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THE ACID RANGES OF SOME SPRING-FLOWERING HERBS WITH REFERENCE TO VARIATIONS IN FLORAL COLOR

By REXFORD F. DAUBENMIRE

It is of common knowledge, derived from even limited field observation, that color in the petals of many of our native flowers is quite variable. Where these variations seem constant, and are accompanied by other characters, taxonomists use color as one of the bases of species differentiation. On the other hand, some species, such as *Phlox divaricata*, treated in this paper, show gradations in floral color from pure white through blue and lavender to pink; these variations are evidently unaccompanied by other constant characters which might indicate racial differences.

While it is usual for flowers pigmented by anthocyanins to vary in shades of color, it is seldom that yellow floral color is found varying. Bartlett (2) reports a variation in *Gratiola aurea*, and suggests that this variation is due to the genetic constitution of the plants. The species would illustrate an instance of duplicate genes having a cumulative effect. The bright yellow color denotes the presence of two color genes, only one of which is present in a more faded type of color, and none are present in the white forms. Cockerell's (4) account of a sunflower with rays prominently marked with red is another interesting variation from the customary constancy of yellow colors. The latter instance seems one of mutation, in the light of results obtained from the observation of the genetic behavior of the sport.

The remarkable tendency of some of these plants in retaining their particular color type favors a genetic explanation of such variations. The writer collected specimens of the tuberous roots of *Delphinium tricorne* during the normal flowering season and, keeping each color type separated from the others, planted the tubers in beds. The following spring each group of plants displayed colors which were evidently identical to what they were before being transplanted into a very different type of soil.

A similar instance of such constancy was related to the writer by Mr. Charles C. Deam, of Bluffton, Indiana, who has a specimen of the white type of *Phlox divaricata* in his botanical gardens which has retained its

original color each of the six or seven years since it was transplanted into the garden.

It is questionable as to whether such albino form should be merely mentioned in species descriptions, or whether they should be given the rank of form, variety, or even species. Plants such as *Campanula americana*, *Scutellaria canescens*, *Impatiens pallida*, *Prunella vulgaris* and *Vernonia altissima*, have, in the writer's observation, albino forms. That *Vernonia* may show an intermediate stage between the purple and white forms (3) is further evidence to support the theory of color being due in some species to duplicate genes having cumulative effect.

Quite a contrast to the previously named instances of color constancy is the note of Fernald (6), who observed an irregular annual change in the color of the petals of *Hepatica* plants which he had transplanted into his garden. This writer expressed a belief that the varying amounts of leaf mulch with which he treated the plants each year might have caused such changes.

The matter of a chemical difference in substratum being responsible for different floral colors has been repeatedly demonstrated by several workers, notably, Molisch, 1897 (7), Atkins, 1923 (1), and Coville, 1924 (5), all of whom found that the addition of aluminum sulphate to soil produced acid conditions which resulted in pink floral color in *Hydrangea* in contrast to the blue color of such plants on neutral or alkaline soils.

It was thought that, in a study of several native flowers, a parallel instance to the foregoing works might be found, namely, one in which the soil reaction would influence floral color indirectly by its affect on the solubility of certain chemicals in the soil, as was especially noted in Atkins' paper. Since it has been found that the acidity of the cell sap within the petals also may control the litmus-like reaction of the anthocyanins, it was suspected that an instance might be found wherein soil reaction may have a bearing upon the sap acidity and hence affect color differences.

The present paper contains the results of an attempt to demonstrate a possible correlation between the acid ranges of the soils of some spring-blooming herbs found in Indiana, whose floral variations were striking, with the extreme color types. Only the soil actually clinging to the roots of the plant when dug was used, and only those specimens of each species were selected for study which demonstrated extremes of the particular type. It was intended in collecting to obtain several

specimens from widely separated parts of the state and from different habitats in each locality. The pH ranges of each color type for each species is presented with other summarized data in the following table. The reaction values were determined by the quinhydrone method:

SUMMARY OF DATA DERIVED FROM 249 SOIL SAMPLES

SPECIES	No. of Counties	Color Forms	No. of Samples	Acid Range	pH Scale			
					5.0	6.0	7.0	8.0
Phlox <i>divaricata</i>	8	Pink	31	6.1-7.9			—————	—————
		Blue	31	5.3-8.0	—————	—————		
		White	19	5.7-7.8		—————		
Phlox <i>bifida</i>	1	Pink	12	6.1-7.1			—————	
		Lavender	8	6.1-8.1			—————	—————
		Blue	4	6.3-6.5			—	
		White	3	6.7-7.5				—————
Tradescantia <i>brevicaulis</i>	4	Pink	11	5.1-6.1	—————			
		Purple	10	5.0-6.4	—————			
		Blue	18	4.9-7.4	—————	—————		
Dodocatheon <i>meadia</i>	1	Pink	10	5.0-6.4	—————			
		White	10	5.0-5.9	—————			
Delphinium <i>tricorne</i>	3	Blue	18	6.4-6.9			—————	
		Blue and White	17	6.0-7.3			—————	
		White	18	6.3-6.9			—————	
Hepatica <i>acutiloba</i>	3	Blue	7	5.5-7.5			—————	
		White	11	5.4-7.7			—————	
Lupinus <i>perennis</i>	1	Blue	5	6.4-7.0			—————	
		White	6	6.0-6.9			—————	

A glance at the plotted acid ranges is sufficient to demonstrate that the results of this work are negative. There is no evident correlation between the color types and any particular part of the pH range of the species. That negative results would be found, at least for some species, was quite evident when, during the collecting of the soil samples, the writer found the roots of two specimens of *Delphinium* very intimately interwoven, one of which bore normal dark-blue flowers and the other the unusual white flowers.

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