Pre-weaning growth performance of F1 and F2 Katjang-Boer crossbreds fed formulated creep feed

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Abstract

The local indigenous Katjang goat is highly prolific but has a small body size and poor growth performance compared to exotic breeds such as the Boer of South Africa. The need for an improved local breed to cater for local market led to a crossbreeding program between Boer and Katjang goats implemented through the 11th Malaysia Development Project. The objective of this study was to describe the pre-weaning growth performance of the F_1 and F_2 crosses of Katjang and Boer (KxB) goats fed diets formulated to meet their requirements. A total of 13 F_1 KxB kids (6 males and 7 females) from the mating of selected purebred Boer females with Katjang males, were kept with their dams and fed formulated creep feed *ad libitum.* Following that, a total of 21 F_2 KxB kids (12 males and 9 females) were sourced from the *inter se* mating program of selected F_1 KxB goats. The weaning weight at 16 weeks for F_1 was lower at 11.47 ± 3.92 kg compared to the F_2 at 12.76 ± 3.27 kg, which indicated better performance of the F_2 through *inter se* breeding however no significant difference were found. The lower feed intake in F_2 compared to F_1 also suggests better feed conversion ratio. Overall, the study demonstrated the improvements in the performance of the F_2 via *inter se* mating and therefore certifying the objectives of the crossbreeding program.

Keywords: Katjang x Boer (KxB) kids, F_1, F_2, feed intake, bodyweight, average daily gain

Introduction

The self-sufficiency level of goat meat in Malaysia has significantly dropped from 15.2% in 2015 to 10.0 % in 2019 with a concurrent decline in goat population from 431,651 in 2015 to 371,747 in 2019 (DVS, 2020). The major challenges to the goat industry are low supply of quality breeding, slaughter stock and readily available feeds which meet the animals' requirements. The local indigenous Katjang goat is highly prolific (Ernie et al., 2010) but has a small mature size of 28.1 – 28.8 (Tsukahara et al., 2008) with poor growth performance of 8 kg (Anothaisinthawee et al., 2010) compared to other improved goat breeds such as Boer crosses in Malaysia of 22 kg (Syahirah et al., 2016) at 3 months. In recent years, the Boer goat has been identified as a potential goat breed based on its robust adaptability to varied environmental conditions (Hirooka et al 1997; Erasmus, 2000) with high growth rate and reproductive performance (Hifzan et al., 2018). In a comparative study it was found that the mature weight of the male and female Boer goats was 80 and 60 kg, respectively, compared to the Katjang at 25 and 20 kg, respectively, whereas, Boer x Katjang crossbred goats reached maturity at 35 and 25 kg for male and female, respectively (DVS, 2013).

Following these findings, almost 64,658 commercial grade Boer goats were imported into the country between 2005 to 2010 following the establishment of several purebred Boer breeding farms (DVS, 2013). To support these established commercial Boer goat breeding farms, the National Boer Breeding Centre was established in Pondok Tanjung, Perak (DVS, 2013) in 2009. However, the Boer goats were observed to be poorly adapted to the local environment and feed resources. Besides reduced reproductive performance (Ching and Zamri, 2010), the Boer goats were also highly susceptible to local gastro-intestinal parasitic infections (Azlina et al., 2014). It was observed that animals with a higher proportion of Boer genome (>93%) had higher growth rate but lower resistance to intestinal parasites and the reverse for Boer goats of less than 87% of boer genetic proportion (Azlina et al., 2014). These factors, besides poor nutrition, led to a drastic drop in its population and the closure of several commercial pure Boer goat breeder farms (Hifzan et al., 2018). On the other hand, the Katjang goats are more suited for humid tropical climate whereby worm burden and poor clinical conditions are commonly seen in goats during the wet season (Dorny et al., 1995).

Crossbreeding provides an opportunity to increase production by combining the desirable traits of two or more breeds and taking advantage of heterosis (Anothaisinthawee et al., 2010). Several attempts were made to crossbreed the Boer with other breeds to utilize its superior genetic resources, in particular the Katjang breed (DVS, 2013; Hirooka et al 1997; Anothaisinthawee et al., 2010). In addition, crossbreeding was also undertaken to obtain an ideal matured weight of 45-55 kg which is more marketable during religious festive seasons, especially for the Malay and Indian community in Malaysia (Hifzan et al., 2018). As the number of Katjang goats is on the decline, hybridization offers a genetic rescue option to increase the fitness of a small and inbred population of goats (Fitzpatrick et al., 2020) which was attempted by the government.

Since hybridization can also cause genetic erosion and outbreeding depression, it is essential to have adequate information on the genetic composition of successive *inter se* generations arising from a crossbreeding programme. In fact, the FAO recommends that for a new breed developed from systematic *inter se* crossing, at least three generations (up to F_3) of *inter se* mating are required after the desired breed proportions are obtained (FAO, 2013). On the other hand, Paim et al. (2020) observed a minimal of five generations for developing the American Brangus breed composite. Most published reports have generally reported as Boer crosses without specifying the genetic makeup and almost scarce information on their successive breeding generations (Fn). Besides genetic composition, the animals also have to have access to sufficient nutrients to ascertain their genetic potential. The information on the nutrients offered and required by the Boer goats is widely available (MLA, 2008) but that of the crossbreds is scarce. The objectives of this study were to describe the pre-weaning growth performance of the F_1 and F_2 crosses of Katjang - Boer crossbred kids fed formulated diets that meet their nutrient requirements.

Materials and Methods

The development of a composite Katjang x Boer (KxB) goat breed was initiated by the Malaysian Agricultural Research and Development in the Kluang station, Johor by mating Boer (B) does with Katjang (K) bucks to produce F_1 progeny of Katjang x Boer (KxB) goats. Full blood Boer does were selected base on criteria described in MLA (2008) where else Katjang buck was selected base on criteria described by Hifzan et al., (2018) and Ernie et al., (2010). A total of 25 does were employed in a batch mating system with a single buck. A total of 12 F_1 KxB kids (6 males and 6 females) were kept with their dams and fed formulated creep feed ad libitum (Table 1). The kid nutrient requirements were based on the recommendations of Kearl (1982). The kids had free access to creep feed and their dams for milk. The dams were fed a commercial feed at 3.5 % of their body weight as dry matter with 60% from fresh Signal grass (*Bracharia Brach humidicola*) forage. The forage was offered at 0900 and 1400 hrs while concentrates at 1030 and 1530 hrs. All kids were weaned at 16 weeks of age.

For the F2 generation study, a total of 12 F_2 KxB kids (6 males and 6 females) were sourced by *inter se* mating of selected F_1 KxB goats base on phenotypic criteria described by Bahtiar et al., (2019). A similar protocol for the F_1 was followed for both the dams and the kids. Bodyweight (BWT) and average daily gain (ADG) data were analyzed with JMP Pro 13 using two-way analysis of variance (ANOVA) to study the interaction between gender and generation in KxB goats. Data of feed intake were presented in a descriptive manner. Samples of creep feed, dam feed and *Bracharia humidicola* were taken randomly for proximate analysis at the Technical Service Centre, MARDI, Serdang and nutritive values derived as described by Harris et al., (1972), McDowell et al. (1974) and Devendra (1979).

Table 1: Creep feed formulation

Ingredient (% DM)	Creep feed
Corn Dried Distiller Grain (%)	12.12
Wheat pollard (%)	16.16
Corn (%)	29.39
Soybean meal (%)	16.16
Molasses (%)	3.03
Soybean hull (%)	16.16
Mineral premix (%)	1.21
Skim milk (%)	3.84
Crude Palm Oil (%)	0.91
CaCO3 (%)	1.02

Result and Discussion

Nutrient composition (Table 2) showed that creep feed had high content of metabolisable energy (ME) and crude protein (CP) of 13.14 MJ/kg and 20.82% respectively. Fibre content of formulated creep feed were lower with crude fibre (CF), neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) of 5.33%, 37.84%, 9.47% and 2.39% respectively. Though there were many factors affecting the digestion of creep feed, it was argued that higher content of effective fibre would increase rumen motility, muscularization and rumen volume and subsequently it was found these kid had thicker rumen muscular layer (Htoo et al., 2018). Reported creep feed formulation has a proximate content of CF below 15%, CP above 14% and ME above 10 MJ/kg concurrent to current finding of the nutrient composition of formulated creep feed (Htoo et al. 2015; Zalikha et al., 2019).

Table 2. Nutrient composition of dam feed and kids creep feed (mean ± standard).

Ingredient (% DM)	Creep feed	Commercial Dam Feed	Forage (*B. Humidicola)*
Metabolisable Energy (MJ/kg)	13.14 ± 0.36	9.78 ± 1.24	6.43 ± 0.83
Crude Protein (%)	20.82 ±3.41	13.92 ± 2.21	5.84 ± 0.44
Ether Extract (%)	3.64 ±0.49	3.13 ±2.26	1.52 ± 0.69
Crude Fibre (%)	5.33 ±0.31	21.20 ± 2.76	39.10 ±1.44
Dry matter (%)	87.17 ±0.84	88.42 ± 0.53	19.80 ±0.90
Ash (%)	5.26 ±0.51	7.13 ± 0.90	4.74 ±0.40
Neutral Detergent Fibre (%)	37.84 ±9.12	59.86 ± 5.02	83.97 ± 4.00
Acid Detergent Fibre (%)	9.47 ±1.78	32.71 ±2.98	41.42 ±0.96
Acid Detergent Lignin (%)	2.39 ±1.08	8.76 ± 0.76	6.19 ±0.55
Phosphorus (%)	0.50 ±0.03	0.40 ± 0.05	0.27 ±0.07
Calcium (%)	1.05 ±0.22	1.15 ± 0.05	0.1 ±0.05

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Body weight comparison between F_1 and F_2 generation of male and female (Table 3) revealed a significant interaction between generation and gender at 4 weeks however no significant difference was found between the mean. Though no significant difference could be found between generation and gender, however body weight of F_2 of 13.87 were higher than F_1 of 12.19. at 16 weeks.

Table 3. Bodyweight (kg) of F_1 and F_2 KxB at birth, 4, 8, 12 and 16 weeks of age

Generation	Gender	Bodyweight[1] (kg)				
		Birth	Week 4	Week 8	Week 12	Week 16
F_1	Male	2.07	5.93	8.25	11.25	14.14
	Female	2.10	3.43	5.12	7.62	10.25
F_2	Male	2.27	5.25	8.08	10.50	14.64
	Female	1.83	4.83	7.72	10.17	13.08
Pooled SEM		0.111	0.285	0.548	0.673	0.819
Mean by generation bodyweight						
F_1		2.08	4.68	6.68	9.43	12.19
F_2		2.05	5.03	7.90	10.33	13.87
Mean by gender bodyweight						
Male		2.17	5.58	8.17	10.87	14.39
Female		1.97	4.13	6.41	8.89	11.67
Pr > F[2]						
Generation		0.8829	0.5511	0.2830	0.5146	0.3223
Gender		0.3821	0.0214	0.1288	0.1597	0.1149
Generation x gender		0.3098	0.0817	0.2244	0.2381	0.4884

[1]Mean of 12 sample per group (n=6), Values within the same column with different letters are significantly different (P < 0.05).
[2] Probability associated with F statistic

Comparison of ADG (Table 4) revealed a significant interaction between gender and interactions between generation and gender. F_1 males had significantly higher ADG compared to F_2 females. Though no significant difference were found across generation, F_2 had higher ADG compared to F_1 at 4,8 and 12 weeks of 99.32g, 97.48g and 92.04g compared to 86.68g, 76.68g and 81.70g. However, F_1 had higher ADG at week 16 of 112.33g compared to 98.45g.

Table 4. ADG (g) of F_1 and F_2 KxB at 4, 8, 12 and 16 weeks of age

Generation	Gender	Average daily gain (g)			
		Week 4	Week 8	Week 12	Week 16
F_1	Male	128.90[a]	103.07	102.03	134.10
	Female	44.45[ab]	50.30	61.37	90.57
F_2	Male	98.62[ab]	96.95	91.48	103.17
	Female	100.02[b]	98.02	92.60	93.73
Pooled SEM		7.940	8.634	7.180	7.947
Mean by generation daily gain					
F_1		86.68	76.68	81.70	112.33
F_2		99.32	97.48	92.04	98.45
Mean by gender daily gain					
Male		113.76	100.01	96.76	118.63
Female		72.23	74.16	76.98	92.15
Pr > F[2]					
Generation		0.4369	0.2449	0.4812	0.3945
Gender		0.0181	0.1527	0.1864	0.1140
Generation x gender		0.0151	0.1375	0.1639	0.2984

[1]Mean of 12 sample per group (n=12), [2]Values within the same column with different letters are significantly different (P < 0.05).
[2] Probability associated with F statistic.

A descriptive study of feed intake between the groups (Table 5) revealed average dry matter intake (DMI) intake obtained (Table 4) were lower for pre weaning kids at 16 weeks of 268 g (F_1) and 174 g (F_2). The intake of ME (MJ/day/animal) and CP (g/day/animal) for F_1 were higher of at 3.49MJ and 55.76g compared to F_2 at 2.27MJ and 36.24g. The DMI in terms of percent body weight at 16 weeks was 2.34% for F_1 compared to 1.37% for F_2 at 16 weeks. F_2 showed better feed conversion (FCR) ratio with a lower FCR of 1.77 compared to 2.39 in F_1. Lower variance was observed for bodyweight and ADG in F_2 compared to F_1.

Table 5. Calculated and actual intake of nutrient supplied through creep feed supplementation at 16 weeks of age for F_1 and F_2 KxB (means ± standard error)

Parameter		Nutrient supplied	
		F_1	F_2
Bodyweight (kg)	Mean and standard error	12.19 ±1.270	13.86 ± 1.037
	Variance	17.179	11.67
Average daily gain (g/d)	Mean and standard error	112.33 ± 12.311	98.45 ± 10.052
	Variance	2105.60	712.66
DMI (g/day)		268.83	174.74
DMI (% of body weight)		2.34	1.37
ME intake (MJ/goat/day)		3.49	2.27
Crude protein intake (g/d)		55.76	36.24
Feed conversion ratio (FCR)		2.39	1.77
Feed cost (RM/day)		0.51	0.33
Feed cost per kg body weight gain (RM/kg)		4.54	3.35

Data pooled by gender; ME = Metabolisable energy intake (MJ/goat/day)

In the present study, mean birth weight achieved were 2.08 kg and 2.05 kg while the 16-week weaning weights were 12.19 kg and 13.87 kg for F_1 and F_2, respectively (Table 3). Most Boer crossbred studies did not have information on breed composition rendering difficulty in evaluating breed performances even though it might appear higher than the values reported in the present study (Syahirah et al., 2016; Htoo et al., 2015). A 3-way cross breeding programme in Thailand involving the crossing of Anglo Nubian and Southern Native Thai (Katjang) goats to produce F_1 subsequently crossing them with Boer goats to produce F_2 generation achieved 3.32 ± 0.69, 16.02 ± 4.02 and 25.68 ± 5.96 kg for birth,12, and 26 weeks body weights, respectively, higher than those found in the current study. The crossbreds were established after 5 to 6 *inter se* matings and continous selection on traits of improved growth rates and meat quality (Anothaisinthawee et al., 2010). Although no significance difference were found in bodyweight between F_1 and F_2, lower variance observed in F_2 compared to F_1 (Table 5) indicated selection imposed towards a stabilized purebred population of Katjang x Boer breed. However, subsequent *inter se* breeding needs to be conducted to evaluate stability of the breed. This clearly demonstrates the need for proper data recording and reporting to ensure successful development of a composite breed with desired traits.

Table 6. Collated data of bodyweight of Katjang, Boer and Boer crosses at different age (week)

Age (week)	Breed						
	Katjang (Hirooka et al., 1997)	Southern Thai breed/ Katjang (Anothaisinthawee et al., 2010)	Imported South African Boer (Van Niekerk et al., 1996)	Malaysian Boer cross (>93% Boer) (Azlina et al., 2014)	Malaysian Boer cross (Syahirah et al., 2016)		Thai Boer (Anothaisinthawee et al., 2010)
	Male (kg)	Average (kg)	Average (kg)	Average (kg)	Male (kg)	Female (kg)	Average (kg)
Birth	1.76 ± 0.42	1.79 ± 0.33	3.5 ± 0.05	3.8 ± 0.77,	2.62 ± 0.062	2.50 ± 0.047	3.32 ± 0.62
4				9.5 ± 1.56,	9.12 ± 0.086	8.57 ± 0.047	
8				17.4 ± 1.89	15.89 ± 0.091	14.63 ± 0.073	
12	8.04 ± 2.18	8.10 ± 2.13		26.3 ± 1.91	22.54 ± 0.101	20.80 ± 0.094	15.8 ± 4.14
17							
21			26.8+0.33				
24							
26	11.49 ± 3.05	12.22 ± 2.63					21.56 ± 5.39

Based on data collated in Table 6, it was found that in the present study, weaning weight obtained in F_1 were closer to those reported for Katjang breed, however increase BWT observed in F_2 were approaching weaning weight of purebred Boer indicating presence of maternal heterosis. Mature body weight estimated using Gompertz and Bertalanffy growth models were 28.1 kg and 28.8 kg for Katjang goats and 58.23+3.08 kg and 59.31+3.44 kg for Boer goats, respectively (Tsukahara et al., 2008; Ariff et al., 2010). It would be expected that mature bodyweight of KxB would fall in between the weight of Katjang and Boer judging from the preweaning weight observed in the current study.

Nutrition has been regarded as an important factor in studying growth performance as it was observed that energy and protein density in feed affect the body weight of Boer goats (Greyling 2000). Therefore, it is imperative to relate feeding regimes to the growth performance obtained in the present study. Total energy and protein supplied cannot be studied in this case as nutrition supplied from dam's milk was not quantified. Higher weaning weight could have been contributed by higher milk and better motherly ability observed in F_1 dam compared to pure breed Boer goats. In a study done, body weight and average daily gain of Boer cross breed fed creep feed without alfalfa at 12 weeks of age were 12.1 kg ± 0.56 and 102.9 g ± 6.43 with creep feed ME and CP content of 12.82 MJ/kg and 14.2% with an average intake of 230 gm/day (Htoo et al., 2015). In the present study, creep feed formulated had higher ME and CP of 13.14 MJ/kg and 20.82 %, (Table 2) with feed intake of 268 g in $F_{1.}$ and 174 gm in F_2 (Table 5) at 16 weeks. In another study, it was found that creep feed supplementation had an average intake of 0.17 to 0.32 gm/day depending on the energy and protein density of the feed (Zalikha et al., 2019). These findings are concurrent to finding of the current study. The difference in feed intake in F_1 and F_2 may be related to difference in quality of feed ingredients that were used as the experiments were conducted at different periods. This is because that higher density of energy and protein could suppress feed intake although high digestibility could be achieved (Zalikha et al., 2019). This may also explain the lower FCR obtained in F_2 (Table 5). However, nutrient composition (Table 2) of creep feed were comprised of average of samples taken between both periods of experimentation.

Creep feed supplementation allows a continuous production of volatile fatty acid (VFA) which aids in the development of rumen in pre weaning kids (Htoo et al., 2018) leading to better weaning weight (Htoo et. al 2015). In the present study, the F_1 dry matter intake was 1.17 % of BWT as early as 45 days, suggesting good early development of rumen function, similar to previous study (Htoo et. al 2015). Dam milk usually drops after peaking at 2 weeks whereby creep feed supplementation allows to supply much needed energy and protein for growth (Htoo et. al 2015) as well as reducing preweaning age so that the dam could be primed for the next breeding cycle. Feed cost per kg body weight gain (Table 5) were lower in F2 of RM 3.35 compared to RM 4.45 due to better feed conversion observed. Thus, to conclude, creep feeding supplementation could be an economical viable management practice especially for dam with multiple litters to boost preweaning performances in K x B kids.

Conclusion

The present study indicated better F_2 kid performance via *inter se* breeding fed creep feed to meet nutritional requirements at preweaning stage. This study demonstrates the improvements gained in a composite breeding program and the need to report accurate genetic composition data for continued assessment and the development of precision feeding systems.

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