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## The Plumage Color and Feathering in Chicken-Quail Hybrids

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### Summary

The hybridization was carried out by artificial insemination of Japanese quail (*Coturnix coturnix japonica*) hens with chicken (*Gallus domesticus*) semen of seven breeds; White Cornish (W.C.), White Leghorn (W.L.), Hinaidori (Hinai.), Nagoya, Rhode Island Red (R.I.R.), Black Minorca (B.M.), and Barred Plymouth Rock (B.P.R.). The dominant white *I* gene of W.C. and W.L., the extended black *E* gene of B.M., the sex-linked barring *B* gene of B.P.R., and the slow feathering *K* gene of Nagoya and B.P.R. were inherited as dominant genes in the chicken-quail hybrids. The shank color of B.M. and Hinai. was dominant to that of Japanese quail in the chicken-quail hybrids.

The first recorded trial of intergeneric hybridization between chicken (*Gallus domesticus*) and Japanese quail (*Coturnix coturnix japonica*) was reported in 1959 (1) and the first hybrids were made in 1961 by Wilcox and Clark (2). Since then intergeneric hybridizations between chicken and Japanese quail have been carried out by several investigators. Some of them have described the plumage color of chicken-quail hybrids (3-5). The purpose of the present study was to obtain further information on morphological traits of these hybrids.

### Materials and Methods

The intergeneric hybridization was carried out by artificial insemination of Japanese quail hens with semen of seven breeds of chicken; White Cornish (W.C.), White Leghorn (W.L.), Hinaidori (Hinai.), Nagoya, Rhode Island Red (R.I.R.), Black Minorca (B.M.), and Barred Plymouth Rock (B.P.R.). The hybridization procedure has been presented in the previous paper (5). The Japanese quail in this experiment was a wild type bird ( $e^+e^+/+, Wh^+/-, y^+/y^+$ ). The observation of phenotypic characteristics was made until the hybrids were six months old. The breast and hackle feathers were plucked from adult birds to observe the distribution of the pigments. After drying, the feathers were placed sequentially

in absolute alcohol for one day, 50% alcohol: 50% xylene for one day, and xylene for two days. The prepared feather samples were then examined with a light microscope.

### Results

The fertility of chicken - quail cross eggs was 20-30%. However, most of them resulted in abnormal development and early embryonic death. The hatchability of the fertile eggs was only 4-10%.

Photographs of W.C.-, Nagoya-, and B.M. -quail hybrids are presented in Figure 1. Photographs of hybrids obtained with the other four breeds of chicken were shown in the previous paper(5). The phenotypic expression of down and plumage colors of  $F_1$  hybrids obtained with chicken semen of seven breeds is shown in Table 1. The down color varied according to the paternal breed of chicken. The down color of the W.C.- and W.L.-quail chicks was cream-yellow, similar to that of paternal breed chicks. The adult plumage color of these hybrids was predominantly white with some rust tinge. The Hinai. -, Nagoya-, and R.I. R.-quail chicks had black and tanbrown stripes on the back and head, which were narrower and less distinct than those of Japanese quail. The remainder of the back and head was a cream-yellow. The adult plumage of these hybrids was a mixture of several colors with black and various shade of brown. Hinai.- and R.I.R.-quail hybrids had predominantly white in the neck and several white tips of the feathers of the dorsal surface. With age, the tips of these feathers and the breast plumage appears to be almost white, while Nagoya- quail  $F_1$  had not any tips at all. The B.M.-quail chick was completely black in color and the pulmage color represented black with some dark brown. The B.P.R.-quail chick had black with a yellow spot on the head and the adult had characteristic black and white banding similar to that of B.P.R..

TABLE 1. *The down and plumage colors of chicken-quail  $F_1$*

Paternal breed	Down color	Plumage color
W.C.	Cream-yellow	White with light red
W.L.	Cream-yellow	White
Hinai.	Black & tan stripes	Several colored mixture (white tips)
Nagoya	Black & tan stripes	Several colored mixture
R.I.R.	Black & tan stripes	Several colored mixture (white tips)
B.M.	Black	Black with dark brown
B.P.R.	Black (yellow spot)	Barring of white & black

Photographs of feathers taken from seven breeds of chickens and Japanese quail are shown in Figure 2. The size, shape, and distribution of the pigment granules of the feathers of Japanese quail were different from that of the chicken breeds. The feathers of Japanese quail contained a lot of large rod-shaped black

granules (eumelanin). Photographs of pigment granules of feathers taken from the chicken-quail hybrids are shown in figure 3. White Cornish and W.L. had no pigment in the white-colored feathers, whereas their hybrids had a few few small yellowish granules (pheomelanin). Hinai., Nagoya, and R.I.R. had both eumelanin and pheomelanin, and their pigment distributions were somewhat different from region to region in the feather. The pigment granules of their hybrids were similar to those of the paternal chicken breeds. Many eumelanin and a few pheomelanin granules were observed in the feathers of B.P.R., B.M., and their chicken-quail hybrids.

The shank color of the chicken-quail hybrids obtained from the seven breeds of chicken is shown in Table 2. The Japanese quail has shanks of pinkish white in color. The Nagoya-quail hybrid had slaty blue color in the shanks similar to those of Nagoya. White Cornish-, Hinai-, B.P.R.-, and R.I.R.-quail hybrids had pinkish white shanks similar to those of Japanese quail.

The featherings of chickens and  $F_1$  hybrids are summarized in Table 3. The feathering rate of Nagoya- and B.P.R.-quail chicks was much slower than that of hybrid chicks obtained with the other breeds of chicken.

TABLE 2. *The shank and beak color of chicken-quail  $F_1$* 

Paternal breed	Shank & beak color
W.C.	Pinkish white
W.L.	Pinkish white
Hinai.	Pinkish white
Nagoya	Slaty blue
R.I.R.	Pinkish white
B.M.	Black
B.P.R.	Pinkish white

TABLE 3. *The feathering rate of 7 breeds of chickens and their hybrids*

Breed	Feathering		$F_1$ feathering
	Phenotype	Genotype	
W.C.	Rapid	$k/k$	Rapid
W.L.	Rapid	$k/k$	Rapid
Hinai.	Rapid	$k/k$	Rapid
Nagoya	Slow	$K/K$	Slow
R.I.R.	Rapid	$k/k$	Rapid
B.M.	Rapid	$k/k$	Rapid
B.P.R.	Slow	$K/K$	Slow

### Discussion

In the 1940's, Hutt presented a complete compilation of the known genes in domestic fowl (6). In a recent review, an alphabetical list of over 250 loci of the

domestic chickens has been presented by Somes (7). Truax and Johnson have presented a list of some 18 different plumage color mutants (8).

In general bird taxonomy is mainly based on different morphological characteristics. It is of interest in the aspects of evolution and domestication to study the genetic differences and the degree of similarity of gene mapping between chicken and Japanese quail.

The dominant white *I* gene of W.L. and barring *B* gene of B.P.R. have been suggested as dominant traits in chicken-quail hybrids. Black Minorca-quail hybrids represented almost black plumage color with considerable extension of black pigment to the shanks. By figure 1, the *I* gene of W.L. and W.C., *B* gene of B.P.R. and extended black mutation gene of B.M. may be epistatic or dominant to the  $e^+$  (brown extension gene) of Japanese quail. Although Nagoya and R.I.R. are estimated to have the same genotypes on plumage color, R.I.R.-quail hybrids had several white flecks on them (9). It may be suggested that the genotypes on plumage color of Nagoya may be a little different from that of R.I.R. or Hinai. It is well known that the *E* locus of chicken is  $E > e^+ > e$ . These observations indicate that it seems probable that the  $e^+$  gene of Japanese quail is ranked approximately equal to the  $e^+$  gene types such as Hinai, R.I.R. and Nagoya.

The dominant white *I* gene of W.C. and W.L. was dominant in the chicken-quail hybrids, but by microscopic observation of feathers of W.C.- and W.L.-quail hybrids, the *I* gene of chicken appears to be unable to inhibit the pigmentation perfectly.

The shank of  $F_1$  hybrids from yellowish-shank chicken  $\times$  Japanese quail are pigmented in the Japanese quail pattern. The  $F_1$  data indicate that the pinkish white shank gene is inherited as a dominant trait. In the mating of Nagoya  $\times$  Japanese quail and B.M.  $\times$  Japanese quail, slaty blue ( $id/id, W/W$ ) of Nagoya and black ( $ID/ID, W/W$ ) of B.M. are inherited as dominant traits.

Of the chicken-quail hybrids, only Nagoya- and B.P.R.-quail hybrids represented slow feathering. When the slow feathering chicken breeds were mated with Japanese quail, the  $F_1$  were all slow feathering chicks. The slow feathering of Nagoya-quail chicks is first reported in this paper. These observations indicate that the inheritance of feathering in chicken-quail hybrids is controlled by a single gene. The feathering of Japanese quail may be estimated to have the genotype symbol  $k/k$ .

Recently a few investigators have given more detailed information on the karyotype by banding patterns and have detected only a minor difference of chromosomes between chicken and Japanese quail by the banding techniques (10, 11). In this paper, it represents the inheritance modes in chicken-quail hybridization are very resemble to those of interbred crossing in chickens. It may be suggested that the gene mapping of chicken is closely related to that of Japanese quail. More mating data will be required to confirm the present hypothesis and

more detailed information on gene mapping of these two species will be necessary to investigate the evolutionary approach.

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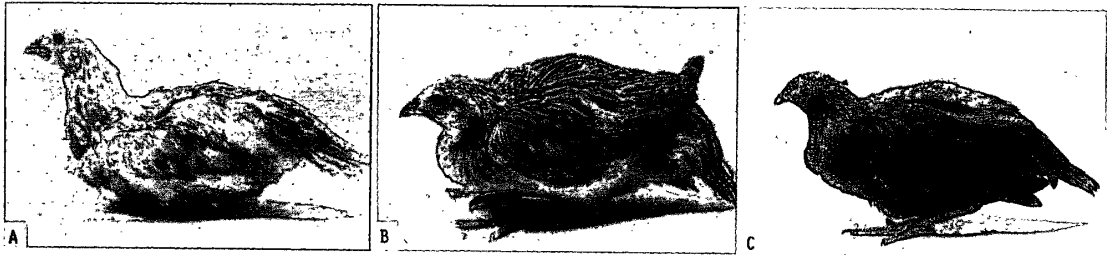


Figure 1 Chicken-quail hybrids (A : W.C. male B : Nagoya male C : B.M. male)

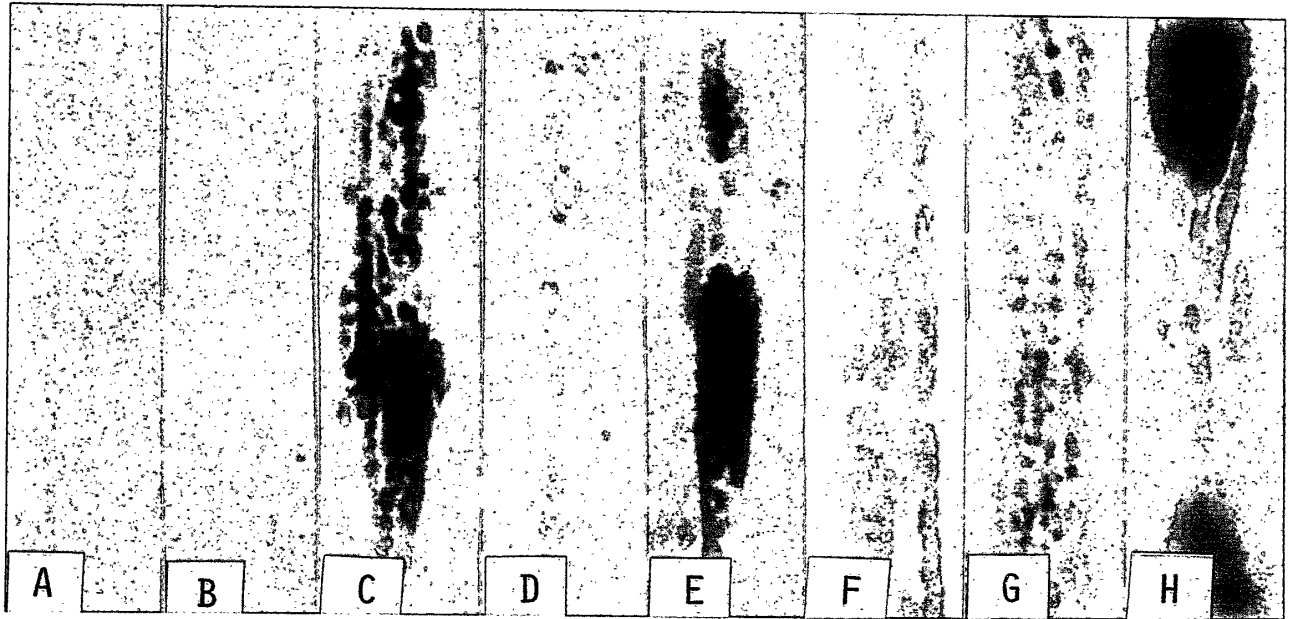


Figure 2 The light microscopic comparison of unstained barbules of chicken (A : W.C. B : W.L. C : Hinai. D : Nagoya E : R.I.R. F : B.M. G : B.P.R. H : Japanese quail)

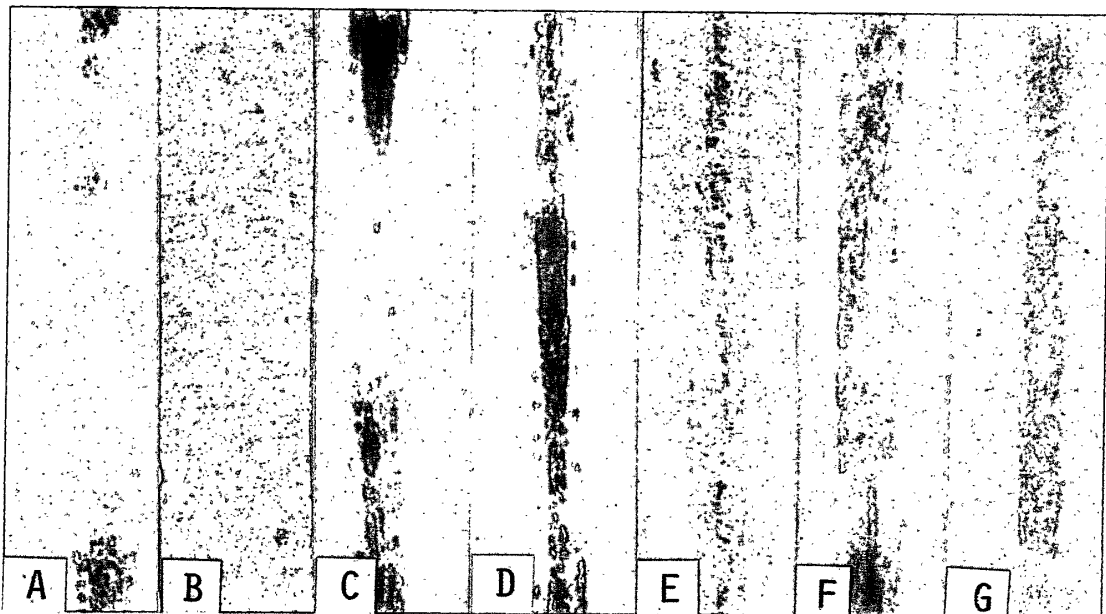


Figure 3 The light microscopic comparison of unstained barbules of chicken-quail hybrids (A : W.C. male B : W.L. male C : Hinai. male D : Nagoya male E : R.I.R. male F : B.M. male G : B.P.R. male)