A Somatic Mosaic or Mutation in Abraxas grossulariata. (*With Plate I.*)

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The specimen is a large female, labelled "A. Horne, Aberdeenshire, 1906," and was most generously given to me by Mr. Robert Adkin. The whole of the upper- and underside of the wings on the left side have a rather heavily marked pattern of typical *grossulariata*, both wings on the right upperside are *lacticolor*. On the underside the right forewing is *lacticolor*.with a large area in the middle of the central band and a smaller one at the termen, showing the pattern of *grossulariata*. The underside of the right hindwing is *lacticolor*, pure white except for the small black discal spot. The insect is a mosaic of a dominant and a sex-linked recessive pattern.

For the benefit of those who have not read the literature on this subject I will preface my attempt to explain its origin by an account of the mode of inheritance of the sex, and of the somatic factors involved. In moths the male is homozygous for sex ; in other words, the spermatozoa are all alike in having one sex-determining or Z chromosome. The female is heterozygous for sex and has eggs of two kinds, one kind male-producing, the other female-producing. The former has a Z chromosome and, when it is fertilised, receives a Z chromosome from the spermatozoon, giving rise to an individual which is homozygous in regard to sex, having chromosomes ZZ in all its cells, and is therefore a male. The latter have instead of a Z chromosome the corresponding W chromosome, which in *grossulariata* may be entirely absent without any apparent effect on the individual. When fertilised it receives a Z chromosome from the spermatozoon, and gives rise to an individual heterozygous for sex with chromosomes WZ in each cell, a female. The Z chromosome in addition to its effect on sex has an effect on the appearance of the markings of the wings, because it carries the dominant factor, which gives rise to the *grossulariata* pattern, or the corresponding recessive factor, which gives rise to the *lacticolor* pattern.

The W chromosome is negligible in this respect. We may represent the Z chromosome carrying the *grossulariata* factor by (7, and that carrying the *lacticolor* factor by ∠. Males may be homozygous for the *grossulariata* factor with chromosomes (7 (7 or heterozygous with chromosomes (7∠, if the female parent was *lacticolor*.

All the spermatozoa of the first or homozygous male will carry (7 in the Z chromosome, and all the offspring of both sexes must be *grossulariata*, but half the spermatozoa of the second, homozygous for sex but heterozygous for the *grossulariata-lacticolor* factors, have the ∠ factor in the Z chromosome. If one of these fertilises a female-producing egg, a *lacticolor* female is the result, since the W chromosome of the egg does not affect the appearance, and the Z chromosome carries no *grossulariata* factor.

This has been proved by many breeding experiments, and is the classical example of sex-linked inheritance in Lepidoptera. Another discovery which bears on the origin of this mosaic was made by Doncaster, who showed that in some eggs of *grossulariata* there are two nuclei instead of one, and that each may be fertilised by a separate spermatozoon. Although only a single insect results from such a union, one part of it may be genetically different from the other.

One explanation of the origin of this mosaic is that, although both parents were *grossulariata* in appearance, the male was heterozygous for the *grossulariata* factor, and the female had binucleate eggs.

If both nuclei of one of these eggs were female producing, and one was fertilised by a spermatozoon carrying the *grossulariata* factor and the other by one carrying the *lacticolor* factor, a *grossulariata-lacticolor* mosaic would be produced.

The part derived from the first union would have chromosomes (7W in all its cells and would be female *grossulariata*, and the part derived from the second union would have chromosomes ZW in its cells and be female *lacticolor*.

In the case of an ordinary egg with a single nucleus, division into two cells takes place after fertilisation, and as a rule each of these by innumerable subsequent divisions gives rise to half the resultant insect. Sometimes, however, cells derived from one of these wander across and mingle with those derived from the other. This is seen readily in gynandromorphs, which may have streaks of male tissue amongst the female or *vice versâ*, although the loss of a Z chromosome, which caused the gynandromorphism, occurred at the first division of the fertilised ovum.

A migration of cells derived from the one fertilised nucleus amongst those derived from the other would explain the streak of *grossulariata* pattern on the *lacticolor* side of this specimen.

It is fortunate that this mosaic occurred in a species in which the cytology has been so thoroughly investigated, and involved somatic characters the inheritance of which are so well known.

All the conditions necessary for its production in the way suggested above are known to occur in wild *grossulariata*. It has also been proved that a somatic mosaic has originated from a binucleate ovum. This example, which occurred in *Drosophila* is described by Morgan in his *Origin of Gynandromorphs* on page 26.

A second possible explanation is that the specimen is a somatic mutation, which originated by loss of the *grossulariata* factor from the Z chromosome, during, or immediately after t he first division of the fertilised ovum.

In this case after the first division of the fertilised ovum was complete, one cell would have a Z chromosome lacking the *grossulariata* factor, and would produce the *lacticolor* part, the other would still have the *grossulariata* factor and would produce the typical part by its subsequent divisions. Both parents in this case might have been typical *grossulariata*. Since the insect is a female, with only one Z chromosome in each cell a mutation occurring in that chromosome would cause a visible difference in outward appearance.

The arguments for and against this origin of mosaics in Lepidoptera by somatic mutation were given in my former paper in the *Entomologist's Record* 1922, XXXIV., p. 105. There is no doubt that it is the cause, which usually operates in *Drosophila*.

A third explanation is that the same mutation occurred in a germ cell of the male parent. Morgan mentions its possibility in this species and points out that it would give rise to a *lacticolor* female, although both parents were normal *grossulariata*.

But to produce a mosaic the spermatozoon in which this mutation occurred would have to fertilise one nucleus of a female-producing binucleate egg and a normal spermatozoon the other.

It is obvious that the third explanation is the most improbable. In favour of the first is the fact that we know that all the conditions necessary for its production do exist in wild *grossulariata*, whereas we do not know that somatic mutations have ever occurred in this species. In addition there is the probability that several similar mosaics would be found in one brood and the chance of capturing one or breeding one from a wild larva would be much greater than in the case of a somatic mutation, because this would only affect a single individual.

Its likelihood depends on the frequency with which *lacticolor* is found in Aberdeenshire, and of this I have no knowledge.

The following are descriptions of two more mosaics in *Abraxas grossulariata*.

(1) A female formerly in the Horne Collection. Left side typical *grossulariata*, right side a lightly marked form.

(2) A female bred by Mr. H. B. Williams in June 1921, from a wild larva found in his garden at Thornton Heath. It is a small specimen with the wings equal on the two sides.

The upper- and undersides of both wings on the left are the usual heavily marked London form of *grossulariata*, with the fringes almost completely black. On the right side the black markings are much reduced, especially those on the outer side of the orange band of the forewings, the median row of spots on the hindwing and the marginal spots, and the fringes are white. Mr. Williams tells me he has never met with a specimen of this lightly marked form in his garden. I have seen specimens of both sexes marked like the light halves of these two mosaics from Argyllshire, Durham and Bath, and elsewhere, so it must have a wide distribution. It may be a recessive like the Q variety, with the factor carried by an autosomal chromosome. Since wild males are found it is not sex-linked. Each of these specimens may have arisen from a binucleate ovum, with the nuclei differing in the constitution of an autosomal chromosome, or with the nuclei alike but fertilised by spermatozoa differing in the same way. On the other hand, since both are females, they may be somatic mutations.

To my list of somatic mosaics published in this journal, 1922, pp. 105 and 200, I add the following:—

Viminia (*Acronicta*) *menyanthidis*, Vieweg. Sex not mentioned. Right side var. *obsoleta*, Tutt, left side much more strongly marked and typical (Tutt, *British Noctuae and their Varieties*, Vol. I., p. 24).

Mimas (*Smerinthus*) *tiliae*, L. Female. Right side typical with large markings on costa and posterior margin, left side with one central spot, var. *centripuncta*, Clark. The latter appears to be recessive to the former (*Bull. Ent. Soc. de France*, 1895, p. xc.).

Dryas paphia. Female.

Right upperside	*valesina nigra* (ohner schiller).
Left upperside	*valesina brunnea* (grund schillernd).

Right underside *valesina subtusaurea.*
Left underside *valesina subtuscoerulea.*

D. paphia. Female.
Right upperside *paphia rutila.*
Left upperside *paphia viridescens.*
Right underside *paphia.*
Left underside *paphia subtusaurea.*

D. paphia. Male.
Upper surface on both sides *paphia.*
Right underside var. *subtusaurea.*

(T. Reuss, *Societas Entomologica*, 1923, p. 26).

Cirrhoedia xerampelina, Hb. Right side typical, left unicolorous, but not agreeing exactly with the description of var. *unicolor*, Stgr. (*Ent. Record*, 1922, XXXIV., p. 18).

Mr. W. Fassnidge took it on the trunk of an ash, between Lützelbourg and Saverne, in Lorraine, in August, 1921. It is a female, in which the ovipositor and both frenula were clearly seen.

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By Commander GEORGE C. WOODWARD, R.N.

(*Concluded from page 6.*)

July 22nd, *Triphaena fimbria* (1), *Leucania lithargyria*, *Leucoma chrysorrhoea* (*similis*), *Drepana falcataria*, *Hypena proboscidalis*, *Zanclognatha grisealis*, *Hydriomena furcata.*

At Wisley, on June 23rd, *P. argus*=*aegon* was still common, *A. aglaia*, *V. urticae*, *P. brassicae*, *P. gamma*. *A. myrtilli*, appeared to be over, as I did not see one.

On July 30th I spent a couple of hours at Box Hill, and the following species were noted :—*Augiades sylvanus*, *Zygaena filipendulae*, very abundant everywhere, *Epinephele jurtina* and *C. pamphilus*, also abundant, *P. rapae*, *O. bipunctaria* and *A. aglaia.*

The evening at Oxshott, on July 31st, produced *Hepialus sylvina*, which I found rather difficult to capture, *A. secalis* and ab. *leucostigma*, *Noctua baja*, *Triphaena pronuba*, *Ennomos elinguaria*, *Leucania impura* common, and *Petilampa arcuosa* common. I found *P. brassicae* quite commonly asleep on the bushes, a most conspicuous object in the rays of the lantern.

On August 1st I again tried Shoreham, in Kent. *Polyommatus* (*Agriades*) *coridon* was most abundant in a grass field close to the station. *A. aglaia* was also quite common, but seemed to be getting worn. In the same field I noticed *P. rapae*, *P. napi*, *P. brassicae*, *Coenonympha pamphilus*, *E. jurtina*, *A. sylvanus*, *Z. filipendulae*, *O. limitata* and *O. bipunctaria.*

At Oxshott, on August 2nd, I found a small sallow bush covered with the secretions of aphids, it simply swarmed with Noctuae, mostly common, for about a couple of nights. The following were in abundance :—*T. pronuba*, *N. baja*, *L. impura*, *Caradrina morpheus*, *H. nictitans*, *A.* ab. *leucostigma*, and also *T. comes*=*orbona*, *T. janthina*, *T. interjecta*, *M. maura*, *A. secalis* and *X. monoglypha* not common.

On August 8th I again went to Bramshott. I found *Vanessa io*