THE INHERITANCE OF DOUBLENESS IN *CHELIDONIUM MAJUS* LINN.

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The most thorough investigation of the inheritance of doubleness in flowers has been made by Miss SAUNDERS (1910, 1911, 1917). In the *Petunia* the double flowers set no seed and all crosses must be made with the single plant as the female parent. In the F_1 of such a cross there is either a segregation into 3 single : 1 double, or into 9 single : 7 double. All single plants selfed or crossed *inter se* produce only singles. SAUNDERS explains these results on the assumption that pollen from the single flower used carries only factors for singleness, while ovaries of the single flowers lack the factor for singleness in some cases and possibly in all. The pollen of double flowers is further assumed to be heterozygous. In the stock the inheritance of double and single flowers is explained on the assumption that two factors are involved which are linked in the pure singles, but not linked in the eversporting singles. It is also assumed that "single" factors are distributed only in the female gametes according to a system of partial linkage.

In the Welsh poppy (*Meconopsis cambrica*) SAUNDERS (1917) found that a simple 3 : 1 ratio was obtained in F_2 by crossing single and double plants. Doubleness was found to be dominant. In the hollyhock (*Althaea rosea*, *A. ficifolia*) the offspring of single $\times$ full double plants were intermediate in F_1 and in the F_2 produced a 1 : 2 : 1 ratio. In the carnation (*Dianthus caryophyllus*) a cross of double $\times$ single produced an F_2 ratio of 3 double : 1 single, while a cross of double $\times$ single in *Dianthus barbatus* (sweet william) gave the same F_2 ratio, but singleness was found to be dominant.

NORTON (1907) and BATCHELOR (1912) have found that doubleness in the carnation is of two types; the ordinary or standard double and the type known as "bullhead" or "buster". By crossing a full double or buster with the single the resulting F_1 is standard double. The F_1

selfed or crossed *inter se* produces an F_2 ratio of 1 single : 2 standard doubles : 1 full double or buster.

The doubling of flowers is usually due to petalody of the stamens, according to DE VRIES. This is true of the plants investigated by SAUNDERS, and has been recorded by many writers, GOEBEL (1913), MASTERS (1869), DE VRIES (1906), and others; but no statistical data have been presented to show the degree of correlation between stamen number and petal number.

The inheritance of doubleness in *Chelidonium majus* and a statistical study of the relation of petals and stamens will be considered in the present paper. A double- and a single-flowered plant growing near the BUSSEY INSTITUTION were transplanted and reciprocal crosses made. In the F_1 about sixty plants of each cross were grown and in each case produced practically an equal number of single and double plants. Seed from the F_1 singles and doubles were planted separately. Of 133 plants raised from seed of single F_1 plants, 109 were single and 24 double. Of 111 plants raised from seed of the double F_1 plants, 6 were single and 105 double. If we assume that the high number of singles resulting from F_1 singles, and the 6 singles among the doubles, were due to contamination by crossing, or possibly due to volunteers from wild plants growing near by, then it appears that singleness is dominant, and that the original cross was made with a heterozygous single. We would then expect a ratio of 1 : 1 in the F_1 irrespective of which plant is used as the female parent. In the F_2 the F_1 single segregates should give a ratio of 3 single : 1 double, while the F_1 double segregates should breed true, when selfed or crossed *inter se*. In the F_2 of this particular cross all of the doubles should be homozygous, while two-thirds of the singles should be heterozygous.

Of the 244 plants raised in the F_2 the petal number and stamen number of the flowers of 147 plants were found. An average of 20.6 flowers per plant were counted.

The average numbers of petals and stamens of the F_2 plants are shown in table 1. The mean petal number is 10.54 ± 0.31 , with a standard deviation of 5.60 ± 0.22 . The mean stamen number is 18.30 ± 0.26 , with the standard deviation of 4.72 ± 0.19 . The coefficient of correlation between stamen and petal number is $-.90 \pm .01$. In table 2 all of the flowers of the 147 F_2 plants are plotted in respect to stamen number and petal number. The mean petal number is 10.89 ± 0.07 with a standard deviation of 5.84 ± 0.05 , while the mean stamen number is

TABLE 2

Stamen number and petal number of all F_2 flowers counted. *Chelidonium*, single $\times$ double.

[illegible]

and stamens of the doubles is 29.49 ± 0.15 with a standard deviation of 2.24 ± 0.12 , while in the singles the mean sum of petal number and stamen number is 27.68 ± 0.14 with a standard deviation of 1.56 ± 0.10 . The sum of the petal number and stamen number in the doubles is significantly larger than in the singles, but with a much greater variation

TABLE 3

Average stamen number and petal number of F_2 double plants. From table 1

		Stamens															
		9	10	11	12	13	14	15	16	17	18	19	20	21			
Petals	8											I			I		
	9													I	I		
	10									2	I	I			4		
	11								I		4	I			6		
	12							3		2		I			6		
	13					2	3	I	2	5	2				15		
	14				4	2	2	4	7	I	2				22		
	15						3	I	I	I					6		
	16				2	2	I			I					6		
	17	I	I	I		2			2						7		
	18			2		2	I	2							8		
	19					3		I							4		
20			I	I			2							4			
21														0			
22						I								I			
		I	2	4	6	13	14	11	13	12	10	4	0	I	91		
Petals		$M = 14.56 \pm 0.20$								$M = 14.99 \pm 0.17$							
		$\sigma = 2.81 \pm 0.14$								$\sigma = 2.39 \pm 0.12$							
		$r = -.58 \pm .05$															

If the pedigree culture results did not show the singles to be dominant, one might expect the larger number of petals and stamens and the greater variability of the doubles to be due to heterozygosis. The behavior of the doubles may, however, be due to splitting of the stamens in some cases, in addition to petalody.

The greater variation in number of parts in the double flowers loses its significance when the doubles of the F_2 are grouped by themselves and compared with the double flowers on individual double plants of the F_2 . The mean petal number of all of the F_2 double plants is 14.56 ± 0.20 with a standard deviation of 2.81 ± 0.14 and the mean stamen number is 14.99 ± 0.17 with a standard deviation of 2.39 ± 0.12 (table 3). In tables 4, 5 and 6, three F_2 double-flowered plants are plotted in respect to petal number and stamen number. In table 4 the

TABLE 4

 Stamen number and petal number of flowers of a single F_2 'double' plant.

		Stamens												
		10	11	12	13	14	15	16	17	18	19	20	21	
Petals	9									1				1
	10													0
	11													0
	12					1	1						1	3
	13				1	1			2			1	1	6
	14					1	2	1	1		1			6
	15								1	1	1		1	4
	16					2	2	3				1	1	9
	17				1	1	2	6	1		2			13
	18			1	1	1			2	3	1			9
	19		1	2		1	2	2	1					9
	20			3	1	1	1	4	1					11
	21	1		1	1	2	2	2						9
	22				1									1
		1	1	7	6	11	12	18	9	5	5	2	4	81

Petals

$$M = 17.23 \pm 0.20$$

$$\sigma = 2.77 \pm 0.14$$

Stamens

$$M = 15.64 \pm 0.18$$

$$\sigma = 2.43 \pm 0.13$$

$$r = -.46 \pm .04$$

TABLE 5

 Stamen number and petal number of flowers of an F_2 'double' plant.

		Stamens										
		8	9	10	11	12	13	14	15	16		
Petals	14						1	1				2
	15							5	1			7
	16			2	5	3	1	2	1	1		14
	17			1	3	1			1			6
	18	2		3	1	6			1			12
	19	2	1									3
	20	2	2	3		1						8
		6	3	9	9	12	7	3	3	1		53

Petals

$$M = 17.15 \pm 0.16$$

$$\sigma = 1.71 \pm 0.11$$

Stamens

$$M = 11.36 \pm 0.18$$

$$\sigma = 1.98 \pm 0.13$$

$$r = -.64 \pm .05$$

mean petal number is 17.23 ± 0.20 with a standard deviation of 2.77 ± 0.14 and the mean stamen number is 15.64 ± 0.18 with a standard deviation of 2.43 ± 0.13 . In table 5 the mean petal number is 17.15 ± 0.16

TABLE 6

Stamen number and petal number of flowers of an F_2 'double' plant.

		Stamens															
		9	10	11	12	13	14	15	16	17	18	19	20	21	22		
Petals	10									1		1				2	
	11							1	2		1	1			1	6	
	12								2		2	1	2	1		8	
	13							1	2	1	2	2				8	
	14						2	1	2	1	1	1	1			9	
	15							1	1		1					3	
	16			1	1											2	
	17															0	
	18					1										1	
	19	2														2	
	20																
		2	0	1	1	1	2	4	9	3	7	6	3	1	1	41	
Petals										Stamens							
$M = 13.29 \pm 0.22$										$M = 16.58 \pm 0.30$							
$\sigma = 2.11 \pm 0.16$										$\sigma = 2.88 \pm 0.21$							
$r = -.66 \pm .06$																	

with a standard deviation of 1.17 ± 0.11 and the mean stamen number is 11.36 ± 0.18 with a standard deviation of 1.98 ± 0.13 . In table 6 the mean petal number is 13.29 ± 0.22 with a standard deviation of 2.11 ± 0.16 and the mean stamen number is 16.58 ± 0.30 with a standard deviation of 2.88 ± 0.21 . The coefficient of correlation of all the F_2 doubles is $-.58 \pm .05$ while the coefficients of correlation of the three F_2 double plants are $-.46 \pm .04$, $-.64 \pm .05$, and $-.66 \pm .06$, respectively. The variability of the petal number and stamen number of all of the F_2 doubles is, in general, not greater than the variability in individual F_2 double plants.

CONCLUSIONS

Doubleness appears to be a simple recessive character in *Chelidonium majus*.

There is apparently a continuous series in degree of doubling from singles to full doubles in the F_2 .

There is much greater variation in the doubles, which are recessive, than in the singles, of which two-thirds are heterozygous. The F_2 doubles are however no more variable than individual double plants of the F_2 .

There is a high degree of negative correlation between petal number and stamen number in the F_2 , due to petalody.

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