



## Analysis of Brazilian livestock transformations: a focus on dairy farming

### Análise das transformações da pecuária brasileira: um enfoque na pecuária leiteira

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#### Abstract

In this study, we investigated the principal transformations in dairy farming among Brazilian federative units in the period from 2006 to 2017. Data were drawn from the Agricultural Censuses from 2006 and 2017. In order to compare the variations between the states and macroregions, descriptive analyses were performed. Pearson correlation was used to test the correlation among the variables. A 4.63% decrease was observed in the number of establishments supporting cattle, notably in the states of PE (-23.02%), RS (-20.67%) and PR (-19.65%). Some states showed greater participation in terms of increase in number of cattle, particularly in the Northern region. No significant change in pasture area was observed. A decrease of 12.92% in number of milk producers was observed, mainly in the traditional dairy basins, such as RS (-36.62%), PR (-27.33%), SP (-24.67%) and SC (-20.21%). Producers who continued in the activity had a rise in the scale of their daily production. Although there was a 9.47% reduction in the number of cows milked, the herd productivity showed a 61.96% surge, particularly in the Southern (72.98%) and South-eastern (62.31%) areas. Milk production revealed higher correlation with number of cows milked ( $P < 0.05$ ;  $r = 0.97$ ) and productivity per cow ( $P < 0.05$ ;  $r = 0.63$ ), than with area of the rural establishments ( $P < 0.05$ ;  $r = 0.38$ ). In conclusion, there were significant changes in dairy farming over an eleven-year period, including changes in the geography of production, greater concentration and professionalization of the activity, as well as the expressive growth of milk production in almost every state, which is reflective of higher productivity of the national herd.

**Key words:** Cattle; Agricultural Census; Federative unit.

#### Resumo

Objetivou-se com este estudo caracterizar as principais transformações ocorridas na pecuária leiteira entre as unidades federativas do Brasil no período de 2006 a 2017. Foram reunidos dados dos Censos Agropecuários de 2006 e 2017. Em seguida, foram feitas análises descritivas para comparação das

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variações entre estados e macrorregiões. Para testar o relacionamento das variáveis foi utilizado o teste de correlação de Pearson. Houve redução de 4,63% no número de estabelecimentos com bovinos, com destaque para os estados de PE (-23,02%), RS (-20,67%) e PR (-19,65%). Houve crescimento da participação de alguns estados no número de bovinos, especialmente da região Norte. A área de pastagem não mudou significativamente com o passar dos anos. Verificou-se redução de 12,92% no número de produtores de leite, principalmente em bacias leiteiras tradicionais, como RS (-36,62%), PR (-27,33%), SP (-24,67%) e SC (-20,21%). Os produtores que permaneceram na atividade aumentaram sua escala de produção diária. Embora houve decréscimo de 9,47% no número de vacas ordenhadas, a produtividade do rebanho aumentou 61,96%, com destaque para as regiões Sul (72,98%) e Sudeste (62,31%). A produção de leite foi mais correlacionada com o número de vacas ordenhadas ( $P < 0,05$ ;  $r = 0,97$ ) e com a produtividade por vaca ( $P < 0,05$ ;  $r = 0,63$ ), do que com a área dos estabelecimentos rurais ( $P < 0,05$ ;  $r = 0,38$ ). Conclui-se que mudanças importantes ocorreram na pecuária leiteira no intervalo de onze anos, incluindo mudanças na geografia da produção, maior concentração e profissionalização da atividade, além do expressivo crescimento da produção de leite em praticamente todos os estados, reflexo da maior produtividade do rebanho nacional.

**Palavras-chave:** Bovino; Censo Agropecuário; Unidade federativa.

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## Introduction

Agribusiness in Brazil, from an economic standpoint, is a vital activity that plays a significant role in providing employment and generating income, thus helping to maintain the trade balance. In agribusiness, raising cattle ranks high among the most critical pursuits. All the Brazilian states are involved in raising beef cattle, defined by a strong dependence on pastures, and ensuring that the zebu genotypes are predominant in the cattle herd<sup>(1)</sup>. Apart from this, dairy farming is also practiced across the national territory, with remarkable heterogeneity in the production techniques, herds and kinds of producers<sup>(2)</sup>. In the recent decades, huge and heterogeneous transformations have occurred in the livestock, in all the sectors, reflective of the technological advancements made in the production systems and organization of the production chain<sup>(3,4)</sup>. Despite these, Brazilian cattle raising continues to require enhancement, from the managerial and productivity angles, to ensure higher levels of competitiveness.

The Agricultural Census survey done periodically by the Brazilian Institute of Geography and Statistics (IBGE), and on a national scale, provides the general data regarding the agricultural establishments and their activities. Such data is fundamental to the characterization of the production systems, giving a clearer picture of the changes that

had taken place over the decades<sup>(5, 6)</sup>.

In light of the significance and specificity of the livestock activity, further research and deeper analyses are still required. In this setting, spatial analyses and inter-census comparisons of the livestock activity can provide crucial data that can help deepen the current knowledge of the characteristics and changes in the geography of production, besides enhancing one's understanding of the likely consequences of the livestock activity and the competitive environment that the country faces. Further, these results promote the formulation of public policies that can boost this sector and thus the regional economy.

Therefore, based on the official census data, we characterize the principal transformations that dairy farming has experienced in the various Brazilian federative units, during the 2006 to 2017 time period.

## Material and Methods

### *Data collection*

Data from the 2006<sup>(7)</sup> and 2017<sup>(8)</sup> Agricultural Censuses were collected and analyzed. The data were compiled from the IBGE Automatic Recovery System (SIDRA), a database of statistical tables, which include aggregated data (without identification of the informant) collected from the IBGE surveys. The digital collection was based on using a descriptor of interest (for instance, territorial level), after which the period of availability was selected (for instance, year 2017), followed by the desired variables (for instance, area of the pasture) and, finally, the data were transferred. In addition, portions of the data were compiled and procured by directly contacting IBGE through e-mail.

### *Definition of the variables*

In this study, several variables were considered for in-depth analyses. The variables and respective units are described in table 1. The values concerning the area were expressed in tenths of hectares, while those regarding the milk production were expressed in thousands of liters.

### *Data analyses*

Data were grouped into tables and subjected to statistical analysis. Descriptive analyses were done and the states and macro-regions were compared with respect to the absolute frequency (observed value) and relative variations, in percentage. From the most recent data, the degree of association among the variables was tested, through an exploratory approach, applying the Pearson linear correlation test<sup>(9)</sup>. This approach reveals associations, without any dependence among the variables and relationships which, in light of the kind of the responses involved, permit the appreciation of dependence of one variable on the other<sup>(10)</sup>. The results produced are thus represented as a correlation coefficient ( $r$ ) and differences were considered when  $P < 0.05$ . Correlation coefficients were attributed as strong ( $r > 0.6$ ), moderate ( $0.6 \leq r \leq 0.4$ ) or weak ( $r < 0.4$ ). All the statistical analyses were done using MS Excel<sup>®</sup> software (Excel 2019, Microsoft Corp., Redmond, WA, USA), together with the Action Stat<sup>®</sup> extension, version 3.7 (Estatcamp São Carlos, SP, Brazil).

**Table 1.** Description of the variables studied and respective units

Variable	Unit
Number of properties with cattle	Producers in million
Area of properties with cattle	Hectare
Pasture area	Hectare
Cattle herd	Heads
Stocking rate	Head/hectare
Number of dairy farms	Producers in million
Milked cows	Heads
Annual milk production	Liters in billion
Milk productivity per cow	Liters in billion
Area of the states	Square kilometers

## Results and Discussion

According to the 2017 Census, 5.07 million agricultural establishments were registered in Brazil. In fact, 2.55 million of them (50.36%) supported cattle. However, in the 2006 Census, 2.67 million agricultural establishments were registered, showing a reduction of 4.63%. This drop was noticeable particularly in the South (-18.09%) and Northeast (-8.49%) parts of the country, with the leading states being Pernambuco (-23.02%), Rio Grande do Sul (-20.67%) and Paraná (19.65%), respectively. The North and Midwest regions, on the other hand, increased by 16.70% and 12.59%, respectively (Table 2). Some of the factors which may have been responsible for the decline in the number of establishments supporting cattle during the intercensal period are listed: (i) aging of the rural population connected with the youth becoming too discouraged to remain in the rural areas<sup>(11)</sup>; (ii) less access to public rural credit policies<sup>(12)</sup>; (iii) productive inefficiency of the family dairy producers<sup>(13)</sup>; (iv) long dry period experienced by the Northeast region, which resulted in desertification and therefore, farmer migration<sup>(14)</sup>; as well as (v) competition of the areas for soybean production in the South<sup>(15, 16)</sup>.

Brazil is a continental country, whose territory extends across nearly 8.51 million square kilometers (851.08 million hectares)<sup>(17)</sup>. According to the 2017 Census 23.87% of this area (203.12 million hectares) included establishments involved in raising cattle. The 2006 Census, on the contrary, revealed 198.81 million hectares of total area supporting establishments with cattle, suggesting that through the years 2.16% expansion has occurred in terms of the size of the area. This rise was noted mostly in the North (22.68%), with the states of Roraima (44.09%), Acre (33.92%) and Amazonas (31.84%) in order of rank (Table 2). On the other hand, in the South and Central-West region, there was a decrease of 6.47% and 4.90%, respectively. It is noteworthy, therefore, that despite the decline in the number of establishments with cattle, there was a corresponding increase in the area of the remaining establishments, in the trend

of land concentration, similar to the observation in agriculture, due to the expansion of soybean, corn and sugarcane<sup>(18)</sup>. The wide variations in technical and economic indicators, as stated by other studies<sup>(19, 20)</sup>, could be a reason for the ranchers to decide to abandon their activity and sell off their land.

**Table 2.** Absolute values and relative variations (%) from 2006 to 2017 in the number and area of the properties with cattle in the federative units of Brazil

Federative Unit	Number of properties			Area of properties		
	2006	2017	Variation %	2006	2017	Variation %
Acre	18,626	22,649	21.60	1,898,325	2,542,280	33.92
Alagoas	45,135	42,3	-6.28	849,604	777,407	-8.50
Amapá	661	684	3.48	187,355	243,721	30.09
Amazonas	13,782	14,612	6.02	1,584,982	2,089,695	31.84
Bahia	314,243	297,894	-5.20	14,392,599	14,394,466	0.01
Ceará	124,456	114,714	-7.83	3,970,588	3,854,072	-2.93
Distrito Federal	1,597	1,468	-8.08	74,399	66,642	-10.43
Espírito Santo	30,935	33,128	7.09	1,049,378	1,363,773	29.96
Goiás	111,693	126,1	12.90	19,190,475	18,302,550	-4.63
Maranhão	93,263	91,296	-2.11	7,145,328	7,517,452	5.21
Mato Grosso	82,558	92,723	12.31	33,389,648	33,233,175	-0.47
Mato Grosso do Sul	48,601	54,931	13.02	26,322,424	23,501,628	-10.72
Minas Gerais	354,062	385,488	8.88	20,142,257	23,076,599	14.57
Pará	83,688	97,769	16.83	15,200,265	19,546,348	28.59
Paraíba	92,024	82,761	-10.07	2,169,735	2,068,301	-4.67
Paraná	211,936	170,296	-19.65	5,164,513	4,391,786	-14.96
Pernambuco	140,226	107,939	-23.02	2,198,318	1,924,717	-12.45
Piauí	75,469	70,48	-6.61	3,887,725	3,414,162	-12.18
Rio de Janeiro	30,464	32,273	5.94	1,438,494	1,775,018	23.39
Rio Grande do Norte	47,48	39,15	-17.54	1,841,549	1,783,325	-3.16
Rio Grande do Sul	329,901	261,717	-20.67	8,619,954	7,941,435	-7.87
Rondônia	63,273	73,129	15.58	6,678,968	7,867,308	17.79
Roraima	4,732	6,903	45.88	1,113,021	1,603,742	44.09
Santa Catarina	147,338	132,522	-10.06	2,035,505	2,420,024	18.89
São Paulo	128,238	107,255	-16.36	7,133,257	5,135,376	-28.01
Sergipe	40,663	43,783	7.67	944,236	962,37	1.92
Tocantins	43,348	50,451	16.39	10,190,508	11,318,784	11.07
<b>Brazil</b>	<b>2,678,392</b>	<b>2,554,415</b>	<b>-4.63</b>	<b>198,813,414</b>	<b>203,116,151</b>	<b>2.16</b>

Source: IBGE (2006; 2017).

The principal food source for beef cattle production in Brazil, is pasture. Over the years, the pasture area showed a slight decrease. In 2017, a value of 159.5 million hectares was reported, 0.34% lower than in the earlier survey. The Northeast region revealed the

highest decline in pasture area (-10.03%), particularly in the states of Paraíba (-35.42%) and Rio Grande do Norte (-21.37%), as shown in Table 3. The reason for this decrease was the migration of farmers to other activities in the wake of droughts that hit this region during the intercensal period<sup>(14)</sup>. Likewise, the state of São Paulo also recorded a considerable decrease in the area of pastureland (-31.57%), as a direct outcome of the land value, apart from the rise in demand across the world for biofuels and an expansion in the sugarcane production<sup>(18)</sup>, all of which affected the replacement of land use in the state.

**Table 3.** Absolute values and relative variations (%) from 2006 to 2017 in the pasture area and cattle herd in the federative units of Brazil

Federative Unit	Pasture area			Cattle herd		
	2006	2017	Variation %	2006	2017	Variation %
Acre	1,051,319	1,474,337	40.24	1,736,100	2,139,795	23.25
Alagoas	873,764	817,206	-6.47	919,865	786,018	-14.55
Amapá	267,063	449,634	68.36	78,815	36,481	-53.71
Amazonas	820,702	1,141,768	39.12	1,170,638	1,252,835	7.02
Bahia	12,863,094	11,831,006	-8.02	10,229,459	8,177,761	-20.06
Ceará	2,614,984	2,368,980	-9.41	2,162,843	1,892,771	-12.49
Distrito Federal	79,796	62,108	-22.17	81,441	62,91	-22.75
Espírito Santo	1,341,585	1,473,072	9.80	1,791,501	1,650,374	-7.88
Goiás	15,838,320	14,991,172	-5.35	18,234,548	17,292,288	-5.17
Maranhão	5,754,670	5,706,338	-0.84	5,812,164	5,419,044	-6.76
Mato Grosso	22,062,659	23,011,251	4.30	20,666,147	24,309,475	17.63
Mato Grosso do Sul	21,055,122	18,439,834	-12.42	20,634,817	19,485,201	-5.57
Minas Gerais	18,217,879	19,371,750	6.33	20,332,335	19,575,839	-3.72
Pará	11,071,104	14,523,938	31.19	13,933,883	14,349,553	2.98
Paraíba	1,680,747	1,085,344	-35.42	1,354,457	1,050,612	-22.43
Paraná	4,733,069	4,016,635	-15.14	9,118,107	8,397,219	-7.91
Pernambuco	1,975,367	1,768,999	-10.45	1,880,432	1,284,796	-31.68
Piauí	2,690,560	2,131,808	-20.77	1,667,456	1,427,467	-14.39
Rio de Janeiro	1,290,362	1,562,220	21.07	1,924,217	1,982,295	3.02
Rio Grande do Norte	1,203,399	946,23	-21.37	907,185	758,453	-16.39
Rio Grande do Sul	9,244,936	9,176,761	-0.74	11,334,510	11,456,896	1.08
Rondônia	4,845,185	6,089,262	25.68	8,542,726	9,827,017	15.03
Roraima	724,175	1,114,772	53.94	536,396	681,061	26.97
Santa Catarina	1,707,633	1,837,195	7.59	3,126,002	3,726,238	19.20
São Paulo	6,976,239	4,773,687	-31.57	10,506,430	8,331,874	-20.70
Sergipe	945,207	877,693	-7.14	899,298	887,354	-1.33
Tocantins	8,113,119	8,454,545	4.21	6,565,729	6,477,537	-1.34
Brazil	160,042,062	159,497,547	-0.34	176,147,501	172,719,164	-1.95

Source: IBGE (2006; 2017).

The North was the only region that increased in pasture area (23.63%), particularly the states of Amapá (68.36%), Roraima (53.94%) and Acre (40.24%; see Table 3), as seen by the advancement of the agricultural boundary in the Legal Amazon, influenced by the availability of credit and animal health protocols in this area<sup>(21)</sup>. A strong correlation ( $P < 0.05$ ;  $r = 0.99$ ) was observed between the pasture area and size of the rural establishments; however, only moderate correlation was identified ( $P < 0.05$ ;  $r = 0.50$ ) between the pasture area and territorial expanse of the states (Table 4). Although no significant changes are noticeable in the pasture regions of Brazil, the productivity in these areas has escalated. While a decline was noted in the native pastures, 10% growth was observed in the cultivated or artificial pastures, the reason being deeper knowledge of the soil-plant-animal relationships<sup>(22)</sup>, besides the implementation of pertinent technologies to intensify pasture utilization<sup>(23-26)</sup>, an outcome of the committed studies done by research institutes and universities<sup>(27)</sup>.

**Table 4.** Linear correlation coefficients of the variables studied in 2017

Parameter	PROP	AR	PAST	CH	SR	DPROP	MC	AMP	PRODC	ARS
PROP	1	$r = 0.45$ $P = 0.02$	$r = 0.53$ $P < 0.01$	$r = 0.52$ $P = 0.01$	NS	$r = 0.97$ $P < 0.01$	$r = 0.86$ $P < 0.01$	$r = 0.83$ $P < 0.01$	$r = 0.49$ $P = 0.01$	NS
AR		1	$r = 0.99$ $P < 0.01$	$r = 0.95$ $P < 0.01$	NS	$r = 0.42$ $P = 0.03$	$r = 0.50$ $P = 0.01$	$r = 0.38$ $P = 0.05$	NS	$r = 0.52$ $P = 0.01$
PAST			1	$r = 0.97$ $P < 0.01$	NS	$r = 0.51$ $P = 0.01$	$r = 0.57$ $P < 0.01$	$r = 0.47$ $P = 0.01$	NS	$r = 0.50$ $P = 0.01$
CH				1	NS	$r = 0.52$ $P = 0.01$	$r = 0.60$ $P < 0.01$	$r = 0.52$ $P < 0.01$	NS	$r = 0.45$ $P = 0.02$
SR					1	NS	NS	NS	NS	NS
DPROP						1	$r = 0.92$ $P < 0.01$	$r = 0.92$ $P < 0.01$	$r = 0.55$ $P < 0.01$	NS
MC							1	$r = 0.97$ $P < 0.01$	$r = 0.48$ $P = 0.01$	NS
AMP								1	$r = 0.63$ $P < 0.01$	NS
PRODC									1	NS
ARS										1

PROP = Number of properties with cattle; AR = Area of properties with cattle; PAST = Pasture area; CH = Cattle herd; SR = Stocking rate; DPROP = Number of dairy farms; MC = Milked cows; AMP = Annual milk production; PRODC = Milk productivity per cow; ARS = Area of the states. NS = Not significant ( $P > 0.05$ ).

According to the 2017 census data, the cattle herd in Brazil was 172.72 million heads. However, the Municipal Livestock Survey (PPM), conducted annually by the IBGE, reported the cattle herd in 2017 was 214.90 million heads<sup>(28)</sup>. This rather huge inconsistency is possibly because in both surveys different methods were followed. While in the PPM, the date of reference is December 31, the 2017 census in Brazil accounted for the bovine herd head present on September 30. As a substantial number of producers adopt the breeding season technique, aiming at scheduling the birth season with the time of the highest pasture availability<sup>(29)</sup>, it is probable that a percentage of the calves will arrive during the last quarter of the year and, therefore, not be included in the count as live animals. Apart from this, the Census data was collected employing the direct interview method, by interrogating those responsible for rural establishments; however, the data in the PPM are drawn as inference from consultation with indirect sources, also a likely reason for the variations.

On comparing the cattle herd mentioned in the 2017 Census with the one in 2006, a slight variation was observed (-1.95%), in which the Northeast region showed a more substantial decrease (-16.06%), particularly, the states of Pernambuco (-31.68%) and Bahia (-20.06%). In the lead was the state of Mato Grosso with a total herd number of 24.31 million heads (showing 17.63% more than the 2006 Census), following the growth trend in beef herds seen since the 1990s for this region. However, in 2006, the herd in the Midwest region exceeded the population of the Northern area by more than 110%. Eleven years later, only 66% difference was observed between these two regions. The high growth rate confirmed in the North region was due to the higher contribution from the states of Roraima (26.97%), Acre (23.25%) and Rondônia (15.03%). This shift in the production geography can be explained by several factors, including the cheaper land price and the likelihood of production outflow via new ports and shipping routes, which were the elements of attraction. In addition, an increase in the competition for the production factors was evident in the traditional regions due to the advanced scale of agriculture<sup>(30)</sup>. It should be noted that additional pressures may appear in the future as the demand for grain rises, for instance in countries like China, and the maintenance of high prices in the global market<sup>(31)</sup>.

On comparing the data from 2006 and 2017, the pasture stocking rate showed a slight increase (1.64%), rising from 0.91 to 0.92 head per hectare, respectively. This result was possibly caused by the different methodologies followed in the two census surveys, with the likelihood of underestimating the number of cattle in 2017. However, another inference could be that because of the lack of any significant change in the pasture area, the increase in the size of the beef herd according to the 2017 PPM was indicative of a higher stocking rate. Despite this, these indices are almost negligible compared to other studies where a sample of technologically more advanced farms was studied (1.50 head/hectare)<sup>(19)</sup> or the productive potential of the production systems was based on, exclusively, the use of pastures (9.60 heads/hectare)<sup>(32)</sup>.

In 2017, Brazil recorded 1.18 million milk-producing establishments, 12.92% lower than in 2006, when 1.35 million milk-producing properties were reported (Table 5). Although several Brazilian producers have ceased to practice this occupation, this number is still below the annual disappearance rate in other countries where milk production is better consolidated and more productive than Brazil, like Germany (2.77%), France (3.00%),

United Kingdom (4.10%)<sup>(33)</sup> and United States (20.00%)<sup>(34)</sup>.

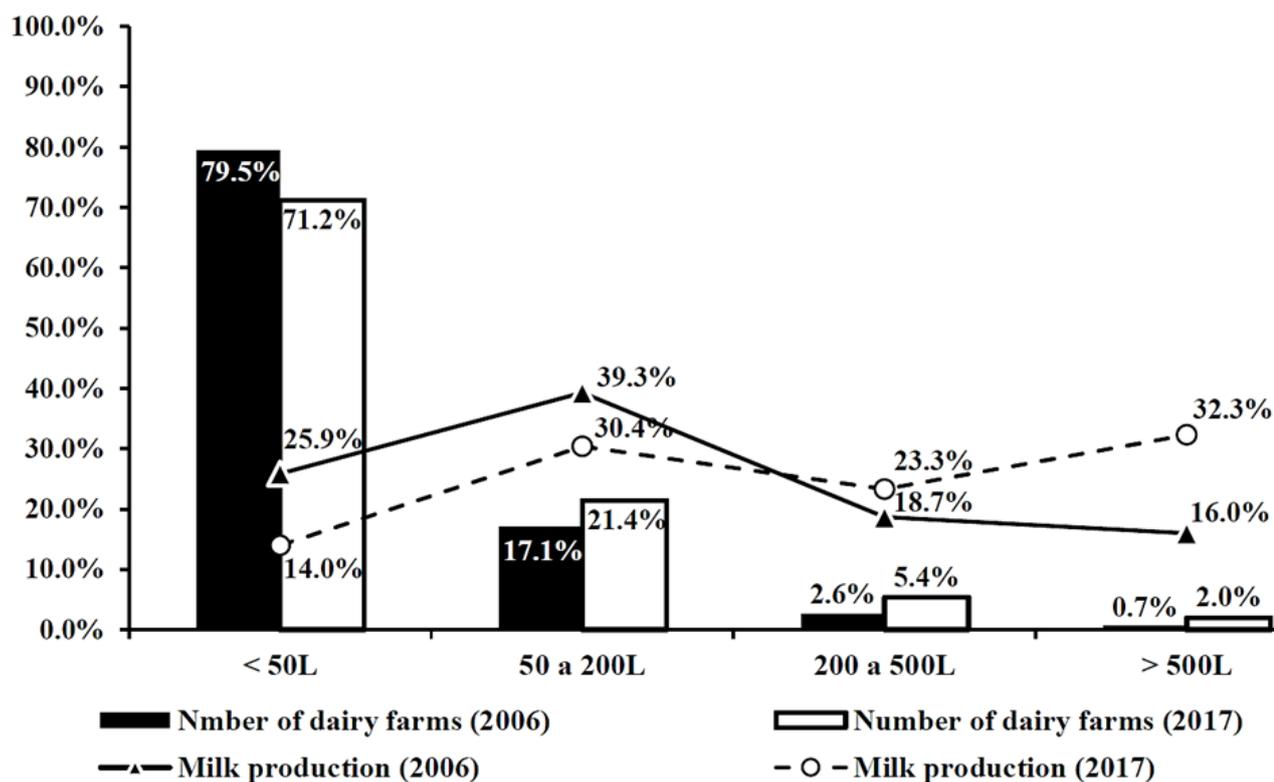
In fact, 15 federative units reported a drop in the number of milk-producing establishments. Rio Grande do Sul was the leading state, showing the most obvious decrease in the number of producers (-36.62%). On the other hand, the North region revealed the highest growth, especially in the states of Amapá (222.92%), Roraima (155.57%) and Amazonas (93.67%), suggesting a displacement of the border for new regions and their consolidation at great distances from the large consumer centers.

**Table 5.** Absolute values and relative variations (%) between 2006 and 2017 in the number of properties with milk production and milked cows in the federative units of Brazil

Federative Unit	Number of dairy farms			Milked cows		
	2006	2017	Variation %	2006	2017	Variation %
Acre	6,451	6,514	0.98	40,225	40,476	0.62
Alagoas	18,386	14,219	-22.66	110,368	81,599	-26.07
Amapá	48	155	222.92	950	1,455	53.16
Amazonas	2,466	4,776	93.67	36,811	59,083	60.50
Bahia	118,8	108,268	-8.87	833,749	650,6	-21.97
Ceará	83,213	73,272	-11.95	399,017	354,776	-11.09
Distrito Federal	1,148	921	-19.77	10,071	7,83	-22.25
Espírito Santo	17,829	17,141	-3.86	245,75	197,109	-19.79
Goiás	69,688	72,353	3.82	1,321,920	1,086,239	-17.83
Maranhão	16,537	17,156	3.74	184,878	159,447	-13.76
Mato Grosso	33,86	34,825	2.85	452,465	427,333	-5.55
Mato Grosso do Sul	24,1	24,087	-0.05	302,109	224,175	-25.80
Minas Gerais	223,073	216,46	-2.96	3,174,871	2,965,954	-6.58
Pará	27,551	35,363	28.35	452,628	487,597	7.73
Paraíba	47,393	38,591	-18.57	208,324	154,057	-26.05
Paraná	119,81	87,063	-27.33	881,577	873,512	-0.91
Pernambuco	54,039	37,643	-30.34	296,178	222,344	-24.93
Piauí	30,747	25,37	-17.49	126,416	92,622	-26.73
Rio de Janeiro	15,032	16,578	10.28	283,541	254,287	-10.32
Rio Grande do Norte	24,358	22,111	-9.22	142,614	114,339	-19.83
Rio Grande do Sul	204,92	129,877	-36.62	982,008	922,639	-6.05
Rondônia	35,384	39,368	11.26	572,447	588,217	2.75
Roraima	817	2,088	155.57	8,948	16,861	88.43
Santa Catarina	89,043	71,051	-20.21	580,228	689,615	18.85
São Paulo	54,323	40,92	-24.67	755,235	527,813	-30.11
Sergipe	16,562	17,627	6.43	109,928	108,197	-1.57
Tocantins	15,231	22,498	47.71	197,445	198,612	0.59
Brazil	1,350,809	1,176,295	-12.92	12,710,701	11,506,788	-9.47

Source: IBGE (2006; 2017).

The data from the 2017 Census suggested that the large majority of producers continue to be small-scale, with 92.6% of them producing up to 200 liters of milk per day. On the other hand, the biggest producers have been grabbing the attention on the national scene. The group producing more than 200 liters per day almost doubled during this period, escalating from 44 thousand liters in 2006 to above 87 thousand in 2017, but still representing only 7% of the total (Figure 1).



**Figure 1.** Number of dairy farms and total milk production separated based on production strata (liters of milk/day), in 2006 and 2017, in Brazil.

Source: IBGE (2006; 2017).

According to the 2017 Census, 11.51 million cows were milked in Brazil. On comparison with the 2006 Census data, the number of cows milked showed a significant drop (9.47%) (Table 5). This decline was observed in the regions of the Northeast (-19.63%), Central-West (-16.34%) and Southeast (-11.53%), especially in the states of São Paulo (-30.11%), Piauí (-26.73%), Alagoas (-26.07%) and Paraíba (26.05%). In the South a slight rise (1.72%) in the number of cows milked was seen, while in the North region a more expressive growth (6.33%) was observed, particularly in the states of Roraima (88.43%), Amazonas (60.50%) and Amapá (53.16%).

In general, land ownership is regarded as one of the limiting factors for the increase in milk production in the states<sup>(35)</sup>. However, in the current study no correlation was observed ( $P > 0.05$ ; Table 4) between the number of milked cows and the territorial expanse of the states.

In 2017, the annual milk production surpassed the 30-billion-liter mark, a dramatic rise

of 46.62% when compared to 2006. In the same year, the Southeast region of Brazil was still the leader in milk production (11,124,177 liters), followed by the South (9,998,757 liters), Midwest (3,873,942 liters), Northeast (3,253,115 liters) and North (1,906,288 liters) regions. The states recording the highest production were Minas Gerais (8,746,559 liters), followed by Rio Grande do Sul (3,928,863 liters), Paraná (3,258,876 liters) and Santa Catarina (2,811,018 liters), in the order of ranking. Between 2006 and 2017, all the federative units in Brazil showed an increase in production, with the exception of Paraíba (Table 6). Therefore, an increase in production was evident even in regions with no tradition in milk production, the reasons being the low land cost in some regions of the country, abundant yield of grains and lower prices of inputs, such as concentrated foods and labor. Furthermore, the annual milk production was observed to be more correlated with the number of cows milked ( $P < 0.05$ ;  $r = 0.97$ ) and productivity per cow ( $P < 0.05$ ;  $r = 0.63$ ), than with the area of rural establishments ( $P < 0.05$ ;  $r = 0.38$ ; Table 4). This indicates that land availability is not the principal determinant for the volume of milk production in the Brazilian herds.

Despite the reduced number of milk-producing establishments and milked cows, the increase in the annual milk production is evident and can be explained by the rise in the productivity of dairy farming, which escalated from 1.6 thousand liters of milk per cow, per year, in 2006, to 2.6 thousand liters of milk, per cow, per year, in 2017. This implies a rise of 61.96%, with more significance in the South (72.98%) and Southeast (62.31%; Table 6). A few states such as Minas Gerais, Rio Grande do Sul, Paraná and Santa Catarina, showed increased production during this time period, higher than the national average production. This may be attributed mainly to the increased professionalism in the management of the activity, improvement programs in animal genetics and more intense implementation of technologies with specialized technical assistance<sup>(36)</sup>, which contributed to a boost in the animal productivity, as well as to other production-related factors, like land, labor and capital. It should be noted, however, that higher rates were observed in a sample of 159 more 'technified' farms from Minas Gerais (3,383 liters/cow/year)<sup>(20)</sup> or in 11,346 farms from New Zealand, in the temperate pastures (3,567 liters/cow/year)<sup>(37)</sup>. This suggests the opportunity for gains in productive efficiency and greater competitiveness of the national dairy product in the international market.

The Agricultural Census reflects production-related information, as well as facilitates tracing the profiles of the producers. In terms of age group, an aging trend was observed among the ranchers. Between 2006 and 2017, the producers aged 65 years or older increased from 20.15% to 26.34%. Similarly, the 55 to 65 years age group showed a rise from 21.37% in 2006 to 24.30% in 2017. By contrast, the share of younger producers in the 25 to 35 years age group decreased from 11.50% in 2006 to 7.55% in 2017; and, interestingly, participants below 25 years of age, also showed a decline from 2.41% in 2006 to 1.41% in 2017. One of the likely reasons for this trend is the increased life expectancy of the Brazilian population and the resultant postponement of exit at the end of the job career<sup>(38)</sup>, associated with the issues with succession from rural properties, and rural exodus by the youngsters<sup>(11)</sup>. It is suggested that the ranchers older in age may possibly negatively influence the adoption of technological innovations<sup>(39)</sup> and explain the deficiency of technical guidance observed (in 2006, technical assistance was given to 25.19% of the properties with cattle versus 19.41% of

the properties in 2017), with non-negligible effects on the productive and economic outcomes of the activity<sup>(40, 41)</sup>. In this context, the technical assistance programs promoted by the government play a significant part in contributing to the dissemination of high-quality technical knowledge, and as a driving force for rural development.

**Table 6.** Absolute values and relative variations (%) from 2006 to 2017 of annual milk production and milk yield per cow per year in the federative units of Brazil

Federative Unit	Annual milk production			Milk productivity per cow		
	2006	2017	Variation %	2006	2017	Variation %
Acre	29,622	38,16	28.82	736	943	28.02
Alagoas	176,588	188,628	6.82	1,6	2,312	44.48
Amapá	1,07	1,507	40.84	1,126	1,036	-8.04
Amazonas	32,672	64,514	97.46	888	1,092	23.02
Bahia	786,891	936,987	19.07	944	1,44	52.59
Ceará	459,331	606,764	32.10	1,151	1,71	48.57
Distrito Federal	18,079	19,933	10.25	1,795	2,546	41.81
Espírito Santo	323,573	400,433	23.75	1,317	2,032	54.29
Goiás	2,088,213	2,670,391	27.88	1,58	2,458	55.63
Maranhão	174,525	188,304	7.90	944	1,181	25.10
Mato Grosso	553,807	759,525	37.15	1,224	1,777	45.21
Mato Grosso do Sul	383,88	424,092	10.48	1,271	1,892	48.88
Minas Gerais	5,720,443	8,746,559	52.90	1,802	2,949	63.67
Pará	476,332	646,799	35.79	1,052	1,327	26.05
Paraíba	232,594	215,916	-7.17	1,117	1,402	25.53
Paraná	1,828,580	3,258,876	78.22	2,074	3,731	79.86
Pernambuco	468,329	520,99	11.24	1,581	2,343	48.19
Piauí	85,933	97,429	13.38	680	1,052	54.74
Rio de Janeiro	432,355	511,895	18.40	1,525	2,013	32.02
Rio Grande do Norte	193,085	228,161	18.17	1,354	1,995	47.39
Rio Grande do Sul	2,457,964	3,928,863	59.84	2,503	4,258	70.13
Rondônia	639,437	899,981	40.75	1,117	1,53	36.97
Roraima	7,224	18,783	160.01	807	1,114	37.98
Santa Catarina	1,396,222	2,811,018	101.33	2,406	4,076	69.40
São Paulo	1,270,615	1,465,290	15.32	1,682	2,776	65.01
Sergipe	148,409	269,936	81.89	1,35	2,495	84.80
Tocantins	181,726	236,544	30.17	920	1,191	29.40
Brazil	20,567,499	30,156,278	46.62	1,618	2,621	61.96

Source: IBGE (2006; 2017).

With respect to gender, although men constitute the majority in the agricultural segment, the number of women participants in the livestock sector showed an increase (from 13.53% in 2006 to 18.18% in 2017). Such inequality in female participation in this

sector is not limited to Brazil<sup>(42)</sup>, being more associated with small rural enterprises<sup>(43)</sup>. Despite the numerous vulnerabilities<sup>(44-45)</sup>, the valorization of women in livestock activity can be partially explained by the public policies aimed at the encouragement of women in this field<sup>(12)</sup>.

In this study, a few probable limitations are identifiable, such as the changes in methodology, reference period and criteria of categorization, adopted by the IBGE. In the most recent survey of the Agricultural Census, innovations in the methodology were included in order to unify the concepts and ensure maximum comparability of the results with those from other countries promoting similar surveys<sup>(46)</sup>. It is also noteworthy that, as cited above, the timing of the application of the two Agricultural Censuses corresponded to different periods. Therefore, in spite of the fact the results from the two surveys may provide valuable support for the investigation and reveal, in part, the dimension and complexity of the rural reality of Brazil, they are not strictly comparable. Additionally, the criteria for classifying dairy farms in Brazil indicate another likely limitation because the IBGE census methodology may include beef cattle farms which sell some surplus calf milk, not necessarily mirroring the reality of the farms in this country<sup>(20)</sup>.

## Conclusions

The Brazilian federative units showed several transformations in livestock farming from 2006 to 2017. The principal ones include the changes in the geography of production, particularly in the Northern part of the country; higher concentration and professionalization of the livestock activity; and a noteworthy rise in milk production, in almost every state, which is reflective of the improved productivity of the national herd, although continuing to be much lower than the average of specialized herds.

The information generated from this study contributes to a better characterization and strategic design in the dairy production chain for the policy makers, private sector, research institutes and the many different links and agents in this chain, in order to further elevate its protagonism in the international scenario.

## Conflict of interests

The authors declare no conflict of interests.

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