

Increased Milk Yield in Borgou Cows in Alternative Feeding Systems

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Keywords

Borgou cattle – Dairy cow – Feeding – Yield increase – Weight gain – Benin.

Summary

The purpose of this study was to assess changes in milk yield (MY), daily weight gain (DWG), dry matter intake capacity (DMI), feed intake (FI) and energy intake (ME) of Borgou cattle in separate feeding systems. Performance records of 48 lactating cows, raised at Okpara State farm, were analyzed. The cows were distributed in three treatment groups, corresponding to three feeding systems: grazing on natural pasture (FSI); grazing on natural pasture plus supplementation with 2 kg cottonseed cakes (FSII); and rationing with 20 kg *Panicum maximum* C1, 2 kg *Brachiaria ruziziensis*, 1 kg *Aeschynomene hirtix* and 2 kg cottonseed cakes (FSIII). Mean estimates were 392.0 ± 28.7 g/d, 1.77 ± 0.84 L/d, 7.88 ± 0.39 kg DM, 118.16 ± 8.59 g DM/kg^{0.75} and 71.62 ± 4.47 Mj for DWG, MY, DMI, FI and ME, respectively. Analyses of variance revealed the significance of non-genetic factors such as feeding system, age at calving, season of calving, stage of lactation, parity number, and feeding system by calving season interaction ($p < 0.05$) on DWG and MY. The greatest impact on DWG and MY was obtained in FSII with 664.7 ± 30.9 g/d and 2.00 ± 0.95 L/d, respectively, followed by FSIII with 318.9 ± 24.9 g/d and 1.90 ± 0.93 L/d.

INTRODUCTION

Dairy production in Benin relies on native cattle breeds, among which the Borgou cattle. This breed accounts for 88% of Benin's cattle population, which is estimated at 1,635,056 head (5). The production system is a traditional low input system involving extensive grazing on natural pasture without supplementation.

Milk production reaches 82.76 million liters per year, equivalent to 13 L/capita (4). At the same time, the population growth (3.2%/year) and urbanization increase the demand for milk and milk products. These figures show that the milk supply in Benin is much lower than the human population demand. It is therefore necessary to increase productivity of dairy cattle in the country. This will require developing breeding activities and management, including animal nutrition and health. The present work was carried out with the general goal to support Borgou cattle breeding and management. The following specific objectives were thus defined:

- To assess changes in the performance of Borgou cattle in answer to changing feeding systems;
- To determine relevant non-genetic factors that contribute to variations in animal performance.

The study focused on Borgou cattle because it is the most popular breed in Benin for milk production.

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MATERIALS AND METHODS

The experiment was conducted at Okpara State farm, located in Borgou Department, between long. E 2°42' and 2°53', and lat. N 9°06' and 9°20', at an altitude of 295 m above sea level. The climate is continental Sudanian with a dry season from October to March and a rainy season from April to November. The average rainfall is 1200 mm/year and the mean annual temperature ranges between 25 and 30°C. The vegetation consists of wooded or shrubby savannas and old fallows overgrown by various graminaceous formations.

Forty-eight lactating cows (2nd to 4th lactation) with average body weight of 244 ± 27 kg were randomly selected from the dairy herds of Okpara State farm and distributed between three treatment groups, corresponding to three distinct feeding systems. Each group comprised 16 lactating cows. The cows in the first feeding system (FSI, control group) were subjected to seven hours grazing (from 9.00 a.m. to 4.00 p.m.) on natural pasture predominantly composed of *Andropogon gayanus*, *Hypparrhenia involu-crata*, *Pennisetum polystachion*, *Setaria sphacelata*, *Brachiaria ruziziensis* and *Stylosanthes hamata*. Animals in the second feeding system (FSII) were supplemented with 2 kg cottonseed cakes (at 7.00 p.m.), after seven hours grazing on natural pasture, while those in the third feeding system (FSIII) were fed a diet composed of 20 kg *Panicum maximum* C1, 2 kg *Brachiaria ruziziensis*, 1 kg *Aeschynomene histrix* and 2 kg cottonseed cakes. The grass and legume fraction of the diet fed to cows in FSIII were cut at the pre-bloom stage of growth and served fresh. The fodder crops involved were grown on an improved pasture at Okpara station. The diet in FSIII was fed *ad libitum* throughout the experimental period with weighing and discarding of refused feedstuff each morning, prior to feeding. Animals of the first and second groups were housed from 7.00 p.m. to 8.00 a.m., whereas those of the third group were permanently penned throughout the experiment. Experiment duration was 60 days (from October 14th to December 12th), preceded by a three-week adaptation phase (from September 20th to October 13th). The experimental period covered the wet, wet-dry and early dry seasons. All experimental cows were weighed at monthly intervals by means of a platform balance of 1000 kg load capacity. They were hand milked twice a day (8.00 a.m. and 6.00 p.m.). Calves were allowed to suck for about one minute in order to stimulate let down of milk. The milk yield (in liters) of each cow was recorded using a graduated 2-L polyethylene bucket. The whole milk collected from each cow was served to its calf by means of a feeding bottle.

To determine feed intake (kg/cow) of cows in FSIII, the amounts of feedstuff supplied and those refused were weighed daily by means of spring balances of 10 to 100 kg load capacity. Based on these measurements and the tables of nutritive values of feeds from Legel (8), the dry matter intake [(DMI) in kg DM/d/cow], feed intake [(FI) in g DM/kg^{0.75}], and energy intake [(ME) in MJ/d] were derived. Energy contents (metabolizable energy) of *P. maximum*, *B. ruziziensis* and cottonseed cakes were determined according to the regression equation used by Legel (8). Determination of energy content of *Aeschynomene histrix* was based on the equation fitted by Xandé et al. (20).

Statistical analysis was performed using the GLM procedure of the SAS 9.1 package (13). Data on milk yield were fitted to the following model:

$$y_{ijklm} = \mu + FS_i + CS_j + (FS * CS)_{ij} + PAR_k + LS_l + b_1 (AC_m - \hat{\mu}_{AC}) + b_2 (AC_m - \hat{\mu}_{AC})^2 + e_{ijklm}$$

where y_{ijklm} is the milk yield of the m^{th} cow; μ the overall mean; FS_i the fixed effect of the i^{th} feeding system, with $i = 1-3$; CS_j the fixed effect of the j^{th} calving season, with $i = 1-4$; $(FS * CS)_{ij}$ the ij^{th} interaction of the feeding system i by the calving season j ; PAR_k the fixed effect of the k^{th} parity number, with $k = 2-4$; LS_l the fixed effect of the l^{th} stage of lactation, with $l = 1-3$; b_1, b_2 the linear and quadratic regression coefficients of the milk yield on cow's age at calving; AC_m the cow's age at calving (in months) as covariate; $\hat{\mu}_{AC}$ the population mean for cow's age at calving; and e_{ijklm} the random error term, with $e_{ijklm} \sim N(0, \sigma_e^2)$.

The seasons 1, 2, 3 and 4 of calving were defined as wet (May-October), wet-dry (November), dry (December-March) and dry-wet (April), respectively. Test day records were classified into three stages of lactation as follows: 1st stage of lactation (0-100 d), 2nd stage of lactation (101-200 d) and 3rd stage of lactation (201-300 d).

For body weight gain, feed intake and energy intake, the following model was used:

$$y_{ijkl} = \mu + CS_i + PAR_j + LS_k + b_1 (AC_l - \hat{\mu}_{AC}) + b_2 (AC_l - \hat{\mu}_{AC})^2 + e_{ijkl}$$

where y_{ijkl} is the dependent variable (body weight gain, feed intake capacity, feed or energy intake of the l^{th} cow); μ the overall mean; CS_i the fixed effect of the i^{th} calving season, with $i = 1-4$; PAR_j the fixed effect of the j^{th} parity, with $j = 2-4$; LS_k the fixed effect of the k^{th} stage of lactation, with $k = 1-3$; b_1, b_2 the linear and quadratic regression coefficients of the milk yield on cow's age at calving; AC_l the cow's age at calving (in months) as covariate; $\hat{\mu}_{AC}$ the population mean for cow's age at calving; and e_{ijkl} the random error term, with $e_{ijkl} \sim N(0, \sigma_e^2)$.

RESULTS AND DISCUSSION

The mean values and standard deviations of daily weight gain and milk yield obtained according to the feeding system, calving season, parity number, stage of lactation and age at calving are presented in table I. Those concerning dry matter intake capacity, feed intake and energy intake are presented in table II. In tables I and II are also presented the results of means comparison subsequent to the analyses of variances (AOV) of the traits studied and the significance level of effects considered in the statistical models. Results regarding feed and energy intake refer only to FSIII.

The overall means and standard deviations were 392.0 ± 4.5 g/d for the daily weight gain and 1.15 ± 0.57 , 0.62 ± 0.31 and 1.77 ± 0.84 L/d for morning, evening and daily milk yields, respectively (Table I). For dry matter intake capacity, feed intake and energy intake, the overall means were 7.88 ± 0.39 kg DM, 118.16 ± 8.59 g DM/kg^{0.75} and 71.62 ± 4.47 MJ/d respectively (Table II).

The milk yield obtained in the current study was higher than most reported milk yields for Borgou cattle under traditional husbandry conditions (3, 11). In the present study, the average milk yield of Borgou cows was estimated on the basis of part lactation records, i.e. 60-day records instead of the 305 days lactation records commonly used in test programs for daily performance evaluation of cows. In addition, the feeding experiment only took place during the first half of the dry season. Thus, experimental cows did not take advantage of the rainy season with regard to abundance and

Table I

Mean values ($\bar{x} \pm s$) of daily milk yields and daily weight gain in Borgou cows according to the feeding system, season of calving, parity number, stage of lactation and age at calving

	Daily weight gain (g/d)	Daily milk yield (L/d)		
		Morning	Evening	Total
Overall means	392.0 ± 28.7	1.15 ± 0.57	0.62 ± 0.31	1.77 ± 0.84
CV%	36.9	31.66	36.26	30.77
Feeding system (FS)	***	***	***	***
I	144.4 ± 36.8 ^c	0.84 ± 0.20 ^b	0.54 ± 0.14 ^b	1.38 ± 0.2 ^b
II	664.7 ± 30.9 ^a	1.30 ± 0.63 ^a	0.71 ± 0.36 ^a	2.00 ± 0.95 ^a
III	318.9 ± 24.9 ^b	1.30 ± 0.62 ^a	0.61 ± 0.34 ^a	1.90 ± 0.93 ^a
Calving season (CS)	***	***	***	***
Wet	471.1 ± 23.3 ^a	1.12 ± 0.55 ^b	0.61 ± 0.29 ^b	1.73 ± 0.80 ^b
Wet-dry	96.7 ± 11.7 ^c	2.01 ± 0.96 ^a	1.17 ± 0.49 ^a	3.16 ± 1.42 ^a
Dry	485.7 ± 36.1 ^a	1.04 ± 0.19 ^b	0.52 ± 0.11 ^b	1.56 ± 0.23 ^b
Dry-wet	221.2 ± 15.1 ^b	1.04 ± 0.25 ^b	0.50 ± 0.15 ^b	1.54 ± 0.25 ^b
Parity number	***	***	***	***
2	550.0 ± 29.9 ^a	0.88 ± 0.14 ^c	0.49 ± 0.16 ^c	1.37 ± 0.23 ^c
3	372.1 ± 36.7 ^b	1.04 ± 0.45 ^b	0.59 ± 0.23 ^b	1.63 ± 0.63 ^b
4	327.6 ± 23.9 ^b	1.62 ± 0.76 ^a	0.81 ± 0.45 ^a	2.43 ± 1.17 ^a
Stage of lactation	***	**	***	***
1	325.4 ± 35.3 ^b	1.55 ± 0.74 ^a	0.88 ± 0.46 ^a	2.43 ± 1.17 ^a
2	415.9 ± 22.6 ^a	1.00 ± 0.45 ^b	0.54 ± 0.16 ^b	1.57 ± 0.57 ^b
3	414.9 ± 38.1 ^a	1.02 ± 0.29 ^b	0.52 ± 0.12 ^b	1.54 ± 0.34 ^b
Interactions FS*CS	***	***	***	***
Regression on cow's age at calving				
Linear (b ₁)	ns	***	*	***
		0.85 ± 0.18	0.29 ± 0.11	1.14 ± 0.27
Quadratic (b ₂)	ns	***	**	***
		-0.003 ± 0.001	-0.003 ± 0.001	-0.011 ± 0.002

* p < 0.05; ** p < 0.01; *** p < 0.001; ns: not significant

quality of fodder crops. Extending the individual test day records to 305 day records, so that records from both wet and dry seasons could be included in the lactation total, may yield higher results.

The dry matter intake capacity of 7.88 ± 0.39 kg DM/d for Borgou cows is close to the value of 7.1 kg DM/d reported by Muinga et al. (9) for Jersey cows fed Napier Gras *ad libitum* under semihumid tropical conditions. Expressed in grams of dry matter per metabolic body weight, the feed intake of Borgou cows (118 g DM/kg^{0.75}) agreed with the mean intake (135 g DM/kg^{0.75}) recommended for cows yielding on average 5000 kg fat-protein-corrected-milk (FPCM) in 305-day lactations (6). With nearly similar dry matter intake per metabolic body weight, the milk performances of Borgou and Jersey cows differ because of differences in genetic potentials. But the energy content of the diets offered can also explain differences in their performances. In fact, the energy intake of Borgou cows in the present study was half the energy requirements (1.07 Mcal/lb or 152.32 MJ per day) recommended by NRC (10) for small cow breeds, i.e. breeds with a weight lower

than 900 lb (408.16 kg) and yielding less than 18 lb (8.16 kg) of milk daily. The Jersey breed ranks in this category. Therefore, Borgou cows would probably respond with higher performances (MY, DWG) when fed a diet with a higher energy content. Additional research is suggested to refine the ration in FSIII by increasing its energy level at the same voluntary intake as that found in the present study. In addition, the coefficient of variation obtained in this experiment for the daily milk yield was higher than that obtained in most improved breeds (15). This indicates that the Borgou breed also has great potential for genetic improvement through selection on milk yields.

Analyses of variance revealed that the feeding system was highly significant with regard to variations in the milk yield and daily weight gain (p < 0.001). The highest daily weight gain and daily milk yield were obtained in FSII with 664.7 ± 30.9 g/d and 2.00 ± 0.95 L/d, followed by FSIII with 318 ± 24.9 g/d and 1.90 ± 0.93 L/d, respectively. Both systems differed significantly from FSI, where a daily weight gain of 144.4 ± 36.8 g/d and

an average milk yield of 1.38 ± 0.28 L/d were obtained. The significance of the effect of the feeding system on the milk yield can be explained by differences in the nutritional values of diets, as the protein supply in FSII and FSIII was obviously higher than that in FSI. Although experimental cows were fed at the same concentrate level (2 kg cottonseed cakes) in FSII and FSIII, the average milk yield of cows was higher in FSII than in FSIII. The difference was probably due to the advantage of selective choice of forage by cows raised under FSII. However, the milk yield difference between FSII and FSIII was not significant. In contrast, differences in body weight gain of cows in FSII and FSIII were significant ($p < 0.05$).

Milk yield, body weight gain and feed intake per metabolic body weight were significantly affected ($p < 0.01$ or $p < 0.0001$) by the season of calving, whereas the dry matter intake capacity and energy intake (metabolizable energy) were not. The significance of the effect of the calving season on milk yields agrees with reports by other authors (2, 7, 18). The average milk yield of cows that calved in the wet-dry season (3.16 ± 1.42 l/d) was significantly higher than those of cows that calved in the wet, the dry and the dry-wet seasons (Table I). This was because cows which parturition occurred in the wet-dry season took advantage of the whole vegetation period (six months) during gravidity. In addition, they were fed green forage of higher feeding value immediately after parturition. Usually, the postpartum period of these cows coincides with the qualitative decline of the biomass, i.e. the beginning of the dry season. But in the study area, the upper horizon of the soil was moist enough to allow for vegetation regrowth, especially when

Table II

Mean values ($\bar{x} \pm s$) of dry matter intake capacity (DMI), feed intake (FI) and energy intake (ME) in Borgou cows according to the calving season, parity number, lactation stage and cow's age at calving

	DMI (kg DM/d)	FI (g DM/kg ^{0.75})	ME (MJ/d)
Overall means	7.88 ± 0.39	118.2 ± 8.6	71.62 ± 4.47
Calving season	ns	*	ns
Wet	7.88 ± 0.42^a	118.9 ± 9.3^a	71.37 ± 4.70^a
Wet-dry	7.90 ± 0.43^a	109.1 ± 6.1^b	72.77 ± 5.06^a
Dry	7.82 ± 0.32^a	121.0 ± 7.7^a	71.22 ± 4.51^a
Dry-wet	8.02 ± 0.26^a	115.9 ± 4.1^a	72.54 ± 3.64^a
Parity number	*	ns	ns
2	8.00 ± 0.36^a	115.4 ± 7.2^a	72.33 ± 4.19^a
3	7.89 ± 0.37^{ab}	119.8 ± 6.9^a	71.58 ± 4.29^a
4	7.69 ± 0.42^b	119.9 ± 11.9^a	70.59 ± 5.25^a
Stage of lactation	ns	ns	ns
1	7.88 ± 0.39^a	109.2 ± 5.4^b	72.86 ± 4.53^a
2	7.90 ± 0.43^a	119.9 ± 8.6^a	71.20 ± 4.74^a
3	7.87 ± 0.36^a	118.6 ± 8.0^a	71.77 ± 4.23^a
Regression on cow's age at calving			
Linear (b_1)	*	ns	ns
Quadratic (b_2)	*	ns	ns

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ns: not significant

bushfire was used. This practice was common place in the whole Borgou Department. There was a significant interaction ($p < 0.05$) between feeding system and calving season on milk yield (Figure 1). This meant that ranking feeding systems based on milk yields varied with the calving season.

The parity number significantly affected the daily weight gain, milk yield ($p < 0.001$) and dry matter intake ($p < 0.05$) of Borgou cows. The milk yield increased also with the increase in lactation number, reaching a peak (2.43 ± 1.17 L/d) at the fourth lactation. The increase in milk yield in relation with the increase in parity number was probably due to the maturity of the milk secretion system. Similarly, the dry matter intake capacity increased with increasing parity number. Inversely, the daily weight gain decreased with increasing parity number, i.e. the highest daily weight gain (550.0 ± 29.9 g/d) was recorded for second parity cows, whereas the lowest daily weight gain (327.6 ± 23.9 g/d) was recorded for fourth parity cows. However, the differences observed in daily weight gains of third and fourth parity cows were not significant.

Variations in milk yield and body weight gain were significantly affected by the lactation stage ($p < 0.0001$) (Table I). Cows in their first lactation stage exhibited the highest performance in milk yield (2.43 ± 1.17 L/d) but the lowest daily weight gain (325.4 ± 35.3 g/d). The milk yields obtained thereafter were lower. The milk yield obtained in the first lactation was significantly higher than those in second and third lactations. There was no significant difference between second and third lactation milk yields. These results agreed with the well known profile of the lactation curve of dairy cows. No significant differences were found between the different lactation stages with regard to dry matter intake per metabolic body weight and energy intake.

The age of cows at calving affected milk yield and dry matter intake capacity in its linear ($p < 0.0001$ or $p < 0.05$) and quadratic ($p < 0.0001$ or $p < 0.05$) functions. The dairy performances of cows of intermediate age were higher than those of younger and older cows (Figure 2). This might be explained by the incomplete body development of younger cows and the physiological deterioration of older ones (17, 19).

The significance of non-genetic factors such as age at calving, season of calving, stage of lactation and parity number on the milk yield of cows has been reported by many authors (1, 12, 14, 15, 16, 18) as it is the rationale for the development of adjustment factors for environmental fixed effects as well as for the use of test day models in breeding value evaluation of dairy cows. Age-season adjusted record is known as breed class average in Canada or as mature equivalent in the United States. Standard correction factors

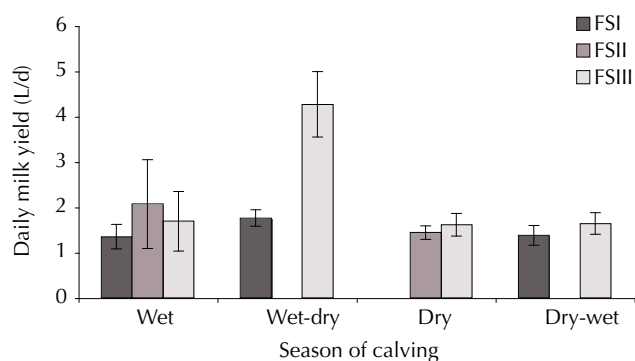


Figure 1: Daily milk yield according to the feeding system (FSI, FSII, FSIII) and calving season in Borgou cows.

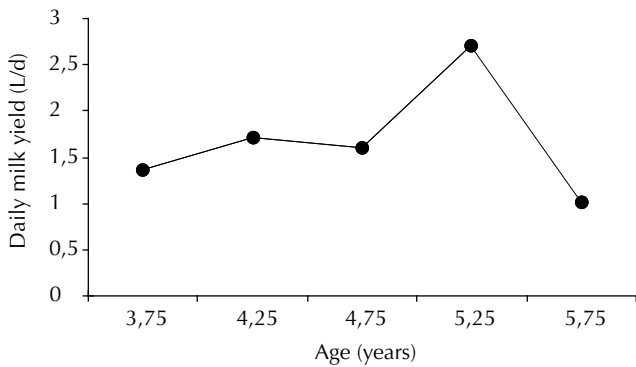


Figure 2: Daily milk yield according to the age of Borgou cows.

for effects such as season and age at calving among others have also been developed by Wilmlink (18) for Dutch Friesian cows. Auran (1) also reported that age at calving explained about 20-40% of the total variation in milk production.

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Résumé

Senou M., Toléba S.S., Adandédjan C., Poivey J.-P., Ahissou A., Touré F.Z., Monsia C. Amélioration de la performance laitière des vaches Borgou dans des systèmes d'alimentation alternatifs

L'objectif de la présente étude a été d'appréhender la variabilité des caractères tels que la performance laitière (PL), le gain moyen quotidien (GMQ), la capacité d'ingestion de la matière sèche (IMS), l'ingestion alimentaire (IA) et l'énergie métabolizable absorbée (EM) chez les vaches Borgou, en fonction du système d'alimentation. Des mesures de performances réalisées sur 48 vaches allaitantes, élevées à la ferme d'Etat de l'Okpara, ont été analysées. Les vaches ont été réparties sur trois lots correspondant à trois systèmes d'alimentation : la pâture sur parcours naturel (SAI), la pâture sur parcours naturel plus supplémentation avec 2 kg de tourteau de coton (SAII), et le rationnement avec 20 kg de *Panicum maximum* C1, 2 kg de *Brachiaria ruziziensis*, 1 kg d'*Aeschynomene histrix* et 2 kg de tourteau de coton (SAIII). Les moyennes estimées ont été de $392,0 \pm 28,7$ g/j, $1,77 \pm 0,84$ l/j, $7,88 \pm 0,39$ kg MS, $118,16 \pm 8,59$ g MS/kg^{0,75} et $71,62 \pm 4,47$ Mj, respectivement pour GMQ, PL, IMS, IA et EM. L'analyse de variance a montré que les facteurs non génétiques tels que le système d'alimentation, l'âge au vêlage, la saison de vêlage, le stade de lactation et la parité ainsi que l'interaction entre le système d'alimentation et la saison de vêlage avaient un effet significatif ($p < 0,05$) sur GMQ et PL. Le plus grand impact sur GMQ et PL a été obtenu avec SAII (respectivement $664,7 \pm 30,9$ g/j et $2,00 \pm 0,95$ l/j), suivi de SAIII ($318,9 \pm 24,99$ g/j et $1,90 \pm 0,93$ l/j).

Mots-clés : Bovin Borgou – Vache laitière – Alimentation – Augmentation de rendement – Gain de poids – Bénin.

Resumen

Senou M., Toléba S.S., Adandédjan C., Poivey J.-P., Ahissou A., Touré F.Z., Monsia C. Aumento del rendimiento de leche en vacas Borgou bajo sistemas de alimentación alternativos

El objetivo del presente estudio fue el de asesorar cambios en el rendimiento de leche (RL), ganancia de peso diaria (GPD), capacidad de ingestión de materia seca (IMS), ingestión de alimento (IF) e ingestión de energía (EM) del ganado Borgou bajo sistemas de alimentación separados. Se analizaron los registros de rendimiento de 48 vacas lactantes, criadas en la finca estatal de Okpara. Las vacas se distribuyeron en tres grupos de tratamiento, correspondientes a tres sistemas alimenticios: pastoreo en pasto natural (SAI); pastoreo en pasto natural más suplemento con 2 kg de tortas de semilla de algodón (SAII) y racionalizado con 20 kg de *Panicum maximum* C1, 2 kg *Brachiaria ruziziensis*, 1 kg *Aeschynomene histrix* y 2 kg tortas de algodón (SAIII). Los promedios estimados fueron de $392,0 \pm 28,7$ g/d, $1,77 \pm 0,84$ L/d, $7,88 \pm 0,39$ kg DM, $118,16 \pm 8,59$ g DM/kg^{0,75} y $71,62 \pm 4,47$ Mj para GPD, RL, IMS, IF y EM respectivamente. Los análisis de varianza revelaron resultados significativos para factores no genéticos, como sistema de alimentación, edad de parto, época de parto, estadio de lactación, número de partos y la interacción de sistema de alimentación por época de parto ($p < 0,05$) sobre GPD y RL. El mayor impacto sobre GPD y RL se obtuvo con SAII con $664,7 \pm 30,9$ g/d y $2,00 \pm 0,95$ L/d, respectivamente, seguido por SAIII con $318,9 \pm 24,9$ g/d y $1,90 \pm 0,93$ L/d.

Palabras clave: Ganado bovino Borgou – Vaca lechera – Alimentación – Aumento del rendimiento – Ganancia de peso – Benin.