SOME EXPERIMENTS IN HEREDITY WITH *ABRAXAS GROSSULARIATA* AND TWO OF ITS VARIETIES.

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The experiments were carried out in conjunction with the Rev. G. Waddington, S.J., who had obtained some larvae of the var. *lacticolor* through the kindness of the Rev. G. H. Raynor of Hazeleigh Rectory, Essex, and Dr L. Doncaster. They were carried out in the intervals of other important work, which must serve to excuse their incompleteness.

The new variety of *Abraxas grossulariata* termed "*Q*" in this note is somewhat like *lacticolor* in appearance, though not quite so pronounced, as the black markings are sharper in outline and generally rather heavier and the distinctive cream colour of *lacticolor* is practically absent; nor has it the soft surface texture of *lacticolor*: it differs also in that the black markings other than the discoidal spots are visible on the under surface of the wings, which is not the case in *lacticolor*. It was found in the grounds of Milltown Park, Dublin.

"*Q*" appears to be a simple recessive to *grossulariata* as the following results show:

F_1. *Grossulariata* ♂ × "*Q*" ♀ gave about 50, all *grossulariata* in type.

F_2. From these six pairings were made: the resulting numbers were small, chiefly owing to heavy mortality in the egg just before hatching due to dryness, and also from the fact that, as the parents were forced out in March, the larvae were in the hibernating stage during

the heat of the summer and were not kept sufficiently damp. The numbers are: *grossulariata* ♂ 12, *grossulariata* ♀ 16, "*Q*" ♂ 8, "*Q*" ♀ 8.

A pairing was also obtained between a "*Q*" ♂ and a *grossulariata* ♀ heterozygous for "*Q*" (from *grossulariata* ♂ × "*Q*" ♀). From this resulted 6 *grossulariata* ♂, 6 *grossulariata* ♀, 5 "*Q*" ♂, 6 "*Q*" ♀.

From three families "*Q*" ♂ × "*Q*" ♀ there resulted only 13 "*Q*" (♂ and ♀), no *grossulariata*.

Included among the *grossulariata* there is another type, rather indeterminate and merging imperceptibly into *grossulariata*, but quite clear in some cases, which is distinguished by a more or less complete gap in the centre of the row of black spots outside the yellow band on the upper wing. Individuals of this type appear to be heterozygous for "*Q*" (though only a small proportion of F_1 *grossulariata* ♂ × "*Q*" ♀ were so marked, about 10 out of 50), for a pairing between two of this type—of uncertain parentage—gave *grossulariata* ♂ 17, *grossulariata* ♀ 14, "*Q*" ♂ 8, "*Q*" ♀ 11.

These experiments seem to make it certain that "*Q*" is a simple recessive to *grossulariata*. The further pairings, which were made with a view to discovering the relations between "*Q*" and *lacticolor*, were very unsatisfactory as regards quantitative results owing to various causes, the chief being ill-advised forcing which left the larvae "hibernating" during the summer of 1914 when owing to absence I could not attend to them, and the necessity of carrying them about in unsuitable boxes in 1915: qualitatively however the results were interesting.

A (i). The first pairing was made on April 5th, 1914, *lacticolor* ♂ × "*Q*" ♀. This resulted in 3 *grossulariata* ♂ and 5 *lacticolor* ♀.

(ii) Another on April 27th, 1914, between similar parents, *lacticolor* ♂ × "*Q*" ♀ gave only 3 *grossulariata* ♂.

B. April 17th, 1914, "*Q*" ♂ × *lacticolor* ♀. This pairing gave 14 ♂ and 19 ♀, all *grossulariata* in type (including some with the gap in the row of black spots outside the yellow band mentioned above).

The interest in these of course lies in the dominant resulting from a cross between two different recessives.

C. August 1st, 1914, a pairing was obtained between ♂ and ♀ of *grossulariata* type from family *B*, i.e. F_2 for both *lacticolor* and "*Q*." This resulted in:

15 *grossulariata* ♂, 3 *grossulariata* ♀, 7 "*Q*" ♂, 5 *lacticolor* ♀.

The preponderance of males is probably due to the fact that 23 out of the 30 went straight through in the autumn without hibernating, only 7 of those that hibernated finally emerging in March 1915.

D (i). July 27th, 1914, *grossulariata* ♂ (from family *B*) × "*Q*" ♀. This gave:

4 *grossulariata* ♂, 2 *grossulariata* ♀, 3 "*Q*" ♂, 3 "*Q*" ♀, 4 *lacticolor* ♀.

(ii) October 30th, 1914, *grossulariata* ♂ (from *A* (ii)) × "*Q*" ♀ gave only 1 *grossulariata* ♂, 1 "*Q*" ♀, 2 *lacticolor* ♀.

E. November 10th, 1914, *grossulariata* ♂ (from family *D* (i)) × *grossulariata* ♀ (from family *B*) gave only 2 "*Q*" ♀.

At this stage the results were submitted to Dr Doncaster, who suggested that they might be explained in the same way as the production of a coloured flower by crossing two different whites in the sweet-pea, or perhaps are more nearly comparable with the production of a wild-coloured rat or rabbit by crossing an albino with a black.

It is clear that the typical *grossulariata* pattern must depend on the presence of two factors, which may be called **G** and **T**. In the absence of the factor **G** the moth is *lacticolor*, and this factor is sex-limited in inheritance, normal males being **GG**, females **Gg**.

The factor **T** is necessary for the production of the type form; when it is absent (or if a notation be preferred which does not commit one to the presence-and-absence hypothesis, when it is modified to **Q**) the moth is of the variety "*Q*." A normal *grossulariata* male is thus **GGTT**, female **GgTT**; a "*Q*" male **GGtt** (or if preferred it may be written **GGQQ**), "*Q*" female **Ggtt**; a *lacticolor* male and female **ggTT**.

If now a "*Q*" male is mated with a *lacticolor* female, the result will be the production of typical *grossulariata* if the *lacticolor* is carrying the factor **T**, thus

"*Q*" ♂ = **GGtt** × **ggTT** = *lacticolor* ♀

♂ **GgTt** **GgTt** ♀,

and when the F_1 moths are mated together the result will be, in the males, typical *grossulariata* and "*Q*" in the ratio of 3 : 1, and in the females *grossulariata*, *lacticolor*, and "*Q*" in the ratio of 3 : 4 : 1, thus:

grossulariata ♂ GgTt × GgTt ♀ *grossulariata*

Spermatozoa GT, Gt, gT, gt ♂ GT, ♂ Gt, ♀ gT, ♀ gt eggs.

F_2 Males		F_2 Females	
GGTT	= *grossulariata*	GgTT	= *grossulariata*
2 GGTt	= *grossulariata*	2 GgTt	= *grossulariata*
GGtt	= "*Q*"	Ggtt	= "*Q*"
GgTT	= *grossulariata*	ggTT	= *lacticolor*
2 GgTt	= *grossulariata*	2 ggTt	= *lacticolor*
Ggtt	= "*Q*"	ggtt	= *lacticolor*

The new form ggtt will doubtless be *lacticolor*, since it lacks the factor G; it will be a *lacticolor* carrying the factor for "*Q*" instead of for the type form.

As will be seen from mating *C* the observed results are in fair accord with the hypothesis, and this is also the case with matings *D* (i) and (ii) and *E*.

If this hypothesis is correct, among the F_2 offspring from the cross "*Q*" ♂ × *lacticolor* ♀ there should be "*Q*" males of type Ggtt and *lacticolor* females of the types ggTt and ggtt, and that such types may exist is indicated by two pairings made subsequently in 1915, viz. *F* and *G*.

F. About March 10th, 1915, "*Q*" ♂ × *grossulariata* ♀ (both parents from family *C*). This gave only: 4 *grossulariata* ♀ and 4 *lacticolor* ♀, besides one extracted dead from the pupa which appeared to be "*Q*" ♀ but might possibly have been *lacticolor* ♀.

G. About the same date, *grossulariata* ♂ (from family *C* or *D* (i)) × *lacticolor* ♀ (from family *C* or *D* (ii)) gave only 3 "*Q*" ♀ and 3 *lacticolor* ♀.

The interest here lies in the fact that in family *F* *lacticolor* ♀ appears showing the constitution of the "*Q*" ♂ parent to have been Ggtt, for a *lacticolor* could not be the offspring of a normal "*Q*" ♂ of the type GGtt. Similarly in family *G* "*Q*" ♀ is produced showing that the *lacticolor* ♀ parent was either ggTt or ggtt (and not ggTT—the normal *lacticolor* constitution).

A test for the form ggtt would be to mate it with a normal "*Q*" ♂ —i.e., one which had not descended through *lacticolor*—in which case the offspring should all be "*Q*."

The fact that only females appear in *F* and *G* may be accidental or possibly the *lacticolor* may have been derived from Dr Doncaster's

unisexual *lacticolor* stock: there is nothing in the hypothesis given above that would account for it.

One further speculation may be of interest—the form "*Q*" is in some respects so like *lacticolor* that one is inclined to wonder whether it may have been produced by the loss of a similar constituent from the normal *grossulariata*. But since the factor which turns *lacticolor* into *grossulariata* is sex-limited in transmission by the female while that which turns "*Q*" into *grossulariata* is not, on the hypothesis that Mendelian factors are borne by chromosomes, it must be supposed that the factor G is in the sex-chromosome while the factor T is in some other chromosome. It might be possible, therefore, for *lacticolor* to have arisen from *grossulariata* by the loss of some constituent of the sex-chromosome, while "*Q*" arose by the loss of a similar constituent from a different chromosome.

EXPLANATION OF PLATE XXX.

Figs. 1—3. *Lacticolor* ♂, ♀, and underside.

Figs. 4—6. "*Q*" ♂, ♀, and underside.

Figs. 7, 8. ♂ and ♀ of form with gap in the row of spots outside the yellow band; this form is possibly heterozygous for "*Q*."

Figs. 9, 10. Normal *grossulariata*, ♂ and ♀.