Characteristics of Size and Shape of Body Dimension of Madura and Rote (Indonesia) Fat-Tailed Sheep Using Principal Component Analysis

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ABSTRACT

Fat-tailed sheep is one of the important livestock resources for meat production especially in dry area of Indonesia such as Madura and Rote Islands. One of criteria for good performance as meat type is body measurement which can be useful to show their characteristics and general body dimension. This experiment was done to identify the size and shape of body dimension of fat-tailed sheep in Madura and Rote Islands. Data of 9 body measurements have been analysed from 136 fat-tailed sheep, 50 rams and 86 ewes. The data obtained were analyzed with Principle Component Analysis (PCA). The results showed that chest deep is a representaion of body size for fat-tailed Madura and Rote rams with correlation coefficient between body size and chest deep were 0.924 and 0.842, respectively. There is a different representation of body size for both ewes. The tail width is the representation of body size for fat-tailed Madura ewes with correlation coefficient is 0.799; in contrast, the wither height is the representation of body size for fat-tailed Rote ewes with the correlation coefficient is 0876. The representations of body shape for both fat-tailed sheep are the cranium width (for fat-tailed Madura rams and ewes and also for fat-tailed Rote ewes) and chest circumference (foe fat-tailed Rote rams). A positive correlation coefficient between cranium width and body shape representation is found (0.785; 0.785; 0.630), but the fat-tailed Rote rams have negative correlation coefficient which is -0.648. Sheep possessing greater tail length and width have smaller body shape, or vice versa. It is concluded that the body size and shape of the rams and ewes of fat-tailed Madura sheep do not differed from those of fat-tailed Rote sheep.

Key word: fat-tailed sheep, principal component analysis (PCA), body size, body shape

INTRODUCTION

Indonesian fat-tailed sheep is one of the largest population of sheep which produce meat in dry area. There are two regions having the largest population which are the Madura Island in the west part of Indonesia, and Rote Island in the east part of Indonesia. The production of meat animals is associated with the growth and development. The development pattern is useful in the assessment of confirmation. Usually the size is measured as body weight while the shape is described by several body measurement or visual appraisal. The problem of size and shape of animal is that the weight does not adequately distinguish the different in body composition. Furthermore, visual appraisal is affected by individual biases and perceptual differences among observers (Carpenter, 1979). Statistical technique with multivariate technique of principal component analysis has been used to combine weight and body measurements into indexes for defining the size and shape (Brown *et al.*, 1973; Carpenter, 1979).

The concept of principal component analysis (PCA) has received limited attention, but it can be used to evaluate variation in body shape (Brown *et al.*, 1973). MacFie (1979) used multivariate statistical techiques to quantify the differences in shape between breed. The use of PCA for analysing the size and shape in Indonesian sheep were rarely. Brown *et al.* (1973) has used the PCA of nine linier measurement and weight to elicit an objective description of different pre-yearling body shape. A similar PCA to that used by Brown *et al.* (1973) was also applied to measure the body size of Garut sheep (Erfan, 2004). The aim of the present paper is to quantify the difference in size and shape of fat-tailed sheep in Indonesia.

MATERIALS AND METHODS

Data

The data used for this study was taken from Madura island as a representative of dry area in the west part of Indonesia and Rote island as a representative of dry area in the east part of Indonesia. The total data were collected from 146 head sheep which consisted of 86 head of Madura sheep (28 rams and 58 ewes) and 50 head of Rote sheep (22 rams and 28 ewes). The fat-tailed sheep of 3 - 4 years age were considered to be mature and used in this experiment.

Body Measurement

Nine body measurements (cm) were taken and this included:body length, wither height, chest width, chest depth, chest circumference, cranium widht, cranium length, tail lenght and tail width. All measurements were taken from the left side of the sheep while standing on a flat ground in right position with paralel legs. Circumference measurements were taken by a tape, while the other measurements were taken by a specially designed caliper. The prosedure and anatomical reference point for the respective body measurements are fully describe elsewhere in Diwyatno (1984), and Salako and Ngere (2002).

Statistical Analysis

The multivariate principal component analysis was used to combine weight and body measurements of sheep into size and shape indexes. The use of the technique in the analysis of biological measurement data has been reported by Jolicoeur and Mossiman (1960). Brown *et al*. (1973) and Carpenter *et al*. (1978). The purpose of the analysis was to determine simultanously the effect of all body measurements on performance rather than to examine each one singly. The principal component transformation involves computation of the Eigen value representing the generalized variance that is explained by each component. The first principal (PC 1) component which usually accounts for the largest proportion of variance may be interpreted as a size vector, provided that all coefficient are positive. The second principal components (PC 2) and also other components with positive and negative cofficients can be considered as shape vectors. In this study the PCA was run on an ovarall correlation matrix.

Principal component analysis is a method for transforming the variables in a multivariate data set, X1. X2. X3….Xp into new variables, Y1. Y2. Y3…Yp which uncorrelated with each other and account for decreasing proportions of the total variance of the original variables defined as:

$$Yj=a_1 1X_1+a_1 2X_2+a_{13}X_3+\ldots+a1pX$$
$$Yj=a_2 1X_1+a_2 2X_2+a_{23}X_3+\ldots+a2pX$$
$$Yj=a_2 1X_1+a_2 2X_2+a_{23}X_3+\ldots+a2pX$$

with the coefficients being chosen; so that Y1. Y2. Y3…Yp are accounted for decreasing proportions of the total variance of the original variables X1. X2. X3…. Xp (Everitt *et al*. 2001) and Gaspersz (2007).

RESULTS AND DISCUSSION

Principal Component of Fat-tailed Madura and Rote Sheep

Principal component analysis show similar results for both fat-tailed sheep rams. The largest coefficient in the first principal component is found for the chest deep. The chest deep is a representation of body size for fat-tailed Madura and Rote rams with correlation coefficient between body size and chest deep were, respectively, 0.924 and 0.842. The cranium length had small similar magnitude coefficients. The PCA results for both ewes differed from those for the rams. The largest coefficient in the first principal component is the tail width for the Madura ewes and the wither height for the Rote ewes. The coefficient for the tail length is small and has similar magnitude (Tables 1 and 2). The tail width is a representation of body size for fat-tailed Madura ewes and the wither height is a reperesentation of body size for fat-tailed Rote ewes with correlation coefficient between body size and tail width for fat-tailed Madura ewes was 0.799 and correlation coefficient between body size and wither height for fat-tailed Rote ewes was 0.876.

The second principal component showed similar result for both fat-tailed Madura and Rote ewes. The cranium width has the largest coefficient. However, the chest circumference in fat-tailed Rote sheep received larger weight than cranium width.

Table 1. The first and second principal components for the rams of fat-tailed Madura and Rote sheep

Variables	Fat-tailed Madura sheep		Fat-tailed Rote sheep	
	PC 1	PC 2	PC 1	PC 2
Wither height (X_1)	0.384	-0.288	0.394	-0.134
Body length (X_2)	0.241	-0.321	0.358	-0.108
Chest width (X_3)	0.343	0.199	0.084	0.419
Chest deep (X_4)	0.394	-0.045	0.412	-0.130
Chest circumference (X_5)	0.337	-0.053	0.245	0.514
Cranium length (X_6)	0.202	0.549	0.182	-0.379
Cranium width (X_7)	0.213	0.644	0.312	-0.217
Tail length (X_8)	0.254	-0.150	0.236	0.507
Tail width (X_9)	0.361	0.010	0.303	0.213

Table 2. The first and second principal component for the ewes of fat-tailed Madura and Rote sheep

Variables	Fat-tailed Madura sheep		Fat-tailed Rote sheep	
	PC 1	PC 2	PC 1	PC 2
Wither height (X_1)	0.349	-0.128	0.493	-0.207
Body length (X_2)	0.350	-0.217	0.118	0.438
Chest width (X_3)	0.404	-0.091	0.202	-0.454
Chest deep (X_4)	0.269	-0.018	0.457	0.312
Chest circumference (X_5)	0.390	0.093	0.245	-0.172
Cranium length (X_6)	0.290	0.562	0.390	0.140
Cranium width (X_7)	0.252	0.593	0.265	0.494
Tail length (X_8)	0.205	-0.458	0.083	-0.113
Tail width (X_9)	0.430	0.204	-0.255	0.394

Table 3. Eigen values and cumulative proportion of variance for the rams of fat-tailed Madura and Rote sheep

Variables	Fat-tailed Madura		Fat-tailed Rote	
	Eigen value	Cumulative	Eigen value	Cumulative
PC 1	5.504	0.552	4.180	0.418
PC 2	1.514	0.702	1.595	0.578
PC 3	1.108	0.813	1.108	0.688
PC 4	0.630	0.876	1.056	0.794
PC 5	0.445	0.920	0.720	0.866
PC 6	0.288	0.949	0.515	0.918
PC 7	0.224	0.972	0.407	0.958
PC 8	0.169	0.989	0.214	0.980
PC 9	0.060	0.995	0.149	0.995
PC 10	0.053	1.000	0.050	1.00

In morfometric applications of the PCA, the first component is acceptable as size vector and the second one as shape vector (Hayasi *et al.*, 1982). The first component accounted for about 55 % for the rams of fat-tailed Madura and Rote sheep with 41 % of generalized variance and the first eight principal components are required to reach 99% of the variance. In the ewes, the first compo nent accounted for about 38 % for the ewes of fat-tailed Madura and Rote sheep and 35 % of generalized variance and the first eight principal components were required to reach 99% of the variance. Most of Eigen vectors have positive values indicating that these components may be acceptable as size vector (Table 3 and 4).

Table 4. Eigenvalues and cumulative proportion of variance for the ewes of fat-tailed Madura and Rote sheep

Variables	Fat-tailed Madura		Fat-tailed Rote	
	Eigen value	Cumulative	Eigen value	Cumulative
PC 1	3.461	0.385	3.162	0.351
PC 2	1.755	0.580	1.629	0.533
PC 3	1.040	0.695	1.191	0.665
PC 4	0.899	0.794	0.819	0.756
PC 5	0.724	0.875	0.708	0.835
PC 6	0.516	0.932	0.521	0.893
PC 7	0.252	0.960	0.421	0.939
PC 8	0.211	0.984	0.384	0.982
PC 9	0.148	1.000	0.160	1.000
PC 10				

The PCA has made it possible of ranking the strains on the basis of their size. The first principal component for the two difference region and sexes clearly indicated that the strains could be divided into three body measurements. The chest deep, tail width, and wither height can be used to quantify differences in the size of fat-tailed sheep. The largest in the second principal component is different for the fat-tailed Rote sheep. The largest coefficient in fat-tailed Rote rams and ewes is tail length. The largest coefficient in the second principal component is found for the cranium width (x7) in fat-tailed Madura rams dan Madura ewes, and also in fat-tailed Rote ewes with correlation coefficient between body shape and cranium width for them were 0.785; 0.785 and -0.648, respectively. The largest coefficient in the second principal component is found for the chest circumference in fat-tailed Rote rams with correlation coefficient between body shape and chest circumference was -0.648.

The coefficients for PC1 are all positive indicating that the first component contrasted the animals based on the overall size (Mc Curley *et al*., 1981). PC1 is interpreted as a measure of general size (Carpenter *et al*., 1971). PC 2 is composed of some positive and negative coefficients for body measurements. These components are interpreted as contrasting the animals based on their body shape arraying them from those that are short in stature and fat to those that are tall and thin. Weight received little emphasis. In bulls, a large positive PC2 value would typify the more compress bull and a large negative PC2 value would represent a more rany type of bull (Brown *et al*., 1973).

These results show the important biological underlying the phenotypic relationships for many traits that are important for breeding program. The PCA can be used for all functional traits and can be useful in both dimension reduction and avoiding co-linearity problems that is common in the analysis of closely related functional trait such as body measurements or fertility (Karacoeren *et al*., 2006).

Principal component of chart of fat-tailed Madura and Rote sheep

The principal component chart (Figure 1.) shows overlapping of the groups of ram from fat-tailed Madura and Rote sheep. It is also clear that there is no difference observed in PC1 (size) and PC 2 (shape) between these two groups. No significant difference is also found in PC1 and PC2 between the ewes of fat-tailed Madura and Rote sheep. This result indicates that the fat-tailed Madura sheep is not distinguishable from that of fat-tailed Rote sheep by the external morphological character such as wool colour, shape, and body size etc., the two subspecies are similar to the common species peculiarity in its body conformation.

Body size and shape of fat-tailed Madura rams and ewes did not differ from those of Rote rams and ewes which are shown by the overlapping distribution. These can be due to genetic and environment factors that are almost the same in both regions. The Madura and Rote islands have the same environment as the majority of dry areas. Body size (size) is more influenced by the environment (Everitt and Dunn, 1999).

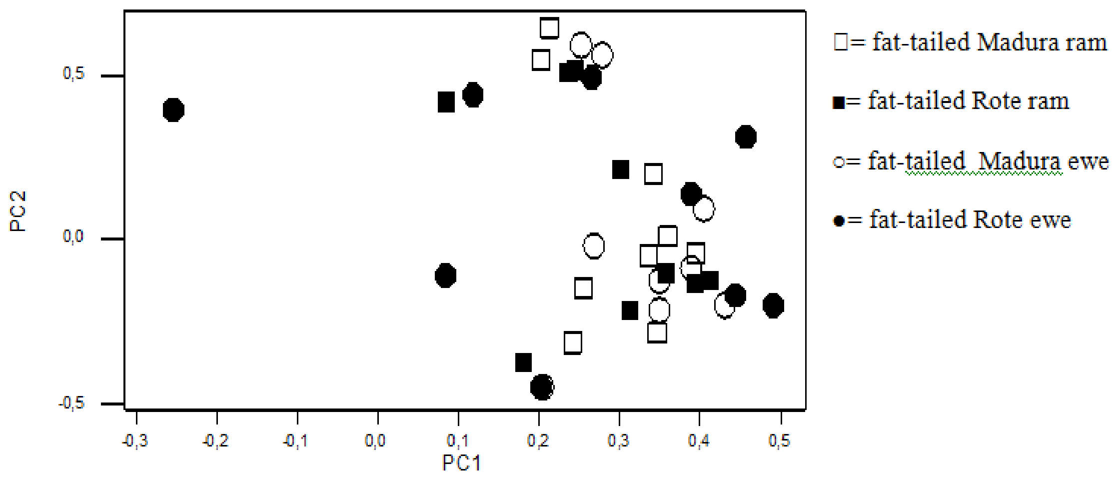

Figure 1. The Principal Component Chart of the First Two Transformed Variable Derived from the Covariance Matrix of Body Measurements Fat-Tailed Sheep Madura and Rote

On the other hand, the genetic factor shows a similarity between fat-tail Madura rams to that of Rote rams. The body shape is better todescribe the potential of animal genetic compared to the body size that is more influenced by the environment (Everitt and Dunn, 1999). A previous study reported that the fat-tailed Rote ram is predicted from the same breed as the rams that were imported from East Java (Madura); these imported rams were used to maintain the local ewe in dry area in Rote island (Gunawan *et al.*, 2007). The animal performance is an expression of genetic and environmental factors (Martojo, 1992).

CONCLUSIONS

The chest deep is a representation of body size for fat-tailed Madura and Rote rams with correlation coefficient between body size and chest deep were, respectively, 0.924 and 0.842. Both fat-tailed ewes differed in the representation of body size. The tail width is the representation of body size for fat-tailed Madura ewes with correlation coefficient is 0.799; in contrast, the wither height is the representation of body size for fat-tailed Rote ewes with the correlation coefficient is 0876. The representation of body shape for both fat-tailed sheep was the cranium width (for fat-tailed Madura rams and ewes and also for fat-tailed Rote ewes) and chest circumference (foe fat-tailed Rote rams). A positive correlation coefficient between cranium width and body shape representation is found (0.785; 0.785; 0.630), but the fat-tailed Rote rams have negative correlation coefficient which is 0.648. Sheep possessing greater tail length and width have smaller body shape, or vice versa. It is concluded that the body size and shape of the rams and ewes of fat-tailed Madura sheep do not differed from those of fat-tailed Rote sheep.

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