Genetic Analyses for the White-Tailed Character of the Chabo (Japanese Bantam)

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In the Chabo (Japanese Bantam) breed of native Japanese chickens, there are birds that have buff-like plumage. This plumage shows yellowish brown at the trunk and white for all the tail feathers and a part of the primaries. In other words, this plumage occurs when areas, normally black for “buff columbian” plumage are replaced by white ones. Genetic analyses revealed that the gene controlling the appearance of the white area is an incompletely dominant autosomal gene. The homozygous condition for the mutant gene completely inhibits the expression of black pigmentation, leading to the replacement of black areas with pure white ones. The inhibition effect in the heterozygote however, is incomplete, resulting in the white areas (feathers) that have a slight gray tinge and many minute gray or black speckles. The mutant gene also has a weak effect in inhibiting the expression of brown color. Furthermore, when birds have the mutant gene with a wild-type genetic background for other plumage color genes, they exhibited the “red-pyle” plumage pattern. Therefore, there is a high possibility that the mutant gene expressing white areas (feathers) in the Chabo is identical to the known dominant white (*I*) gene, because the effect and mode of inheritance of the mutant gene possessed by the Chabo are quite similar to those of the *I* gene. This could be the first finding of a dominant mutant gene controlling white plumage in Japanese fancy fowls.

Key words : Chabo, dominant white, Japanese Bantam, native Japanese chicken, plumage color mutation

Introduction

In Japan, we have 40–50 breeds of native Japanese chickens (Tsudzuki, 2003). Almost all breeds of native Japanese chickens are ornamental breeds, of which two groups (the Jidori and Shamo groups) and 15 breeds have been designated as “Natural Monuments” by the Japanese Government (Kuroda *et al.*, 1987). The Chabo (Japanese Bantam) breed is one of the Natural Monuments. The ancestors of the Chabo are thought to have been introduced to Japan from Vietnam around the beginning of the 17th century (Oana, 1951), thereafter improvement has been performed for their body shape and plumage colors, and currently the Chabo breed has many

plumage color varieties authorized by fancier associations (Mitsui, 1979). The buff, which has yellowish-brown plumage all over the body, is one of these varieties. However, though currently in Japan there are no birds that show complete buff plumage, there are birds that have buff-like plumage. The buff-like plumage shows white tail feathers and partially white primaries, although the trunk is yellowish brown in color (Fig. 1).

This article describes the characteristics and the mode of inheritance of the white-tailed character seen in the buff-like Chabo.

Materials and Methods

After detailed observation for the buff-like (white-

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Fig. 1. Buff-like (left and right) and “buff-columbian” (middle) males of the Chabo. In buff-like (white-tailed) Chabos, black regions of the buff-columbian plumage are replaced by white. The white region in the homozygote for the mutant gene (right) is larger than the heterozygote (left). The brown coloration is also lighter in the homozygote than in the heterozygote.

Table 1. Incidence of the white-tailed character in intra-Chabo and inter-breed matings*

Matings	Segregation ratios of characters				P (χ^2 -test)
	Observed			Expected	
	WT	ST	BT	WT : ST : BT	
Female×Male					
Intra-Chabo mating					
WT×WT	7	0	0	1 : 0 : 0	—
WT×BT	0	14	0	0 : 1 : 0	—
ST×ST	5	9	5	1 : 2 : 1	—
ST×WT	4	3	0	1 : 1 : 0	P=0.51**
BT×ST	0	21	16	0 : 1 : 1	.50>P> .40
Inter-breed mating					
Brown Leghorn (BT)×WT Chabo	0	40	0	0 : 1 : 0	—
F ₁ (ST)×F ₁ (ST)	13	14	6	1 : 2 : 1	.20>P> .10
F ₁ (ST)×Brown Leghorn (BT)	0	16	18	0 : 1 : 1	.80>P> .70

* WT=white tail, ST=speckled tail, BT=black tail.

** Binomial test.

tailed) character, we performed two kinds of mating experiments. One is an intra-Chabo mating, taking the combination of tail colors into consideration. In the mating experiment, we set up five kinds of combination of tail colors (Table 1). All the Chabos used here had the *Co/Co e^v/e^v* genotype for plumage color genes in the background.

A second mating experiment is an inter-breed mating with white-tailed Chabos and Brown Leghorns that have wild-type plumage with black tail

feathers. In this experiment, we performed *inter se* matings of the F₁ birds derived from the matings of the Chabo and the Brown Leghorn breeds to produce F₂ progeny. Subsequently, we mated the F₁ birds to the Brown Leghorns to obtain a backcross generation (Table 1).

We examined segregation ratios for tail color characters for each mating in both the intra- and inter-breed mating experiments. Finally, the data from the intra- and inter-breed matings were com-

Table 2. Summary of incidence of the white-tailed character in mating experiments*

Matings	Segregation ratios of characters				P (χ^2 -test)
	Observed			Expected	
	WT	ST	BT	WT : ST : BT	
Female $\times$ Male					
WT $\times$ WT	7	0	0	1 : 0 : 0	—
WT $\times$ BT	0	14	0	0 : 1 : 0	—
BT $\times$ WT	0	40	0	0 : 1 : 0	—
Total	0	54	0	0 : 1 : 0	—
ST $\times$ ST	18	23	11	1 : 2 : 1	.30 $> P >$.20
ST $\times$ WT	4	3	0	1 : 1 : 0	P = 0.51**
BT $\times$ ST	0	21	16	0 : 1 : 1	.50 $> P >$.40
ST $\times$ BT	0	16	18	0 : 1 : 1	.80 $> P >$.70
Total	0	37	34	0 : 1 : 1	.80 $> P >$.70

* WT = white tail, ST = speckled tail, BT = black tail.

** Binomial test.

bined, to take the combination of tail colors in matings into consideration (Table 2). Statistical analyses for the segregation ratios were performed by the χ^2 -test or binomial-test.

Results and Discussion

Morphology

The primary plumage pattern of the buff-like Chabo is the same as that of the "buff columbian" plumage (Smyth and Somes, 1965 ; Brumbaugh and Hollander, 1966 ; Smyth, 1990). In the buff-like Chabo plumage, the black areas of the buff-columbian plumage (*i.e.* tail feathers and a part of the primaries) were replaced by white ones (Fig. 1). Detailed observation revealed that there are two types of plumage for the buff-like Chabos. One is a bird that shows pure white in the white region, and the other has a light grayish tinge and minute gray or black speckles in the white region (feathers) (Fig. 2). Hereafter, for the convenience of description, we will call the former type character "White Tail" (WT) and the latter type character "Speckled Tail" (ST). Also, we will call the character showing no white areas "Black Tail" (BT). In the ST Chabo, the brown color in plumage was lighter than that of the BT Chabo. In the WT Chabo, the brown color was lighter than that of the ST Chabo. Moreover, in the WT Chabo, some of the hackles, saddle hackles, tail coverts, primaries, and secondaries, which are originally brown in color, were whitish or white (Fig. 1).

Mode of inheritance

Table 1 shows the results of intra-Chabo matings

Fig. 2. Feathers from a buff-like (white-tailed) cock heterozygous for the mutant gene. Left : a primary feather. Right : a tail feather. In both feathers, minute gray or black speckles are seen.

and inter-breed matings. The data from the intra-Chabo mating suggested that the white-tailed character of the Chabo is controlled by an incompletely dominant autosomal gene. In the inter-breed mating, all the F_1 progeny showed ST. In the F_2 generation obtained by the *inter se* matings of ST birds, WT, ST, and BT segregated in a ratio of 1 : 2 : 1. In the backcross generation obtained by matings of the F_1 (ST) and the Brown Leghorn (BT), ST and BT segregated in a ratio of 1 : 1. The data from inter-breed matings also suggested incompletely dominant autosomal inheritance. Then, the data from the intra- and inter-breed matings were combined based

Fig. 3. **The red-pyle plumage.** The black areas in the wild-type plumage are replaced by white. This male is heterozygous for the mutant gene, in which gray or black minute speckles appear in the white region.

on the combinations of tail colors in matings, because there was essentially no difference in the segregation ratios of tail characters between the two kinds of matings. The combined data are shown in Table 2. WT parents produced only WT progeny. The reciprocal matings of WT and BT birds produced ST progeny only. The *inter se* matings of ST birds produced WT, ST, and BT progeny in a 1 : 2 : 1 ratio. The matings of ST and WT birds produced ST and WT progeny in a 1 : 1 ratio. In the reciprocal matings between the BT and ST birds, ST and BT birds segregated in a ratio of 1 : 1. All ratios obtained from each mating were in agreement with the expected ratios, based on the hypothesis that the white-tailed character seen in the Chabo is controlled by an autosomal dominant mutant gene and the gene effect is incomplete under the heterozygous condition.

In the F_2 and backcross generations of the interbreed mating, the males having the combination of the mentioned mutant gene and the wild-type ($co^+/co^+ e^+/e^+$) background showed the “red-pyle” plumage pattern (Fig. 3) — that is, the black regions of the black-breasted red (wild-type) plumage were replaced by white ones (Somes, 1988 ; Smyth, 1990 ; Roberts, 1997).

Thus, it can be concluded that the mutant gene is an inhibitor to black pigmentation, the homozygote exhibits pure white feathers instead of black feathers, and the heterozygote expresses white feathers with a light gray tinge and minute gray or black speckles. Furthermore, judging from the observation of the two types of white-tailed Chabos (Fig. 1), it is apparent that the mutant gene has a dilution effect on brown pigmentation. The effect is thought to be more intensive in homozygotes than in heterozygotes. These characteristics and mode of inheritance of the mutant gene in question are quite similar to those of the known dominant white (I) gene. The I gene also is an incompletely dominant autosomal gene that inhibits black pigmentation and dilutes brown pigmentation, and exhibits the “red-pyle” plumage pattern under a wild-type genetic background (Somes, 1988 ; Smyth, 1990). Thus, there is a high possibility that the mutant gene is identical to the I gene. Recently, the dominant white mutation (I) was revealed to be exclusively associated with a 9-bp insertion in exon 10 of the *PMEL17* gene (Kerje *et al.*, 2004). Molecular analyses for the *PMEL17* gene possessed by the white-tailed Chabo will resolve this problem in the future. Regardless of the aforementioned, this could be the first finding of a dominant gene controlling white plumage in Japanese fancy fowls.

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