Should Heifers Calve at 2 Years of Age or Later?

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Introduction

Age at first calving of Nelore and other Bos indicus cattle is an important question in Brazilian beef production today. Both economics and biology are crucial considerations in this discussion. At present, Brazil slaughters approximately 23% of its national cattle population each year whereas in the USA, over 34% of the national cattle population is slaughtered on an annual basis. Therefore, the relative maintenance cost of breeding and slaughter animals per kg of beef produced is proportionally much greater in Brazil than the USA. Several factors can influence this discrepancy such as average age at slaughter, reproductive efficiency, feeding system (e.g. grass vs. grain), etc. One factor that limits efficiency in Brazil is that most Nelore heifers do not produce their first calf until they are 3 to 4 years of age, whereas in the USA, a majority of heifers give birth to their first calf at 2 years of age. If heifers in Brazil were physiologically capable of giving birth at 2 years of age, managed to achieve this end, and subsequently reproduce at a rate similar to heifers that calve later in their lifetime, the biological and economical efficiency of beef production could be enhanced.

Calving at 2 or 3 years of age in USA cattle

It is a surprise to some that while a majority of heifers in the USA calve at 2 years of age today, this question that is currently being debated in Brazil was a topic of discussion and disagreement between US beef producers and scientists throughout a majority of the 1900s. The first scientific paper we found that discussed this issue was published in 1921 and was entitled: *The effect of early breeding upon range cows* (McCambell, 1921). This author concluded that the cow "never fully recovers from the shock of calving at this age" and that "when a beef cows calves at two

years of age, neither she nor her calves (in subsequent years) will be as large as they would have been had she dropped her first calf at three instead of two years of age". In a review paper published in 1994 (Short et al., 1994) it was reported that in Florida less than 50%, and in Texas, about 35% of heifers calved after 2 years of age. Current estimates suggest that in these regions in 2012, there are still a substantial number of heifers that calve first at 2.5 to 3 years of age; especially in Bos indicus influenced cattle. Conversely, in the same paper it was estimated that over 95% of heifers in the northern and central USA, comprised mainly of Bos taurus genetics, calved first at 2 years of age. This paper will primarily focus on research in the USA that led to the transition from calving at 3 years of age to the current practice of calving most heifers at 2 years of age. In the accompanying presentation, the feasibility of calving at 2 years of age in Nelore and Nelore x Bos taurus crossbreds in Brazil will be discussed and data from Brazil regarding this practice will be presented.

Although the first paper published on this topic (McCambell, 1921) gave discouraging results regarding calving at 2 years of age, most subsequent research demonstrated an advantage of this practice over calving at later ages relative to lifetime productivity of the female. A 1930 report from Oregon (Witheycombe et al., 1930) compared calving at 2 or 3 years in Hereford heifers over a 6 year period (n = 100) with a variety of winter feeding programs. For heifers that calved at 2 years of age, their calving rate as 3 and 4 years of age was 15% and 14% less, respectively, than heifers that calved first at 3 years of age, but not different thereafter. This subtle reduction in calving rate for 2 years did not offset the advantage of calving first at 2 years of age relative to lifetime productivity. Heifers that calved first at 2 years of age produced an average of 0.7 more calves/cow than those calving first at 3 years of age by the time all cows were 6.5 years of age.

Calves from the heifers at 2 years of age were smaller than from older cows; whether they calved first at 2 or 3 years of age. However, after this initial calf, there was no difference in birthweight or weaning weight between different calving age groups. The heifers that were raising a calf at 2 years of age weighed approximate 90 kg less than the non-lactating 2 year olds at this age. However, this difference was reduced to approximately 39 kg by the time all heifers were 4 years old. A detailed economic analysis indicated that the difference in profit at the end of 4 years was $36.15/cow. This number is not very exciting without realizing that $36.15 in 1930 would be equal to $490 in 2012!

In a later report in which the experiment was started in 1948 (Pinney et al., 1972), no difference in mature cow weights were reported for Hereford heifers calving at 2 vs. 3 years of age. In their lifetime, cows calving first at 2 years of age appeared to produce 154 kg more weaning weight during their lifetime than cows calving first at 3 years of age. Chapman et al. (1978) reported that feeding level was an important determinant of the success of programs of calving at 2 years of age. A comprehensive international review of reports on age at first calving was provided by Morris (1980). Several general conclusions were drawn from this exhaustive review. First, lifetime production was either greater, or not significantly different, when heifers first calved at 2 vs. 3 years of age. Overall, heifers calving at 2 years of age produced 0.7 more calves in their lifetime than if calving first at 3 years of age. In most studies, mature cow size was unaffected by age at first calving but differing nutritional levels between heifers managed in these two systems varied in some cases so it was suggested this difference may be greater at equal planes of nutrition.

The most comprehensive comparison of calving age in beef cattle was performed at the USMARC, Clay Center, NE. This project was initiated in 1960 and continued until all cows (n = 328) that remained in the herd were at least 12 years of age (Nunez-Dominquez et al., 1985; 1991). Cows were Angus, Hereford or Shorthorn or F1 crosses of these breeds. Heifers not pregnant in their first breeding season at 1 (17.9%) or 2 (18.6%) years of age were culled. After the initial breeding, cows were culled from the herd if they remained not pregnant for two consecutive years. Natural service breeding seasons averaged approximately 75 d across the experiment. Objectives were to determine the impact of the initial mating at 1 or 2 years of age (designated as M1 and M2 respectively) on cumulative performance, herd input/output efficiency and the impact of age at first culling (i.e. culling of heifers not pregnant to first breeding) on repeatability of subsequent pregnancy rate.

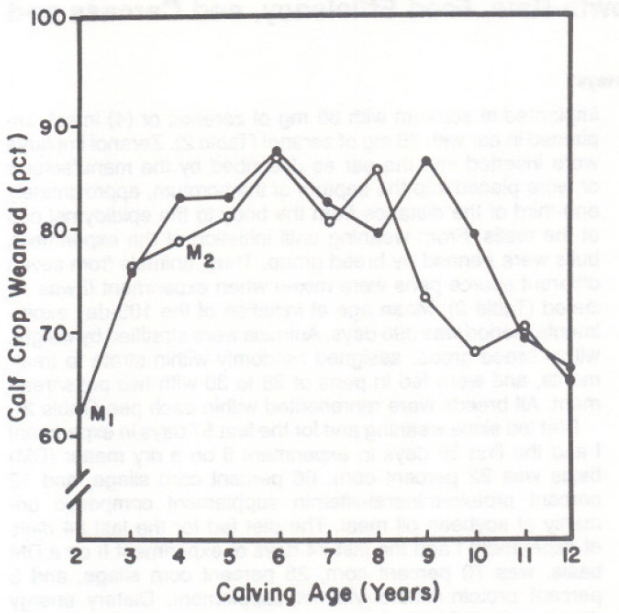

Figure 1 – Calf crop weaned per cow exposed to breeding by age of cows first mated as yearlings (M1) or 2-year-olds (M2) From Nunez-Dominquez et al., 1985)

Figure 1 illustrates the impact of the initial mating on the percent of females that produced calves at weaning, as a function of all females exposed to breeding in this experiment (Nunez-Dominquez et al., 1985). Two main points are illustrated in Figure 1. First, the number of calves weaned per cows exposed to breeding after the initial breeding was less in those heifers calving first at 2 years of age than those calving first at 3 years of age. While pregnancy rate was similar

between these groups, calf survival to weaning was approximately 14% less in M1 than M2. Contributing to this difference was approximately 4% lesser calving rate (fetal loss) and 8% lower calf survival to 72 h. This second category is probably due to the substantially greater calving difficulty that occurs in Bos taurus heifers calving at 2 vs. 3 years of age for the first time (Pope, 1967; Bellows 1968). Across ages, pregnancy rate for M1 was actually greater than for M2 by 3% (88.1% vs. 85.1% respectively) but across all ages, percent born (84.1 vs. 82.1), and calf crop weaned (77.7 vs. 77.3) did not differ for M1 and M2. Figure 2 indicates 200 d weaning weights on a basis of per calf and per cow exposed to breeding in pounds (Nunez-Dominquez et al., 1985). Heifers calving for the first time at 2 years of age produced lighter calves at weaning than heifers calving for the first time at 3 years of age by approximately 35 lbs (~16 kg).

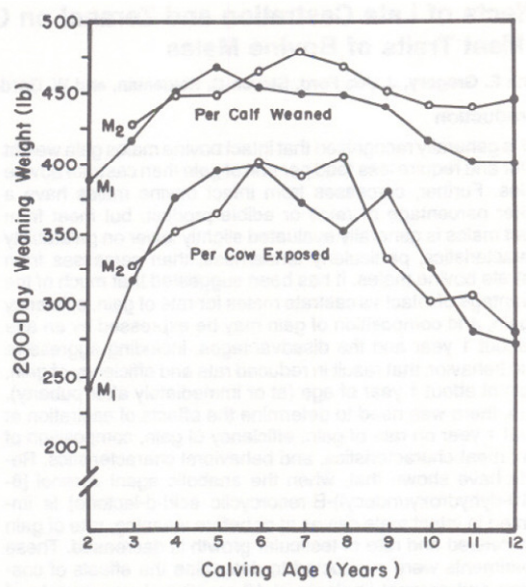

Figure 2 – Weaning weight per calf weaned and weaning weight per cow exposed to breeding by age for cows first mated as yearlings (M1) or 2-year-olds (M2). From Nunez – Dominquez et al. (1985).

Average 200 d weaning weights throughout the experiment were greater in the M2 than M1 females by 20 pounds (~9 kg). This difference was partially due to the lighter weights of the first calf in M1, as when weights were compared for only calves born from 3 to 12 years of age, the difference in 200 day weight/calf declined to ~7 kg. The weaning weight per cow exposed to breeding, which is an important factor in terms of total herd output, did not differ for M1 (345 lb – 157 kg) and M2 (349 lb – 159 kg).

Figure 3 shows the cumulative survival for M1 and M2 females (Nunez-Dominquez et al., 1985; 1991) under both the actual culling policy (AM1 and AM2) and a modeled policy that was imposed (IM1 and IM2). The imposed policy was that all nonpregnant females were culled at any time they were open after the breeding season. With the actual culling policy, M1 cows tended to have better survival after the third breeding season. The authors suggested that culling of females for failure to become pregnant at 1 year of age may more effectively select for fertility at later ages, than going through the same process at 2 years of age. This idea was supported by calculation of the repeatability of being pregnant for M1 and M2 females. In M1, females that were not pregnant the previous year had an almost identical chance as those pregnant the preceding year, to be pregnant the following year (88% vs 90%, respectively). However, in M2, females not pregnant the previous year, they had a lower likelihood of being pregnant the next year (68%) than those pregnant the preceding year (87%). Thus, while the repeatability of pregnancy status from year to year was only 2% in M1, it was 19% (87% - 68%) in M2, further supporting that selection for fertility is more effective at 1 than 2 years of age. The importance of pregnancy in the first breeding season was emphasized in another report (Bellows, 1968), where females pregnant in their first breeding season had a lifetime calf crop production of 87% whereas heifers not pregnant in their first season, but retained in the herd for subsequent seasons only had a lifetime calf crop production of 55%.

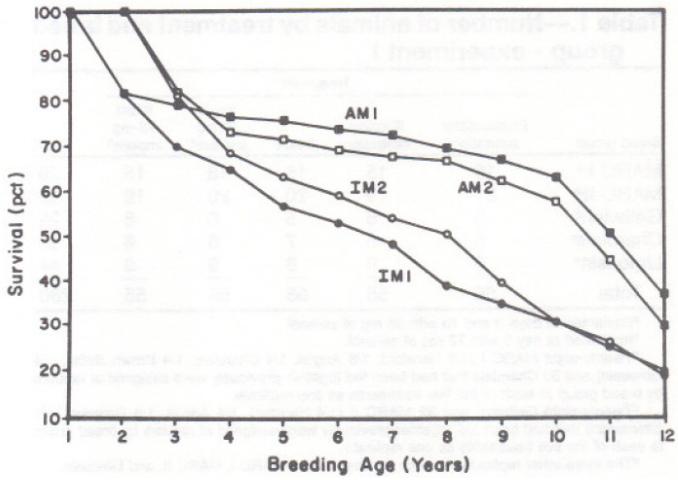

Figure 3 – Cumulative survival of cows first mated as yearlings (M1) or as 2-year-olds (M2) under the actual (A) culling policy (AM1 and AM2; culled if not pregnant to first mating, then culled if open two consecutive years thereafter) or an imposed (I) culling policy (IM1 and IM2; culled if not pregnant at the end of the breeding season at any age). From Nunez – Dominquez et al. (1985).

Clearly, capacity to become pregnant in the first season is an important measure of lifetime fertility, and it appears from the study of Nunez-Dominquez et al. (1985; 1991) that selection for this characteristic is more effective if accomplished at 1 than at 2 years of age. As would be expected, these authors showed that if females were culled if they were open for 1 breeding season (imposed policy) the likelihood of survival was reduced across treatment. With this method, cumulative survival tended to be less in M1 than M2 cows and appeared to be largely driven by the difference in the number of opportunities to fail to conceive. For example, in year 8, survival differed by ~10%. However, after 7 breeding seasons (year 7 in M1 and year 8 in M2) survival was 49% and 51%, respectively. It was suggested that if heifers are bred for the first time at 1 year of age, that culling based upon a single non pregnant season was not advisable.

Cumulative lifetime productivity for heifers initially exposed to breeding at 1 or 2 years of age (Nunez-Dominquez et al., 1991) is illustrated at various time points over 12 years in Table 1 and final productivity for additional variables at the end of 12 years is highlighted in Table 2.

Table 1. Cumulative performance of heifers initially mated at 1 year (M1) or 2 years (M2) of age expressed as performance per initial heifer exposed to breeding.

		Actual Culling Policy*			
Age	Treatment	Breeding Seasons	Calves Weaned	200 d weight weaned per initial heifer exposed, kg	Difference, kg
2	M1	1.00	.63	110.0	110
3	M1	1.82	1.25	228.8	79.5
3	M2	1.00	.77	149.3	
4	M1	2.61	1.91	364.5	85.1
4	M2	1.82	1.41	279.4	
6	M1	4.13	3.21	634.6	104.5
6	M2	3.27	2.61	530.1	
8	M1	5.59	4.41	878.5	99.0
8	M2	4.64	3.75	779.5	
10	M1	6.95	5.52	1094.8	128.7
10	M2	5.93	4.67	966.1	
12	M1	8.09	6.30	1240.9	138.2
12	M2	6.95	5.36	1102.7	

*Heifers and cows 10 years old or older diagnosed as not pregnant were culled the first time they were open. After the first breeding season through 9 years of age, cows failing to conceive in two successive breeding seasons were culled. Cows were also culled for severe health problems. Adapted from Nunez-Dominquez et al. (1991).

Lifetime cumulative 200 d weight was greater throughout for the M1 than M2 treatment (Table 1) and by 12 years of age, was 138 kg more per cow in the M1 than M2 females. Similar advantages of M1 vs. M2 management in terms of kg of calf weaned per initial female were

Table 2. Cumulative lifetime production up to 12 years of age per female initially assigned to breeding at either 1 year (M1) or 2 years (M2) of age.

	Actual Culling Policy*		
Item	**M1**	**M2**	**M1 – M2**
Number of Breeding Seasons	8.09	6.95	1.1
Number of Pregnancies	7.12	5.92	1.2
Number of Calves Born	6.80	5.71	1.1
Number of Calves at 72 hours	6.57	5.57	1.0
Number of Calves weaned	6.30	5.36	.94
Total 200 d weight (kg) weaned/ initial heifer exposed to breeding	1241	1103	138

*Heifers and cows 10 years old or older diagnosed as not pregnant were culled the first time they were open. After the first breeding season through 9 years of age, cows failing to conceive in two successive breeding seasons were culled. Cows were also culled for severe health problems. Adapted from Nunez-Dominquez et al. (1991).

reported in other experiments (Pinney et al., 1972; Chapman et al., 1978). In the comprehensive

international review by Morris (1980) previously mentioned, the average advantage across experiments was 113 kg for M1 vs. M2 management in terms of lifetime production.

An economic evaluation was performed using these data (Nunez-Dominquez et al., 1991) to estimate economic efficiency of these two management options. Production outputs were predicted from the data collected over the 12 year project. Average calf ($1.72/kg) and cull cow ($0.93/kg) prices from 1980 – 1989 were used. Cost of developing replacements were $217.94 for M1 heifers and $394.44 for M2 heifers. The authors estimated efficiency across terminal ages from 6 to 12 years. In other words, efficiency was predicted if all cows that attained 6 years of age were culled after weaning their calf, and this analysis was repeated for each terminal age up to 12 years of age to assess efficiency with varying terminal ages at which cows were culled. Tables 3, 4 and 5 indicate economic efficiency and the differences in efficiency with mandatory

culling of cows after reaching 6, 9 or 12 years of age. Comparison of data across these three

Table 3. Optimal weaning age: Estimated economic efficiency in herds of 100 cows in which heifers are initially mated at 1 year (M1) or 2 years (M2) of age and cows that are 6 years of age are culled after weaning their calves.

	At 6.5 years of age	
Item	**M1**	**M2**
Number of replacements	24	31
Total weaning wt. output, kg	15,317	16,276
Weaning wt. output(-replacements)	11,604	11,294
Income from calves, $	20,075	19,538
Cull cow wt output, kg	11,781	15,279
Cull cow value, $	10,956	14,209
Total output, $	**31,031**	**33,747**
Cost of replacements, $	5,283	12,073
Cost of cow unit, $	23,095	22,204
Total input, $	**28,378**	**34,277**
Input $/output $ (< 1 = profit)	**0.914**	**1.016**
Difference, (M1 – M2) x 100, %	**10.2%**	

Adapted from Nunez-Dominquez et al. (1991)

examples indicate that the greatest efficiency for M1 management was achieved between 6 and 9 years, and decreased thereafter. With M2 management, this system was most efficient with culling of cows at 8 to 9 years of age. Regardless of system, efficiency declined substantially if culling based upon age was delayed until 12 years of age. Comparison of M1 and M2 systems indicate that input costs per unit of output (efficiency) ranged from 10.2 to 5.2% greater for M1 than M2; being greatest with culling at 6 years of age and least at 11-12 years of age. The authors compared various culling strategies (actual, imposed and no culling) across these ages. With optimal or typical terminal ages of 7 to 9 years, the difference in economic efficiency was 6 to 8% greater with M1 as compared to M2 management; regardless of culling strategy used.

Table 4. Optimal weaning age: Estimated economic efficiency in herds of 100 cows in which heifers are initially mated at 1 year (M1) or 2 years (M2) of age and cows that are 9 years of age are culled after weaning their calves.

	At 9.5 years of age	
Item	**M1**	**M2**
Number of replacements	16	19
Total weaning wt. output, kg	15,789	16,590
Weaning wt. output(-replacements)	13,275	13,462
Income from calves, $	22,967	23,290
Cull cow wt output, kg	7,691	8,837
Cull cow value, $	7,153	8,219
Total output, $	**30,120**	**31,509**
Cost of replacements, $	3,469	7,437
Cost of cow unit, $	24,221	23,729
Total input, $	**27,690**	**31,161**
Input $/output $ (< 1 = profit)	**0.919**	**0.989**
Difference, (M1 – M2) x 100, %	**7.0%**	

Adapted from Nunez-Dominquez et al. (1991)

Table 5. Optimal weaning age: Estimated economic efficiency in herds of 100 cows in which heifers are initially mated at 1 year (M1) or 2 years (M2) of age and cows that are 12 years of age are culled after weaning their calves.

	At 12.5 years of age	
Item	**M1**	**M2**
Number of replacements	12	14
Total weaning wt. output, kg	15,267	15,846
Weaning wt. output(-replacements)	13,380	13,566
Income from calves, $	23,148	23,471
Cull cow wt output, kg	5,748	6,618
Cull cow value, $	5,345	6,154
Total output, $	**28,493**	**29,625**
Cost of replacements, $	2,694	5,674
Cost of cow unit, $	24,842	24,484
Total input, $	**27,536**	**30,158**
Input $/output $ (< 1 = profit)	**0.966**	**1.018**
Difference, (M1 – M2) x 100, %	**5.2%**	

Adapted from Nunez-Dominquez et al. (1991)

Summary

Results from experiments in the USA during the 1900s that are described above demonstrated that with Bos taurus breeds used in the temperate regions of the country that efficiency of production, total kg of weaned calf produced and economic efficiency is optimized if heifers are mated to calve at 2 rather than 3 years of age. This is the normal practice in the USA for beef cow calf production with these cattle breeds, but in the southern USA, where Bos indicus breeds are used, a substantial number of heifers still become pregnant at 18 to 24 months. In Brazil, the question is being asked whether the approach of mating heifers at 12-15 months of age is physiologically possible in regions of the country dominated by the Nelore breed, and second, if it is economically feasible for innovative producers to enhance their economic efficiency. Our research over the past few years at Fazenda Esplanada has addressed this question. The initial basis for this work was a series of experiments in the USA (Gasser et al., 2006a; b; c; and d) which demonstrated that timely nutritional supplementation could induce precocious puberty in Angus x Simmental heifers. Our hypothesis was that timely nutritional management of Nelore heifers would permit; with the aid of reproductive technologies available for puberty induction and timed AI, successful AI of Nelore heifers between 12 and 15 months of age. We have data for the last 5 years that indicates that a significant proportion of Nelore heifers can become pregnant to timed AI at 11 to 14 months of ages and at a rate typical of that seen in Nelore heifers in which timed AI is not attempted until 2 to 3 years of age.

No selection for genetic merit for precocious puberty was performed in our experiments before timed AI was attempted. An aggressive nutritional program to increase body weights between weaning and timed AI, and a hormonal program for puberty induction was performed before

initiation of the timed AI protocol. Thus, with only nutritional and hormonal intervention, heifers became pregnant to timed AI at an acceptable rate. The potential exists that with genetic selection, the extent of nutritional and hormonal intervention necessary to achieve pregnancy at 11 to 15 months of age in Nelore heifers might be reduced, or, pregnancy rates to timed AI could be further enhanced. For example, if application of precocious breeding is practiced within a herd, it would be anticipated that indirectly, genetic potential for precocious breeding would increase for this herd each generation. Additionally, tools exist to identify genetic potential for precocious puberty in the Nelore breed. With these genetic strategies, it is conceivable that over time, the degree of nutritional supplementation and the necessity for hormonal induction of puberty before timed AI could be decreased. The impact of this approach in heifers that have been selected for precocious puberty has not been investigated. Preliminary data from our work, and from others in Brazil, as well as preliminary estimates of the economic feasibility of this approach, will be highlighted in the presentation that accompanies this paper.

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