STUDIES IN WILD SPECIES OF COTTON

I. VARIATION WITHIN *GOSSYPIUM ANOMALUM*

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Received 9.vii.58

I. INTRODUCTION

Gossypium anomalum Wawra and Peyr is a wild diploid cotton indigenous to the African continent. It lacks spinnable lint having only a short khaki fuzz appressed to the seed. This species and *G. somalense* have been collected in natural vegetation in the Sudan, and their distribution in that country has been described by Knight (1949). A botanical description of *G. anomalum* was published by Hutchinson, Silow and Stephens (1947).

One accession only of *G. anomalum* has been extensively studied. This work was carried out by Silow (1941) who investigated the comparative genetics of *G. anomalum* and the Asiatic cottons. The type he used represents the most widely known form of the species and is maintained under the number WB1-1. At the present time 15 accessions of *anomalum* are grown at Shambat, near Khartoum, in the northern Sudan. These represent the following areas: 1 from W. Africa (WB1-1), 10 from different districts of the Sudan and 4 from southern Africa.

The 15 types are grown perennially in the collection of wild species. The most striking feature of these representatives of *anomalum* from widely separated areas is their remarkably uniform appearance. Small differences are discernible in habit; there is some variation in boll shape; the southern types flower somewhat later than the northern accessions and 3 of the 4 southern types have a magenta flower colour, the northern all being cream. Only one glabrescent *anomalum* has been found and this was collected in the south. One accession from the Sudan was found to possess a distinct leaf shape.

Because the variation within *anomalum* described above has so far not been reported, this study was carried out. The genetics of flower colour, leaf shape and hairiness will be discussed here.

2. MATERIALS AND METHODS

The strains of *G. anomalum* used in this study were:

WB1-1: Densely hairy on all parts of the leaf and stem; pale cream flower sometimes tinged with anthocyanin; $\frac{3}{4}$ cut leaves usually 5-lobed. Collected in W. Africa.

WB1-5: Differs from WB1-1 only in that the leaves are about $\frac{1}{2}$ cut into 3 broad lobes. Collected in the Sudan.

WB1-14: Magenta-coloured flower; glabrescent leaves and plant body. Leaf shape similar to WB1-1. Collected in S.W. Africa.

WB1-5 and WB1-14 were crossed with WB1-1 and F_2 and F_3 families were raised. The results will be given below.

The seeds of *anomalum* possess a very hard testa and because of this seeds germinate very erratically under ordinary conditions of cultivation. All seeds were therefore chipped, germinated on damp filter paper and raised as seedlings in a greenhouse for later planting in the field.

Cotton flowers are selfed at Shambat by clipping a small endrin-impregnated paper bag over the unopened flower. A poor set was obtained with *anomalum* treated in this way and the F_2 families were small in consequence. This difficulty was overcome by removal of the bag at the time when the flower had opened for mechanical application of self pollen to the stigma with subsequent replacement of the bag. When this was done a satisfactory boll setting was obtained.

3. RESULTS

(i) Flower colour

Flower colour was graded by eye estimation and five grades were used; a description follows:

Grade	Description	Parents and Hybrids
1 2	Pale cream Pale cream tinged pink	WB1-1 range
3 4	Weak magenta Moderate magenta	WB1-14 range
5	Strong magenta	Hybrid segregates only

Nine F_1 plants were grown from the cross WB1-1 (cream) $\times$ WB1-14 (magenta). Although a note was made that this F_1 was a light magenta colour no grade was recorded since at that time the cross was intended solely for a study of hairiness. From these nine plants F_2 s were grown.

It was decided in 1956 that these families should be used for a study of corolla colour inheritance. At the end of the season it was realised that the method of grading colour was unsatisfactory and that the assessment of tones in the bright glare of the sun could be subject to considerable error.

One entire F_2 family G233/56 was individually selfed and the resultant F_3 s raised in 1957. Colour assessment was made on flowers brought into the laboratory and examined at a well-lit window out of the glare of the sun. The parent types were always available for comparison. It was found that by using this method flowers could be placed with complete confidence into one or another of the grades 1 to 5. The results are set out in table 1.

Differences in flower colour grade can be due to both genetic and environmental influences. Silow (1941) recorded variability of anthocyanin expression within plants and explained this as being due to differences in exposure of flower buds to the sun. The writer has

repeatedly observed flowers of differing grades upon the same plant. This being the case, family grading based upon one flower per plant can obviously be subject to error, but this error has to be accepted since replication of flower colour assessment was not a practicable measure in view of the amount of work involved. Since this type of error can equally well occur in all families, differences in mean grade are more likely to be due to genetic causes.

A complete understanding of the nature of corolla colour inheritance within *anomalum* would require considerably more extensive study

TABLE 1
F₃ families from the cross WB1-1 × WB1-14

G Family 1957	Colour Grades					Total	Mean Grade
	1	2	3	4	5		
WB1-1 .	...	...	...	...	...	...	1.5
WB1-14 .	...	7	23	19	...	49	3.2
G222/57 .	33	2	2	...	...	37	1.2
220 . .	36	22	...	...	...	58	1.4
228 . .	24	7	3	...	...	34	1.4
217 . .	54	46	3	...	...	103	1.5
219 . .	23	22	1	...	...	46	1.5
225 . .	47	73	10	...	...	130	1.7
223 . .	18	17	10	1	1	47	1.9
227 . .	37	47	26	1	...	111	1.9
221 . .	30	39	21	3	...	93	2.0
218 . .	7	30	21	19	...	77	2.7
224 . .	3	8	46	22	1	80	3.1
226 . .	...	7	20	62	2	91	3.6

than it has been possible to give it here. However, the data presented shows more variation than would be expected if the control of colour was monogenic. This clearly points to polygenic influence on the intensity of pigmentation.

(ii) Leaf shape

The leaf-shape gene normally encountered in *anomalum* was given the symbol *L^A* by Silow (1939) who found that it was a member of a multiple allelic series for leaf shape in the Asiatic cottons. He used two indices to record leaf shape, they were:—

$$\text{Index C} = \frac{\text{Sinus Length}}{\text{Leaf Length}}$$

$$\text{Index D} = \frac{\text{Lobe Width}}{\text{Leaf Length}}$$

These indices are reciprocals of those used in earlier studies on the cotton leaf made by Hutchinson (1934) and are used in the work reported here. Indices are $\times 100$ eliminating decimals.

L^A is the leaf-shape gene of WB1-1, a $\frac{3}{4}$ cut palmatifid leaf of 5 lobes (fig. 1a). WB1-5 has a leaf $\frac{1}{3}$ palmately cut and is 3-lobed (fig. 1b). In 1956 nine plants from a bulk cross between WB1-1 and WB1-5 were grown and selfed. The F_2 families were grown in the season 1956/57. Of these only four segregated for leaf shape, the remainder being homozygous for the L^A gene. It was realised later that the WB1-5 stock which is grown perennially at Shambat was not pure for the leaf-shape allele under study and that some plants heterozygous for this gene and L^A were crossed to WB1-1 ($L^A L^A$) to produce the F_1 which was thus mixed and hence gave the non-segregating families in F_2 . The families which did segregate gave 20 to 6, 16 to 4, 5 to 5 and 4 to 5 palmatifid L^A types to palmate types. The two largest families suggest monofactorial segregation. In view of the small F_2 family numbers it was necessary to grow an

FIG. 1a.—Palmatifid.

FIG. 1b.—Palmate.

adequate number of F_3 s. One family G243/56 (giving the ratio 20 to 6 mentioned above) was entirely individually selfed with the exception of two rather weak plants, so leaving the family effectively as 19 to 5. The resulting F_3 families are set out in detail in table 2. Without exception the seven families segregating for the shape genes show excellent approximations to 3 : 1 expectations, thus confirming the indication given in the F_2 families that a single locus is involved.

It is of interest to note here that the family G243/56 with an observed 20 dominants to 6 recessives, which is an excellent fit to a 3 : 1, is in fact spuriously so when the F_3 data are examined. Table 2 shows that 12 of the F_2 plants must have been homozygous palmatifid, 7 heterozygous and 5 homozygous palmate allowing for the two plants which did not bear seed. This is in poor agreement with an expected 6 : 12 : 6.

The data for the seven segregating families have been combined and index C plotted against index D in table 3. It can be readily seen that the real difference between palmatifid and palmate lies in sinus length, lobe width hardly differing at all. Stephens (1944) when comparing L^A and I found that the difference lay in sinus length

and came to the conclusion that L^A “. . . has an extremely localised effect in the sinus region of the leaf”.

The gene for palmatifid is incompletely dominant over that for palmate leaf. Table 3 shows that the palmatifid homozygote and the

TABLE 2
F₃ families from the cross WB1-1 × WB1-5

Parent genotype	G Family 1957	Observed		
		Palmatifid	Heterozygote	Palmate
Palmatifid	229	14	...	...
	234	3 ²	...	...
	235	3 ²	...	...
	237	3 ¹	...	...
	238	3 ¹	...	...
	239	45	...	...
	245	7 ¹	...	...
	246	69	...	...
	247	80	...	...
	248	57	...	...
	249	45	...	...
	25 ¹	4 ¹	2 *	...
Heterozygote	230	28		8
	232	65		20
	240	25		10
	242	6		2
	244	34		14
	250	53		17
	252	5 ¹		15
Palmate	231	...	...	81
	233	...	1 *	39
	236	...	...	33
	241	...	...	5
	243	...	3 *	33

* Possible outcrosses.

heterozygote merge into one another in respect of the indices but are distinctly separate from the palmate homozygote. In correlation tables for individual families this separation is much more marked, but in bulking the data for table 3 family differences blur the distinction. All heterozygotes had a higher value for index C than the homozygotes although this distinction was not marked enough for confidence in placing them in a separate class. Thus the type of dominance found here is in agreement with the field series of Hutchinson (1934), *i.e.* dominance is in the direction of deep-cut leaves.

Modifier control over lobe width has been noted in previous leaf-shape studies (Silow, 1939). Evidence of a lobe width modifier will be presented here also. If the mean values for C and D for each of the segregating families are plotted in such a way that each family

TABLE 3

Combined data on leaf shape from *F₂* families G230/57, G232/57, G240/57, G242/57, G244/57, G250/57 and G252/57

Index C																														
	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	...	70				
Index D	84	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1			
	82	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
	80	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
	78	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
	76	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
	74	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3		
	72	.	.	.	.	.	2	3	.	.	2	1	1	.	.	.	1	2	1	1	.	.	.	.	.	.	.	11		
	70	.	.	3	.	1	1	7	.	1	1	.	.	.	.	.	.	1	1	3	.	.	.	.	.	.	.	14		
	68	.	.	.	.	2	4	5	6	1	1	.	.	.	.	.	.	3	5	1	1	.	.	.	.	.	.	28		
	66	.	.	1	2	4	3	8	6	2	1	2	.	.	.	.	.	1	3	3	.	.	.	.	.	.	.	33		
	64	1	3	3	3	2	7	10	6	1	1	.	1	.	3	1	1	3	1	3	.	3	1	.	.	.	.	39		
	62	1	3	3	4	4	5	6	4	2	3	1	1	.	.	1	2	1	1	.	1	.	.	.	.	.	.	36		
	60	3	5	9	3	1	6	4	5	2	2	1	1	.	.	.	2	1	1	.	1	.	.	.	.	.	.	40		
	58	3	2	4	5	2	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	28		
	56	1	2	4	1	1	1	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15		
	54	.	1	1	1	.	.	3	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	9		
	52	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	
	50	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	
	48	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	
}																														
Observed																														
6 18 34 26 18 33 39 40 16 11 14 3 4														1 2 7 8 13 19 11 12 5 3 2 2 1																
(Palmatifid homozygotes + heterozygotes)														(Palmate homozygotes)														348		
262														86																
Expected 3:1																												348.00		

has two means, one for the dominant group and one for the recessive group and these two values joined by a line, this line then acts as a pointer to the related values and also defines the slope between them. The seven families are then seen to fall into three distinct groups (see fig. 2) and these groups are in the proportions 2 : 3 : 2. A further point emphasising the reality of this grouping is the noticeably different slope of the lines of the middle group, all of which are similar within the group. The two outside groups are similar to each other in slope.

These findings can be interpreted as being due to a modifier *M* which increases the W/L value; *mm* causes no change and *Mm* is intermediate in value between this and *MM*. In fig. 2 G230/57 and

FIG. 2.—Each family is represented by two means joined by a line indicating the slope between the means. The group at the lower end of index C is Palmatifid + heterozygotes and the group at the higher end of index C is Palmate.

G232/57 then become *MM*; G240/57, G250/57 and G252/57 become *Mm*; G242/57 and G244/57 *mm*. The observed distribution of these groups of 2 : 3 : 2, while in reasonable agreement with an expected 1 : 2 : 1, cannot be taken as reliably establishing the existence of the modifier because of the small number of families. If this modifier is acting here it is of interest to note that when heterozygous (*Mm*) it acts unequally upon the palmatifid and palmate classes so giving the difference in slope observable between the middle group and the others. Silow (1939) drew attention to modifiers which acted differentially upon the three phases of a main gene. The homozygous broad leaf was made even broader, the heterozygote broader to a lesser extent and the homozygous narrow leaf hardly affected at all. The differential here appears to be in the heterozygous phase of the modifier but the effect is similar to Silow's findings in that the broad leaf is made even broader and that the narrower allele is affected to a slightly less extent.

The effect of this modifier upon the homozygous families is observable but not easily analysable since the distribution is continuous, the heterozygotic families are simpler because of the use that can be made of the angle of slope joining the dominant and recessive groups.

(iii) Hairiness

The two accessions studied may be described with respect to hair as follows:—

- (a) WB1-1: strongly hairy with dense soft hair on both leaf surfaces, moderate length. Densely hairy on all vascular tissues with hair at two levels. Long simple single or double hairs dominant; the second level stellate hairs, eight or more arms, not more than half the length of the simple hairs and considerably less dense.
- (b) WB1-14: distribution of hair the same as for WB1-1 but with the absence of long simple hairs from the vascular tissues. Hair very sparse on all surfaces and hence described as glabrescent.

In an analysis of the hairiness of WB1-1, it would be desirable to cross it with a fully glabrous *anomalum* but no such strain has been recorded and the glabrescent WB1-14 was therefore used. The F_1 was found to be only slightly more hairy than the glabrescent parent. Fully hairy appeared to be recessive and this was confirmed in later work.

Grading for hairiness was done in the field on one leaf per plant. The first fully expanded leaf was used at about the commencement of flowering. Because of the two-level hairiness it was necessary to grade for both length and density. Grades 0-8 were used for density and grades 1-8 for length. Four surfaces were examined, lower leaf lamina, upper leaf lamina, stem or petiole and upper main vein surfaces. Studies on hairiness in cotton have been in progress at Shambat for some time and it has been found necessary to include all these surfaces for an adequate analysis of the inheritance of hairiness.

Since the classes "Fully Hairy" and "Glabrescent + Slightly Hairy" are unmistakably distinct the data will not be presented under the grades recorded in the field but grouped under these heads.

The small F_2 families gave very little guidance as to the true nature of the segregation. However, the bulked data (26 Fully Hairy to 64 Glabrescent) suggest a single gene difference between dense and very sparse hair.

The F_3 families leave no doubt that this interpretation is justified. The entire F_2 family G233/56, segregating 11 glabrescents to 2 fully hairiness, was individually selfed and the results are presented in table 4.

Of the 11 glabrescents in G233/56, 3 were found to be homozygous glabrescent, 7 segregated for hair and one produced no seed, the 2 fully hairies breeding true. Thus G233/56 gave 3 homozygous glabrescents, 7 heterozygous hairiness and 2 fully hairies. This is in good agreement with an expectation of 3.0, 6.0 and 3.0 for the same classes for a 1 : 2 : 1 ratio. In most segregating families (see table 4)

TABLE 4
F₃ families from the cross WB₁₋₁ × WB₁₋₁₄

Parent Genotype	G family 1957	Observed			Parent Plant no. G233/56	Parent plants of families G/57				Description of two-level hairiness of families G/57	
		Glabrescent	Slightly hairy	Fully hairy		Hair grading * Density/Length (e.g. 6 ⁶)				Short stellate	Long simple
						L.L.L.	U.L.L.	a. S	b. U.M.V.		
<i>H</i> ^{A1} <i>H</i> ^{A1} <i>H</i> ^{A2} <i>H</i> ^{A2} <i>H</i> ^{A1} <i>H</i> ^{A2}	WB1-1 WB1-14 F ₁	*	*	*	Average grade	6 ¹ 1 ¹ 2 ¹	6 ¹ 2 ¹ 2 ³	3 ² 3 ² 3 ²	6 ⁶ 0 3 ⁵	3 ² 1 ² 1 ²	Dense Absent Present
<i>H</i> ^{A1} <i>H</i> ^{A1}	218 224			83 87	2 8	7 ² 6 ²	7 ² 6 ²	6 ² 0	2 ⁵ 6 ⁵	3 ² 4 ⁴	Sparse Dense
<i>H</i> ^{A1} <i>H</i> ^{A2}	217	28	50	25	1	2 ²	2 ²	0	4 ⁵	1 ²	Absent or observed Preponderant
	221	36	34	20	5	2 ²	2 ²	4 ²	2 ⁶	1 ²	Occasional
	223	11	28	16	7	1 ²	1 ²	3 ²	2 ⁵	1 ¹	Segregating
	225	28	64	34	9	2 ²	2 ²	0	3 ⁵	1 ²	Usually present
	226	21	43	21	11	1 ²	1 ²	0	3 ⁴	1 ²	Moderate but less dense than long
	227 228	20 15	60 12	26 5	12 13	3 ² 1 ³	3 ² 2 ³	2 ² 3 ²	4 ⁵ 1 ⁴	1 ² 1 ²	Segregating Preponderant
											Moderate but less dense than short
<i>H</i> ^{A2} <i>H</i> ^{A2}	219 220 222	46 57 38			3 4 6	0 1 ¹ 1 ¹	1 ² 2 ² 1 ²	0 1 ² 1 ²	1 ⁵ 2 ⁵ 2 ⁵	0 1 ¹ 1 ¹	Absent Occasional Glabrous

* L.L.L. = Lower Leaf Lamina, U.L.L. = Upper Leaf Lamina, S. = Stem or Petiole; a. = short stellate, b. = long simple, U.M.V. = Upper Main Vein.

it was possible to place plants into each of the three classes, but in two families, G221/57 and G228/57 glabrescent and slightly hairy were too close in phenotype for accuracy in separating the two classes. There was of course no doubt at any time concerning the fully hairy class. The figures require no comment since in all cases the agreement with expectation is excellent. Sparse hair and dense hair are therefore due to allelic genes and the following symbols are proposed, H^{A1} for the densely hairy condition of WB1-1 which is recessive to H^{A2} , the sparsely hairy condition of WB1-14. This scheme allows for the possibility of other alleles at the same locus being discovered. However, a revision may be necessary should it be possible to test the homology of this locus with those of the New World or Asiatic cottons.

TABLE 5
F₂ and F₃ families of the cross WB1-1 × WB1-14

		Bulk of families G233/56 to G241/56		G223/57		G227/57	
		Hairy	Glabre- scent	Hairy	Glabre- scent	Hairy	Glabre- scent
Long simple preponderant .	Observed	7	23	8	7	6	25
Long simple/short stellate No preponderance . .	Observed	13	26	2	26	10	47
Short stellate preponderant .	Observed	6	14	6	6	9	9
Totals	Observed	26	63	16	39	25	81

WB1-1 and WB1-14 differed also in one other respect with regard to hair. WB1-1 possessed two levels of hairiness on the vascular tissues and WB1-14 only one. An examination of the grading for length and density of stem hair showed that this condition was under apparently simple control, *i.e.* a single factor determines the relative amounts of long simple hairs and short stellate ones on the stem and petiole. The data were divided into three classes where segregation for this factor was occurring. These classes were, 1. long simple hairs preponderant, stellate sometimes absent, 2. long simple and short stellate present in approximately equal densities and 3. short stellate preponderant, long sometimes absent. These classes corresponding to what might be expected to be found from the action of gene pairs AA , Aa or aa respectively on the H^A locus. All families showing variation for this character were plotted against segregation for hair density due to H^{A1} and H^{A2} (see table 5).

The bulked figures for the F_2 families give a very good agreement indeed with the expectation for independent segregation of two

factors except in the Long-equal/Glabrescent section. Here difficulties in grading glabrescents are thought to be contributory causes leading to error. Jointly long plus equal give a good 3:1 to short. G223/57 and G227/57 show large discrepancies at certain points in the tables but the individual 3:1 and 1:2:1 ratios are good. It is felt that in spite of the discrepancies there is very good evidence for the independent action of a gene affecting the two-level character of stem hair. The nature of the stem hair in those families not segregating for this character is noted in table 4, giving further evidence of its action. This modifier shows no dominance and its mode of action could be that of a suppressor controlling the production of a certain substance which determines the relative amounts of each hair type grown. The symbol proposed for this gene is therefore Su^h , i.e. hair suppressor, and represents the type found in WB1-1, namely, dominant long simple hairs, short stellate sparse or absent. It follows that su^h represents dominant short stellate, long simple sparse or absent as in WB1-14.

4. DISCUSSION

Two new genes have been described for *G. anomalum* and a preliminary investigation into flower colour made. Apart from this variation the species is remarkably uniform. The extremely wide distribution of *G. anomalum*, stretching across the entire width of Northern Africa and occupying the S.W. of Southern Africa but discontinuous between these areas, might lead one to expect greater divergencies than are actually found. Since the natural habitat of the plant is extremely xerophytic each small group of wild plants is often separated from others by great distances. This is particularly true of the Sudan where as few as one or two plants may occupy a stony Jebel separated from the next Jebel by many miles of arid desert; thus the isolation of plants within the distribution is quite marked.

If a more intensive study were possible it is quite likely that plants collected from different localities, in particular those from the south in comparison with those from the north, would show differences in genetic balance due to selective response to locality. This is perhaps indicated in disturbances noticed in flower structure in the F_3 material from the cross between the northern WB1-1 and the southern WB1-14. The flowers of the parent strains, apart from colour, are identical, yet the hybrid material contained minutely petalled flowers, short corollas which did not open and from which the stigmas protruded, and lastly petalody.

Two other magenta-flowered accessions exist in the collection, both from the S.W. However, it is not known whether the flower colour mechanism within these is similar to WB1-1. No magenta-flowered *anomalum* is known in the north.

Wagner and Mitchell (1955) discuss very fully the types of modifiers reported in the literature. They say, "Many intermediate conditions exist which lie between the extreme examples of suppressor and complementary genes on the one hand, and genes which seemingly produce

their phenotypic effect completely independently of all other genes, on the other hand. Most of the intermediate types are best described by the general term modifiers. . . ." If the genotype acts as a co-ordinated whole, which presumably it must, then all genes are to some extent modifiers of one another—these effects are not readily observable except when the genotypic balance is disturbed by hybridization as is the case in the examples noticed here. The modification of the main gene type may have no significance beyond an indication of a disturbed genotypic balance which is ascribable to a unit gene or block of genes.

5. SUMMARY

1. Attention has been drawn to the uniformity of the species *G. anomalum* despite its extremely wide range and isolation within that range.
2. No final conclusions could be drawn about the genetics of flower colour. It was thought that at least one gene of large effect was present operating against a polygenic background which gives a wide range of colour types in hybrid populations.
3. A single gene difference between palmatifid and palmate leaf shape is described. Since the relationship with Silow's L^A has not been studied, no symbol is assigned to the new gene for palmately cut leaf. Evidence is presented for the existence of a gene affecting lobe width.
4. The hairiness of *G. anomalum* is basically due to control at a single locus. Dense hairiness is recessive to very sparse hairiness and the symbols H^{A1} and H^{A2} have been given to these conditions respectively. The two-level hairiness of the stem and petiole is clearly under monogenic control. This gene Su^h , has been so called because of its suppressor-type action.
5. The significance of the occurrence of modifiers was discussed.

Acknowledgment.—My thanks are due to Professor Sir Joseph Hutchinson for reading the manuscript and giving helpful criticism.

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