Heterosis on morphometric traits of crossbreds from Anglo Nubian and Etawah Grade goats

L Praharani, A Anggraeni and A A R Hapsari
Research Institute for Animal Production, Jl. Banjarwaru III, Bogor, 16002

Corresponding author: lisapraharani@pertanian.go.id

Abstract. Crossbreeding was applied to increase production performance of local goats. This study was conducted to evaluate the heterosis effect of morphometric traits in crossbred does produced from a mating between Anglo Nubian (AN) and Etawah Grade (PE) goats. A total of 34 does of AN, 66 F-1 ANxPE and 40 PE were used to analyze heterosis effect of morphometric traits. Data were analyzed using general linear model with age and genotype as fixed effects. Morphometric traits were affected significantly by genotype (P<0.05), but head with, body length and chest width were not. Heterosis of body weight, head length, head width, ear length, ear width, body length, heart girth, chest width, wither height, hip height, hip width, foreleg length, rear leg length, tail length, tail width were -2.75, -2.60, -2.09, -13.79, -3.90, 0.21, -3.82, 0.14, -3.1, -5.42, 6.06, -6.16, -5.88, -9.44 and 2.88%, respectively. Crossbreeding of Anglo Nubian and Etawah Grade resulted in low heterosis effects of morphometric traits. This study indicated crossbreeding of Anglo Nubian and Etawah grade need to be considered.

1. Introduction
Crossbreeding is a way of realizing quicker genetic improvement and benefiting from complementarity combining different characteristics of genetically different animals in the crossbreed. This program was applied to increase production performance of indigenous and local goats [1]. The crossbred offspring have the tendency to be superior in some quantitative traits referred to as hybrid vigor [2].

There are many exotic goat breeds which had been used for crossbreeding in many countries, such as Anglo Nubian [1]. The Anglo Nubian (AN) has the highest adaptability in the tropic condition as dual-purpose goat, for milk and meat [3]. This breed has been used for improving production of indigenous and local breeds through crossbreeding program in the tropics.

Morphological characterization is one of the crucial means for describing the goat breeds. Some studies related linear body measurements to production and reproduction performance in goats [4–5]. Body measurements are important tools for phenotypic description. These measurements include heart girth, wither height, body length, hip height, head length, neck length, etc. Goat morphology shows considerable variation influenced by breed, age, sex, nutritional condition and environmental factors [6–7].

This study was conducted to evaluate the heterosis effect of morphometric traits in crossbred does produced from a mating between Anglo Nubian (AN) and Etawah Grade (PE) goats. This information will be beneficial for developing Anglo Nubian goats in Indonesia.
2. Materials and methods
This study was carried out at the Dairy Goat Unit of Indonesian Institute for Animal Production, in Bogor. It was located on 250-350 m above sea level.

A total of 34 does of AN, 66 F-1 ANxPE and 40 PE were used in this study. The does were divided into 2 groups of age: young (between 12 and 24 month) and mature (24–48 months).

All animals were reared in the same management system. They were fed 0.8 kg/head/day of concentrate 16-17% Crude Protein and 65-70% Total Digestible Nutrients. Forages containing of King grass were given about 4-5 kg/head and 0.5-0.6 kg/head/day of legumes (Calianandra, Leucaena, Gliricidae). Clean water was available ad libitum.

The morphometric traits evaluated were body measurements (body weight, body length, heart girth, chest width, wither height, hip height, hip width, foreleg length, rear leg length), head measurements (head length, head width, ear length, ear width) and tail measurements (tail length and tail width). All measurements are applied while animals are standing in normal pose were carried out by the same person in order to avoid between-individual variations using tailor tape.

Percent heterosis were calculated as 
\[ \text{Heterosis} \% = \frac{P_{F1} - \frac{P_N + P_E}{2}}{\frac{P_N + P_E}{2}} \times 100; \]
where:
- \( P_{F1} \) = Mean performance of F1 crossbreds
- \( P_N \) = Mean performance of Anglo Nubian
- \( P_E \) = Mean performance of Etawah Grade.

The data generated were subjected to analysis of variance using the General Linear Model (GLM) of SAS [8]. Genotype and age of does were included in the model as source of variation. Effects were considered significant at 0.05 level using P-DIFF test.

The model employed for analyses of morphometric traits measured was:
\[ Y_{ijkl} = \mu + G_i + A_j + \epsilon_{ijkl}, \]
where:
- \( Y_{ijkl} \) = the observed k (morphometric traits) in the ith age genotype and jth age,
- \( \mu \) = overall mean,
- \( G_i \) = the effect of ith Genotype group (i: 1(Etawah Grade), 2(Anglo Nubian), 3(ANxPE)),
- \( A_j \) = the effect of jth Age (j=1(young) and 2(mature))
- \( \epsilon_{ijkl} \) = random residual error.

3. Results and discussion

Table 1 presented least square means of the morphometric traits. Results showed that body weight, head length, ear length, ear width, heart girth, wither height, hip height, hip width, foreleg length, rear leg length, tail length and tail width were affected significantly by genotype of does (\( P<0.05 \)). The body weight, head length, ear length, body length, heart girth, chest width, wither height, hip width, foreleg length, and tail length were also affected significantly by age of does (\( P<0.05 \)). Some studies reported breed and age effects on body measurements in goats [9–10]. Significant increase in zoometric values with increasing age observed for body weight, body length, heart girth, wither height, chest width, hip width in goats of age 2 - 4yrs [9] was similar to this present study.

Table 1 showed The Anglo Nubian had the highest body weight and ear width (\( P<0.05 \)). The Etawah grade had the highest ear length, wither height, hip height, foreleg length, rear leg length, tail length and width, but lowest head length (\( P<0.05 \)). The ANxPE crossbreds had the lowest heart girth, tail length and width (\( P<0.05 \)). The body weight, head length, head width, body length, chest width, hip width, of ANxPE crossbreds similar to PE. The head length, head width, ear length, ear width, body length, chest width, heart girth, wither height, hip height, hip width, foreleg length and rear leg length of ANxPE crossbreds were not different from AN.

Body measurements in this study showed differences from some studies. It was reported by [11] that higher wither height (85.22 cm), body length (83.78 cm) and heart girth (87.22 cm) than present study due to different sex of Anglo Nubian. The body length (67-69 cm), wither height (64-60 cm), heart girth (76-82 cm) and chest width (16 cm) of Cuban Creole were lower than this present study [12], also lower body length (80,63 cm) and similar wither height (77 cm) to those found by [13] in Anglo Nubian. Some studies of [4] and [5] found lower body measurements of PE (wither height 72-77 cm; body length 70-74 cm; heart girth 78-85 cm) than this present study.
| Traits       | Etawah Grade | Anglo Nubian | AN x PE | P-value  | Heterosis (%) |
|--------------|--------------|--------------|---------|----------|---------------|
| N            | 40           | 34           | 66      |          |               |
| Body weight  | 44.37±0.51\textsuperscript{a} | 48.71±0.37\textsuperscript{b} | 45.26±0.48\textsuperscript{a} | <.0001   | -2.75        |
| Head length  | 23.87±0.20\textsuperscript{b} | 24.77±0.27\textsuperscript{a} | 24.24±0.26\textsuperscript{b} | 0.0197   | -2.60        |
| Head width   | 17.72±0.23   | 17.94±0.24   | 17.46±0.18 | 0.2948   | -2.09        |
| Ear length   | 33.21±0.75\textsuperscript{a} | 26.72±0.79\textsuperscript{b} | 25.83±0.58\textsuperscript{b} | <.0001   | -13.79       |
| Ear width    | 11.49±0.17\textsuperscript{a} | 10.26±0.18\textsuperscript{b} | 10.45±0.13\textsuperscript{b} | <.0001   | -3.90        |
| Body length  | 70.98±1.50   | 72.25±1.58   | 71.77±1.16 | 0.8376   | 0.21         |
| Heart girth  | 80.94±0.74\textsuperscript{a} | 84.06±1.01\textsuperscript{b} | 84.26±0.96\textsuperscript{b} | 0.0081   | 2.13         |
| Chest width  | 20.85±0.90   | 21.21±0.94   | 21.06±0.69 | 0.9605   | 0.14         |
| Wither height| 81.15±0.62\textsuperscript{a} | 76.06±0.65\textsuperscript{b} | 76.16±0.47\textsuperscript{b} | <.0001   | -3.11        |
| Hip height   | 84.22±1.15\textsuperscript{a} | 77.45±1.21\textsuperscript{b} | 76.45±0.89\textsuperscript{b} | <.0001   | -5.42        |
| Hip width    | 17.94±0.43   | 20.56±0.54   | 21.89±0.78 | 0.0108   | 6.06         |
| Foreleg length| 52.85±0.64\textsuperscript{a} | 46.09±0.67\textsuperscript{b} | 46.42±0.49\textsuperscript{b} | <.0001   | -6.16        |
| Rear leg length| 56.94±0.67\textsuperscript{a} | 50.97±0.70\textsuperscript{b} | 50.78±0.51\textsuperscript{b} | <.0001   | -5.88        |
| Tail length  | 18.58±0.29\textsuperscript{a} | 17.00±0.30\textsuperscript{b} | 16.11±0.22\textsuperscript{c} | <.0001   | -9.44        |
| Tail width   | 5.76±0.17\textsuperscript{a} | 7.05±0.18\textsuperscript{b} | 6.59±0.13\textsuperscript{c} | <.0001   | 2.88         |

\textsuperscript{a,b,c} means with the same superscript in the same row are not significant different at P<0.05

Genetic morphometric could be useful in classifying animals by types and functions. Body weight, body length, wither height and chest depth are four growth traits which have important impacts on the production of chevon and skin [6]. The body measurements in animals, along with growth and carcass traits have dominant difference in all breeds [9]. Moreover, based on the relationship between milk yield and body measurements it may be inferred that the goats with better body weight and size produced generally more milk [7]. While cephalic dimensions, measured by head length and width, have also been used as indicators of breed and relationships within species while wither height has been used as an indicator of meat type, because it indicates long bone growth [14].

The ANxPE crossbreds in this study showed to be superior to the PE, but in similar size to purebred AN. This study was differed from [14] stated crossbreeding of AN and Creole breed are significantly larger than purebred. However, it was reported that AN crossed with local crossbreds resulted in smaller body measurements to the AN purebred [15].

Heterosis is the difference in phenotype between the mean of crossbreds and their purebred parents [15]. In animal breeding, this is usually expressed as mid-parent heterosis or the superiority of the F1 cross over the mean performance of the 2 parents and has been shown to occur across species [2].

Heterosis effects of morphometric traits in present study ranged between -13.79 to 6.06%. Heterosis effect of ear length was the lowest and hip height was the highest (P<0.01). Traits with high heritability might result in low heterosis [2]. The heritability values of body measurements were moderate-high [7–10].

Crosses between improved goat breeds and indigenous goats have often expected large amounts of heterosis because of the large genetic distance between goat types. Heterosis is proportional to the level of heterozygosity of the crossbreds, and the level is inversely proportional to the degree of genetic resemblance between the parents [2]. There was a significant heterosis for morphometric measurements in Boer x locals [15]. AN was a composite breed composed from Nubian breed (Africa), Indian breed (Jumnapary) and English breed [15]. While PE breed had Indian goat blood (Etawah) closed to Jumnapary [5]. There was a negative relationship between level of heterosis and genetic distances [2].
Conclusions
Morphometric traits were significantly affected by genotype and age. The Anglo Nubian x Etawah Grade crossbreds showed similarity in body measurements to the Anglo Nubian. Crossbreeding of Anglo Nubian and Etawah Grade resulted in low heterosis effects of morphometric traits. Crossbreeding between Anglo Nubian and Etawah grade need to be considered.

References
[1] García V, Rovira S, Boutoial K and López MB 2014 Small Rumin Res 121 51–7
[2] Bunning H, Wall E, Chagunda MGG, Banos G and Simm G 2019 J Anim Sci 97 29–34
[3] Lôbo A M B O, Lôbo R N B, Facô O, Souza V, Alves A A C, Costa A C and Albuquerque M A M 2017 Small Rum Res 153 9–16
[4] Winaya A, Prihartini I, Ramadhan S W, Adhim A T F and Rico M J I 2017 Proc Pakistan Acad Sci B Life Environ Sci 54 301–9
[5] Mulyono R H, Sumantri C, Noor R R, Jakarta and Astuti D A 2018 Trop Anim Sci J 41 77–84
[6] Sanni M T, Okpeku M, Onasanya G O, Adeleke M A, Wheto M, Adenaike A S, Oluwatosin B O, Adebambo O A and Ikeobi C O 2018 Agric Trop Subtrop 51 51–61
[7] Waheed A, Khan M S, Eyduran E, Khan M A, Faraz A, Mirza R H 2019 J Anim Plant Sci 24 425–30
[8] SAS Institute Inc. 2011 SAS/QC 9.3 User’s Guide Cary (NC. USA) p 1–2253
[9] Yusuff A T and Fayeye T R 2016 J Agric Food Environ 12 1–6
[10] Nazeer M and Shah S H 2018 J Agric 34 258–67
[11] Praharani L, Krishnan R and Supryati 2017 Tampilan eksterior kambing perah jantan Anglo Nubian, peranan Etabah dan persilangannya Proseding Seminar Industri Peternakan I 137–9
[12] Chacón E, Macedo F, Velázquez F, Paiva S R, Pineda E, Mcmanus C 2011 Rev Bras Zootec 40 1671–9
[13] Ferreira T A, Pereira I G, Gouveia A M G, Pires A V, Facó O, Meira C T, Garcia I F F and Guimaraes M P S L M P 2013 Rev Bras Zootec 42 857–61
[14] Chiemela P N, Sandip B, Egbu C F, Akpolu E S, Ugbo E H 2015 Int J Adv Acad Res 1 1–13
[15] Silvestre E D A, Costa M da S, da Silva P O, Bajay M, Pinheiro J B, Zucchi M I, Campelo J E G and Britto F 2015 Bras Zootec 44 155–60