Research Article

Growth Performance Evaluation of Belgian Blue Cattle and Their Crossbred in Indonesian Livestock Breeding Centers

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Abstract | Growth performance is one of the characteristics that should be considered and evaluated in a crossbreeding program. This study evaluated the growth performance of newly introduced Belgian Blue cattle and their crossbred to local cattle (Brahman, Friesian Holstein, and Ongole Grade). In this study, the growth performance data of 151 heads of Belgian Blue (BB, n=9), BB x Brahman (BB-B, n=94), BB x Friesian Holstein (BB-FH, n=24), and BB x Ongole Grade (BB-OG, n=24) were collected for analysis. The effects of different genotypes were tested using one-way variance analysis, followed by Duncan's multiple range test. The parameters analyzed were body weight (BW), chest circumference (CC), body length (BL), and shoulder height (SH) at birth, weaning (205 days), and yearling (365 days). The principal component analysis was performed to find the specific identifier characteristic among the genotypes. As a result, BB cattle's BW, CC, and BL were superior at birth compared to the crossed genotype. However, these excellences did not persist in weaning and yearling. The PCA analysis showed that the identifier characteristics for the BB, BB-B, and BB-FH cattle were BW at birth, BW205+CC205, and BL205, respectively. These findings are essential for future development and crossbreeding program policy of the Belgian Blue cattle in Indonesia.

Keywords | Belgian Blue, crossbred, Indonesia, local, cattle, growth performance

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INTRODUCTION

Indonesia has been striving to fulfill the demand for increased beef consumption. Ditjenpkh (2022) reported that beef consumption in Indonesia was 2.56 kg/capita/year, with the total beef demand reaching 696,950 tons. Whereas beef production was estimated at 425,980 tons, there was still a 270,970 tons (38.87%) deficit between the demand and supply. The crossbreeding program of local cattle has been the most successful way to escalate national beef production by increasing the population and slaughter weight. Since the 1980s, crossbreeding has been started using beef-type taurine bulls, such as Simmental and Limousin, as male genetic donors through an artificial insemination program (Widyas *et al.*, 2018).

Furthermore, consideration of utilizing other taurine breeds began in 2013 with the introduction of Belgian Blue (BB) cattle. The BB breed has the advantage of prominent muscle development in particular body parts known as double-muscle cattle. The double muscle phenomenon in BB cattle would impact increasing carcass weight and percentage (Bittante *et al.*, 2023; Purchas *et al.*, 1992). BB cattle have color variations ranging from white (all white), black (pie-black), black and white (black-white), and gray (pie-blue) (Mason, 1996). Adult male BB cattle can reach a weight of 1,100- 1250 kg, while adult females can weigh 850 – 900 kg (Porter, 2020). BB cows are not resistant to hot and humid climates (Baena *et al*., 2019), so they require good maintenance with good quantity and quality of feed. High environmental temperatures increase body temperature, causing productivity to decrease and reproduction to be disrupted (Seifi-Jamadi *et al*., 2020). In addition, one of the weaknesses of BB cattle is their high birth weight, which causes dystocia and the need for cesarean section (Bellinge *et al*., 2005). The crossbreeding program between Belgian Blue and local cattle is expected to reduce the risk of dystocia.

Livestock growth performance is reflected in body weight and size (Chalid *et al*., 2023; Praharani *et al*., 2019). Body measurements are important to characterize the breed of cattle (Hailu and Getu, 2015). Linear body measurement in cattle is associated with reproductive and productive performance. According to the previous reports, there were significant differences in body measurements due to breed, age, sex, nutritional condition, and environmental factors (Bittante *et al*., 2018; Bunning *et al*., 2019; Domingo *et al*., 2015; Manzi *et al*., 2018).

The BB crossbreeding program with local cattle is expected to produce better offspring with higher growth performance (Primananda *et al*., 2021). The performance of purebred Indonesian BB and their crossbred F1 offspring, especially in Indonesian livestock breeding centers, has not been intensively studied. Therefore, this study aimed to evaluate the growth performance of the Indonesian breed of BB and its crossbred F1 offspring (BB x Brahman, BB x FH, and BB x Ongole Grade) in several Indonesian livestock breeding centers.

MATERIALS AND METHODS

Materials

This study used data recorded from 2018 to 2022. The data was collected from the National Livestock Embryo Center (NLEC) Cipelang in West Java Province, Livestock Breeding Center (LBC) Baturraden in Central Java Province, and Livestock Breeding Center Sembawa in South Sumatera Province. The data were obtained from 9 heads of Belgian Blue (BB) cattle (3 male and 6 female), 94 heads of BB x Brahman (BB-B) cattle (54 male and 40 female), 24 heads of BB x Friesian Holstein (BB-FH) cattle (8 male and 16 female), and 24 head BB x Ongole Grade (BB-OG) cattle (18 male and 6 female). All animals were given the same feeding management depending on their physiological statuses. The feed given is forages (elephant grass, mini elephant grass, field grass) and additional feed (concentrate), with a proportion of 10% forage and 1% concentrate of body weight.

Data collection

The collected data consisted of climate conditions and the growth performance of the purebred BB cattle and BB x local cattle F1 crosses. The climate conditions parameters comprised temperature, humidity, and temperature humidity index (THI). A thermo-hygrometer was used three times daily (at 7 a.m., 12 p.m., and 5 p.m.) to measure the microclimate in pens and paddocks. The THI was calculated using the formula from Bulitta *et al*. (2015), as follows:

$$THI = 0{,}8Tab + RH\ (tab - 14{,}4) + 46{,}4$$

Where THI = temperature humidity index, Tab = relative ambient temperature (°C), RH = relative humidity (%).

The growth performance data of BB cattle and their crossbred F1 offspring consisted of body weight (BW), body length (BL), shoulder height (SH), and chest circumference (CC) at birth, weaning (205 days), and yearling (365 days). BW was measured using a calibrated scale. BL and SH are determined using a livestock measuring stick, while CC uses a measuring tape. The BL, CC, and SH were measured as follows:

BL = distance between the *tuberculum humeralis lateralis* and the end of the *tuberculum ischiadum*; CC = wrapping the measuring tape just behind the elbow of the front leg; SH = the straight distance from the highest point of the shoulder to the ground.

Statistical analysis

The morphological size of the BB cattle and BB crossbred F1 offspring was presented in descriptive statistics. The analysis of variance used to test the effect of breeds on the morphometric traits using the formula as follows (Mattjik and Sumertajaya, 2013):

$$Yij = \mu + ai + eij$$

Where Yij = body morphometric observations, μ = overall means, ai = the effect of breed, and eij = random error.

The principal component analysis (PCA) of the body measurement was derived from the covariance matrix (Gasperz, 1992) with the model as follows:

$$Yp = a1pX1 + a2pX2 + a3pX3 + a4pX4 + \ldots + anpXn$$

Where Yp = the p principal component, a1p, a2p, ... anp = vector eigens, and X1, X2, …, Xn = observed variables.

RESULTS AND DISCUSSION

Microclimate conditions

The average daily microclimate conditions in National Livestock Embryo Center (NLEC) Cipelang, Livestock Breeding Center (LBC) Baturraden, and Livestock Breeding Center (LBC) Sembawa are provided in Table 1. Based on data, it showed that the highest temperature and humidity were in the noon and morning, respectively, at all studied locations. Temperature-humidity index (THI) was used to indicate stress and divided into alert, damage, and emergency levels (Díaz *et al*., 2020). Dimov *et al*. (2020) stated that there were four levels of environmental stress for animals based on the THI: THI values up to 74 as normal thermal comfort, 75 to 78 as alert, 79 to 83 as danger, and 84 as an emergency. The THI values of LBC Baturaden (63.3–82.9) and NLEC Cipelang (63.7–70.1) had almost similar values, indicating that both sites are relatively comfortable and have low-stress levels. Oppositely, the LBC Sembawa (THI = 66.5 – 94.6) showed a medium–high level of stress environment, which could affect the comfort of the livestock. Treatment is needed to reduce the environmental stress.

The altitude gap between the locations may cause the differences. The NLEC Cipelang and LBC Baturraden are located in the highlands and middle-land areas; hence, their THI is low. Low THI conditions are considered a suitable environment for the growth performance of *Bos taurus* cattle, which means less heat stress for the cattle. Taurus breed had poor heat regulatory capacities and higher heat loading at the skin, which caused them to evaporate substantially more heat to maintain normal body temperatures (Blackshaw and Blackshaw, 1994). Furthermore, environmentally induced hyperthermia decreases efficiency and production which reduce nutrient intake (O'Brien *et al*., 2010).

Table 1: Environmental status in study sites.

Location	Livestock breeding center baturaden	Livestock breeding center sembawa	National livestock embryo center cipelang
Altitude (mdpl)	600 – 725	10 - 20	900 – 1200
Temperature (°C)			
Morning	21.06	26.94	21.13
Noon	28.13	28.13	24.34
Night	19.06	23.94	21.14
Humidity (%)			
Morning	77.20	91.64	65.04
Noon	71.20	86.64	57.36
Night	75.20	89.64	64.81
THI	63.3-82.9	66.5-94.6	63.3-70.1

THI= Thermal Humidity Index.

Growth performance of BB cattle and its crossbred offspring

The performance of body weight and body sizes of BB cattle and their crosses is presented in Tables 2 (male) and 3 (female). The statistical test showed that the genotype of cattle significantly ($p < 0.05$) affects body weight and body measurement. Based on Table 2, male BB cattle's body weight and body sizes are higher than crossed cattle's at birth. However, after 205 days (weaning) and 365 days (yearling), the male BB cattle performance was smaller than the crossbred's. The BB-FH cattle had maximum body weight and body size performance compared to BB-Brahman and BB-OG cattle at 205 days and 365 days. The BB-Brahman and BB-OG cattle had relatively similar growth performance and body size at 205 days and 365 days.

The growth performance of the female purebred BB cattle and its crossed offspring differs slightly from the male performance, except at birth age (Table 3). The female BB cattle also had the highest BB, CC, and BL compared to the crossed offspring, except for the SH trait at birth. The female BB and BB-B cattle constantly have the highest CC and SH at all ages, respectively. The BB-FH had the maximum length for the BL trait compared to other breeds at 205 days (115,73±1,45 cm) and 365 days (129,11±1,39 cm). The female BB-OG cattle had minor points in all characteristics and age, except for the BW at birth (36,08±2,22 kg), CC and SH at 205 days (126,18±3,13 cm and 105,03±1,99 cm, respectively), and SH at 365 days (115,26±1,94 cm).

The higher performance of purebred BB cattle than the crossed cattle at birth age in this study was similar to the result reported by Praharani *et al*. (2019). In their research, the purebred BB cattle had a higher body weight and chest girth than the F1 BB x FH reared at the Dairy Goat Unit of the Indonesian Institute for Animal Production (IRIAP). The phenomenon in BB cattle may be caused by the condition of multiple muscles so that birth weight and body size are more prominent, which is caused by the influence of the myostatin (MSTN) gene (Fiems, 2012). The double muscle phenomenon appears in homozygous individuals because they have mutations in the MSTN gene, which causes hypertrophic muscle growth (Jakaria *et al*., 2021). It has been reported by Meyermans *et al*. (2022) that the 11-deletion (known as nt821(del11)) occurs in the MSTN sequence of BB cattle, which leads to a premature stop-codon and dysfunctional protein. However, several reports found that a higher birth weight leads to a higher risk of dystocia (Druet *et al*., 2014; Konovalova *et al*., 2021, 2020; Simões and Stilwell, 2021). To reduce the effect of dystocia, almost all the purebred BB offspring in Indonesia were delivered using a cesarean section procedure. In contrast, 90% of the crossbreed BB cattle in NLEC Cipelang, LBC Sembawa and Baturrated were naturally delivered.

Table 2: The growth performance of male Belgian Blue cattle and its crossbred (F1).

Variable	Genotype (N)			
	BB (3)	BB-B (54)	BB-FH (8)	BB-OG (18)
Birth				
BW (kg)	47.50±2.83[a]	34.19±0.67[c]	40.38±1.73[b]	36.89±1.16[c]
CC (cm)	83.00±2.09[a]	70.35±0.49[c]	71.13±1.28[c]	73.67±0.85[b]
BL (cm)	68.67±2.02[a]	61.90±0.50[c]	69.75±1.25[a]	64.83±0.90[b]
SH (cm)	73.00±1.76[b]	73.87±0.41[b]	71.62±1.08[c]	75.66±0.72[a]
Weaning (205 days)				
BW (kg)	154.80±15.29[c]	187.68±3.60[b]	226.84±9.36[a]	178.26±6.24[bc]
CC (cm)	118.00±4.46[c]	129.31±1.05[b]	137.41±1.90[a]	127.63±1.82[b]
BL (cm)	88.70±2.90[c]	103.95±0.67[b]	119.35±1.80[a]	102.92±1.17[b]
SH (cm)	87.00±2.40[c]	108.46±0.56[b]	110.97±1.47[a]	111.32±0.98[a]
Yearling (365 days)				
BW (kg)	240.60±17.93[b]	221.48±4.23[c]	285.10±10.98[a]	203.73±7.32[d]
CC (cm)	145.00±5.38[c]	148.90±3.29[b]	152.05±3.30[a]	144.07±2.20[c]
BL (cm)	109.00±3.38[d]	118.82±0.79[b]	129.35±2.07[a]	114.02±1.38[c]
SH (cm)	103.66±2.42[b]	120.45±0.57[a]	121.26±1.48[a]	120.85±0.98[a]

Different superscript within the same row indicated significant differences ($p < 0.05$); BW = Body weight; CC = Chest circumference; BL = Body length; SH = Shoulder height; BB = Belgian Blue; BB-B = Belgian Blue X Brahman; BB-FH = Belgian Blue X Friesian Holstein; BB-OG = Belgian Blue X Ongole Grade

Table 3: The growth performance of female Belgian Blue cattle and its crossbred (F1).

Variable	Genotype (N)			
	BB (6)	BB-B (40)	BB-FH (16)	BB-OG (6)
Birth				
BW (kg)	51.00±2.22[a]	35.35±0.85[c]	40.06±1.36[b]	36.08±2.22[c]
CC (cm)	84.25±1.94[a]	71.45±0.75[c]	74.00±1.19[b]	67.83±1.95[d]
BL (cm)	70.83±1.73[a]	62.25±0.67[b]	69.37±1.06[a]	59.17±1.73[c]
SH (cm)	74.16±1.97[a]	74.85±0.76[a]	73.43±1.21[a]	68.66±1.97[b]
Weaning (205 days)				
BW (kg)	214.15±11.68[ab]	175.02±4.52[b]	220.22±7.15[a]	166.78±11.68[bc]
CC (cm)	137.88±3.13[a]	125.35±1.21[b]	137.20±1.20[a]	126.18±3.13[b]
BL (cm)	105.65±2.37[b]	101.70±0.91[c]	115.73±1.45[a]	101.35±2.37[c]
SH (cm)	98.12±1.99[c]	107.82±0.77[a]	105.68±1.21[b]	105.03±1.99[b]
Yearling (365 days)				
BW (kg)	331.41±19.46[a]	258.45±7.53[c]	311.39±1.91[b]	221.00±9.46[d]
CC (cm)	159.45±3.90[a]	146.60±1.50[b]	156.44±2.40[a]	144.98±3.90[b]
BL (cm)	120.71±2.27[b]	117.15±0.88[c]	129.11±1.39[a]	116.00±2.27[c]
SH (cm)	108.90±1.94[c]	119.36±0.75[a]	119.36±1.19[a]	115.26±1.94[b]

Note: Different superscript within the same row indicated significant differences ($p < 0.05$); BW = Body weight; CC = Chest circumference; BL = Body length; SH = Shoulder height; BB = Belgian Blue; BB-B = Belgian Blue X Brahman; BB-FH = Belgian Blue X Friesian Holstein; BB-OG = Belgian Blue X Ongole Grade

Besides that, we suspect the environmental microclimate affects the low performance at 205 days and 365 days in BB cattle. Coopman *et al.* (2007) reported that in their original location, Belgium (sub-tropic climate), the body weight of Belgian Blue cattle at seven months old could reach 242±42 kg (male) and 189±37 kg. Then, at 13 months old, it could reach 430±70 kg and 332±78 kg for male and female cattle, respectively. Their findings were higher than the results of purebred BB cattle in this study. The BB cattle is a *Bos taurus* cattle primarily maintained in sub-tropic climates. Therefore, their performance would decrease when developed in Indonesia with a hot (tropical) climate.

In contrast with its crossed offspring, the male BB-FH cattle performed very well compared to other crosses (BB-B and BB-OG) at 205 days and 365 days of age. In producing beef in Indonesia, many crosses are carried out using *Bos taurus* cattle, which show good crossbreed performance (Putra, 2017). The FH cattle, which are

Taurean cattle, have higher meat-producing ability than Ongole Grade (OG) and Brahman cattle as medium carcasses. In addition, genetically, the first cross (F1) is the highest heterozygosity combination, thus giving a hybrid vigor effect to BB-FH crosses and other crosses compared to purebred BB cattle (Jakaria *et al*., 2021).

Based on Belgian Blue's development implementation guidelines (Permentan No. 17010/OT.050/F2.1/01/2018), the development of BB cattle should be in closed-breeding program within Indonesia's livestock breeding center. The Indonesian government is cautious in developing BB cattle because they require good maintenance and quality management to support the body's metabolism so that their superior potential can emerge. The purebred BB cattle and their crossed cattle will be monitored closely until a further recommendation from the breeding stock commission is developed throughout Indonesia. The next exploration by developing F2 and backcrossing the F2 with purebred BB males are also part of the development stages of BB cattle to evaluate its growth and reproduction performance.

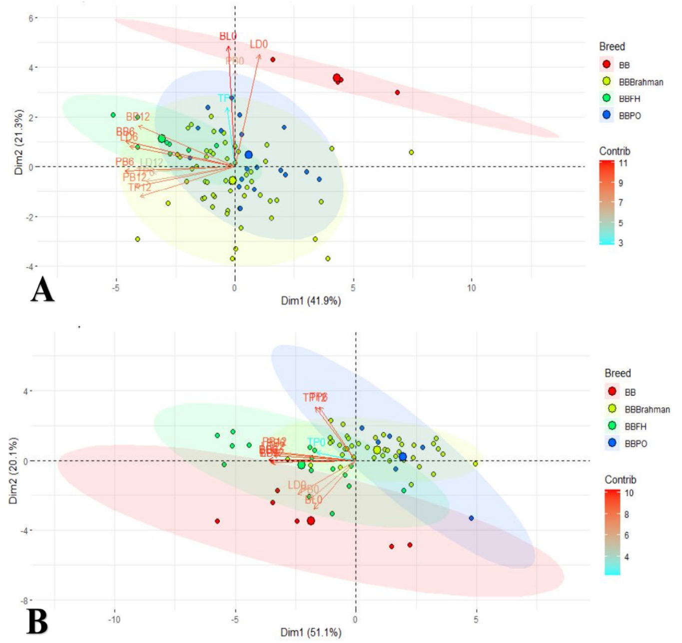

Figure 1: Principal component analysis (PCA) in BB cattle and their crosses: (A) male, (B) female.

Principal component analysis of BB cattle and its crossbred offspring

Principal component analysis (PCA) in BB cattle and their crosses (BB-B, BB-FH, and BB-OG) based on body weight and body sizes at various ages, are presented in Figure 1A (male) and 1B (female). Figure 1A shows that the results of the PCA analysis on male BB cattle are separated from their cross cattle. In addition, the male BB cattle had BB, CC, and BL variables as markers at birth. The BW205, BW365, and CC205 could be used as an identifying indicator for the male BB-FH cattle. Meanwhile, BL205, SH205, BL365, CC365, and SH365 for the male BB-B cattle were used as the characterizing variables. Figure 1B shows that the results of the PCA analysis on female BB cattle and their crosses show differences between breeds, but the differences are not separate. This proves that the double muscle trait in BB cattle is passed on to their offspring. The myostatin gene in BB cross (F1) individuals is heterozygous; specific evidence is found in the third exon of the myostatin gene (Agung *et al*., 2016). This study identifies BB cattle indicators differently from Aminurrahman *et al*. (2021). Their finding reported that the dominant contributing variables of BB cattle were body size, chest circumference, chest width, chest depth, and hip width. For the BB-PO cattle, the identifying variables were body length, shoulder height, and hip height. The PCA analysis is a refinement that can better explain correlations between biometric traits. It indicated the relative relevance of each characteristic in describing the individuals (Tolenkhomba *et al*., 2013).

Table 4: Eigenvalues and percentage of variance explained by components of male cattle.

Dimension	Eigenvalue	Variance (%)	Cumulative variance (%)
Dim.1	5.03	41.91	41.91
Dim.2	2.56	21.31	63.22
Dim.3	1.64	13.68	76.90
Dim.4	0.90	7.52	84.42
Dim.5	0.71	5.95	90.37
Dim.6	0.36	2.98	93.35
Dim.7	0.30	2.48	95.82
Dim.8	0.18	1.53	97.35
Dim.9	0.13	1.05	98.39
Dim.10	0.09	0.78	99.18
Dim.11	0.06	0.48	99.66
Dim.12	0.04	0.34	100.00

Tables 4 and 5 show the estimated factors recovered by eigenvalues and the variation explained by each component for male and female cattle, respectively. Figures 2A (male) and 2B (female) show the scree plots. In both sexes, only three factors with eigenvalues greater than one were retrieved. The first component accounted for 41.91% (male cattle) and 51.06% (female cattle) of the variation in the current study out of a total of 12 original measures. In male cattle, the first three components had eigenvalues of 5.03, 2.56, and 1.64, respectively, and explained approximately 76.90% of the total variation. Besides, the female cattle exhibited 6.13, 2.41, and 1.41 eigenvalues at similar components, with a cumulative variance of 82.89%. It was represented the significant positive high value of BW0, CC0, and BL0. Tolenkhomba *et al*. (2013) stated that these factors seemed to be explaining the body of the cow, i.e general size of the cow. Previously, there were five and six factors revealed in Zobawng bulls (Tolenkhomba *et al*., 2021) and Manipuri local cattle (Tolenkhomba *et al*., 2013). In Pasundan cattle, there were four factors of PC1, PC2, PC3, and PC4 that explained about 89.38% of the total variations (Putra *et al*., 2020).

Table 5: Eigenvalues and percentage of variance explained by components of female cattle.

Dimension	Eigenvalue	Variance (%)	Cumulative variance (%)
Dim.1	6.13	51.06	51.06
Dim.2	2.41	20.10	71.16
Dim.3	1.41	11.72	82.89
Dim.4	0.64	5.32	88.20
Dim.5	0.43	3.54	91.75
Dim.6	0.30	2.49	94.24
Dim.7	0.24	1.98	96.22
Dim.8	0.13	1.12	97.34
Dim.9	0.12	1.03	98.38
Dim.10	0.09	0.75	99.13
Dim.11	0.07	0.62	99.75
Dim.12	0.03	0.25	100.00

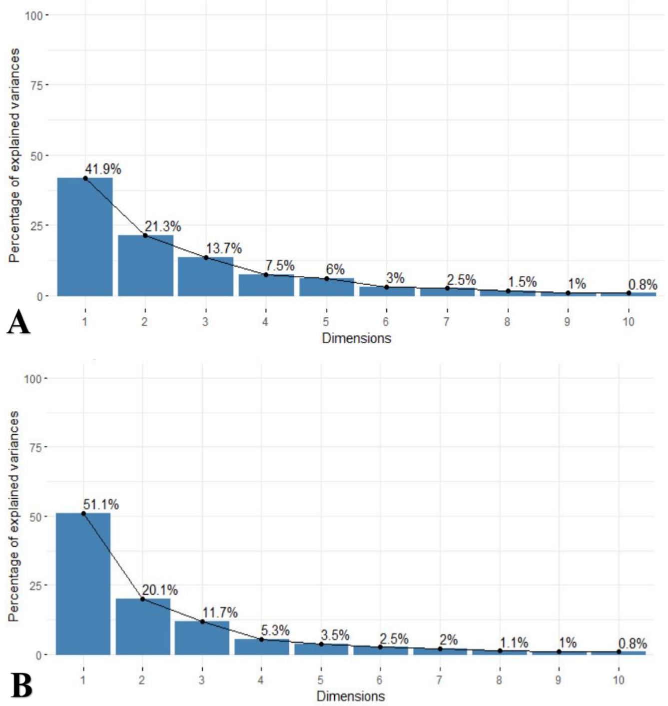

Figure 2: The scree plot: (A) male, (B) female.

It is critical to identify the key morphological features of each breed. According to Heryani *et al.* (2022), body measurement is strongly related to body weight. One of the variables strongly influencing body weight is the chest circumference and body length. Furthermore, Fourie *et al.* (2002) found that chest circumference positively correlates with growth traits, increasing shoulder height and frame size. By identifying the identical characteristics of each breed, further recommendation development programs could be done.

CONCLUSIONS AND RECOMMENDATIONS

The variation of genotype significantly affects body weight and body measurement. The BB cattle are superior on BW, CC, and BL traits at birth compared to the other genotypes (BB-B, BB-FH, and BB-OG). The factors that served as shape qualities for BB cattle were BW at birth, BW205 and CC205 for BB-FH cattle, and BL205 for BB-B cattle. Evaluation of pure BB cattle and their crosses must be done on other characteristics such as reproductive characteristics and meat quality.

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NOVELTY STATEMENT

The Belgian Blue cattle are a newly introduced breed in Indonesia and have been used as male genetic sources for crossbreeding. So far, the Belgian Blue has been crossed to the Brahman, FH, and Ongole Grade cattle. Body weight and body size are indicators of growth performance and should be evaluated at every age level. The output of this study hopefully could be a reference to the following breeding program policy of Belgian Blue cattle in Indonesia.

AUTHOR'S CONTRIBUTION

YMY, RP, and J designed and coordinated the study. RP and J supervised the experiment. YMY experimented, analyzed the data, and drafted the manuscript. RP and J took part in critically checking this manuscript. All authors read and approved the final manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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