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Qualitative Morphological Characterization of Male Indonesian Local Sheep Breeds on Java Island, Indonesia

Alek Ibrahim[1,3], I Gede Suparta Budisatria[1], Endang Baliarti[1], Aprilianna Putri Zahara Nafsina Luvita Sari[1], Wayan Tunas Artama[2], Rini Widayanti[2], Endang Tri Margawati[3], Amaq Fadholly[3], Bayu Andri Atmoko[4]

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ABSTRACT

Background: Sheep is one of the small ruminant types widely distributed and popular in Indonesia, especially on Java Island. This study aimed to characterize male Indonesian local sheep breeds on Java Island based on their qualitative morphological traits.

Methods: This study identified twenty-nine qualitative morphological characteristics in 627 head sheep consisting of Priangan, Garut, Batur, Wonosobo, Javanese Thin Tailed (JTT), Javanese Fat-Tailed (JFT) and Sapudi sheep. Data were analyzed using descriptive analysis, Chi-square analysis (X^2), multiple correspondence analysis (MCA) and hierarchical clustering analysis (HCA). Data analysis was performed using SPSS version 25 and NTSYS-pc version 2.11.

Result: All the qualitative morphological traits variables were significantly different ($P<0.01$) between the seven sheep breeds. Seven sheep breeds could be categorized into three groups: 1) JFT and Sapudi sheep; 2) JTT, Priangan and Garut sheep; and 3) Batur and Wonosobo sheep. The Garut and Batur sheep have the most distant relationship (26.781). The JFT and Sapudi sheep have the closest relationship (1.345), as well as between Batur and Wonosobo sheep (10.064) and between Priangan and JTT sheep (2.453). Garut sheep have the most distant relationship with other sheep breeds, except with Priangan (4.259) and JTT (8.157) sheep. It was concluded that male Indonesian local sheep breeds on Java Island could be characterized using qualitative morphological traits.

Key words: Exterior characteristics, Indigenous sheep, Multiple correspondence analysis, Phenotypic characteristics, Qualitative traits.

INTRODUCTION

Sheep is one of the popular and widely-distributed small ruminants in Indonesia. This livestock has a high economic value, is adapted to Indonesia's topography, is easy to raise and has a strategic position in the community, especially for the local sheep breeds. Besides that, they can also be a unique genetic source in a specific area (Ibrahim *et al.*, 2020; Ibrahim *et al.*, 2021). Genetic resources are substances contained in individuals of the livestock breeds population that are genetically unique and can be utilized and developed to form superior breeds or strains (Ministry of Agriculture, 2006). Until 2021, the Republic of Indonesia Government has determined ten Indonesian local sheep breeds/strains through a Decree of the Ministry of Agriculture of the Republic of Indonesia. The ten Indonesian local sheep are Garut, Wonosobo, Batur, Sapudi, Palu, Kisar, Priangan, Compass Agrinak, Bahtera Agrinak and Komposit Garut Agrinak sheep.

The genetic resources of local sheep in Indonesia have their physical characteristics and adaptability to tropical environments that vary according to the origin place and the development areas (Ibrahim *et al.*, 2020). The morphological traits diversity can occur due to mutation processes due to selection, crossbreeding and natural disasters that can result in the loss or drift of specific genes (Hill and Mackay, 2004). The implementation is that the process affects the genetic level, which is actualized into quantitative and qualitative morphological traits (Koseniuk and Slota, 2016; Widayanti *et al.*, 2022).

[1]Department of Animal Production, Faculty of Animal Science, Universitas Gadjah Mada, Jl.Fauna No.3, Karangmalang, Yogyakarta-55281, Indonesia.

[2]Department of Biochemistry and Molecular Biology, Faculty of Veterinary Medicine, Universitas Gadjah Mada, Jl.Fauna No.2, Karangmalang, Yogyakarta-55281, Indonesia.

[3]Research Center for Applied Zoology, National Research and Innovation Agency (BRIN), Jl.Raya Bogor Km.46, Cibinong-16911, West Java, Indonesia.

[4]Research Center for Animal Husbandry, National Research and Innovation Agency (BRIN), Jl.Raya Bogor Km.46, Cibinong-16911, West Java, Indonesia.

Corresponding Author: Alek Ibrahim, Department of Animal Production, Faculty of Animal Science, Universitas Gadjah Mada, Jl.Fauna No.3, Karangmalang, Yogyakarta-55281, Indonesia. Email: alek.ibrahim@mail.ugm.ac.id

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Characterization and inventory of genetic resources is the first step in implementing genetic improvement strategies (Budisatria *et al.*, 2022; Ibrahim *et al.*, 2022). Identifying qualitative and quantitative characteristics in sheep can help sheep characterize and see the resulting expression of these sheep's rearing and developing process. This study aimed

to characterize seven male Indonesian local sheep breeds on Java Island based on their qualitative morphological characteristics. The results of this study were expected to provide information related to the profile of Indonesian local sheep breeds on Java Island and can help develop knowledge regarding Indonesian local sheep breeds.

MATERIALS AND METHODS

Research sites and animals

This study has obtained permission and approval based on the Ethical Clearance Certificate of the Faculty of Veterinary Medicine Research Ethics Commission, Universitas Gadjah Mada (no. 002/EC-FKH/Int./2019). Samples were taken by purposive sampling by determining the sheep origin or development areas that widely raised the sheep by farmers according to the specified breed. Sheep kept by smallholders and/or halls were identified with qualitative morphological characteristics. The samples were collected from 2019 to 2021. However, this study was conducted in October-December 2021 in the Laboratory of Meat, Drought and Companion Animals, Universitas Gadjah Mada.

A total of 627 rams from seven Indonesian local sheep breeds were observed for their qualitative morphological characteristics. Observations were conducted in the local sheep development areas (Fig 1), namely Priangan sheep (40 heads) and Garut sheep (190 heads) in Garut and Indramayu Regencies, Batur sheep (119 heads) in Banjarnegara Regency, Wonosobo sheep (76 heads) in Wonosobo Regency, Javanese Thin-Tailed (JTT) sheep (59 heads) in Bantul and Sleman Regencies, Javanese Fat-Tailed (JFT) sheep (112 heads) in Pasuruan and Sleman Regencies and Sapudi sheep (31 heads) in Jember Regency (UPT Pembibitan Ternak dan Hijauan Makanan Ternak). The sampling sites are shown in Fig 1 and an example of the male Indonesian local sheep phenotypic in this study is shown in Fig 2.

Identification of animals

Data were collected by identifying the qualitative morphological characteristics of the sheep samples. The data observed in this study refers to the FAO (2012) guidelines plus several variables that can be used to characterize Indonesian local sheep breeds on Java Island. The qualitative morphological characteristics data observed included hair and body-color characteristics, head and neck characteristics and body and tail characteristics, which consisted of twenty-nine variables. Qualitative data is filled in on the sheet provided and then tabulated and converted to categorical values to facilitate analysis.

Hair and body color characteristics includes: Fiber type (1a:hair, 1b:coarse wool, 1c:medium wool and 1d:fine wool), hair length (2a:medium hair and 2b:long hair), hair shape (3a:straight/smooth and 3b:dreadlocks), body skin color (4a:pigmented and 4b:not pigmented), body hair coat color pattern (5a:plain, 5b:patchy/pied and 5c:spotted), body hair coat color (6a:white chalk, 6b:off-white, 6c:pale yellow, 6d:black, 6e:brown, 6f:white dominant, 6g:black dominant and 6h:brown dominant), head hair coat color (7a:white chalk, 7b:off-white, 7c:pale yellow, 7d:black, 7e:brown, 7f:white+black, 7g:white+brown, 7h:black+white, 7i:black+brown, 7j:brown+white, 7k:brown+black and 7l:mixed), neck hair coat color (8a:white chalk, 8b:off-white, 8c:pale yellow, 8d:black, 8e:brown, 8f:white+black, 8g:white+brown, 8h:black+white, 8i:black+brown, 8j:brown+white, 8k:brown+black and 8l:mixed), torso hair coat color (9a:white chalk, 9b:off-white, 9c:pale yellow, 9d:black, 9e:brown, 9f:white+black, 9g:white+brown, 9h:black+white, 9i:black+brown, 9j:brown+white, 9k:brown+black and 9l:mixed), leg hair coat color (10a:white chalk, 10b:off-white, 10c:pale yellow, 10d:black, 10e:brown, 10f:white+black, 10g:white+brown, 10h:black+white, 10i:black+brown, 10j:brown+white, 10k:brown+black and 10l:mixed) and tail hair coat color (11a:white chalk, 11b:off-white, 11c:pale yellow, 11d:black, 11e:brown, 11f:white+black, 11g:white+brown, 11h:black+white, 11i:black+brown, 11j:brown+white, 11k:brown+black and 11l:mixed).

Head and neck characteristics includes: Facial (head) profile (12a:straight, 12b:concave, 12c:convex), facial wool/face cover (13a:absent and 13b:present), eye circumference

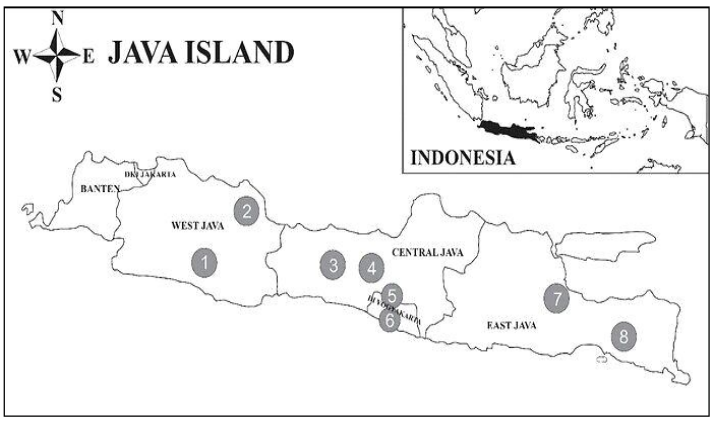

Fig 1: Sampling sites of Indonesian local sheep breeds on Java Island, Indonesia. 1: Garut, 2: Indramayu, 3: Banjarnegara, 4: Wonosobo, 5: Sleman, 6: Bantul, 7: Pasuruan and 8: Jember Regencies.

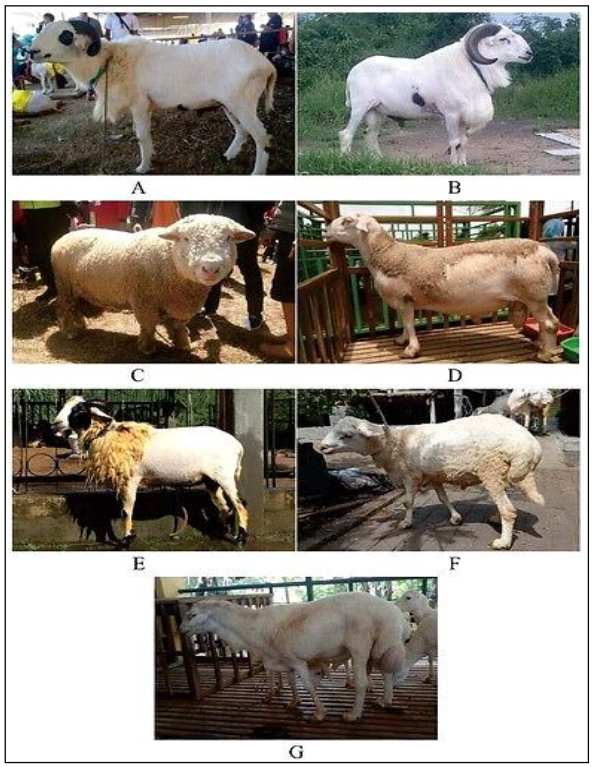

Fig 2: An example's photographs of the Indonesian local sheep breeds. A: Priangan, B: Garut, C: Batur, D: Wonosobo, E: Javanese Thin-Tailed, F: Javanese Fat-Tailed, G: Sapudi sheep.

color pattern (14a:absent and 14b:present), horn presence (15a:absent and 15b:present), horn size (16a:absent, 16b:small, 16c:medium and 16d:large), horn shape (17a:polled, 17b:scurs/stumps, 17c:straight, 17d:curved, 17e:spiral, 17f:corkscrew and 17g:multi horns), horn orientation (18a:polled, 18b:stumps, 18c:lateral, 18d:upward, 18e:backward, 18f:forward, 18g:downward and 18h:asymmetric), horn color (19a:absent, 19b:light color, 19c:dark color and 19d:mixed color), ear shape (20a:gopher, 20b:elf and 20c:natural), ear orientation (21a:erect, 21b:semi-pendulous, 21c:pendulous and 21d:carried horizontally) and ruff (22a:absent and 22b:present).

Body and tail characteristics includes: Back profile (23a:straight, 23b:slopes up towards the rump, 23c:slopes down from withers and 23d:dipped/curved), rump profile (24a:flat,24b:sloping and 24c:roofy), tail type (25a:thin, 25b:fat rump, 26c:thick at base and 26d:fat), tail shape (26a:cylindrical and straight, 26b:cylindrical and turned up at end, 26c:broad without lobe, 26d:bi-lobbed with appendage, 26e:bi-lobbed without appendage and 26f:long fat tail), tail orientation (27a:straight, 27b:curved and 27c:sigmoid), tail length (28a:short tail and 28b:long tail) and tail size (base-mid-end: 29a:small-small-small, 29b:medium-small-small, 29c:medium-medium-small, 29d:large-medium-small and 29e:large-large-small).

Data analysis

Data was analyzed by using descriptive analysis (percentage). The effect of qualitative morphological

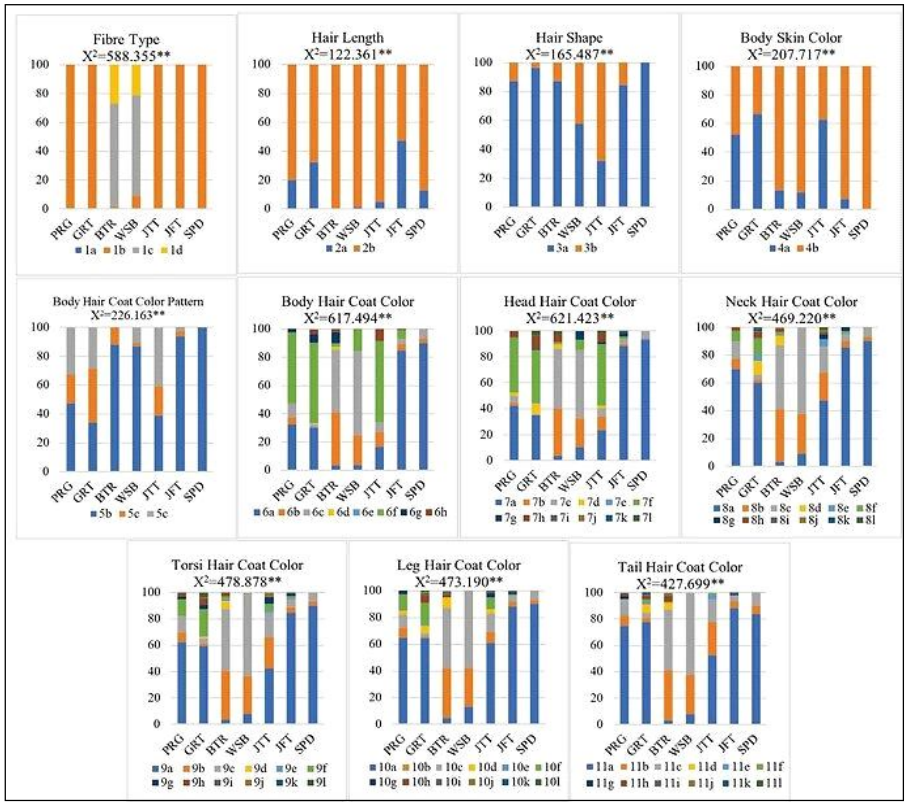

Fig 3: Hair and body coat color characteristics of male Indonesian local sheep breeds. **P<0.01.

characteristics variables on male Indonesian local sheep breeds was analyzed by Chi-square analysis (X^2). Multiple correspondence analysis (MCA) was performed to determine the relationship between variables and determine which characters influenced each sheep breed's characteristics by constructing a typological plot. Hierarchical clustering analysis (HCA) was performed to determine the dissimilarity matrix using the squared-Euclidean distance method and build a dendrogram. Descriptive analysis, Chi-square analysis, MCA and HCA were performed using the SPSS version 25 software (IBM, USA), while the dendrogram was constructed using the NTSYS-pc version 2.11 software (Rohfl, 2009).

RESULTS AND DISCUSSION

Qualitative morphological traits

Male local sheep in different breeds had different hair and body color characteristics (P<0.01) concerning the observed variables (Fig 3). The head and neck characteristics of the local sheep in this study differed significantly (P<0.01) between breeds of sheep (Fig 4). Overall, the local sheep had a different body and tail characteristics between breeds (P<0.01) (Fig 5). Body exterior character is a qualitative phenotypic character that can classify livestock into specific groups. In addition to qualitative phenotypic traits, it is also

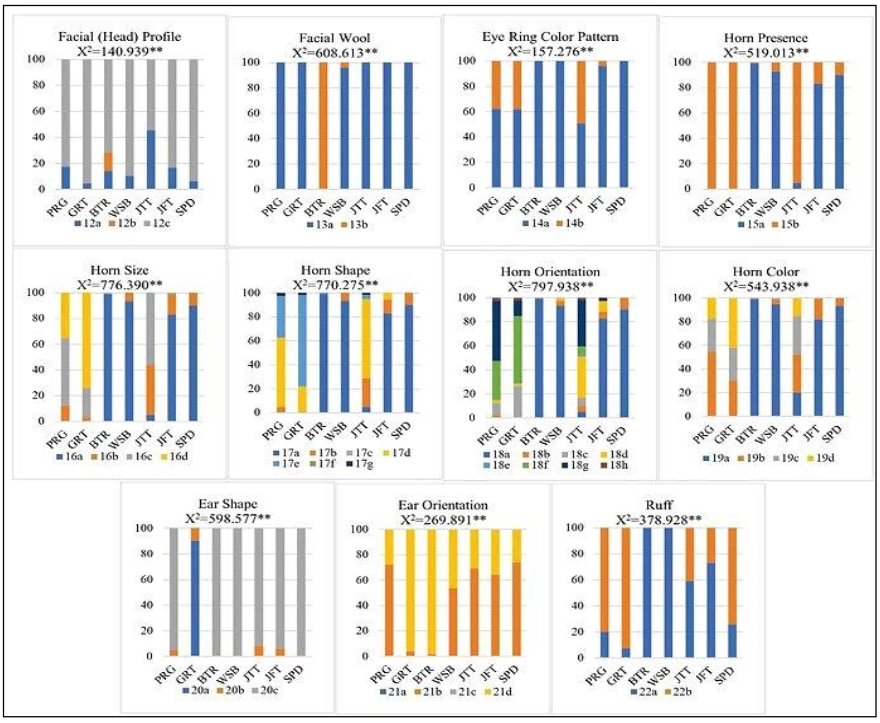

Fig 4: Head and neck characteristics of male Indonesian local sheep breeds. **P<0.01.

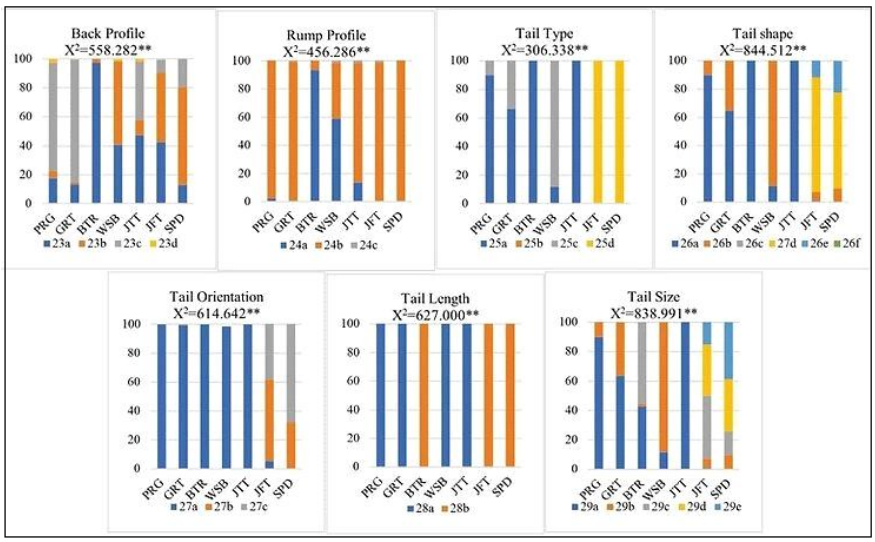

Fig 5: Torso and tail characteristics of male Indonesian local sheep breeds. **P<0.01.

necessary to conduct studies related to its quantitative phenotypic and genetic characteristics to classify livestock and determine the characteristics of livestock type. Qualitative and quantitative morphological traits can describe the characteristics of a breed. These characteristics can be influenced by different genetic, environmental and rearing management (Sumantri *et al.*, 2007; Wibowo *et al.*, 2021).

Typology of qualitative morphological characteristics

Discrimination measures variables in the MCA are presented in Table 1 and the representation of each variable is presented in Fig 6. The discriminant relationship of each variable to the two dimensions is shown in Fig 7. The distribution of individual Indonesian local sheep is presented in Fig 8 and the typology of Indonesian local sheep breeds based on qualitative morphological characteristics is illustrated in Fig 9. The centroid point shows that the seven Indonesian local sheep breeds on Java Island are spread into three quadrants: the JFT and Sapudi sheep in quadrant I, the Garut, Priangan and JTT sheep in quadrant III and the Batur and Wonosobo sheep in quadrant IV.

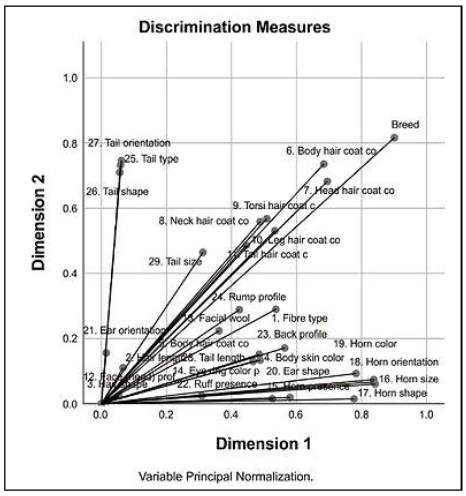

Fig 6: Representation of discriminant measures of variables.

In MCA, the distance between two or more categories of different variables can be interpreted in terms of the relationship or association that exists in them. If two categories show high coordinates and are close together in space, the categories tend to be related. If two categories are seen at high coordinates but are not close together (with opposite signs), the variables tend to be inversely associated (Di Franco, 2016; Hayanti *et al.*, 2022). Discrimination measures on dimensions 1 and 2 will build a plot of the relationship between categories presented in Fig 7. The qualitative morphological characteristics of the JFT and Sapudi sheep are remarkably close. Trait variables that characterize these two breeds with other breeds are the tail's character. The closest character to the Batur sheep is the hair type in the form of medium/1c and fine/1d wool and there is a concave face profile/12b and the presence of wool covering the face/13b. The back profile that slopes up towards the rump/23b character is close to the Wonosobo sheep, while the straight back profile/23a character is close to the Batur sheep.

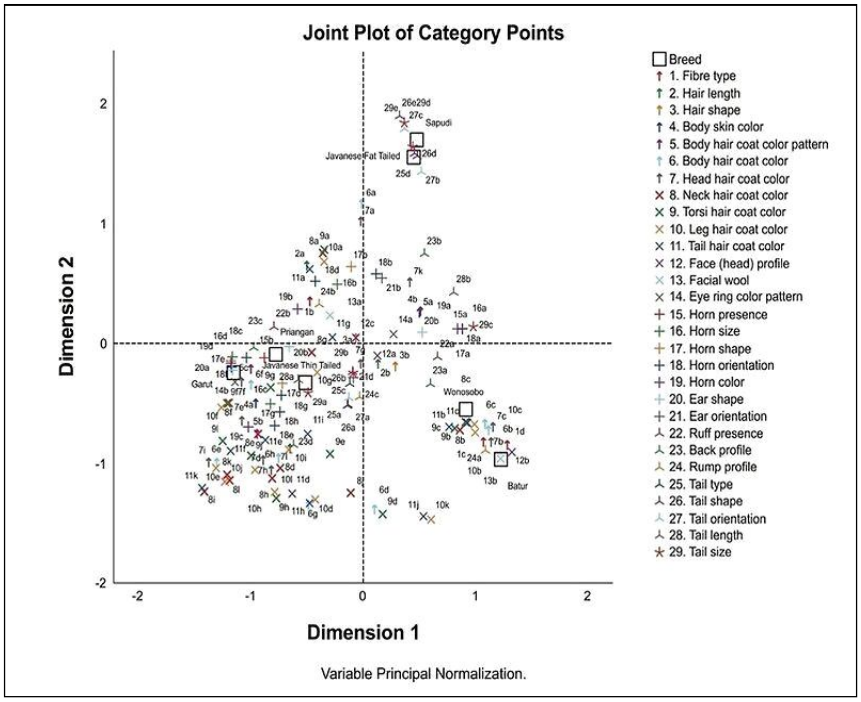

Fig 7: Joint point of category points of the male Indonesian local sheep breeds.

In JTT, Priangan and Garut sheep, the distribution of body qualitative morphological characteristics is diverse and close to each other. In Garut sheep, the closest characters were spotted body color pattern/5c, eye-ring pattern color/ 14c, large horn/16d with a spiral shape/17e and gopher ear shape/20a. The closest characters in JTT sheep were short/ 28a with a small-small-small size/29a of the tail, the curved/ 17d and downwards orientation/18g of the horns and the white chalk of the legs coat hair color/10a. While the Priangan sheep have close characteristics to JTT and Garut sheep, such as the horn present/15b, white dominant/6f and mixed/9g of body hair coat color, ruff present/22a, and sloping down of back profile/23c.

Fig 9 illustrates the distribution and center of the sheep samples observed. Based on the center point of distribution from dimensions 1 and 2 of the seven sheep breeds observed, they can be divided into three groups. Group-1 consisted of JFT and Sapudi sheep in quadrant I; group-2 consisted of JTT, Priangan and Garut sheep in quadrant III; and group-3 consisted of Batur and Wonosobo sheep in quadrant IV. There are differences in morphological variables due to environmental adaptation of differences in origin and the effect of introgression or crossbreeding (Depison *et al.*, 2021; El Moutchou *et al.*, 2017).

Relationship between male Indonesian local sheep breeds on Java Island

The proximity matrix and the clusters division assuming the number of clusters formed was presented in Table 2 and 3, respectively. The matrix and cluster results are illustrated in Fig 10. Table 2 shows that the highest dissimilarity value is between Garut and Batur sheep (26.781) and the smallest is between JFT and Sapudi sheep (1.345).

It was inferred that when the seven sheep breeds are divided into two clusters, cluster-I consists of Priangan, Garut and JTT sheep. In contrast, cluster-II consists of Batur, Wonosobo, JFT and Sapudi sheep (Table 3 and Fig 10). These results also indicated that Batur and Wonosobo sheep formed one group, separated from JFT and Sapudi sheep by forming three clusters. These results indicate that JFT sheep have a close relationship with Sapudi sheep, in which the dissimilarity distance between the two sheep is the most minor (1.345). Garut sheep have the highest dissimilarity value compared to other sheep breeds, except for Priangan sheep (4.259) and JTT sheep (8.157).

It is inferred that the relationship distance based on qualitative morphological characteristics between Garut and Batur sheep is the farthest and the closest is between JFT and Sapudi sheep. Priangan sheep have the closest relationship to JTT sheep (2.453), but on the other hand, Garut sheep also have the smallest dissimilarity value or the closest relationship to Priangan sheep (4.259) compared to other sheep. The study using D-loop mitochondrial DNA sequences resulted that Batur and Wonosobo sheep had remarkably close genetic distances. The JFT and JTT sheep

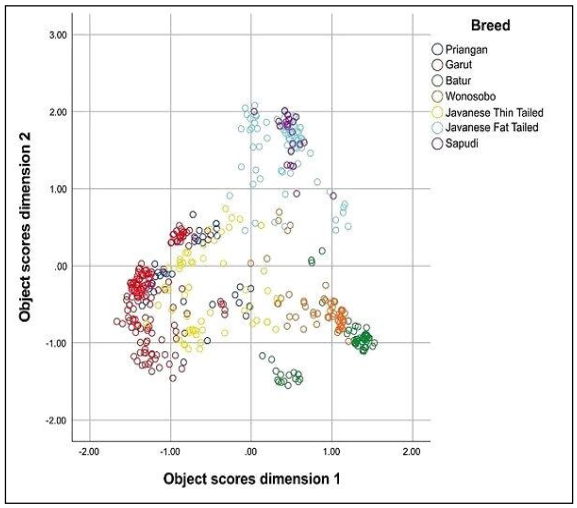

Fig 8: Bi-dimensional representation of the object scores dimension variables associated with the individual sampled in each male Indonesian local sheep breed on Java Island using qualitative morphological variables.

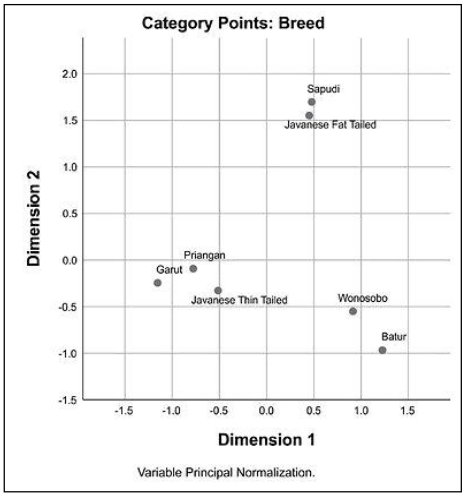

Fig 9: The typology of Indonesian local sheep breeds on Java Island based on qualitative morphological characteristics.

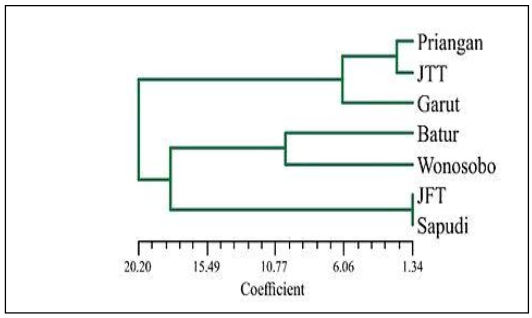

Fig 10: The dendrogram of Indonesian local sheep breeds based on qualitative morphological characteristics.

have a close relationship and are closer to the Batur and Wonosobo sheep than the Priangan and Garut sheep. Garut sheep have the most distant relationship with other breeds (Ibrahim *et al*., 2020). However, it differs from the analysis of blood protein polymorphisms, where JTT and Batur sheep have a closer relationship than between JTT and Wonosobo sheep or between Batur and Wonosobo sheep (Noviani *et al*., 2013).

Table 1: Discrimination measures of qualitative morphological traits variables.

Variables	Dimension		Mean
	1	2	
Breed	0.901	0.816	0.859
Fiber type	0.536	0.290	0.413
Hair length	0.067	0.111	0.089
Hair shape	0.018	0.008	0.013
Body hair coat color	0.485	0.152	0.318
Body skin color	0.488	0.134	0.311
Body hair coat color	0.684	0.736	0.710
Head hair coat color	0.694	0.682	0.688
Neck hair coat color	0.488	0.559	0.523
Torso hair coat color	0.508	0.568	0.538
Leg hair coat color	0.533	0.531	0.532
Tail hair coat color	0.445	0.486	0.466
Face (head) profile	0.053	0.026	0.039
Facial wool (face cover)	0.362	0.224	0.293
Eye ring color pattern	0.309	0.025	0.167
Horn presence	0.777	0.015	0.396
Horn size	0.837	0.074	0.456
Horn shape	0.841	0.061	0.451
Horn orientation	0.837	0.067	0.452
Horn color	0.783	0.093	0.438
Ear shape	0.580	0.019	0.300
Ear orientation	0.015	0.156	0.085
Ruff presence	0.526	0.015	0.271
Back profile	0.564	0.171	0.367
Rump profile	0.424	0.289	0.356
Tail type	0.062	0.747	0.404
Tail shape	0.057	0.710	0.383
Tail orientation	0.059	0.732	0.395
Tail length	0.466	0.130	0.298
Tail size	0.312	0.465	0.388
Total (Eigenvalue)	13.710	9.090	11.400
Cronbach's alpha	0.959	0.921	0.944
Inertia	0.457	0.303	0.380
% of variance	45.698	30.300	37.999

Table 2: Dissimilarity matrix (squared Euclidean distance) of male Indonesian local sheep breeds.

Breeds	Priangan	Garut	Batur	Wonosobo	JTT	JFT	Sapudi
Priangan	0.000						
Garut	4.259	0.000					
Batur	23.449	26.781	0.000				
Wonosobo	19.410	22.056	10.064	0.000			
JTT	2.453	8.157	20.213	17.192	0.000		
JFT	16.716	19.931	18.705	16.238	17.840	0.000	
Sapudi	17.657	21.016	20.016	17.191	20.146	1.345	0.000

Table 3: Hierarchical clustering of male Indonesian local sheep breeds.

Breeds	Cluster number				
	6	5	4	3	2
Priangan	1	1	1	1	1
Garut	2	2	1	1	1
Batur	3	3	2	2	2
Wonosobo	4	4	3	2	2
JTT	5	1	1	1	1
JFT	6	5	4	3	2
Sapudi	6	5	4	3	2

CONCLUSION

Male Indonesian local sheep breeds on Java Island can be characterized using qualitative morphological characteristics. The Javanese Fat-Tailed and Sapudi sheep have the closest relationship, followed by the Batur and Wonosobo sheep and the Priangan and Javanese Thin Tailed sheep. Garut sheep have the most distant relationship with other sheep breeds, except with Priangan and Javanese Thin Tailed sheep.

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Conflict of interest: None.

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