



Epidemiological aspects of natural poisoning by *Prosopis juliflora* in ruminants in semiarid areas of the state of Bahia, Brazil, invaded by the plant¹

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ABSTRACT.- Mendonça M.F.F., Pedroso P.M.O., Pimentel L.A., Madureira K.M., Macêdo J.T.S.A., D'Soares C.S., Silva A.W.O. & Peixoto T.C. 2020. **Epidemiological aspects of natural poisoning by *Prosopis juliflora* in ruminants in semiarid areas of the state of Bahia, Brazil, invaded by the plant.** *Pesquisa Veterinária Brasileira* 40(7):501-513. Laboratório de Patologia Veterinária, Escola de Medicina Veterinária e Zootecnia, Universidade Federal da Bahia, Av. Adhemar de Barros 500, Salvador, BA 40170-110, Brazil. E-mail: tcpeixoto@ufba.br

Poisoning by *Prosopis juliflora* (mesquite) leads to neurological signs, cachexia and death, mainly in cattle and goats. Although the uncontrolled spread of mesquite in the Caatinga biome (biological invasion), which alters the epidemiological conditions of intoxication by this plant, has been proved for approximately 20 years, strategies for its control and prophylaxis still remain out of date. These new epidemiological conditions have allowed the uncontrolled consumption of large amounts of *in natura* mesquite pods by ruminants for long periods in invaded pastures, thus resulting in increased history of poisoning. This study aimed to describe the new epidemiological aspects of *P. juliflora* poisoning in cattle and goats, 78 years after the introduction of this plant in the country, with emphasis on its degree of invasion, and to update the control and prophylaxis measures of this intoxication and the mapping of areas of outbreak occurrence in the semiarid region of the state of Bahia, Brazil. Seven outbreaks of natural mesquite poisoning, two in goats (OB 1 and OB 2) and five in cattle (OB 3, OB 4, OB 5, OB 6, and OB 7), were studied *in loco* in the municipalities of Juazeiro, Iaçú, Tucano, Santa Teresinha, Barra do Mendes, Barra and Tabocas do Brejo Velho. In the studied outbreaks, clinical-epidemiological (OB 1 to OB 7) and histopathological (OB 1, OB 2, OB 3, and OB 5) findings were compatible with mesquite poisoning, and this was the first anatomopathological proof of poisoning by this plant in this state. In addition, in the state of Bahia, disease occurs in an area approximately three times larger than previously known. On the farms investigated, mesquite introduction occurred between 1980 and 2005, through the single planting of an average of 33 seedlings. Since then, propagation of this plant has occurred progressively, with gradual invasion of native pastures, which enabled the evaluation of plant spread (biological invasion) on these farms 15 (OB 2), 25 (OB 7), 30 (OB 5 and OB 6), 35 (OB 3) and 40 (OB 1 and OB 4) years after its introduction. Historical information on the introduction and spread of mesquite in the state of Bahia had never been analyzed. In 2020, a degree of mesquite invasion an average 59.57% was verified in the pastures of

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the seven farms where the outbreaks occurred. The great biological invasion capacity of this plant drew attention, especially in OB 5. The high degree of mesquite invasion observed (new epidemiological conditions) justifies the increased number of cases of poisoning observed in this study. Processing of *P. juliflora* pods (grinding) was not carried out on any farm (OB 1 to OB 7), and ruminants uncontrollably consumed large amounts of pods *in natura* for long periods in invaded pastures, which allowed massive dispersal of seeds through feces over decades. The main factors responsible for the gradual invasion of pastures by mesquite over time were absence of crop management plans (silvicultural treatments) and lack of knowledge by producers on disease etiology. Given the new epidemiological conditions, restriction of animal access to *in natura* pods in pastures and supply of mesquite bran are crucial for the control and prophylaxis of this poisoning, as consumption of *in natura* pods had a strong correlation with the high degree of invasion in the pastures where the seven outbreaks occurred. Additionally, although the commercialization of pods and exploitation of wood of mesquite trees can provide livestock farmers with extra income – being the correct management for areas invaded by this plant, such practice is either not yet known or not carried out technically or satisfactorily by farmers. In addition to being a threat to the Caatinga's biodiversity, the increasing invasion of semiarid areas by mesquite 78 years after its introduction in the Northeast region of Brazil, is a risk for herds, since the occurrence of poisoning outbreaks may become more frequent. Therefore, it is highly advisable that effective measures be adopted to control *P. juliflora* propagation.

INDEX TERMS: Epidemiology, natural poisoning, *Prosopis juliflora*, ruminants, state of Bahia, Brazil, neurotoxic plant, invasive plant, Caatinga biome regeneration, mesquite beans, neuronal degeneration.

RESUMO.- [Aspectos epidemiológicos da intoxicação natural por *Prosopis juliflora* em ruminantes em áreas do semiárido baiano invadidas pela planta.]

A intoxicação por *Prosopis juliflora* (algaroba) cursa com sinais neurológicos, caquexia e morte, principalmente em bovinos e caprinos. Embora a disseminação descontrolada da algaroba na Caatinga (invasão biológica) tenha sido comprovada há cerca de 20 anos, o que altera as condições epidemiológicas dessa intoxicação, as estratégias de controle e profilaxia permanecem desatualizadas. Essas novas condições epidemiológicas permitem o consumo descontrolado de grande quantidade de vagens *in natura* de algaroba, por longos períodos, nas pastagens invadidas, o que tem resultado em aumento dos históricos de intoxicação. Objetivou-se com esse estudo descrever os novos aspectos epidemiológicos da intoxicação por *P. juliflora* em bovinos e caprinos, 78 anos após a introdução da planta no país, com ênfase no grau de invasão da planta, bem como atualizar as medidas de controle e profilaxia dessa intoxicação e das áreas de ocorrência dos surtos no semiárido baiano. Foram estudados *in loco* sete surtos (S1 a S7) de intoxicação natural por algaroba, sendo dois em caprinos (S1 e S2) e cinco em bovinos (S3, S4, S5, S6 e S7) no semiárido baiano (Juazeiro, Iaçú, Tucano, Santa Teresinha, Barra do Mendes, Barra e Tabocas do Brejo Velho). Nos surtos estudados, os achados clínico-epidemiológicos (S1 a S7) e histopatológicos (S1, S2, S3 e S5) foram compatíveis com intoxicação por algaroba, sendo essa intoxicação comprovada, pela primeira vez, com exames anatomopatológicos na Bahia. Ademais, na Bahia a doença ocorre em uma área cerca de três vezes maior do que a, até então, conhecida. Nas fazendas estudadas a introdução da algaroba ocorreu entre 1980 e 2005, através do plantio único de, em média, 33 mudas. Desde então, a disseminação da planta ocorreu de forma progressiva, invadindo gradativamente as pastagens nativas, o que permitiu avaliar a disseminação da planta (invasão biológica) nessas fazendas cerca de 15 (S2), 25 (S7), 30 (S5 e S6), 35 (S3) e 40 (S1 e S4) anos, após sua introdução. Informações históricas acerca da introdução da algaroba e sua disseminação na Bahia nunca haviam sido estudadas. Em 2020, verificou-se que nas

pastagens das sete fazendas onde os surtos ocorreram, o grau de invasão por algaroba alcançou, em média, 59,57%. Chamou a atenção a grande capacidade de invasão biológica da planta, sobretudo, no S5. O alto grau de invasão da algaroba observado (novas condições epidemiológicas) justificou o aumento dos casos de intoxicação verificados nesse estudo. O beneficiamento das vagens (moagem) não era realizado em nenhuma fazenda (S1 a S7) e os ruminantes consumiam de forma descontrolada (livre) grande quantidade de vagens *in natura*, por longos períodos, nas pastagens invadidas, o que possibilitou a dispersão massiva das sementes da planta pelas fezes ao longo das décadas. O que aliado à inexistência de um plano de manejo do cultivo (tratamentos silviculturais) e ao desconhecimento da etiologia da doença pelos produtores foram os principais fatores responsáveis pela invasão gradativa da planta nas pastagens, ao longo dos anos, o que justifica o aumento dos casos de intoxicação observados na Bahia. Frente às novas condições epidemiológicas, a restrição do acesso dos animais às vagens *in natura* nas pastagens e o fornecimento do farelo de algaroba são cruciais para o controle e profilaxia dessa intoxicação, pois o consumo das vagens *in natura* teve forte correlação com o alto grau de invasão das pastagens onde os sete surtos ocorreram. Adicionalmente, embora a comercialização das vagens e a exploração da madeira da algaroba possam proporcionar renda extra aos pecuaristas e serem boas formas de manejo de áreas invadidas por algaroba, tais práticas ainda não são conhecidas ou não são realizadas de forma técnica ou a contento. A crescente invasão da algaroba no semiárido, 78 anos após a sua introdução no Nordeste, além de ser uma ameaça à biodiversidade da Caatinga é um risco para os rebanhos, visto que, a ocorrência de surtos de intoxicação podem se tornar mais frequentes. Desta maneira alerta-se para adoção de medidas efetivas de controle da propagação descontrolada da algaroba.

TERMOS DE INDEXAÇÃO: Epidemiologia, intoxicação natural, *Prosopis juliflora*, ruminantes, Bahia, Brasil, planta neurotóxica, planta invasora, regeneração da Caatinga, algaroba, degeneração neuronal.

INTRODUCTION

Poisoning by plants results in significant economic loss in national livestock due, in part, to the large number of herds raised in native pastures or under extensive or semi-extensive management (Riet-Correa & Medeiros 2001, Tokarnia et al. 2012, Pessoa et al. 2013). A study showed that the highest number of deaths of animals poisoned by plants occurs in the North, Northeast and Center-West regions of Brazil (Riet-Correa & Medeiros 2001); however, there is still a lack of information on some of these poisoning occurrences in the state of Bahia. In this context, *Prosopis juliflora* poisoning stands out, presenting neurological signs, cachexia and death, mainly in cattle (Figueiredo 1993, Dantas & Menezes 1994, Silva et al. 2006, Câmara et al. 2009, Galiza et al. 2010) and goats (Lima et al. 2004, Lemos et al. 2016) and, to a lesser extent, in sheep (Almeida et al. 2017), associated with neurological injuries, especially in the trigeminal nerve motor nucleus (Lima et al. 2004).

P. juliflora is a xerophilic plant of the Fabaceae family, subfamily Mimosoideae, popularly known as mesquite (Ribaski et al. 2009). It is native to Mexico, Central America and northern South America (Peru, Ecuador, Colombia, and Venezuela) and has been used as food by humans since prehistory. In the 1940s, *P. juliflora* was introduced in northeastern Brazil - in the municipalities of Serra Talhada (PE, 1942), Angicos (RN, 1946) and Seridó (RN and PB, 1948) - through the planting seeds from Peru and Sudan as a technological alternative to cope with drought (Azevedo 1961, SPA 1989). It aimed to provide palatable forage with high nutritional value and low cost for animal feed (SPA 1989) and be used as firewood and in the production of stakes and charcoal. In addition, it was believed that its cultivation would promote regional development because of its adaptation to high temperatures and poor soils, high productivity, resistance to drought, multiple uses of its wood, source of food for herds and resource for beekeeping, as well as a solution for reforestation (Cunha & Silva 2012).

In 1951, the Brazilian Ministry of Agriculture began to supply technicians, rural producers, and city halls in the state of Rio Grande do Norte with mesquite seeds. In the following years, the plant spread to other northeastern states (Azevedo 1961, SPA 1989). By 1979, mesquite planting in the region occurred in an estimated area of more than 90,000 ha, encouraged by public institutions such as the Brazilian Institute for Forestry Development (IBDF) (Reis 1985, SPA 1989). In this context, the only program that supported the development of semiarid areas in the Brazilian Northeast region ("Project Sertanejo") deserves special mention. This project financed the planting mesquite in properties ranging from 20 to 500 ha as part of a strategy to strengthen agricultural production units (Cunha & Silva 2012). At that time, *P. juliflora* was already considered the most successful xerophilous plant introduced in the semiarid region (SPA 1989), and the Brazilian Agricultural Research Corporation (Embrapa), through its unit responsible for the semiarid region - Embrapa Semiarid Agriculture, introduced mesquite specimens from Argentina, Chile, Peru, Mexico, the United States, Honduras, Pakistan, Cape Verde and Senegal in order to genetically improve the mesquite trees in the Northeast region (Lima 1999).

In the 1990s, the area covered by mesquite, planted or of natural expansion, in the northeast semi-arid region was estimated in over 500,000 ha (Tabosa et al. 2004), with higher

concentration in the states of Paraíba, Pernambuco and Rio Grande Norte, especially, in areas with greater anthropic activities, close to dams, streams and highways. These axes are located along the semiarid hinterland depression, in wilderness areas, along the São Francisco River, around the Araripe plateau, and along the coast of Ceará state (Lima 2005). Since then, mesquite spread has occurred in the different agroecological areas of the Northeast region, with millions of scattered specimens with no precise estimate on planted or regenerated areas (Lima 1999). Cunha and Silva (2012) emphasized the inexistence of an economic analysis of the contribution of mesquite to the semiarid economy and affirmed that, for over 60 years, the coexistence of individuals and groups with this species has been marked by enthusiasm, controversy, and criticism.

Although *P. juliflora* was also introduced in the state of Bahia decades ago, there was no historical information on its expansion. Only in 2005, the study conducted by Lima and collaborators, with the support of Embrapa Semiarid Agriculture, followed the expansion process of this plant in the region of the municipality of Juazeiro, state of Bahia, through the analysis of satellite images, and precisely confirmed the evolution of its biological invasion in the Caatinga biome. This study found that mesquite shows exceptional spontaneous regeneration, with a gradual annual increase in its coverage area. In 10 years, the areas invaded by mesquite increased from 19.93 ha in 1986 to 33.03 ha in 1996 (increase of 65.68%), and the area regenerated with the plant showed an increase of 37.85% in two study locations. This difference was attributed to the existence of water in the site. All areas of invasion studied in the Northeast region were located close to watercourses (riverbanks or alluvial areas) (Lima 2005).

Due to the natural advance of *P. juliflora* in the Caatinga biome, a series of plant structure analyses were carried out in invaded areas to measure the frequency, abundance, dominance and regeneration of the plant in some areas of the Northeast region. In the state of Bahia, phytosociological surveys of areas invaded by mesquite were conducted in Juazeiro (Lima et al. 2003, Barbosa & Lima 2005) and in the riparian forest of Rio de Contas in Manoel Vitorino (Lima & Kiill 2003). Among the trees and/or shrubs studied, *P. juliflora* was the most frequent found in Juazeiro and Manoel Vitorino (95-100% and 88%, respectively), with higher abundance in Serra Branca (654 ind./ha), followed by Salitre (575 ind./ha), Massaroca (440 ind./ha), Manoel Vitorino (370 ind./ha), and Juremal (313 ind./ha). As for regeneration, mesquite presented 1,255 ind./ha, which corresponded to 60.8% of the seedlings regenerated in Manoel Vitorino, and in the two location of the study conducted in Juazeiro, it corresponded to 47.3 and 78.53%, respectively (Lima et al. 2003, Barbosa & Lima, 2005).

Similar findings were reported in areas of native vegetation invaded by the plant in the municipalities of Taperoá (Marques et al. 2003) and Monteiro in the state of Paraíba (Marques et al. 2004) and of Santa Maria da Boa Vista (Lima et al. 2004a), Igaraci (Lima et al. 2004b) and Inajá (Lima et al. 2004c) in the state of Pernambuco. In this series of studies, there were a large number of mesquite plants in relation to that of native species, confirming the excessive proliferation of the exotic species (biological invasion). This excess alerts to the need to identify the agents that facilitate the plant

propagation in order to control its invasion in the Caatinga biome (Lima et al. 2003, Lima & Kiill 2003, Marques et al. 2003, Lima et al. 2004a, 2004b, 2004c, Marques et al. 2004, Barbosa & Lima 2005, Lima 2005). However, the possibility of increased frequency of mesquite poisoning outbreaks in ruminants under these new epidemiological conditions (biological invasion) has not been considered or discussed. In 2009, the impacts caused by the mesquite invasion on the phytodiversity and the shrub-tree component structure of the Caatinga in the state of Rio Grande do Norte were studied, showing that the plant threatens the native biodiversity of this biome (Andrade et al. 2009).

Prosopis juliflora has been highlighted in international debates on the ecological impact of invasive species (Gallaher & Merlin 2010, Tessema 2012, Pegado et al. 2006, Perera et al. 2005). Biological invasion is the process of occupying a space where the invasive plant does not originate (outside its geographic distribution) in a disorderly manner, with subsequent alteration in the structure of native biological communities and/or in the functionality of ecosystems (ecological imbalance) (Pegado et al. 2006). The management of these species was defined as one of the millennium goals, as they are identified as one of the leading causes of the loss of biodiversity worldwide (Tessema 2012).

Approximately 80 years after its introduction in Brazil, thousands of *P. juliflora* specimens are spread across all agroecological zones in the Northeast region. The expansion of mesquite as an invasive species has been associated with absence of natural enemies, high resistance to drought and salinity (Lima 2005) and seed dormancy in soil for up to 10 years, as well as with massive production of seeds and their efficient dispersion (GISP 2005). Additionally, it has been proposed that the uncontrolled and massive seed dispersal through the feces of extensively created cattle, goats, and mules (Souza et al. 1999) is the main factor associated with the process of mesquite invasion in northeastern semiarid areas (GISP 2005). In addition, the eco-sociological characteristics of the Northeast region and the lack of forestry tradition resulted in neglected plant management and, consequently, in the invasion of extensive areas of Caatinga (Andrade 2013).

Another current problem is the unregulated exploitation of mesquite wood, one of the effects of its invasive plant status. There is no regulation and control of the cutting and marketing of wood in the northeastern semiarid region, with wood used in industrial ovens (bakery and pottery) and in charcoal production (Cunha & Silva 2012). Thus, the trajectory of mesquite in the northeastern semiarid region was marked by two phases: expansion (stimulated by public financing) and, recently, by disordered exploitation (use of pods and wood).

These new epidemiological conditions resulting from the biological invasion of mesquite in the semiarid region in many regions of the state of Bahia provide ruminants with free access to plant pods and their uncontrolled consumption in pastures for long periods, which has resulted in an increased history of intoxication. However, the real economic importance of this poisoning in regions invaded by the plant and the adoption of possible alternatives for the control and prophylaxis of this poisoning are currently not discussed.

Outbreaks of natural poisoning by *P. juliflora* have already been described in ruminants in several states in the

Northeast region: in cattle, in Paraíba, Rio Grande do Norte and Pernambuco (Figueiredo 1993, Dantas & Menezes 1994, Silva et al. 2006, Câmara et al. 2009, Galiza et al. 2010); in goats, in Paraíba (Lima et al. 2004) and Pernambuco (Lemos et al. 2016); and, recently, in sheep, in Pernambuco (Almeida et al. 2017). However, no cases of poisoning by *P. juliflora* in the state of Bahia have been reported in the literature. It is likely that this intoxication, even requiring special conditions (ingestion of a large amounts of pods, that is, more than 50% of the diet, for prolonged periods) (Tokarnia et al. 2012), has been underdiagnosed and/or mistaken for other neurological and cachectic diseases in this state. This study aimed to describe the new epidemiological aspects of *P. juliflora* poisoning in cattle and goats, 78 years after the introduction of this plant in the country, with emphasis on its degree of invasion, and to update the control and prophylaxis measures of this intoxication and the mapping areas of outbreak occurrence in the semiarid region of the state of Bahia, Brazil.

MATERIALS AND METHODS

Seven outbreaks (OB 1 to OB 7) of spontaneous poisoning by *Prosopis juliflora* in goats and cattle in different municipalities of the state of Bahia were studied *in loco*. Data on disease epidemiology over decades, in particular, on the introduction and propagation (biological invasion) of the plant, the use of its wood and pods, and the history and clinical signs of poisoning were obtained from farm owners and/or veterinarians during visits.

In January 2020, the areas in hectares (ha) invaded by mesquite (areas where the plant was not planted) were estimated on each farm based on their respective total pasture areas. This estimate was made visually by the same appraiser based on the observation of predominance of regenerated trees and seedlings (germinated seeds, existence of seedlings, and regrowth of previously explored stumps or roots) of mesquite (exotic species) over native plants. According to Lima (2005), this indicates environmental imbalance. Such data enabled estimation of the current degree of plant invasion (%) on the farms (uncontrolled dissemination) in different periods after its introduction (15 to 40 years), through the single planting of seedlings, as well as verification of possible correlations between biological invasion and 1) outbreaks of poisoning in cattle and goats, 2) access to pods (free or controlled); 3) use of pods (fresh or ground), and 4) management of trees (thinning and use of wood in cuttings, posts, or production of firewood and/or charcoal) aiming at updating the control and prophylaxis measures of poisoning in the face of new epidemiological conditions.

Necropsies and histopathological evaluations of OB 1 and OB 3 were performed by the "Setor de Patologia Veterinária" of the "Universidade Federal do Recôncavo da Bahia" (SPV-UFRB), whereas those of OB 2 and OB 5 were conducted by the "Laboratório de Patologia Veterinária" of the "Universidade Federal da Bahia" (LPV-UFBA). At necropsy of the animals during OB 1, OB 2, OB 3 and OB 5, fragments of the central nervous system, masseter and biceps femoris muscles, and abdominal and thoracic organs were collected. This material was fixed in 10% buffered formaldehyde, processed routinely for histopathology, and stained with hematoxylin-eosin (HE).

RESULTS

Epidemiology. Outbreak one (OB 1) occurred in the municipality of Juazeiro (360 m asl; 9°24'42" S; 40°29'55" W) in 2011 and outbreak two (OB 2) occurred in Iaçú (242

m asl; 12°46'02" S; 40°12'42" W) in 2015, both affecting only goats. In outbreaks three (OB 3), four (OB 4) five (OB 5), six (OB 6), and seven (OB 7), only cattle were poisoned. OB 3 occurred in Tucano (209 m asl; 10°57'47" S; 38°47'12" W) in 2014, OB 4 in Santa Terezinha (227 m asl; 12°46'19" S; 39°31'24" W) in 2016, OB 5 in Barra do Mendes (700 m asl; 11°38'27" S; 42°00'39" W) in 2019, OB 6 in Barra (406 m asl; 11°05'20" S; 43°08'31" W) in 2017, and OB 7 in Tabocas do Brejo Velho (541 m asl; 12°42'21" S; 44°00'25" W) in 2018. All outbreaks occurred in regions of semiarid climate, with high temperatures, and scarce and poorly distributed rainfall. In the seven outbreaks studied, the etiology of the disease was unknown to the producers. The main epidemiological data on the seven outbreaks of natural mesquite poisoning in the state of Bahia are summarized in Table 1.

Outbreaks in goats. OB 1 occurred on a farm with an area of 61.8 ha. According to the farm's mesquite was introduced in this property in 1980, through the single planting of 40 seedlings. During the technical visit, it was found that the property currently has thousands of mesquite specimens, with approximately 38.6 ha of invaded native vegetation (uncontrolled natural spread). The herd assessed consisted of 150 goats and 50 sheep under semi-extensive rearing, with feed and common salt in troughs, two to three times a week. According to the farm owner, from 2006 to 2010, 22 goats kept in areas heavily invaded by mesquite showed a similar clinical condition, with evolution of six months until death. During a technical visit in May 2011, two 2.5-year-old SRD goats with clinical signs compatible with mesquite poisoning were observed in the herd. Due to the unfavorable prognosis, the farm owner opted for euthanasia and necropsy aiming diagnosis.

OB 2 occurred on a goat farm with an area of 300 ha, where mesquite was introduced through the single planting of 30 seedlings in 2005. During the inspection of pastures, there were hundreds of *Prosopis juliflora* adult trees with many pods in the pastures, lowland, and close to the shed where the animals were kept, with approximately 50 ha invaded by the plant. The herd consisted of 20 Boer goats under semi-extensive management. The pastures were formed by Buffel grass (*Cenchrus ciliaris*) and native pasture with mineral salt was provided in troughs. According to the property owner, in October 2014, four goats with mean age of 4.5 years presented a similar clinical condition, and two of them died five months after onset of clinical signs. In February 2015, the other two goats were sent to the "Centro de Desenvolvimento da Pecuária" (CDP) at UFBA, where they remained hospitalized for ten days with clinical signs compatible with mesquite poisoning. Due to the unfavorable prognosis, both animals were euthanized and necropsied for diagnostic confirmation.

Outbreaks in cattle. OB 3 occurred on a 55-ha property, in which the plant was introduced in 1985, through the single planting of 50 seedlings. There was approximately 30 ha of native vegetation heavily invaded by thousands of mesquite trees during the technical visit. The herd consisted of 30 cattle, 15 buffaloes, and 70 sheep raised under extensive system on native pastures and mineralized salt in troughs. According to the farm owner, three Girolando cows aged >10 years showed chronic clinical signs (six months). The first case occurred in 2007 and the other two were clinically evaluated during technical visits in July and September 2014.

Table 1. Epidemiological data on outbreaks of natural poisoning by *Prosopis juliflora* in ruminants in the state of Bahia

Outbreak (OB)	Affected species and time of outbreaks	Municipality and management system	Introduction of the plant		Farm area (ha)			Plant management ^e			Intoxicated animals		
			Planting year and time elapsed until 2020	Number of seedlings planted	Total	Invaded by mesquite in 2020	Degree of invasion	Thinning and use of wood ^b	Storage, trough supply and marketing of pods	Herd size	Total cases ^c	Average age (years) and sex ^d	Mortality ^e
1	Goats (G) 2006-2011	Juazeiro Semi-extensive	1980 40 years	40	61.8	38.6	62.45%	No	No	150	24 ^e	2.5 F	16%
2	Goats 2015	Iaçú Semi-extensive	2005 15 years	30	300	50	16.66%	No	No	20	4 ^e	4.5 F	20%
3	Cattle (C) 2014	Tucano Extensive	1985 35 years	50	55	30	54.54%	Yes	Yes	30	3 ^e	>10 F	10%
4	Cattle 2006-2016	Santa Terezinha Semi-extensive	1982 38 years	60	390	310	79.48%	Yes	Yes	110	21	8 F	19%
5	Cattle 2016-2019	Barra do Mendes Extensive	1989 31 years	4	280	266	95%	Yes	No	20	7 ^f	>4 F and M	35%
6	Cattle 2018	Barra Extensive	1990 30 years	30	50	20	40%	No	No	40	12	10 F	30%
7	Cattle 2018-2019	Tabocas Extensive	1995 25 years	20	266	170	63.90%	No	No	50	10	>7 F	20%
Average	-	-	29.85 years	33	200.5	126.37	59.57%	-	-	60	12 (G) 10.6 (C)	3.5 years (G) >7.8 years (C)	18% (G) 22.8% (C)

^a On the seven farms, ruminants had free access to areas intensely invaded (without fences) by mesquite with uncontrolled consumption of large amounts of fresh pods in pastures for long periods; ^b Use of wood from the pruning of mesquite trees in the property (stakes, posts, fences, or production of firewood and/or charcoal) or its commercialization; ^c The period of time considered varied in each outbreak according to the history of the poisoning occurrence; ^d F = female, M = male; ^e Two animals were euthanized; ^f One bovine was euthanized.

On these occasions, clinical signs compatible with mesquite poisoning were observed, and the two cows were euthanized and necropsied for diagnostic clarification.

OB 4 occurred on a 390-ha farm where *P. juliflora* was introduced through the single planting of 40 seedlings in 1982. During the technical visit, it was observed that approximately 310 ha had been slowly invaded by thousands of trees, forming a real “mesquite forest”. The herd consisted of 110 cattle with varied age range. The animals were raised semi-extensively on native pasture and fed forage palm (*Opuntia cochenillifera*) and mineral salt in troughs. According to the property owner, from 2006 to 2016, 20 cattle showed a similar clinical condition, followed by death approximately six months after the onset of signs. In August 2016, during the technical visit, an 8-year-old SRD cow with the disease was examined, and a clinical condition compatible with mesquite poisoning was verified. One month after the visit, the animal died, but the owner did not authorize the necropsy.

OB 5 occurred on a 280-ha farm. In this property, mesquite was introduced through the planting of only four seedlings in 1989. The herd consisted of 20 SRD cattle of varying age, raised extensively on pasture formed almost exclusively by mesquite trees (thousands) - the plant had heavily invaded an area of approximately 266 ha. According to the farm owner, from 2016 to 2018, six cattle (both male and female) had a similar chronic clinical condition for six months, followed by death. In January 2019, a 4-year-old male bovine presenting clinical signs of the disease was examined during the technical visit. Due to the unfavorable prognosis, the property owner opted for euthanasia followed by necropsy for diagnostic confirmation.

OB 6 occurred on a 50-ha property where *P. juliflora* was introduced through the single planting of 30 seedlings in 1990. On this farm, 40 cattle (Nelore and mestizo) were raised extensively on native pastures, some of them intensely invaded by mesquite (approximately 20 ha) and fed mineral salt in troughs. During the technical visit of January 2019, the farm owner reported that 12 cows with mean age of 10 years died after presenting a similar clinical condition for five months in 2018. The epidemiological conditions observed at the site, associated with the history and reported clinical signs, were compatible with intoxication by mesquite.

OB 7 occurred on a 266-ha farm where the plant was introduced through the single planting of 20 seedlings in 1995. In this property, the herd consisted of 50 Nelore and SRD cattle raised extensively on native pastures with common salt offered in troughs. Mesquite had invaded approximately 170 ha of the property. According to the owner, in 12 months (from 2018 to 2019), ten cows aged >7 years presented a similar clinical condition and died in June 2019, six months after the onset of signs. The epidemiological conditions observed *in loco*, associated with the history and reported clinical condition, were compatible with mesquite poisoning.

Mapping. In this study, outbreaks of natural poisoning by *P. juliflora* were mapped in four mesoregions of the state of Bahia: São Francisco Valley (OB 1 and OB 6), North-central (O2, O4 and O5), Northeast (O3) and Far West (O7), which included seven microregions of the state [Juazeiro (OB 1), Itaberaba (OB 2), Euclides da Cunha (OB 3), Feira de Santana (OB 4), Irecê (OB 5), Barra (OB 6) and Cotegipe (OB 7)] (Fig.1).

Introduction and propagation of the plant. On the seven farms where the outbreaks occurred, mesquite introduction occurred through the single planting of an average of 33 seedlings (minimum of four and maximum of 60) from 1980 to 2005 [1980 (OB 1), 1982 (OB 4), 1985 (OB 3), 1989 (OB 5), 1990 (OB 6), 1995 (OB 7) and 2005 (OB 2)]. The single planting of mesquite seedlings enabled evaluation the plant spread (biological invasion) on these farms approximately 15 (OB 2), 25 (OB 7), 30 (OB 5 and OB 6), 35 (OB 3) and 40 (OB 1 and OB 4) years after its introduction. Planting was carried out on the farmers’ initiative. Since then, no seedlings have been planted on the farms, and the spread has occurred naturally and progressively, gradually invading native pastures. In 2020, the degree of mesquite invasion in pastures where the seven outbreaks occurred was, on average, 59.57%, with a range of 40 to 95% between the seven properties studied (Table 1). There was also an absence of herbaceous species in the community’s lower strata in most invaded pastures (Fig.2).

Clinical signs and pathology (outbreaks 1 to 7). Clinically, the alteration that most drew the attention of producers was the classic lateral tilting of the head (“twisted face”) (Figs. 3 and 4), as this can be easily observed by inspecting the herd at a distance. Loss of facial sensation, protrusion and decreased lingual tone, dysphagia, and head tremors were also observed.

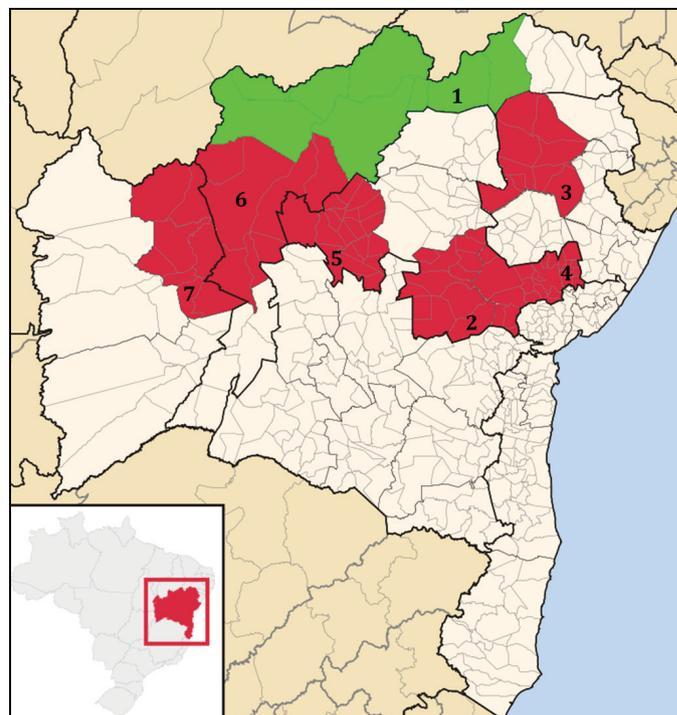


Fig.1. Update of the geographic distribution of *Prosopis juliflora* in the state of Bahia, Northeast region of Brazil (microregions in which the plant presents livestock importance in the semiarid areas of the state). Numbers 1 to 7 correspond to the municipalities where the outbreaks occurred: Juazeiro (1), Iaçú (2), Tucano (3), Santa Terezinha (4), Barra do Mendes (5), Barra (6), and Tabocas do Brejo Velho (7). The six microregions highlighted in red (Itaberaba, Euclides da Cunha, Feira de Santana, Irecê, Barra, and Cotegipe) were mapped in this study. The microregion highlighted in green (Juazeiro), where OB 1 occurred, was the only previously mapped (known) area in the state of Bahia.

In addition, cachexia was commonly observed - poisoned animals showed marked weight loss, with up to 50% reduction in body weight (chronic, lethal and cachectic condition). The other animals in the herd, raised under the same conditions, showed no poisoning, and exhibited adequate nutritional status. It was also found that, in general, the mandible becomes pendulous, which can be better evidenced during the manual movement of the head and when walking. This alteration is responsible for the popular denomination "dropped jaw", attributed to mesquite poisoning in the studied semiarid region of the state of Bahia.



Fig.2. *Prosopis juliflora* wood on the farm where the OB 4 occurred. Santa Terezinha/BA. Note the absence of herbaceous species in the lower stratum of the community and the free access of cattle to areas with large amounts of mesquite.



Fig.3. Natural poisoning by *Prosopis juliflora* in cattle. Note the cachexia and lateral deviation of the head ("twisted face") during chewing. OB 3. Tucano/BA.

At necropsy, there was, in particular, marked atrophy and pallor of the masseter muscles, and a large number of recognizable fragments of mesquite pods and seeds were observed amid the dry contents of the rumen and reticulum (Fig.5 and 6), which confirmed the ingestion of the plant. Histopathological evaluation showed degeneration (vacuolization) of neurons in the trigeminal nerve (Fig.7), which enabled diagnostic confirmation.

DISCUSSION

The diagnosis of the seven outbreaks of natural poisoning by *Prosopis juliflora* in cattle and goats in the semiarid region of the state of Bahia was established by the association of the history of uncontrolled consumption of *in natura* pods of this plant for long periods with the clinical-epidemiological data and inspection of pastures, which showed that the ruminants had free access to areas heavily invaded by mesquite. This diagnosis was confirmed, for the first time in the state of Bahia, based on anatomopathological findings (OB 1, OB 2, OB 3, and OB 5), which were similar to those described in goats (Tabosa et al. 2000, Lima et al. 2004, Lemos et al. 2016) and cattle (Dollahite & Anthony 1957, Figueiredo 1993, Figueiredo et al. 1995/96, Câmara et al. 2009, Galiza et al. 2010) intoxicated with mesquite.

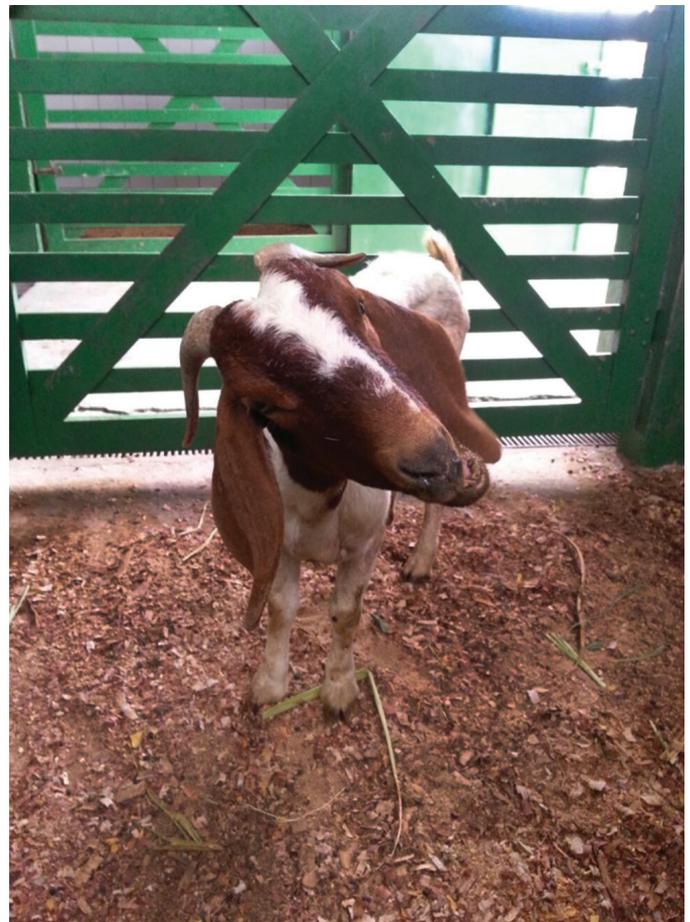


Fig.4. Natural poisoning by *Prosopis juliflora* in goats. Lateral deviation of the head ("twisted face") during hospitalization at the CDP-UFBA. OB 2. Iaçú/BA.

Interestingly, in some of these outbreaks, producers and veterinarians mistakenly stated that the animals adopted the “twisted face” position as a result of tooth wear (caused by the firm consistency of pods) to keep the food in the oral cavity or of a probable contagious disease. Such an erroneous association demonstrates that, although the pathogenesis of this intoxication has already been elucidated (Tokarnia et al. 2012), there are still great misconceptions about mesquite poisoning. This fact reinforces the importance of the extension service (continuing education) offered by CDP-UFBA and SPV-UFRB to producers. The present study confirmed that the signs of “twisted face” and muscle atrophy are due to neurological injuries in the motor nucleus of the trigeminal nerve, corroborating the descriptions by Tabosa et al. (2006). This poisoning has a peculiar pathogenesis, as it is characterized by primary, selective, chronic and progressive neurological damage caused by plant alkaloids (Tabosa et al. 2004).

It is noteworthy that, in six (OB 2 - OB 7) of the seven outbreaks, poisoning occurred in microregions of the state whose livestock importance of mesquite was, until then,

unknown (Itaberaba, Euclides da Cunha, Feira de Santana, Irecê, Barra, and Cotegipe). It was possible to update the geographical distribution of *P. juliflora* in the state of Bahia (Fig.1) previously described by Riet-Correa et al. (2011) and Tokarnia et al. (2012). Thus, it was found that, currently, poisoning occurs in an area approximately three times larger than the hitherto known in the state. This finding demonstrates that invasion of this plant in the Caatinga biome (Andrade et al. 2009) has expanded the areas with outbreaks of poisoning in this state’s semiarid region. Recent estimates point out that mesquite has already invaded one million hectares in the northeastern semiarid region (Fabricante & Siqueira Filho 2013). This fact, associated with the occurrence of poisoning in ruminants from other states in the Northeast region (PB, RN, and PE) (Figueiredo 1993, Dantas 1996, Riet-Correa et al. 2002, Lima et al. 2004, Tabosa et al. 2004, Câmara et al. 2009, Galiza et al. 2010, Lemos et al. 2016, Almeida et al. 2017), highlights the importance of discussing the current economic impacts and perspectives on northeastern livestock resulting from the uncontrolled spread of mesquite (biological invasion) proved in the 2000s (Lima et al. 2003, Lima & Kiill 2003, Barbosa & Lima 2005, Lima 2005, Marques et al. 2003, Marques et al. 2004, Lima et al. 2004a, Lima et al. 2004b, Lima et al. 2004c). It is worth mentioning that, today, approximately 20 years after such a proof, there are still no updates on the strategies for the control and prophylaxis of this poisoning, given the new epidemiological conditions. It is recommended that the administration of mesquite pods be immediately suspended after observation of the first clinical signs or that pods be administered at safe concentrations for each species (Riet-Correa et al. 2011).

There are no estimates of the economic impact caused to farmers in the state of Bahia by the indiscriminate use of mesquite, and they are scarce in other states. However, in some properties of the states of Rio Grande do Norte and Paraíba in 1981 and 1992, respectively, mesquite poisoning



Fig.5. Natural poisoning by *Prosopis juliflora* in goats in the state of Bahia. Whole mesquite seeds amid the dried ruminal content. OB 2. Iaçú/BA.



Fig.6. Natural poisoning by *Prosopis juliflora* in cattle in the state of Bahia. Rumen content with recognizable fragments and intact mesquite pods. OB 3. Tucano/BA.

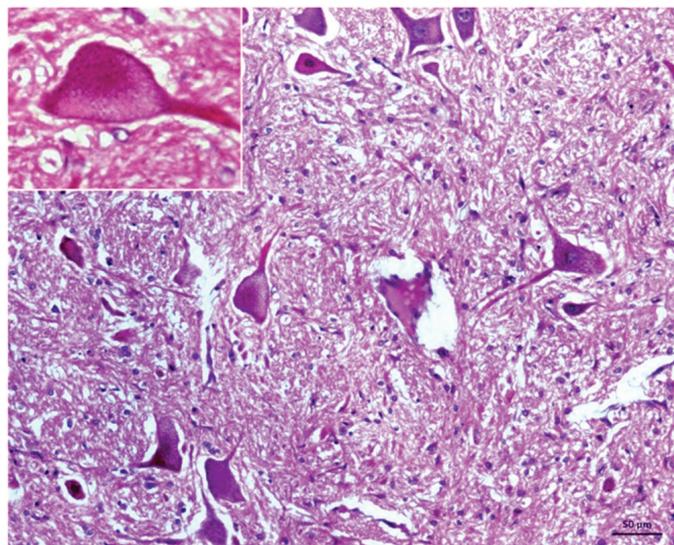


Fig.7. Natural poisoning by *Prosopis juliflora* in goats. OB 2. Iaçú/BA. Trigeminal nerve nucleus. Neurons with marked cytoplasmic vacuolization and others with hypereosinophilic cytoplasm and shriveled nuclei. HE, obj.20x. Insert: accentuated neuronal vacuolization.

was responsible for the death of more than 50% of the bovine herd (Dantas 1996). In the state of Pernambuco, from 2006 to 2007, prevalence of cattle poisoning was low in two farms [1.72% (1/58) and 2.63% (1/38)] and, reached 9.28% (112/1,206) of the herd in one farm (Câmara et al. 2009). In the present study, the prevalence of *P. juliflora* poisoning in cattle varied, being considered sporadic in OB 3 (three cases in 2014), OB 4 (21 cases in 10 years, 2006-2016) and OB 5 (seven cases in three years, 2016 -2019), since only two to three animals were affected per year. In OB 6 and OB 7, it was considered occasional, with an average of 11 cases per year in each property (22 cases in 12 months, 2018-2019). In the five poisoning outbreaks in cattle (OB 3 to OB 7), approximately 11 cattle were affected, with mortality of 23% of the herd. Among these, OB 6 and OB 7 stand out, with mortality rates of 30 and 20%, respectively, in only 12 months from 2018 to 2019.

Poisoning of cattle by mesquite has become more frequent since 2018, with increased biological invasion in the semiarid region of the state of Bahia. It is noteworthy that Dantas (1996) had already called attention to the sharp increase in cases of mesquite poisoning since 1992 in the state of Paraíba and Rio Grande do Norte, where until then, they were considered sporadic. Perception of increased occurrence of poisoning outbreaks in the state of Bahia approximately 26 years after this observation in the states of Paraíba and Rio Grande do Norte can be justified by the fact that mesquite was introduced in the latter at least four decades before in it was introduced in the first; therefore, the pasture invasion occurred later in the semiarid of region of Bahia. It is also believed that *P. juliflora* poisoning in ruminants in Bahia has been underdiagnosed and/or mistaken for other neurological and cachectic diseases, especially tuberculosis, which affect the herds in this state.

Concerning goats, it was found that in OB 1, 24 (16%) animals died from poisoning by the plant in six years (2006-2011). In OB 2, in one year (from 2014 to 2015), there was mortality of four animals in a batch of 20 goats (20%), which reinforces the hypothesis that mesquite poisoning has become more frequent as a result of pasture invasion by the plant and absence of control and prophylaxis measures. Lima et al. (2004) suggested that cases of mesquite poisoning may be more frequent than has been mentioned in the literature. These authors observed the death of 31 goats in a herd of 200 animals (15.5%) during three years in the state of Paraíba. Lemos et al. (2016) found poisoning in six goats in a batch of 25 animals (24%) in the state of Pernambuco.

Despite the fact that goats and sheep were raised together on the farm where OB 1 occurred, no cases of poisoning were observed in sheep and in goats kept in mesquite-free pastures. Similarly, in OB 3, sheep and buffaloes raised concomitantly with poisoned cattle also showed no poisoning signs. However, a study recently conducted by Almeida et al. (2017) found that, in addition to cattle and goats, natural poisoning by *P. juliflora* can also affect sheep. These authors reported the poisoning of four sheep in a herd of 500 animals (0.8%); however, these animals received feed based on mesquite pods at concentrations of up to 80% for 21 months. Although sheep are considered the least susceptible to poisoning compared with goats and cattle (the most sensitive species), natural intoxication can occur under certain feed management conditions. Nevertheless, given the new epidemiological

conditions, which denote biological invasion associated with the failure to adopt control and prophylaxis measures, observed on the farms assessed, this poisoning in sheep may become more frequent.

On the farms where the outbreaks occurred, there was significant regional importance of mesquite in livestock, with all producers reporting that the use of pods in animal feed was essential and the only solution for keeping them during drought periods. It is noteworthy that disease etiology was still unknown to producers in the seven outbreaks studied and that, even in OB 1, OB 2, OB 4, OB 5, OB 6 and OB 7, convincing the farmers of the real cause of the disease was a difficult task. This difficulty can be explained by the fact that the press, especially the Northeast region, played an essential role in disseminating the culture of mesquite in Brazil, as it emphasized the advantages of using this plant as forage (Spa 1989). It is interesting to remember that, at the beginning of the 1950s, this plant was almost unknown to most of the northeasterners and that the Brazilian Society of Zootechnics played an essential role in publicizing this plant's potential as forage. They attributed it to the recovery of livestock in the state of Rio Grande do Norte with the discourse that "the herds would stop starving" [*sic*]. Other salvation speeches have also been reaffirmed by rural associations: "no plant is given characteristics such as drought and salinity resistant, rapid development, and production in times of drought like mesquite" (Cunha & Silva 2012), which stimulated the use of the plant in the Northeast region (Spa 1989). In Brazil, histories of tax and media incentives of this magnitude and nature aiming at the dissemination of other exotic plants that, later on, were classified as toxic to livestock, are rare. Among these, exceptions are *Panicum* spp., *Stylosanthes* spp. and *Brachiaria* spp., whose cultivation and dissemination has been recommended by Embrapa and have resulted in severe economic losses (Tokarnia et al. 2012).

Currently, mesquite is widely known by the population and always associated with its benefits to livestock, making it difficult for producers to recognize that, under certain conditions, it can cause poisoning and death of animals. This observation also makes it challenging to adopt measures for the control and prophylaxis of poisoning and favors the plant's uncontrolled spread (invasion). However, at the end of the 1980s, mesquite was responsible for environmental damage (drying up springs and causing the poisoning and death of cattle) (Cunha & Silva 2012) that did not have the same repercussion observed in the period of introduction of the plant. Studies discussing the positive and negative aspects of mesquite planting/use are not common in the literature, and will be discussed ahead.

Historical information on the introduction and dissemination of mesquite in the state of Bahia, as described in the present study, had never been analyzed. The excellent propagation capacity of this plant (biological invasion) drew attention especially in OB 5. On this farm, where only four seedlings were planted, 95% of the pastures (266 ha) had been invaded by the plant 30 years later. In contrast, in OB 2, where the lowest degree of invasion (16.66%) was observed, some considerations can be made. In this property, although the plant was introduced through the planting of 30 seedlings, it was carried out more recently (15 years ago) compared with the other studied farms, where the plant was introduced 10

to 25 years before. In addition, the farm where OB 2 occurred was large (300 ha) and the herd was small (only 20 animals) when compared with the average area (200 ha) and herd size (60 heads) of all farms. Moreover, it is known that among animals considered natural disseminators of mesquite seeds through feces, goats eliminate a smaller amount of seeds suitable for germination than cattle and mules (Souza et al. 1999). Such factors may justify the lower degree of mesquite invasion on this farm.

Concerning the absence of herbaceous species observed in the lower strata of the community in most invaded pastures, it is likely that competition for nutrients/water or allelopathy justify this “association problem” between mesquite and herbaceous or native trees (Lima 2005).

On the farms where OB 3 and OB 4 occurred, the producers harvested, dried (Fig.8) and stored mesquite pods, and then administered them *in natura* to the cattle. The surplus of pods was sold at regional free markets or mediated by agents, who sold it directly to feed factories with values ranging from BRL 0.30 to 0.70 per kg. These producers associated the sale of pods with the economic importance of the plant. In fact, in some municipalities in the states of Bahia and Pernambuco, the largest mesquite pod sales centers are concentrated in the São Francisco River basin. Animal feed factories are the biggest buyers, which has encouraged producers to adopt this practice (Lima 2005). Additionally, in these two properties (OB 3 and OB 4), the animals also had free access to areas intensely invaded by mesquite, which allowed the uncontrolled consumption of a large amount of fresh pods in the pastures for long periods, similarly to what occurred in the other five properties studied (OB 1, OB 2, OB 5, OB 6, and OB 7). This observation evidences that these are essential factors in the origin of this poisoning outbreaks, since they occurred in a way similar to that described in other cases of poisoning in ruminants (Figueiredo 1993, Dantas & Menezes 1994, Lima et al. 2004, Câmara et al. 2009, Galiza et al. 2010, Lemos et al. 2016, Almeida et al. 2017). In the studied outbreaks, another factor that drew attention was the total absence of fences

in areas invaded by mesquite in the seven properties, thus evidencing the lack of adequate management in the availability of mesquite for animal consumption.

Whether the consumption of fresh mesquite pods occurs in troughs or pastures in a controlled or uncontrolled way, the uncontrolled dispersal of its through feces is maintained. This spread contributes to the invasion of pastures (Fig.9) and risk of poisoning, as verified in the present study. It should be noted that the average percentage of seeds suitable for germination eliminated in manure reaches 9.3% in goats, 14.8% in cattle, and 37.3% in mules (Souza et al. 1999). These high germination rates are likely to occur as a result of the reduced drying of seeds provided by the humid environment of the feces (Ribaski et al. 2009). On the other hand, sheep partially destroy the ingested pods, while the pigs were found to destroy all seeds (Pasicznik et al. 2001).

Some considerations should be made regarding the processing of mesquite pods. Although toxicity is maintained in the mesquite bran obtained by grinding the pods (Tabosa et al. 2006), the seeds are destroyed in this preparation, thus preventing the uncontrolled propagation of the plant. Grinding should always be recommended for preparation of animal feed, as it is a good alternative (rational use) for controlling plant spread (biological invasion). In addition, this process allows the control of the amount of feed eaten by animals in the trough according to the non-toxic concentrations known for each species (Table 2), thus preventing cases of poisoning. However, mesquite pods were not processed (grinding) in any of the farms investigated, which justifies the massive pasture invasion (59.57%, on average) over the years, the appearance of the so-called “mesquite forests” observed in OB 3, OB 4, OB 5, OB 6 and OB 7 (Fig.2), and the increased occurrence of poisoning cases.

Installation of a micro-plant to process mesquite pods in the properties and/or at a regional level should be encouraged. According to Lima (2005), a mesquite pod processing unit located in the municipality of Monteiro, state of Paraíba, mills approximately 30 tons of pods a year, providing farmers in the region with mesquite bran for animal feed. Riocon® (Fazendas



Fig.8. Pods of *Prosopis juliflora* in the sun drying process after harvesting on the farm where OB 3 occurred. Tucano/BA. Process carried out prior to the storage of pods that are subsequently supplied to animals or sold in the region.



Fig.9. Uncontrolled dispersal of *Prosopis juliflora* seeds in feces. Note the germination of several seeds of the plant, amid feces, found in the pasture of the farm where OB 4 occurred. Santa Terezinha/BA.

Reunidas Rio de Contas Ltda) started its activities in 1993 in the municipality of Manoel Vitorino, located in the semiarid region of southwestern Bahia. They invested in the installation of mesquite bran production units to promote integration between local family producers to supply pods and expand the production of mesquite bran (Riocon 2019), which demonstrates the feasibility and benefits of this processing. As for intensive rearing, in which the pods are not crushed, another strategy to avoid the spread of seeds in the property would be manure composting or appropriate discard, noting that indiscriminate use of manure in crops or pastures can be compromising.

On the farms where OB 3, OB 4, and OB 5 occurred, thinning of mesquite trees for the use of wood (stakes, posts, fences, or production of firewood and/or charcoal) or their commercialization have already been modestly practiced (Fig.10); however, this activity has no longer been carried out for approximately 15

Table 2. Recommended (non-toxic) concentrations of mesquite in the diet of ruminants

Species	Concentration in the diet	Period	References
Cattle	30%	12 months	Medeiros et al. (2012)
Goats	50 to 70%	6 to 12 months	Riet-Correa et al. (2012)
Sheep	50/60 to 90%	Without restriction/12 months	Sharma (1997), Riet-Correa et al. (2012)



Fig.10. Strategy for the control of *Prosopis juliflora* trees. Extraction of wood for the production of posts, fences, and use as firewood on the farm where OB 3 occurred. Tucano/BA.

years. According to Lima (2005), mesquite wood is sold for BRL 30-40 per m³, which can generate extra income for producers. The absence of a management plan for mesquite cultivation in the seven farms studied since the plant's introduction has also contributed to its high degree of pasture invasion. In this context, it is essential to note that, in 2005, a management plan for areas invaded by mesquite in the Northeast region was prepared to convert natural "mesquite forests" into sustainable production systems, reducing biological invasion through the rational use of their products (feed, firewood, and charcoal) and conserving the Caatinga biome (Lima 2005). Adoption of these silvicultural treatments in pastures invaded by mesquite in the semiarid region of the state of Bahia should be encouraged to prevent future cases of poisoning resulting from the uncontrolled spread of the plant and conserve the Caatinga biome. Riocon[®] also stood out in the production of ecological charcoal using industrial automation and raw material based on reforested mesquite trees (Riocon 2019). Such strategies were recommended to producers in order to use the potential of *P. juliflora*, adding economic and social value to these regions.

It is important to note that Africa and Asia (India and Pakistan) also face problems caused by mesquite invasion. Governmental actions have been taken to reduce the damage caused by encouraging the exploitation of fruits and wood (Franco 2008). In South Africa, Australia, India and Sudan, mesquite occupies millions of hectares. In these countries, invasions that occurred along extensive riverbanks and in degraded regions have resulted in a high population densities (Ribaski et al. 2009). In the state of Bahia, during the visits to the properties where the outbreaks occurred, a growing dispersion of the plant was verified along the margins of highways and rivers (Fig.11), particularly in the municipality of Itapicuru, contributing to increased silting. These occurrences corroborate the findings of a study conducted by Lima (2005) that monitored, through satellite images, the expansion of areas invaded by mesquite in the Juremal region, Juazeiro (BA) for ten years (1986-1996). This author found that this arboreal species has played an exceptional role in the regeneration of the semiarid region, with increasing propagation areas over these years.



Fig.11. Uncontrolled propagation (invasion) of *Prosopis juliflora* in riparian forest on the farm where OB 3 occurred. Tucano/BA.

It is essential to highlight that some countries do not recommend the planting of invasive species and have been advocating the eradication of mesquite. It has even been verified that the use of herbicides or mechanical removal cannot eradicate this species because of its high regrowth power (Lima 2005). Assessment of the Brazilian reality shows that *P. juliflora* is the most successful xerophilic plant among those introduced in the northeastern semiarid region. It plays a fundamental economic role in agriculture (Spa 1989), which was confirmed in the present study. In this context, its eradication is not justified; however, its propagation should be controlled in the Northeast region, which can be done based on the sustainable forest management techniques discussed here.

CONCLUSIONS

This seems to be the first study addressing pathological outbreaks of natural poisoning by *Prosopis juliflora* in cattle and goats in the state of Bahia with emphasis on six microregions of the state (Itaberaba, Euclides da Cunha, Feira de Santana, Irecê, Barra and Cotegipe). The marked biological invasion of the Caatinga biome by mesquite changes the epidemiological conditions of this intoxication, expanding the areas outbreak occurrence and making them more frequent in the semiarid region of the state of Bahia.

The uncontrolled consumption of mesquite pods without processing (*in natura*/not grinding) for long periods has allowed massive dispersal of plant seeds through animal feces. This consumption, combined with the lack of a cultivation management plan (silvicultural treatments), and the lack of knowledge by producers on disease etiology are the main factors responsible for the gradual invasion of this plant in pastures. Over the years, this justifies the increased number of cases of poisoning observed in the state of Bahia.

Given the new epidemiological conditions, the restriction of animal access to fresh *P. juliflora* pods in pastures and the supply of mesquite bran are crucial factors for the control and prophylaxis of this intoxication. The consumption of fresh pods has a strong correlation with the high degree of pasture invasion, consequently increasing the risk of poisoning.

The growing invasion of mesquite in semiarid areas, 78 years after its introduction in the Northeast region, is a threat to the biodiversity of Caatinga and a risk for herds, since the occurrence of poisoning outbreaks may become more frequent. Thus, it is highly advisable that effective measures be adopted to control *P. juliflora* propagation.

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