

Stocking rates of pastures in Goiás state, Brazil

ABSTRACT

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Goiás state has the third largest cattle stocks among the Brazilian states, with 22.8 million heads, and the second largest herd of lactating cows. These animals are kept under grazing on pastures, which occupy 41% (14 Mha) of whole Goiás state' territory. This study analyses the stocking rates of the pastures of Goiás, identifying their current state of degradation and production potential. Therefore, data on cattle herd, stratified by age and sex, besides the pasture mapping obtained by satellite images was used. Therefore, the results provide more accurate estimates than before on the pasture situation and, consequently, of the cattle ranching in the state, allowing greater potential for increased productivity. The stocking rates of pastures is 1.3 animal unity / hectare, which could be considered low in terms of potentials, due to the poor use of production and management technology. Despite of having the highest concentration of feedlots in Brazil, Goiás state keep cattle mainly on pastures.

KEYWORDS: bovine herd, support capacity, pastures, spatial analysis.

1 INTRODUCTION

Brazil is the largest beef exporter worldwide and the second largest producer, behind the United States of America. Cattle production in Brazil and, especially in Goiás, which owns the third largest cattle stocks in 2016 among the Brazilian states with 22.8 million head, is based on pastures (planted and natural), regardless of the main raising systems: intensive and extensive. Brazil has about 175 Mha (or 21% of its territory) with pastures, while in Goiás, 41% (14 Mha) of its territory is pastured (Parente et al., 2017). Therefore, it is necessary to measure the efficiency to obtain the optimum in its use (Strassburg et al., 2014; Sparovek et al., 2018).

The essence of animal production is feed, in the case of livestock pasture in Goiás and its degradation is a factor that must be analysed and studied continuously. Knowing the stocking rates of the pastures of each municipality of the state is of high relevance to tackle low yield indexes of Goiás cattle herds. The stocking rates is determinant to know if a pasture is in the process of degradation (overgrazing) or underutilization (sub grazing), both cases generating economic losses for the cattle rancher, due to the non-optimization of resources. The search for economic efficiency goes through the optimization of systems, production, costs and so on. Thus, the stocking rate of pastures is an indicator that serves the study's aim and the one that best fits the definition of optimization in the case of pastures.

Dias-Filho (2014) points out the high incidence of areas of degraded pastures that, although worrisome, shows as a positive point the existence of a great potential for the increase of productivity of the national livestock through the recovery of these low-productivity areas. The Sectoral Plan for Mitigation and Adaptation to Climate Change for the Consolidation of a Low Carbon Economy (ABC Plan) has seven programs, the main one being the Degraded Pasture Recovery Program (RPD), which in turn, by 2020, has the goal of recovering 15 million hectares (Mha) at a cost of R\$ 31.3 billion and R\$ 26.7 billion for the priority and free allocation areas, respectively (Observatory ABC, 2017). In Goiás state, the RPD program invested more than R\$ 1 billion between 2013 and 2017, which represented more than 60% of the resources of the ABC Plan in the state.

National policies assume that between 50% and 70% of the pastures have some level of degradation (Dias-Filho, 2011) and that, in extreme cases, there are suggestions of zero deforestation due to the better use of the areas of degraded pastures. Degraded pasture areas present low biomass production during dry and rainy seasons. In case of recovery, these could be intensified, promoting higher production efficiency and, consequently, partially allocated for other uses. Arantes et al. (2018) measured the cattle stocks of the national pastures by means of data from the Agricultural Census of 2006, self-declared by the respondents, and the Municipal Livestock Survey (PPM), both from the Brazilian Institute of Geography and Statistics (IBGE). However, the study assumes a series of parameters that do not allow to present an accurate result regarding the pasture areas, especially in Goiás state.

The objective of this study was to analyse the stocking rates of the pastures of Goiás state, making it possible to know its current state of degradation and its productive potential, contributing to evaluate the ongoing policies and the formulation of future public policies. For this purpose, the database of the Goiás Agricultural Defence Agency (Agrodefesa) has information of the herds stratified

by age and sex, as well as quantitative data on pastures, mapped by satellite images. Another objective of this study is to mitigate this gap using more accurate data on the Goiás cattle herd. The methodological development can be applied to other regions of the country, so that the analyses on pastures has a higher external validity.

In addition to this introduction, the study has four sections. Section 2 presents the materials and methods used in the study, examining the cattle herd, stocking rate and other concepts. Section 3 presents the main results and analyses them. Finally, section 4 presents the final considerations of the study.

2 MATERIAL AND METHODS

2.1 Cattle herds and pastures in Goiás state

Among the 25.2 million animals raised in Goiás (cattle, buffaloes, horses, pigs and goats), PPM / IBGE data show that the state currently has more than 22.8 million cattle heads. This represents 10.5% of the national cattle herd and 30.5% of the Middle-West region's herds. In 1974, the situation was quite different, Goiás state had a cattle population of 10.9 million heads, i.e. 11.8% and 47.9% of the national cattle herds and the Middle-West, respectively (IBGE, 2017a). From 2000 until today, the figure has changed as much as before, since in 2000 the state had 18.2 million cattle heads (10.8% and 30.8%).

A qualitative analysis shows that the cattle raising system changed substantially during this period. Several factors contributed to this change, with emphasis on technology and the dynamics of the value chain, in which the agri-food industry grew to encourage the production of inputs at local level.

Cattle raising systems in Goiás state is structured as follows: i) calve producers - whose final product is the sale of calves, usually using low technological level of production, in regions of low fertility lands and are in greater number than the others types; ii) heifer raisers - buy the calves from calve producers and raise them until they are ready to enter fattening (feedlots or on pastures). They use improved production technology and they move the primary market of purchases; iii) fatteners - work at the end of the raising process and fatten the animals for slaughtering. They use more advanced technologies, confine animals and test the latest technologies. There are also those cattle raisers who do the complete cycle, that is, they produce calves, raise the heifers and fatten adult animals for slaughterhouses. The last category is the minority.

Another important area that concerns the cattle herd is the dairy production. Goiás has the second largest herd of lactating cows and the fifth largest milk production among the Brazilian states. This production surpassed 3.5 billion litres in 2017, when Goiás state accounted for 8.7% of the national production and more than 70% of the production of the Middle-West (IBGE, 2017b). Just that year, more than US\$ 565 million in milk and dairy products were exported by the state. In addition, milk production is the main activity of the family farmers of Goiás state, where almost half of all farms had this activity (IBGE, 20017).

Despite this high production, Goiás state does not rank among the states with the highest yield per animal or yield per area within Brazil. The state ranks 13th

with 3.6 litres/cow/day, well behind Rio Grande do Sul state with a yield of 8.7 litres/cow/day (IBGE, 2017b). One reason for this low productivity is inadequate feeding. Therefore, this is another factor that points out the need to improve the quality of pastures in Goiás state.

In all these cases, the main feeding form of livestock is pasture (Figure 1), unlike the major European and American producers. So, in Goiás state, cattle raising is mainly "green" (pasture based). This peculiar characteristic differentiates it from their peers in double purpose beef-and-dairy producing countries. Therefore, to the Goiás' cattle ranchers, pasture is the basis of their activity.

Figure 1 - Distribution of pasture area cultivated in the state of Goiás, with emphasis on the territorial boundaries of the regional offices of Emater Extension Agency.

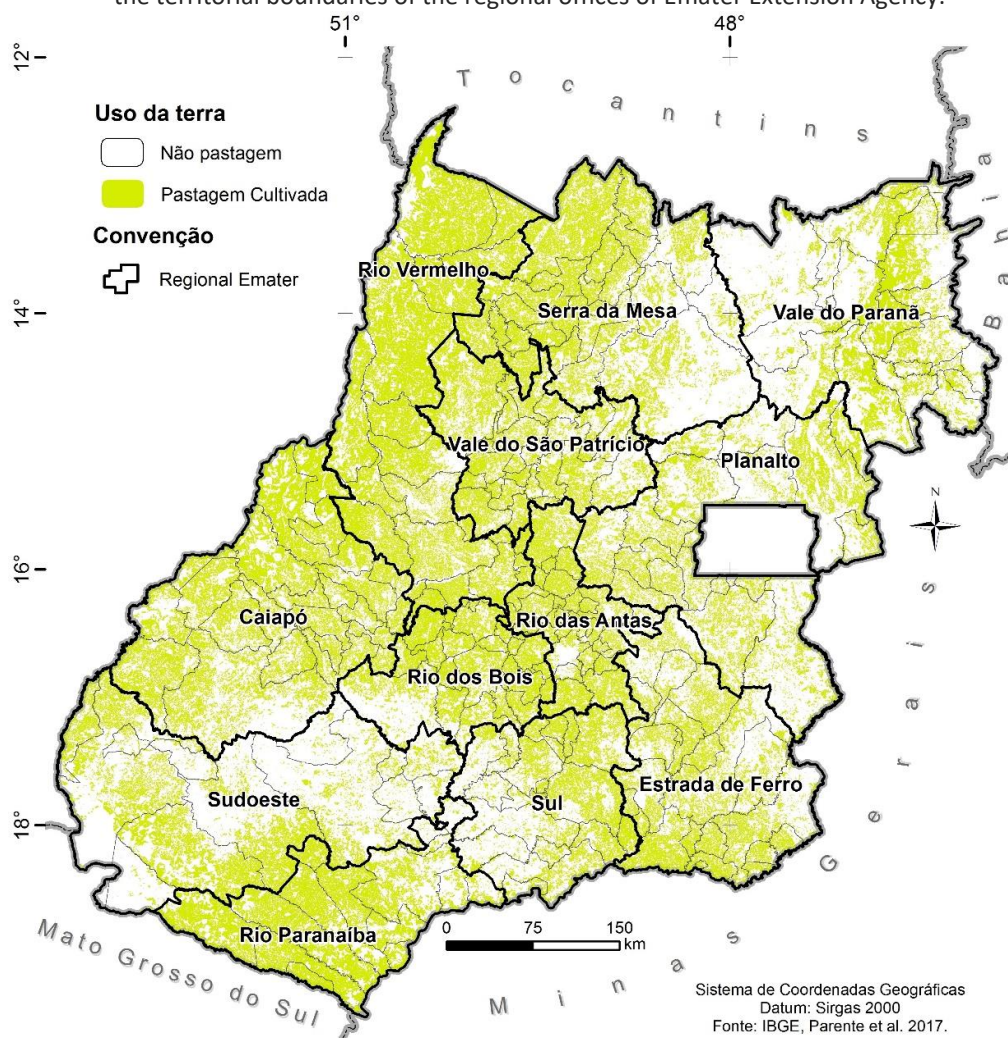


Figure 1 shows that cultivated pastures are located throughout the state, with concentrations in the Araguaia River basin, subject to annual floods that fertilize soils (organic matter) and add moisture for longer periods; in the center-south region with more fertile soils; and in the southwest of Goiás state, where the Guarani Aquifer is located. The planted pasture that dominated the region was of the Panicum genus, more demanding on soil fertility and concentrated the feed lots. The other regions of the state produced calves that are fattened (finished) in this region. Gradually, with the exhaustion of the soils, pastures are being replaced by Brachiaria spp, less demanding in soil fertility. In the north-eastern part of the

state, there is a large nature conservation unit, the Chapada dos Veadeiros National Park, and a colony of "quilombolas"¹, almost preserved sites.

The pasture situation is approached by several studies, which in their diagnoses classify as mostly degraded, such as Garcia et al. (2013), which verified that the pasture areas of Cerrado vegetation in Goiás state are of low quality and that several municipalities (major producers of cattle) have the stocking rate of their pasture areas seriously constrained. In this way, the stocking rate is low, providing Brazil and Goiás state with low, have a low slaughter rate of the herd due to the low stocking rate of the pastures.

The data of the Agricultural Census of 2017 (IBGE) show that 46.5% of the rural area of Goiás state is occupied by cultivated pastures, which reaches 15 Mha or 57.1% of the total rural area, when considering natural pastures. Of the pastures of Goiás, 92.5% of the area is considered as "pasture planted in good conditions". The fragility of this information must be emphasized, and it was included only for comparisons with other data of this study.

It is interesting to observe the quantity and monetary values of the Degraded Grassland Recovery contracts, subprogram of the ABC Plan, in the pastures of the municipalities of Goiás state. Between 2013 and 2017, an additional R\$ 1 billion was invested in the recovery of 1.5 million hectares, that is, an average of approximately R\$ 1,000/ha. Despite the unavailability of the microdata, there was a correlation of 0.67 between the total RPD investments per municipality and the area classified as "poorly planted pastures", which suggests that the program has directed its resources to the most needed regions.

According to CEPEA (2017), Goiás state concentrates the largest number of cattle feedlots in Brazil. With the broader adoption of the Integrated Crop-Livestock-Forest Systems (ICLFS), agriculture is carried out at the same time as livestock farming is practiced during the critical pasture shortage season (July to October), when there is practically no rainfall in the state. Almost all native or planted pastures is composed of grasses. Experiments with leguminous crops in direct grazing or intercropping plantations have not yet convinced cattle ranchers.

Confined animals respond more efficiently to feeding. In general, this product is destined to export to the European Union more demanding in terms of quality and animal health. The highest cost of raising livestock is feed and has direct influence on the meat quality. Southern hemisphere cattle raisers primarily use pastures to feed their herds, while those in the northern hemisphere use silage, soybean bran and other sources. In the national case, increased pasture productivity, animal breeding and improved animal health are more profitable than feedlots, which may turn Brazilian beef more competitive in international markets. In addition, with the popularization of ICLFS, there is a higher availability of pasture to graze and even to ensilage and confine. This integration tends to increase the profitability of farms.

The Annual Report on Social Information (RAIS) of the Ministry of Labour and Employment shows that in 2016 there were 273 companies from the Slaughtering and Meat Products group of economic activities, in the National Classification of

¹ "Quilombolas" are villages founded by refugees of the Brazilian slavery regime during 18th and 19th century.

Economic Activities (CNAE 2.0), which generated 31.1 thousand jobs. In 2002, there were 178 companies and 12,800 jobs in the same group.

2.2 Database and methods

This study presents the stocking rate of the Goiás pastures by means of an accurate measurement of the cattle herd. The research used the Agrodefesa database, with cattle vaccination data (November 2017 stage) of all bovine animals in the state, stratified by sex and age, unprecedented information for this type of analysis. The calculations were based on the main studies of the area of knowledge, raised in the literature review, and compared other studies to check possible divergences.

The information on pasture quality comes from the Agricultural and Livestock Census of 2017, from IBGE, and data from the RPD program were provided by the Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA).

The pasture stocking rate is the number of animal units (AU) per hectare of pasture in a given period (one year). As the cattle herd is composed of animals in different ages, from calves to fat animals or in full production (dairy) for the measurements have consistency it is necessary that there is a common unit. The AU is the reference for the measurement of the herds, since they are composed of living animals that are in certain age, that even complete in the broad sense of their functions, are different in the variables time and development, there including weight, height, size, consumption, age, etc. In addition, the composition of the herds is not homogeneous, varying according to race, environmental conditions, raising system and other variables. An AU is considered a 450 kg living weight (Lopes & Vieira, 1998; Arantes et al., 2018). The stocking rate of pastures of each municipality of Goiás state was obtained by transforming the stratified herds into animal units, dividing this number by the amount of existing pastures (ha).

For cattle to be able to transform pastures into feed, it is necessary being productive, well-deployed and managed, under threat of rapid degradation and not fulfilling their role as feed for animals. Malformed or poorly preserved pasture is reflected in the quality of the herd that feeds on it. Mismanagement leads to degradation. Therefore, the correct management of pasture should have as objectives: forage production; efficiency of use of the forage produced; pasture stability; animal performance; and animal production per hectare.

An examination in the technical and scientific literature shows a lot of studies on pasture stocking rate in which comparative analysis is difficult. It is common to find the concept of pasture stocking rate as a ratio between number of animals and area (ha) used. However, such a unit is very variable when examining the consumption of pasture, feed, medicines, fences, water, CO₂ generation, milk and meat production, manure generation, quantity of urine and thus so that their inequality is considerable.

Lopes and Vieira (1998) propose values of equivalence between the animal categories to be used to size of cattle herds, so that this would be a function of the size of the area and the carrying capacity of the fodder established therein, expressed in animal units. Table 1 shows the conversion factors of the different institutions and authors showing the variability of each one. Thus, the

discrepancies found in the conversion factor used by different institutions can cause identical situations to reach different results (Table 1). Therefore, it is essential to choose based on scientific evidence, that is, in the bibliographic survey, together with the characteristics of the herd analysed, which in the case of this research, has detailed information about sex and age.

Table 1 - Conversion factors by sex (F = female, M = male) and age (months) - by institution and study

Animal category, sex and age	INCRA CO *	Lopes Vieira (1998)	CE-PLAC	Em-brapa	IAGRO MS	Emater MG	Emater PR	Emater GO	BNB
M: 0-12	0.31	0.25	0.25	0.25	0.35	0.30	0.40	0.25	0.33
M: 13-24	0.5	0.50	0.50	0.50	0.75	0.65	0.70	0.50	0.50
M: 25-36	0.75	0.75	0.75	0.75	1.00	1.00	1.00	0.75	1.00
M: >36	1.00	1.00	1.00	1.00	1.50	1.25	1.00	1.50	1.00
Bull	1.39	1.25	1.25	1.25	1.50	1.25	1.20	1.50	1.50
F: 0-12	0.31	0.25	0.25	0.25	0.35	0.30	0.40	0.25	0.25
F: 13-24	0.50	0.50	0.50	0.50	0.65	0.65	0.70	0.50	0.50
F: 25-36	0.75	0.75	0.75	0.75	0.75	0.75	1.00	0.75	1.00
F: >36	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Source: Own compilation based on cite studies.

* INCRA in the Midwest region gives a highlight for early calves with higher conversion rates, see INCRA Normative Instruction no. 11 of April 04, 2003.

It is important to note that “Agrodefesa” data discriminate the sex and ages of the herd. Therefore, this stratification made it possible to more accurately measure the Animal Units per hectare and, consequently, to identify more precisely the degree of use of the Goiás state’ pastures. This is important because it has direct effects on the identification of pasture degradation, which influences CO₂-emission, water absorption, etc.

Briefly, the literature shows that there is no uniqueness on the subject. However, there are recurrent values. Thus, one of the criteria used in this study was the statistic, opting for mode, that is, the conversion that more often in the literature survey (Table 2). Therefore, this application is recommended until specific studies offer data for a better calibration to Goiás state reality of the diverse cattle herd.

Table 2 - Coefficients of conversion to Animal Unit (AU)

Age (months)	Multiplier	Male	Female
0-12	0.25	0.3125	0.25
13-24	0.5	0.625	0.5
25-36	0.75	0.9375	0.75
> 36	1	1.25	1

Source: Own compilation.

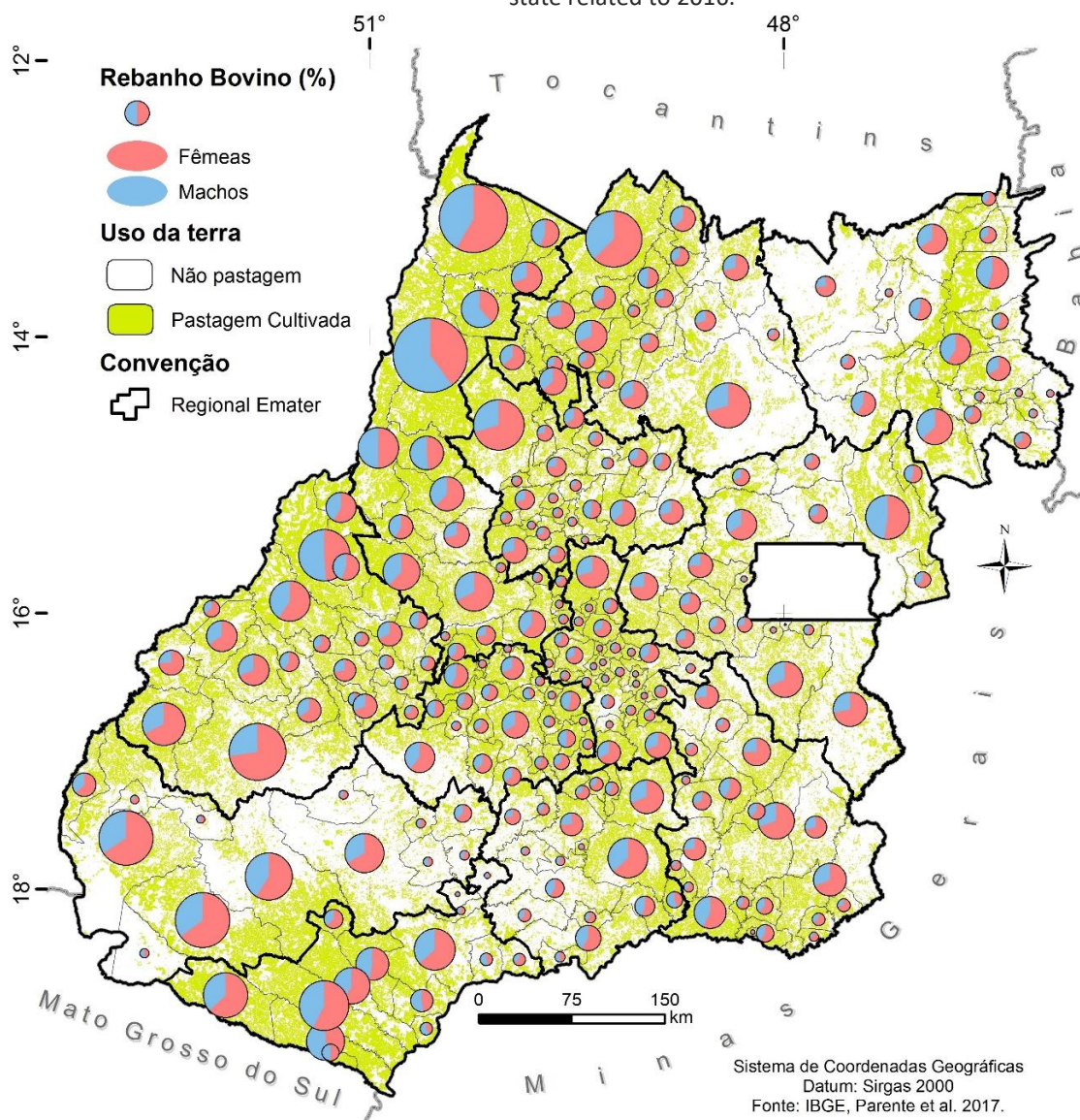
The historical origin of these coefficients relates to the time of the introduction of the rural extension service in Brazil in the 1950`s. The planning of so-called Rural Credit and Supervised Rural Credit, which obliged the extensionist to plan the farms in order to allow access to credit. Thus, it was up to the extension workers of the Association of Credit and Rural Assistance (ACAR) to plan and size the herd evolution, feed consumption, covered troughs, mineral consumption, silage, water, etc. The instruments used rural credit forms, adapted from the similar American ones, from which almost all the Brazilian extensionist reference

came. The original AU value (1,000 pounds, equivalent to 453.5 kg) and its conversion factors date back to this time, which were accepted by financial planning institutions and used in international fundraising projects. The multiplication of planning firms in Brazil, most of them, with human talent coming from extensionist experience, the use of these units was diffused, which are already consolidated as a way of measuring stocking rates.

3 RESULTS AND DISCUSSION

According to “Agrodefesa” data, in the year 2017, the state of Goiás had 22.8 million head of cattle, 12.4 million of cows which were equivalent to 63% of the total herd. It also indicates the predominance of cows among adult animals. One of the reasons is the dairy herd, which is formed mostly by adult cows, as well as the beef cattle calve-producing cows.

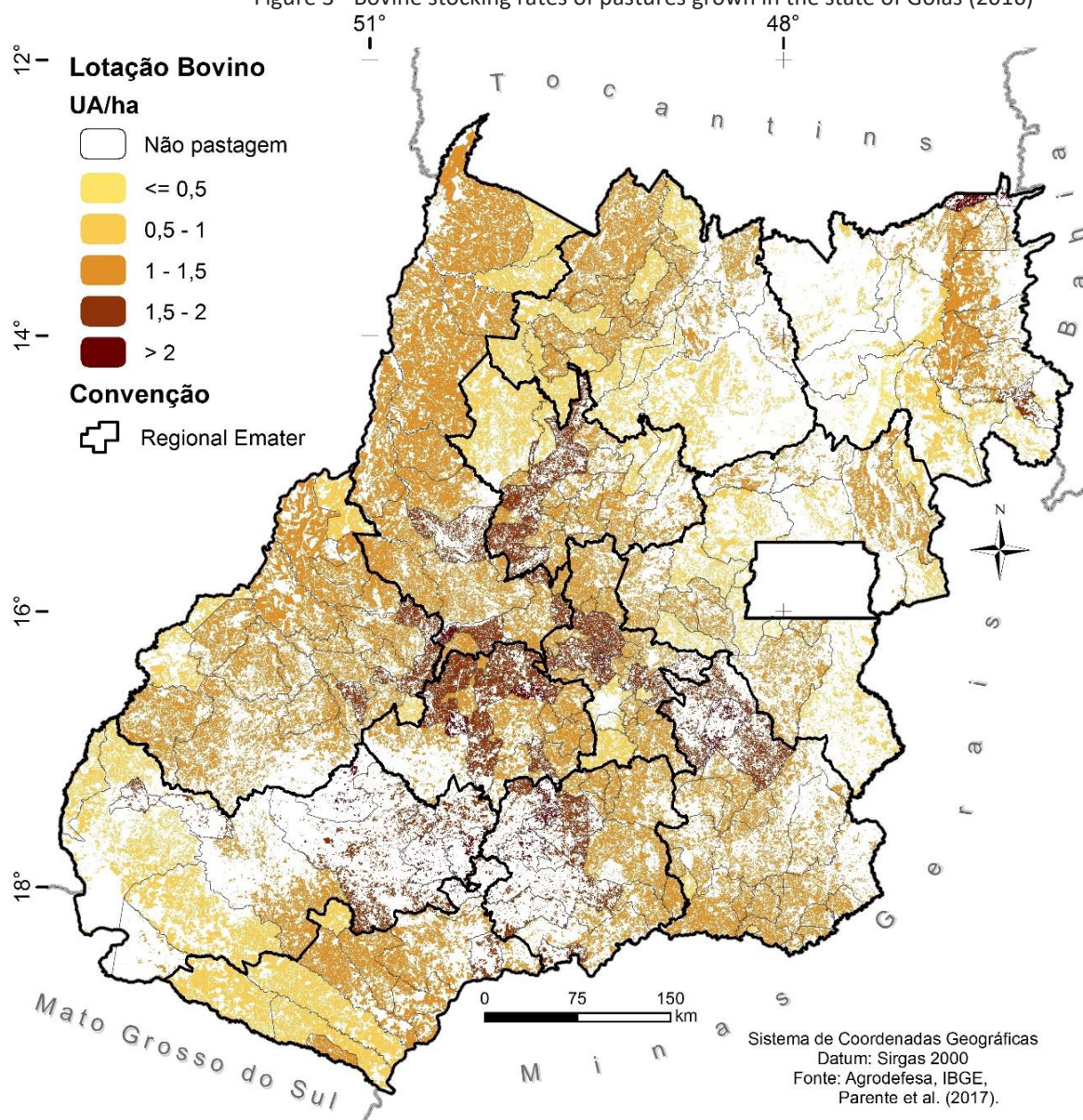
Figure 2 - Proportion of the cattle herd in females and males per municipality in Goiás state related to 2016.



Livestock production occurs throughout the state and is practiced by almost all farmers: the small in the production of milk and the medium and large areas in the production of beef cattle in the different specialties. The dairy farms also provide male calves for the other stages of beef production.

Figure 3 shows where there is a concentration of pasture, there is also a reasonable concentration of cattle, with some exceptions, such as the corridor in the south-central region of the state. Cattle have been growing throughout the region even though much of the agriculture is being practiced in areas of degraded pastures. Costa et al. (2008) affirm that the expansion of the cultivated pastures was due to the value increase of agricultural land, rural credit and introduction of more adapted species and cultivars, besides the development of planting techniques. In addition, the price of land and the ability to be stocked alive, among others, lead farmers in agricultural frontier areas to focus on pasture-based cattle raising (Dias & Filho, 2010).

Figure 3 - Bovine stocking rates of pastures grown in the state of Goiás (2016)



Regarding the stocking rate, the state had 16.5 million Animal Units (AU), out of which 11 million were females (cow and heifers) (66.5% of the total). Table 3 shows the AU by age. Although 22% of the herd was up to 12 months in AU terms, this represented only 8.6% of total herds, so the low weight given to the youngest animals influenced this result. And 8.3 million animals older than 3 years (36.5% of the total) accounted for 51.7% of the state's AU. Dividing the AU found by the total pasture area in Goiás a stocking rate of 1.3 AU/ha is obtained (Figures 4).

Table 3 - Animal Units (AU) of cattle in Goiás state (2017) - by age (months)

Type	0-12	12-24	24-36	> 36	Total
AU	1,428,824	2,917,029	3,648,592	8,541,774	16,536,219
% AU	8.6%	17.6%	22.1%	51.7%	100.0%

Source: Own compilation based on Agrodefesa (2017).

The results obtained in this research converge with most studies on this issue, however, it is worth highlighting that there is a significant growth potential in terms of animal capacity per ha, as evidenced by Arantes et al. (2018) and Carvalho et al. (2010). The last study, says that it is possible to double cattle production in Mato Grosso increasing the pasture stocking rate (2008) from 0.97 AU/ha to 1.6 AU/ha, with an improved herd. Despite this, investment in pasture reform would only be economically compensated if the intensification of this herd was greater than 2.0 AU/ha.

Dias-Filho (2014) still attributes low pasture productivity to factors such as the preference for the best areas being used for crop production and the lower use of technology, inputs and manpower for livestock. The ability to self-transport allows the herd to adapt to regions with poor transport access and greater distances from the consumer market. In addition to perpetuating the tradition of low investment in livestock, this situation contributes to the degradation of pastures, further damaging the environment.

Costa et al. (2008) point out that the races not selected for precocity also reflect the lengthening of the reproductive cycle and, consequently, the low yield rates. Pires et al. (2012) show that other factors affect the productivity of several crops and, consequently, also pastures. One of the most important is the soil and the way it is managed, which interferes in its physical, chemical and biological attributes, such as density, nutrients and biological population. The study also concluded that animal trampling changes the soil structure (Pires et al., 2012).

Strassburg et al. (2014) discuss the rationalization of pasture-areas use for beef production, since the demand for food is expected to double in the next decades, increasing the competition between farming and natural resources. The paper suggests that current pasture productivity is only 32-34% of its potential and that if it were increased to 49-52% of the potential, it would be sufficient to meet the demands of meat, wood products and biofuels until at least 2040, without any additional conversion of natural ecosystems into agricultural land.

The preference for cattle raising on pastures in the Midwest is due to the existence of areas to be occupied and the lower price than in traditional farming regions, such as the South and Southeast regions, which also concentrate large cattle herds. In the central region of Goiás, there is a concentration of the cattle raisers who obtain higher stocking rate of the pastures, in the fertile soils of some areas of Goiás state and near the centres of technology availability. Even in these

municipalities the stocking rate is still low in terms of the possibility technology in the fodder production. In addition, in the region near to the state capital Goiania, there are indications that the availability of technology and soil quality interfere in the better use of the areas with higher stocking rate of the pastures.

Finally, the profile of the herd varies significantly between the regions, in relation to age and to the sex of the animals. In some cases, especially in the regions with feedlots, as in the western part of the state, where the Araguaia Valley is located, it is possible to verify that the profile is of older cows (> 36 months) and young cattle (between 13 and 36 months), because the northwest region is typically raising and fattening. Possibly from 0 to 12 months, the animals in the region are those born there, thereafter a progressive increase of males, up to 36 months, when they are in the fattening phase and at that age are slaughtered in the regional slaughterhouses. In general, the other cases, over 36 months, are of calves producers and animals that failed to reach slaughtering weight. With females, there is stability in the herd until 36 months of age, showing that there is a concern of retention, preservation and safety of animals for future slaughter. As mother cows remain with life until 8 to 10 years of age, in dynamic cattle-raising regions the situation is compatible with the reality of the northwest and southeast regions of Goias state.

4 CONCLUSIONS

The cattle herd is distributed throughout the state of Goias with concentration in dairy regions and Araguaia Valley, in case of beef cattle. The pasture stocking found here is like literature data, converging in affirming that there is potential for improvement.

The number of animals that these pastures can carry, over a period (one year) is the pasture stocking rate. The Goias state level stocking rate in 2017 was 1.3 AU/ha, which may be considered low in potential terms, indicating a poor use of pasture resources, production technology and management.

The pastures are almost all grasses, and the technologies available and its costs for the use of legumes in the pastures have not been enough to convince the farmers to adopt them. Despite being the state that concentrates the largest number of animals in feedlots in the country, the cattle production in Goias state is done mainly on pastures, predominantly *Brachiaria* spp.

The stratification of the "Agrodefesa" database allowed to measure with higher precision the degree of utilization of the pastures, which is important because it has direct effects in the identification of pasture degradation. Therefore, the governments can act, with technical assistance projects, in a more effective and efficient way in the recovery of pastures.

The use of grass species and varieties more adapted to the state's regions, genetically improved herds, better pasture management, intensified use of technologies and inputs, can significantly increase pasture productivity, reflecting higher pasture's stocking rates. This is a fundamental issue because it links to the wider environmental and economic discussion, which demands ever higher efficiency.

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Taxa de lotação de pastagens no estado de Goiás, Brasil

RESUMO

Goiás possui o terceiro maior efetivo bovino entre os estados brasileiros, com 22,8 milhões cabeças, e o segundo maior rebanho de vacas ordenhadas. Esses animais têm sua alimentação baseada predominantemente nas pastagens, que ocupam 41% (14 Mha) de todo o território goiano. Este estudo analisa a capacidade de suporte das pastagens de Goiás, possibilitando conhecer o seu estado atual de degradação e sua potencialidade produtiva. Para isso, utiliza dados do rebanho bovino, estratificados por idade e sexo, além do mapeamento das pastagens obtido por imagens de satélite. Portanto, os resultados oferecem estimativas mais precisas que as anteriores sobre a situação dos pastos e, conseqüentemente, sobre a pecuária do estado, possibilitando um maior potencial para o aumento de produtividade. A capacidade atual de suporte das pastagens goianas é de 1,3 UA/ha, que pode ser considerada baixa em termos potenciais, indicando um uso deficiente de tecnologia de produção e manejo. A predominância dos sistemas de criação de bovinos é em pastagens, mesmo Goiás sendo o estado com maior concentração de confinamento bovino do Brasil.

PALAVRAS-CHAVE: rebanho bovino, capacidade de suporte, pastagens, análise espacial.

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