NOTE ON A BRONZE-BOURBON RED MOSAIC

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(With Plates II–IV)

Several cases of lateral asymmetry have been reported in the domestic fowl. These vary from cases such as Macklin's (1923) gynandromorph, where one side resembles that of the male while the other resembles that of the female, to cases such as reported by Lambert (1929), Knox (1931) and Crew (1932) where the only apparent difference is in the skin colour or the shank colour of the right and left sides. Mosaic feathers have also been reported by Serebrovsky (1926). Cases which may have been similar to those reported by Serebrovsky have been described briefly by Robertson (1925) for turkeys.

The mosaic

The present case, a female, occurred in the F₁ generation from an original cross of a Bronze male on a Bourbon Red female. It was first observed when it was removed from the pedigree basket, the day after it was hatched.

The distribution of the colour in the plumage is shown in Figs. 1 and 2 of Pl. II. The left wing, back, most of the rump or saddle, part of the right wing, part of the breast, the abdomen and the thighs are covered with feathers typical of the Bourbon Red variety. The neck, most of the breast, part of the right wing, the tail and part of the saddle or rump were covered with typical bronze feathers. The anterior and posterior extremities were thus typically bronze in colour while there was a complete band of Bourbon Red plumage around the middle of the bird. There were, however, in the wings areas of Bronze plumage completely surrounded by Bourbon Red pattern feathers.

Several mosaic feathers were observed. Some of these are shown on Pl. III. These mosaic feathers clearly show areas of red and bronze colouring which does not conform to any pattern nor is red confined to one side of the feather and bronze to the other side.

The bird was mated to a Bourbon Red male. All of the progeny that survived past the twentieth day in the incubator had Bourbon Red down and those raised had Bourbon Red plumage.
Note on a Bronze-Bourbon Red Mosaic

The Bronze-Bourbon Red cross

Robertson (1929) crossed the Bronze and Bourbon Red varieties and concluded that they differ in a single pair of autosomal genes, the gene R (Bronze plumage) being incompletely dominant over the gene r (Bourbon Red plumage). Our results appear to agree with those obtained by Robertson, but since he has only published a brief abstract it seems advisable to present the data obtained by us.

Reciprocal crosses were made. The $F_1$ poult's all had the same colour pattern as the Bronze poult's but were readily distinguished from the Bronze by their slightly lighter, brownish colour. Both differed from the down colour of the Bourbon Red poult's (cf. Pl. IV, fgs. 1–3). The juvenile plumage of the $F_1$ birds was distinct from that of the parent breeds, being black with distinct but irregular crescentic or parallel pencilling of brown. The young birds are distinctly brown in colour but become darker as they get older, the adult plumage of the $F_1$ birds being like that of the Bronze parent except for the tips of the saddle and tail feathers (which are white or a light yellow in the Bronze, brown in the $F_1$) and the secondary flight feathers which are lighter in colour and more irregularly marked than the barred flight feathers of the Bronze. The $F_1$ birds differ in both down and plumage colour from the Bronze; at no time do they resemble closely the Bourbon Red in down or plumage colour.

The $F_2$ generation segregated into three groups, Bronze, $F_1$ pattern, and Bourbon Red, as shown in Table I. Embryos that survived past the twentieth day, but failed to hatch, were broken out of the shell, the down pattern noted after which they were discarded. These wet embryos were slightly more difficult to classify than poult's that had hatched and were

dry an

TABLE I

Down patterns of the $F_2$ generation from the cross Bronze x Bourbon Red; also of the progeny obtained by back-crossing the $F_1$ birds on the Bronze and on the Bourbon Red breeds

<table>
<thead>
<tr>
<th>Mating</th>
<th>Hatched</th>
<th>Failed to hatch</th>
<th>Totals: hatched and failed to hatch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bronze</td>
<td>$F_1$</td>
<td>Red</td>
</tr>
<tr>
<td>Actual numbers</td>
<td>$F_2 \times F_2$</td>
<td>53</td>
<td>54</td>
</tr>
<tr>
<td>Expected numbers</td>
<td>$F_2 \times F_2$</td>
<td>52.9</td>
<td>51.2</td>
</tr>
<tr>
<td>Actual numbers</td>
<td>$F_2 \times Bronze$</td>
<td>73</td>
<td>76</td>
</tr>
<tr>
<td>Expected numbers</td>
<td>$F_2 \times Bronze$</td>
<td>74.5</td>
<td>73.5</td>
</tr>
<tr>
<td>Actual numbers</td>
<td>$F_2 \times Red$</td>
<td>49</td>
<td>58</td>
</tr>
<tr>
<td>Expected numbers</td>
<td>$F_2 \times Red$</td>
<td>53.5</td>
<td>53.5</td>
</tr>
</tbody>
</table>

Segs of mo and ri (1932) say:

The egg only a

Knox

Robertson; however, weight save it

Ac Poultry.
dry and well fluffed. For this reason, the figures for hatched poultls are
segregated from those for poultls that failed to hatch. The ratio is approxi-
mately 1:2:1 as would be expected on the basis of a one factor difference
where the hybrids differ from the parents. Back-crosses on the Bronze
and Bourbon Reds give a ratio of approximately one $F_2$ pattern to one
Bronze or Bourbon Red pattern. None of the deviations from the
expected numbers are statistically significant.

There was considerable variation in the colour of the tips of the
saddle and tail feathers of the $F_2$ generation. Among these were birds
with brown-tipped saddle and tail feathers and considerable black on
the secondary flight feathers that otherwise resemble the Bronze and
were so classified. The genetics of this variation has not been completely
worked out. Robertson (1929) found that the Narragansett differs from
the Bronze by a recessive gene which he designated $n$. We have verified
his results but find that the Narragansett also differs from the Bourbon
Red by a recessive sex-linked gene. It is not yet certain whether the
Bourbon Red carries the same dominant sex-linked gene ($N$) as the
Bronze, although it appears probable that such is the case. These facts
are mentioned to show that there may be some differences in the plumage
pattern of the Bronze and Bourbon Red varieties besides the most
obvious ones which depend upon a single pair of genes. There appears to
be no doubt, however, that the differences observed in the mosaic depend
upon this one pair of genes.

According to the Standard of Perfection published by the American
Poultry Association, the Bronzes are heavier than the Bourbon Reds.
However, the Bronze and Bourbon Reds used for the original cross
weighed about the same and there were no other differences observed
save in the plumage colour.

**Discussion**

Several explanations have been offered to account for the occurrence
of mosaics. Bilateral mosaics (birds) differing in the size of the left
and right sides are attributed to non-disjunction (Crew, 1928). Crew
(1932) has also suggested that “the loss of a part of an autosome during
the second cleavage division” could account for cases where there was
only a difference in the right and left leg. Lambert (1929) has pointed
out that such cases are more probably due to gene mutations. A some-
what similar case—one green and one yellow leg—was explained by
Knox (1931) on the basis of a gene mutation.

Roberts & Quisenberry (1935a) have suggested that their case which
Note on a Bronze-Bourbon Red Mosaic

differed in size, plumage colour and leg feathering of the right and left side could be explained on the basis of the loss of a part of a chromosome. They mention non-disjunction and somatic mutation as other possible explanations. They (Roberts & Quisenberry, 1935b) consider the suggestion of Castle (1935), that double fertilization occurred, untenable.

Stern (1936) considers that somatic crossing-over is the most prevalent mechanism accounting for mosaic production in Drosophila melanogaster. There is in such cases no loss of entire chromosomes or of their parts. Deletions and non-disjunction also account for many of the mosaics in animals and plants and in many cases the only deviations observed are mosaic spots or areas (Stern, 1936, and others).

The Bronze-Bourbon Red mosaic might be assumed to have been heterozygous for plumage colour. If that was the case, a complete segregation of genes must have occurred in such a way that one cell and its descendants became homozygous for the genes for Bronze plumage (RR) while the other cell and its descendants became homozygous for the genes for Bourbon Red plumage (rr). It is difficult to see how the distribution of plumage colours in this bird can be accounted for unless this segregation occurred at the first cleavage division. If this was preceded by somatic crossing-over it might explain this case.

If the zygote was heterozygous for the genes involved, deletion of a small fragment of a chromosome or mutation does not seem to account for the results observed since some cells would presumably have remained heterozygous. This apparently was not the case. Non-disjunction might offer a possible explanation if it is assumed that RR = RRr or rr = rrrR, and RR = R or r = rr.

Gene mutation and somatic segregation might furnish the explanation if the zygote was homozygous for Bronze or Bourbon Red. The fact that the breeding behaviour of this bird was that of a Bourbon Red might be considered to favour the assumption that the zygote was homozygous for the Bourbon Red plumage pattern. However, it is possible that segregation would have occurred in such a way that the gonads were of the RR constitution just as certain papillae had this constitution while other papillae had the RR constitution being pure for the Bronze pattern.

Considerable cell migration must have occurred if the original change is traced back to the zygote. If the change is postulated to have occurred after a number of cell divisions had taken place, it is necessary to assume the occurrence of the same event in a number of cells which is unlikely, or that one out of many cells gave rise to a disproportionately large part.
of the mature bird. However, it is evident from the foregoing discussion that any explanation offered is at best highly speculative.

The occurrence of mosaic feathers has been observed to occur not only on hybrid birds (Serebrovsky, 1938) but also as a result of grafting by Danforth (1929, 1935). Danforth has pointed out that such mosaic feathers may result from the independent action of genetically different cells or from the interaction of groups of cells. Whatever the mode of action of these cells may be, it seems evident that the papillae which produce mosaic feathers comprise cells which differ with respect to the genes for plumage colour. This agrees with the fact that such feathers occurred where the areas of red and bronze feathers met. It does not appear to be necessary to invoke the interaction of groups of cells to account for the results although this is not excluded.

**SUMMARY**

A mosaic occurred in the $F_2$ generation of a cross of a Bronze male on a Bourbon Red female. This bird was bronze on the head, neck, shoulders, tail and part of the rump with some patches of bronze feathers surrounded by red on the wings. The rest of the bird was covered with feathers typical of the Bourbon Red variety which thus formed a continuous band around the middle of the body.

The difference in the plumage colour of the two varieties was found to depend upon a single pair of autosomal genes, the ratio in the $F_2$ generation being approximately 1 Bronze to 2 $F_1$ pattern to 1 Bourbon Red. The hybrids resembled the Bronze variety more than the Bourbon Red, particularly in down pattern and adult plumage, but were readily distinguished from both parental varieties.

The possible mechanisms that may account for this case are discussed.

**REFERENCES**


Note on a Bronze-Bourbon Red Mosaic


EXPLANATION OF PLATES II—IV

**PLATE II**

Fig. 1. Dorsal view of the Bronze-Bourbon Red mosaic. Note the single Bronze pattern primary flight feather. The feathers on the left (upper) wing, back and much of the right wing are typical of the Bourbon Red.

Fig. 2. Ventral view of the Bronze-Bourbon Red mosaic. Note the clear-cut demarcation between the Bronze and Bourbon Red feathers on the breast.

**PLATE III**

Fig. 1. Feathers from the rump (1, 2), shoulder (3, 4, 5), wing (6, 7, 8, 9) and breast (10, 11, 12) of the mosaic turkey. Nos. 1, 3, 4, 6, 9 and 11 are mosaic feathers, Nos. 8 and 10 are Bronze pattern, while Nos. 2, 5, 7 and 12 are Bourbon Red pattern feathers.

**PLATE IV**

Fig. 1. Z, pattern (out of Bronze x Bourbon Red) poult. These can be distinguished from the Bronze poult by their slightly lighter brownish coloured down.

Fig. 2. Bronze pattern poult.

Fig. 3. Bourbon Red pattern poult.