

Original Research Paper

# Characteristics and Pre-Weaning Growth of Crossbred between Belgian Blue and Wagyu Bulls with Brahman Cross Dams

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**Abstract:** This study was conducted to observe characteristics and pre-weaning growth traits of calves born from crossbreeding between Wagyu and Belgian Blue (BB) bulls with Brahman Cross (BX) dams. The experiment was conducted to compare two different crosses Belgian Blue (BB) x BX, Wagyu x BX and also with BX pure breed (BX x BX). In the first two crosses, we used Artificial Insemination (AI), while in the third natural mating occurred. The number of calves in the experiment was 18 from the first cross (BB-crossed), 17 from the second cross (Wagyu-crossed), and 15 from the third (BX). The calves were raised together with their dams until they reached weaning age in 180 days. The data collected was analyzed by Kruskal-Wallis Test and Mann-Whitney Test for significant differences. The coat colors of BB-crossed calves were predominantly black (77.22%), and all Wagyu-crossed calves were red; whereas BX calves' coat colors vary: 37.5% black, 31.25% red, and 31.25% white. There was no significant difference among groups in body size (except the withers height) and weight at birth. The BB-crossed, Wagyu-crossed and BX calves showed the pre-weaning growth on body length of  $0.15\pm 0.03$ ,  $0.17\pm 0.03$  and  $0.11\pm 0.03$  cm/day; withers height of  $0.18\pm 0.02$ ,  $0.14\pm 0.02$  and  $0.10\pm 0.02$  cm/day; heart girth of  $0.32\pm 0.05$ ,  $0.24\pm 0.03$  and  $0.16\pm 0.03$  cm/day and daily body weight of  $0.74\pm 0.13$ ,  $0.62\pm 0.06$  and  $0.39\pm 0.11$  kg/day respectively. The average daily gain of body length on BB-crossed and Wagyu-crossed calves was higher ( $P<0.05$ ) than that of BX calves. The average withers height, heart girth, and body weight daily gain of BB-crossed calves were higher ( $P<0.05$ ) than those of Wagyu-crossed calves and Wagyu-crossed calves were higher ( $P<0.05$ ) than those of BX calves. It is concluded that crossing Brahman Cross dams with Belgian Blue and Wagyu bulls improves body size and weight gain of calves; further, crossbreeding with Belgian Blue bulls gives better improvement than that with Wagyu bulls.

**Keywords:** Belgian Blue Bulls, Brahman Cross Dam, Crossbreeding, Pre-Weaning Period, Wagyu Bulls

## Introduction

Beef is an important food for animal-origin protein sufficiency, which is why it is a strategic commodity (Agus and Widi, 2018). The Indonesian government has given a special concern concerning the national beef production and demand. The idea to obtain meat self-

sufficiency had been in government programs since 2005. Attempts were made as a response to the program but the result is far from satisfactory. The main problem with achieving food security in Indonesia nowadays relies on the fact that there is a disequilibrium between supply and demand. Along with population and income growth as well as changes in food preferences, national meat consumption

is constantly increasing over time; beef production, however, has yet to be sufficient. Directorate General of Livestock and Animal Health, Minister of Agriculture of the Republic of Indonesia (2020) reported that the national beef demand was 717,150 tons; whereas the production was 422,533 tons or only 58%; the and the gap was filled with importations of both cattle and/or frozen meat.

Cattle importation to Indonesia is mainly dominated by Brahman Cross (BX) from Australia. These cattle have larger body frames and faster growth when compared to local cattle. They also possess high tolerance towards hot climates and feed of low quality while having better parasites resistance than their *Bos taurus* ancestors. BX was also preferred to be imported due to their stock abundance and relatively cheaper price (Sutarno and Setyawan 2015; Priyadi *et al.*, 2017). Attempts to increase national meat production can be attained by population expansion and/or by improving the cattle's genetics. Crossbreeding is a common practice to genetically improve beef cattle within a short period. According to the genetic impact assessment by Widi *et al.* (2021), crossbreeding utilizing exotic cattle breeds as male genetic resources contributed to the increase in beef cattle production in Indonesia.

The introduction of improved sire breeds in a population of local female cattle is expected to yield offspring with better performance concerning the dam's population, possibly as an effect of heterosis (Agung *et al.*, 2016). Improved cattle breeds suitable as sires in crossbreeding programs with BX are Belgian Blue and Wagyu. Belgian Blue cattle excel in its meat production due to its double muscle property (Fiems 2012; Agung *et al.*, 2016), whereas Wagyu has high meat quality in terms of marbling (Motoyama *et al.*, 2016). It is expected that crossbreeding between BX dams with these improved exotic cattle shall yield crossbred offspring which acquired both adaptability and high productivity from their two distinct ancestors (Agung *et al.*, 2016; Priyadi *et al.*, 2017; Hartatik *et al.*, 2020).

As a means to support the success of a crossbreeding program, continuous monitoring and evaluation of the offspring's characteristics and productivity is required. Exterior characteristic is defined as directly observable, measurable, and describable traits that distinguish cattle classification and become basic information in the cattle's development (Rahmawati *et al.*, 2022). Among measurable production, traits are pre-weaning growth. Growth by definition is a change in body measurements that comprise live weight gain, shape, linear body dimensions, and body composition including changes in body components. Pre-weaning growth is a critical phase after birth during which the calves are highly dependent on the dams' condition. The mortality rate during this period is also considerably high; which is why it was defined as a critical period in a cattle's life

(Maulana *et al.*, 2018; Baliarti *et al.*, 2020; Budisatria *et al.*, 2021). Crossbreeding between BX dams and Belgian Blue and Wagyu sires had been conducted; reports of their crossbred offspring, however, were yet to be published. The objective of this study is hence to present the characteristics and pre-weaning growth performance of crossbred between Belgian Blue and Wagyu sires with BX dams.

## Materials and Methods

### *Ethical Clearance*

The design of this research has been approved by the Research Ethics Commission, The Faculty of Veterinary Science, Universitas Gadjah Mada, Yogyakarta (No: 0065/EC-FKH/EKs/2020).

### *Research Location and Materials*

The experiment was conducted at PT. Widodo Makmur Perkasa, Klaten, Central Java. The experiment was conducted to compare two different crosses. Belgian Blue x BX, Wagyu x BX and also with BX pure breed (BX x BX). In the first two crosses, we used artificial insemination (AI), while in the third natural mating occurred. The number of calves in the experiment was 18 from the first cross (BB-crossed), 17 from the second cross (Wagyu-crossed), and 15 from the third (BX). The dam selection was based on recording in the research location (breeding company), namely: Age  $29.08 \pm 7.20$  months (first parity), body weight  $360.67 \pm 45.19$  kg, and body conditioning score of 3. BB.

### *Animal Maintenances*

Calves were reared along with their dams until weaned at six months of age. Calves along with their dams were grouped in pens according to their sires' breed with standard management practices. The pens held the cattle in groups, open (no full walls), with monitor roof type, concrete floor, and intact feeding and water banks. The pen's floor was layered with sawdust and cleaned every two weeks. The sawdust served as bedding and absorbed the water content from urine and feces. The same amount and quality of feed were given to the cattle. The feed consisted of commercial concentrate, king grass, and rice straw. The experimental feed was given twice a day and compositions were formulated according to NRC (2018). The daily ration for each dam consisted of commercial concentrate (5.6 kg), chopped king grass (5 kg), and rice straw (7 kg). The calves were given feed similar to the dams after three months of age as creep feeding with the following ration: Concentrate (2.6 kg), chopped king grass (1.5 kg), and rice straw (2 kg) per head per day until the age of six months. Water was provided ad libitum and deworming was conducted in pre-weaning when the calves were at the age of three months. The Nutritional contents of the feed showed in Table 1.

### Data Collection

The data observed in this research inclusive of exterior characteristics (coat colors) and pre-weaning growth on body weight and body measurements. Coat colors were observed on the crossbred calves from birth to six months (180 days) of age based on the most dominant color (s). Body weight and body size measurements were conducted every 60 days from birth to weaning. The calves were weighed every morning before feeding using a cattle scale (Kenko KK-300, Indonesia) integrated with the crate, with a capacity of 2.500 kg and a precision of 0.5 kg. The measured body size variables were including wither height, body length, and heart girth. The measurements were conducted when the calves stood straight on all four, the body positioned in the parallelogram within the crate using a measuring stick and a measuring tape (Agrilab Indonesia, accuracy 0.05 cm). Gain data was obtained by calculating the difference between initial (birth) and final (weaned) values of each variable divided by the number of days of observations (180 days).

### Data Analysis

The adjustments were required before comparisons were made between male and female cattle. Body weight and body measurements data were adjusted towards male cattle following the formula of Hardjosubroto (1994); where

$$Adjusted = observed_{female} \times \frac{observed_{male}}{observed_{female}} \quad \text{Coat colors}$$

were presented as a percentage; whereas body weight and body measurements data were analyzed by Kruskal-Wallis Test and continuing with Mann-Whitney Test for significant differences. The statistical analyses were conducted in Statistic Package for the Social Science (SPSS) version 16.0.

## Results

### Exterior Characteristics

Coat colors of the BB-crossed, Wagyu-crossed, and BX calves were presented in Table 2. The coat colors of BB-crossed calves were predominantly black (77.22%), and all Wagyu-crossed calves were red; whereas BX calves' coat colors varied: 37.5% black, 31.25% red, and 31.25% white.

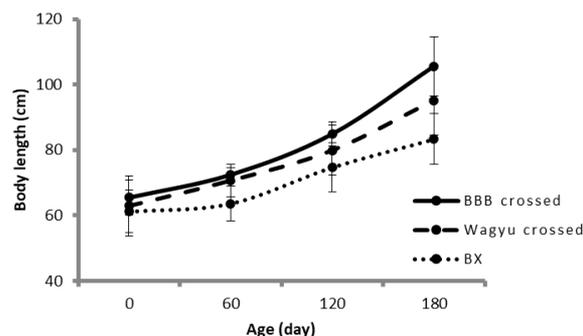
### Birth Weight

The dam's body weight at the time of delivery, calves' birth weight, and their fractions of BB-crossed, Wagyu-crossed, and BX were presented in Table 3. The birth weight of BB-crossed, Wagyu-crossed, and BX were  $31.43 \pm 5.75$ ;  $30.62 \pm 9.76$ , and  $29.49 \pm 7.09$  kg respectively; there were no significant differences

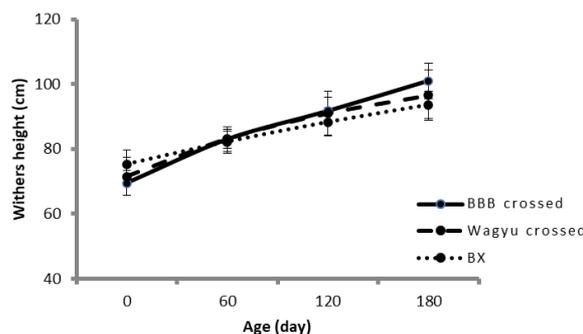
among groups. The fraction of calves' birth weight on the dam's body weight at the time of delivery was  $7.54 \pm 1.83$ ;  $6.32 \pm 1.18$  and  $7.60 \pm 2.65$  for BB-crossed, Wagyu-crossed, and BX respectively; there were no significant differences among groups. Table 3 showed that the BX dams had considerably similar body weights among groups, hence, the calves' birth weight did not differ significantly.

### Pre-Weaning Growth

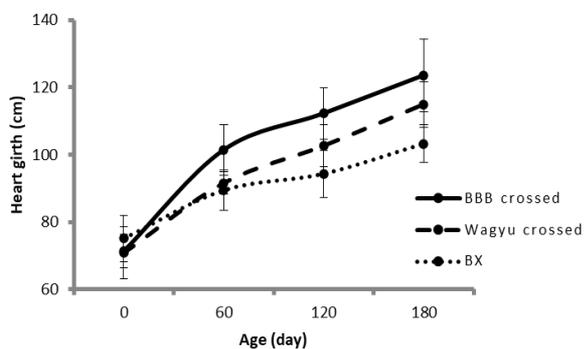
The observation of pre-weaning growth included body measurements (body length, wither height, and hearth girth), and body weight in this study is presented in Table 4. The significant differences in the growth traits among the three experimental (born, weaned, and gain) were only observed on the wither's height parameter. The withers height of BB-crossed calves was lower than Wagyu-crossed calves ( $P < 0.05$ ) and the wither height of Wagyu-crossed calves was lower than BX calves ( $P < 0.05$ ) at birth. On the contrary, the withers height of BB-crossed calves was higher than Wagyu-crossed calves ( $P < 0.05$ ) and the wither height of Wagyu-crossed calves was similar to BX calves.



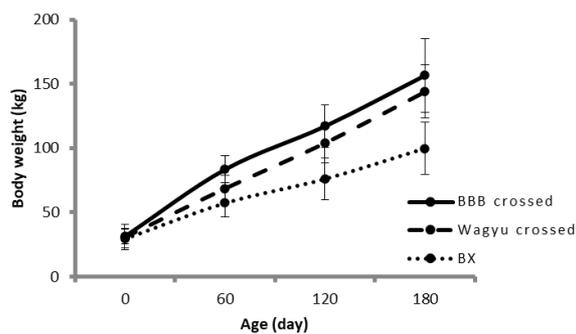
**Fig. 1:** Body length of BB-crossed, Wagyu-crossed, and Brahman-crossed calves from birth to weaning (mean  $\pm$  standard deviation)



**Fig. 2:** Withers height of BB-crossed, Wagyu-crossed, and Brahman-crossed calves from birth to weaning (mean  $\pm$  standard deviation)



**Fig. 3:** Heart girth of BB-crossed, Wagyu-crossed, and Brahman-crossed calves from birth to weaning (mean ± standard deviation)



**Fig. 4:** Body weight of BB-crossed, Wagyu-crossed, and Brahman-crossed calves from birth to weaning (mean ± standard deviation)

**Table 1:** Nutrient contents of the feed

Nutrient contents	Feedstuff			
	Concentrate	Total King grass	Rice straw	
Dry matter (%) <sup>a</sup>	91.69	26.13	92.80	
Organic matter (%) an	89.62	8.72	81.90	
Crude protein (%) an	18.09	4.88	4.20	
Crude fat (%) <sup>a</sup>	3.70	1.62	1.40	
Crude fiber (%) <sup>a</sup>	14.12	39.81	35.10	
Organic matter without N (%) <sup>a</sup>	53.70	44.97	41.20	
TDN (%) <sup>b</sup>	42.15	53.94	49.80	
Feed provision (kg)	5.60	5.00	7.00	
Dry matter (kg)	5.13	1.31	6.50	12.94
Organic matter (kg) <sup>a</sup>	5.02	0.44	5.73	11.19
Crude protein (kg) <sup>a</sup>	1.01	0.24	0.29	1.55
Crude fat (kg)	0.21	0.08	0.10	0.39
Crude fiber (kg)	0.79	1.99	2.46	5.24
Organic Matter without N (kg)	3.01	2.25	2.88	8.14
TDN (kg)	2.36	2.70	3.49	8.54

<sup>a</sup>Proximate analysis of Animal Nutrition Laboratory, Faculty of Animal Science UGM

<sup>b</sup>calculated with formula by Hartadi *et al.* (2005)

TDN: total digestible nutrient

**Table 2:** The coat colors of BB-crossed, Wagyu-crossed, and BX calves

Coat colors	Breed		
	BB-crossed	Wagyu-crossed	BX
Predominantly black (%)	72.22	-	37.50
Red (%)	11.11	100	31.25
White (%)	-	-	31.25
Black with white spots (%)	16.67	-	-

**Table 3:** Dam's body weight at the time of delivery, calves birth weight, and their fractions in percentage (mean ± standard deviation)

Variable	Breed		
	BB-crossed	Wagyu-crossed	BX
Body weight of dams at the time of delivery (kg) <sup>ns</sup>	429.08±61.580	381.00±47.550	383.30±57.150
Birth weight of calves (kg) <sup>ns</sup>	31.43±05.750	30.62±09.760	29.49±07.090
Fractions (%) <sup>ns</sup>	7.54±01.830	6.32±01.180	7.60±02.650

<sup>ns</sup>non-significant

**Table 4:** Pre-weaning growth of BB-crossed, Wagyu-crossed, and BX calves (mean ± standard deviation)

Variable	Breed		
	BB-crossed (n = 18)	Wagyu-crossed (n = 17)	BX (n = 15)
<b>Body length</b>			
Born (0 days) (cm) <sup>ns</sup>	65.48±5.39	62.94±09.12	61.20±6.53
Weaned (180 days) (cm)	105.52±8.98 <sup>a</sup>	95.15±10.73 <sup>b</sup>	83.35±7.84 <sup>c</sup>
Gain (cm/day)	0.22±0.05 <sup>a</sup>	0.18±00.03 <sup>b</sup>	0.12±0.03 <sup>c</sup>
<b>Wither height</b>			
Born (0 days) (cm)	69.44±3.79 <sup>a</sup>	71.47±5.83 <sup>a,c</sup>	75.25±4.32 <sup>b,c</sup>
Weaned (180 days) (cm)	100.99±5.44 <sup>a</sup>	96.56±7.80 <sup>a,b</sup>	93.62±4.22 <sup>b</sup>
Gain (cm/day)	0.18±0.03 <sup>a</sup>	0.14±0.02 <sup>b</sup>	0.10±0.02 <sup>c</sup>
<b>Heart girth</b>			
Born (0 days) (cm) <sup>ns</sup>	71.31±04.95	70.85±7.86	75.11±6.85
Weaned (180 days) (cm)	123.50±10.80 <sup>a</sup>	114.89±6.79 <sup>b</sup>	103.27±5.67 <sup>c</sup>
Gain (cm/day)	0.29±00.06 <sup>a</sup>	0.24±0.03 <sup>b</sup>	0.16±0.03 <sup>c</sup>
<b>Body weight</b>			
Born (0 days) (cm) <sup>ns</sup>	31.43±05.75	30.62±09.76	29.49±07.09
Weaned (180 days) (cm)	156.48±28.64 <sup>a</sup>	144.04±20.56 <sup>a</sup>	99.83±20.23 <sup>b</sup>
Gain (kg/day)	0.69±00.16 <sup>a</sup>	0.63±00.11 <sup>a</sup>	0.39±00.11 <sup>b</sup>

<sup>a,b,c</sup> Different superscripts in the same row indicated significant difference (P<0.05)

<sup>ns</sup>non-significant

The average daily gain from birth to weaning (180 days) on withers height, body length, and heart girth on BB-crossed calves was significantly higher (P<0.05) than Wagyu-crossed calves; and Wagyu crossed calves were higher (P<0.01) BX calves (Table 4). The average daily gain of body measurement variables of BB-cross calves was the highest; followed by Wagyu-crossed and then BX; which showed that the crossbred between Belgian Blue sires and BX dams produced calves with the best pre-weaning growth. The pre-weaning daily growth of BB-crossed, Wagyu-crossed, and BX are presented in Fig. 1-4. It is visible that the crossbred calves showed better growth rates compared to BX calves. With approximately similar birth weight, while accounting for the accumulated growth rate, it is expected that the crossbred calves would have a higher weaning weight compared to BX.

## Discussion

### Exterior Characteristics

Coat color is a trait that can define exterior characteristics qualitatively (Rahmawati *et al.*, 2022). There were no BB-crossed calves with white coat color (Table 2); this result differed from an experiment by Jakaria *et al.* (2020) which reported that calves from the mating between Belgian Blue sires and Ongole Grade (PO) dams had white coat color (11.11%) and black and white coat color (88.89%). The sires in these experiments all had black and white color whereas the dams were 90% all white and 10% spotted (black and white). Adi *et al.* (2019) reported that 50% of the crossbred between Belgian Blue sires and Sumba Ongole were black and the other 50% were spotted (black-white).

Based on Table 2, the coat color of Wagyu-crossed calves was all red. This result was different patterns than

that of Adi *et al.* (2019) who reported that crossbred offspring of Wagyu sires were 25% dark brown and 75% blackish-brown. The coat color patterns of Wagyu-crossed followed the paternal lineage which is of the Wagyu breed and with coat colors of brown to reddish black (Armstrong, 2018). According to Ofori *et al.* (2021), coat colors and patterns are related to adaptation and heat regulation mechanisms. Dark-colored coats absorbed more environmental heat compared with the lighter-colored ones. Hence, cattle with dark coat colors are susceptible to heat stress which disturbs their metabolic processes and enhance the thyroid hormone activity; this is counterproductive as it might interfere with feed intake in growth, especially in the tropics and even so with the occurrence of climate change. According to Bedada *et al.* (2019), uniformity of coat color indicates low variation due to selective breeding and/or environment. Coat color is important as it contributes to the regulation of physiological processes and cattle's adaptation to a specific environment. Monau *et al.* (2018) mentioned that coat color also acts as a protective measure against external factors; such as protecting the inner parts of the body against excessive solar radiation. Spotted or mixed coat color can be beneficial in an environment where the weather fluctuates.

### Birth Weight

The dam's body weight at the time of delivery were no significant differences among groups. The mean of the dam's body weight at the time of delivery in this study is in agreement with Maylinda and Wahyuni (2020); they reported that the body weight of BX dams at the time of delivery was 429.71±54.1 kg. Table 3 showed that the BX dams had considerably similar body weights among

groups, hence, the calves' body weight has not differed significantly. There is, however, a tendency for positive correlations between the dam's body weight and the calves' birth weight (Muslim *et al.*, 2013; Maylinda and Wahyuni, 2020). Muslim *et al.* (2013) reported that the body weight of BX dams affected the calves' body weight as much as 22% on male calves and 24.6% on female calves; hence, every 1 kg difference in a dam's body weight is equal to the increase in calves birth weight of 0.03 kg. Maylinda and Wahyuni (2020) reported that the dam's body weight had an influence of 33.5% on the calves' birth weight or every 1 kg increase in the dam's body weight is equal to an increase of 0.04 kg in the calves' birth weight.

The crossbred calves' birth weight was not significantly different from the BX calves. Preceding studies mentioned that the birthweight of Brahman's calves was 30 to 33 kg (Browning *et al.*, 1995), and Wagyu calves were 31 kg (Greenwood *et al.*, 2006) to 37 kg (Cases and Cundiff, 2014). The birth weight of Belgian Blue calves was around 42.4 to 51.4 (Cases and Cundiff, 2014); whereas crossbred calves between Belgian Blue and Zebu were around 35.3 kg (Nogueira *et al.*, 2016) to 42.3 kg (Cases *et al.*, 2011). The calves' birth weights of the three experimental groups in our study were relatively lower compared to the previous studies.

The birth weight of BB-crossed calves in this study was considerably similar to the crossbred calves between Belgian Blue sires and Sumba Ongole (SO) dams, which was  $31.33 \pm 4.93$  kg (Aji *et al.*, 2017) because the effect of the mutation in the myostatin gene in Belgian Blue (Charlier *et al.*, 1995). Arthur (1995) reported that the birth weight of double-muscled cattle crossed with conventional cattle was 26.9-34.7 kg; whereas calves from both double-muscled parents were 31.9-42.2 kg. The average birth weight of male Belgian Blue calves was 43.9 while female calves were 40.8 kg (Casas *et al.*, 2011). Aji *et al.* (2017) stated that in Indonesia, the birth weight of Belgian Blue crossbred calves is similar to the crossbred calves from other exotic breeds. The double muscle trait was not observable, because the mutation in the myostatin gene in Belgian Blue calves occurred when they reached one month of age. The fraction of calves' birth weight on the dams' body weight (in percentage) on local cattle was 5.2% in Bali cattle (Maulana *et al.*, 2018) and 5.7% in BX (Maylinda and Wahyuni, 2020).

### Pre-Weaning Growth

The withers height of BB-crossed calves was lower than Wagyu-crossed calves ( $P < 0.05$ ) and the wither height of Wagyu-crossed calves was lower than BX calves ( $P < 0.05$ ) at birth. Hence, crossbreeding with both Belgian Blue and Wagyu has yielded no improvement

about withers height. Theoretically speaking, Belgian Blue cattle have a larger body frame compared to Wagyu, the results of this study, however, proved otherwise. The calves' withers height in this study is not in agreement with the paper from Buchanan and Lenstra (2015), which mentioned that Wagyu cattle have small to medium body frames; whereas BX and Belgian Blue have medium to large body frames. The body measurements of BB-crossed and Wagyu-crossed in this study are similar to those of calves from Sumba Ongole dams inseminated with BB semen; their wither height, body length, and heart girth were  $68.33 \pm 4.57$ ;  $64.66 \pm 4.16$  and  $71.68 \pm 1.54$  cm respectively (Aji *et al.*, 2017). Recent results obtained in Brazil in the state of Goyas indicate the birth weight of Belgian Blue x Zebu Nelore crosses is on average 41.1 Kg. (Medeiros and Leroy, 2021)

The average daily gain of body measurement variables of BB-cross calves was the highest; followed by Wagyu-crossed and then BX; which showed that the crossbred between Belgian Blue sires and BX dams produced calves with the best pre-weaning growth. According to Ngadiyono *et al.* (2019); Budisatria *et al.* (2021), growth is affected by genetic and environmental factors and the interactions between both. In this study; the environmental effect was controlled; hence, any differences in the growth parameters are assumed to be affected solely by genetic factors. Belgian Blue cattle have a mutant copy of the myostatin gene which is responsible for the double muscle trait; hence, the crossbred calves have a better growth rate.

The average daily body weight gain of BB-crossed and Wagyu-crossed did not differ significantly ( $0.69 \pm 0.16$  and  $0.63 \pm 0.11$  kg/day); higher than that of BX calves ( $0.39 \pm 0.11$  kg/day). These results are in agreement with the previous studies; Adi *et al.* (2019) reported that the average daily body weight gain of BB x BX and Wagyu x BX calves accumulated up to 90 days was  $85.32 \pm 2.85$  dan  $88.25 \pm 2.43$  cm; higher than the results of this study. Coopman *et al.* (2007) reported that the average daily weight gain for Belgian Blue cattle was 0.31 until 1.08 kg/day, but their crossbred calves have it lower. Cafe *et al.* (2009) reported average daily weight gain of Wagyu cattle was 0.71 kg/day. Based on Fig. 1 and 4, it is visible that the crossbred calves showed better growth rates compared to BX calves. With approximately similar birth weight, while accounting for the accumulated growth rate, it is expected that the crossbred calves would have a higher weaning weight compared to BX. Aji *et al.* (2017) reported that the birth weight of Belgian Blue crossbred calves is similar to that of crossbred calves with conventional sires.

The average daily gain of body measurement variables has similar patterns; where BB-crossed calves were the highest, followed by Wagyu-crossed and then BX. The withers height measurement, body length, and hearth girth of BB-crossed calves were higher ( $P < 0.05$ ) compared to

Wagyu-crossed and BX. Meanwhile, the weaning weight of BB-crossed and Wagyu-crossed calves was not significantly different, but higher ( $P < 0.05$ ) than the weaning weight of BX calves. Withers height of Wagyu-crossed calves was similar to BX calves; withers height is a variable in classifying cattle type. Wagyu cattle were classified as having a small to medium body frame with a moderate growth rate (Buchanan and Lenstra, 2015). These facts are not a problem because the goal of rearing Wagyu cattle is to produce premium meat at a higher price in the market (Gotoh *et al.*, 2014).

BB-crossed calves have larger body sizes which is a combination of both parents. Buchanan and Lenstra (2015) stated that Brahmas is classified as a breed with medium to large body size with moderate growth rate; whereas Belgian Blue is classified as a large cattle breed with high growth rate and high feed efficiency. It is related to the fact that Belgian Blue cattle carry mutant copies of the myostatin gene defect that causes muscle fiber hyperplasia; hence, the muscle mass increased up to 20% (Albrecht *et al.*, 2006). The weaning weight of the crossbred calves in this study was higher than that of BX cattle under an intensive farming system in Central Java which was  $121.32 \pm 32.87$  kg but smaller than BX calves under a palm-oil integrated farming system in South Kalimantan, which was  $174.28 \pm 20.74$  (Widi *et al.*, 2019).

## Conclusion

It can be concluded that the crossbreeding between Belgian Blue and Wagyu sires with BX dams managed to improve the body size and average daily gain of the calves. Crossbreeding with Belgian Blue sires gave better improvements compared to Wagyu sires.

## Acknowledgment

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## Author's Contributions

**Panjono:** Conceived and planned the experiments, carried out the experiments, took the lead in writing the manuscript, interpretation of the results, and also revised the manuscript.

**Ali Agus, Tety Hartatik, Sigit Bintara, Ismaya, Budi Prasetya Widyobroto and I Gede Suparta Budisatria:** Conceived and planned the experiments, contributed to the interpretation of the results and also provided critical feedback, and helped shape the research, analysis, and manuscript.

**Pascal Leroy and Nicolas Antoine-Moussiaux:** Contributed to the interpretation of the results and also

provided critical feedback and helped shape the research, analysis, and manuscript.

## Conflict of Interest

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organizations related to the manuscript.

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