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Economic viability of artificial insemination intensification through use of the "*in vitro*" fertilization and crossbreeding

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Summary

Reproductive biotechnologies and crossbreeding in beef cattle are tools to increase the reproductive efficiency. However, it is important to evaluate the genetic and economic viability of these tools. The objective of the study was to evaluate the genetic and economic consequences of changing from a scenario characterized by the use of artificial insemination (AI-Nellore) to a scenario with using of fixed time artificial insemination (FTAI-Nellore and Angus-crossbreeding) associated to the *in vitro* fertilization (IVF-Nellore). A production system was simulated (1000 AU; one animal unit (AU) corresponding of 450 kg of weight), with continuous grazing and variable stocking rate. The first scenario simulated using conventional AI-Nellore (40% of the progeny) and natural mating using Nellore bulls (60% of the progeny). The second scenario used IVF-Nellore (15% of progeny) and fixed time artificial insemination (Nellore and Angus) (85% of progeny – 60% Nellore and 25% Angus). Compared to natural mating, the AI and IVF resulted in an additive genetic gain of 5% and 10% for animals' weight, respectively. For crossbreeding (FTAI), it a superiority of 15% for the animals was considered, compared to natural mating, due the heterosis gain. For the calculation of income, in both scenarios, the sale of bulls (40 at) and donors (70 at) was considered (one at = unit of weight corresponding to 32 pounds of beef). The second scenario resulted in a higher percentage of animals for commercialization as bulls and donors, but with lower profit (4.9 $at.ha^{-1}$). Even with the high level of biotechnology used, the economic responses did not explain the investments made. Thus, the use of the first scenario, respecting current response rates, is the most recommended. In contrast, if the current cost of pregnancy of *in vitro* fertilization decline in 25% and the additional remuneration of top animals up to 25%, the second scenario would be more profitable (9.25%).

Keywords: Angus, biotechnology, genetics, profitability, Nellore, reproduction.

Introduction

Use of reproductive biotechnologies and crossbreeding are an alternative to increase the results for the reproductive system in beef cattle. These techniques help to increase the economic indicators and could provide gains, due the use of superior animals or the heterosis

(Gilchrist et al., 2010). However, it is necessary to assess the cost-effectiveness of these tools, for the estimation of the consequences of their use and to define adequate intensity of use, emphasizing the importance of the use of precision livestock farming (Oaigen et al., 2008).

The objective of this study was to evaluate the economic and productive consequences of changing from a scenario of artificial insemination (AI) to a scenario with using of hormonal protocols (FTAI), *in vitro* fertilization (IVF) and crossbreeding (Angus), using a deterministic simulation.

Material and methods

Common indicators between scenarios

Two different scenarios were compared (one scenario with AI and natural mating and other associated IVF with FTAI). Some indicators were common in both scenarios. The complete systems scenarios were simulated with adjusted stocking rate of 1000 AU, using continuous grazing and different stocking. The Nellore herd were simulated and the Angus breed were used in the crossbreeding scenario. We considered 5% of mortality until the weaning and 1% until the yearling. The pregnancy rate range according to the age of the dam, being ~ 80%. Dams had ages ranging from 2 to 10 years, and the disposal rate was 20% per year due to failure in the reproductive season and advanced age. The progeny was maintained with dams up to seven months of age, and yearling at the continuous grazing until the 21 months (except for the Angus that was taken to feedlot after weaning). The animals were finished in feedlot by 120 and 90 days, for males and females respectively, and later slaughter. Approximately 60% of the females were kept for replacement of dams.

Sale of the animals at weaning or slaughter was simulated in all scenarios in order to compare the additional income with the risk of the owner's decision to take over the yearling and feedlot of cattle. It was also simulated, in all scenarios, the sale or not of a percentage of superior animals like bulls and donors, according to the genetic merit calculated in each scenario. A carcass yield of 57% and 55% for Nellore males and females and 59% and 56.4% for ½ Angus-½ Nellore males and females were considered, respectively.

General characterization of the standard and comparative scenario

The first scenario was characterized by AI and natural mating with Nellore bulls (AI/NM). About 40% of the calves were from AI. In the second scenario, the techniques used were *in vitro* fertilization, associated with fixed time artificial insemination (IVF/FTAI). This technique aimed to produce improved females for replacement and sale, as well as improved males for the production of bulls. Nellore IVF progeny rate was assumed to be 15% and FTAI rate was 85% (25% ½ Angus-½ Nellore and 60% Nellore).

To estimate the economic gain, the total income of the progeny and discarded animals was calculated. The costs were divided into fixed, variable and those applied to reproductive biotechnology and calculated at the end of the production cycle. Initially, the costs related to the production system were calculated by animal category and later diluted by the amount of progeny produced in each simulated scenario. It was calculated the cost of the dam with supplementation, management and animal health. The calves cost was calculated with animal health and identification. In the case of crossbreeding, it was considered creep-feeding for 210 days, eliminating the yearling. For Nellore yearling animals, costs with pasture, supplementation and health were calculated. For the feedlot, fixed and variable costs were assumed, which included management, animal health and consumption, resulting in daily cost.

The production profit was calculated simply by the difference between revenue and cost, divided by total area of the farm and de at's value (at = unit of weight corresponding to 32 pounds of beef). The offspring rate was also calculated as a ratio between the total animal body weight sold to the total animal body weight present in the stocking on the production system.

To determine the genetic gain of the herd, due to the adoption of reproductive biotechnologies, it was assumed that the progeny of AI and IVF achieved a higher weight compared to the animals of NM (5% and 10%) and the superiority of 15% of crossbreeding (FTAI), to the animals of NM, resultant from gains with heterosis (Alves et al., 2004).

In the first scenario, the 20% best males and 5% best females were considered as top animals, used to sale as bulls and donors, respectively. The increase of these percentages in the second scenario was calculated using the expected genetic gain due to the use/intensification of reproductive biotechnologies.

Results and discussion

The total cost of the second scenario was higher than the first, as a result of:

i) the dams presented higher average weight in the second scenario, which increased costs with feeding and supplementation; ii) the ½ Angus-½ Nellore calves in the second scenario had an additional cost with "creep feeding"; iii) the Nellore yearling animals from the second scenario had an average cost increase of about 6.5%, for having higher weight; iv) reproductive cost per calves was higher for scenario 2 (U$ 13.30 *vs* U$ 33.40).

The average weight of the animals in the second scenario was always higher in all categories compared to the animals in the first scenario. The second scenario produced 3.6% less weaned calves than the first scenario.

Table 1. Weight (pounds) of males and females Nellore and ½ Angus-½ Nellore in function of the age and the progeny.

	Weaning	Yearling	Feedlot
NM-Male-N	384.6	699.3	1058.6
NM-Female-N	352.0	642.0	868.6
AI-Male-N	400.4	731.8	1108.1
AI-Female-N	366.5	671.0	908.9
FTAI-Male-A	634.6	-	1042.6
FTAI-Female-A	597.0	-	854.7
IVF-Male-N	416.4	762.5	1157.8
IVF-Female-N	381.2	700.3	949.4

NM-Male-N: Nellore male bovine, progeny from natural mating; NM-Female-N: Nellore female bovine, progeny from natural mating; AI-Male-N: Nellore male bovine, progeny from artificial insemination; AI-Female-N: Nellore female bovine, from artificial insemination; FTAI-Male-A: Angus male bovine, progeny from fixed-time artificial insemination; FTAI-Female-A: Angus female bovine, progeny from fixed-time artificial insemination; IVF-Male-N: Nellore male bovine, progeny from *"in vitro"* fertilization; IVF-Female-N: Nellore female bovine, progeny from *"in vitro"* fertilization.

The amount of top animals calculated with using the second scenario was 31.92% for males and 10.56% for females, for sale of bulls and donors, while the first scenario traded 20% and 5% bulls and donors respective.

The second scenario (IVF associated FTAI) counted higher revenues, both for sale the best animals and for sale for the slaughter. However, the aggregate cost with adoption of biotechnology in the second scenario was U$ 41,970.00, results in a profit decline of 16.5% when compared to first scenario. The second scenario continued with higher costs for sale the animals after the feedlot, and not surpass the total income of the first scenario (U$ 461,608.00 *vs* U$ 482,892.00), even selling more bulls and donors. The justification is based to the amount of animals produced in each scenario.

First scenario presented a higher profit than the second scenario (1.28 at.ha^{-1} more profitability). Due the higher animal's weight in the second scenario, the offspring rate at weaning was 33.67%, while in the first scenario it was 29.24%. However, changing the sale option to the feedlot, the first scenario, recorded an offspring rate of 1.04% higher.

Table 2. Total profit (with or without the sale of animals such as bulls and donors), at weaning and after feedlot and offspring rate.

	Scenario 1	**Scenario 2**
Weaning profit_T (U$)	167.849,25	141.816,53
Feedlot profit_T (US)	266.942,53	211.587,61
Weaning profit_WT (U$)	110.381,42	103.035,45
Feedlot profit_WT (U$)	175.189,73	143.239,54
Offspring rate Weaning (%)	29,24	33,67
Offspring rate Feedlot (%)	55,59	54,55

Weaning profit_T: profit from the sale of animals at weaning considering sale of bulls and donors; Weaning profit_WT: profit from the sale of animals at weaning without consideration sale of bulls and donors; Feedlot profit_T: profit from the sale of animals after feedlot considering sale of bulls and donors; Feedlot profit_WT: profit from the sale of animals after feedlot without consideration sale of bulls and donors; Offspring rate weaning: offspring rate calculated considering the sale of the animals at weaning; Offspring rate feedlot: offspring rate calculated considering the sale of animals to slaughter;

Conclusion

The intensification of the AI, using the IVF combined to FTAI and crossbreeding, is not justified, in economics terms. The highest individual animal's values did not offset the difference in the amount of progeny produced (the second scenario produced 3.6% less weaned calves). Therefore, unless the cost of these biotechnologies (IVF/FTAI and crossbreeding) reduce to 25% and the progeny of IVF/FTAI and crossbreeding result in an additional remuneration of 25% (due to the quality of the beef sold), is not justified, in similar circumstances, the choice of the second scenario as a replacement for the first scenario.

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