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## A PERSISTENT MUTATION IN THE CALIFORNIA QUAIL

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The persistence for forty-five years of a recessive gene mutation in the California Quail (*Lophortyx californica*), or its repeated reappearance during that time, is a matter worthy of record. The mutation in question is a fawn or "dove-colored" variant of the normal plumage, far more striking in its divergence than any variations in plumage that separate different subspecies of quail. This mutation, which apparently is due to a single recessive factor, may appropriately be referred to as "dilute." Since the exact moment or even generation in which a gene mutation actually occurs is difficult to establish, we cannot be certain whether a newly observed trait is of recent origin, caused perhaps by experimental treatment, or results from a mutation that had occurred some time in the past and had been carried along by heterozygous individuals, only to make its first visible appearance when just the right parental combination occurred.

We first observed the dilute character in 1933 in young quail hatched in the course of some experiments on the effects of hormones and skin grafting. In March of that year (permission having been obtained from the proper authorities), a number of native California Quail were captured on the Stanford campus and confined in a large, wire-enclosed yard which offered ample opportunity for normal activity. The females laid eggs which were collected at intervals and placed in an incubator. Of 62 chicks hatched, 59 were normal and 3 were dilute. The latter had markings similar to the others but with all colors so pale or bleached in appearance as to give a general effect of uniform light yellow or "tow-color," as shown in figure 71. All three of these original dilutes died within a few days after hatching.



Fig. 71. Two normal and three dilute California Quail one day old.

In the following three years, 1934, 1935, and 1936, a few dilute young appeared each season among the normal chicks but all died before they reached maturity. As it is possible that they may have been offspring of experimental birds, we here include a condensed protocol for two of the experiments.

### Experiment 1; Male 461

March 12, 1933.—Bird captured.

March 13.—Bird etherized and a few feathers plucked from several regions showing sexual difference.

March 21 to 23.—Bird kept in small inside pen and given 0.6 milligrams of thyroxin each day by mouth.

March 23.—Bird replaced in outside yard and recaptured from time to time for observation of the regenerating feathers.

Experiment 2; Male 456

Dates of capture, plucking, and treatment were the same as in Experiment 1. In place of thyroxin, 300, 200, and 100 rat-units of theelin in water were injected subcutaneously.

It does not seem likely that this treatment of the male birds could have had any relation to the production of dilute young, for in the case of a recessive mutation occurring only in the male, homozygous young would not appear until the F<sub>2</sub> generation the following year.

In 1937 a dilute male was raised to maturity. This bird was one of a brood of 14 young (11 normal and 3 dilute) which were captured by children on the Stanford campus who saw them falling from a palm tree on Alvarado Row where they evidently had just been hatched. These three dilutes are shown in figure 71. The parents were observed at close range as they ran about near by in anxiety; both were normal in plumage. Two of the young dilutes were lost in the process of getting them adopted by foster parents, but the third, although not vigorous, survived and assumed adult male plumage, in the dilute form, at the same time as the other males of the brood.

The following spring this dilute male was placed in a separate pen with two older females, no. 29 and no. 30, which from previous records we suspected might be heterozygous for dilute. Twenty-nine eggs were obtained from these two females before they were separated and from these were hatched 19 normal and 10 dilute young. After the females were separated, no. 30 produced one normal chick; and no. 29 produced 12 normal and 13 dilute young.

In 1939 the final test of mating two dilute individuals was attempted, but the only dilute female which had reached maturity died before any eggs were obtained. Subsequently we have not had two dilute birds of opposite sex at the same time. But it would seem evident from our observations, which are summarized in the following table, that the dilute character is due to a single recessive genetic factor.

Parents; phenotype and assumed genotype	Observed ratio		Expected ratio	
	normal	dilute	normal	dilute
1937				
Male—normal (Dd)	11	3	10.50	3.50
Female—normal (Dd)				
1938				
Male—dilute (dd)	19	10	21.75	7.25*
Female no. 30—normal (DD)				
Female no. 29—normal (Dd)				
Male—dilute (dd)	1	0	1	0
Female no. 30—normal (DD)				
Male—dilute (dd)	12	13	12.50	12.50
Female no. 29—normal (Dd)				

\*If both females were equally prolific; actually no. 29 was more so during the rest of the season, which might really bring the expected ratio into even closer agreement with the results obtained.

When the first dilute quail was hatched in 1933, it seemed probable that the character might be a recent mutation. Later, however, a search of the quail collection in the Stanford Natural History Museum brought to light the two adult dilute specimens which are shown in figures 72 and 73.

The dilute male (S.U.N.H. no. 7123) was collected on November 10, 1896, by George Hall at San Carlos, California—about seven miles northwest of the Stanford campus. The dilute female (S.U.N.H. no. 7127) was also collected at San Carlos, on December 21, 1912, by Chase Littlejohn. Together with these dilute quail we show

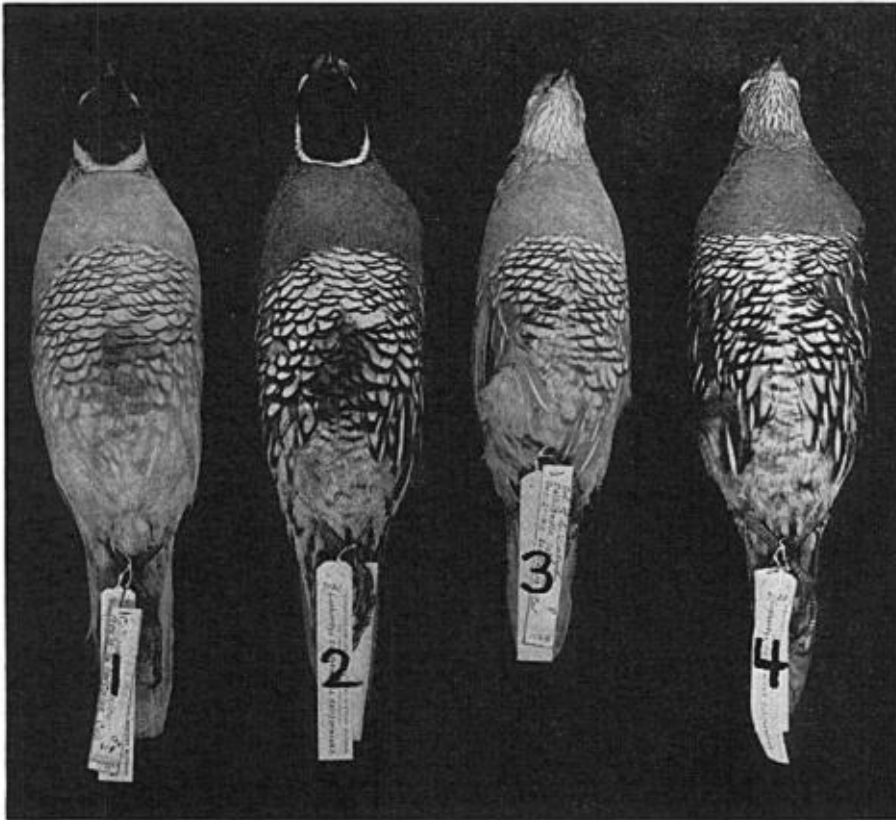


Fig. 72. Comparison of adults of dilute and normal California Quail. 1, dilute male (no. 7123 S.U.N.H.); 2, normal male; 3, dilute female (no. 7127); 4, normal female.

two normal specimens for comparison. Both were collected at Redwood City, California, by Chase Littlejohn, the male in 1907 and the female in 1895.

Since both the dilute quail were collected within seven miles of the Stanford campus where the dilute young appeared in 1933, it seems probable that for the past forty-five years at least the quail in this region have carried the recessive character for dilute, in spite of the fact that dilute adult quail are almost never encountered in the field. The probable explanation for this latter fact is that this mutation is semi-lethal in its effects. The dilute young we observed were all decidedly weaker and less vigorous than the normal young. In the wild condition the mortality is heavy among young quail in the first few days after hatching. A pair of quail will often hatch 14 or more eggs in a season, but frequently only one or two of the brood will reach maturity. Under these conditions it is probable that nearly all the dilute young perish soon after hatching. On the other hand, two-thirds of their "normal" brothers and sisters would carry the gene and thus provide for appearance of the trait from time to time when two heterozygous parents happen to mate, as in the case of the pair that nested in a palm tree on Alvarado Row.

As we have seen, the existence of this mutation among the quail of a particular locality is easy to overlook. It would be interesting to know if the dilute factor is confined

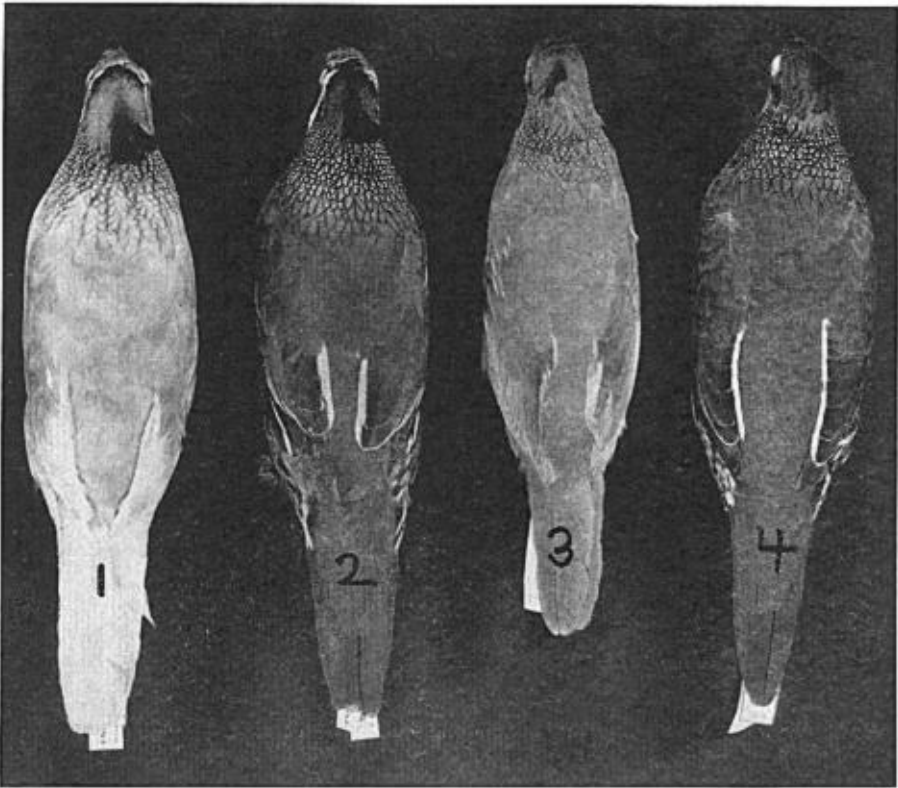


Fig. 73. Dorsal aspect of quail shown in figure 72.

to the region about Stanford, or whether it may exist among the quail in other regions of the state. Adequate information on this point would throw light on whether this is a unique or recurrent mutation and would be of special interest to those students of mathematical biology who are interested in the persistence of genes for adverse traits in wild populations.

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