A Study of Morphometric-Phenotipic Characteristic of Indonesian Chicken: Kampong, Sentul and Wareng-Tangerang, Based on Discriminant Analysis, Wald-Anderson Criteria and Mahalanobis Minimum Distance*

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ABSTRACT

An observation of linear body sizes was conducted in this study; this includes femur length (X_1), tibia length (X_2), shank length (X_3), shank circle or circumference (X_4), the third finger length (X_5), wing length (X_6), maxilla length (X_7), comb height (X_8) and sternum length (X_9). Grouping or classifying on the basis of morphometric characteristic between Indonesian native chicken: Kampong, Sentul and Wareng-Tangerang, is carried out using discriminant analysis, Wald-Anderson criteria and Mahalanobis minimum distance. Discriminant function equations for Kampong vs Wareng-Tangerang chicken, for males is $Y = 0.07X_1 + 0.29X_2 + 0.004X_3 + 0.38X_4 – 0.51X_5 + 0.04X_6 + 0.27X_7 + 0.27X_9$, and for females is $Y = 0.16X_1 + 0.28X_2 + 0.23X_3 + 0.67X_4 + 0.10X_5 + 0.03X_6 + 0.07X_7 – 0.06X_9$. Several numbers of female from Kampong and Wareng-Tangerang chicken is found not in the right group. In female group, data for Kampong chicken that is group as Wareng-Tangerang is 2.1%; on the other hand, data for Wareng-Tangerang chicken that is classified as Kampong chicken is 2.2%. The Mahalanobis minimum distances for male and female between Kampong and Wareng-Tangerang, respectively are 2.9925 and 2.9864. The greater distance for males indicates a non similarity of morphometric of males is greater than that of females. This means that actual separation for males is easier than that for females for both groups of chicken. The equation of discriminant function for Kampong vs Sentul chicken for males is $Y = 0.12X_1-0.05X_3+0.25X_5-0.12X_8$, and for females is $= 0.0005X_1 + 0.33X_2 + 0.64X_3 + 0.19X_5 – 0.09X_6 – 0.86X_7 – 0.10X_8 - 0.11X_9$. Calculation result at actual group shows that numbers of male and female from Sentul and Kampong chicken are found not to be in the right group. For male group, the data for Sentul chicken that is grouped as Kampong chicken is 4.3%, and for Kampong chicken that is grouped as Sentul chicken is 2.2%. For female group, the data for Sentul chicken that is grouped as Kampong chicken is 11.1%, and for Kampong chicken that is group as Sentul chicken is 5.2%. It is much more difficult to determine the males because of the numbers of determinant variables are smaller. The Mahalanobis minimum distances for males and females of Kampong and Sentul chicken are, respectively, 1.2801 and 1.6900. A non-similarity of morphometric for Kampong vs Sentul indicates that the size of females is greater than that of males. Therefore, actual separation is easier to be done at female group. For Wareng-Tangerang vs Sentul chicken, the discriminant function equation for males is $Y = -0.18X_1 -0.03X_2 + 1.20X_3 + 1.09X_4 + 0.20X_5 -0.36X_6 + 0.06X_7 – 0.54X_8 + 0.11X_9$, and for females is $Y = 0.02X_1 + 0.32X_2 + 0.93X_3 + 1.30X_4 + 0.69X_5 – 0.10X_6 – 0.22X_7 – 0.81X_8 – 0.29X_9$. There is only the male that is found not in the right group. Separation among males is more difficult than separation among females although all of variable observed are determinant variables for both males and females. For males, data for Wareng-Tangerang chicken which is classified as Sentul chicken is 4.3% and for Sentul chicken which is grouped as Wareng-Tangerang is not found. The Mahalanobis minimum distance for males and females between Wareng-Tangerang and Sentul chicken is, respectively, 2,9925 and 2,9864. A greater distance for males demonstrates a non-similarity of morphometric for males that is greater than for females. Actual separation for males should be easier than for females; however, a reverse situation is observed in this experiment. This is because of a similarity in feather colour of Wareng-Tangerang chicken to that of Sentul chicken. In conclusion, the highest distance of a non-similarity of morphometric is caused by the largest numbers of determinant variables; this has increased the accuracy of grouping separation. Wareng-Tangerang chicken is different from Kampong and Sentul chicken. A similarity of morfometry between Kampong and Sentul chicken is closer than that with Wareng-Tangerang. Kampong and Sentul chicken are Indonesian native chicken; however, the Wareng-Tangerang chicken is originated from abroad that have adapted with Indonesian condition.

Key words: discriminant analysis, Wald-Anderson criteria, mahalanobis minimum distance, Kampong chicken, Sentul chicken, Wareng-Tangerang chicken

INTRODUCTION

Kampong and Sentul chicken are local chicken producing eggs and meat (dual-purpose) (Nataamijaya, 2000). Wareng-Tangerang chicken is claimed from Tangerang district having performance as fairly productive laying chicken; it is originally from abroad (Iskandar *et al*., 2004[b]). Kampong, Sentul, Wareng-Tangerang chicken have long been adapted and domesticated in Indonesia. They are included in the 31 clumps of local chicken in Indonesia (Nataamijaya, 2000). This pattern has lead to the group formation of specific and typical species of local chickens.

Variables of body skeleton sizes are sufficiently accurate to be used as distinguishing variables or markers that can give overviews of specifications of local chickens that are heterogeneous. The purpose of this study was to compare the distinguishing variables among Kampong, Sentul and Wareng-Tangerang chicken based on discriminant function. Phenotypic characteristics of body skeleton sizes in each group of chickens can be used to determine the groupings of individuals that are not matched with its actual groups based on Wald-Anderson grouping criteria, and to estimate genetic distance of morphometric non-similarity based on D^2 Mahalanobis minimum distance criteria. The results, then, can be used as one tool or selection criteria in policy making in the observed breeding chicken.

MATERIALS AND METHODS

Locations and Sampling Determination

The experiment was conducted at the Livestock Research Center (Balai Penelitian Ternak) Ciawi-Bogor for the measurement of Kampong and Wareng-Tangerang chicken, and at people farms in Cigembor and Ciulu villages, Ciamis district for the measurement of Ciamis-Sentul chicken. The study was conducted from August to September 2006. The determination of locations was conducted by purposive sampling in which the location for sampling is done on purpose based on the existence of Kampong, Wareng-Tangerang and Sentul chicken.

Materials

The observed chicken were 125 Kampong chicken (28 males and 97 females), 110 Wareng-Tangerang chicken (20 males and 90 females) and 50 Sentul chicken (23 males and 27 females). All of the observed chickens are foundation stocks that are developed through selection by the Livestock Research Center in Ciawi Bogor. All of the observed chickens have reached matured conditions.

Variables

The variables measured are femur length (X_1), length of the tibia (X_2), tarsometatarsus length (X_3), circumference tarsometatarsus (X_4), third finger length (X_5), length of wing (X_6), length of maxilla (X_7), comb hight (X_8) and the length of the sternum (X_9).

Procedures

All variables were measured in the body of Kampong, Wareng-Tangerang and Sentul.

Data Analysis

T^2-Hotteling Test

The average vector value of the two groups of chicken in each sex was tested to determine whether there were statistical differences between the average values of the tested traits (Gaspersz, 1992). Testing was done by formulating the following hypotheses:

$H_0 : U_1 = U_2$ meaning that the average vector value from the first population is equal to the second population if

$$T^2 \leq \frac{(n_1 + n_2 - 2)p}{n_1 + n_2 - p - 1} F_{\alpha;v_1,v_2}$$

$H_1 : U_1 \neq U_2$ meaning that the average vector value from the two populations are different if

$$T^2 \succ \frac{(n_1 + n_2 - 2)p}{n_1 + n_2 - p - 1} F_{\alpha;v_1,v_2}$$

Then the values

$$F = \frac{n_1 + n_2 - p - 1}{(n_1 + n_2 - 2)p} T^2$$

distribute following F values with the degree of freedom is $V_1 = p$ dan $V_2 = n_1 + n_2 - p - 1$

in which :

T^2 = T^2-Hotteling statistic value

F = calculated value for T^2-Hotteling

n_1 = amount of observed data in the first group
n_2 = amount of observed data in the second group
$\bar{x}_1$ = the average vector value of the random variables of the first group
$\bar{x}_2$ = the average vector value of the random variables of the second group
S_G^{-1} = pooled covariance matrix inverse (inverse of the matrix SG)
p = number of variables measured

If the results of testing the hypotheses are rejected, this shows both average values of the observed traits are different; so that the discriminant function is used to assess differences in the traits that are found among the chicken groups.

Grouping Based on Fisher Linear Discriminant Function

Fisher linear discriminant function according to Gaspersz (1992) is defined as follows:

$$Y = \underline{a}' \underline{X} = \left(\bar{x}_1 - \bar{x}_2 \right)' S_G^{-1} \underline{X}$$

Description :

$\underline{a}$ = loading vector coefficient for discriminant function
$\underline{X}$ = random variables vector identified in the discriminant function model
$\bar{x}_1$ = the average vector value of the random variables of the first group
$\bar{x}_2$ = the average vector value of the random variables of the second group
S_G^{-1} = pooled covariance matrix inverse (inverse of the matrix SG)
S_G = pooled covariance matrix

Classification Based on Wald-Anderson Statistical Test

Wald-Anderson statistical test can be used to classify individuals from the observed chicken group which is defined by Gaspersz (1992) as follows:

$$W = x' S_G^{-1} \left(\bar{x}_1 - \bar{x}_2 \right) - 1/2 \left(\bar{x}_1 + \bar{x}_2 \right)' S_G^{-1} \left(\bar{x}_1 - \bar{x}_2 \right)$$

Description:

W = Wald-Anderson statistical test value
$\underline{x}'$ = vector of individual random variables
$\bar{x}_1$ = the average vector value of the random variables of the first group
$\bar{x}_2$ = the average vector value of the random variables of the second group
S_G^{-1} = pooled covariance matrix inverse (inverse of the matrix SG)

Classification criteria based on the W statistics is:

1) allocation of x to the first group (population), if: $W > 0$
2) allocation of x to the second group (population), if: $W \leq 0$

Classification Based on the D^2-Mahalanobis Minimum Distance

D2- Mahalanobis minimum distance between any two chicken groups in each sex is calculated based on the quantitative characteristics of the body skeleton which is formed by discriminant function.

The minimum genetic square distance according to Gaspersz (1992) is defined as follows:

$$D^2_{(1/2)} = \left(\bar{x}_1 - \bar{x}_2 \right)' S_G^{-1} \left(\bar{x}_1 - \bar{x}_2 \right)$$

$D^2_{(1/2)}$ = D2- Mahalanobis minimum distance as a measurement of squared distance between the two chicken groups (between the first and the second group)
S_G^{-1} = pooled covariance matrix inverse (inverse of the matrix SG)
$\bar{x}_1$ = the average vector value of the random variables of the first group
$\bar{x}_2$ = the average vector value of the random variable of the second group

RESULTS AND DISCUSSION

Classification of Male and Female in Kampong vs Sentul Chicken, Kampong vs Wareng-Tangerang Chicken, and Wareng-Tangerang vs Sentul Chicken

The results of T^2 Hotteling test show there are differences in vector average values of linear body size variables between the two groups of chicken that are observed ($P<0.05$). These are between Kampong and Wareng-Tangerang chicken; Kampong and Sentul chicken, and Wareng-Tangerang and Sentul chicken. The

differences between Kampong, Wareng-Tangerang and Sentul chicken in its characteristic of linear body size variables at the adult aged are the results of factors such as genetic, gene mutation and adaptation (Iskandar *et al*., 2004[a]; Iskandar *et al*., 2004[b]).

Herren (2000) explained that bone and muscle tissue grew on a regular basis during growth period, rapid growth occurred from birth up to adult matured body have been reached. Then, bone and muscle growth stopped and continued with the development of fat. Thus, the linear body size variables can be related with body weight in this study.

Among the chicken types, the largest linear measures of body size variables are found in Sentul chicken, which is followed by Kampong and Wareng-Tangerang chicken. This is consistent with the previous results obtained by Iskandar *et al.* (2004[b]) and Iskandar *et al*. (2006). Male and female adult body weights, respectively, were 2,500 g and 1,850 g for Sentul chicken, 1,815±353 g and 1,382±290 g for Kampong chicken, and 1,000 g and 841 g for Wareng-Tangerang chicken (Iskandar *et al*., 2004[b]; Iskandar *et al*., 2006).

Significant differences in the vector average of linear body size variables are obtained in this study based on statistical tests T^2 Hotteling ($P<0.05$) between the two types of chickens, Kampong, Wareng-Tangerang and Sentul chiken. Thus, the discriminant function can be used to assess differences in morphometric characteristics between these two types of chicken.

Table 1. Average, Standard Deviation and Coefficient Variation of Body Size Observed in Kampong and Wareng-Tangerang Chicken

Body size variables	Kampong Chicken (n=125)			Wareng-Tangerang Chicken (n=110)		
	♂(n=28)	♀(n=97)	♂+♀	♂(n=20)	♀(n=90)	♂+♀
	(mm)					
Femur Length	102.29 ± 6.45 (6.31)	83.48±3.79 (4.54)	87.69 ± 9.06 (10.33)	84.05±4.46 (5.31)	71.19±5.06 (7.12)	73.52±7.01 (9.53)
Tibia Length	152.95±10.24 (6.69)	123.14±5.92 (4.81)	129.82±14.34 (11.05)	120.90±5.17 (4.28)	103.33 ± 6.82 (6.60)	106.53±9.43 (8.85)
Shank Length	110.04±9.11 (8.28)	85.81±4.52 (5.27)	91.24±11.69 (12.81)	86.96±2.81 (3.23)	71.31 ± 3.96 (5.55)	74.15±7.14 (9.63)
Shank Circumference	53.29±7.44 (13.96)	39.64±3.02 (7.62)	42.70±7.20 (16.86)	35.47±2.29 (6.46)	31.67±2.38 (7.51)	32.36±2.78 (8.59)
Third finger Length	64.27±5.93 (9.23)	52.64±5.16 (9.80)	55.25±7.21 (13.05)	52.77±2.40 (4.55)	41.08±3.33 (8.12)	43.21±5.53 (12.79)
Wing Length	234.79±15.10 (6.43)	192.14±11.61 (6.04)	201.70±21.74 (10.78)	188.95±9.78 (5.18)	159.27±11.99 (7.53)	164.66±16.32 (9.91)
Maxilla Length	35.99±3.65 (10.14)	31.70±1.86 (5.87)	32.66±2.97 (9.09)	30.77±1.48 (4.81)	28.19±1.64 (5.82)	28.66±1.89 (6.59)
Comb Height	49.45±19.40 (39.23)	16.84±10.09 (59.92)	24.14±18.63 (77.17)	35.02±6.64 (18.96)	20.07±4.78 (23.82)	22.79±7.74 (33.96)
Sternum Length	130.76±10.31 (7.88)	105.24±8.08 (7.68)	110.96±13.71 (12.36)	103.18±6.53 (6.33)	88.49±7.08 (8.00)	91.16±8.99 (9.86)

Note: ♂= male, ♀= female, n = number of samples; numbers in parentheses express the coefficient of variability in percent (%)

Table 2. Classification of Male Data of Kampong vs Wareng-Tangerang Chicken Based on Wald-Anderson Criterion

Actual Group	Classification		% Correction
	Kampong Chicken	Wareng-Tangerang Chicken	
Kampong chicken (n=28)	28	0	28/28 x 100% = 100.0%
Wareng-Tangerang chicken (n=20)	0	20	20/20 x 100% = 100.0%
Total (n=48)	28	20	48-(0+0)/48 x 100% = 100.0%

Note: n = number of samples.

Kampong vs Wareng-Tangerang Chicken

For the males between Kampong vs Wareng-Tangerang chicken, classification based on discriminant function showes that comb height (X_8) between the two types of male chickens is not different.

This is because the value of the correlation coefficient of discriminant function is not significant at 95% of confidence interval. Thus the discriminant function formed for males between these two types of chicken282is $Y = 0.07 X_1 + 0.29 X_2 + 0.004 X_3 + 0.38 X_4 - 0.51 X_5 + 0.04 X_6 + 0.27 X_7 + 0.27 X_9$. The Variables that distinguish males between Kampong vs Wareng-Tangerang chicken are femur length, tibia length, shank length, third finger length, and wing length, length of maxilla and length of the sternum.

Classification of males for both type of chicken based on Wald-Anderson criteria shows none the male data deviates from the discriminant function (Table 2). This classification also indicates that high similarity in comb height of the males between Kampong and Wareng-Tangerang chicken did not cause errors in the separation between these two types of chicken.

Discriminant function which is formed in the females of Kampong vs Wareng-Tangerang chicken shows the same trend as the males. All the observed variables, except comb height (X_8), are distinguishing factors. Discriminant function equation that is formed between these chicken females is : $Y = 0.16 X_1 + 0.28 X_2 + 0.23 X_3 + 0.67 X_4 + 0.10 X_5 + 0.03 X_6 + 0.07 X_7 - 0.06 X_9$.

The results of Wald-Anderson criteria show that corrected data of females both in Kampong vs Wareng-Tangerang chicken are 97.9% based on distinguishing variables in discriminant function (Table 3). Corrected data for females of Wareng-Tangerang chicken classified as a group of female of Kampong chicken are 97.9%, and for females of Kampong chicken classified as a group of female of Wareng-Tangerang are 97.8%. These are because two females of Kampong chicken are included in female group of Wareng-Tangerang chicken, and two females Wareng-Tangerang chicken are classified into the female group of Kampong chicken. Corrected data of females of Kampong chicken which are classified as females of Wareng-Tangerang chicken is 2.1% (100% - 97.9%). The corrected data of females of Wareng-Tangerang chicken is 2.2% (100% - 97.8%) and classified as females of Kampong chicken. Based on calculation of actual group, some females of Kampong chicken and Wareng-Tangerang are found in groups that are not appropriate although eight variable sizes between these two groups are different. This indicates that the females are more difficult to be distinguished in comparison to the males in Kampong and Wareng-Tangerang chicken.

Table 3. Classification of Females in Kampong vs Wareng-Tangerang Chicken Based on Wald-Anderson Criterion

Actual Group	Classification		% Correction
	Kampong Chicken	Wareng-Tangerang Chicken	
Kampong Chicken (n=97)	95	2	95/97 x 100% = 97.9%
Wareng-Tangerang Chicken (n=90)	2	88	88/90 x 100% = 97.8%
Total (n=187)	97	90	187-(2+2)/187 x 100% = 97.9%

Note: n = number of samples.

Table 4. Classification of Individuals Data in Males at Kampong vs Sentul Chicken Based on Wald-Anderson Criterion

Actual Group	Classification		% Correction
	Sentul chicken	Kampong chicken	
Sentul Chicken (n=23)	22	1	22/23 x 100% = 95.7%
Kampong Chicken (n=28)	4	24	24/28 x 100% = 85.7%
Total (n=51)	26	25	51-(4+1)/51 x 100% = 90.2%

Note: n = number of samples.

Table 5. Classification Group of Individual Data in Female of Sentul vs Kampong Chicken Based on Wald-Anderson Criterion

Actual Group	Classification		% Correction
	Sentul chicken	Kampong chicken	
Sentul Chicken (n=27)	24	3	24/27 x 100% = 88.9%
Kampong Chicken (n=97)	5	92	92/97 x 100% = 94.8%
Total (n=24)	29	95	124-(5+3)/124 x 100% = 93.5%

Note: n = number of samples.

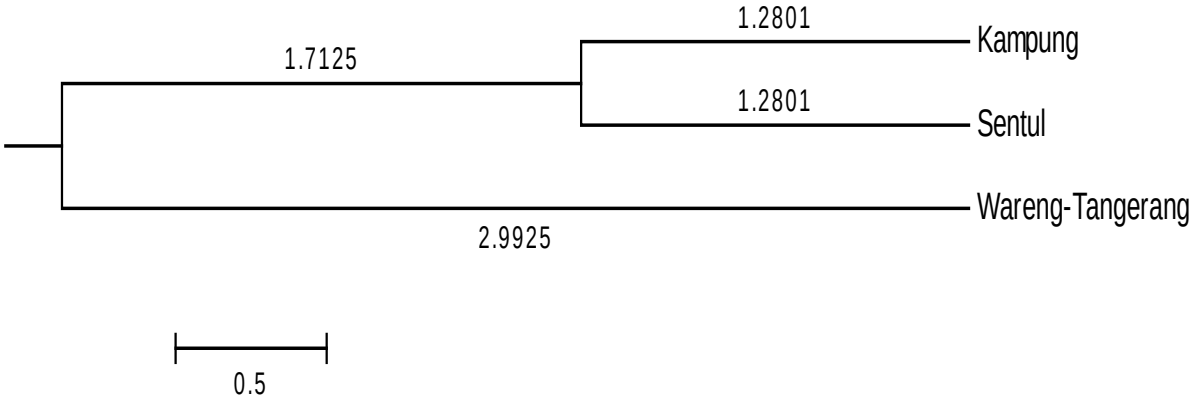

Figure 1. Dendogram of Linear Body Measurement Dissimilarity in Male of Kampong, Sentul and Wareng-Tangerang Chicken

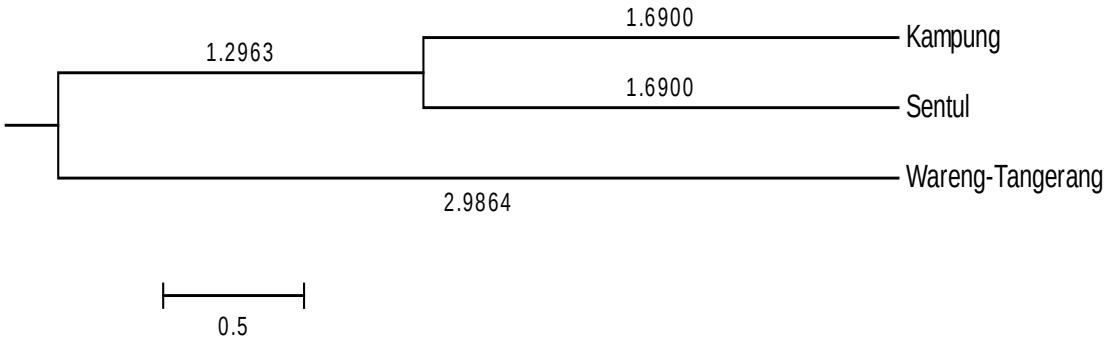

Figure 2. Dendogram of Linear Body Measures Dissimilarity in Female of Kampong, Sentul and Wareng-Tangerang Chicken

Mahalanobis minimum distance in males and females between Kampong and Wareng-Tangerang chicken, respectively, are 2.9925 and 2.9864. A greater distance in males shows that morphometrics dissimilarity in males among Kampong chicken vs Wareng-Tangerang is larger than the females. This means that the actual separation is more easily done on the males than that on the females in these two types of chicken. Figure 1 and 2 present dendograms of the Kampong, Sentul and Wareng-Tangerang chicken in males and females.

Eight variables are used as body size variables that distinguish male and female groups in Kampong vs Wareng-Tangerang chicken. This indicates morphometric dissimilarity between these two chicken groups. Figure 2 shows that dissimilarity in males is larger than in females, so males between the two types of chickens are easily distinguished. Nishida *et al.* (1982) state that the length of wing and long bones (femur, tibia, shank or tars metatarsus) were effective to distinguish the body conformation of chicken. Campbell and Lack (1985) state that the origin, domestication process, selection and crossing, may influence phenotypic variation in body morphology of birds.

Morphometric dissimilarity distance found between the two types of chicken shows that the two types of chicken are from different breeds. Nataamijaya (2000) states that the kampong chicken was a local chicken natively to Indonesia, while Iskandar (2004[b]) states that the Wareng-Tangerang chicken came from abroad, namely from Russia. Genetically, these two chicken types are different but they can adapt well to the Indonesian environment.

Differences in selection goals result in morphometric phenotypic differences shown by the eight variables of differences. Sartika (2000) states that the diversity of phenotypic characteristics (productivity performance, egg quality, size and height comb) in Kampong hicken is still high in the basic population for selection purposes. Indirect selection at Kampong chicken for the purpose of dual-purpose also occurred among farmers or communities. Susanti *et al*. (2006) state that the Wareng-Tangerang chicken was the result of selection and crosses. This chicken has small body posture (posture Wareng) as laying chickens. Selection for egg production in Wareng-Tangerang chicken is followed by indirect selection on the linear body size. The result of this study shows that comb height is not distinguishing variables. This indicates that selection towards the establishment of Kampong and Wareng-Tangerang chicken does not consider the comb height although the Wareng-Tangerang chicken combs are uniform (single comb).

Kampong vs Sentul Chicken

On the basis of discriminant function classification, morphometric similarity is high for males of Kampong vs Sentul chicken. This is because of there are four distinguish variables from nine variables of linear body size variables. These are femur length, shank length, third finger length (X_5) and high cockscomb (X_8). These four variables are highly correlated to the discriminant function equation at 95% confidence interval. Discriminant function equation formed between the two types of chicken males is: $Y = 0.12\ X_1 - 0.05X_3 + 0.25\ X_5 - 0.12X_8$. Table 4 presents the data classification of individuals Kampong vs Sentul chicken on the basis of Wald-Anderson criteria. Kampong chickens are 85.7%. This is because one male Sentul chicken is found in the male. The corrected male individuals data in the two groups are 90.2% based on the distinguishing variable in the discriminant function. Male individuals which are classified as group of Sentul chickens that have been corrected are found to be 95.7% and as a group of Kampong chickens are 85.7%. This is because one male Sentul chicken is found in the male Kampong chicken group based on Wald-Anderson classification, and four males of Kampong chicken are grouped in Sentul male chicken group. The corrected data of male Sentul chicken which are classified as male Kampong chicken are 4.3% (100% -95.7%). The 14.3% (100% - 85.7%) data is the corrected data of male of Kampong chicken which is classified as male chicken Sentul.

Discriminant function that is formed in the female Sentul vs Kampong chicken shows that all variables of linear body size can be used as distinguishing variables, except for the shank circumference. These variables are the lengths of the femur, tibia, shank, third finger, wing, maxilla, and sternum, and comb height. These variables are significant ($P<0.05$) at 95% of confidence interval and has a strong correlation to the discriminant function scores.

Equation of discriminant function formed between the two types of chicken females is $Y = 0.0005\ X1 + 0.33\ X2 + 0.64\ X3 + 0.19\ X5 - 0.09\ X6 - 0.86\ X7 - 0.10\ X8 - 0.11\ X9$. Table 5 shows that the corrected data of individuals in both groups of females (Sentul vs. Kampong chicken), based on Wald-Anderson criteria is 93.5%. Those that are classified as a group of females of Sentul chicken that has been corrected is 88.9% and as a group of females of Kampong chicken is 94.8%. This is because of three females of Sentul chicken are included in the group of female of Kampong chicken, and five females of Kampong chicken are included in the Sentul female chicken based on Wald-Anderson classification. Female individual data of Sentul chicken corrected and classified as females Kampong chicken are 11.1% (100% -88.9%). The 5.2% (100% -94.8%) is the data for female individuals of Kampong chicken that are corrected and classified as female individual data of Sentul chicken.

Based on the calculation of actual group, several females and males from both in Sentul and Kampong chicken are found in groups that are not appropriate. Males are more difficult to be distinguished because they have less numbers of distinguishing variables.

Mahalanobis minimum distance in males and females between Kampong and Sentul chickens is 1.2801 and 1.6900 (Figures 1 and 2).

Greater distances in females show that morphometric dissimilarity among females is larger than males in Kampong vs Sentul chicken. The actual separation is more easily done on the female group than on the male group and females is a result of differences in response to genetic variation, environmental, and genetic-environment interactions that relate to differences in selection goals and crossing (linebreed) in each type of chicken.

Mahalanobis minimum distance obtained in the present observations in males and females between Kampong vs Sentul chicken is much closer than between Kampong vs Wareng-Tangerang chicken. Sartika *et al.* (1997) and Sartika, *et al.* (2004) stated that Kampong and Sentul chicken had a close genetic distance because they come from the same family or ancestor based on observations of microsatellite DNA marker at locus Abr 359, Abr 297, Abr 339, Abr and 28 based on REML (Restricted Maximum Likehood Estimation) method. Similarity of the origin of the two groups were actualized in the discriminant function that is formed, especially for the males group that has only four distinguishing variables, of the nine observed variables. Differences in distinguishing variables in males and females of Sentul or Kampong chicken are due to differences in tightness of selection. Selection of males group is allegedly not as tight as the female group; it has been shown that distinguishing variables in the male group are less than those in female group.

Shank circumference is not a distinguish-ing variable in both in males and females of Kampong vs Sentul chicken. This is because of the purpose of selection in both types of chickens is directed toward the dual-purpose chicken with medium body size. Shank circumference has a role in supporting the body of a chicken. Indonesian territory demographic factors may be the possible causes of phenotypic differences and similarities of linear body measurement variables of these two types of chicken. Based on the origin of the chicken used in the observation, Kampong chicken comes from different locations in West Java i.e. the area of maintenance of Balitnak, Bogor, Depok, Garut and Jatiwangi (Sartika, 2000). Kampong chicken has a high phenotypic variation compared to that of Sentul chicken and from Ciamis, West Java (Table 1).

Wareng-Tangerang vs Sentul Chicken

The classification based on discriminant function indicates that high differences in males of Wareng-Tangerang vs Sentul chicken are because of all the observed variables are distinguishing variables. These are the length of the femur, tibia, shank, third finger, wing, maxilla, and sternum, shank circumfrerence, and comb height. All the variables are highly correlated to the discriminant function equation which is established through testing simultaneous confidence interval at 95%. Discriminant function equation which is formed between the two groups of male chickens is : $Y = -0.18\ X_1 - 0.03\ X_2 + 1.20\ X_3 + 1.09\ X_4 + 0.20\ X_5 - 0.36\ X_6 + 0.06\ X_7 - 0.54\ X_8 + 0.11X_9$. The results (Table 6) show that the corrected data of females in Wareng-Tangerang vs Sentul is 97.7%% based on the distinguishing variables in the discriminant function. Individuals who are classified as male group of Sentul chicken that have been corrected is 95.7% and as a male group of Wareng-Tangerang is appropriately corrected for 100%. One male Sentul chicken based on Wald-Anderson classification is included in the males of Wareng -Tangerang chicken.

The corrected data for males of Wareng-Tangerang chicken and classified as males of Sentul chicken is 4.3% (100% - 95.7%). The corrected data for male of Wareng-Tangerang chicken is 100%. A male of Wareng-Tangerang chicken is found in the male of Sentul chicken. None of male of Sentul chicken is found in the males of Wareng-Tangerang chicken.

Discriminant function which is formed in the females group in Wareng-Tangerang vs Sentul chicken shows that all variables of linear body size are found to be distinguishing variables, as it occurred in the male group.

Distinguishing variables of the females in Sentul vs Wareng-Tangerang chicken are femur length, tibia length, shank length, shank circumference, third finger length, wing length, maxilla length, comb height and length of the sternum. These variables are significant ($P<0.05$) in the simultaneous confidence interval at 95% and has a strong correlation to the discriminant function scores.

Table 6. Classification of Individual Data on Male Group of Wareng-Tangerang vs Sentul Chicken Based on Wald-Anderson Criterion

Actual Group	Classification		% Correction
	Sentul chicken	Wareng-Tangerang Chicken	
Sentul Chicken (n=23)	22	1	22/23 x 100% = 95.7%
Wareng-Tangerang Chicken (n=20)	0	20	20/20 x 100% = 100.0%
Total (n=43)	22	21	43-(1+0)/43 x 100% = 97.7%

Description: n = number of samples.

Table 7. Classification of Data Group of Females at Sentul vs Wareng-Tangerang Chicken Based on Wald-Anderson Criterion

Actual Group	Classification		% Correction
	Sentul chicken	Wareng-Tangerang Chicken	
Sentul Chicken (n=27)	27	0	27/27 x 100% = 100.0%
Wareng-Tangerang Chicken (n=90)	0	90	90/90 x 100% = 100.0%
Total (n=117)	27	90	117-(0+0)/117 x 100% = 100.0%

Description: n = number of samples.

Discriminant function equation that is established between these two types of female chicken is : $Y = 0.02\ X_1 + 0.32\ X_2 + 0.93\ X_3 + 1.30\ X_4 + 0.69\ X_5 - 0.10\ X_6 - 0.22\ X_7 - 0.81\ X_8 - 0.29\ X_9$. The results show that the data of individuals in both groups of females that have been corrected is 100% based on the discriminant function (Table 7). Females who are classified as a group of Sentul chicken that has been corrected is found to be 100% and as a group of Wareng-Tangerang is 100%. None of female of Sentul chicken is grouped into females of Wareng-Tangerang chicken, and vice versa.

The separation between the groups of Wareng-Tangerang and Sentul chicken in actual groups which is not appropriate, is only found in the males. Males are more difficult to be separated than females although all the observed variables are distinguishing variables in both sexes.

Mahalanobis minimum distance in males and females between Wareng-Tangerang and Sentul chicken is 2.9925 and 2.9864 (Figures 1 and 2). A greater distance in males showed that morphometric disimilarity among males in Sentul vs Wareng-Tangerang is larger than the females. The actual separation should be more easily done on the male group, but an opposite situation occur in this study. The discriminant function which is formed in males and females shows the same number of distinguishing variables.

Morphometric differences in linear body size of Sentul and Wareng-Tangerang chicken are indicated by the size of the body of Wareng-Tangerang chicken which is much smaller than Sentul chicken (Table 1). Discriminant function that is established shows all linear body size variables are distinguishing variables between these two groups of chicken, both in males and females. Differences of origin, selection destination and the difference in genetic variation, environmental and interaction between them, are the cause of these differences. According to Iskandar (2004[b]), Sentul chicken were the Indonesian native chicken, and Wareng-Tangerang chicken came from Russia having high adaptation through domestication and selection since the 1980s. Differences of the origin distinguish the phenotypic response based on the potential for additive genes controlling the linear body size of each type of chicken to the nature of growth, development and osteogenesis body frame. Selection to the superior layer type (mild type) in the Wareng-Tangerang chicken shown by linear size variables of the observation body is the smallest compared to the other two types of chicken and is the most uniform relative to the male group (Table 1). However, this is not the case in the female group. In Wareg chicken, selection toward the superior layer, also affect indirectly the linear measures of body variables. Susanti *et al.* (2006) states that the Wareng-Tangerang chicken is categorized as mild type of chicken having potential as productive layer type.

Sentul chicken is selected as dual-purpose type. Sentul is laying chicken that have a large body size. North and Bell (1990) stated that one of the functions of bone-sustaining linear variable measures are body muscle attachment. This condition is found in Sentul as broiler chicken

type. Sartika (2000) states that the correlation between the length of tarsometatarsus, tibia length and femur length with body weight is positive, with the highest closeness in the relationship between shank length and tibia length.

Differences of selection goals and crossing of the breeding program policies on Sentul and Wareng-Tangerang chicken are suspected to be factors causing differences in distinguishing variables from the discriminant function that is formed besides the differences of the origin. Susanti *et al.* (2006) stated that the Wareng-Tangerang was categorized as a lightly type of chicken with potential as productive layer type chickens, whereas Sentul chicken were selected for production purposes that was more directed as a dual-purpose type chickens (Iskandar, 2004[b]). This chicken has a greater skeleton size than Wareng-Tangerang chicken. Sentul chicken were the Indonesian native chickens, while Wareng-Tangerang chicken came from Russia which had undergone domestication and selection since the 80s (Iskandar (2004[b])

Table 8. Minimum Distance Matrix of D^2-Mahalanobis in Males between Kampong, Wareng-Tangerang and Sentul Chicken Based on Body Size Variable

Types of Chicken	Kampong	Wareng-Tangerang	Sentul
Kampong	0.0000		
Wareng-Tangerang	22.5180	0.0000	
Sentul	6.5544	52.1980	0.0000

Table 9. Minimum Distance Matrix D^2 of Mahalanobis in Females between Kampong, Wareng-Tangerang and Sentul Chicken Based on Body Size Variable

Types of Chicken	Kampong	Wareng-Tangerang	Sentul
Kampong	0.0000		
Wareng-Tangerang	17.7196	0.0000	
Sentul	11.4249	59.8460	0.0000

Table 8 presents the minimum distance matrix of D^2-Mahalanobis between the two types of chickens that are observed in males. The highest minimum distance is found between Sentul and Wareng-Tangerang chicken in the males; and the lowest is found between the Kampong and Sentul chicken. The same phenomenon is also found in the female group in Table 9.

The dendogram constructed based on the minimum distance matrix D^2-Mahalanobis in males and females of Kampong, Wareng-Tangerang and Sentul chicken can be seen in Figures 1 and 2. Grouping between Kampong and Sentul chicken indicate that these two types of chicken have high similarity based on measures of body size variables that are observed. Separate grouping of Wareng-Tangerang chicken indicates that this type of chicken has different body size variables that are higher than those in other two types of chicken.

CONCLUSIONS

Eight distinguishing variables are found, both in males and females based on discriminant function in the Kampong vs Wareng-Tangerang chicken. Four distinguishing variables are found in males and eight distinguishing variables are found in females in in the Kampong vs Sentul chicken. Nine distinguishing variables are found both in males and females in the Wareng-Tangerang vs Sentul chicken.

The classification based on the actual group shows that the chicken are found in the wrong group. In females, some of the data of Kampong chicken are found in Kampong vs Wareng-Tangerang chicken and vice versa. Some of the data of Sentul chicken are found in Kampong chicken and vice versa both in males and females. Some of the data of Wareng-Tangerang chicken that are found in Sentul chicken are only found in males. Grouping between Kampong and Sentul chicken indicate that these two types of chicken have high similarity based on measures of body size variables that are observed. Separate grouping of Wareng-Tangerang chicken indicates that this type of chicken has different body size variables that are higher than those in other two types of chicken.

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