

Bioeconomics considerations on the modal production system of beef cattle in Pantanal

Considerações bioeconômicas sobre o sistema de produção modal do gado de corte no Pantanal

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ABSTRACT

Beef cattle production is one of the main agricultural activities in Brazil accounting for approximately 75% of agricultural properties in the country and significantly impacting gross domestic product (GDP) figures. However, raising beef cattle is a complex activity, with great variability in the combination of production factors. In this study, we assessed scale gains in beef cattle and performed a temporal analysis of the modal system in the Pantanal biome, central-west Brazil. Beef cattle production systems were analyzed for Corumbá, state of Mato Grosso do Sul. Typical farms of 3,600 hectares (ha), 9,000 ha, 14,400 ha, and 30,000 ha were determined from primary data from focus group surveys conducted by CEPEA. Results showed that the smallest property was the most efficient in using natural resources and had the highest economic return relative to the effective operational cost (EOC), followed by the largest property. Profitability increased significantly over the years due to record calf prices in 2014 and increased production. Intermediate-sized properties had the worst economic results and negative net margin even when the producer's pro-labore is not considered.

Keywords: production cost, agribusiness, agricultural system.

RESUMO

Este trabalho teve como objetivo avaliar os ganhos de escala na pecuária de corte no bioma Pantanal. Para isso, foram analisados os sistemas modais de produção de gado de corte em Corumbá/MS, município que possui o segundo maior rebanho no Brasil. As propriedades típicas foram determinadas nos levantamentos de dados primários de painel, também denominados grupos focais, realizados pelo Cepea em parceria com a CNA, no ano de 2014, com 3.600 hectares, 9.000 hectares, 14.400 hectares e 30.000 hectares. A propriedade menor foi a que apresentou a maior eficiência no uso dos recursos naturais, assim como maior retorno econômico por real investido em relação ao Custo Operacional Efetivo, seguida pela propriedade maior. Foi observado que o grande gargalo são as propriedades de tamanho intermediário, que apresentaram os piores resultados econômicos, com margem líquida negativa mesmo desconsiderando o pró-labore do produtor.

Palavras-chave: custo de produção, agronegócio, sistema de produção.

1 INTRODUCTION

Beef cattle production is one of the main agricultural activities in Brazil (IBGE, 2006), and approximately 75% of agricultural properties in the country have cattle operations. Moreover, its importance to the national economy is evident in gross domestic product (GDP) figures. In 2014, the contribution of agribusiness to the GDP reached 22.54% (CEPEA, 2014). Brazil has the largest commercial cattle herd in the world (Meyer and Rodrigues, 2014) and the state of Mato Grosso do Sul (MS), Central-West Brazil contributes with a herd of over 21 million heads, corresponding to 10% of the national herd, of which approximately 26% is raised within the Pantanal biome. The municipality of Corumbá ranks second in cattle herd size in Brazil with a population of 1,802,976 heads or 0.85% of the entire national herd (PPM-IBGE, 2013). According to McManus et al. (2016), the municipalities of Corumbá, Juara, and Cáceres in the mid-western region of MS registered significant increases in the number of cattle from 1977 to 2011.

Raising beef cattle is a complex activity, with great variability in the combination of production factors (Tramontini et al., 2018). For example, there may be considerable diversity in production systems even within a specific biome (Gomes et al., 2012). Thus, knowledge of the characteristics and parameters that describe the performance of these systems is important to provide the basis for assessments, comparisons, and decision-making by producers, their organizations, and the public sector (Pereira and Costa, 2014).

According to data by Famasul (2014), only five of the 880 geotagged farms in the Pantanal biome have an area less than 100 hectares (ha). The same database showed that farms $\leq 5,000$ ha account for 61% of the properties but extend over only 18% of the total area. Farms

with 5,001 to 10,000 ha of land account for 18% of the properties and 19% of the total area, whereas farms with 10,001 to 20,000 ha correspond to 14% of the properties and 28% of the total area. Finally, farms $\geq 20,001$ ha represent only 7% of the properties, but notably occupy 35% of the total area. The economies of scale show that the higher the volume produced, the lower the product's average unit costs, as fixed costs are diluted within a greater volume. In other words, production is increased by keeping fixed costs constant (Lopes et al., 2007). Nevertheless, the role of small and large farms in economic development and the development politics of promoting different types of farms have been the subject of considerable debate, especially in regions with particular characteristics (Dürr, 2016).

Cattle-raising in the Pantanal is known for its peculiar characteristics due to the biome's structural and logistical difficulties, including insufficient roads, lack of electricity, great distances from major urban centers, and the lack or inefficiency of public services, which are all compounded by the complexity of the environment. During the rainy season, ranches are flooded and herd management becomes more complex and difficult. The environment foregrounds the Pantanal production system and native forage provides the main support for livestock activity. The great variety of environments occupied by different plant species (grasses, legumes, and sedges) favors livestock activity because it offers cattle greater grazing opportunities, but makes pasture management more difficult to control. The strategic use of cultivated pasture for more susceptible categories such as rearing and first calving females, young bulls that will be used in breeding, and bulls at sexual rest is important to minimize the effects of seasonality of the active pasture on animal performance (Abreu et al., 2010).

According to Araújo et al (2018), livestock production systems in the Pantanal region are organized as such that each farm represents a territory, a space used by livestock, a use that varies according to the supply of resources and access to the channels of circulation and commercialization of the animals. Under this arrangement, it is not uncommon for owners to own more than one farm, and administrative management integrates different areas of a farm or different farms that form a territory, arranged as a network or as a so called territory-network.

In Brazil, the cow-calf phase is the least profitable activity (Euclides Filho, 2000). This low profitability partly explains the fact that calf production takes place in areas that are distant from the consuming centers. However, calves are the basis of the entire beef production chain. Recently, calf prices have risen significantly and impacted the entire chain (CEPEA, 2014). Consequently, beef cattle production costs have also increased. Thus, considering the importance of the calf production system, its relevance in the Pantanal region and its contribution to the national beef production chain, this study investigates the effects of production scale, the

evolution of production structure, and the profitability of modal production systems in the Pantanal biome in 2009, 2011, and 2014.

2 MATERIALS AND METHODS

The panel or focus group methodology is a qualitative assessment technique commonly used in social research (Carey, 2015). The method is more revealing than other types of surveys such as individual research because participants feel at ease to reveal the nature and the origins of their opinions about a certain subject, which helps researchers to have a broader understanding of the issues (Thiollent, 1986; Carey, 1994).

The method's main advantages are its low cost and non-compromised information quality. The focus group relies on a theoretical model that can be used to characterize the production mode of a particular region. In the current study, through the local producers' experience, the focus group was used to characterize the representative rural property, also called modal or typical.

The model describes not only the final volume produced, but also every form of production by detailing the entire production system with information on total area, human resources, technologies employed, and productivity achieved. Thus, the model determines the structure that best represents the size and the production system of the local properties that account for the largest part of the production, even if they are few in numbers (Elliot, 1928; Plaxico & Tweeten, 1963; Feuz & Skold, 1991).

In the early 1960s, Plaxico and Tweeten (1963) highlighted that the representative farm system applies to studies and public policies for rural production units. In short, the characterization of a region's typical farm should have the endorsement of rural producers. Every tally of the responses retrieved from the panel such as productivity indexes, deployment costs, fixed and variable costs, tends to be fairly close to the reality of the regional production mode. In our study, we also conducted a temporal analysis of the beef cattle modal production system in Corumbá. Typical farms were determined by the focus group and were also based on the panel's primary data surveys conducted by the Center for Advanced Studies on Applied Economics (CEPEA) in partnership with the Brazilian Confederation of Agriculture and Livestock (CNA) in 2009, 2011, and 2014. Due to the production diversity in the Pantanal biome, four modal systems, by which the typical farm represented several production scales, were established.

Although ranchers from Corumbá were aware of the difficulty in defining small, medium, and large-scale operations, the sizes of the typical farms were established as follows after a long

discussion: between 0 and 5,000 ha, 5,001–10,000 ha, 10,001–20,000 ha, and > 20,001 ha. It should be noted that this definition partially results from the focus group methodology.

The methodology employed to define the typical farm is an adaptation of cost survey and monitoring systems conducted in other countries. Production costs are calculated by filling worksheets, which form the basis of the panels. Results are computed using the production cost methodology by Matsunaga et al. (1976). The following parameters were estimated:

1) The effective operational cost (EOC) refers to every expense incurred by the property over one year and consumed during that period. This item includes variable and fixed costs. Variable costs vary according to the quantity produced, for example: vaccines and medicines, mineral supplementation, dietary concentrate, maintenance of improvements, machinery, perennial and annual forage. When machinery and implements are used in such operations as the maintenance of annual and perennial crops and pasture, the rates of hour-machine and hour-implement are also determined. Fixed costs are also accounted for, that is, the expenses that do not vary according to the quantity produced such as some improvements and taxes, including the Rural Territorial Tax (RTT) and other dues.

2) The total operating cost (TOC) is the EOC plus the depreciation rate of improvements, machinery and implements, and service animals. Pasture depreciation refers to expenditure for *renovation works* and labor remuneration. This item also includes revenues, including the producers' monthly pro-labore in accordance with their participation in the production process.

3) The calculation of machine depreciation and implement costs was similar to that for depreciation due to construction works, improvements, and equipment, which all include the linear depreciation with respective unit value, the residual value, and the useful life (in years) of each asset.

4) The gross margin (GM) is calculated by subtracting the effective operational cost (EOC) from the gross revenue. The GM amounts to the effective annual operational return per hectare and per arroba (approximately 15 kg of carcass weight) in each region under analysis.

5) The net margin (NM) is calculated by subtracting the total operating cost (TOC) from the gross revenue calculated in each panel. The NM amounts to the total annual operating return per hectare in each region under analysis.

6) The Return for every Brazilian Real (R\$) Invested (RRI), which is the ratio of total revenue to EOC and TOC, i.e., how much the producer earned for each Brazilian Real spent.

After the panel meetings, the evolution of the costs was monitored monthly. Price variations were recorded in every municipality where the panel took place through telephone surveys with agricultural supply retailers. Retailers also discussed market price changes, a crucial

item for understanding regional cost variations. In the case of beef cattle, the prices of approximately 4,000 inputs are collected on a monthly basis. Variations of the nominal input prices feed the structure formed by the information originally obtained from the focus group or panel.

3 RESULTS AND DISCUSSION

The survey conducted in the region of Corumbá, MS revealed that the representative property in the 0–5,000-ha group operates a cow-calf production system and has 3,600 ha, of which only 10 ha is cultivated pasture. The property owners raise beef cattle as their only source of income. In addition to their work, two cowhands manage the herd. One cowhand's wife is hired as a cook. The annual herd average is 824 heads.

In the 5,001–10,000-ha group, the representative property also operates a cow-calf production system and has a total area of 9,000 ha, of which only 180 ha is cultivated pasture. Similarly to the small property, cattle production is the only activity conducted by the farm owner. Six employees work on the property: a cook, a housekeeper (*praieiro* in the region's jargon), and four cowhands. An additional 540 daily wages a year are paid to third-party service providers. The annual herd average is 2,444 animals.

The 10,001–20,000-ha property also operates a cow-calf production system and has a total area of 14,400 ha, of which 300 ha is cultivated pasture. Similarly to the 0–5,000 and 5,001–10,000 ha properties, cattle raising is the only activity developed by the rancher, who employs 13 workers. Throughout the year, other employees provide services, with 970 daily wages paid. The annual herd average is 3,919 animals.

In the > 20,000-ha group, the modal property had a total area of 30,000 ha, of which 500 ha is cultivated pasture. The panel participants stressed that, even in large properties, the producers' main activity is beef cattle. Owners sleep on the ranch for days and even weeks. Twenty-one employees are hired, three of whom are female. Throughout the year, 1,460 daily wages are paid to outsourced service providers. The annual herd is 8,951 heads. Table 1 shows the efficiency measures of beef production by modal property size.

The production parameters indicated that herd productivity was greater in the typical small property (total area of 3,600 ha) than in the medium- and large-scale properties as measured by mortality rates before and after weaning, interval between births, age of first calf, and cow age. In addition, other indicators such as bull-to-cow ratio, number of offspring produced per cow, birth rate, and off-take rates were higher in the small property than in the medium- and large-scale properties. Stocking rate in the pasture area was the only parameter that was worse in

small-sized properties, and productivity did not vary considerably when medium- and large-sized properties are compared.

Table 1. Production parameters of livestock production in Corumbá, MS, Brazil.

Variable	Total area of typical farm			
	3,600 ha	9,000 ha	14,400 ha	30,000 ha
Pre-weaning mortality rate (%)	5.0	5.26	5.11	5.11
Post-weaning mortality rate (%)	2.0	5.0	5.0	5.0
Bull-to-cow ratio	25.0	15.0	14.29	14.29
Calving interval (months)	24.0	26.0	26.0	26.0
Age at first calving (months)	44.0	48.0	48.0	48.0
Calves produced per cows	6.0	5.62	5.62	5.62
Age of cows (years)	15.67	16.67	16.67	16.67
Birth rate (multiparae, %)	50.0	46.15	46.15	46.15
Birth rate (herd cows, %)	52.5	48.0	48.0	47.5
Cow replacement rate (%)	10.0	10.0	10.0	10.0
Bull replacement rate (%)	12.5	14.29	14.29	14.29
Slaughter rate (%)	30.66	28.58	28.58	28.27
Age of calf at sale (months)	10	10	10	10
Stocking rate (AU/ha/month)	0.18	0.21	0.21	0.24

Because calf prices have risen significantly over the last few years, the modal system revenue increased. In December 2014, the average value of a calf (ESALQ/BM&F Bovespa Indicator — 8 to 12-month-old Nellore, in the state of Mato Grosso do Sul, Brazil) reached the highest price in the CEPEA historical series. De Zen and Santos (2015) showed that 2014 was highly profitable for calf producers but unprofitable for post-weaning beef farmers despite the significant rise in the price of the arroba (ESALQ/BM&F Bovespa Indicator — state of São Paulo, Brazil), which reached record prices in Brazilian Real (R\$) for 2014, when one accounts for the exchange ratio (number of arrobas needed to purchase a calf) — since 2009 there has been an increase trend in this indicator, especially in 2014.

The gross margin (GM) was positive across ranches, except for the 9,000-ha property, and was highest, in absolute terms, in the 30,000-ha property, whereas the small property showed the highest return, in relative terms, for each Brazilian Real (R\$) invested. However, the net margin (NM) was negative in all properties (Table 2). These results were not only due to depreciation, but also the producer's pro-labore. If the pro-labore is not factored in, the NM becomes positive for the 3,600-ha and 30,000-ha properties. In the medium-sized properties, the NM is negative even when the pro-labore is not considered.

Table 2. Cost and revenue in 2014 by farm size.

Variable	Total area of typical farm			
	3,600 ha	9,000 ha	14,400 ha	30,000 ha
TOC (R\$)	287,319	1,071,745	1,382,732	2,503,634
Total revenue (R\$)	209,395	590,533	948,048	2,250,426
GM (R\$)	81,076	-95,339	89,742	636,686
NM (R\$)	-77,924	-481,212	-434,684	-253,208
RRI/EOC	1.63	0.86	1.1	1.39
RRI/TOC	0.73	0.55	0.69	0.9

EOC: effective operational cost; TOC: total operating cost; GM: gross margin; NM: net margin; RRI/EOC: return for every Brazilian Real (R\$) invested/effective operational cost; RRI/TOC: return for every Brazilian Real invested/total operating cost.

Corumbá is the main municipality of the Pantanal biome in the Central-West region of Brazil with large rural properties. Helfand et al. (2015) analyzed the productivity of rural properties in Brazil by farm size using the total factor productivity (TFP) method and reported that the TFP of Central-West properties increased with an increase in farm size.

Pantanal ranches have large areas of extensive beef cattle production (Abreu et al., 2010). The lower GM and worse performance of medium-sized properties (9,000 ha) are supported by the findings of Helfand et al. (2015), who showed that TFP growth was slow in medium-sized properties, possibly due to several constraints (e.g., credit, information, incentives).

Several policies may contribute to increasing the technical efficiency of medium-sized producers, who in Brazil face many bottlenecks and high transaction costs due to the government's inadequate investment in public infrastructure. Roads and railway construction and other investments that reduce transport costs may increase the technical efficiency and competitiveness of Brazilian agriculture. Additionally, improvements in agricultural extension services may increase technical efficiency and promote the growth of the TFP for a large portion of the medium-sized Brazilian producers.

The area of the typical medium-sized farm did not change during the period under analysis. Total area comprised 10,000 ha, of which 2,000 ha were legal reserve (20% of the total area as required by Brazilian federal law), whereas pasture area was approximately 8,000 ha (80% of total area), with some small variations during the study period. In the same production area, the herd size increased significantly from 2009 to 2014. In 2009, the total herd population was 3,096 heads or 1,632.69 animal units (AU), at a stocking rate of 0.21 AU/ha. Each AU is equivalent to 450 kg of live weight. In 2011, the total herd was 3,290 animals or 2,084.16 AU, with a stocking rate of 0.27 AU/ha. The increase in herd size was even more significant in 2014: total herd was 4,241 animals or 2,608.5 AU at a stocking rate of 0.33 AU/ha. The herd comprised

bull calves, heifer calves, heifers, bulls, cows, and calved cows during the entire period. Income was derived from the sale of bulls and cull cows, heifers, bull calves, and heifer calves, and the sale of heifers was the main product commercialized in the region of Corumbá. During the period under analysis, the number of animals commercialized also increased. Table 3 shows the production parameters of beef cattle from cost survey data.

The increase in productivity over the years was significant as indicated by the number of animals per area and other production parameters such as decreased mortality rates, increased birth rate, and number of calves per cow. Increased herd dynamics was reported as a result of increased culling and cow and bull replacement. In addition to increased productivity, labor productivity also improved between 2009 and 2014. All production indicators showed a trend for intensification of the extensive system, probably due to the adoption of technologies in the extensive livestock system in the Pantanal during the period under analysis. In 2009, five employees were needed to tend the herd and manage the cattle ranch. In 2011, the number of employees increased to seven because of increased production, but was down to five again in 2014 even with an increasing herd. However, there were 120 daily wages paid throughout the year. Panel participants reported that the reduced number of employees was due to the difficulty in finding hired labor.

Table 3. Production parameters of livestock production by year in Corumbá, MS, Brazil.

Variable	Year		
	2009	2011	2014
Pre-weaning mortality rate (%)	9.0	8.0	3.0
Post-weaning mortality rate (%)	3.0	1.0	1.0
Bull-to-cow ratio	25	20	25
Calving interval (months)	24	22	15
Age at first calving (months)	40	48	40
Calves produced per cows	4.43	5.18	6.33
Age of cows (years)	12.19	13.50	11.25
Birth rate (multiparae, %)	50.0	55.0	80.0
Birth rate (herd cows, %)	56.0	54.0	65.0
Cow replacement rate (%)	11.0	12.0	15.0
Bull replacement rate (%)	9.0	13.0	17.0
Slaughter rate (%)	27.2	27.3	22.0
Stocking rate (AU/ha/month)	0.18	0.21	0.21

According to Alves et al. (2012), the 1995–1996 and 2006 censuses showed that land and labor alone fail to explain the growth of agriculture, and that the influence of technology, which is knowledge created by research, has triggered development and increased production. Thus, ranches which incorporated technology, either because they had specialized technical assistance or their managers were knowledgeable of this technology, achieved economic sustainability and stability over the long term.

As a result of higher calf prices, increased revenues were also achieved in the Corumbá modal system which were not exclusively due to increased production. Total revenue was R\$ 458,084 in 2009, R\$ 585,225 in 2011, and R\$ 861,067 in 2014, a nominal increase of 88% between 2009 and 2014. However, production costs also rose significantly. Between 2009 and 2014, the EOC had a variation of 85%, three percentage points lower than revenue increase. Total EOC was R\$ 191,858 in 2009, R\$ 297,053 in 2011, and R\$ 355,254 in 2014. The purchasing of animals, labor, mineral supplementation, and administration services, taxes, interests, and energy supply were the most influential items on EOC during the years under analysis.

The comparison between revenues and costs showed an improvement in profit margins. Total revenue was higher than the EOC with positive GM across years, indicating that the activity is economically sustainable in the short term. However, in 2009, the TOC was higher than the revenues and NM was negative. In the medium and long terms, however, cash flow would be insufficient for replacing improvements, equipment, utilities, and even animals. Nevertheless, GM and NM were positive in 2011 and 2014 as a result of higher calf prices and increased productivity, indicating that, in recent years, cattle raising may be sustainable in the short, medium, and long terms. Analysis of the Return for every Brazilian Real Invested (RRI) revealed a significant improvement in TOC over time. In 2009, for every Brazilian Real invested producers lost eight cents (R\$ 0.08), but earned R\$ 0.13 and R\$ 0.14 in 2011 and 2014, respectively.

4 CONCLUSIONS

The advantages of the economies of scale were significant for modal systems larger than 20,000 ha, whereas medium-sized properties were the most sensitive with regard to economic return. Medium-sized farms face inefficiencies caused by increased production scale and are unable to offset the average cost of the product as the typical large farm does. Moreover, medium-sized properties face several bottlenecks and high transaction costs due to inadequate investment in public infrastructure and the lack of technicians specializing in rural extension that can disseminate technology to this category of beef cattle producer.

Results of the panel survey revealed that the modal system in the region of Corumbá, MS showed significant improvements in 2009, 2011, and 2014. First, there were improvements in production parameters, including reduced mortality rates before and after weaning and interval between births. Similarly, there were increases in the number of calves per cow, bull breeding capacity, and stocking rates. In addition to improved productivity, calf prices rose significantly during the period under analysis, which also boosted the total revenue of the modal system.

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