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Inheritance of a New Albino Mutation in Brazilian Free-range Black Chickens

■ Author(s)

Jorge W[1]
Cunha LM[1]

[1] Departamento de Biologia Geral. Instituto de Ciências Biológicas. Universidade Federal de Minas Gerais, Belo Horizonte.

■ Mail Address

W Jorge
Rua Carrara, 111
Bairro Bandeirantes
31.340-710. Belo Horizonte, MG, Brasil.

E-mail: wiljorge@icb.ufmg.br

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ABSTRACT

A genetically recessive albino mutation, which inhibits pigment development in the eyes, skin, and feathers of domestic chickens from Brazil, is described. This mutation appeared in a flock of completely black chickens of a private breeder. There are no information on the origin, breed, or specific line of the birds. Pigment inhibition is apparently complete in the feathers and eyes. Bird sight is very impaired, but no histological examination was carried out. Ratios obtained in F2 and backcrossed birds indicate that a single autosomal recessive gene is responsible for the condition. The data suggest that the absence of melanin in the eyes, skin, and feathers (symbol cc) is a mutation of the pigmented C wild gene.

INTRODUCTION

The term "albinism" comprises a wide range of traits, all of which result from pigment production or distribution disorders. The phenotype is due to a defect in melanin synthesis that results in partial or complete absence of this pigment in the skin, hair, feather, and eyes. The trait can be inherited by autosomal (recessive or dominant) or Z-linked (X-linked in mammals) inheritance. Several different vertebrates may present the phenotype due to a defect in melanin synthesis arising from a gene mutation. To date, about 60 different mutations were isolated in many different species of vertebrates.

In most domestic animals, albinism is caused by recessive autosomal or X-linked inheritance, except for the dominant autosomal gene in horses, in which the homozygous form is lethal. Total or complete albinism is described in cats (Turner *et al.*, 1981) and Suffolk sheep (Rowett & Fleet, 1993). In humans and mice, the C locus was determined as the structural locus for the tyrosinase gene (Tobita-Teramoto *et al.*, 2000).

In the chicken, there are different mutations, resulting in different degrees of depigmentation, and consequently several types of albinism. According to Smith Jr. (1990), there are two general types of pigments in chickens : melanin and carotenoids. Melanin (a natural pigment) plays a major role in the color of feathers, skin, shanks, beak, and eyes, while carotenoids (xanthophyll) are responsible for the yellow color of skin, fat and egg yolk. These two types of pigment can interact with each other and/or other cell types to produce a variety of shank and eye colors, as well as different feather shine levels.

The inheritance of pinkeye was first described by Warren (1940) in White Plymouth Rock chickens, indicating that pinkeye was due to an autosomal recessive gene (pk). Roberts *et al.* (1952) studied a "red-eye" mutation, which is a recessive autosomal gene, and is less viable than dark-eye in the chicken. Both mutations cause sight impairment.

Braumbaugh *et al.* (1983) reported three types of albinism at the multiple allelic "C" locus in the chicken: "C^+", which allows full pigmentation; "c" which is recessive to wild type, but dominant to albinism; and "ca", which is the most recessive allele.

The sex-linked genes for imperfect albinism in chickens are designated as: s^{al-s}, s^{al-c}, and S*ALS. They were analyzed as to their general genetic aspects (Silversides & Crawford, 1990), neonatal effects (Silversides & Crawford 1991), and effects on egg production (Silversides and Crawford 1991, Hsu *et al.*, 1994, Hsu *et al.*, 1996), mortality (Silversides et al 1992), early egg production (Silversides *et al.*, 1993), metabolism (Santos & Silversides, 1996a; 1996b), and sex differentiation (Santos & Silversides, 1996c).

The study reported in this paper was developed to obtain further information on the mode of inheritance of a mutation that produces white feathers and pink eyes in a flock of free-range Brazilian chicken.

MATERIAL AND METHODS

The albino mutant chickens were obtained from a private farm located near Universidade Estadual Paulista (UNESP), Botucatu campus, São Paulo, Brazil.

Birds were housed at the University, where they kept for 4 generations. All studied individuals derived from two normal black males (Male 1 and 311 in the tables), which resulted from breeding an albino male to a black female.

According to the information provided by the farmer, the flock had experienced a process of inbreeding for many years, without any control.

The albino birds presented translucent red eyes with no evidence of any pigmentation. Their feathers were completely white and their eyes were pink (Figure 1). In order to prevent mortality, favorable environmental conditions were provided. For instance, they were maintained in a poultry house with limited space to allow them to find food and water. Adult birds were housed in individual layer cages and submitted to natural insemination.

Figure 1 - The albino kid chicken which original animal possess translucid red eye and white feathers.

The methodology consisted in determining albinism ratios involving albinism (Table 1 to 4). During the study, different sets of matings were performed,. involving crossing heterozygous individuals; test crossing; and test for sex-linked inheritance.

RESULTS AND DISCUSSION

Matings between normal individuals (black plumage and eyes) were carried out to determine the mode of inheritance, e.g. Male 1 was mated to seven females (301, 302, 304, 306, 307, 308, and 321) (Table 1), and male 311 was mated to females 305 and 307 (Table 2).

Out of the 144 offspring 44 were pink-eyed albinos and 100 were completely black. According to the hypothesis of recessive autosomal inheritance locus, this result indicate that males and females were heterozygous for autosomal albinism. The expected values of 108 (black) to 38 (albino pink-eyed) was consistent with the expected 3:1 segregation ratio. However, sex-linked loci also would give a 3:1 segregation ratio. Matings used to determine the

Table 1 - Ratios for mating involving albinism in chicken.

Mating type (Cc X Cc)	Feather and eye color of offspring: black feather /black eye	albino feather/pink eye	Total	expect.ratio	Q^2
male 1 X female 306	09	03	12		
male 1 X female 321	21	13	34		
male 1 X female 302	08	03	11		
male 1 X female 301	27	11	38		
male 1 X female 308	18	04	22		
male 1 X female 307	02	06	08		
male 1 X female 304	10	03	13		
male 311 X female 305	01	01	02		
male 311 X female 307	04	-	04		
T 0 T A L	100	44	144	3:1	2,37

Table 2 – Ratios for mating involving albinism in chicken

Mating type (black X albino)	Feather and eye color offspring Test crossing Black feather/black eye	Albino /pink eye	Expected Total	ratio	Q^2
male 1 X female 2	15	15	30		
male 1 X female 12	14	11	25		
male 1 X female 3	-	02	02		
T O T A L	29	28	57	1:1	0,017

segregation ratio of the test crossing involved Male 1 and three albino females (Table 2). Out of the 57 offspring, 28 were pink-eyed albino and 29 were black. The expected ratio of 28.5 (albino) to 28.5 (black) was consistent with the expected 1:1 segregation ratio. Here, the sex-linked loci would also give a 1:1 segregation ratio.

The results of matings involving analyses of sex-linked inheritance are shown in Table 3 and 4. According to this hypothesis, all males should have been black. However, the occurrence of five and two albino male offspring suggests that the albino phenotype in these chickens is due to autosomal recessive inheritance.

Warren (1933) was the first to describe autosomal recessive albinism mutation in White Wyandotte chickens to which the symbol "a" was given. Albino birds presented white feathers and pink eyes. Their sight was impaired, making it difficult for birds to find food and water. The crosses used by Warren indicated that those traits are due to separated alleles.

Mueller & Hutt (1941) found imperfect albinism in Barred Plymouth Rock chickens caused by a sex-linked recessive gene (al). Affected birds present "ghost barring" in their feathers, because melanin production is low. Their sight is also slightly impaired.

Champion (1958) determined the mode of inheritance of pink-eye condition in White Leghorn chickens as caused by a simple sex-linked recessive gene. It is suggested that this gene is identical to the al gene previously reported by Mueller & Hutt (1941).

Bitgood & Smith (1991) suggested a new mutation at the C locus in White Leghorn chickens showing bright pink eyes, which is characteristic of recessive albinism.

CONCLUSION

Our data suggest that the absence of melanin in the eyes, skin and feathers of the studied flock of Brazilian free-range chickens is an autosomal recessive mutation. Comparison of this mutation to other autosomal recessive albinism mutations suggests total albinism (total absence of melanin in the skin, feathers, and eyes). The abnormal sight and the difficulty to find food and water by the chickens with the albino mutation described in this paper indicate that this mutation has a semi-lethal effect.

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Table 3 - Ratios for mating involving analyses of sex-linked albinism in chicken - Feather and eye color of offspring.

Mating type (Cc X Cc)	m black	f black	m albino	f albino	not det.	Total
male 1 X female 306	4	5	1	2	-	12
male 1 X female 321	7	4	3	6	14	34
male 1 X female 302					11	11
male 1 X female 301					38	38
male 1 X female 308	8	1	1	1	11	22
male 1 X female 307	2			2	4	8
male 1 X female 304		5			8	13
male 311 X female 305					2	2
male 311 X female 307	3		1			4
T O T A L	27	17	5	11	86	144

f=female; m=male; not det.= no determined.

Table 4 - Ratios for mating involving albinism in Brazilian chicken. Feather and eye color of offspring. Test crossing.

Mating type (black X albino)	m black	f albino	m albino	f albino	not det.	Total
male 1 X female			02	01	27	30
male 1 X female 12					12	12
male 1 X female 3	-			02		02
T O T A L						57

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