Analysis of the Opal color variant of the domestic pigeon (Columba livia)

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ABSTRACT

Is there a gene present that is the causal agent for the Ash-red mimic in pigeons which seems to be a variant of opal? Hollander didn't think so (Hollander, pers. comm.), and no testing had been done to make a determination. We set out to do breeding tests, in individual pens, evaluating whether genetics could be the source of the phenotype in question. Our initial results suggested an allelic gene to opal was at the root. Additional breeding in numbers provided statistically significant results lending strength to the identification of a new (recessive) opal allele as the factor responsible. This ash-red mimic has been given the name "cherry" and symbolized as (ch). Offspring from a cherry x wild type mating were put back to the cherry parent with a result of 43% cherry young and 57% wild type young. We also determined cherry was a recessive allele to opal using complementation tests.

INTRODUCTION

The recessive opal gene in pigeons, most commonly found in homing pigeons, has generally shown two identifiable phenotypes. The one more frequently seen has been a quite variable effect referred to as chocolate or mosaic by homer breeders, and ultimately dubbed the "blue-phase" opal and symbolized (o) (Hollander 1938). Less often observed is an Ash-red mimic phenotype described variously as "extreme" opal (Hollander 1938), "reddish type" opal (Levi 1941:317), or "red phase" opal (Gibson 1995:81). This more stable consistent appearing phenotype has not been studied or tested previously.

Testing has shown opal to be a simple recessive, on the same chromosome as both the pattern series (c) and Spread (S) (Hollander 1938, Quinn 1971:55). The lighter Ash-red mimic phenotype occasionally seen on opal birds had not previously warranted serious study and was thought to be the result of a thyroid condition (Hollander 1938). What study was done on the "red phase" opal phenotype did not result in identification of a genetic source for the phenotype.

The purpose of this study is to evaluate the "red phase" opal phenotype to determine conclusively if it is the result of a medical thyroid condition, or is rooted in a genetic cause. Standard breeding tests intended to isolate any possible gene, or demonstrate that no gene cause is present, were used in this study to further the available information. As a result of our initial breeding data, testing was also done to determine if the potential gene was an allele of opal. This ash-red mimic has been given the name "cherry" and symbolized (ch).

METHODS

Background information: With a determination needing to be made as to if a genetic source vs. a medical source is the root cause of the phenotype being evaluated; the testing needed to look for an allelic gene to opal as one potential causal variable. Standard breeding tests (Mendel 1866, Levi 1941:301, Quinn 1971:108) were used with an emphasis on looking for allelism also.

Protocols: All breeding was done with pigeons (Columba livia) in individual breeding pens. First round eggs from new pairings were discarded to eliminate possible latent sperm held within the female. All pens were housed at the same location and afforded the same lighting and ventilation. All mated pairs were fed and watered from the same supply source.

In order to determine if the "cherry" mutant was the result of an identifiable gene, several matings were done with a cherry and a wild type pigeon, using both a cherry male with a wild type female, and a cherry female with a wild type male. The resulting F1 young were mated to each other, to cherry birds, and to normal "blue phase" opal birds. Opal birds were then mated to cherry birds to evaluate allelism using complementation. Finally, cherry birds were mated to birds which were heterozygous for both opal and cherry.

Data were summarized using n and mean with measures of variability reported with Standard Deviation.

RESULTS

Cherry has been noticed with curiosity for a number of years, primarily in homing pigeon flocks. Those who experience the occasional cherry bird also seemed to have some number of opal birds in their loft. The cherry phenotype is very consistent in color and form, unlike opal which shows extreme variability in its appearance (Quinn 1971). Cherry presents a smooth uniform ash-red appearance of the clumped and smooth spread areas of the feathers, while the course spread portions, when a wing pattern is present, are generally cherry / rose colored similar to the effect of $\mathbf{B^A}$ on pattern.

Unlike opal, cherry is quite uniform from bird to bird with no noticeable variation in color or hue. The cock birds are strikingly good Ash-red mimics, while the hens are a slightly more grey / ash color but also maintain the overall uniformity from hen to hen. The cherry phenotype does not change from molt to molt, as Hollander noticed when discussing "Extreme" opal (Hollander 1938). Six and eight year old cherry birds appear the same color and configuration as when first feathered out.

Fig. 1 shows the outcome of mating homozygous cherry to wild type, with 100% of the young appearing as a wild type phenotype.

When mating F1 birds together **Fig. 2** illustrates the distribution of F2 approached the Mendelian norm for an autosomal recessive with 78% appearing as wild type and only 22% cherry young produced.

cherry mated to wild type	
total young	32
opal	0
wild type	32
cherry	0

Fig. 1

F1 mated to F1	
total young	18
opal	0
wild type	14
cherry	4

Fig. 2

When mating F1 birds (being heterozygous for cherry, and wild type) to homozygous opal birds, **Fig. 3** shows 45% of the young have an opal phenotype with the balance appearing as wild type.

Fig. 4 provides data on the reverse of the Fig. 3 process whereby homozygous cherry birds of both sexes were used to mate to birds that were heterozygous for opal and wild type. With a larger sampling of young, the resulting offspring were 50% opal, and 50% wild type phenotype. As in the previous testing (Fig. 3) the offspring of this mating process displaying an opal phenotype would be genetically heterozygous for opal and cherry, while those showing a wild type phenotype would be heterozygous for wild type and cherry.

opal mated to F1	
total young	20
opal	9
wild type	11
cherry	0

Fig. 3

cherry mated to het opal/wild type	
total young	46
opal	23
wild type	23
cherry	0

Fig. 4

When mating homozygous cherry birds to heterozygous opal/cherry birds, **Fig. 5** shows no young with a wild type phenotype. All birds produced were of opal or cherry phenotypes.

Taking F1 birds and mating them to homozygous cherry, **Fig.6** indicates an expected result given the previous data. All offspring were either wild type phenotype (57%) or cherry in appearance (43%). No young demonstrated an opal appearance.

cherry mated to het cherry/opal	
total young	17
opal	10
wild type	0
cherry	7

Fig. 5

cherry mated to F1	
total young	21
opal	0
wild type	12
cherry	9

Fig. 6

DISCUSSION

With the results of the various breeding tests concluded, it would appear that the statistical representation indicates that root source of the cherry phenotype is a genetic one, and not a simple random medical causation. Even if the phenotype had been caused by a failure of the thyroid gland, the failure would have had to have a genetic cause in order for typical Mendelian results to have been produced.

When mating a cherry bird (of either sex) to a corresponding wild type (+) all offspring (F1) produced were of a wild type phenotype. This would indicate that cherry was an autosomal and not a sex-linked gene. This being the case, the cherry phenotype birds will have 2 genes at the specific loci they reside on, both of them being the now described cherry (ch) gene.

To confirm the cherry gene is an autosomal recessive gene, we then mated the F1 young together. This produced young where 22% were of the cherry phenotype, and the balance (78%) appearing as wild type. The genes present at the opal loci for the non-cherry phenotype birds can not be determined without additional breeding tests on those birds.

Breeding opal birds to F1 (heterozygous cherry and wild type) birds produced only opal young (45%) or wild type young phenotypes (55%). Reversing the process and breeding cherry birds (homozygous for cherry on the opal loci) to birds that were heterozygous for both wild type and opal at the opal loci produced a 50/50 distribution of wild type phenotype and opal phenotype young.

This would indicate that birds which were heterozygous for cherry and wild type (as the F1 were, as well as the 50% wild type phenotypes shown in **Fig. 4**) would have no indication that they were not pure for wild type. In this way cherry acts as opal does, displaying no outwards appearance when in its heterozygous form. Conversely those young producing an opal phenotype as described in **Fig. 4** would have a genotype consisting of one gene for opal and one gene for cherry at the opal loci. This would suggest that opal and cherry are alleles, with opal being the more dominant of the two genes. When cherry has been present in domestic pigeon lofts, it is infrequent, and often mistaken for Ash-red. The lower frequency of cherry young in random breeding situations (especially in homer breeding lofts, where flying performance is the criteria, not bird color) would lend strength to cherry being recessive to opal.

Pairing homozygous cherry birds to mates with a genotype of heterozygous cherry and heterozygous opal at the opal loci produced no wild type offspring (**Fig. 5**). All young produced were either of an opal phenotype (59%) or of a cherry phenotype (41%). The 5% ± 4 deviation of statistical expectations can be attributed to the opal females being poor breeders (Hollander 1938) showing greater infertility and embryonic death than the hatchability of young of other colors.

The results shown in **Fig. 6** where cherry genotype birds were mated to F1 birds, continues to demonstrate cherry is an autosomal gene. The young produced were either cherry (43%) or wild type (57%). No opal phenotype birds were produced from this mating. Additional testing will need to be done to determine the fertility and hatch rate for both opal and cherry birds, but it is clearly not at 100% of eggs laid.

I believe additional breeding tests should be done with F1 birds to each other, and with birds heterozygous for cherry and opal among themselves, to determine more grounded statistics, and to help with the hatchability study mentioned previously.

This study and the results reported, demonstrate that the cherry phenotype is in fact genetic in origin, and is a simple autosomal recessive allele of opal, bringing to rest the question of a medical causation to the appearance shown by cherry birds.

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