The PHILIPPINE JOURNAL OF
Veterinary Medicine

(Short Communication)

Effects of Proportion of Brahman Genetics on the Reproductive Performance of Female Crossbreds in Western Highlands of Vietnam

Pham Van Gioi[1,], Nguyen Thanh Dat[1,a], Nguyen Van Trung[1,a], and Su Thanh Long[2,a]*

[1] Animal Genetics and Breeding Department, National Institute of Animal Science (NIAS), Hanoi 11913, Vietnam
[2] Vietnam National University of Agriculture Hanoi 12406, Vietnam
[a] These authors contributed equally to this work.

*Corresponding author: Gioikhiet@yahoo.com.vn. (Pham Van Gioi)

Submitted: 17 Jul. 2024 Revised: 31 Oct. 2024 Accepted: 30 Jun. 2025 Published: 15 Jul. 2025

Abstract

Background: Brahman crossbreds exhibit heavy weight, good health, nice coat-color and docility, making them advantageous for beef production. Appropriate proportion of Brahman genetics in female herds is crucial for sustainable development in Western Highlands of Vietnam. This study aims to evaluate the effects of different proportions of Brahman genetics on reproductive performance of crossbred females. **Methods:** Data were collected from 1,285 breeder cows in Dak-Lak and Gia-Lai provinces between 2017 and 2021. The traits measured included age at first service (AFS), weight at first service (WFS), age at first calving (AFC), and days open (DO). Data was analyzed using the GLM and linear regression. The statistical models included province, dam breed group, birth year of heifers and parities as fixed effects. **Results:** AFS, WFS, AFC and DO were higher in female crossbreds with higher proportion of Brahman genetics. Incorporating Brahman genetics to female herds improved WFS, but not AFS, AFC and DO. For every 1% increase of Brahman genetics, AFS, WFS, AFC and DO increase by 1.39 days, 1.55 kg, 1.42 days and 0.813 days, respectively. **Conclusions:** When breeder cows were upgraded with Brahman genetics, body weight at first service was improved. However, the other reproductive traits were negatively affected.

Keywords

Beef cattle, Body weight, Brahman cattle, Reproductive performance

1. Introduction

Breeding strategy, herd management, and the establishment of breeding herd are key determinants of economic efficiency in beef cattle production [1,2]. The use of breeder cows with high genetic merit for production traits and reproduction traits can serve as foundation breeding stocks [1,3,4-11]. Further, to produce calves for feedlot fattening, cows with Brahman blood, Local Yellow cattle (LYC), and Red Sindhi cattle (RSC) are often crossed with introduced breeds [19-26].

Brahman cattle is widely recognized for their adaptability to hot and humid climates, resistance to internal and external parasites, and excellent reproductive performance in tropical and subtropical environments [12-17]. In Vietnam, the Brahman breed is particularly valued in rural and remote areas for its appealing appearance, including its red coat, skin color, high wither, and large dewlap, aligning with local cattle farmers' preferences. This breed also exhibits a large frame, heavier weight compared to the LYC or RSC, with superior carcass performance, and efficient feed conversion. Additionally, Brahman crossbreds in Vietnam demonstrate strong disease resistance, heat tolerance, tick resistance, and docility [18]. On the other hand, LYC and RSC are common choices as base genetics of crossbred cows to leverage maternal effects and improve reproductive traits with economic importance such as age at first service (AFS), weight at first service

(WFS), age at first calving (AFC), and days open (DO).

Determining the reproductive performance of female breeders with varying proportions of Brahman genetics is therefore warranted. Establishing the best performing female genetics in a base herd is crucial for its efficient utilization. The findings of this research may provide a long-term solution for local offices and central government authorities involved in improving beef cattle productivity in the Western Highlands of Vietnam.

2. Materials and Methods

2.1 Animals

Breeder females on each farm were individually identified based on physical characteristics such as coat and skin color, horn type, frame size, ear tag number, or tattoos, with additional identification provided by cattlemen. The WFS was estimated using standardized tape measurements. Records of AFS, AFC, and DO were provided by owners, local technicians, or inseminators.

Local Yellow Cattle (LYC) and Red Sindhi Cattle (RSC) were identified based on physical appearance and verified through its owners, local technicians, or inseminators. As shown in Table 1, crossbred females were classified according to the proportion of Brahman genetics, which is reflected first, followed by either a proportion of LYC or RSC (example, 25Br-75LYC). "LYC" or "RSC" are breed groups without Brahman blood (0%). A total of 1,285 females from 113 farms in Dak-Lak and Gia-Lai provinces were included in the study. Data were collected between 2017 and 2021 and classified into 10 breed groups based on Brahman genetic proportions and base female breeds.

2.2 Management practices

Cattle grazed on pastures during the daytime and supplemented with concentrate while housed in barns. They were released daily between 08.00 and 09.00 AM and returned to barns between 18.00 and 19.00 PM. Concentrate was provided twice daily using a uniform formulation across all farms (Table 2). Pregnant female and lactating cow were fed 0.5 kg/day and 0.7 kg/day. While housed in barns, cattle were offered forage, hay, and rice straw *ad libitum*.

2.3 Data analyses

Fixed-effects models were constructed to evaluate the impact of varying Brahman genetic proportions while controlling for non-genetic factors. Three models were utilized: Model 1 analyzed age at first service (AFS), weight at first service (WFS), and age at first calving (AFC) in heifers; Model 2 analyzed days open (DO) in cows; and Model 3 assessed the effect of a 1% increase in

Table 1. Data distribution based on breed groups and provinces.

Breed groups by Brahman genetics	Breed groups by dam resources	Dak-Lak province	Gia-Lai province	Total
25% Brahman	25Br-75LYC (25BrLYC)	19	29	48
	25Br-75RSC (25BrRSC)	14	22	36
50% Brahman	50Br-50LYC (50BrLYC)	35	40	75
	50Br-50RSC (50BrRC)	125	155	280
75% Brahman	75Br-25LYC (75BrLYC)	8	20	28
	75Br-25RSC (75BrRSC)	17	97	114
87.5% Brahman	87.5Br-12.5LYC (875BrLYC)	8	14	22
	87.5Br-12.5RSC (875BrRSC)	7	18	25
0% Brahman	LYC	179	128	307
	RSC	198	152	350
	Overall	**610**	**675**	**1,285**

Table 2. Ingredients, nutritional values, and regimes for concentration.

A	Ingredients	(%) in ration
1	Rice bran	45
2	Yellow maize powder	45
3	Bone meal	9
4	Salt	0.5
5	ADE mixture	0.5
	Total	*100*
B	**Nutritional values [1]**	**Amount**
1	Crude Protein (%)	11.75
2	ME (Kcal/kg)	2,600.00

[1] = Estimated according to ingredients and nutritional values in Monograph of National Institute of Animal

Brahman genetic proportion on AFS, WFS, AFC, and DO. All statistical analyses were performed using SAS 9.4. Pairwise comparisons of least squares means was applied as the posthoc test with p-value < 0.05 considered as statistically significant.

<u>Model 1</u>

$$Y_{ijklm} = \mu + P_i + BG_j + (P^*BG)_{ij} + YB_k + F_l(P_i) + e_{ijklm} \quad (1)$$

Where:

Y_{ijklm} is the observation (AFS, WFS or AFC) of the m^{th} heifer, kept in the l^{th} farm, born in the k^{th} year, belonging to the j^{th} breed group, kept in the i^{th} province,

μ is the overall mean

P_i is the fixed effects of the i^{th} province (i = 2: Dak-Lak and Gia-Lai provinces)

BG_j is the fixed effects of the j^{th} breed group (j = 10: LYC, RSC, and various crossbred groups; with j = 5 when analyzed based on breed groups according to different proportions of Brahman breed: group 0%, 25%, 50%, 75% and 87.5% of Brahman genetics).

$(P^*BG)_{ij}$ is the interaction between provinces and breed groups

YB_k is the fixed effects of the k^{th} birth year of heifer (k=10: 2010 and before, 2011, …, 2019)

F_l is the effect of the l^{th} farm

$F_l(Pi)$ is the random effect of the l^{th} farm in the i^{th} province, assuming that $N(0, \sigma^2_F)$

e_{ijklm} is the random residual errors, assuming that $N(0, \sigma^2_e)$

Model 2.

$$Y_{ijklmno} = \mu + P_i + BG_j + (P^*BG)_{ij} + Par_k + S_l + YC_m + F_n(P_i) + e_{ijklmno} \quad (2)$$

Where:

Y_{ijklmo} is the Days Open of the o^{th} cow, reared on the n^{th} farm, calved in the m^{th} year, in the l^{th} calving season, at the k^{th} parity, belonging to the j^{th} breed group, kept in the i^{th} province, μ is the overall mean.

P_i is the fixed effects of the i^{th} province (i = 2: Dak-Lak and Gia-Lai provinces)

BG_j is the fixed effects of the j^{th} breed group (j = 10: LYC, RSC, various crossbred groups; with j = 5 when analyzed based on female groups according to various proportions of Brahman genetics: group 0%, 25%, 50%, 75% and 87.5% of Brahman genetics).

$(P^*BG)_{ij}$ is the interaction between Provinces and breed groups

Par_k is the fixed effect of the k^{th} parity (K=6: Parity 1, 2, …, 6 and more).

S_l is the fixed effect of the l^{th} calving season (l=2: Summer-Autumn from April to September; Winter-Spring is left calving months)

YB_m is the fixed effects of the m^{th} birth year of heifer (m=10: 2010 and before, 2011, …, 2019)

$F_n(Pi)$ is the random effect of the n^{th} farm nested in the i^{th} province, assuming that $N(0, \sigma^2_F)$

e_{ijklm} is the random residual errors, assuming that $N(0, \sigma^2_e)$

Model 3.

$$Y = a + bx + e \quad (3)$$

Where:

Y is the dependent variable (AFS, WFS, AFC, and DO of various breed groups), a is a constant (basic performance), b is the slope (increment), x is an independent variable (proportion of Brahman genetics in breed groups from two dam groups: LYC and RSC and crossbred groups according to the different proportions of Brahman genetics)

e is the random residual errors assuming that $N(0,\sigma^2_e)$.

3. Results

3.1 Performance of different breed groups from LYC and RSC

Age at first service (AFS): The results in Table 3 showed that AFS of LYC was significantly lower (P<0.05) than that of RSC (517.22±17.14 days versus 569.76±16.55 days). Among crossbreds, the higher the proportion of Brahman genetics is upgraded, the older the AFS would be. The 87.5% Brahman-LYC crosses were older by 152 days compared to LYC females, while 87.5% Brahman-RSC crosses were older by 92 days compared to RSC females. Within LYC dam resources, AFS of LYC (0% Brahman) was (517.22±17.14 days) significantly different from 25BrLYC (572.90±21.99 days) (P<0.05). AFS of 25BrLYC crosses significantly differed from 50BrLYC, 75BrLYC and 875BrLYC crosses (P<0.05). But differences among 50BrLYC, 75BrLYC and 875BrLYC crosses were not statistically significant (P>0.05). For RSC dam resources, AFS of RSC (0% Brahman) was (569.76±16.55 days) significantly different from 25BrRSC (627.00±31.95 days) (P<0.05). But AFS of crosses from 25% Brahman to 87.5% Brahman were not significantly different (P>0.05). When considering two crossbred groups with equal proportion of Brahman genetics, the breed group based on RSC dams usually had AFS lower than the group based on LYC dams, except for dam groups with 25% of Brahman genetics. However, the differences among them were not statistically significant (P>0.05).

Weight at first service (WFS): The results in Table 3 indicated that the body weight at first services of LYC was of 185.72±7.31 kg/heifer, significantly lower (P<0.05) than that of RSC (219.35±7.75 kg/heifer). Similarly, in crossbreds, a higher proportion of Brahman genetics corresponded to a heavier WFS. The 87.5% Brahman-LYC crosses were 158.17 kg heavier than LYC females, while the 87.5% Brahman-RSC crosses were 113.57 kg heavier than RSC females. For crosses based on the same LYC dam resources, the differences in WFS among them were statistically significant (P<0.05). Similarly, for crosses based on the same RSC dam resources, the differences in WFS were also statistically significant (P < 0.05); except between the RSC (0% Brahman) - 25 Brahman-RSC (25BrRSC) group with the 50% Brahman-RSC (50BrRSC) and the 75% Brahman-RSC (75BrRSC)-87.5%Brahman-RSC (875BrRSC) group. When comparing groups with the same Brahman genetic proportion, WFSs of breed groups based on LYC dams were lower than those based on RSC dams at the proportions of 25% and 50% Brahman genetics. However, at the proportions of 75% and 87.5% Brahman genetics, their WFSs were nearly equivalent, although WFSs based on LYC were a little bit higher than RSC. However, among them the differences were also not statistically significant (P>0.05). More specifically, in the crossbred group of 25% of Brahman genetics, the WFSs of crossbred groups based on LYC dams (216.62±8.65 kg/heifer), were lower than those of crossbreds based on RSC dams (229.85±14.03 kg/heifer). This difference was not significant (P>0.05).

Age at first calving (AFC): As shown in Table 3, AFC in LYC was averaged as 795.95±17.10 days, which was significantly lower (P<0.05) than that of RSC (849.01±16.61 days). Similar to the traits mentioned above, a higher proportion of Brahman genetics in crossbreds resulted in a longer AFC. Moreover, the 87.5% Brahman-LYC crosses were longer by 157.43 days to LYC females, while the 87.5% Brahman-RSC crosses were longer by 94.24 days to RSC females. Besides, the AFC of 25BrLYC was (852.26±22.12 days) significantly different from LYC (0% Brahman) and crossbred groups (50BrLYC, 75BrLYC and 875BrLYC). However, the differences in AFC among 50BrLYC, 75BrLYC, and 875BrLYC were not significant (P>0.05). On the other hand, AFC of 25BrRSC was (905.95±32.06 days) significantly different from RSC (849.01±16.61 days) and 875BrRSC

Table 3. Performance of reproductive females by different breed groups.

Breed Groups	AFS		WFS		AFC		DO	
	n	LSM±SE	n	LSM±SE	n	LSM±SE	n	LSM±SE
LYC	153	517.22±17.14[a]	128	185.72±7.31[a]	156	795.95±17.10[a]	307	83.09±4.07[a]
RSC	105	569.76±16.55[b]	81	219.35±7.75[b]	105	849.01±16.61[b]	333	86.59±3.27[a]
25BrLYC	48	572.90±21.99[bc]	44	216.62±8.65[b]	48	852.26±22.12[bc]	37	87.58±6.97[a]
25BrRSC	36	627.00±31.95[cd]	32	229.85±14.03[bc]	36	905.95±32.06[c]	27	95.64±8.51[ac]
50BrLYC	46	650.47±18.50[d]	44	256.53±6.82[c]	42	930.93±19.01[d]	75	116.07±5.75[b]
50BrRSC	102	630.45±16.96[cd]	101	280.61±6.66[d]	102	909.75±17.03[cd]	224	111.26±3.86[bc]
75BrLYC	28	663.18±25.13[d]	28	320.94±9.05[e]	28	945.69±25.26[d]	28	154.41±8.28[d]
75BrRSC	68	643.70±25.93[cd]	61	319.11±9.52[ef]	68	916.74±25.99[cd]	102	147.57±6.29[d]
875BrLYC	22	669.38±26.88[d]	22	343.89±9.76[f]	22	953.38±27.01[d]	20	144.10±9.40[d]
875BrRSC	25	662.03±30.04[d]	25	332.92±11.00[ef]	25	943.25±30.11[d]	25	159.62±9.25[d]

Notes: AFS: Age at first service (days); WFS: Weight at first service (kg); AFC: Age at first calving (days); DO: Days open (days). In the same column, the LSM values with the same superscript are not significantly different (P>0.05).

(943.25±30.11 days) (P<0.05), but not significantly different from 50BrRSC (909.75±17.03 days) or 75BrRSC (916.74±25.99 days) (P>0.05). For crossbred groups with the same Brahman genetic proportion but different dam sources, crossbred groups based on LYC dams were usually higher than the groups based on RSC dams, with exception of 25% Brahman's genetic group. However, the differences between each corresponding RSC and LYC pair of a given Brahman introgressed genetic population were not statistically significant (P>0.05). Similarly, for AFC of crosses based on the same dam resources, the differences among them were also statistically significant (P<0.05). Thus, when Brahman genetic resources were upgraded into crossbreds resulted in prolonging AFC, this upgrading negatively affected reproductive performance in the beef cattle population of the Western Highland.

Days open: The results from this investigation revealed that RSC had a higher DO than LYC (86.59±3.27 days versus 83.09±4.07 days), but this difference was not statistically significant (P>0.05). For the breed groups born from LYC dams, there was a strange change. When upgrading 25% Brahman genetics into crossbreds, DO in the group of 25% Brahman genetics (87.58±6.97 days) was lower than that in LYC dam (95.64±8.51 days). However, this difference was not statistically significant (P>0.05). Whereas, in the crossbred group, when increase of Brahman genetic proportions, DO was risen from 87.58±6.97 days in the group of 25% Brahman genetics, amounted to 154.41±8.28 days in the group of 75% Brahman genetics. It then decreased to 144.10±9.40 days in the crossbred group of 87.5% Brahman genetics. Besides, LYC and 25BrLYC had no significant difference of DO (P>0.05), but DOs from both were significantly differed from other crosses (50BrLYC, 75BrLYC and 875BrLYC) (P<0.05). The DO of 50BrLYC (116.07±5.75 days) was significantly different from all other groups (LYC, 25BrLYC, 75BrLYC and 875BrLYC) (P<0.05). The DOs of 75BrLYC (154.41±8.28 days) and 875LYC (144.10±9.40 days) showed no significant difference (P>0.05). In the crossbred groups born from RSC dam group, DO was gradually increased from RSC to crossbred groups when they were upgraded with Brahman genetics. Specifically, RSC got DO of 86.59±3.27 days; when they were upgraded with 25% Brahman genetics, their DO was extended to 95.64±8.51 days. When they were further increased to 50% Brahman genetics, their DO was increased to 111.26±3.86 days and achieved the plateau of 159.62±9.25 days in the crossbred group of 87.5% Brahman genetics. On the other hand, DO of 25BrRSC (95.64±8.51 days) was not significantly different from RSC (86.59±3.27 days) and with 50BrRSC (111.26±3.86 days) (P>0.05), but it was different from 75BrRSC (147.57±6.29 days) and 875BrRSC (159.62±9.25 days) (P<0.05). Besides, the findings indicated that there is no statistical difference between 875BrLYC and 875BrRSC (P>0.05).

From this outcome, we found that they were significantly different (P<0.05). Thus, DO was unusually high in LYC dam groups, but it was gradually increasing in RSC dam group. These results also confirmed that when upgrading Brahman genetics into crossbreds, DO tended to extend and had disadvantageous influence on reproductive performance as well as lifetime production and their overall herds.

3.2 Performance of pooled dam groups by different Brahman's breed proportions

Age at first services: In the dam group without Brahman genetics, AFS averaged as 542.01±12.50 days. This trait was increased to 586.70±18.03 days in the group of 25% Brahman genetics, and continuously increased along with increase of Brahman genetics, amounted to 663.87±19.97 days in the group of 87.5% Brahman genetics. The differences among them showed statistically significant (P<0.05). Specifically, the AFS of the crossbred group of 25% Brahman was significantly different from the group of 0% Brahman. The AFS of these two groups were apparently different from the groups of 50%, 75% and 87.5% Brahman. The AFS of three crossbred groups of 50%, 75% and 87.5% Brahman were not significantly different. According to these findings, when upgrading Brahman genetics in LYC or RSC, the AFS was prolonged, and affected unfavorably the reproductive efficiency of female herds (Table 4).

Weight at first services: In the group of no Brahman genetics, their WFS was of 204.89±5.93 kg/heifer, and was enhanced in the group of 25% Brahman genetics (229.52±7.46 kg/heifer), continued grading-up in the group of 50% Brahman genetics achieved 267.37±4.99 kg, increased continuously in the group of 75% Brahman genetics and acquired 317.98±6.67 kg/heifer, and in the group of 87.5% Brahman genetics with 335.56±7.63 kg/heifer. These differences were statistically significant (P<0.05). Thus, when LYS or RSC were upgraded using Brahman genetic resources, reproductive female herds tended to improve their body weights and statures, thereby being more effective as base females for crossbreeding with exotic high-yielding breeds (Table 4).

Age at first calving: Derived from these results, for the breed groups of LYC or RSC (the groups of zeroed Brahman genetics), the average AFC was 819.96±12.54 days. Crossbreeding and introducing 25% Brahman genetics increased the AFC to 864.43±18.18 days, while upgrading to 50% Brahman genetics further increased it to 912.78±13.03 days. With 75% Brahman genetics, the AFC rose to 929.01±17.69 days, and at 87.5% Brahman genetics, it reached 945.82±20.08 days.

Specifically, AFC of the crossbred group of 25% Brahman genetics was significantly different from the 0% Brahman group, and the AFCs from both groups were significantly different compared to all other groups (P<0.05). AFCs of the 50%, 75% and 87.5% Brahman crossbred groups were not significantly different. Thereby, upgraded crossbred females using Brahman genetic resources increased their AFC and affected reproductive performance (Table 4).

Days open: Similarly, gradual upgrading of LYC or RSC with Brahman genetic resources increased their DO with significant difference observed from 50 – 87.5%. Specifically, the DO of 0%, 25%, 50%, 75%, and 87.5% Brahman are as follows 86.15±3.05 days, 88.93±5.59 days, 110.74±3.39 days. 146.72±5.14 days, and 148.80±6.92 days. Thus, 50 – 87.5 % upgraded LYC or RSC with longer DO lowers their reproductive performance (Table 4).

Table 4. Performance of breed groups by various Brahmans' breed proportions on pooled dam group.

Percentage of Brahman	AFS		WFS		AFC		DO	
	n	LSM±SE	n	LSM±SE	n	LSM±SE	n	LSM±SE
0	258	542.01±12.50[a]	209	204.89±5.92[a]	261	819.96±12.54[a]	640	86.15±3.05[a]
25	84	586.70±18.03[b]	76	229.52±7.46[b]	84	864.43±18.18[b]	64	88.93±5.59[a]
50	148	634.35±12.74[c]	145	267.37±4.99[c]	144	912.78±13.03[c]	299	110.74±3.39[b]
75	96	652.04±17.55[c]	89	317.98±6.67[d]	96	929.01±17.69[c]	130	146.72±5.14[c]
87.5	47	663.87±19.97[c]	47	335.56±7.63[e]	47	945.82±20.08[c]	45	148.80±6.92[c]

In the same column, LSM values with different letters are significantly different (P<0.05).

3.3 Increments in body weight and reproductive performance

The results in Table 5 indicated that all the estimated parameters were statistically significant (P<0.05).

In the pooled dam group, the results also showed that AFS, WFS, AFC, and DO in the herds without Brahman genetics were averaged as 549.75±8.68 days, 197.48±6.23 kg, 827.07±8.28 days and 77.61±7.69 days, respectively. Nevertheless, for every 1% of Brahman genetics was increased into crossbred groups, these traits were increased by 1.39±0.15 days, 1.55±0.11 kg, 1.42±0.14 days and 0.81±0.13 days, respectively. These results further supplemented that in crossbreeding and upgrading LYC or RSC with Brahman cattle, their body weight was favorably improved but affected reproductive performance negatively.

Specifically, in the groups of LYC dams, the average of AFS in the population was 529.54±17.43 days. When crossbreeding with Brahman genetics, for every increase of 1% Brahman genetics, their AFS was prolonged to 1.79±0.30 days. For WFS, the overall mean was 176.44±8.52 kg, and when they were crossbred with Brahman genetics, for every 1% increase of Brahman genetics, WFS was enhanced by 1.86±0.15 kg. Regarding AFC, the population mean of the group with 0% Brahman genetics was 807.73±16.96 days, but every 1% increase in Brahman genetics added 1.85±0.30 days to AFC. Furthermore, female herds with 0% Brahman genetics, the DO was 76.43±9.26 days, but for every 1% increase in Brahman genetics, DO was prolonged by 0.86±0.16 day. These results showed that there was an increase in body weight but lowered reproductive traits in LYC dams with increasing Brahman genetics resources.

Table 5. Base values and increment of performance traits of reproductive female crossbreds by various Brahman genetic proportions in two dam's groups.

Traits	Parameters[1]	LYC dams		RSC dams		Pooled dams	
		DF	$E \pm SE_E$	DF	$E \pm SE_E$	DF	$E \pm SE_E$
AFS	a	1	529.54±17.43	1	584.07±12.10	1	549.75±8.68
	b	1	1.79±0.30	1	0.90±0.21	1	1.39±0.15
WFS	a	1	176.44±8.52	1	209.61±8.44	1	197.48±6.23
	b	1	1.86±0.15	1	1.41±0.15	1	1.55±0.11
AFC	a	1	807.73±16.96	1	863.21±13.09	1	827.07±8.28
	b	1	1.85±0.30	1	0.88±0.23	1	1.42±0.14
DO	a	1	76.43±9.26	1	78.83±7.17	1	77.61±7.69
	b	1	0.86±0.16	1	0.87±0.13	1	0.81±0.13

Notes: [1]: All the estimated parameters are statistically significant.
a is intercept coefficient – basic performance, b is slope – increment of performance when increase of 1% Brahman genetics into crossbreds. E: Estimates of parameters; SE_E: Standard errors of Estimates. DF: Degree of freedom.-smaller font

Similarly, in the breed groups of RSC dams, females with 0% Brahman genetics had an average AFS of 584.07±12.10 days in the base population. For every 1% Brahman genetic upgrade, AFS was increased by 0.90±0.21 day. Moreover, the WFS for RSC dams with 0% Brahman genetics was 209.61±8.44 kg, but for every 1% Brahman genetic upgrade, their WFS was enhanced by 1.41±0.15 kg. Similarly, with AFC in basic female herds, AFC averaged 863.21±13.09 days, and for every 1% Brahman genetic upgrade, AFC was prolonged by 0.88±0.23 days. For DO, RSC females averaged 78.83±7.17 days, but in crossbreeding, for every 1% Brahman genetic upgrade, DO was prolonged by 0.87±0.13 days. These results also additionally confirmed that when Brahman genetic resources were increased in RSC dams, there was also an increase in body weight but their reproductive performance tended to lessen in relation to increasing input to produce a calf.

4. Discussion

Brahman genetics positively affected growth performance of their crossbreds from birth to 12 months old [28]. This concurs with our current findings where WFS increases for every increase of 1% in Brahman genetics. WFS was enhanced from 1.41±0.15 kg to 1.86±0.15 kg, depending on the base dam groups. Recently, in order to produce commercially high-yielding crossbreds, cattlemen in the Western Highlands and adjacent regions usually use the basic reproductive female herds as LYC, RSC or 50% Brahman genetic crossbreds. These females are artificially inseminated with frozen semen of exotic breeds as Brahman, Red Angus, Charolais, and Limousine cattle [29,]. Body weight and carcass performance of the crossbreds of 50% Brahman genetics were enhanced by 20% to 50% as compared to existent beef cattle herds, thus, economic efficiency was clearly improved [22,24,26]. However, small-sized basic reproductive females would be difficult to apply for mating or AI with large-sized high-yielding beef bulls, due to declining reproductive performance such as increasing difficulty in calving. But when large-sized cows were introduced, they would encountered difficulties resulting from limited proper knowledge and economic potential capacity for nourishment.

In recent years, many farmers have their female cattle artificially inseminated with frozen semen of Belgian Blue Breed (BBB), and thus, it is compulsory to improve both stature and frame of their reproductive females. The results from this research showed that LYC, although possessing a small size, expressed slightly better reproductive performance than RSC. Similarly, when upgrading to 25% Brahman genetics, their crossbreds based on LYC dam still maintained this advantage. However, when Brahman genetics exceeded 50%, the advantage for reproductive performance shifted and favored crossbreds based on the dam derived from RSC genetic resources. This phenomenon was actually observed in intensive farms in the Western Highlands, where ranchers often prefer crossbreds with high proportions of Brahman genetics derived from RSC as base females for commercial beef production [30]. The results from this research also indicated that increasing the proportion of Brahman genetics in female herds enhanced body weight but had a negative impact on reproductive performance. Farmers in the Western Highlands expect the beef cattle industry to acquire high economic efficiency, each cow should annually produce a calf and their calves need to adapt and grow up well within locally available conditions and based on crossbreeding from their own females. However, the large-framed reproductive females are not the choice of the majority of small-scaled beef cattle farmers in the Western Highlands because they would require much more inputs including feeds. In the Western Highlands, many farmers would like to keep small-sized females because these cows consume less feed but they prefer to have their cows inseminated with high-yielding beef breeds (BBB, Charolais). This is antagonistic with the actual practice because the large-sized reproductive females can be well utilized with exotic high-yielding beef breeds as their expectation. Meanwhile, the results from this research showed that although LYC and RSC possessed more outstanding reproductive performance than all crossbreds, their stature was smaller and the WFSs were quite low (176.44±8.52kg and 209.61±8.44 kg per female). The crossbreds with 25% Brahman genetics are also difficult to be mated or artificially inseminated with large-sized beef breeds due to smaller body weight. Crossbreds of 50% Brahman genetics relatively improved their body weights since their WFS were from 256.53±6.82 kg to 280.61±6.66 kg. In addition, their reproductive performance was likely better than that of the crossbred groups with higher Brahman genetic proportions. The crossbred group with 75% and 87.5% Brahman genetics have good enough (more than 300 kg) WFS thus, they were quite appropriate for crossbreeding with large-sized beef breeds such as Charolais or BBB, aligning with the current cattlemen's trend. However, their DOs were prolonged from 144.10±9.40 to 159.62±9.25 days, which reduced the lifetime productive efficiency of the females.

Several scientists stated that utilization of 50% Brahman genetic crossbred females for producing commercially high-yielding crossbreds would result in efficient growth performance and considerable economic efficiency [20,22,26]. On the other hand, utilization of crossbreeding would keep hybrid vigour in the herds. Applying breeding management strategies to maintain heterosis in a herd offers numerous economic benefits to the beef cattle efficiency [2].

From our findings, crossbred group of 50% Brahman genetics should be utilized as base reproductive females for smallhold farms, where they were lowly invested and applied technically simple knowledge. In order to be inseminated with large-frame beef breeds (BBB), the female must weigh at least 280 kg [31-33]. Therefore, crossbreds with the proportions of 75% or 87.5% Brahman genetics have larger body weight and would be effective for crossbreeding with exotic breeds, but their reproductive performance was worse, and thus, they need to be applied the appropriately updated technologies for feeding and management. They would be more appropriate to be applied in intensive farms, where they were well invested and with the advanced technologies. It is necessary to introduce moderate Brahman fractions, from 25% to 50% into female herds for small-scaled farms, and the fraction over 50% for intensive beef production systems in the Western Highlands of Vietnam.

From all mentioned above, females that were upgraded by Brahman genetics with moderate proportion, from 25 to 50% Brahman genetics, would be appropriate in small scaled farms. Those with over 50% of Brahman genetics seemed to be reasonable and appropriate for reproductive females in intensive beef farms because that body weight of reproductive females would not be so heavy and their reproductive performance would not be greatly affected.

5. Conclusions

It was concluded that incorporating Brahman genetics into reproductive female herds favorably improved body weight. However, traits such as age at first service, age at first calving, and days open were negatively affected. It is recommended to introduce moderate Brahman fractions (25% to 50%) for small-scale farms, while fractions exceeding 50% are better suited for intensive beef breeding herds in the Western Highlands of Vietnam.

Availability of Data and Materials

All data used in this research are available.

Author Contributions

Conceptualization, P.V.G., S.T.L., and N.V.T.; Methodology, P.V.G., N.T.D., N.V.T., and S.T.L.; Investigation, P.V.G., and N.V.T.; Writing – Original Draft, P.V.G., S.T.L., and N.T.D.; Writing – Review & Editing, P.V.G., and N.T.D.

Ethics Approval and Consent to Participate

The current research has been permitted from NIAS in the research project from Agricultural Ministry at the beginning. Finally, it was approved by the ethics committee of Vietnam Animal Welfare Association (Approval no. 2024-01/QĐ-VAWA).

Funding

This research was funded by the Ministry of Agriculture and Rural Development of the government of Vietnam.

Conflict of Interest Statement

The authors declare no conflicts of interest. All of us have seen and agreed on the contents of the manuscript and there is no financial interest to report. We certify that the submission is original work and is not published in any other journal.

References

[1] Brzáková, M., Čítek, J., Svitáková, A., Veselá, Z., & Vostrý, L. (2020). Genetic parameters for age at first calving and first calving interval of beef cattle. *Animals, 10(11)*, 2122. https://doi.org/10.3390/ani101 12122.

[2] Terry, S.A., Basarab, J.A., Guan, L.L., & McAllister, T.A. (2021). Strategies to improve the efficiency of beef cattle production. *Canadian Journal of Animal Science, 101(1)*, 1–19. https://doi.org/10.1139/cjas-2020-0022.

[3] Diskin, M.G., & Kenny, D.A. (2014). Optimising reproductive performance of beef cows and replacement heifers. *Animal, 8(Suppl 1)*, 27–39. doi: 10.1017/S175173111 400086X.

[4] Burns, B.M., Fordyce, G., & Holroyd, R.G. (2010). A review of factors that impact on the capacity of beef cattle females to conceive, maintain a pregnancy and wean a calf - Implications for reproductive efficiency in

northern Australia. *Animal Reproduction Science, 122(1–2)*, 1–22. doi: 10.1016/j.anirep rosci.2010.04.010.

[5] Espinoza, J.L., Peña, D.G., Espinoza, A.P., Ortega, R., & Guillén, A. (2016). Genetic parameters of days open in Charolais cattle of Cuba. *Revista Colombiana de Ciencias Pecuarias, 29(1)*, 16–24. doi:10.17533/udea. rccp.v29n1a02.

[6] Krupová, Z., Krupa, E., & Wolfová, M. (2020). Economic weights of current and new breeding objective traits in Aberdeen Angus. *Journal of Animal Sciences, 65(3)*, 77–85. doi: 10.17221/255/2019-CJAS.

[7] Kusaka, H., Yamazaki, T., & Sakaguchi, M. (2023). Association of age at first calving with longevity, milk yield, and fertility up to the third lactation in a herd of Holstein dairy cows in Japan. *Journal of Reproduction and Development, 69(6)*, 291–297. doi: 10.1262/ jrd.2023-012.

[8] McHugh, N., Evans, R.D., & Berry, D.P. (2019). Using the difference in actual and expected calf liveweight relative to its dam liveweight as a statistic for interherd and intraherd benchmarking and genetic evaluations. *Journal of Animal Sciences, 97(12)*, 4737–4745. doi: 10.1093/jas/skz331.

[9] Pardo, A.M., Elzo, M.A., Gama, L.T., & Melucci, L.M. (2020). Genetic parameters for growth and cow productivity traits in Angus, Hereford and crossbred cattle. *Livestock Science, 233*. 103952. https://doi.org/10.1016/ j.livsci.2020.103952.

[10] Šlyžienė, B., Mečionytė, I., Žilaitis, V., Butkienė, E., Anskienė, L., Šlyžius, E., & Palubinskas, G. (2023). The association between Charolais cows' age at first calving, parity, breeding seasonality, and calf growing performance. *Animals, 13(18),* 2901. https://doi.org/10.3390/ani13182901.

[11] Toušová, R., Ducháček, J., Stádník, L., Ptáček, M., & Beran, J. (2014). The effect of selected factors on the growth ability of Charolais cattle. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 62(1)*, 255–260. doi: 10.11118/ actaun201462010255.

[12] Ahammed, M., Akter, T., Nooruzzaman, M., Alam, M.R., Islam, M.T., & Chowdhur, E.H. (2020). Superior performance of the Brahman cattle in terms of meat production and disease resistance in comparison with the indigenous cattle of Bangladesh. *Bangladesh Journal of Veterinary Medicine, 18(2)*, 59–63. doi: https://doi.org/10.33109/bjvmjd2020rm5.

[13] Cassidy, W. (2015, Feb 24). Genetic resistance to parasites: An option besides chemicals? [Internet]. Cassidy Woolsy. Progressive Cattle. Retrieved Feb 24, 2015, from: https://www.progressivecattle.com/topics/ reproduction/ genetic-resistance-to-parasites-an-option-besides-chemicals.

[14] Collier, R.J., & Gebremedhin, K.G. (2014). Thermal biology of domestic animals. *Annual Review of Animal Bioscience, 3*, 513–532. doi.org/10.1146/annurev-animal-022114-110659.

[15] Davila, K.M.S., Hamblen, H., Hansen, P.J., Dikmen, S., Oltenacu, P.A., & Mateescu, R.G. (2019). Genetic parameters for hair characteristics and core body temperature in a multibreed Brahman-Angus herd. *Journal of Animal Science, 97(8)*, 3246–3252. doi.org/10.1093/jas/skz188.

[16] Dikmen, S., Mateescu, R.G., Elzo, M.A., & Hansen, P.J. (2018). Determination of the optimum contribution of Brahman genetics in an Angus-Brahman multibreed herd for regulation of body temperature during hot weather. *Journal of Animal Science, 96(6)*, 2175–2183. doi.org/10.1093/jas/sky133.

[17] Mateescu, R.G., Davila, K.M.S., Dikmen, S., Rodriguez, E., & Oltenacu, P.A. (2020). The effect of Brahman genetics on body temperature plasticity of heifers on pasture under heat stress. *Journal of Animal Sciences, 98(5)*, 1–9. doi:10.1093/jas/skaa126.

[18] Binh, N.V. (2016, Jan 17). Introduction of some high-yielding beef crossbreds in Western Highland. [internet]. Retrieved Jan 17, 2016, from from: https://wasi.org.vn/789-2/ [in Vietnamese].

[19] Hang, L.T.T., Thao, L.D., Nam, L.V., Hoan, L.T., Long, T.N., Huong, D.T., Tam, V.T.M., & Dung, D.V. (2022). Growth performance and carcass composition of (BBB x Lai Braham) and (Red Angus x Lai Brahman) crossbred cattle in Quang Ngai province. *Journal of Animal Science and Technology, 134*, 45–52 [in Vietnamese].

[20] Hung, B.N., Ngan, H.T., Quyen, P.V., Tien, N.V., Sal, G.V., Thuy, N.T., Hai, P.T., & Lap, D. V. (2022). Growth of calves crossbred between Charolais and Red Angus bulls with Brahman cows were born at the Ruminant Research and Development Center. *Journal of Animal Husbandry Sciences and Technics, 282*, 27–34 [in Vietnamese].

[21] Lap, D.V., Hai, P.T., Que, L.B., Dung, L.A., Tuan, P.V., Loan, L.T., Bien, M.T.H., Thanh, M.T., Tuan, N.D., & Nguyen, N.H. (2021). Growth performance of three groups of crossbreds between Charolais, Red Angus and Droughtmaster bulls with Brahman crossbred cows in Tu Nghia District, Quang Ngai province. *Journal of Animal Science and Technology, 128*, 14–22 [in Vietnamese].

[22] Loan, L.T., Hai, P.T., Que, L.B., Dung, L.A., Lap, D.V., Tuan, P.V., & Hanh, C.X. (2023). Growth performance of the crossbreds between Red Angus and Charolais bulls with Brahman crossbred cows raised at Moncada station. *Journal of Animal Science and Technology, 141*, 35–46 [in Vietnamese].

[23] Quyen, P.V., Cam, T.T., Hieu, L.T.M., Sal, G.V., & Hung, N.N. (2018). Productivity of some crossbred beef cattle F1 Red Angus x Laisind and F1 Brahman x Laisind in Tay-Ninh province. *Journal of Animal Science and Technology, 86*, 19–34 [in Vietnamese].

[24] Quyen, P.V., Sal, G.V., Hung, B.N., Tien, N.V., Hai, N.N., Phong, T.V., Thao, H.V., & Hai, T.T. (2020). Productivity of some crossbred beef cattle in Tra-Cu District, Tra-Vinh province. *Journal of Animal Science and Technology, 107*, 32–39 [in Vietnamese].

[25] Tuan, P.V., Hai, P.T., Que, L.B., Dung, L.A., Lap, D.V., Loan, L.T., Hoa, N.T.T., Hanh, C. X., Hai, P.V., & Hieu, V.T. (2021). The growth performances of crossbreds between Charolais, Red Angus and Drought Master bulls with Brahman crossbred cows in Ha Noi, Hung Yen and Thai Nguyen. *Journal of Animal Science and Technology, 127*, 33–42 [in Vietnamese].

[26] Vu, D.D., Tin, N., Thanh, T.V., Hai, D. ., & Van, N.T. (2022). Growth performance of some beef cattle breed groups in Ninh Thuan province. *Journal of Animal Science and Technology, 134*, 13–21 [in Vietnamese].

[27] National Institute of Animal Science. (2001). Ingredients and nutritional values of animal feed resources for livestock in Vietnam. *Agricultural Publication House in Hanoi*. [Monograph, in Vietnamese].

[28] Gioi, P.V., Dung, D.V., Son, P.V., Lap, D.V., & Tiem, P.V. (2023). Effects of Brahman genetic resource proportion on growth performance traits of beef crossbreds in Western Highlands of Vietnam. *Agriculture and Natural Resources, 57(4),* 677–688. https://li01.tci-thaijo.org/index.php/anres/article/view/260456.

[29] Nguyen T.M.L. (2022). Reproductive performance of Brahman crossbred cows mated with Droughtmaster, Charolais, Red Angus and meat production capacity of their progeny in Quang Ngai province. PhD dissertation. University of Agriculture and Forestry, Hue University [in Vietnamese].

[30] Nguyen V.D., Nguyen D.D., Nguyen T.P., Nguyen D.T., and Vu D.T. (2022). Features, performance and efficiency of beef production in Western High Lands. *Vietnam Journal of Agricultural Sciences, 20(6)*: 741–750. [in Vietnamese].

[31] Xuan D. (2016, May 12). Technics for BBB crossbred cattle production. Lam-Dong Agricultural Extension Centre. Retrieved May 12, 2016, from https://khuyennong.lamdong.gov.vn/hoat-dong-khuyen-nong/chuyen-giao-khkt/217-k-thu-t-nuoi-bo-bbb. [in Vietnamese].

[32] Southern breeding livestock company limited. (2020, May 28). Technics for BBB cattle crossbreeding. Southern Livestock Breeding Limited Company. Retrieved Mar 28, 2020, from https://giongmiennam.com/ ky-thuat-lai-tao-giong-bo-bbb-3b[in Vietnamese].

[33] Van Dinh. (2017, May 11). Technics for BBB cattle crossbreeding. Vietnam Animal Husbandry. Retrieved May 11, 2017 from https: *Vietnam J. Agri. Sci.,* //nhachannuoi.vn/ky-thuat-chon-giong-bo-bbb/ [in Vietnamese].