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INHERITANCE OF COAT COLOR OF KEJOBONG GOAT IN PURBALINGGA REGENCY, CENTRAL JAVA, INDONESIA

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ABSTRAK

Tujuan penelitian ini adalah untuk mengetahui pola pewarisan warna bulu kambing Kejobong. Materi yang digunakan adalah keluarga kambing Kejobong dengan garis keturunan yang jelas sebanyak 130 keluarga yang terdiri dari 201 ekor cempe, 130 ekor induk dan 51 ekor pejantan. Warna bulu yang diamati meliputi hitam, hitam putih, hitam coklat, coklat, putih coklat dan putih. Tipe warna bulu dikelompokkan menurut pigmentasi dan pola warna. Pola warna keluarga kambing baik tetua maupun anak dinotasikan dalam simbol lokus yang sesuai. Kemungkinan susunan gen warna bulu kambing Kejobong yaitu B-C-S-ii (hitam), -- cc -- -- (putih), BBC-ssii (hitam putih), BbC-ssii (hitam coklat), bbC-ssii (putih coklat) dan bbC-S-ii (coklat). Pengamatan silsilah warna di lapangan (observasi) dan rasio fenotipe harapan digunakan dalam perhitungan Chi Kuadrat. Hasil penelitian menunjukkan bahwa pola pewarisan warna bulu kambing Kejobong tidak berada dalam keseimbangan Hardy-Weinberg, kecuali persilangan antara tetua berwarna hitam dengan hitam coklat; coklat hitam dengan putih coklat yang menunjukkan tingkat kepercayaan paling tinggi.

Kata kunci: pola pewarisan, warna bulu, kambing Kejobong

ABSTRACT

The objective of this research was to examine the inheritance of coat color pattern of Kejobong goat. The material used was goat family with clear lineage, in which the number of samples were 130 Kejobong family, consisted of 201 kids, 130 does and 51 bucks. Coat color of black, black white, black brown, brown, white brown and white, were observed. The coat color types were classified and genetically grouped according to the pigmentation types and color patterns. Probability compilation gene of coat color of Kejobong goat were B-C-S-ii (black), -- cc -- -- (white), BBC-ssii (black white), BbC-ssii (black brown), bbC-ssii (white brown) and bbC-S-ii (brown). Inheritance of coat color observed and fenotipe ratio expected were used to calculate Chi-square. Results of study showed that the inheritance of coat color pattern of Kejobong goat were not in Hardy-Weinberg equilibrium with exeption of mating between black and black brown and mating between brown black and white brown showing similarity in observations and expectations.

Keywords: inheritance, coat color, Kejobong goat

INTRODUCTION

The goat is productive animal, easy to be handled and adapted to a various tropical environmental conditions, that is insufficient environment and management. Therefore, the selection may occur and resulted in a new breed like Kejobong goat.

Kejobong goat is a new breed resulted from crossbreeding between Etawa and Kacang breeds, and concentrated in Purbalingga Regency, Central Java, especially in Kejobong District (Kurnianto *et al.*, 2013). According to Dinas Peternakan dan Perikanan Kabupaten Purbalingga (2013), the number of Kejobong goats in 2013 was about 43.708 heads spreading in 18 subdistrict. The most population of Kejobong goat was in Kejobong subdistrict (20.906 heads), then Pengadegan subdistrict (10.476 heads).

Coat color expression is controlled by a gene may be use as breed indicator (Inounu *et al.*, 2009), and therefore could be used as a selection criteria of small ruminant in the tropical environment (Peters *et al.*, 1982; Adedeji *et al.*, 2011; Adedeji, 2012). Coat color is characteristic trait that easy to be identified, therefore it was used as phenotypic model in studying of gene expression and correlation among traits. Inheritance of coat color is influence by of polygene in each breed, although few of gene express color pattern in each individu (Trifena *et al.*, 2011). Pigmentation traits expressed in animals are visual characteristics to distinguish among breeds and strains within breed (Liu *et al.*, 2009). The combination of colors from two different breeds will result a mixed of colors to produce color variations in the offspring (Beatriz *et al.*, 2007).

Inheritance of color in Angora goats deviates from mechanisms previously reported in other breeds and types of goats as reported by Sponenberg *et al.* (1998). Here, it is important to know the inheritance of coat color in Kejobong goats to decide a mating pattern in order to obtain offspring with a certain color. Inheritance of coat color in Kejobong goats has not been studied yet. Based this reason, a study to examine the inheritance of coat color pattern of Kejobong goat was conducted.

MATERIALS AND METHODS

The materials used in this research were goats family found in Purbalingga regency, spreading in four subdistrict such as Kejobong, Pengadegan, Bukateja and Kaligondang. Purposive sampling was applied to determine location based on the population density of the Kejobong goat in Purbalingga regency. Goat families with clear lineage were used as the sample. The number of samples were 130 Kejobong goats family consisted of 201 kids, 130 does and 51 bucks. Five groups of coat color were recorded, those were black coat color, black white, black brown, brown, white brown and white. Some of coat color patterns in Kejobong goat are presented in Figure 1.

Statistical Analysis

The coat color of parent and offspring were classified and genetically grouped according to the pigmentation types and color patterns. The possibility of genotype of coat color in Kejobong goat were B-C-S-ii (black), -- cc -- -- (white),

Figure 1. Some examples of coat color patterns in Kejobong goat. black (A), black white (B), white black (C), white (D), brown white (E), white brown (F), brown black (G) and black brown (H).

BBC-ssii (black white), BbC-ssii (black brown), bbC-ssii (white brown) dan bbC-S-ii (brown). On the basis of coat color, all possibilities of mating were constructed, then expected phenotypic ratio was obtained. Observation result on color pedigree and expected phenotypic ratio was used in Chi-square analysis (Noor, 2000; Sudjana, 2005; Yakubu *et al*., 2010). The formula of Chi-square is:

$$X^2 = \sum \frac{(O - E)^2}{E}$$

Where:

X^2 = Chi-square
O = Observed
E = Expected

In this study, there was some zero number in the expectation. In this case, all elements both of observation and expectation were added by 1 value in order to Chi-square could be perfomed.

RESULTS AND DISCUSSION

The possibility of genotype of coat color in Kejobong goat is:

1. Black
   B-C-S-ii (BBCCSSii / BBCCSsii / BbCCSSii / BbCCSsii / BBCcSSii / BBCcSsii / BbCcSSii / BbCcSsii)
2. White
   -- cc -- -- (BBccSSII / BBccSsII / BBccSSii / BBccSsii / BbccSSII / BbccSsII / BbccSSii / BbccSsii / bbccSSII / bbccSsII / bbccSSii / bbccSsii / BBccssII / BBccssii / BbccssII / Bbccssii / bbccssII / bbccssii / BBccSSIi / BBccSsIi / BbccSSIi / BbccSsIi / bbccSSIi / bbccSsIi / BBccssIi / BbccssIi / bbccssIi)
3. Black white (white black)
   BBC-ssii (BBCcssii / BBCCssii)
4. Black brown (brown black)
   BbC-ssii (BbCCssii / BbCcssii)
5. White brown (brown white)
   bbC-ssii (bbCcssii / bbCCssii)
6. Brown
   bbC-S-ii (bbCCSSii / bbCcSSii / bbCCSsii / bbCcSsii)

Table 1 presents mating between black and black color producing the offspring with black color (33.33%), black white (33.33%) and black brown (33.33%). Expected ratio was obtained from all possible matings between those two parents. The largest of expected number of color (70.54%) was black (B-CCS-ii), whereas the smallest one (1.49%) was white brown. The observation of the expected values showed highly significant difference ($P<0.01$). It means that the differences between observations and expectations were not in Hardy-Weinberg equilibrium. Based on the expectations, mating goat between black and black produced most of the black color in their offsprings. The fewest color in the expectation was white brown. It was observed the black, black white and black brown in the offprings, but no found the brown, white brown and white although it may occure in the expectation.

The occurrences of black color in the offspring (B-CCS-ii) was due to the presence of B gene either homozygous or heterozygous dominant in both of the parents. This is in agreement with the statement of Sponenberg *et al.* (1998) that the expression of eumelanin as either black or brown was controlled by the brown gene. Furthermore, it stated by Adalsteinsson (1991) that brown loci produce black or brown with the presence of eumelanin pigment. Noor (2000) stated that the genes in the B locus will determine whether melanin be changed into black or brown color. The B dominant gene would produce black color.

Appearance of black white color (BBC-ssii) and black brown (BBC-ssii) were due to the S gene in a homozygous recessive (ss) causing spot colors. According to Adalsteinsson (1991), spotting locus indicated the presence or absence of the recessive white markings. According to Noor (2000) and Axenovich *et al.* (2004), irregular spotting patterns (piebald) was recessive

Table 1. Chi-square Test of a Mating between Black with Black

Offspring	Number of	
	Observation	Expectation
Black	6	12.69
Black White	6	0.71
Black Brown	6	0.58
Brown	0	1.38
White Brown	0	0.27
White	0	0.36

*The number of parent pair = 12
X^2 calculation = 95.59**; X^2 table (5%) = 11.1; X^2 table (1%) = 15.1

(ss) inherited. The dominant allele (S) will generate a smooth color pattern.

Table 2 shows that black goat mated to black white resulted in black white offspring (46.67%), followed by black (25%), black brown (20%) and white brown (8.33%). Black offspring was the largest number in expectations (57.32%), while the smallest one was brown (1.22%).

The results of the Chi-square test from the mating of black color to black white showed highly significant differences (P<0.01). It means that mating between those two colors resulted in color in disequilibrium of Hardy-Weinberg Law. This was possible due to the uncontrolled selection for black color conducted by farmers at hundreds year ago. Migration of goat from- and to other area may also creas stated by Kurnianto (2009) that the gene and genotypic frequencies in a population may not change from generation to generation long as there is no mutation, migration (genetic flow), genetic drift and selection (Hardy-Weinberg Law). According to Lasley (1978), the frequency of an allele possibility may differ if there is a selection. Selection can increase the frequency of some genes and decreased the frequency of other genes.

The highly significant differences (P<0.01) was found in offspring coat color from mating between parent in black and white brown (Table 3). It means that the difference between observations and expectations were not in Hardy-Weinberg equilibrium. Meanwhile, there was no significantly difference in offspring coat color resulted from mating of black to black brown (Table 4), in which this result was in Hardy-Weinberg equilibrium. The black and black brown offspring were the most found from the mating between black (B-CCS-ii) and black brown (BBC-ssii).

The mating of parents between black white and black white (Table 5) showed highly significant differences (P<0.01) indicating the mating between those colors were not in the Hardy-Weinberg equilibrium. The black white or white black (BBC-ssii) will predominantly generate black white offspring, followed by 3 other colors, those were Black (B-CCS-ii), black brown (BbC-ssii) and white brown (bbC-ssii). Just two coon. The black white color existed because of the gene B and gene s, while the white

Table 2. Chi-square Test of a Mating between Black with Black White

Offspring	Number of	
	Observation	Expectation
Black	15	35.12
Black White	28	12.44
Black Brown	12	5.85
Brown	0	0
White Brown	5	0
White	0	6.58

*The number of parent pair = 37
X^2 calculation = 77.77**; X^2 table (5%) = 11.1; X^2 table (1%) = 15.1

Table 3. Chi-square Test of a Mating between Black with White Brown

Offspring	Number of	
	Observation	Expectation
Black	3	3.33
Black White	3	0.23
Black Brown	2	2.72
Brown	0	1.98
White Brown	2	0.99
White	0	1.11

*The number of parent pair = 7
X^2 calculation = 37.69**; X^2 table (5%) = 11.1; X^2 table (1%) = 15.1

Table 4. Chi-square Test of a Mating between Black with Black Brown

Offspring	Number of	
	Observation	Expectation
Black	4	4.88
Black Wwhite	1	0.86
Black Brown	5	1.67
Brown	0	0.80
White Brown	0	0.68
White	0	1.11

* The number of parent pair = 6
X^2 calculation = 9.41^{ns}; X^2 table (5%) = 11.1; X^2 table (1%) = 15.1

color occured due to the presence of gene c and gene I. According to Noor (2000), the white color is caused by the inhibitor of I dominant gene. Recessive genotype (ii) allow the appearance of color which is controlled by another gene. The I dominant gene depress the development of melanin with the concequence in producing white coat color. In addition, the white color is caused by a recessive cc gene homozygote, while the other colors are caused by a dominant C gene. The recessive white gene is different from albino, because the albino is a pigmentation in the eye.

The highly significant differences ($P<0.01$) was found from mating of black white to brown black (Table 6), indicating the mating of these two colors were not in the Hardy-Weinberg equilibrium. This mating resulted in most similarity both in observation and expectation for black white (BBC-ssii).

Mating of white brown color to black white (Table 7) showed highly significant differences ($P<0.01$), indicating the observation and expectation were not in Hardy-Weinberg equilibrium. This resulted was possible due to the uncontrolled selection and migration. In fact, variation of Kejobong coat color are still found as reported by Kurnianto *et al.* (2012).

Table 8 presents the possibility of offspring genotypes when whe brown and white parents were mated each other. The result showed significant difference ($P<0.05$), indicating disequilibrium of Hardy-Weinberg Law. Mating between these two colors just resulted in white brown. The existence white brown color was due to the b gene and s gene, while the white color appeared due to the c gene and the I gene (inhibitor gene). This is in agreement to Noor (2000) that the albino gene in mammals is an excellent exampcessive epistasis gene. The C dominant gene controls the production of melanin, while recessive homymes producing melanin, so that the appeared colors are white. According to Tang *et al.* (2008), pigmentation in mammalian is controlled by eumelanin and pheomelanin in melanocytes. Chen *et al.* (2012) stated that tyrosinase is the regulatory enzyme of melanogenesis and plays a major role in mammal coat color. Melanogenesis takes place in various celltypes. Melanin is present as the black-brown eumelanin and the yellow–red pheomelanin, and the ratio and amount of the two pigments determine the color of the skin, eyes, and hair.

Table 9 show mating of white brown and white brown highly significant differences

Table 5. Chi-square Test of a Mating between Black White with Black White

Offspring	Number of	
	Observation	Expectation
Black	5	0
Black White	17	29.33
Black Brown	7	0
White Brown	4	0
White	0	3.67

*The number of parent pair = 21
X^2 calculation = 21.56**; X^2 table (5%) = 9.49; X^2 table (1%) = 13.3

Table 6. Chi-square Test of a Mating between Black White with Brown Black

Offspring	Number of	
	Observation	Expectation
Black	4	0
Black White	7	8.00
Black Brown	3	7.10
White Brown	2	0
White	0	0.89

*The number of parent pair = 10
X^2 calculation = 25.86**; X^2 table (5%) = 9.49; X^2 table (1%) = 13.3

Table 7. Chi-square Test of a Mating between White Brown with Black White

Offspring	Number of	
	Observation	Expectation
Black	3	0
Black White	16	0
Black Brown	2	23.11
White Brown	5	0
White	0	1.89

*The number of parent pair = 16
X^2 calculation = 123.96**; X^2 table (5%) = 9.49; X^2 table (1%) = 13.3

Table 8. Chi-square test of a Mating between White Brown with White

Offspring	Number of	
	Observation	Expected
Black	0	0.16
Black White	0	0.16
Black Brown	0	0.16
White Brown	2	0.18
White	0	1.33

*The number of parent pair = 2
X^2 calculation = 12.29*; X^2 table (5%) = 9.49; X^2 table (1%) = 13.3

Table 9. Chi-square Test of a Mating between White Brown with White Brown

Offspring	Number of	
	Observation	Expected
Black White	4	0
Black Brown	3	0
White Brown	8	13.33
White	0	1.67

*The number of parent pair = 10
X^2 calculation = 15.57**; X^2 table (5%) = 7.81; X^2 table (1%) = 11.3

Table 10.Chi-square Test of a Mating between Brown Black with Brown Black

Offspring	Number of	
	Observation	Expected
Black	1	0
Black white	1	1.11
Black brown	2	2.22
White brown	1	1.11
White	0	0.56

*The number of parent pair = 5
X^2 calculation = 13.3**; X^2 table (5%) = 9.49; X^2 table (1%) = 13.3

Table 11. Chi-square Test of a Mating between Brown Black with White Brown

Offspring	Number of	
	Observation	Expected
Black white	1	0
Black brown	1	2.67
White brown	4	2.67
White	0	0.67

*The number of parent pair = 4
X^2 calculation = 6.7^{ns}; X^2 table (5%) = 7.81; X^2 table (1%) = 11.3

(P<0.01), in which this result was not in Hardy-Weinberg equilibrium. Introducing of brown pattern Ettawa grade and Jawarandu goats into of Purbalingga regency may affect inheritance of brown color, such as black brown (BbC-ssii) and white brown (bbC-ssii). It was stated by Lasley (1978) the migration is a factor that can lead to changes in gene frequency expressing coat color

The highly significant differences (P<0.01) was found in offspring coat color resulted from mating of brown black and brown black (Table 10). This result indicated that difference between observations and expectations were not in Hardy-Weinberg equilibrium. Brown black color in offspring was due to gene B, gene b and s. According to Adalsteinsson (1991), the locus brown may produce black or brown pigment in the presence of eumelanin. According to Noor (2000), the pattern of irregular white patches (piebald) is inherited as recessive (ss).

The offspring coat color resulted from mating between two parents of brown black color and white brown (Table 11) were not significantly different (P>0.01). It means that this results were in Hardy-Weinberg equilibrium.

CONCLUSION

The inheritance of coat color of Kejobong goat was not in Hardy-Weinberg equilibrium with exeption of mating between black and black brown and mating between brown black and white brown showing similarity in observations and expectations.

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