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Bioeconomic simulation of productive systems in beef cattle production activities which emphasis in maintenance and pasture recovery

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SUMMARY

Correct determination of beef cattle production costs remains a relatively confusing subject and is therefore difficult for producers to apply. In the present study, a bioeconomic simulation model, which describes various livestock production systems, was used to determine profitability, and to emphasize the impact of maintenance activities and pasture recovery. Eight productive systems were evaluated in the Cerrado region; a standard system, named as Modal, and seven Improved systems, named 1 to 7, using different techniques and activities such as pasture management, nutritional management, reproduction, and health. In all simulated scenarios, the size of the property was uniform (1500 hectares), whereby 20% of the area was set aside for environmental reserves. The profitability of the simulated scenarios was R$ 41 997 for Modal, R$ 389,924 for Improved 1, R$ 395 427 for Improved 2, R$ 341,509 for Improved 3, R$ 454,198 for Improved 4, R$ 433 390 for Improved 5, R$ 47 221 Improved 6 and R$ 348 587 Improved 7. The results indicate that with an increase in the level of adoption of technologies in the property, productions costs also increased; however, it also led to a considerable increase in revenues, leading to an improvement in the use of technological resources. The use of activities linked to pastures had a positive impact, enabling greater profitability and increasing the production costs, as seen in Improved scenarios 4 and 5, with an expenditure of R$ 0.21 and R$ 0.27 on pasture for head/day paid. Expenditure on pastures is suggested to be viable for producers as it improves productivity and profitability.

ADDITIONAL KEYWORDS

Cost.
Modelling.
Profit.

Simulação bioeconômica de sistemas produtivos em atividades de produção de bovinos de corte com ênfase em manutenção e recuperação de pastagens

RESUMO

A determinação correta dos custos de produção de bovinos de corte continua a ser um assunto relativamente confuso e, portanto, difícil para os produtores aplicar em prática. No presente estudo, foi utilizado um modelo de simulação bioeconômica, que descreve diversos sistemas de produção pecuária, para determinar a lucratividade e enfatizar o impacto das atividades de manutenção e recuperação de pastagens. Foram avaliados oito sistemas produtivos na região do Cerrado; um sistema padrão, denominado Modal, e sete sistemas Melhorados, denominados de 1 a 7, utilizando diferentes técnicas e atividades como manejo de pastagem, manejo nutricional, reprodução e saúde. Em todos os cenários simulados, o tamanho da propriedade foi uniforme (1500 hectares), onde 20% da área foi destinada à reserva ambiental. A rentabilidade dos cenários simulados foi de R$ 41 997 para o Modal, R$ 389 924 no Melhorado 1, R$ 395 427 no Melhorado 2, R$ 341.509 no Melhorado 3, R$ 454 198 no Melhorado 4, R$ 433 390 Melhorado 5, R$ 47 221 Melhorado 6 e R$ 348.587 Melhorado 7. Os resultados indicam que com um aumento no nível de adoção de tecnologias na propriedade, os custos de produção também aumentaram, no entanto, houve um aumento considerável das receitas, conduzindo a uma melhoria na utilização dos recursos tecnológicos. A utilização de atividades vinculadas às pastagens apresentou um impacto positivo, possibilitando uma maior rentabilidade mesmo havendo um aumento nos custos de produção, como visto nos cenários Melhorados 4 e 5, com um gasto de R$ 0,21 e R$ 0,27 em pastagem por cabeça/dia respectivamente. Os gastos com pastos provaram ser viáveis para os produtores, melhorando a produtividade e rentabilidade da atividade.

PALAVRAS-CHAVE ADICIONAIS

Custos.
Lucro.
Modelagem.

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INTRODUCTION

The Brazilian cattle industry has undergone some positive changes over the years, due to the use of technological tools that serve to facilitate producers to better understand the activities on the farm, thereby encouraging producers to abandon the traditional system, where animals are bred extensively (Macedo, 2006).

According to Mazzetto *et al.* (2015) Brazilian cattle breeding must deal with two major obstacles in the coming years, the first one, competition for land with good productivity, the second one would be an increase in production to meet food demand, according to the authors, the best Way to reconcile the two problems in a single action would be to revitalize degraded pastures and avoid further deforestation.

This type of activity is strongly indicated in the Cerrado region where the association of poor soil and lack of fertilization results in areas of low productivity (Lobato *et al.*, 2014). Considering that the extensive system is the most used in the country, since pasture is the cheapest form of food available for production, the correct management of soil fertility can leverage the zootechinical indexes of the property.

The degradation process is one of the most important problems in beef cattle production in Brazil, highlighting that at least 60% of the entire area under study is at some advanced stage of degradation (Macedo, 2009). It is believed that more than half of the area destined to pastures cultivated in the Cerrado region is already degraded or at least to some degree of degradation (Volpe *et al.*, 2008).

Therefore, understanding the reform and maintenance activities on pastures are critical to producers who want be more competitive in the market. However, it is not a simple task to maintain a balance between production and finances. There are several factors that can interact and influence performance, such as the prices of raw materials, animals, pastures, and costs associated with health maintenance and handling (Beretta *et al.*, 2002). Due to these factors, many variables affect the activity of beef cattle production systems. Pini *et al.* (2014) suggested the use of simulation models in order to simplify and understand the realities of how such variables affect production and activity, since these consider the main factors in beef cattle production.

The present study aimed to simulate and evaluate the profitability of different scenarios in beef cattle production, emphasizing the activities of maintenance and pasture recovery.

MATERIALS AND METHODS

In this study, we used the bioeconomic simulation model as described by Brumatti *et al.* (2011), with adaptations in the pastures module. This model describes livestock production systems in terms of full cycle, breeding, rearing and termination of fattening animals on pastures, and feedlot. For the full cycle system, the simulator uses a deterministic system that simulates a herd for a fixed number of matrices by integrating annual costs and revenues of various simulated scenarios.

This model is based on the interaction of three major calculation centers: production rates, herd simulator, and control of costs and revenues. By the interaction of these centers, it becomes possible to obtain economic values in terms of investments, revenues, costs, expenses, and profitability.

The bioeconomic simulation model can estimate the amount of animals in the herd and their respective weights in kilograms, using information that integrates the reproductive, sanitary and productive rates informed by the user.

These quantities directly influence the real stocking rate, which is confronted and adjusted to the desired stocking rate. In this sense, the calculations are developed for the determination of the total quantity and average weights of the animal categories along an initial herd development until reaching the stability of the same one, fact that occurs in the sixth year of implantation of the system.

For each animal category worked, their respective zootechnical indexes are applied, in terms of mortality rates and weight gains, as reported by the user in the respective control centers. In addition, for breeding categories, the fertility rates reported in each scenario are applied. Therefore, the quantities obtained for each animal category is conditioned to their respective zootechnical indexes. Once the stable herd has been obtained, it supplies the quantities of animals needed to simulate a fully active property.

To perform the simulation, eight productive scenarios were used, including six adapted scenarios from Corrêa *et al.* (2006), classified as: Standard scenario, called *Modal* and *Improved* scenarios 1 to 5, and two adapted scenarios, from Euclides Filho *et al.* (2000), called *Improved* scenarios 6 and 7 **(table I)**.

The simulations were carried out based on properties located in the center-west region of Brazil, called *Cerrado*, a biome similar to the savanna. This region is characterized by the predominant warm climate where there are well defined periods of rainfall and drought.

All simulations to Improved scenarios were performed by an increase in activities compared to the Modal scenario presented by Corrêa *et al.* (2006), as described in **table II**. It is valid to point out that for all these first six scenarios were obtained through roundtable between producers of the State of Mato Grosso do Sul - Brazil, researchers from EMBRAPA Beef Cattle, and technical expertise in the area from institutions like Pantanal Institute, State Agency for Health Protection Animal and Plant (IAGRO) and Bank of Brazil.

The features taken into consideration for the adaptation of the Modal scenario include: the absence of any kind of planning, lack of control of revenues and expenses, as well as the zootechnical indices, especially the practice of overgrazing.

On the other hand, the Improved scenarios adopted many different activities that involves control of revenue until expenses, and labor-work trainer, with a greater emphasis on nutritional management of animals, recovery and maintenance of grassland activities, or providing mineral, protein, and/or energy supplementation periodically.

In all simulated scenarios, the total property size was 1500 ha, with 20% of the total area designated as the environmental reserve. To determine the price per hectare, factors such as cultural practices, nutrition, and health, as well as taxes and wages were included. The average price of US dollar during the period was R$ 3 084, according to the Brazilian Central Bank.

In each Improved scenario, activity performance, in terms of recovery and maintenance, was standardized by allowing activities to be performed in 5% and 35% of the total area, except for Improved scenario 7, where a higher rate of recovery and maintenance of approximately 10% and 43%, respectively, was applied.

A total of 1.33 tons of dolomite lime total real neutralizing power (TRNP) 90%, 440 kg of superphosphate simple, 60 kg of potassium chloride, 40 kg of fritted trace elements (FTE), and 160 kg of agricultural urea was applied to the recovery area.

The need of inputs on maintenance is lower than on recovery; therefore, 675 kg of dolomite lime TRNP 90%, 220 kg of superphosphate simple, 30 kg of potassium chloride, 20 kg of FTE, and 160 kg of agricultural urea were used. All quantities were adapted from Corrêa *et al.* (2006).

Among the activities conducted on pasture, the Modal scenario used just a regular land clearance, which includes only one manual mowing. Improved scenarios had various methods of land clearance, which included liming, two harrowing; one heavy and one

Table I. **Average zootechnical indices of Mato Grosso do Sul herd and systems involving breeding, rearing, and fattening with increased intensive use of technology** (Índices zootécnicos médios do rebanho sul-mato-grossense em sistemas envolvendo cria, recria e engorda, com uso mais intensivo de tecnologia).

Parameters	Systems							
	Modal*	1*	2*	3*	4*	5*	6**	7**
Natality (%)	60	80	80	80	80	80	70	80
Mortality at weaning (%)	6	3	3	3	3	3	6	4
Mortality other categories (%)	2	1	1	1	1	1	3	2
Age at weaning (month)	8	7	7	7	7	7	7	7
Male weaning weight (kg)	150	180	180	180	180	230	180	180
Age at first calving (year)	4	3	3	3	3	3	3	2
Age at slaughter (month)	48	48	36	36	24	12	36	24
Live weight at slaughter of cattle (kg)	490	480	480	480	480	464	430	450
Steer carcass yield (%)	53	53	53	53	53	55	54	57
Steer carcass weight (kg)	260	254	254	254	254	255	230	240
Cow carcass weight (kg)	195	195	195	195	195	195	195	195
Culling of cows (%)	15	20	20	20	20	20	20	20
Disposal of bulls (%)	15	20	20	20	20	20	20	20
Ratio of bull:cow	1:25	1:35	1:35	1:35	1:35	1:35	1:35	1:35

Source: Modified from Corrêa *et al.* (2006); *Modified from Zimmer and Euclides Filho (1997); **Quoted by Euclides Filho (2000)(**).

leveler, and sowing and land clearance; maintenance by mowing, and clearing land.

RESULTS AND DISCUSSION

Table III describes all economic values, as an Economic Income Statement. The source of income of the scenarios studied show a similarity, that is, the contribution of the various categories is highly similar (%); however, the values were remarkably different, at least when comparing the Improved scenarios and the Modal scenario, with a notable increase in revenue. This increase can be explained by several factors, such as herd size, stocking rate, weight gain of the animals, and better carcass yield, resulting in the sale of a higher number of animals (Pötter *et al.*, 2000).

The most notable revenue is evidenced by Improved scenario 5, as the animals are weaned heavier, and also reach slaughter weight earlier, leading to an increase in the number of animals sold in a year (about 756 heads), contradictory to the revenue of the Modal scenario, which weans lighter calves, requires longer time for the animals to reach slaughter weight, and is associated with high mortality rates throughout the cycle resulting in the sale of fewer animals in a productive year (about 213 heads).

Comparison of the revenues from the Improved scenarios revealed that scenario 6 had the lowest revenue, which is justified by the lower number of matrices (545) in the system, followed by a low stocking rate (0.68 AU/ha), resulting in the sale of 284 heads per year. Improved scenario 1, in which no special supplementation was used, except mineral salt, was inferior to Improved scenario 2. Although it does have the same amounts of matrices and stocking rate, Improved scenario 2 sold more finished cattle than the other categories compared to Improved scenario 1, showing a better technical-economic efficiency.

Table III, shows that the costs of reproduction and health had no impact on the profitability of improved

Table II. **Nutritional management of simulated scenarios** (Manejo nutricional dos cenários simulados).

	Strategy and nutritional management of animals
Modal scenario	Only pasture
Improved scenario 1	Only pasture
Improved scenario 2	Pasture with the addition of concentrate in the 3rd dry season
Improved scenario 3	Pasture and protein to both 1st dry season and concentrate at the end of the 2nd rainy season
Improved scenario 4	Pasture and concentrate in the 1st dry season and feedlot in the 2nd dry season
Improved scenario 5	Creep feeding to the calves during lactation followed by feedlot
Improved scenario 6	Pasture and mineral salt with urea to matrices and herds of 24 and 36 months per 90 days, and protein in the dry season to cattle of 24 and 36 months
Improved scenario 7	Pasture and mineral salt with urea to matrices and herds of 24 and 36 months, steers and bulls per 90 days, proteins in the dry season to cattle of 24 and 36 months and cull cows and heifers of 14 and 24 months during 60 days

Mineral salt was used in all simulated scenarios.

Table III. Financial statement of the evaluated systems (Resultados econômicos dos sistemas avaliados).

Components	Modal		Improved 1		Improved 2		Improved 3	
	R$	%	R$	%	R$	%	R$	%
Revenue								
Cattle	217 956	52	522 666	49	574.444	54	694 227	56
Cows	117 351	28	269 753	26	238 594	22	276 780	22
Heifers	74 235	18	252 654	24	236 384	22	258.906	21
Bulls	6775	2	11 139	1	11 059	1	12 712	1
Total gross revenue	416 319	100	1056,214	100	1060,482	100	1242,627	100
Costs								
Inputs								
Nutrition	27 078	7	61 896	6	73 501	7	285 721	23
Health	12 327	3	20 415	2	19 059	2	20 980	2
Forage	23 299	6	174 930	17	174 930	16	174 918	14
Reproduction	24 144	6	39 814	4	39 527	4	45 437	4
Labor-work	75 020	18	117 676	11	106 413	10	116 105	9
Maintenance	11 595	3	13 755	1	13 755	1	13 755	1
Fuels	8700	2	8700	1	8700	1	8700	1
Depreciation	68 196	16	73 356	7	73 356	7	73 356	6
Total costs	250 362	60	510 545	48	509 243	48	738 974	59
Expenses								
Administration	25 559	6	40 226	4	40 178	4	41 162	3
Manager remuneration	60 000	14	60 000	6	60 000	6	60 000	5
Total expenses	85 559	21	100 226	9	100 178	9	101 162	8
Taxes	38 400	9	55 517	5	55 633	5	60 981	5
Net profit	41 997		389 924		395 427		341 509	
Net margin	10.1%		36.9%		37.3%		27.5%	

systems. The increase in the cost of animal health in the Improved scenarios is justified by an increase in the use of vaccinations and deworming. Corroborating data by P**ötter** *et al.* (2000), who studied production of different ages of primiparous beef heifers, showed that the amount of anthelmintics used is lower than that in the traditional system (Modal), and also, the use of vaccines and drugs increases proportionally to the number of animals within the system.

The factors that contribute to the increase in inputs cost included pasture and nutrition. In Modal scenario, it is evident that there was some expenditure on both inputs, while in other scenarios, the costs of these varied according to the techniques applied. Costa *et al.* (2006) studied the economic viability of beef cattle, and reported a higher expenditure on food in properties with intensive systems (R$ 37.93/ha) compared to those with the traditional system (R$ 15.52/ha); this result is attributed to the fact that almost all categories received some kind of special diet.

In relation to labor-work, the values fluctuated in accordance with the number of employees for carrying out the activities inside the property. Consequently, Improved scenario 5 showed the highest expenditure on labor-work (R$141,580), because of the increased management applied. These results follow a similar pattern as obtained by Corrêa *et al.* (2006), who demonstrated that Improved scenario 5 showed higher expenditure on labor-work (R$ 34,327) compared to the other scenarios. However, the inflationary delay and the real gain of wages over the last ten years should be taken into consideration.

It is also valid to note that the cost of labor-work was the highest in the Modal scenario (R$ 75,020). Evaluation of the cost of labor-work showed that although it was the main expense in the Modal scenario, it was lower than that in any Improved scenario, it did not apply any technology or improvements in production that would involve an increase in the number of laborers (Costa *et al.*, 2006).

Among the scenarios evaluated, it was observed that Improved scenario 4 presented the best operating income of R$ 594,790, followed by Improved scenario 5 with R$ 573,251. The lowest was achieved by the Modal system, due to its low income, noting that to calculate the operating income, one must deduct all costs from gross revenue with exception of depreciation.

Improved scenarios 4 and 5 presented the best results in all aspects, similar to the results obtained by Corrêa *et al.* (2006), who used the same zootechnical indices and technologies in the field, and found that the scenario which used pasture with concentrate during the first dry season and feedlot during the second dry season, had presented higher profitability. The superiority of Improved scenario 4 can be justified by the observation of Figueiredo *et al.* (2007) that there is a close relationship between economic viability of systems, which includes supplementation and the cost

Table III. Financial statement of the evaluated systems (continued) (Demonstrativo dos resultados econômicos dos sistemas avaliados (continuação).

Components	Improved 4		Improved 5		Improved 6		Improved 7	
	R$	%	R$	%	R$	%	R$	%
Revenue								
Cattle	750 523	53	897 398	56	365 044	53	665 017	56
Cows	314 266	23	351 463	22	190 461	28	262 102	22
Heifers	276 464	20	332 181	21	121 146	18	248 284	21
Bulls	14 478	1	16 523	1	8 913	1	12 947	1
Total Gross Revenue	1355 732	100	1597 567	100	685 565	100	1188 351	100
Costs								
Inputs								
Nutrition	288 791	21	492 450	31	90 284	13	142 010	12
Health	21 210	2	21 693	1	14 820	2	18 595	2
Forage	174 918	13	174 756	11	174 918	26	276 394	23
Reproduction	51 747	4	56 911	4	31 266	5	43 027	4
Labor-work	117 145	9	141 580	9	86 928	13	103 674	9
Maintenance	14 549	1	14 476	1	13 755	2	13 755	1
Fuels	8 700	1	8 700	1	8 700	1	8 700	1
Depreciation	80 592	6	79 861	5	73 356	11	73 356	6
Total Costs	757 655	56	990 429	62	494 029	72	679 514	57
Expenses								
Administration	42 212	3	43 071	3	38 803	6	40 761	3
Manager remuneration	60 000	4	60 000	4	60 000	9	60 000	5
Total Expenses	102 212	8	103 071	6	98 803	14	100 761	8
Taxes	41 666	3	70 676	4	45 510	7	59 488	5
Net Profit	454 198		433 390		47 221		348 587	
Net Margin	33.5%		27.1%		8.7%		29.3%	

of the supplement; indicating that making use of more available food sources in your region may result in lower cost, minimizing the production cost.

In contrast, the profitability results in **table III** show that although there are several differences between the scenarios evaluated, both at the technical as well as physical level, all simulations were positive, even in the Modal system. However, even if Modal shows a profit, it has the worst economic result, very close to a possible loss, a fact that corroborates with that pointed out by Yokoyama *et al.* (1999), who studied different pasture recovery systems; they discovered that the exploitation of livestock in degraded pastures is uneconomical.

Table IV. Financial statement of unit costs of activities linked to pasture (Resultados econômicos para custos unitários das atividades associadas à pastagem).

	Systems			
Costs	Modal	1*	2*	3*
	R$			
Pasture/ha	19.42	145.78	145.78	145.77
Pasture/U.A.	31.76	105.83	126.85	132.76
Pasture/head/day	0.06	0.21	0.24	0.21
	Systems			
Costs	4*	5*	6*	7*
	R$			
Pasture/ha	145.77	145.63	145.77	230.33
Pasture/U.A.	139.25	145.50	215.07	267.72
Pasture/head/day	0.21	0.27	0.33	0.39
Improved scenarios (*).				

Another factor that contributed to the profitability of all scenarios studied was the amount that corresponded to depreciation, because it was not that high in proportion to the size of the property. In an analysis of the production profitability of beef cattle grazing system, Damasceno *et al.* (2012) showed the high contribution of depreciation as a cause of disruption of activities, suggesting that a better use of the structure, that is, an increase in the scale of production in order to optimize resources and minimize fixed costs.

The results presented in **table IV** show that there is a large difference between the costs of pasture per hectare between Improved scenarios compared to the Modal scenario. It is also noteworthy that Improved scenario 7 showed higher values compared to the other improved scenarios.

The assumed value of the cost of pasture may seem discouraging to the producer because they often believe that these costs will disrupt the activities. According to Martha Júnior *et al.* (2012), some producers prefer to explore new areas, increasing their agricultural frontier and possibly obtain satisfactory results within a short time, instead of working on their pasture area better. Lobato *et al.* (2014) reported that currently there are several studies on different production techniques suitable for farmers; however, these techniques will only be incorporated by the producers if they prove to be more competitive than those currently practiced.

Analyzing the costs of recovery and maintenance of pasture per head, the advantage of applying such activities on the property is clear, due to the low cost compared to revenue gains and nutritional expenses, for example, the feedlot in the Modal scenario, the annual expenditure on pasture per head was low at R$ 21.60, since it involved only periodic mowing in the area. However, this cost in Improved scenario 4 was approximately R$ 75.05, the difference between both is compensated when comparing the gains on revenue.

The cost of the pasture area per year in the simulated systems were similar to that found by Santana *et al.* (2013) (R$ 135.00) in semi-intensive systems. The difference in the average of R$ 10.00 between the costs in the present study and Santana *et al.*'s study can be explained by the influence of rising inflation between the two study periods.

The same way as the activities related to pasture should be essential in the current scenario of beef cattle, which should be applied consciously. Analysis of the costs of Improved scenario 7 **(table IV)** shows that overuse of these activities can reduce the profitability or even disrupt production. The use of a larger number of animals in the area would yield positive results, further reinforcing the concept of Damasceno *et al.* (2012) that the property should be as optimized as possible.

Analysis of data obtained from different production scenarios reveal that, with an increase in the adoption of technologies in the property, production costs increase but it also leads to a considerable increase in revenue.

CONCLUSIONS

Among the simulated production systems studies, Improved scenarios 4 and 5 showed highest profitability, and as expected, the Modal scenario had the lowest profitability.

The use of the recovery and maintenance of pastures showed a positive impact on the properties studied, enabling higher profitability despite increased production costs. Thus, these strategies prove to be viable to producers and a low cost tool compared to nutritional management, thereby improving productivity and profitability.

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