Differentiation of three sheep breeds which have a genetic relationship by body sizes

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Abstract. Sumatera Composite (SC) sheep and Barbados Black Belly cross (BC) sheep are two sheep that have half the genetics of Sumatera local (SL) sheep. Populations with partially the same genetic composition are sometimes difficult to distinguish. Based on female body size sheep, an analysis was carried out to distinguish the three breed sheep that have genetic relationship. The research was conducted using SC, BC and SL ewe measured in body weight and 8 body sizes. Analysis of variance and canonical discriminant analysis, Mahalanobis distance, plotting canonical and dendogram were performed by SAS software ver. 9.0. Body weight and all body sizes of SC and BC sheep were significantly different from SL sheep. Canonical discriminant analysis successfully could differentiate among the three sheep breeds that have genetic relationship. The results of genetic distance estimation showed that SC sheep had genetic closeness to BC sheep compared to SL sheep. The size of the skull length, body weight and chest girth were the breed differentiation variable in this study.

1 Introduction

Term of breed is defined as "a subspecific group of domestic livestock with definable and identifiable external characteristics that enable it to be separated by visual appraisal from other similarly defined groups within the same species, or a group for which geographical and/or cultural separation from phenotypically similar groups has led to acceptance of its separate identity" [1]. The term "breed" as "a group of animals selected by man to have a uniform appearance that distinguishes them from other members of the same species" [2]. From the definitions, we have the fact in common that a breed is a subspecific group of domestic livestock that share definable phenotypes and/or characteristics.

Each member of a breed has a very high similarity with each other in terms of phenotypes because of the genetic similarity possessed by each individual. Genetic similarity within breeds can be due to natural selection or artificial selection by humans for specific purposes. Each breed has inter-individual diversity within that breed with different degrees of variation from one breed to another. Based on the genetic diversity of each individual in a breed, it is possible to estimate the genetic distance between one breed and another.

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Genetic distance is a measure of genetic differences between two different populations or closely related species, and it is generally computed by using allele frequency data from many different loci of the two populations [3]. Genetic distance between breeds can also be estimated based on the phenotype of the breed. Some methods have been reported used in estimating genetic distance in sheep, both based on genetic characteristics and phenotypes, for example based on microsatellite DNA marker [4, 5], RAPD (Random amplified polymorphic DNA) markers [6, 7], mitochondrial DNA sequencing [8, 9], blood protein types [10, 11], body measurements [12], behaviour characteristic [13], voice characteristics [14].

Multivariate analysis has been carried out by Handiwirawan et al.[15] and succeeded in distinguishing five sheep breeds that have genetic relationship. In this study, three breeds of sheep were used, all of which were genetically related. The aim of this study was to differentiate and estimate genetic distance based on body sizes among three sheep breeds that have a genetic relationships.

2 Materials and methods

Three breeds of sheep were used in this study, namely Sumatera Composite (SC), Barbados Black Belly cross (BC), and Sumatera local (SL) sheep. SC sheep has a genetic composition of 50% SL, 25% Barbados and 25% St. Croix sheep, while BC sheep have a genetic composition of 50% SL and 50% Barbados sheep while SL sheep are 100% Sumatera local sheep. A total of 197 ewe were observed consisting of 70, 39 and 88 ewe for SC, BC and SL sheep, respectively, which more than 1 years old. Measurements were not conducted in the pregnant sheep to eliminate the influence of several body sizes.

Phenotype characterization of every sheep breed was observed following the method of Handiwirawan *et al.* [16]. Body weight (BW), and eight body sizes were observed from several parts of the body of the sheep, namely skull length (SKLLGT), ear length (EARLGT), wither height (WITHGT), body length (BDYLGT), chest girth (CHEGRT), chest depth (CHEDPT), hip height (HIPHGT), tail length (TAILGT).

PROC GLM SAS software ver. 9.0 was used for analysis of variance of quantitative traits and significance test was conducted to compare quantitative traits between sheep breed [17]. Linear model used was:

$$Y_{ij} = \mu + B_i + \varepsilon_{ij}$$

where:
Y_{ij} = Body weight/size
μ = Population mean
B_i = Effect of i-th sheep breed (i= 1, 2, 3)
ε_{ij} = Random effect

SAS software ver. 9.0 was used to perform canonical discriminant analysis to calculate the Mahalanobis distance, canonical coefficient and give a visual interpretation of the differences in sheep [17]. Based on the Mahalanobis distance matrix, performed a hierarchical clustering, and then the dendogram for the three sheep breeds was created [17, 18].

3 Results and discussion

Body weight and eight body sizes of BC, SC and SL sheep are presented in Table 1. Body weight of SC and BC sheep were not significantly different, but the two breeds of sheep were significantly different from SL sheep. It has been reported by Subandriyo *et al.* [19] that the body weight of SL sheep is smaller than that of SC and BC sheep so that to increase their

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productivity, crosses have been carried out with St. Croix and Barbados Black Belly sheep. The cross of SL sheep has produced SC and BC sheep with better productivity.

Table 1. Least squares means of body sizes of Sumatera Composite (SC), Barbados Black Belly cross (BC), and Sumatera local (SL) sheep.

Body measurements	Breed of sheep		
	SC	BC	SL
BW (kg)	$26.29^{a}\pm0.62$	$25.09^{a}\pm0.80$	$17.06^{b}\pm0.54$
SKLLGT (cm)	$20.52^{a}\pm0.29$	$18.83^{b}\pm0.37$	$14.78^{c}\pm0.25$
EARLGT (cm)	$11.88^{a}\pm0.28$	$11.08^{a}\pm0.36$	$10.18^{b}\pm0.24$
WITHGT (cm)	$61.57^{a}\pm0.65$	$58.38^{b}\pm0.85$	$54.67^{c}\pm0.57$
BDYLGT (cm)	$55.82^{a}\pm0.91$	$53.45^{a}\pm1.18$	$49.32^{b}\pm0.80$
CHEGRT (cm)	$71.00^{a}\pm0.89$	$71.05^{a}\pm1.16$	$61.80^{b}\pm0.78$
CHEDPT (cm)	$26.19^{a}\pm0.49$	$24.90^{a}\pm0.64$	$22.97^{b}\pm0.43$
HIPHGT (cm)	$60.47^{a}\pm0.59$	$58.53^{b}\pm0.78$	$53.99^{c}\pm0.52$
TAILGT (cm)	$18.75^{a}\pm0.48$	$19.60^{a}\pm0.63$	$14.51^{b}\pm0.42$

Different superscript on the same row indicates significant different ($P < 0.05$)
BW = body weight, SKLLGT = skull length, EARLGT = ear length, WITHGT = wither height, BDYLGT = body length, CHEGRT = chest girth, CHEDPT = chest depth, HIPHGT = hip height, TAILGT = tail length

SL sheep are the smallest sheep compared to SC and BC sheep. It can be seen that the entire body size of SL sheep is smaller than the other two sheep families. Meanwhile, body weight and almost all sizes of SC and BC sheep were not significantly different except for the sizes of SKLLGT, WITHGT, and HIPHGT.SC sheep have larger SKLLGT, WITHGT and HIPHGT sizes than BC sheep, so the three body sizes differ between the three breeds. Jashari et al. [20] reported that the structure of the skull is a unique feature of each animal, allowing for the distinguishment of not only species and breeds, but also individuals. Even sexual dimorphism is strongly manifested in the skeleton of the head of ruminants [21].

Several body sizes in this study have a strong influence on typical sheep breeds. SKLLGT (0.950420), BB (0.779536) and TAILGT (0.754495) are body measurements that has a relatively high value and the differentiating variable for the breed of sheep. The differentiating variable obtained in studies may differ depending on the sheep used in research. For example in the study reported by Handiwirawan *et al*. [15] that the variables tail width, horn base circumference, horn length, tail length, and body length were differentiating variables for sheep breeds.

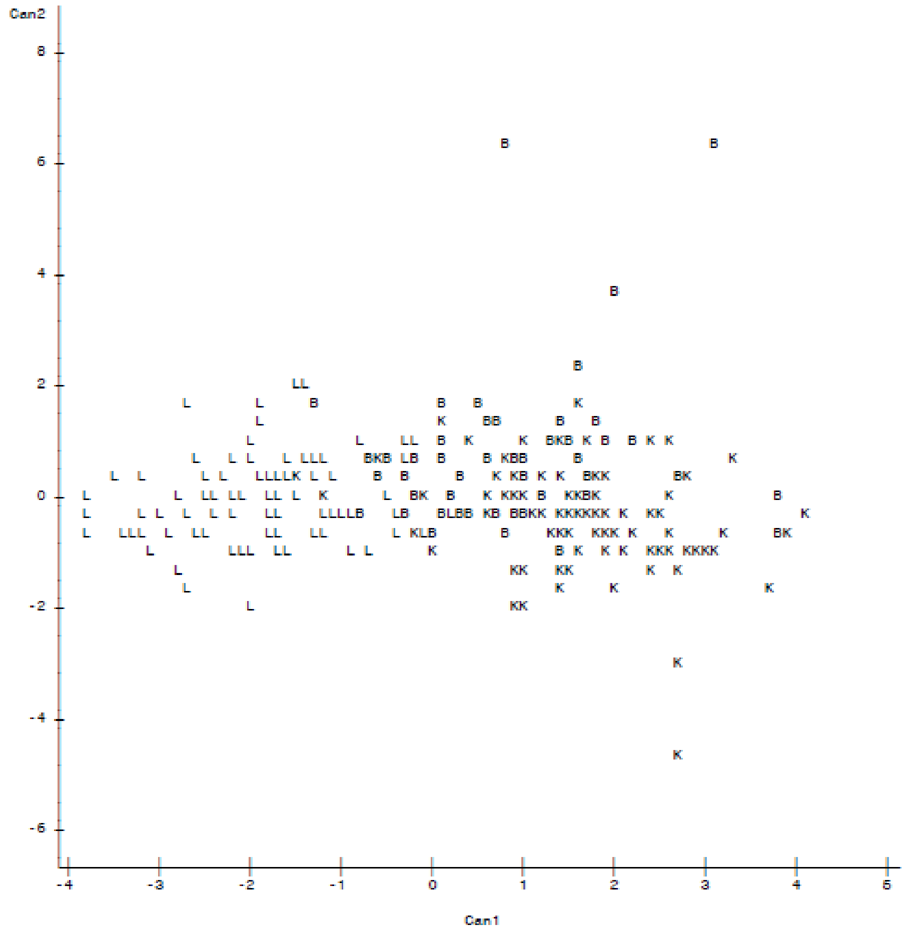

Fig. 1. Canonical plotting that describes sheep breed grouping based on body sizes (symbol of K=SC, B=BC, L=SL).

The canonical plots of the three sheep breeds depicted as clusters or subgroups are presented in Figure 1. Each breed is represented by a letter symbol, namely K for SC sheep, B for BC sheep, and L for SL sheep. It can be seen in the figure that based on body weight and body size, SL sheep are a separate cluster or subgroup of sheep breeds from the other two breeds of sheep. On the other hand, SC and BC sheep are described as occupying the same cluster or subgroup (regions with overlapping symbols). This means that SC and BC sheep cannot be distinguished based on cluster analysis and this is in accordance with the results of the analysis of variance which found that almost all the body sizes of the two sheep were not significantly different. By using discriminant analysis, Dauda et al. [22] can differentiate between several breed sheep in Nigeria, and Hayanti et al. [23] can also distinguish the origin of Bali cattle in the Jambi province of Indonesia. Discriminant analisys can also as a tool to identify bovine and ovine meat produced from pasture or stall-fed animals [24]. Based on body size, the results obtained depend on the breed used and genetic similarity.

The results of the discriminant analysis get the Mahalanobis distance value between the three breeds of sheep as shown in Table 2 and then the results of Hierarchical Clustering are depicted in a dendogram as shown in Figure 2. The probability value of the distance between the three sheep breeds is very significant as shown in Table 2, which means that the three breeds are separate sheep clusters. The distance values between breeds as presented in Table 2 are 1.54471 between SC and BC sheep, 8.58460 between SL and BC sheep, and 12.35242 between SC and SL sheep.

Table 2. Mahalanobis distance value and probability of significance between three sheep breeds.

Breeds of sheep	SC	BC	SL
SC	0	1.54471	12.35242
BC	<.0001	0	8.58460
SL	<.0001	<.0001	0

Value on above of the diagonal shows the value of Mahalanobis distance
Values on the below of the diagonal shows the probability of significance of Mahalanobis distance

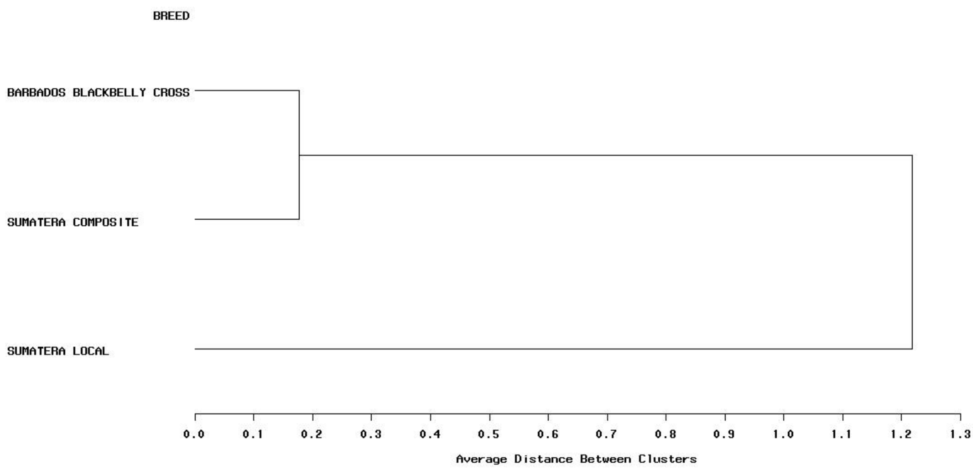

Fig. 2. Dendogram based on the Mahalanobis distance of the Sumatera Composite (SC), Barbados Black Belly cross (BC) and Sumatera local (SL) sheep.

The distance value is visually depicted as well as the dendogram in Figure 2. In Figure 2 it can be seen that the BC sheep breed is closer to SC sheep than SL sheep. These results are in accordance with the genetic composition of each breed due to the crossing-program carried out to form SC and BC sheep.SC sheep have a genetic composition of 50% SL, 25% BC and 25% St. Croix sheep, meanwhile BC sheep consist of 50% SL and 50% Barbados Black Belly and SL sheep are 100% pure Sumatera local sheep. Looking at the genetic composition of the three sheep breeds, it can be explained that SC and BC sheep have a higher genetic similarity than SL sheep because of the genetic contribution of Barbados Black Belly sheep and SL sheep.

4 Conclusion

Discriminant canonical analysis based on data from body weight and eight body measurements could differentiate among the sheep of Sumatera Composite, Barbados Black Belly cross, Sumatera local sheep. Mahalonobis and Hierarchical clustering were shown that Sumatera Composite, and Barbados Black Belly cross sheep closer than Sumatera local sheep. The variable of skull length, body weight and tail length are a differentiator variable of sheep breeds.

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References

1. S. Galal, Small Ruminant Research **60**, 75 (2005)
2. S. J. G. Hall and D. G. Bradley, Trends in Ecology & Evolution **10**, 267 (1995)
3. M. Nei, in *Brenner's Encyclopedia of Genetics*, edited by S. Maloy and K. Hughes (Academic Press, New York, 2013), pp. 248–250
4. R. M. Al-Atiyat, N. M. Salameh, and M. J. Tabbaa, Electronic Journal of Biotechnology **17**, 168 (2014)
5. C. Sumantri, A. Faradjallah, and U. Fauzi, in *Proceeding of the 4th International Seminar on Tropical Animal Production* (Faculty of Animal Science, Universitas Gadjah Mada and Indonesian Society for Sustainable Tropical Animal Production (ISTAP), Yogyakarta, 2006), pp. 25–32
6. Z. S. Al-Allak, M. A. Dragh, and A. S. Hussain, Basrah Journal of Veterinary Research **19**, 147 (2020)
7. D. N. Hatkar, L. L. L. Prince, A. R. Sirothia, and C. Paswan, Journal of Applied Animal Research **38**, 129 (2010)
8. A. Ibrahim, I. G. S. Budisatria, R. Widayanti, and W. T. Artama, Veterinary World **13**, 2625 (2020)
9. J. Liu, X. Ding, Y. Zeng, Y. Yue, X. Guo, T. Guo, M. Chu, F. Wang, J. Han, R. Feng, X. Sun, C. Niu, B. Yang, J. Guo, and C. Yuan, PLoS ONE **11**, 1 (2016)
10. M. Ozdemir, O. C. Bilgin, and N. Esenbuga, The Journal of Animal & Plant Sciences **21**, 459 (2011)
11. C. Manwell and C. M. Ann Baker, Genetical Research **29**, 239 (1977)
12. Depison, W. P. B. Putra, Gushairiyanto, Y. Alwi, and H. Suryani, Tropical Animal Science Journal **44**, 386 (2021)
13. E. Handiwirawan, R. R. Noor, C. Sumantri, and Subandriyo, Indonesian Journal of Animal and Veterinary Sciences **19**, 239 (2014)
14. E. Handiwirawan, R. R. Noor, C. Sumantri, and Subandriyo, Indonesian Journal of Animal and Vtererinary Sciences **20**, 257 (2015)
15. E. Handiwirawan, R. R. Noor, C. Sumantri, and S. Subandriyo, Journal of the Indonesian Tropical Animal Agriculture **36**, 1 (2011)
16. E. Handiwirawan, S. A. Asmarasari, and B. Setiadi, *Goat and Sheep Characteristics Guide (in Indonesia)* (Indonesian Center for Animal Research and Development, Bogor, 2007)
17. SAS, *SAS/STAT User's Guide Release 9.0 Edition* (SAS Institute Inc., Cary, North Carolina, 2002)
18. M. Herrera, E. Rodero, M. J. Gutierrez, F. Peña, and J. M. Rodero, Small Ruminant Research **22**, 39 (1996)
19. Subandriyo, B. Setiadi, E. Handiwirawan, M. Doloksaribu, E. Romjali, and K. Diwyanto, in *Proceeding of the 2nd International Seminar on Tropical Animal Production* (Faculty of Animal Science, Universitas Gadjah Mada and Indonesian

Society for Sustainable Tropical Animal Production (ISTAP), Yogyakarta, 1998), pp. 63–69

20. T. Jashari, S. Duro, O. Gündemir, T. Szara, V. Ilieski, D. Mamuti, and O. P. Choudhary, Biologia **77**, 423 (2022)
21. F. Kobryńczuk, M. Krasińska, and T. Szara, Annales Zoologici Fennici **45**, 341 (2008)
22. A. Dauda, H. Y. Abbaya, and V. N. Ebegbulem, Journal of Genetics and Genetic Engineering **2**, 11 (2018)
23. S. Y. Hayanti, E. Handiwirawan, Zubir, Bustami, and E. Susilawati, Indian Journal of Animal Research **56**, 1041 (2022)
24. M. Acciaro, M. Decandia, M. Sitzia, C. Manca, V. Giovanetti, A. Cabiddu, M. Addis, S. P. G. Rassu, G. Molle, and C. Dimauro, Italian Journal of Animal Science **19**, 1065 (2020)