Lightning fatalities in the livestock industry in the Brazilian Amazon region (2012 – 2019)

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***Abstract*— In this paper lightning damages on livestock in the Brazilian Amazon region is analyzed and discussed. The period of observation is between 2012 and 2019. Currently, the Brazilian Amazon region is expanding the livestock economy, which has significantly increased the number of animals on farms. In addition, the region has a high lightning density, which is a threat to the livestock economy if no protection would be performed.**

***Keywords*— Livestock, lightning, deaths, Legal Amazon region, bovines.**

I. INTRODUCTION

According to the Brazilian National Institute for Space Research (INPE), Brazil was the country with the highest lightning rate in the world in the period 2012-2017, with an annual average of 77.8 million of lightning [1]. The tropical zone is the region of the globe with the most cumulonimbus clouds, which is dominant in stormy days and it is the main source of lightning. Brazil is one of the most extensive countries in the Tropical zone, that is, it becomes the main target of this natural phenomenon [2]. According to INPE, the Brazil's Federation unit with the highest lightning density is Tocantins, with 17.1 lightning/km2/year, followed by Amazonas (15.8), Acre (15.8), Maranhão (13.3), Pará (12.4), Rondônia (11.4), Mato Grosso (11.1), Roraima (7.9), Piauí (7.7) and São Paulo (5.2), being the top 10 states with the highest lightning density per square kilometer per year [3]. Figure 1 shows the lightning density map in Amazon region calculated with STARNET [4] reprocessed data for the average for the years 2013 – 2017.

The Legal Amazon Region was established on January 6, 1956. Currently, the region has an area of approximately 5.2 million km² and corresponding to about 60% of the Brazilian territory, is composed by 9 states: Acre, Amapá, Amazonas, Maranhão, Mato Grosso, Pará, Rondônia, Roraima and Tocantins [5] (See Fig. 2). Due to its humid and equatorial climate, the formation of storms and lightning occurrence is more likely in the region [6].

The growing of the livestock sector in the legal Amazon region is fast. The number of cattle herds is increasing rapidly, and huge open fields have been made to livestock. With the arrival of storms, the cattle herds tend to be under trees and sometimes near to the fences, being susceptible to being struck by lightning [7], as will be explained with an emphasis in the case study. These occurrences are very bad to farmers.

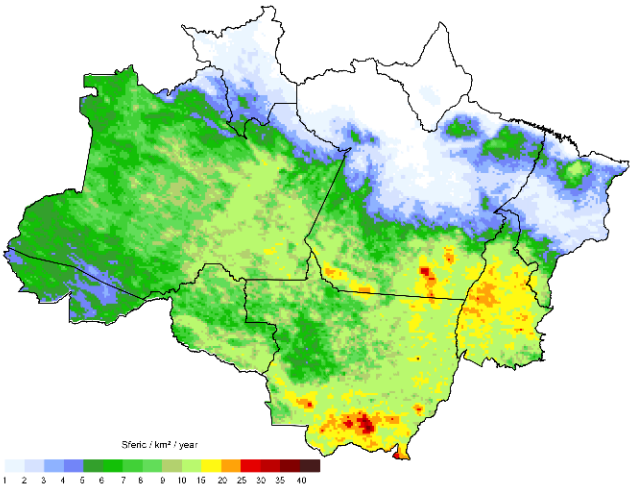

Fig. 1. Annual sferics density in the Amazon region (Average 2013-2017). Source: STARNET.

Fig. 2. Legal Amazon region [8].

There are several studies related to human deaths caused by lightning [9, 10 and 11], however, there is just a few related to animal deaths caused by lightning [7]. There is a lack of information for lightning damages in the livestock industry, mainly in the Legal Amazon Region. The aim of this paper is to describe the damages caused by lightning in the livestock over the Amazon region for the period of 2012-2019, in order to assist future theoretical and experimental research.

II. MATERIALS AND METHODS

A. *Data searching*

The data that underlies this paper is based on a systematic searching on the internet (webpages of newspapers, magazines, and blogs). Different keywords were used in order to perform the search, such as: "death of cattle caused by lightning in the Legal Amazon Region"; "cattle die struck by lightning in (State name)". In addition, we applied different filtering Google tools to search for data in a specific year. We found 20 cases. All of them were confirmed by at least 2 websites. The list of cases can be found in the Appendix.

B. *Data Classification*

After data searching, we organize the data by date, city, state, a number of dead cattle and the losses in local currency (see Table I). We choose the event with more cattle deaths to study in detail, this event is our study case. In addition, a methodology to estimate the monetary losses for the events with no information about it was performed, and in order to standardize the data analysis, the values of the losses reported in the news were updated.

The information of monetary losses was reported in eleven cases and was estimated by livestock farmers. Hence, a methodology to estimate the losses for the other cases was needed. We developed a methodology to estimate monetary losses according to the value of the cattle in the local market for a period of observation.

Initially, the characterization mass of a "fat cattle" (510 kg) ready for slaughter, corresponding to 17 arrobas, was used as reference. The value of the damage would then be given by the multiplication of 17 by a number of cattle dead and by the value of the arroba at the local market in the date of the event. However, most of the results diverged sharply from the estimated quantities. One reason would be the fact that for some locations the real value of the arroba was not found, only for a neighboring region. Additionally, cattle health was not known during the event.

As the calculated values were always higher than the estimated ones. We improved the methodology by reducing the weight of ready-to-slaughter "fat cattle" from 510 kg to 420 kg, corresponding to 14 arrobas. After that, we recalculated the losses for all events.

Thus, approximations of most of the initial values have obtained, then the initial amounts have updated and new information has added to the data with no information on monetary losses.

TABLE I. DATA TABLE

Date	City	State	Deaths	Reported financial loss in (R$)	Estimated financial loss in (R$)	Estimated financial loss in (U$)*
01/31/2012	CÁCERES	MT	22	-	26,796.00	6,771.45
02/10/2013	BURITIS	RO	3	-	4,032.00	1,018.90
03/28/2014	PEDRO AFONSO	TO	51	60,000.00	84,252.00	21,290.81
09/28/2014	PARAÍSO	TO	60	-	101,640.00	25,684.83
01/02/2016	CACOAL	RO	15	-	26,880.00	6,792.68
03/21/2016	ALTO PARAÍSO	RO	38	57,000.00	72,352.00	18,283.63
03/21/2017	OURO PRETO DO OESTE	RO	45	70,000.00	80,640.00	20,378.05
03/30/2017	NOVO HORIZONTE	RO	8	-	13,888.00	3,509.55
08/28/2017	ÓBIDOS	PA	26	40,000.00	44,408.00	11,222.08
11/21/2017	TALISMÃ	TO	12	-	21,840.00	5,519.05
01/07/2018	GURUPI	TO	4	5,000.00	7,840.00	1,981.20
01/07/2018	TALISMÃ	TO	7	15,000.00	13,720.00	3,467.10
01/08/2018	TALISMÃ	TO	80	-	156,800.00	39,623.98
02/17/2018	NOBRES/POCONÉ	MT	93	200,000.00	173,166.00	43,759.73
03/09/2018	CACOAL	RO	103	130,000.00	191,766.00	48,460.02
03/19/2018	NOVA GUARITA	MT	32	-	59,136.00	14,943.90
10/27/2018	ARIPUANÃ	MT	34	60,000.00	64,260.00	16,238.75
12/20/2018	SINOP	MT	14	-	26,656.00	6,736.08
12/23/2018	NOVA XAVANTINA	MT	80	-	152,320.00	38,491.86
01/29/2019	COLINA VERDE	RO	6	15,000.00	11,508.00	2,908.12
Total	-	-	**733**	-	**1,333,900.00**	**337,081.77**

* Conversion to US dollars in (May 10, 2019).

III. GENERAL CHARACTERISTICS OF LIVESTOCK IN THE LEGAL AMAZON

In Brazil, the cattle herds were concentrated in the central-west region. However, recently the north region has significantly increased the number of cattle heads and now occupy second place in the national market [12] (see Fig.3).

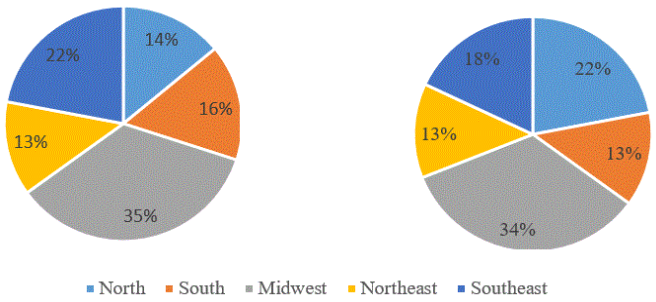

Fig. 3. Percentage of cattle heads per region in 2010 and 2016. Adapted from [12].

According to Fig. 3, the percentage of cattle heads in the north region of Brazil increased from 14% to 22%. The scenario of cattle heads in Brazil in 2017 [13] is shown in Fig. 4.

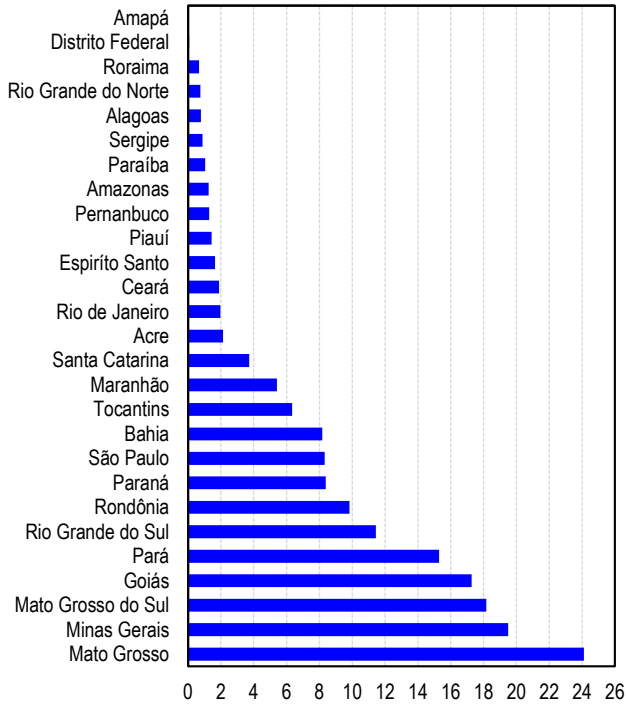

Fig. 4. Cattle herd (millions of head) per State in 2017 [13].

Note that in Fig. 4, the states with higher number of cattle heads, most of the states belong to the legal Amazon region. Mato Grosso is in the first position for the Amazon region, with approximately 30 million cattle heads.

In the Southern Amazon region, the period of greatest precipitation occurs between November and March, and from May to September, the precipitation is lower. April and October are transitional periods [14] (Fig. 5).

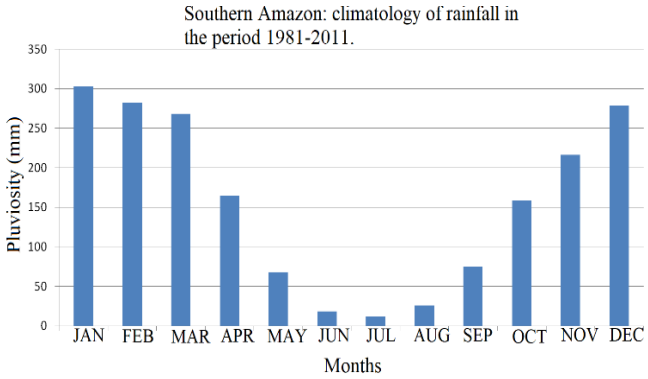

Fig. 5. Southern Amazon rainfall in the period 1991-2011. Adapted from [15].

IV. STATISTICAL ANALYSIS OF DATA

Twenty accidents were analyzed in this work. We analyzed: (a) location of events; (b) number of cattle deaths; (c) accidents per month; (d) accidents per year; (e) lightning density and (f) damages for the livestock farmers.

According to Fig. 6, the majority of cases of lightning accidents involving cattle herd occurred during the period of greatest precipitation, which is at the beginning and at the end of the years.

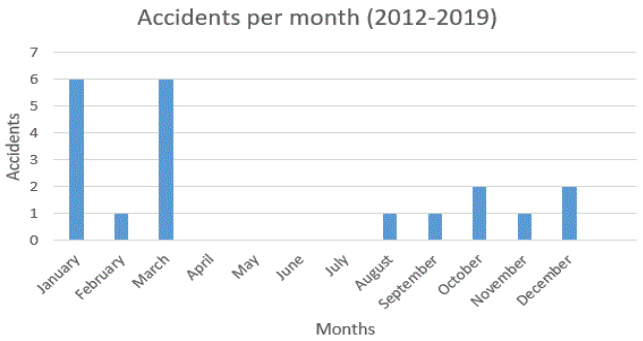

Fig. 6. Accidents per month in the period 2012-2019.

Figure 6 shows that in the period 2012-2019, most of the accidents occurred in January and March when heavy storms are common with huge cumulonimbus clouds and high lightning occurrence.

When starts to rain, usually the cattle go under the trees, or in the minority of cases, they approach the fences [7]. In both cases, single lightning that strikes a tree or a fence can kill lots of cattle. This occurs because, in the open field, lightning are more likely to strike the tallest object. Trees usually are the tallest object in the open field and provide immediate security to animals. When the return stroke occurs, the lightning current dissipates on the ground and crosses the cattle body, and consequently kill them.

Since 2000 the number of people in Brazil with access to the Internet has grown year by year [16], perhaps because of that the number of reported accidents has been growing along the years (see Fig. 7). Other reason can be the fast increase in the number of cattle heads in the Amazon region (see Fig. 3). This shows that measures to protect livestock are being insufficiently practiced. It is important to note that this work searched for accidents until April 2019, so that the results for 2019 are partial.

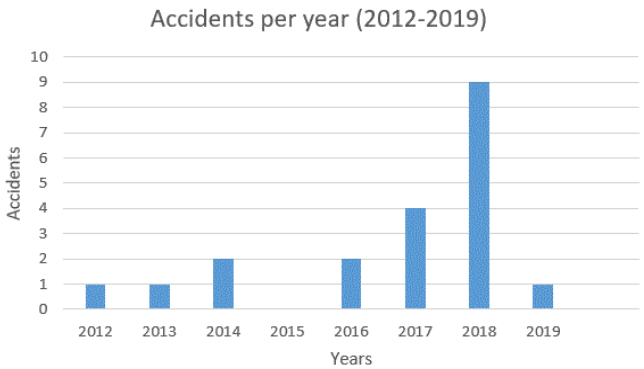

Fig.7. Accidents per year in the period 2012-2019

Figure 8 shows the number of accidents per state in the Legal Amazon region.

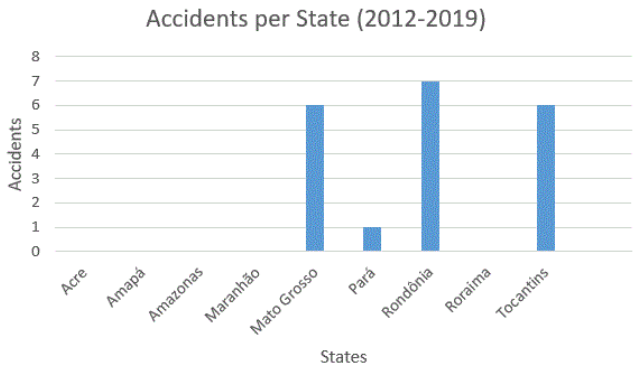

Fig. 8. Accidents per State in the period 2012-2019.

Figure 9 shows the amount of cattle deaths per State in the period from 2012 to 2019.

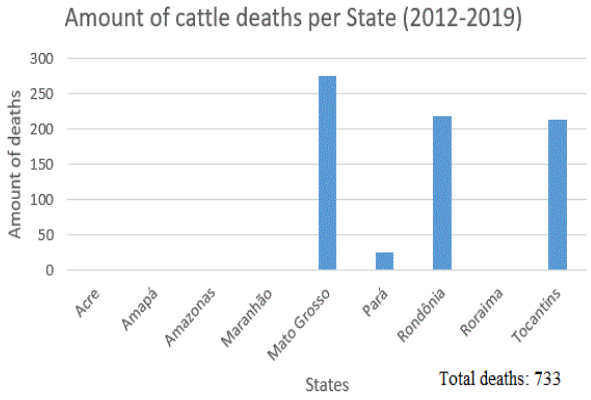

Fig 9. Amount of cattle deaths per State in the period 2012-2019.

According to Fig. 8, Rondônia was the state with more accidents to cattle due to lightning. Mato Grosso was the second in number of accidents, followed by Tocantins and Pará. On the other hand, the state with the highest number of cattle deaths was Mato Grosso, according to Fig. 9.

In order to investigate better the reason for those states had more accidents than the other states, we checked the number of cattle heads per state (see Fig. 4). In addition, we calculated the cattle density per state as shown in Fig. 10.

The State with the most cattle head is Mato Grosso, followed by Pará and Rondônia. However, after calculating the cattle density per state, we noticed that Rondônia is the state with the highest cattle density, followed by Mato Grosso and Tocantins.

Both the number of cattle per state or cattle density per state are related to the number of cattle deaths due to lightning.

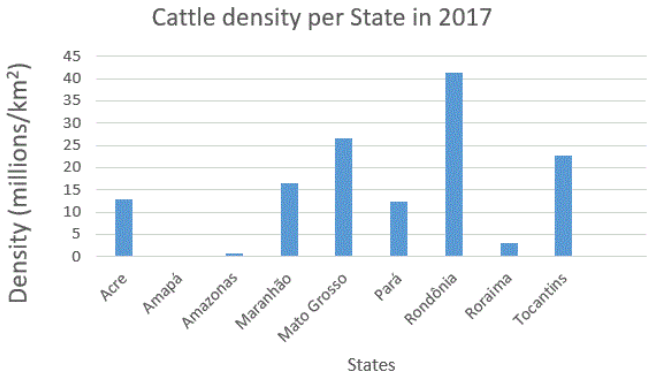

Fig. 10. Cattle density per State in 2017. Adapted from [13].

In order to complement the analysis, the average (2013-2017) of lightning density per state is shown in Fig. 11.

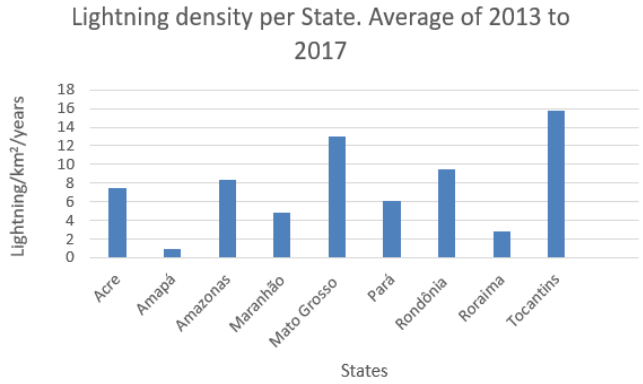

Fig. 11. Lightning density per State. Average of 2013 to 2017, according to STARNET reprocessed data.

According to Fig. 11, the state with the highest lightning density in the period of 2013-2017 was Tocantins, followed by Mato Grosso and Rondônia. These 3 states have a large amount of cattle heads, that consequently can be struck by lightning.

Although Rondônia has the highest number of accidents and the highest density of cattle, it was Mato Grosso the state with the highest number of cattle deaths. Perhaps, because it has the highest number of cattle heads.

The peaks of lightning density, cattle density and cattle deaths in Figures 9, 10 and 11 are all related to states of Mato Grosso, Rondônia and Tocantins. These states of Brazil are the ones where cattle fatalities due to lightning are more likely to occur.

Lightning fatalities related to human beings usually report a low number of deaths [11]. On the other hand, when lightning hits a tree or fence in a farm, many cattle can be killed in a single accident.

The total loss in the period 2012-2019 was approximately R$ 1,333,900.00 (337,081.77 dollars currently), with an annual average of R$ 166,737.50 (42,105.42 dollars currently). Hence, farmers need to be aware of mechanisms to protect these animals during thunderstorms.

Lightning is an unpredictable natural phenomenon so that actions should be taken to minimize the occurrence of cattle deaths. Lectures and events should be carried out by the cities and agencies in order to make farmers aware of the danger of lightning accidents, and explain how they can protect their livestock farms. An example of a lightning protection system and methodology to deal with cattle during thunderstorms is presented and discussed in [17]. Banks could also launch insurance for livestock deaths.

V. Case Study

Among the 20 cases cataloged in this work, the one with the highest number of cattle deaths occurred in the city of Cacoal-Rondônia, on March 15, 2018. In this accident occurred 103 cattle deaths, the animals were close to a tree. Possibly, the lightning struck the tree and the current dissipated in the ground and killed the cattle. The estimated losses for this event was about R$ 191,766.00.

Figure 12 shows the fatality that occurred in Cacoal, most probably the lightning struck the top trees and the current flowed on the ground and killed the cattle heads.

Fig. 12. Cattle fatality in Cacoal, Rondonia, Brazil. [Appedix, 7].

The fatality occurred in March 2018. According to statistics of lightning density for the city of Cacoal for this same year, the month with the highest lightning density was September, followed by October and March (see Fig. 13).

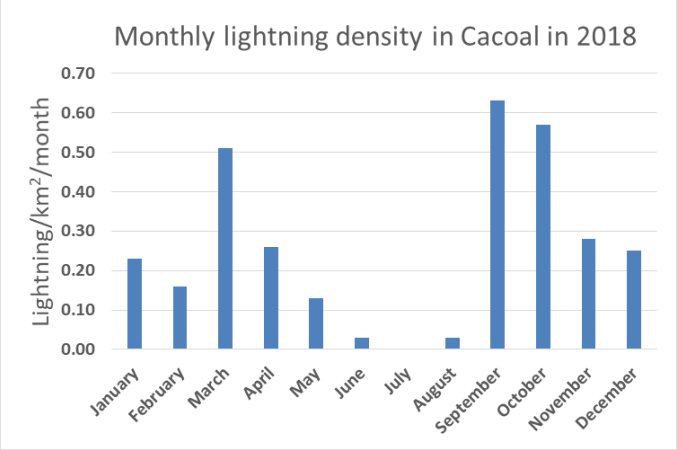

Fig. 13. Lightning density per month in Cacoal in 2018, according to STARNET data.

VI. Conclusion

In this paper, we analyzed cattle deaths caused by lightning in the legal Amazon region of Brazil. We analyzed a period of 6 years (2012-2019) and we catalog 20 accidents, in which 733 cattle were killed by lightning. We showed a strong relationship between the fatalities and lightning density and cattle density per state. The 3 states (Mato Grosso, Rondônia, and Tocantins) with the highest number of cattle deaths, were also the states with the highest lightning density (average of 2013-2017 according to STARNET reprocessed data) and highest cattle density. We estimated annual monetary losses of about R$ 166,737.50 (U$ 42,105.42 currently). However, possibly many accidents were not reported and consequently could not be found on the internet, so that this number can be higher. Future research is needed in the region in order to disseminate knowledge about the subject, reduce the occurrence of fatalities, and preserve animal life.

Appendix

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6. G1. (2012, Jan. 31). Vinte e duas vacas morrem atingidas por raio no interior do Mato Grosso [Online]. Available: http://g1.globo.com/mato-grosso/noticia/2012/01/vinte-e-duas-vacas-morrem-atingidas-por-raio-no-interior-de-mato-grosso.html

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