MORPHOSTRUCTURAL TRAITS IN INDONESIAN FEMALE GOAT BREEDS OF BOER, BOERKA, KACANG AND ETTAWA CROSS

S. Elieser[1] Hartati[1] W. P. Putra[2] E. Handiwirawan[1] R.Hutasoit[1] T. L. Tyasi[3]
Researcher Researcher Researcher Researcher Researcher Researcher

[1]Res. Cent. Anim. Husb., Nat. Res. Innov. Agency., Indonesia
[2]Res. Cent. Appl. Zool., Nat. Res. Innov. Agency, Indonesia
[3]Dept. Agric. Econ. Anim. Prod., University of Limpopo, Polokwane, South Africa
simo005@brin.go.id

ABSTRACT

Morphostructural characterization can be used to identify unique characteristics in different animal breeds and an essential tool for the identification and classification of these breeds. The objective of this study was to characterize four Indonesian goat breeds based on their morphostructural traits. A total of 315 female goats (does) at 2.5 - 3.5 years of age were used currently and consisted of 28 Boer, 118 Boerka, 141 Kacang and 28 Ettawa cross. Total eleven body measurements and ten body conformations were measured to describe the morphostructure of goats. Two statistical methods of canonical discriminant analysis (CDA) and hierarchical cluster analysis (HCA) were used to differentiate goat breeds. Body measurement and body index were able to discriminate goat breeds with canonical correlation (Function 1) of 0.81 and 0.77, respectively. According to HCA of morphostructural traits, Boerka and Kacang does are classified into similar cluster. Body measurement is better for discriminating goat breeds rather than body conformation.

Keywords: body measurements, does, Indonesia, traits, animal breeds.

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التصنيف الشكلي التركيبي لسلالات اناث الماعز الاندونيسي Boer وBoerka وKacang وEttawa Cross

T. L. Tyasi[3] R. Hutasoit[1] E. Handiwirawan[1] W. P. Putra[2] Hartati[1] S. Elieser[1]
باحث باحث باحث باحث باحث باحث

[1] مركز بحوث تربية الحيوان – الوكالة الوطنية للأبداع البحثي / اندونيسيا.
[2] مركز بحوث تطبيقات علوم الحيوان – – الوكالة الوطنية للأبداع البحثي / اندونيسيا.
3 قسم الاقتصاد الزراعي والإنتاج الحيواني –جامعة Limpopo ، بولوكوين – جنوب افريقيا.

المستخلص

يمكن استخدام التصنيف الشكلي التركيبي لتمييز الخصائص الفريدة لسلالات الحيوانات المختلفة وتؤدي دوراً ضرورياً في تعريف وتصنيف هذه السلالات. ان الهدف الرئيسي من هذه الدراسة هو لتمييز أربعة سلالات ماعز اندونيسية اعتماداً على الخصائص الشكلية والتركيبية لها. استعملت في الدراسة الحالية 315 من اناث الماعز بعمر 2.5 –3.5 سنة تألفت من 28 من سلالة Boer و118 من سلالة Boerka و141 من سلالة Kacang و28 من سلالة Ettawa Cross. تم اجراء أحد عشر قياس لأبعاد الجسم وعشرة قياسات لتشكل الجسم خلال مدة التجربة الحالية. استعملت طريقتين احصائيتين لتحليل النتائج هما طريقة تحليل التمييز الكنسي (CDA) وتحليل العنقودية الهرمي (HCA) لتمييز سلالات الماعز الأربعة. وجد ان قياسات الجسم ودليل الجسم يمكن استعمالها لتمييز سلالات الماعز باستعمال معاملي ارتباط كنسي مقدارهما 0.81 و0.77 على التوالي. واستناداً الى الخصائص الشكلية والتركيبية باستعمال طريقة تحليل العنقودية الهرمي تم تصنيف سلالتي Boerka وKacang على انهما ذات عنقود متماثل. وقد كانت قياسات الجسم أفضل في تمييز سلالات الماعز مقارنةً بقياسات تشكل الجسم.

الكلمات المفتاحية: تحليل التمييز الكنسي، اناث الماعز، تحليل العنقودية الهرمي، اندونيسيا، قياسات الجسم.

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INTRODUCTION

Indonesia has diverse genetic resources for goats, which contribute to the supply of meat and in relatively small amounts, milk products. Goat meat is a popular source of protein and is consumed widely throughout the country. In addition, goat milk is increasingly recognized for its nutritional benefits (22). The demand for goat meat and other goat products has been steadily increasing in Indonesia, making goat farming an attractive option for small-scale farmers looking to diversify their income streams. Goat farming is particularly important in rural areas, where it provides a source of income and livelihood for small-scale farmers. Local goats have adapted well to the local climate and are well-suited to small-scale, backyard farming systems and are spread across all provinces in Indonesia, which currently has a population of 19.4 million (11).The Boer, Boerka, Kacang, and Ettawa Cross are four popular goat breeds in Indonesia, each with its unique characteristics and attributes. Kacang and Ettawa Cross are the main goat breeds where the population is quite large, and the distribution is relatively wide. Besides that, there are variants of Kacang goats, imported goats from other countries, and hybrid goats. The Boer goat is a goat breed introduced to Indonesia and used to increase productivity through crossbreeding with the Kacang goat. Crossbreed Boerka goats are the result of crossing Boer and Kacang goats that have adapted to the environment and management of breeders in Indonesia and show good productivity (15, 3, 14). Morphostructural characterization, which involves the measurement and evaluation of physical characteristics such as body weight, height, length, and other traits, is an essential tool for the identification and classification of animal breeds. Understanding the morphostructural characteristics of different goat breeds is essential for selecting breeding animals and improving the overall genetic quality of the herd. Morphostructural characterization can be used to identify unique traits and characteristics in different animal breeds. This knowledge can be used to develop breeding programs aimed at improving specific traits or creating new breeds with desirable characteristics (17). Morphometric studies can be used to study the genetic diversity of a breed (20, 35, 10, 4) breed types and functions (30, 8, 21), prediction of body weight and carcass (3, 12), prediction of daily milk production (33, 27, 21), udder health (31, 33), embryo growth (19), differentiation and estimation of genetic distance between populations/breeds (25, 7) and differentiation based on origin (18) are as well as giving recommendations for genetic improvement and management of livestock genetic resources in the context of conservation (23). The diversity of livestock breeds can also be estimated based on genetic diversity, both in gene regions associated with certain traits (2, 13) and non-gene regions/microsatellite markers (16). However, estimating genetic diversity based on DNA diversity is more difficult, requiring appropriate laboratory equipment and analytical skills compared to estimating genetic diversity based on body size, so it is often chosen to be used. Therefore, this paper was aimed to investigate comprehensive morphostructural characterization of four Indonesian female goat breeds, namely the Boer, Boerka, Kacang, and Ettawa Cross. We will analyze the physical attributes of these breeds and compare their differences and similarities. This study will contribute to the understanding of the morphostructural characteristics of these breeds, providing valuable insights into their breeding and genetic potential of the main breed goat in Indonesia.

MATERIAIS AND METHODS

All experiments were approved by the animal ethics committee of the Indonesian Agency for Agricultural Research and Development (Balitbangtan/Lolitkambing/Rm/15/2017). A total 315 female goats (does) at 2.5 - 3.5 years of age were used currently. The does were kept at the Goats Research Center of Sei Putih, Deli Serdang Regency, North Sumatra Province - Indonesia (Figure 1). This area located at latitude 98.89° S and longitude 3.43° E with 10 m asl. This area have 22.7 - 33.0 °C of air temperature, 85% of relative humidity and 2.294 – 2.452 mm/year of rainfall. Thus, the does in this study consisted of four breeds *i.e.* Boer (28 heads), Boerka F1 (118 heads), Kacang (141 heads) and Ettawa cross (28 heads) as ilustrated in Figure 2.

Figure 1. The research site of Goats Research Center (red circle) at Deli Serdang Regency, North Sumatera Province of Indonesia

Figure 2. The exterior characteristics in Boer (A), Boerka (B), Kacang (C) and Ettawa cross (D) does

The feed given consisted of concentrate and field grass. The composition of concentrate consisted of fine bran (25%), coconut meal (50%), ground corn (12.5%), fish meal (3.75%), shellfish meal (3.75%), salt (2.5%) and minerals (2.5%). Concentrate feed was given to all goats in the morning at around 8.00 – 9.00 in an amount of 1.25% BK/day of the total body weight of the goats in the group pens and drinking water was given ad libitum. Analysis of the nutritional content of feed was carried out every three months, by taking feed samples from each pen. The nutrient composition of the concentrate feed given was shown in Table (1).

Table 1. The nutrient composition of the concentrate feed

Nutrient composition	%
Water content	7.66
Ash content	11.18
Crude Protein	11.2
Crude Fat	12
Crude Fiber	17.1
Energy (k.cal/g)	4.2

Beef Goat Research Station Laboratory, Sei Putih North Sumatera Eleven body measurements, body length (BL), chest [I THINK HEART TERM IS MOST CORRECT] girth (CG), chest depth (CD), shoulder width (SW), head length (HL), head width (HW), withers height (WH), cannon circumference (CC), rump height (RH), rump length (RL) and rump width (RW) were measured in each doe as ilustrated in Figure 3. According to Boujenane et al. (2016) (5), BL is measured as a distance from the point of the shoulder to the pin bone. CG is measured as a perimeter of the chest just behind the front legs and withers. CD is measured as a distance from the backbone at the shoulder to the brisket between the front legs. SW is measured as a distance from left to right upper arm. HL is measured from between the horn site (poll) to the lower lip. HW is measured as the widest point of the head. WH is measured as a vertical distance from ground to the point of withers measured vertically from the ridge between the shoulder bones (*os vertebrae thoracalis*) to the fore hoof. CC is measured as the smallest circumference of the cannon bone of foreleg. RH is measured from rump (*tuber coxae*) to the surface of the platform on which the animal stands. RL is measured from hips to pins. RW is measured as the distance between bothof the hip bones (*tuber ischii*).

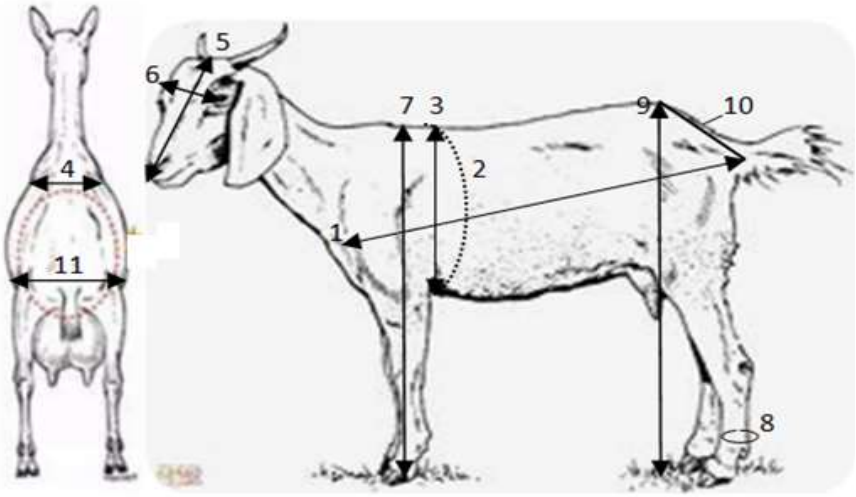

Figure 3. Scheme of body measurements in goat such as: body length (1), chest girth (2), chest depth (3), chest width (4), head length (5), head width (6), withers height (7), cannon circumference (8), rump height (9), rump length (10) and rump width (11).

Ten body conformations of length index (LI), thoracic index (TI), depth index (DI), thoracic development (TD), conformation index (CI), body index (BI), proportionaliy (Pr), area index (AI), dactyl thoracic index (DTI) and cannon thickness index (CTI) were measured using the mathematical formulas as follows (30, 8, 21):

$LI = (BL / WH) \times 100$
$TI = (SW / CD) \times 100$
$DI = (CD / WH) \times 100$
$TD = (CG / WH) \times 100$
$CI = CG^2 / WH$
$BI = (BL / CG) \times 100$
$Pr = (WH / BL) \times 100$
$AI = WH \times BL$
$DTI = (CC / CG) \times 100$
$CTI = (CC / WH) \times 100$

According to BI value, the goat can be described as three categories of brevigline (BI<85.0), medigline (85.0<BI<88.0) and longiland (BI>88.0). According to DTI value, the goat can be described as four categories of light meat animal (DTI<10.5), intermediary meat animal (10.6<DTI<10.8), light meat animal (10.9<DTI<11.0) and heavy meat animal (DTI>11.0). Moreover, goat with TD value more than 120 was classified into good performance. While goat with TD value lower than 120 was classified into adequate performance (6, 13, 11). The statistics parameter of mean and standard deviation in body measurements and body conformations were calculated with SPSS 16.0 computer program. Therefore, a canonical discriminant analysis (CDA) was performed in this study using similar software to obtain the discriminant variables from body measurements and body conformations. In the CDA, Mahalanobis distance (D^2), tolerance

(T), and canonical correlation (R) values were computed to obtain the discriminating variable for the animal from two different altitude areas. Here, the CDA was applied with the backward-stepping automatic elimination method for the variables, with F-value entry = 3.84 and F-value removal = 2.71. The T-value (0–1) was computed to detect the correlation among the discriminant function variables. Suppose a variable is positively correlated with one or more of the others. In that case, the negative value is minimal, and the resulting estimates of the discriminant function coefficient may be unstable. Therefore, the hierarchical cluster analysis (HCA) was used to cluster the Kacang goats from different populations. In this study, the HCA was conducted using combination data (BW, body measurements, and body indices) with the nearest-neighbor method, the Euclidean distance measure, and the Z score's transformed value.

RESULTS AND DISCUSSION

Mostly the body measurements in Boerka and Kacang does were similar as shown in Table (2), except for CC. While, BL, CG, RL and RW measurements in Boer and Ettawa cross does were similar. The Boer does generally has the highest body measurements among the four breeds.

Table 2. The morphostructural traits of Indonesian female goat (doe) breeds (Mean ±SE).

Parameter	Boer (N=28)	Boerka (N=118)	Kacang (N=141)	Ettawa cross (N=28)
Body measurement (cm)				
BL	64.36±10.77^{b}	55.20±7.29^{a}	56.57±6.37^{a}	63.71±5.99^{b}
CG	73.96±12.62^{b}	63.95±8.81^{a}	64.47±7.24^{a}	71.25±6.22^{b}
CD	33.11±5.29^{b}	27.96±3.56^{a}	27.96±3.72^{a}	30.07±3.18^{c}
SW	17.21±3.51^{b}	14.05±1.92^{a}	14.01±1.63^{a}	15.93±2.14^{c}
HL	15.36±2.18^{b}	13.45±1.55^{a}	13.71±1.42^{a}	16.32±1.92^{c}
HW	12.28±1.84^{b}	10.38±1.12^{a}	10.18±1.04^{a}	11.25±0.89^{c}
WH	62.39±7.98^{b}	54.84±6.25^{a}	55.16±5.48^{a}	68.18±5.54^{c}
CC	8.70±1.12^{b}	7.46±0.68^{a}	7.51±5.76^{c}	7.55±0.68^{a}
RH	59.39±8.09^{b}	53.60±5.69^{a}	53.43±4.74^{a}	69.32±5.68^{c}
RL	15.25±2.87^{b}	13.13±1.70^{a}	12.91±1.81^{a}	15.89±1.31^{b}
RW	14.27±3.55^{b}	12.14±2.16^{a}	12.20±1.76^{a}	13.39±1.91^{b}
Body conformation				
LI	102.75±6.97^{a}	100.59±6.23^{a}	102.60±6.74^{a}	93.51±5.78^{b}
TI	51.77±4.50^{ab}	50.49±5.41^{a}	50.51±5.31^{a}	52.95±4.35^{b}
DI	52.89±2.73^{a}	51.01±3.60^{b}	50.61±3.67^{b}	44.06±2.16^{c}
TD	118.01±8.08^{a}	116.41±7.42^{a}	116.87±6.39^{a}	104.57±5.09^{b}
CI	88.06±19.79^{a}	74.86±13.50^{b}	75.56±10.99^{b}	74.63±8.66^{b}
BI	87.28±5.99^{a}	86.67±6.83^{ab}	87.87±4.84^{ab}	89.50±5.21^{b}
Pr	97.74±6.42^{a}	99.78±6.11^{a}	97.88±6.45^{a}	107.33±6.58^{b}
AI	4092.40±1129.76^{a}	3068.10±677.38^{b}	3148.90±601.67^{b}	4368.60±706.03^{a}
DTI	11.88±0.98	11.81±1.35	11.64±8.15	10.62±0.67
CTI	13.98±0.99	13.70±1.28	13.59±9.68	11.10±0.81

BL = Body length; CG = Chest girth; CD = Chest depth; SW = Shoulder width; HL = Head length; HW = Head width; WH = Withers height; CC = Cannon circumference; RH = Rump height; RL = Rump length; RW = Rump width; LI = Length index; TI = Thoracic index; DI = Depth index; TD = Thoracic development; CI = Conformation index; BI = Body index; Pr = Proportionality; AI = Area index; DTI = Dactyl thoracic index; CTI = Cannon thickness index; N: number of animal; superscript in the different row differ significantly (P<0.05)

Three body conformations of LI, TI and Pr in Boer, Boerka and Kacang does were similar as shown in Table (2). In addition, LI, TI and Pr in Ettawa cross does were the lowest than those does. Thus, the CI in Boer does was the highest than the other breeds of doe. According to Table (2), Boer, Boerka and Kacang does under study are medigline goat with heavy meat and adequate performance. While, Ettawa cross does under study are a longiland goat with light meat and adequate performance. Total nine body measurements and seven body conformations were detected as the discriminant variables to characterize four Indonesian goat breeds as shown in Table (3). Therefore, those discriminant variables were able to characterize four goat breeds under study with the maximum canonical correlation (R) value of 0.81 (body measurement) and 0.77 (body conformation) as shown in Figure (4).

Table 3. Factor selected by stepwise discriminant analysis to discriminate Boer, Boerka, Kacang and Ettawa cross does

Step	Variable entered	Tolerance	F_{remove}	D^2	Wilk's λ
Body measurement					
1	Head width	0.22	11.14	1.42	0.19
2	Cannon circumference	0.34	30.26	0.57	0.22
3	Head length	0.23	6.17	1.36	0.18
4	Body length	0.16	4.29	1.37	0.17
5	Chest girth	0.11	10.64	1.53	0.18
6	Rump height	0.23	31.96	1.53	0.22
7	Rump width	0.13	13.91	1.57	0.19
8	Shoulder width	0.29	4.73	1.54	0.17
9	Withers height	0.14	15.07	1.58	0.19
Body conformation					
1	Area index	0.03	23.77	0.34	0.41
2	Depth index	0.60	12.50	0.31	0.37
3	Proportionality	0.01	14.16	0.34	0.37
4	Conformation index	0.01	13.74	0.34	0.37
5	Thoracic development	0.01	15.02	0.21	0.38
6	Body index	0.02	7.95	0.15	0.35
7	Thoracic index	0.67	5.05	0.34	0.34

D^2: Mahalanobis distance

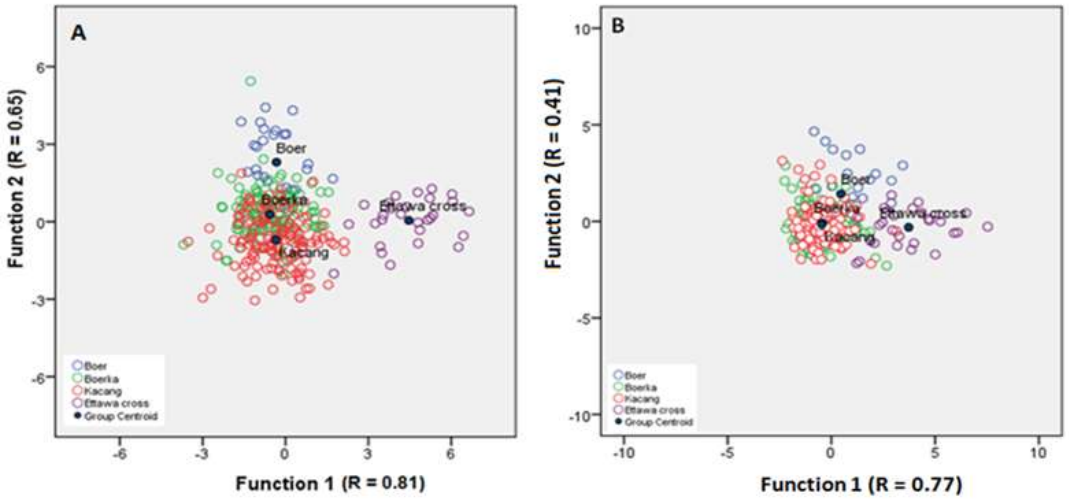

Figure 4. Canonical discriminant plots of body measurement (A) and body conformation (B) to characterize Boer, Boerka, Kacang and Ettawa cross does

Nine discriminant variables of body measurement in this study able to characterize Boer (82.10%), Boerka (67.80%), Kacang (71.60%) and Ettawa cross (96.40%) does into their original population. Meanwhile, discriminant variable of body conformation in this study able to characterize Boer (53.60%; Boerka (49.20%), Kacang (61.70%) and Ettawa cross (89.30%) does into their original population (Table 4). Hence the body measurement are more accurate to discriminate four goat breeds under study rather than body conformation.Table 4).

Table 4. Percentage of individual classification per breed based on discriminant analysis

Parameter	Breed	Predicted group membership (N)				Total (N)
		Boer	Boerka	Kacang	Ettawa cross	
Body measurement	Boer	82.10 (23)	17.90 (5)	0.00 (0)	0.00 (0)	100 (28)
	Boerka	5.10 (6)	67.80 (80)	27.10 (32)	0.00 (0)	100 (118)
	Kacang	4,30 (6)	24.10 (34)	71.60 (101)	0.00 (0)	100 (141)
	Ettawa cross	0.00 (0)	0.00 (0)	3.60 (1)	96.40 (27)	100 (28)
Body conformation	Boer	53.60 (15)	28.60 (8)	10.70 (3)	7.10 (2)	100 (28)
	Boerka	11.00 (13)	49.20 (58)	37.30 (44)	2.50 (3)	100 (118)
	Kacang	14.20 (20)	22.70 (32)	61.70 (87)	1.40 (2)	100 (141)
	Ettawa cross	3.60 (1)	0.00 (0)	7.10 (2)	89.30 (25)	100 (28)

N: number of animal

Table (5) shown Squared Mahalanobis distance among Boer, Boerka, Kacang and Ettawa cross does. Based on body measurements, the shortest distance was between Boerka and Kacang goats, which was 2.44 while the farthest distance was between Boerka and Ettawa cross goats, which was 576.95. The squared Mahalanobis distance (D^2) of body measurement and body conformation between Boerka and Kacang does were 2.44 and $6.54E^3$, respectively. Hence, the morphological characteristics of both does are similar.

Table 6. Squared Mahalanobis distance among Boer, Boerka, Kacang and Ettawa cross does

Parameter	Breed	Boerka	Kacang	Ettawa cross
Body measurement	Boer	328.97	293.61	155.26
	Boerka	-	2.44	576.95
	Kacang	-	-	545.35
Body conformation	Boer	$1.05E^6$	$8.90E^5$	$7.69E^4$
	Boerka	-	$6.54E^3$	$1.69E^6$
	Kacang	-	-	$1.49E^6$

The dendogram in goats under study revealed that Ettawa cross goat was classified in the separated cluster. While, Boer, Boerka and Kacang goats were classified in the similar cluster as shown in Figure 5. Interestingly, Boerka and Kacang goats were classified in the similar subcluster because both goats have the similar morphostructural characteristics.

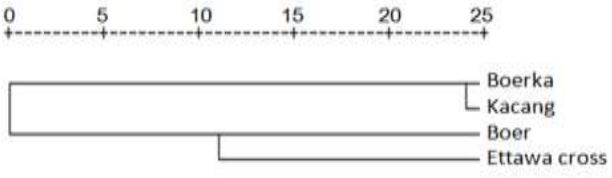

Figure 5. Dendogram of Boer, Boerka, Kacang and Ettawa cross does based on morphostructural characteristics

Comparison of the body measurements of Boer, Boerka, Kacang and Etawa cross goats that have been carried out based on previous studies in various countries is shown in Table (6). According to Table (6), BL and CG measurements in Boer does under study were lower than in South Africa, Austria, German and Egypt (1, 29, 24). Thus, mostly the body measurements in Kacang does at Gorontalo was higher than in the present study as reported by (17), (8) reported that the general body measurements in Kacang does at Jambi Province (Indonesia) was lower than those in the present study (Table 6). Therefore, BL and CG measurements in Ettawa cross under study were lowest than those in several Indonesian region as shown in Table 6. In addition, (32) reporting the lower general body measurements of Boerka does at East Java than those in the present study. In this study, the hybrid vigor (heterosis) effect did not observe in the Boerka crossbred goat (Boer × Kacang) since their morphometrics close to Kacang goat. (6) stated that the hybrid vigor effect can be observed when the crossbred offsprings have the highest performance than their both origin parental purebreeds. Body measurements in the livestock can be influenced by genetic, nutrition, management system and climate (26). Information on body measurement of goats among breeds can provide a better understanding of the characteristics of purebred goats, assist in selecting the right breeds, planning efficient rearing, optimal care, breeding programs, and facilitating further scientific research. Based on observations of the body size of Boer, Boerka, Kacang and Etawa cross goats that have been carried out previously in various countries, body conformation calculations were carried out, the results of which are shown in Table (7). Commonly, Boer does in another countries are a longiland goat with heavy meat animal and good performance as shown in Table (7). Thus, Kacang does at Malaysia, Jambi and Gorontalo are a longiland goat with light to intermediary meat and adequate to good performance. Nevertheless, Kacang does at Bali are a brevigline goat with heavy meat and good performance (Table 7). According to Table (7), mostly Ettawa cross does in Indonesia are a longiland goat with adequate performance. Otherwise, Boerka does at East Java are a longiland goat with adequate performance (Table 7) and similar to Boerka does under study. Therefore, (8) reported that Cuban Creole does are a medigline goat (BI=85.29) with light meat type (DTI=9.58). While, Anglo-Nubian does are a brevigline goat (BI=81.96) with light

meat type (DTI=9.15). Thus, (13) reported that Assam hill does are a medigline goat (BI=86.87) with light meat type (DTI=9.82). Otherwise, South African non-descript does are a medigline goat (BI=87.43) with heavy meat type (DTI=14.48) as reported by (25). Body conformations in the animal can be caused by nutrition, management, selection and inbreeding. In the Bali cattle (*Bos javanicus*), the inbreeding coefficient of 12.5% able to reduce the general morphostructure at the breeding station (27).

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