

## Evidence of Introgressive Hybridization and Mutation in Certain Colorado Populations of *Aquilegia*

JEANETTE S. PELTON, Butler University<sup>1</sup>

Hybridization has often been reported for the genus *Aquilegia* (Anderson and Schafer 1931, Cockerell 1916, Grant 1952, Skalinska 1928a, 1928b, 1929, 1931). When individuals of two species of *Aquilegia* occur sympatrically isolating mechanisms between them are often weak or absent permitting crossing, the resulting hybrids frequently being fertile. Such a sympatric occurrence of individuals of *Aquilegia caerulea* James and *A. elegantula* Greene in Gunnison County, Colorado was the basis for the present study, in which the possibility of introgressive hybridization was investigated. In addition, the discovery of possible mutations in the putative hybrid swarm will be discussed.

### Methods

The plants included in the present study grew near the Rocky Mountain Biological Laboratory, which occupies the ghost town of Gothic at 9,500 feet nine miles north of Crested Butte in Gunnison County, Colorado. In the study area plants of *caerulea*, characterized by large blue and white erect flowers, grew either in the full sun of *Festuca* dominated meadows or in the semi-shade of Aspen groves where soil conditions were fairly moist. By contrast, the *elegantula* members have smaller red and yellow nodding flowers and are restricted locally to rocky, very moist hillsides in the shade of Spruce-Fir forests. An area transitional between these two distinct habitats included an intermixture of Spruce, Fir, Aspen, open meadow, and a streambank site. A moister soil prevailed in this area. Here, the putative hybrid swarm was growing. In the summer of 1957 collections of both species and their apparent hybrids were made from the extreme and transitional habitats described above.

Anderson's hybrid index (Anderson 1949) was computed on 44 living flowers from the collection. These flowers are retained as voucher specimens (Nos. 601-645) in the personal herbarium of the author. The eight characteristics used in the index, based on those used by Harrington (1954), are as follows: (1) length of spur, (2) color of spur, (3) length of sepal, (4) color of sepal, (5) length of petal, (6) color of petal, (7) stamens exerted or not, and (8) flowers nodding or erect. Two points were scored for characteristics that resembled *caerulea*, zero points for those like *elegantula*, and one point for intermediate characteristics. Thus, a plant of pure *caerulea* would score sixteen points, one of *elegantula* zero points, and putative hybrids an intermediate score.

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## Results

Results of the hybrid index described above vary from zero to sixteen points with most of the individuals scoring near the *caerulea* parent.

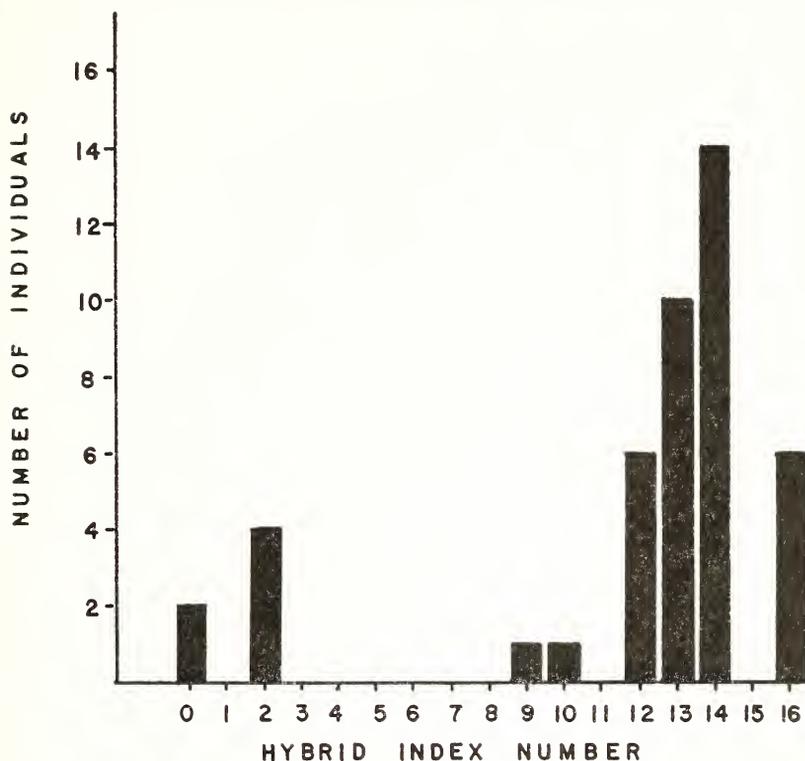


Figure I. Results of the hybrid index for 44 flowers rated for 8 characteristics. 2 points were scored for *caerulea* characteristics, 0 points for those of *elegantula*, and 1 point for intermediate conditions.

These results are summarized in Figure I. The distribution of the scoring of the eight characteristics used in the index is shown in Table I, together with the range of variation given for each species by Harrington (1954).

In addition to the above results several different appearing flowers were noticed in the study area. These were collected and are included in the voucher collection (Nos. 646-651) for this study. Among the variations were flowers that were entirely spurless, some with greatly reduced spur length, and some with variegated blue and white petals. One spurless flower also had blue petals as well as sepals and was on the same plant with normal appearing *caerulea* flowers. The two other spurless flowers, representing different plants, had whitish sepals and petals tinged with green and light blue.

## Discussion

On the basis of the results of the hybrid index introgressive hybridization, as defined by Anderson and Hulbricht (1938), may have occurred

TABLE I. Distribution of characteristics used in the hybrid index. The characteristics are those used by Harrington (1954)

Characteristics	Number of Flowers		
	caerulea	intermediate	elegantula
(1) Length of spur caerulea: 30-77 mm long elegantula: 15-22 mm long	37	3	4
(2) Color of spur caerulea: blue elegantula: red	8	30	6
(3) Length of sepal caerulea: 20-40 mm long elegantula: 7-11 mm long	38	3	3
(4) Color of sepal caerulea: blue elegantula: green & red	6	32	6
(5) Length of petal caerulea: 15-25 mm long elegantula: 7-11 mm long	35	4	5
(6) Color of petal caerulea: white elegantula: yellow	36	2	6
(7) Stamens exerted or not caerulea: stamens little if any longer than petals elegantula: stamens 4-6 mm longer than petals	32	4	8
(8) Nodding or erect flowers caerulea: flowers erect elegantula: flowers nodding	24	11	9

between *Aquilegia caerulea* and *A. elegantula* in the area studied. While both of these species are regarded by Munz (1946) as valid species, it is well known that hybridization between distinct species of *Aquilegia* will occur either in nature or artificially. Evidence that hybridization was followed by backcrossing to the parental types, especially to the *caerulea* parent, can be inferred from the index numbers (Fig. I). For example, thirty-one of the forty-four flowers scored 10 to 14 points, which is close to the 16 points allotted to *caerulea*. Analysis of the habitat of the putative hybrid swarm might also support this hypothesis. While the habitat contained some of the requirements of *elegantula* the open meadows, Aspen association, soil condition, and sun-shade balance would be more favorable to *caerulea* backcrosses. Thus, if Anderson's hypothesis that habitats more similar to those of one parental species of a hybridizing pair of species would favor survival of the backcross to that parental type is accepted (Anderson 1948) the above conclusion would be possible. Further study of the ecology of the area over a period of years, however, is necessary to determine whether these backcrossed plants will continue to survive and maintain their separate identity. The above conclusions can be considered tentative, further study being needed such as artificial crosses between the two species and pollination studies such as that by Grant (1952).

Evidence of introgressive hybridization is not the only noticeable change taking place in these populations of *Aquilegia*. In addition, radical differences in flower configuration in some of the individuals were observed. These variations in phenotype could be the result of mutations. The possibility of increased mutation in an area of putative hybridization is intriguing in light of the suggestion by Stebbins that hybridization may increase the mutation rate (Stebbins 1950). The evolutionary significance of such an hypothesis, however, must wait further understanding of the genetics of *Aquilegia*, which is dependent upon breeding studies and careful examination of samples of allopatric species populations as well as the sympatric ones.

### Summary

Evidence of possible introgressive hybridization between *Aquilegia caerulea* James and *A. elegantula* Greene was obtained in a location where the two species meet in Gunnison County, Colorado. A hybrid index based on eight characteristics for 44 individuals is presented. In addition, several possible mutations were found in the putative hybrid population, giving support to the hypothesis that hybridization may increase the mutation rate.

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