

Growth patterns and reproductive performance of grazing Brahman cows in a tropical environment

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ABSTRACT: Two experiments were conducted in the neotropical savannas of Carimagua, Colombia to test the hypothesis that Brahman females subjected to sustained grazing undernutrition as heifers can attain high reproductive performance as mature cows, if allowed to make compensatory gains. Experiment 1 subjected weaned heifers to three distinct, but modest, rates of weight gain (H, M, and L) on a poor quality tropical pasture until reaching mating weight at 270 kg. Each group was then subdivided and grazed on pastures that allowed high (h) or low (l) weights gains. Experiment 2 allowed heifers of the same type to achieve continuous high weight gains and served as a control. Regardless of earlier treatment, all h cows in Experiment 1 achieved mature body size and reproductive performance comparable to those of the well-fed animals of Experiment 2. It is concluded that the potential exists for a wide range of grazing managements of Brahman heifers in the tropics, and it is possible to achieve levels of performance that represent a substantial improvement over current standards at a modest management cost.

Key words: Brahman, grazing, growth pattern, heifers, reproductive performance

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Patrones de crecimiento y desempeño reproductivo de vacas Brahman a pastoreo en un medio ambiente tropical

RESUMEN: Se realizaron dos experimentos en Carimagua, en las sabanas neotropicales de los Llanos Orientales de Colombia, para probar la hipótesis de que hembras Brahman expuestas a condiciones de subnutrición, pueden llegar a tener alto desempeño reproductivo como vacas maduras si se les permite realizar ganancias compensatorias de peso. El Experimento 1 expuso novillas destetas a tres regímenes de pastoreo en una pastura de baja calidad para lograr ganancias de peso diferentes pero modestas (H, M y L) hasta el peso de entore de 270 kg. Luego, cada grupo se subdividió en dos y fueron pastoreados en pasturas que permitieron ganancias de peso altas (h) o bajas (l). El Experimento 2 permitió al mismo tipo de novillas realizar ganancias altas en forma continua y constituyó un control positivo. Independientemente del tratamiento experimentado como novillas, todos los animales en el tratamiento h del Experimento 1 lograron pesos maduros y desempeño reproductivo comparables con los de los animales mucho mejor alimentados del Experimento 2. Se concluye que existe un amplio rango de manejos nutricionales en condiciones de pastoreo para el levante de novillas Brahman de carne y que se pueden lograr niveles altos de desempeño comparados a los predominantes en la región, con costos modestos de manejo.

Palabras clave: Brahman, crecimiento, novillas, pastoreo, reproducción

Introduction

Reproductive rates of cattle under range- and low input pasture-based systems of the tropics are generally low (Galina and Arthur, 1989b; Mukasa-Mugerwa, 1989). Throughout the neotropical savannas, and frequently else-

where also, raising replacement heifers represents the least input- and management- intensive part of the beef cattle industry (Pott, *et al.*, 1987). Heifers are subjected to deficient feeding regimes and are maintained on poor quality pastures, as described by Kleinheisterkamp and Habich (1985) and Squires and Vera (1992), among others. The economic

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rationale of these practices has been discussed by several authors (Vera and Seré, 1985, 1990; Brockinton *et al.*, 1986). Previous papers (Vera, 1991; Vera *et al.*, 1993) have examined the long-term consequences of sustained undernutrition on the growth and lifetime reproductive performance of Brahman heifers. The results indicated that a great deal of flexibility can be exercised in terms of the nutritional management of Brahman heifers, assessed by liveweight gains, without significantly prejudicing their performance as breeding dams in commercial operations. Also, alternative growth management patterns were suggested that would enable achievement of adequate growth and reproductive performance in pasture fed heifers as suggested by Galina and Arthur (1989a). In essence, it was postulated that compensatory weight gain could be used to rapidly raise the liveweight of underfed grazing heifers, once they reach mating weight, so that these animals attain calving and weaning performance that would represent a significant quantitative improvement over current practices. The tradeoff would be a requirement for an improved grazing management regime, and possible negative effects on lifetime performance relative to a more regular and continuous growth pattern.

The above hypotheses have been explored in a series of long-term grazing experiments carried out in the Colombian savannas. Two of these experiments are reported herein. The objective of the first trial was to test the hypothesis that replacement females subjected to sustained grazing undernutrition as heifers can achieve and maintain relatively high reproductive performance as mature dams if allowed to make compensatory gains on improved pastures after attaining the target mating liveweight of 270 kg. The second experiment represented a positive control, wherein heifers were raised following a strategy that would allow them to reach and maintain high liveweights based on well managed, unsupplemented, grass-only pastures. These strategies, as well as animal and pasture management employed, were as close as possible to those generally found in the region (Kelinhesterkamp and Habich, 1985; Vera and Seré, 1985; Smith *et al.*, 1997).

Materials and Methods

The experiments were carried out at the Carimagua Experiment Station located in the tropical savanna region of Colombia (4° 37' N, 70° 30' W; 150 masl; 2 100 mm rainfall distributed between April and December). Both trials were contemporary and were run in adjacent areas, but the management requirements of each, and the temporal growth patterns of the animals, prevented formal statistical comparisons between them. All the animals came from the same breeding herd composed mostly of Brahman cows bred to purebred Brahman bulls maintained on native rangelands, and subjected to minimal culling.

Experiment 1. Phase I of the experiment began in September 1984 and ended in June 1986, and Phase II began at the latter date and finished in August 1990.

Phase I included three growth rate treatments applied to 42 weaned grazing Brahman female calves with mean initial age of 410 days (SE 17 days) and mean weight of 165 kg (SE 2 kg). An attempt was made to obtain three growth rates by means of three stocking rates (1.28, 1.71 and 2.24 head/ha) on a low quality (Hoyos and Lascano, 1988) *Brachiaria humidicola* pasture. These resulted in relatively high (H), medium (M) and low (L) growth rates of 0.197, 0.192 and 0.096 kg/day, respectively. Phase I ended when the mean weight across all treatments was 270 kg.

In Phase II, the animals were equally split into treatments of low (l) or high (h) growth rates, with target gains of 0.250 and 0.350 kg/day, respectively. To obtain these contrasting weight gains, animals were grazed on a *B. humidicola* pasture (treatment l) or on *B. decumbens* (treatment h), thus resulting in six groups differing in weight gain strategies, corresponding to a 3 x 2 factorial arrangement of treatments.

The only supplement offered was a mineral mixture containing 80 g/kg phosphorus and a complete mix of macro and micro-minerals.

Animals were weighed at intervals of three months. At the beginning of Phase II tested purebred Brahman bulls were introduced, and rotated every three months. The ratio of females to bulls was 20:1. Mating was continuous thereafter as is the common practice in the region. Calvings were recorded daily. Dams were palpated per rectum every three months but no voluntary culling was exercised. Mean calf age at weaning was 270 days.

Cow weights were fitted to a logistic growth model of the type:

$$W_{it} = W_{\max} / (1 + b * \exp(-k * t)) \quad [1]$$

where W_{it} is the liveweight of animal i at time t (days), and W_{\max} , b and k are parameters.

Experiment 2. The experiment was carried out between November 1981 and August 1988.

It included 26 Brahman females, which began as heifers with a mean initial age of 806 days (SE 28 days) and mean weight 271 kg (SE 3 kg).

Throughout the experiment the herd was continuously grazed on a well managed *Brachiaria decumbens* pasture with a mean stocking rate of 1.5 animal/ha. The experimental paddock was rejuvenated at periodic intervals of three years by means of two light diskings, as is common practice in the region, followed by a light fertilizer application of P, Ca, K, and Mg. At these times, the herd was moved to an adjoining, identical, paddock.

Heifers were initially mated at a mean age of 1 071 days (SE 28 days) and weight of 358 kg (SE 5 kg). Contrary to common practice, mating was seasonal and consisted of 90 days in mid-late rainy season (August-October) followed by a second period lasting 45 days in April-May. Purebred, tested, Brahman bulls were used in all cases.

Animals were weighed off the paddock four times per year. Calves were weighed within 24 hours of birth.

Cows' liveweights throughout the experiment were fitted to an asymptotic equation of the type:

$$W_{it} = W_{\max} (1 - c * \exp(-d * t)) \quad [2]$$

where W_{it} is the weight of animal i at time t (days), and W_{\max} , c and d are parameters. Having observed that mature weights appeared to decrease with age, a second model (equation [3]) with a linearly decreasing asymptote was fitted to the data, as follows:

$$W_{2it} = (W_{\max} - b * t) * (1 - c * \exp(-d * t)) \quad [3]$$

To estimate cows' conception and calving weights in both experiments, values recorded near to these events were used. As it turned out conception weights (CONWGT) were those recorded 8 days (SE 3 days) after the calculated conception date. Pre calving weights (PRECALV) were assessed 67 days (SE 4 days) before actual calving. Cow and calf weights at weaning (COWWEAN and CALFWEAN, respectively) were recorded at the time of that event. Calves' weaning weights were adjusted to 270 days of age.

All statistical analyses were performed using the GLM procedure of SAS (Statistical Analysis Systems Institute, 1988). Least square means were calculated as appropriate.

Results

Experiment 1. Phase I lasted 657 days and included two dry seasons during which animals lost weight which was recovered in the following rainy seasons (Figure 1). Average weight gains realized during this phase were 0.197, 0.192, and 0.096 kg/day ($P < 0.05$) for treatments H, M, and L, respectively. Weight gains during the 1 514 days of Phase II depended upon the treatment received and, initially at least, were influenced by Phase I treatments (Figure 1). However, gains were within the initial target limits. Table 1 shows the weight gains made during the first year of Phase II, a period

during which they were not generally affected by pregnancy except for animals of treatment H. Animals in treatments Hh and Mh generally maintained the highest liveweights throughout the experiment.

The estimated weight at first conception was similar for all treatments ($P > 0.05$) and averaged 310 kg. This led to differences in age at first calving. The mean calving age was 1583 days (SE 20), and the effect of treatments interaction (Phase I by Phase 2) was significant ($P < 0.002$). In essence, age at first calving was significantly longer in treatment combination L1 (1920 d, SE 54) than in the remaining cases. On the other hand, weight changes during the first lactation (Table 2) were significantly influenced by both Phase I and Phase II treatments ($P < 0.01$), whereas the interaction between them was not significant ($P = 0.13$). Nevertheless, and due to the design of the experiment that allowed continuous mating, lactations were spread throughout the year such that weight changes during lactation were partially confounded with season. Another statistical analysis was therefore carried out that accounted for the season during which lactation took place. Three periods were defined as follows: (1) lactation from the beginning of the dry season until mid rainy season; (2) lactation during the rainy season, and (3) lactation from late rainy season to the end of the dry season. Regardless of the season, all animals in treatment l lost weight (0.053 kg/d), whereas those of treatment h lost weight only if the bulk of the lactation coincided squarely with the dry season (season 3). The interaction between both sets of treatments was not significant ($P > 0.05$). Weighted liveweight gains for treatments l and h were 0.058 and -0.053 kg/day ($P < 0.005$), and for seasons (1), (2) and (3) they were 0.008, 0.065 and -0.064 kg/day, respectively ($P < 0.005$). This influence of season on the dam's weight change during first lactation was not reflected in the weaning weights of calves ($P > 0.05$), which averaged

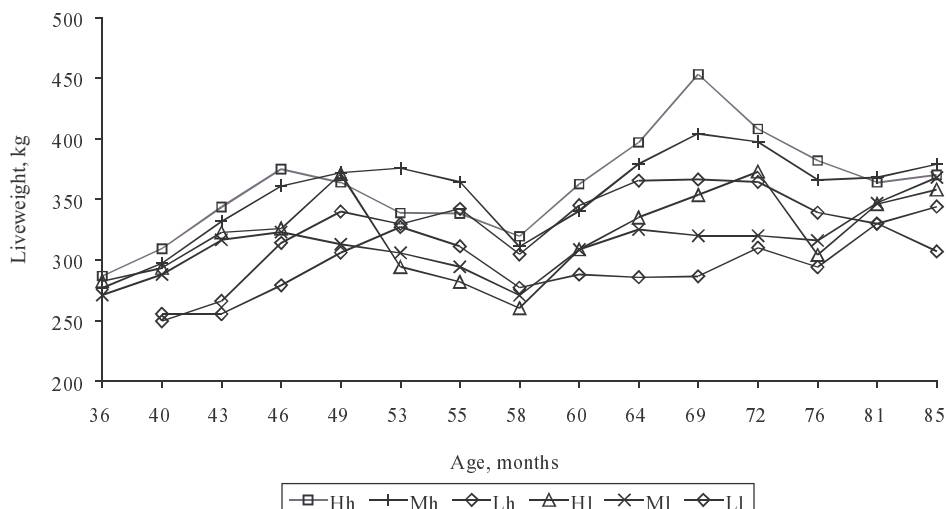


Figure 1. Change of liveweight (kg) with age (months) of Brahman cows in the six treatment combinations of Experiment 1. See page 15 for description.

163 kg (SE 24 kg). However, calves weaned at the end of season (2) were 8% heavier than the rest. On the other hand, calf weaning weights were influenced by Phase II treatments, with means of 173 and 152 kg for treatments h and, l respectively ($P < 0.01$).

During the second lactation no seasonal effects on dam's weight change were detected ($P > 0.05$), whereas the influence of Phase II treatments on calf weaning weight was again significant ($P < 0.01$) and of similar magnitude to that observed in the first lactation.

Averaged over the two lactations, the dams' weight at weaning was 336 and 273 kg for h and l treatments, respectively ($P < 0.05$).

Consistent with the above trends, the intervals between the first and second calvings were 543 and 723 days for h and l treatments, respectively ($P < 0.001$).

By the end of the experiment, cows in treatment h had weaned a total of 382 kg of calf liveweight and had themselves an uncorrected weight of 372 kg, whereas those of treatment l had weaned 253 kg and weighed 351 kg. Both these differences were significant ($P < 0.05$, SE of 119 and 14 kg, respectively). In neither case was the effect of Phase I treatment significant ($P > 0.05$).

Cow weight throughout the experiment was well fitted by the logistic function. The parameter values are shown in Table 3. The values of W_{\max} and of b were significantly influenced only by treatments in Phase II ($P < 0.01$), whereas k, an estimate of the relative growth rate, was influenced only by treatments in Phase I ($P < 0.01$).

Experiment 2. Cow weights throughout the experiment increased asymptotically and adjusted well to the two models (equations [2] and [3]) tested (Table 4).

Calving weights (PRECALV) decreased between calvings 1 and 3 ($P < 0.02$) and recuperated slightly in the fourth calving (Table 5). This trend was also reflected in CONWGT ($P < 0.001$), but it disappeared at weaning (CONWEAN).

Liveweight performance of the weaned calves, although high by local standards (Kelinheisterkamp and Habich, 1985; Vera and Seré, 1985), decreased with succeeding weanings at the rate of 11.5 kg per cycle ($P < 0.001$), as shown in Table 5.

Calving intervals were marginally longer between the first and second calving (472 days, se 29), but differences

Table 1. Daily liveweight gains (kg) realized during Phase I and the first year of Phase II of Experiment 1.

Treatment combination	Phase I	Phase II
Hh	0.197	0.215
HI	0.197	0.246
Mh	0.192	0.265
MI	0.192	0.117
Lh	0.096	0.347
LI	0.096	0.194

See page 15 for description.

Table 2. Weight changes of the dam during the first lactation in Experiment 1

Treatment combination	Liveweight change/kg/day
Hh	0.047
HI	-0.056
Mh	0.208
MI	-0.024
Lh	-0.040
LI	-0.098
Se	0.105

See page 15 for description.

Table 3. Values of the parameters in the logistic equation fitted to cow weights of Experiment 1.

Treatment combination	Parameter		
	W_{\max}	B	k
Hh	387	1.5591	0.0024
HI	349	1.4655	0.0026
Mh	390	1.8302	0.0024
MI	345	1.2005	0.0024
Lh	381	1.8230	0.0018
LI	332	1.2517	0.0018
se	44	0.4275	0.0005

See page 15 for description.

Table 4. Parameters of the asymptotic equations [2] and [3] fitted to cow weights (kg) as a function of age (t, days) in Experiment 2.

Equation		Parameters				R^2	Model SE
		W_{\max}	b	c	D		
2	parameter value	387.7	-	2.106	0.00299	0.81	32.4
	SE	7.6		0.398	0.0005		
3	parameter value	422.2	0.016	38.086	0.00569	0.55	27.1
	SE	26.1	0.011	69.130	0.00221		

Table 5. Cow mean weights (kg) near conception (CONWGT), near calving (PRECALV), and at weaning (COWWEAN), and calves' adjusted weaning weights (CALFWGT) in Experiment 2.

Parity	CALFWGT	CONWGT	PRECALV	COWWEAN
1	202	421	452	354
2	183	415	396	341
3	172	378	388	369
4	168	373	418	358
SE	3	5.1	7.6	5.9
P<	0.001	0.001	0.02	0.36

between calving numbers were not significant ($P > 0.05$). Overall, the mean calving interval was 445 days (SE 15).

Both experiments. The mean length of the calving intervals in each treatment of both experiments was linearly regressed on mature body size as estimated by W_{\max} (Table 3 and equation [2] in Table 2). The results and the fit are shown in Figure 2.

Discussion

The experimental protocol used allowed highly contrasting growth patterns that qualitatively and quantitatively represent a wide range of existing feeding strategies in current cow-calf systems (Mahadevan *et al.*, 1972; Kleinheisterkamp and Habich, 1985; Squires and Vera, 1992). Nevertheless, the liveweight required for first conception was similar in all treatments of Experiment 1, and it was comparable to those reported by Doogan *et al.* (1991), Vera (1991), and Vera *et al.* (1993) for the same type of animals, which suggests that this weight is an important benchmark. On the other hand, conception in Experiment 2 was deliberately delayed until cows reached a much higher liveweight, in an attempt to attain and maintain heavier weights. Even then, conception in this experiment took place at a mean age of 1458 days, comparable to that for treatment L of experiment 1. This contrast illustrates one of the tradeoffs between achieving either early conception or greater growth in unsupplemented grazing heifers in a low input extensive tropical system. The other important tradeoff relates to a strategy of growth at low rates versus lifetime productivity, given the small but significant correlation of the latter with age at first parturition (Silva *et al.* 1986).

Once first conception took place, subsequent performance was mainly determined by the grazing regime imposed in Phase II, with little residual effects of the earlier growth pattern during Phase I. This finding agrees with the literature reviewed by Alden (1970) referred mostly to dairy heifers experiencing much larger compensatory gains than in the present experiments, and with those reported by Van Niekerk *et al.* (1990) for beef heifers. In fact, Park *et al.* (1987) found that a 5-2-5-2 regime (5 months maintenance and 2 months compensatory growth, respectively) was a simple and cost effective method of raising Holstein heif-

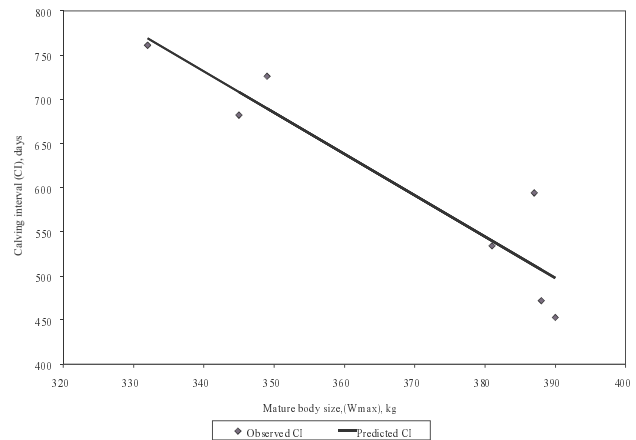


Figure 2. Regression of calving interval (days) on mature body size, W_{\max} (kg) for Brahman cows in the two experiments.

ers, there being even some evidence of increased feed efficiency relative to the control animals.

The only consistent residual effect was a delay in initial conception and, therefore, age at this and following reproductive events. Delays of this nature would be expected to affect economic performance, given the opportunity costs for other uses of good quality pastures (e.g., fattening or milk production), but in extensive systems this effect is of limited importance (Vera and Seré, 1985; Brockington *et al.*, 1986). Phase II treatments brought about large differences in reproductive performance as shown by cows' calving and weaning weights, calf weights, and calving intervals. It is worth noting, however, that regardless of treatment in Phase I, all cows had a mean maternal weaning weight in their first parity (325 kg) that was close to that of the well fed cows (354 kg) in Experiment 2. The same was true of the weaning weight of their calves (174 and 168 kg at comparable ages, respectively). All of these weights were much larger than those found for cows and calves in treatment I and those reported earlier by Vera *et al.* (1993). These findings emphasize the overriding importance of Phase II treatments.

The same trend regarding the effect of compensatory gains was noted in terms of mature body sizes, W_{max} . In effect, all animals in treatment h attained practically the same asymptotic weight regardless of earlier treatment. Furthermore, these weights were indistinguishable from those attained by cows in Experiment 2. With regard to the latter, and under the experimental conditions used, there was evidence that the high liveweights realized early on were not sustained as shown by the significant decrease with time as described by Equation [3]. It is hypothesized that one of the causes of this effect may have been the decline in pasture quality and carrying capacity that made necessary periodic rejuvenation of the experimental paddocks. Degradation of tropical, grass-only pastures is a well known, although poorly documented, phenomenon (Spain and Gualdrón, 1991; Vera *et al.*, 1998). Even so, the feeding strategy used in Experiment 2 led to high beef production and reproductive performance relative to current levels (Vera and Seré, 1985).

The finding of a close correlation between mature body size and calving interval is not surprising (Marshall *et al.*, 1984), but the steep slope of the curve attests to the extreme sensitivity of the more productive strategies tested here to management changes. In effect, the range of weights was relatively narrow but still had marked consequences on calving intervals. The mean intervals reported herein (472 days in Experiment 2, and 543 and 723 days for treatments h and l, respectively, in Experiment 1) imply that modest adjustments in the grazing strategy can lead to calving percentages ranging markedly from 50 to 75%. It also implies that the initial hypothesis of the existence of wide latitude in grazing management of replacement heifers and brood cows is indeed correct, and that it is feasible to achieve levels of reproductive performance in formerly underfed grazing females that represent a major improvement over current levels, at a modest management cost. Also, and as suggested by Doogan *et al.* (1991), liveweight proved to be a useful indicator of fertility, particularly certain reference weights such as CONWGT and W_{max} . From a producer's point of view, feeding to achieve certain target weights for given cows' genotypes, would be a practical approach.

Adoption of some of the above strategies on a regional level would have major temporal repercussions in terms of the cattle population of otherwise understocked frontier regions as modeled by Seré and Estrada (1985). The results of this and earlier studies (Vera, 1991; Vera *et al.*, 1993) have shown that a wide range of functional practical management strategies is available; further elaboration for practical applications would probably benefit from the development of a decision support system.

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