Characteristics of Body Measurement and Shape of Garut Sheep and Its Crosses with Other Breeds

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ABSTRAK

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Ukuran tubuh penting untuk diketahui karena dapat digunakan untuk menduga bobot badan dan dapat digunakan untuk membedakan karekteristik bentuk dan ukuran tubuh hewan dari galur yang berbeda ataupun lingkungan yang berbeda. Penelitian ini ditujukan untuk mempelajari karakteristik morfometrik pada ukuran dan bentuk tubuh dari 78 ekor domba Garut (GG), 29 ekor domba HG {persilangan antara domba St. Croix jantan (HH) dan domba Garut betina (GG)}, 36 ekor domba MG {persilangan antara domba Mouton Charollais jantan (MM) dan Garut betina (GG)}, 62 ekor domba MHG (MG x HG) dan 38 ekor domba HMG (HG x MG). Sembilan peubah yang diamati ádalah meliputi tinggi pundak (X1), tinggi panggul (X2), panjang tubuh (X3), lebar dada (X4), dalam dada (X5), lebar panggul (X6), lingkar dada (X7), lingkar kanon (X8) dan panjang panggul (X9). Data yang diperoleh dianalisis dengan menggunakan uji t dan diteruskan dengan Analisis Komponen Utama (AKU). Berdasarkan AKU, didapatkan bahwa lingkar dada merupakan penciri utama untuk ukuran-ukuran tubuh pada domba jantan dan betina Garut, HG, MG, MHG dan HMG dengan nilai vektor *Eigen* masing-masing 0,689; 0,709; 0,689 dan 0,681 secara berturut turut. Penciri utama pada bentuk tubuh kelompok domba Garut adalah lingkar dada dan tinggi panggul dengan nilai vektor *Eigen* masing-masing -0,600 dan 0,551. Kelompok domba HG menjadikan panjang tubuh sebagai penciri utama untuk bentuk tubuh dengan nilai vektor *Eigen* -0,725. Kelompok domba MG menjadikan lingkar dada, tinggi panggul dan tinggi pundak sebagai penciri utama pada bentuk tubuh dengan nilai vektor *Eigen* masing-masing -0,600; 0,558 dan 0,555. Kelompok domba MHG menjadikan tinggi pundak sebagai penciri utama pada bentuk tubuh dengan nilai vektor *Eigen* 0,608. Kelompok domba HMG menjadikan panjang tubuh sebagai penciri utama bentuk tubuh dengan vektor *Eigen* 0,764. Bentuk tubuh domba HG dan MG agak berbeda dengan domba Garut, tetapi bentuk tubuh domba MHG dan HMG mendekati domba Garut. Hal ini mengindikasikan daya adaptasi domba HMG dan MHG mendekati daya adaptasi domba Garut.

Kata kunci: Domba, Ukuran Tubuh, Bentuk Tubuh

ABSTRACT

INOUNU, I., ERFAN and R. H. MULYONO. 2009. Characteristic of body measurement and shape of Garut sheep and its crosses with other breeds. *JITV* 14(4): 295-306.

It is important to know body measurement because it could be used to estimate body weight as well as to differentiate the chrateristic of body measurement and shape of animal due to different breed or environment. This research was carried out to study morphometric characteristic of body size and body shape from 78 of Garut sheep (GG), 29 HG sheep {crossbred between St. Croix (HH) and Garut sheep (GG)}, 36 MG sheep {crossbred between Mouton Charollais (MM) and Garut sheep (GG)}, 62 MHG sheep (MG x HG) and 38 HMG sheep (HG x MG). Body part measured were wither height (X1), rump height (x2), body length (X3), chest width (X4), chest depth (X5), hip width (X6), chest girth (X7), cannon circumference (X8) and hip length (X9). Data obeserved were analised using t test and Principle Components Analysis (PCA). Based on PCA it was showen that chest girth was the primary identity for body measurement on males and females of Garut, HG, MG, MHG and HMG with its *Eigenvector* value 0.689; 0.709; 0.689 and 0.681 respectively. The primary indentity for body shape of Garut sheep were chest girth and hip heigth with *Eigenvector* value -0.600 and 0.551 respectively. The primary indentity for body shape of HG sheep were body length with *Eigenvector* value -0.725. The primary indentity for body shape of MG sheep were chest girth, rump heigth, and wither heigth with *Eigenvector*s value: -0.600; 0.558 and 0.555 respectively. The primary indentity for body shape of MHG sheep was wither height with *Eigenvector* value 0.608. The primary indentity for body shape of HMG was body length with *Eigenvector* value 0.764. Body shape of HG and MG sheep is different than that of Garut sheep, but the body shape of MHG and HMG were close to Garut body shape. This result indicated that the adaptability to environment of HMG and MHG is close to that of Garut sheep.

Key words: Sheep, Body Size, Body Shape.

INTRODUCTION

Research Institute for Animal Production (RIAP) has conducted a cross breeding between Garut sheep (GG) and St. Croix (HH) and Mouton Charollais (MM). This breeding resulted in HG (50% St. Croix and 50% Garut) and MG (50% Mouton Charollais and 50% Garut). Further crossing then produced MHG, crossing between MG ram and HG ewe, and HMG, crossing between HG ram and MG ewe.

Body measurement is often used as an indicator in evaluating growth of animal; but it doesn't indicate body composition. This body measurement includes body length and heart girth. Moreover, according to DIWYANTO *et al.* (1984) body measurement indicates exterior performance of sheep.

According to EVERITT dan DUNN (1998) that the oldest multivariate method and widely used is Principle Component Analysis (PCA). Basically this analysis describes the structure of variance-covariance through linier combination variables. PCA is variable reduction procedure. It is useful when there is data on a number of variables (possibly a large number of variables), and believed that there is some redundancy in those variables. It is also often be used in dimension reduction of group of unstructured random variable for data analysis and interpretation (KARSON, 1982). In this case, redundancy means that some of the variables are correlated with one another, possibly because they are measuring the same construction. Because of this redundancy, it should be possible to reduce the observed variables into a smaller number of principal components (artificial variables) that will take account for most of the variance in the observed variables.

According to OTSUKA *et al.* (1982) PCA is used to differentiate the population. While NISHIDA *et al.* (1982) and EVERITT and DUNN (1998), stated that PCA is used to differentiate body measurement. In morphometric application, the first primary component could be accepted as body measurement vector and the second component as body shape. This condition explains different variation level in body condition of certain flock caused by different body measurement as demonstrated in first primary component.

According to HAYASHI *et al.* (1982) based on his study using wild Banteng, there were two ways to analyze principle component. The first, using covariant matrix and the second, using correlation matrix. The analysis power increased as covariant matrix was used.

This research was aimed to study morphometric characteristic to differentiate the chrateristic of body measurement and shape of animal due to different breed namely Garut, HG, MG, MHG and HMG sheep based on principle component analysis. The information resulted from this research could enrich the available information about body conformation and adaptability of Garut crossbred to the environment.

MATERIAL AND METHOD

This research was done in Small Ruminant Research Station, Research Institute for Animal Production located on Pajajaran Street. In this research Garut and its crossbred sheep were used. These are: GG, HG, MG, HMG, and MHG. HG (50%H and 50%G) was formed by mating Hair sheep (HH) ram to Garut (GG) ewe. MG was formed by inseminating Garut (GG) ewe with frozen semen of Mouton Charollais (MM). The composite breeds were formed from the mating between HG ram and MG ewe resulted in HMG (25%H, 25%M and 50%G) and the mating between MG ram and HG ewe resulted in MHG (25%M, 25%H and 50%G).

Animals that were used in this research were mature male and female sheep of all crossbred, consisted of: 78 heads of Garut: seven males and 71 females; 29 heads of HG: five males and 24 females; 36 heads of MG: four males and 32 females; 38 heads of HMG: seven males and 31 females. The grand total was 243 heads.

The feed offered was chopped grass at the level of 10% of body weight and concentrate at 2% of body weight. The concentrate contained 16% crude protein and 68% TDN and tofu waste at about 100g/h/d, and water was provided *ad-libitum.*

Equipments used were measurement tape (cm), caliper (cm), and weight scale (kg) and forms to record the data.

Body measurement

Body measurement was done based on method standardized by Wagyu Cattle Registry Association in 1979 (AMANO *et al*., 1980). There are nine parameters observed, namely: wither height (X1), rump height (X2), body length (X3), chest width (X4), chess depth (X5), hip width (X6), heart girth (X7), cannon circumference (X8), and hip length (X9).

1. Whither height (X1) was the distance of the highest part of shoulder from the ground, measured using measurement stick (cm).
2. Rump height (X2) was the distance of the highest part of the hip from the ground, measured using measurement stick (cm).
3. Body length (X3) was the distance in horizontal line from the tip of *processus spinosus* to *os ischium,* measured using measurement stick (cm).
4. Chest width (X4) was the distance between the tips of *os scapula* right and left sides measured using caliper (cm).

5. Chess depth (X5) was the distance of the highest part of shoulder to the chest bone, measured using measurement stick (cm).
6. Hip width (X6) was the distance between outer part of the right hip to the left hip, measured using caliper (cm).
7. Heart girth (X7) was the circumference of the chest right behind the shoulder joint, measured by measurement tape (cm).
8. Cannon circumference (X8) was the circumference of fore foot, measured by measurement tape (cm).
9. Hip length (X9) was the distance of outer hind bone to *os ischium,* measured using measurement stick (cm).

After all the measurement were done then all animal were weighed to obtain additional information.

Data analysis

The data then were analyzed based on t-test to identify the similarities and differences among body measurement. The t-test was to analyzed two populations in different number (n) of animal observed as described in the following equation (STEEL and TORRIE, 1980):

$$t = \frac{\overline{X}_1 - \overline{X}_2}{s_{\overline{X}_1 - \overline{X}_2}}$$

Where:

$$s_{\overline{X}_1 - \overline{X}_2} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}.$$

Where s^2 is the unbiased estimator of the variance of the two samples, n = number of participants, 1 = group one, 2 = group two. For use in significance testing, the distribution of the test statistic is approximated as being an ordinary Student's t distribution with the degrees of freedom calculated using

$$\mathrm{D.F.} = \frac{(s_1^2/n_1 + s_2^2/n_2)^2}{(s_1^2/n_1)^2/(n_1 - 1) + (s_2^2/n_2)^2/(n_2 - 1)}.$$

The similarities and differences between every parameter in the two groups of population then were made into diagram of measurement and shape based on PCA to obtain equations of measurement and shape generated from covariance matrix (GASPERSZ, 1992). The PCA equation is as follow:

$$Y_p = a_{1p}X_1 + a_{2p}X_2 + \ .\ .\ .\ . \ + a_{pp}X_p$$

Where:

Y_p = pth principle component
a_{1p} - a_{1p} = pth Eigenvector (p= 1, 2, ...,9)
X_p = pth varibale (p = 1, 2, ..., 9).

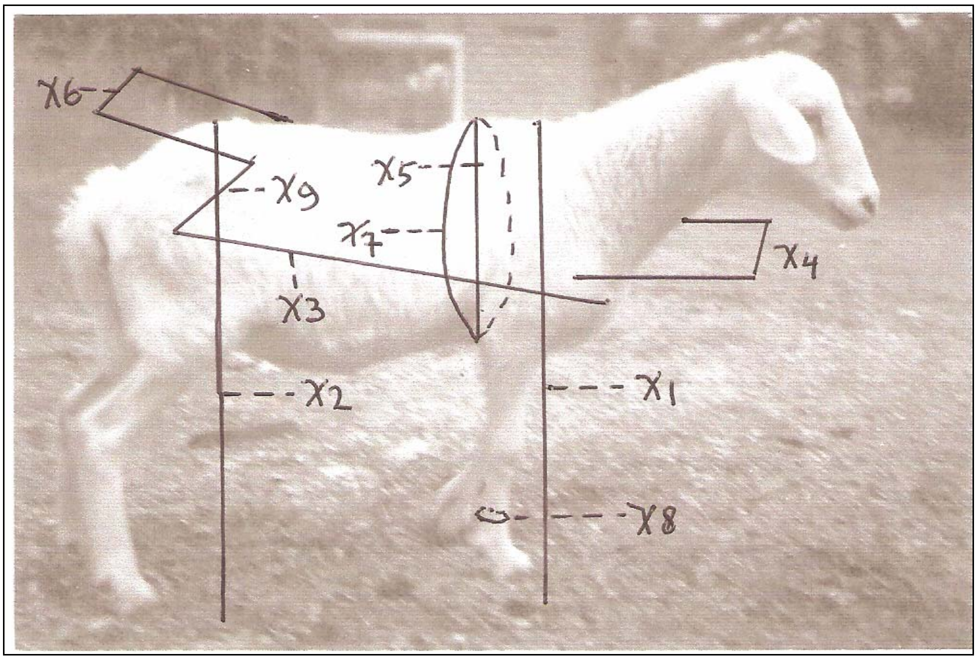

Figure 1. Body parts that were measured

Where:

X1= Whiter height	X4= Chest width	X7= Heart girth
X2= Rump height	X5= Chest depth	X8= Cannon circumference
X3= Body length	X6= Hip width	X9= Hip length

Two primary components that have the highest total variant value are used as equation of body measurement and shape. Correlation between measurement and shape to the parameter observed were calculated based on equation stated by GASPERSZ (1992). Correlation was calculated using Eigenvector and Eigenvalue obtained from PCA with mathematical model as follow:

Where:

$$r_{xiyj} = \frac{a_{ij}\sqrt{\lambda_j}}{S_i}$$

:r_{xiyj} = correlation between variables x_i and Yj^{th} principle component (j=1,2)

a_{ij}= j^{th} Eigenvector.

λ_j = j^{th}

RESULTS AND DISCUSSION

Body measurement

The mean and the standard deviation of the measurement and body weight of GG, HG, MG, HMG, and MHG are presented in Table 1 and 2. Data were analyzed by t-test and the results were presented in Table 3. These measurements (X1 – X9) were not different in both groups (male and female). It is shown in Table 3 that in male group X1 up to and X9 were not different for all 5 genotypes, except for X6: Garut<HG. While in female group X1 up to X9 were not different for all five genotypes, except X2: HG<MHG, and X4: MHG<HG. For certain measurement HG sheep has the biggest measurement. Male HG has the biggest X6 (hip width) while female HG has the biggest X4 (chest width).

Result of t-test showed similarities and differences in the measurement among the five genotypes (Garut, HG, MG, HMG, and MHG). Those similarities and differences are presented in PCA diagram (Table 3).

Characteristic of body measurement and body shape

Based on these t-test results, the analysis was then continued using graphs that explained the measurement and shape resulted from PCA for each genotype. The axis represents body measurement and Y represents body shape.

Table 1. Means and standard deviation of body measurement (cm) and body weight (kg) from rams observed

Variables	Garut (n=7)	HMG (n=7)	MHG (n=6)	HG (n=5)	MG (n=4)
Wither height (X1)	64.1 ± 4.1	63.7 ± 6.4	61.8 ± 7.0	63.8 ± 2.6	61.4 ± 9.3
Rump height (X2)	65.3 ± 3.0	63.1 ± 6.8	63.2 ± 5.5	64.7 ± 1.3	62.0 ± 9.6
Body length (X3)	62.1 ±4.2	59.1 ± 9.6	58.4 ± 6.8	66.5 ± 6.4	55.5 ± 10.2
Chest width (X4)	16.3 ± 0.9	16.7 ± 2.5	16.5 ± 2.1	18.6 ± 3.1	15.5 ± 2.2
Chest depth (X5)	29.1 ± 2.6	27.4 ± 4.9	26.2 ± 5.2	29.3 ± 3.0	25.5 ± 4.4
Hip width (X6)	15.4 ± 1.5	14.6 ± 2.6	14.3 ± 2.6	17.8 ± 1.6	12.8 ± 3.4
Heart girth (X7)	78.2 ± 6.6	73.3 ± 11.8	71.4 ± 13.6	82.8 ± 7.7	69.3 ± 14.6
Cannon circumference (X8)	7.0 ± 0.5	7.1 ± 0.8	7.2 ± 0.8	7.9 ± 0.8	6.4 ± 0.8
Hip length (X9)	18.6 ± 1.5	17.3 ± 3.6	18.2 ± 2.1	20.5 ± 2.3	15.9 ± 2.4
Body weight	37.5 ± 10.7	35.9 ± 11.8	32.6 ± 16.6	46.2 ± 8.3	30.9 ± 16.6

Table 2. Means and standard deviation of body measurement (cm) and body weight (kg) from ewes obeserved

Variables	Garut (n=71)	HMG (n=31)	MHG (n=56)	HG (n=24)	MG (n=32)
Wither height (X1)	61.7 ± 4.0	58.7 ± 3.8	60.5 ± 4.4	58.3 ± 4.3	61.9 ± 3.5
Rump height (X2)	60.0 ± 4.2	59.0 ± 4.1	61.5 ± 4.3	59.3 ± 4.0	62.9 ± 3.1
Body length (X3)	58.4 ± 4.0	58.2 ± 4.9	59.7 ± 4.5	60.6 ± 5.3	58.1 ± 4.0
Chest width (X4)	15.0 ± 1.5	15.6 ± 1.9	16.0 ± 1.8	16.7 ± 1.7	15.4 ± 1.1
Chess depth (X5)	26.9 ± 2.8	25.0 ± 2.7	26.2 ± 2.7	25.4 ± 3.3	26.5 ± 2.2
Hip width (X6)	14.7 ± 1.7	14.8 ± 2.3	16.0 ± 2.1	16.0 ± 2.4	15.7 ± 1.5
Heart girth (X7)	73.1 ± 7.1	71.3 ± 8.2	73.7 ± 7.0	72.6 ± 8.02	73.8 ± 5.1
Cannon circumference (X8)	6.6 ± 0.5	6.7 ± 0.5	6.8 ± 0.4	6.9 ± 0.6	6.5 ± 0.4
Hip length (X9)	17.8 ± 1.8	17.3 ± 2.1	17.8 ± 1.9	17.7 ± 2.0	17.6 ± 1.2
Body weight	31.3 ± 8.5	29.8 ± 8.5	32.7 ± 7.6	33.6 ± 7.5	31.0 ± 5.0

Table 3. Summary t-test results of body measurement from Garut, HG, MG, MHG, and HMG sheep

Variables	Sex	Variables comparison
Wither height (X1)	Males	MG=MHG=HMG=HG=Garut
	Females	HG=HMG=MHG=Garut=MG
Rump height (X2)	Males	MG=HMG=MHG=HG=Garut
	Females	HMG=HG<MHG=Garut=MG
Body length (X3)	Males	MG=MHG=HMG=Garut=HG
	Females	MG=HMG=Garut=MHG=HG
Chest width (X4)	Males	MG=Garut=MHG=HMG=HG
	Females	Garut=MG=HMG=MHG<HG
Chest depth (X5)	Males	MG=MHG=HMG=Garut=HG
	Females	HMG=HG=MHG=MG=Garut
Hip width (X6)	Males	MG=MHG=HMG=Garut<HG
	Females	Garut=HMG=MG=MHG=HG
Heart girth (X7)	Males	MG=MHG=HMG=Garut=HG
	Females	HMG=HG=Garut=MHG=MG
Cannon circumference (X8)	Males	MG=Garut=HMG=MHG=HG
	Females	MG=Garut=HMG=MHG=HG
Hip length (X9)	Males	MG=HMG=MHG=Garut=HG
	Females	HMG=MG=HG=MHG=Garut

Note: ≤:less than; ≥:higher than; =equal

Garut sheep

The equation of body measurement and shape resulted from PCA are presented in Table 4. The total variance of the equation of body measurement was 85.4% while that of the equation of shape was 6.7%. Eigenvalue of body measurement and body shape were 102.70 and 8.07 respectively.

Measurement presented in Table 4, shows that heart girth (X7) was the biggest primary identity of measurement with Eigenvector of 0.689. Heart girth had the biggest contribution in measurement score. Heart girth (X7) and rump height (X2) had the biggest contribution in body shape of Garut sheep, with Eigenvector of -0.600 and 0.551 respectively.

Correlation coeffisient among body measurement and body shape are presented in Tabel 5. The correlation coeffisien of X7 is the biggest (0.970). It means that X7 had positive correlation to body measurement, so in Garut sheep, the bigger the X7 the bigger the body shape will be. Heart girth oftenly used as the primary identity of ruminant body weight.

HG sheep.

The equation of body measurement and shape resulted from PCA of HG sheep are presented in Table 6. The total variance of the equation of body measurement was 82.7% while that of the equation of body shape was 8.2%. Eigenvalue of body measurement and shape were 145.99 and 14.45% respectively.

Measurement presented in Table 6, shows that heart girth (X7) was the biggest primary identity of measurement with Eigenvector (λ) of 0.709. Body length (X3) had the biggest contribution in body shape in HG sheep, with Eigenvector (λ) of -0.725.

Table 4. The equation for body measurement and body shape with total variance (V_T) and Eigenvalue (λ) of Garut sheep.

Measurement=	0.369X1 + 0.378X2 + 0.355X3 + 0.119X4 + 0.264X5 + 0.140X6 + 0.689X7 + 0.040 X8 + 0.123 X9
V_T =	85.4%
λ =	102.70
Shape=	0.405X1 + 0.551X2 + 0.3522X3 - 0.150X4 - 0.205X5 - 0.083X6 - 0.600X7 - 0.008X8 - 0.093X9
V_T =	6.7%
λ =	8.07

Table 5. Correlation coefficient of body measurement and body shape of Garut sheep

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9
Measurement	0.918	0.905	0.866	0.786	0.941	0.860	0.970	0.578	0.701
Shape	0.282	0.370	0.241	-0.278	-0.105	-0.143	-0.238	-0.042	-0.149

Table 6. The equation for body measurement and shape with total variance (V_T) and Eigenvalue (λ) of HG sheep

Measurement=	0.313X1 + 0.291X2 + 0.400X3 + 0.152X4 + 0.274X5 + 0.175X6 + 0.709X7 + 0.044X8 + 0.156X9
V_T =	82.7%
λ =	145.99
Shape=	0.522X1 + 0.396X2 - 0.725X3 - 0.145X4 - 0.001X5 - 0.041X6 + 0.086X7 - 0.036X8 - 0.116X9
V_T =	8.2%
λ =	14.45

Note for Table 4, 5 and 6
x1 = whither height
x2 = rump height
x3 = body length
x4 = chest width
x5=chess depth
x6=hip width,
x7= heart girth
x8 = cannon circumference
x9 = hip length

The highest correlation coeffisient in body measurement was reached by heart girth (X7) which was 0.980, and that of chest depth (X5) was 0.930 (Table 7). In this case X7 and X5 dictated body score. According herat girth, body length, chest width, and cannon circumference positively related to sheep growth in an extensive condition.

MG sheep

The equation of body measurement and shape resulted from PCA of MG sheep are presented in Table 8. The total variance of the equation of body measurement was 78.4% while that of the equation of body shape was 12.2%. Eigenvalue of body measurement and shape were 90.20 and 14.00 respectively.

It is shown in Table 8 that heart girth (X7) became the primary identity of body measurement in MG sheep with Eigenvector value of 0.641. Heart girth (X7) had the biggest contribution in body shape of this sheep with Eigenvector of -0.600; beside rump height (X2) and wither height (X1) whose Eigenvector value were 0.558 and 0.555 respectively.

The highest correlation coeffisient in body measurement was reached by heart girth (X7) which was 0.928, and that of body length (X3) was 0.921. In this case X7 and X3 dictated body measurement score. According FOURIE *et al*. (2002) heart girth, and body length affected body weight. On the other hand heart girth (X7) had negative correlation with body shape (-0.342), while the correlation coeffisient of rump height (X2) and wither height (X1) were the highest, namely 0.517 and 0.488 respectively. In the case of MG sheep the bigger the heart girth the smaller the body shape, but the higher the rump and wither the bigger the body shape.

MHG Sheep

The equation of body measurement and shape resulted from PCA of MHG sheep are presented in Table 10. The total variance of the equation of body measurement was 81.4% while that of the equation of body shape was 9.1%. Eigenvalue of body measurement and shape was 115.91 and 13.01 respectively.

Table 7. Correlation coefficient of body measurement and shape of HG sheep

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9
Measurement	0.832	0.841	0.832	0.895	0.930	0.906	0.980	0.532	0.818
Shape	0.436	0.360	-0.474	-0.268	-0.001	-0.067	0.037	-0.206	-0.191

Table 8. Equation of body measurement and shape, total variance (V_T) and Eigenvalue (λ) of MG sheep

Measurement=	0.378X1 + 0.349X2 + 0.474X3 + 0.097X4 + 0.221X5 + 0.174X6 + 0.641X7 + 0.034X8 + 0.098X9
V_T =	78.4%
λ =	90.20
Shape=	0.555X1 + 0.558X2 + 0.044X3 - 0.055X4 - 0.096X5 - 0.081X6 - 0.600X7 + 0.013X8 + 0.003X9
V_T =	12.2%
λ =	14.00

Table 9. Correlation coefficient of body measurement and shape of MG sheep

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9
Measurement	0.844	0.820	0.921	0.710	0.858	0.838	0.928	0.718	0.650
Shape	0.488	0.517	0.034	-0.159	-0.147	-0.154	-0.342	0.108	0.008

Note for Table 7, 8 and 9

X1 = whither height
X2 = rump height
X3 = body length
X4 = chest width
X5=chess depth
X6=hip width,
X7= heart girth
X8 = cannon circumference
X9 = hip length

It is shown in Table 10 that heart girth (X7) became the primary identity of body measurement in MHG sheep with Eigenvector of 0.689. Wither height (X1) had the biggest contribution in body shape of this sheep with Eigenvector of 0.608.

The highest correlation coefficient achieved was between body measurement and heart girth (X7), it was 0.961. In this case the higher the heart girth in MHG sheep the bigger the body measurement score will be. The body measurement observation result from MHG; HMG and Garut sheep was not significantly different; all of them were affected by heart girth. While correlation coefficient achieved between body shape and wither height (X1) was 0.473 and that of body shape with rump height (X2) was 0.453. This is indicating that in MHG sheep the higher the wither and rump, the bigger the body shape score is.

HMG sheep

The equation of body measurement and shape resulted from PCA of HMG sheep are presented in Table 12. The total variance of the equation of body measurement was 85.2% while that of the equation of body shape was 6.5%. Eigenvalue of body measurement and shape were 156.65 and 12.03 respectively.

It is shown in Table 12 that heart girth (X7) became the primary identity of body measurement in HMG sheep with Eigenvector of 0.681. This fact was very similar to fact of Garut sheep. Body shape of HMG sheep was highly affected by body length (X3) with the Eigenvector of 0.764. While Table13 presents the correlation coefficient of each parameter with body measurement and shape of HMG sheep.

Table 10. Equation of body measurement and shape, total variance, and Eigenvalue of MHG sheep.

Measurement=	0.371X1 + 0.350X2 + 0.379X3 + 0.125X4 + 0.245X5 + 0.170X6 + 0.689X7 + 0.026X8 + 0.127X9
V_T =	81.4%
λ =	115.91
Shape=	0.608X1 + 0.547X2 - 0.033X3 - 0.195X4 - 0.005X5 - 0.149X6 - 0.519X7 + 0.006X8 + 0.022X9
V_T =	9.1%
λ =	13.01

Table 11. Correlation coefficient of body measurement and shape of MHG sheep

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9
Measurement	0.861	0.865	0.869	0.731	0.900	0.858	0.961	0.569	0.732
Shape	0.473	0.453	-0.025	-0.382	-0.006	-0.252	-0.242	0.044	0.042

Table 12. Equation of body measurement and shape, total variance, and Eigenvalue of HMG sheep

Measurement=	0.335X1 + 0.357X2 + 0.402X3 + 0.152X4 + 0.247X5 + 0.164X6 + 0.681X7 + 0.039X8 + 0.148X9
V_T =	85.2%
λ =	156.65
Shape=	0.214X1 + 0.145X2 + 0.764X3 - 0.069X4 - 0.123X5 - 0.056X6 - 0.569X7 + 0.049X9
V_T =	6.5%
λ =	12.03

Note for Table 10, 11 and 12

X1 = whither height
X2 = rump height
X3 = body length
X4 = chest width
X5=chess depth
X6=hip width,
X7= heart girth
X8 = cannon circumference
X9 = hip length

The highest correlation coefficient achieved was between body measurement and heart girth (X7), namely 0.969. In other words, the bigger the heart girth, the bigger the body measurement will be. According to DIWYANTO *et al.* (1984), body measurement of Garut sheep was highly affected by heart girth (X7).

The correlation coefficient between body shape and body length (X3) was the highest (0.451). In other words, the longer the body the bigger the body shape is. Primary identity of body shape of HMG sheep was different from that of Garut sheep, even though Garut sheep was the parent stock of HMG. This fact indicating that paternal effect was inherited from male HG.

Primary identity of body measurement and shape

Table 14 presents the component of body measurement and shape that are the primary identity of body measurement and shape observed in this research. It is shown that body measurement score of GG, HG, MG, MHG and HMG was affected by heart girth (X7). This result shows that heart girth is highly correlated to body weight especially for male sheep. This result is in agreement to DIWYANTO *et al.* (1984) that heart girth (X7) was highly correlated to body weight. More over, stated that heart girth, and body length highly affected body weight.

The result of this study also indicated that there is an indirect correlation between heart girth as primary identity and body weight. There for it is concluded that heart girth can be selected as the first primary identity in selection related to body weigt.

Cluster of body measurement and shape based on genotype observed

Figure 2 and 3 presented the result of data clustering of body measurement and shape of each genotype for male and female sheep respectively. Generally speaking, the body measurement of male sheep was bigger than that of female sheep observed. This result is in agreement to DIWYANTO *et al.* (1984) that body measurement of male sheep was bigger than that of female sheep.

Bigger body shape score of female than that of male was found in: Garut, HG, MG, and HMG, while for MHG body shape score of female was smaller than that of male. It is concluded that male body shape compared to that of female of each genotype had its own characteristics. MHG sheep has its own characteristic that is different from that of Garut, HG and MG.

It happened because the crossing of Garut and Hair sheep was done to improve the body measurement of Garut sheep, so that HG has bigger figure. According to DIWYANTO AND INOUNU (2001) that HG had big figure and also big body measurement. This statement is supported by the fact that HG had high body weight (Table 2).

Cluster of body shape score of male Garut sheep was scattered in wide range. Garut male, had similar body measurement score to that of HG and MG, since big Garut male resulted from selection program were used in this study.

Garut sheep is local tropical sheep that is very adaptable to its environment. Body shape of this sheep is better than that of other local sheep. There for body shape score of Garut sheep is a good primary identitysince the graph of its data do not scatered out compared to those of other genotypes. There for body shape score can become good indication of Garut sheep adaptability to its environment. This result is supported by EVERITT dan DUNN (1991) that the second primary component – indicating body shape- was more important than the first primary component – indicating body measurement- in talking about morphology of animal. While body measurement score of Garut sheep was less suitable to be choosen as primary identity in adaptability of Garut sheep to its environment. This result is in agreement that there is a negetive correlation between body measurement and adaptability of the animal.

It is shown that the location of cluster of body measurement and shape of HG and MG to that of Garut located farther than those of MHG and HMG to those of Garut. HG and MG are crosbreed sheep expected to be adapted to the environment of Indonesia. However, it shows that the effect of genotype and environment still excist. This because the genetic composition of these cross bred consist was equal between Garut and exotic breed (50% Garut and 50% of exotic breed).

Table 13. Correlation coefficient of body measurement and shape of HMG sheep

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9
Measurement	0.886	0.922	0.857	0.926	0.945	0.898	0.969	0.830	0.788
Shape	0.157	0.177	0.451	0.116	0.130	0.085	0.224	0.000	0.072

Table14. Primary identity of body measurement and shape of Garut, HG, MG, MHG and HMG sheep

Genotype	Primary identity of body measurement	Primary identity of body shape
Garut	Heart girth (X7)	Heart girth (X7) and Rump height (X2)
HG	Heart girth (X7)	Body length (X3)
MG	Heart girth (X7)	Heart girth (X7), Rump height (X2) and Wither height (X1)
MHG	Heart girth (X7)	Wither height (X1)
HMG	Heart girth (X7)	Body length (X3)

Note for Table 13 and 14
X1 = whither height
X2 = rump height
X3 = body length
X4 = chest width
X5=chess depth
X6=hip width
X7= heart girth
X8 = cannon circumference
X9 = hip length

The aim of creating MHG and HMG sheep is to inrcrease their productivity over the local breed. Genotype and environment interaction occure in HG and MG is expected could be minimized by creating MHG and HMG sheep that have higher Garut genetic composition (50% G, 25% H dan 25% M).

Figure 3 presents the result of data clustering of body measurement and shape of each genotype for female. Body shape score of female sheep observed was not different than what was found in male sheep. HG, MG, MHG and HMG was made to have the same body shape as Garut sheep to get a good adapatability in Indonesian environment.

Figure 3 shows that cluster of MHG body measurement score was shifted to the right. This happened because MHG sheep has the superiority in measurement. While body measurement score of HG and MG sheep almost the same as the body measurement score of Garut sheep. The superiority of composite breed expected from the study was to get relatively bigger frame size and with good carcass percentage.

CONCLUSIONS

From research to study morphometric characteristic of body measurement and body shape on Garut sheep and its crossed to other breed, it is concluded that chest girth was the primary identity for body measurments on rams and ewes of Garut, HG, MG, MHG and HMG with its *Eigenvector* value 0.689; 0.709; 0.689 and 0.681 respectively. The primary indentity for body shape Garut sheep were chest girth and rump heigth with *Eigenvector* value -0.600 and 0.551 respectively. The primary indentity for body shape of HG sheep were body length with *Eigenvector* value -0.725. The primary indentity for body shape of MG sheep were chest girth, rump heigth and wither heigth with *Eigenvector*s value -0.600; 0.558 and 0.555 respectively. The primary indentity for body shape of MHG sheep was wither height with *Eigenvector* value 0.608. The primary indentity for body shape of HMG was body length with *Eigenvector* value 0.764. Body shape of HG and MG sheep is different from that of Garut sheep, but the body shape of MHG and HMG were close to Garut body shape. This is an indication that the adaptability to environment of HMG and MHG is close to that of Garut sheep.

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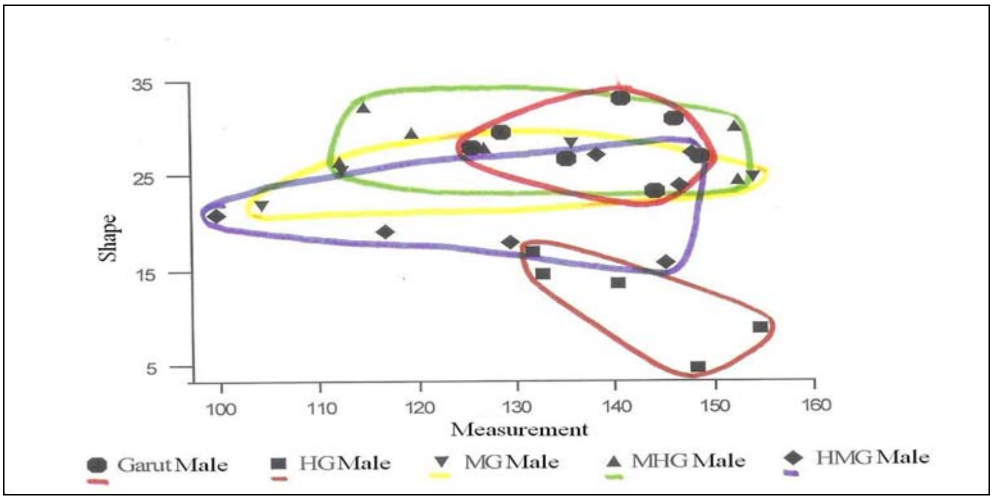

Figure 2. Diagram body measurement and shape from Garut, HG, MG, MHG and HMG male sheep

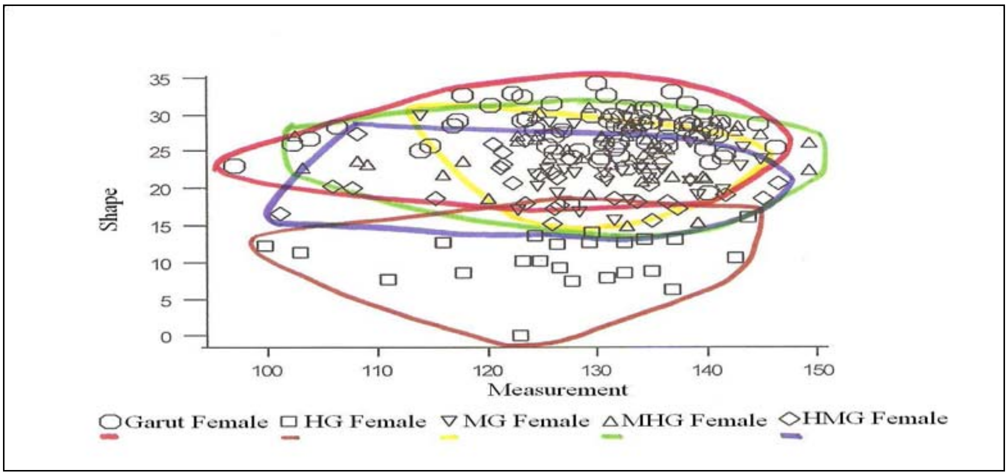

Figure 3. Diagram body measurement and shape from Garut, HG, MG, MHG and HMG female sheep

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