論 說

FLAKED AND MOSAIC HEADS OF *GOMPHRENA GLOBOSA*

Yoshitaka IMAI and Yasuo IINUMA

Furitsu-Kôtôgakko, Tokyo, and Tokyo Imperial University

Received October, 30 1937

The globe amaranth, *Gomphrena globosa* L., which is native to India, is a popular herb in our gardens. As to the colour of the flower heads, several forms are found; namely, red, pink, and white as well as flaked. In the coloured heads, the bracts covering each flower are coloured. The present paper deals with the flaked form, it being hoped that our experiments will serve as a contribution to the genetics of flaked flowers in terms of the mutable genes (DEMEREK 1931; IMAI 1934b, 1935b; IMAI and TABUCHI, in press).

The flaked heads are marked with red (RIDGWAY's Violet purple) flakes on pink (Pale amparo purple) background. The degree of variegation varies to a considerable extent, from pink with a few spots to heavily flaked. The experiments were begun by the senior writer in 1933 with a single flaked plant. In 1934, offspring were raised from it, with results as shown in Table 1.

Table 1. Data from the 1934 culture.

Red	Flaked	Mosaic	Almost pink	Pink	Total
2	54	4	1	0	61

As will be seen from the table, the flaked individual does not breed true to type, showing inconstancy in flaking. The flaked offspring exhibited various degrees of variegation, the gradation, however, being continuous. Of the flaked, one plant bore pink heads with a few red spots or small flakes, so that the type might be separated, although not quite sharply, from other flaked. In addition to these, two fully red variants were also produced. Red-and-flaked mosaics were rather frequently observed, but those listed as mosaics in the foregoing table (and also in those to follow) were restricted to plants, each of which bore at least one fully red head out of the flaked. The 1935 culture gave the data as shown in Table 2.

Table 2. Data from the 1935 culture.

Mother plant	Pedigree No.	Red	Flaked	Mosaic	Almost pink	Pink	Total
Red	1	30	10	2	0	0	42
	2	18	6	0	0	0	24
	Total	48	16	2	0	0	66
Flaked	3	1	20	1	2	0	24
	4	0	18	0	0	0	18
	5	2	25	5	3	0	35
	6	0	16	3	0	1	20
	7	0	25	0	2	0	27
	8	3	32	2	0	0	37
	Total	6	136	11	7	1	161
Almost pink	9	0	0	0	13	0	13

Since two red variants tested were heterozygous for red and flaked, the plants are regarded as mutants, the origin of which is attributed to the inconstancy of the flaked gene. In the flaked pedigrees were again mixed some red, mosaic, and almost pink plants, in addition to which, the occurrence of one pure pink plant as a mutant is a new experience from our examination. The almost pink plant that appeared in 1934 bred true to type, although a slight variation was observed. The gradation of the variegation, therefore, is genetic, having been proved at any rate to this extent. Additional proofs from the results of the 1936 culture are shown in Table 3.

Table 3. Data from the 1936 culture.

Mother plant	Pedigree No.	Red	Flaked	Mosaic	Almost pink	Pink	Total
Red	8- 1	13	5	5	0	0	23
	- 2	88	0	0	0	26	114
Flaked	5- 1	2	7	3	1	0	13
	- 2	1	21	12	0	0	34
	- 3	2	11	3	1	0	17
	- 4	0	14	0	1	0	15
	- 5	3	9	6	0	0	18
	- 6	1	52	11	0	0	64
	- 7	0	31	4	2	0	37
	- 8	1	18	3	0	0	22
	- 9	1	54	7	0	1	63
	-10	0	14	2	0	0	16
	-11	4	18	4	0	0	26
	-12	0	11	4	1	0	16
	-13	0	14	1	7	0	22

Table 3. (Continued)

Mother plant	Pedigree No.	Red	Flaked	Mosaic	Almost pink	Pink	Total
Flaked	-14	0	15	0	5	0	20
	-15	0	24	3	0	0	27
	Total	15	313	63	18	1	410
	5-16	0	16	0	0	5	21
Almost pink	3- 1	0	0	0	8	1	9
	- 2	0	13	1	21	1	36
	5-17	0	6	2	20	1	29
	-18	0	0	0	39	0	39
	-19	0	2	1	24	0	27
	7- 1	0	0	0	12	0	12
	- 2	1	17	1	33	0	52
	Total	1	38	5	157	3	204
Pink	6- 1	0	0	0	0	20	20

The genotype of two red variants from a flaked pedigree (No. 8) were tested, one of them segregating recessive flaked (including some mosaics), while the other segregated monogenically red and pink. Sixteen pedigrees were also raised from the flaked plants of Pedigree No. 5, the data, excepting the record of one pedigree, containing 15 red, 18 almost pink, and 1 pink mutants. For the flaked families, the complete available data for these three years are :

Red	Flaked	Mosaic	Almost pink	Pink	Total
23	503	78	26	2	632
3.64%	79.59%	12.34%	4.11%	0.32%	

The percentages are the average proportions of the respective mutants and mosaics in the flaked families.

One flaked pedigree, No. 5-16, 1936, segregated monogenically flaked and pink, showing the recessive nature of the latter to the former. The genotype of seven almost pink mutants from Pedigree Nos. 3, 5, and 7 were tested. Some of the families bred true to type, while others gave a mixed population, comprising flaked, mosaic, and pink. The cause of the mixed offspring is due partly to inconstancy of the almost pink gene and partly to inaccurate identification of the mother plants. It is very difficult sometimes to separate almost pink from flaked with slight variegation. The mother plants of such pedigrees, Nos. 3-2 and 7-2, might genetically be an intergrade between the general flaked and almost pink. The flaked plants that appeared

in almost pink pedigrees are usually of slight variegation—additional proofs of genic diversity in variation in the degree of flaking. The mosaics in the matter of degree of flaking, probably due to somatic mutation, were also at times observed.

Five red-and-flaked mosaics that appeared in 1935 were examined for genotypes of sports, the results being shown in Table 4.

Table 4. Offspring of sported and flaked heads, 1936.

Mother plant	Red	Flaked	Mosaic	Almost pink	Pink	Total
a { Red	1	11	1	0	0	13
{ Flaked	0	1	0	0	0	1
b { Red	2	5	0	1	0	8
{ Flaked	6	16	13	3	0	38
c { Red	15	4	1	0	0	20
{ Flaked	1	11	3	3	0	18
d { Red	2	21	3	0	0	26
{ Flaked	0	26	8	1	0	35
e { Red	0	2	0	0	0	2
{ Flaked	0	0	1	0	0	1

Out of 5 tests for red sports, 1 segregated red and flaked monogenically, while the others bred like the flaked. An anatomical survey showed that the intense anthocyanin pigment of the red bracts are present in all the tissues, 3-5 cell thick, even in sports with genetically flaked sub-ectohistogen. Since in *Polygonum*, the thin stipules that contain chlorophyll are supposed to be derived from single ectohistogen (IMAI 1934a), it may imply that all the components of the bract are also derived from ectohistogen only. Experiments showed that there are two types of red sports, namely, (1) those with mutated, or red, sub-ectohistogen, and (2) those with unchanged, or flaked, sub-ectohistogen. The stem of the globe amaranth is invariably red, even in that race which bears white heads. Since the first type should inherit the red character, the segregation from its offspring was monogenic, whereas the second type did not affect the offspring. The 1937 records for the tests of sports are shown in Table 5.

Table 5. Progeny tests of sports, 1937.

Number of sports	Mother branch	Red	Flaked	Mosaic	Almost pink	Pink	Total
2 {	Red	21	5	1	0	0	27
	Flaked	5	22	6	3	0	36
12 {	Red	15	179	18	10	1	223
	Flaked	23	188	34	4	0	249

All told, we tested 19 red sports during our experiments, of which 3 segregated monogenically red and flaked, whereas 16 bred like the flaked. The former type of sports is therefore less frequent than the latter type; in other words, red sports with unchanged sub-ectohistogen occur more frequently than those with changed sub-ectohistogen. It is not clear whether the globe amaranth is dihistogenic or trihistogenic, although the majority of dicotyledons consist of three histogens (IMAI 1934b, 1935a).

In 1937, genotype tests were made with 12 red mutants that appeared in the flaked families, the data being shown in Table 6.

Table 6. Tests of red mutants from flaked families, 1937.

Number of pedigrees	Red	Flaked	Mosaic	Almost pink	Pink	Total
1	100	0	0	0	0	100
9	263	64	12	8	0	347
2	9	30	16	5	0	60

Out of 12 tests, 1 was homozygous for red and 9 were heterozygous, whereas the remaining 2 gave unexpected results. The mother plants of the last 2 bore equally all red heads. This apparent anomaly is explained by regarding them as periclinal sports, not individual mutants. As to the dimension of the sported areas in individual plants, owing to differences in the ontogenic stage during which somatic mutation arises, the red-and-flaked mosaics occur in various ways. The two exceptional red mother plants are therefore believed to be originally flaked, and that early somatic mutation resulted in apparently red individuals owing to the predominance of the sported tissues. The fact that the red sports cannot be identified until the heads are formed interferes with the detection of the small flaked portion when it does not cover the inflorescence. Of the total 14 true red mutants that appeared in the flaked pedigrees which were tested, 1 was homozygous, 1 heterozygous for pink, and the remainder heterozygous for flaked. From the heterozygous family for pink, the offspring of 7 red and 4 pink were tested, the data being shown in Table 7.

Table 7. Progeny tests for No. 8-2, 1937.

Mother plant	Number of pedigrees	Red	Pink	Total
Red	2	88	—	88
	5	73	28	101
Pink	4	—	155	155

All the pink bred true to type, indicating the constancy of the pink gene. Out of 7 red, 2 were homozygous and 5 were heterozygous; the latter segregated monogenically red and pink.

So far as our tests went, the homozygous red families invariably bred true to type, indicating that the mutant red gene is fully constant. For almost pink, 5 plants from Pedigree No. 3-1 were tested, the results being shown in Table 8.

Table 8. Progeny tests for No. 3-1, 1937.

Pedigree No.	Red	Flaked	Almost pink	Pink	Total
3-1-1	0	0	12	0	12
-2	0	0	6	0	6
-3	0	1	21	0	22
-4	0	0	42	0	42
-5	0	0	60	0	60
Total	0	1	141	0	142

These families were highly constant for the almost pink character, showing only 1 flaked variant, although slight variations occurred.

From these facts we may conclude that the flaked gene is mutable, changing at times to red, almost pink, and pink, of which red and pink are fully constant, while almost pink is inconstant. The direction of recurrent mutation is according to the following scheme :

Between flaked and almost pink, mutation is reversible, but the change occurs in only one direction from flaked to red and pink, and from almost pink to pink. Although we lack records for the change from almost pink to red, its occurrence is quite possible if many more families are bred.

The flaked itself shows variation with genic changes. As already pointed out, almost pink, which is a type of least flaking, is genetic, and so is the slightly flaked form, which links moderate flaked with almost pink. Fragmentary observations showed that the heavily flaked mothers gave

offspring greatly predominating in heavily flaked. From these experiences it may be said that graded variation in the amount of variegation may be manifested by a series of certain flaked alleles; in other words, certain flaked genes link red and pink in an allelic series. The flaked and pink are recessives for red, and flaked is dominant to pink, indicating multiple alleles. Within the allelic series, recurrent mutation arises in one or in reversible directions (*cf.* IMAI 1935b).

The expenses of the present investigation were defrayed by a grant from the Hattori-Hôkôkai, to which we express our hearty thanks.

Summary

1. The flaked heads of the globe amaranth is manifested by the flaked gene, which is mutable, changing at times to red and pink. The red, flaked, and pink form multiple alleles, of which the first- and last-named are fully constant.

2. The red sports that appeared on the flaked plants genetically consisted of two types, the one monogenically segregating red and flaked, the other breeding like the flaked: hence the former is believed to have red sub-ectohistogen, and the latter to have flaked sub-ectohistogen. The red sports, in the majority of cases, had unchanged sub-ectohistogens.

3. The flaked itself exhibited variation due to genic changes. The flaked alleles in a graded series are regarded as changes in the red-and-pink locus. Within the allelic series, recurrent mutation occurs in one or in reversible directions.

References

- DEMEREZ, M. 1931. Behaviour of two mutable genes of *Delphinium Ajacis*. Journ. Genetics **24**: 179-193.
- IMAI, Y. 1934a. An apparently simple inheritance of variegation in *Polygonum orientale*. Journ. Genetics **29**: 147-151.
- 1934b. On the mutable genes of *Pharbitis*, with special reference to their bearing on the mechanism of bud-variation. Journ. Coll. Agri., Tokyo Imp. Univ. **12**: 479-523.
- 1935a. The structure of *albomarginata* and *medioalbinata* forms. Journ. Genetics **31**: 53-65.
- 1935b. Recurrent reversible mutations in the dusky allelomorphs of *Pharbitis Nil*. Zeitschr. f. ind. Abst.- u. Vererbgs. **68**: 242-264.
- IMAI, Y. and TABUCHI, K. In press. Recurrent mutation in the flaked alleles of *Pharbitis purpurea*. Journ. Genetics.

千 日 草 の 條 斑 穂 竝 に モ ザ イ ク 穂

今 井 喜 孝 ・ 飯 沼 康 雄
府立高等學校(東京) ・ 東京帝國大學農學部

摘 要

1. 千日草の條斑穂は一つの易變遺傳子の表現によるもので、屢々紅色穂と桃色穂とに轉化する。紅色穂・條斑穂・桃色穂は複對立性を構成し、その中第 1, 第 3 者は共に恒性が高い。
 2. 條斑株に芽條變異として發現した紅色穂は二型を含み、一つは次世代で紅色株と條斑株とを單純比に分離し、今一つは大體條斑株に純殖する。前者は外組織原は勿論のこと、中組織原(千日草が 2 組織原から構成されるものならば内組織原)も亦紅色遺傳子を含み、後者は外組織原だけが轉化遺傳子を擔荷する。併し、芽條變異の紅色穂は多くの場合、中組織原の遺傳的變化を伴はない。
 3. 條斑、それ自身にも遺傳的轉化が起る。この階段的變化に關與する條斑遺傳子群は桃色遺傳子座に於ける變異と認められる。この遺傳子群間に於て、一方向的又は可逆的な頻發突然變異が起る。
-