environments along with a larger sample of plants in transplant gardens, is necessary to give further support to these hypotheses.

The data in this study suggest that the smaller leaves of the southern populations are due to environmental modification and not to genetic differences. Typically, vegetative characteristics, such as leaf size, are easily modified by the environment (Clausen, 1951). However, in this study two clones grown in Georgia had slightly larger leaves than their counterparts in Iowa. Because of these exceptions and the small size of the sample, no definite conclusions can be drawn at this time regarding the basis for the differences in leaf size between northern and southern populations of *Vernonia gigantea.*

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