International Journal of Advanced Engineering Research and Science (IJAERS)
Peer-Reviewed Journal
ISSN: 2349-6495(P) | 2456-1908(O)
Vol-8, Issue-12; Dec, 2021
Journal Home Page Available: https://ijaers.com/
Article DOI: https://dx.doi.org/10.22161/ijaers.812.10

Retrospective study of foot-and-mouth disease in border regions of the State of Mato Grosso do Sul

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Received: 16 Sept 2020,
Received in revised form: 20 Nov 2021,
Accepted: 28 Nov 2021,
Available online: 10 Dec 2021

***Keywords*— foot-and-mouth, IAGRO, vesicular disease.**

***Abstract*—** *The State of Mato Grosso do Sul has a border area of 1,365 km, which causes the Agency for Animal and Plant Sanitary Defense (IAGRO), through uninterrupted activities, to carry out health surveillance actions. In these border regions until September 30, 2021, 37,889 Animal Transit Guides - GTAs were issued and 1,019,120 cattle and buffaloes were moved. The control of health surveillance in these regions is very important, so the objective of this work is to conduct a study on the foci of foot-and-mouth disease and characterize the border region of the State of Mato Grosso do Sul. It is noteworthy that the state has been without cases of foot-and-mouth disease for more than 15 years, and in this study, the outbreaks that occurred in the municipalities of Porto Murtinho (1998), Naviraí (1999) and the last, in 2005 and 2006, in Eldorado, Mundo Novo and Japorã were described. These focuses had immediate control actions, where IAGRO, with the support of the federal, state and municipal government, dedicated itself to the health emergency being addressed as soon as possible, according to data presented; and that measures such as health surveillance, health education and traffic control in fixed and mobile posts often occur in these regions. Today, six years ago, the state has a vaccination coverage above 99.20%. IAGRO is implementing its health control and surveillance actions in these regions, empowering its technical staff, acquiring and putting into operation new technologies, aiming to have a work of excellence with the main*

objective of having recognition with the status of foot-and-mouth disease-free area without vaccination, which is the greatest csuit of the entire productive class of the state.

I. INTRODUCTION

Foot-and-mouth disease is an acute infectious disease with high potential for transmissibility among susceptible animals, and can cause the disease in all animals of a herd in a short time [1]. Bortot and Zappa (2013) point out that, regardless of national borders, because it is rapidly dissected, the disease has very serious socioeconomic consequences, mainly affecting the trade in animals and animal products in international relations [2].

The last outbreaks of the disease in Brazil in 2006 (Mato Grosso do Sul and Paraná), and also the outbreaks of Rio Grande do Sul (in the years 2000 and 2001) occurred in the border regions [3]. Brazil (2017), reports that the extensive Brazilian borders with specific attributes and vulnerabilities, denote a great challenge to agricultural health surveillance and defense, especially in the entry of pathogens into the territory [4].

a) Geographical characterization of the border region of Mato Grosso do Sul, Bolivia and Paraguay.

Bolivia and Paraguay border the State of Mato Grosso do Sul (MS) internationally. According to Pereira (2009), the Brazilian border line with these two countries has an extension of 1,365.4 km, being 436.9 km of dry border and 928.5 km of border by rivers. In total, the state has forty-four (44) municipalities along the border strip [5].

Of the 44 municipalities in the border strip, Franco et al (2019) point out that only 12 (twelve) municipalities are located on the border line, being 11 (eleven) bordering Paraguay and only 1 (one) with Bolivia, also identifying that most municipalities of the MH have an urban area near the headquarters of the municipality of the neighboring country and this characteristic provides ease in traffic of people, animals and goods, as well as the exchange of services provided.

The Brazilian Institute of Geography and Statistics (IBGE), based on the Federal Constitution, identifies and characterizes the municipalities (fig. 1) of the border strip as follows:

> *"The Border Strip means "the range of up to one hundred and fifty kilometers wide, along the land borders", according to the Federal Constitution, Article 20 – paragraph 2. Based on this definition, which welcomes the parameters of Law No. 6,634, of 05/02/1979, IBGE, for geoscientific and statistical purposes, identifies and represents Brazilian municipalities with an area wretoldly or partially located in the Border Strip, which is the internal strip of 150 km wide, parallel to the land dividing line of the national territory, adding the existing information (geographic code and name of the municipality) with those produced in the identification and/or classification of the municipality of the municipality within the range, such as: borderline, partially or totally in the strip, references of the head of the border line and the boundary of the inner strip." (IBGE, 2020).*

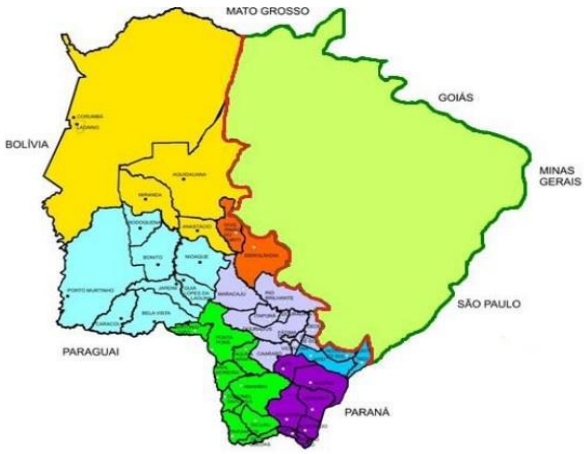

Fig. 1: Municipalities of the state of Mato Grosso do Sul (border strip)

Source: Ministry of Defense

According to information from the Portal of the Government of Mato Grosso do Sul (2018) with 3,442 km long, the Paraguay-Paraná waterway, is one of the continental integration corridors of Latin America that stands out most due to its importance, crossing 890 km from the Brazilian territory, connects Cáceres (MT) to Nueva Palmira (Uruguay) and is linked to the Tietê-Paraná waterway[6].

Also according to the Portal of the Government of Mato Grosso do Sul (2018), the Tietê-Paraná waterway has 2,400km of which, 600 km are in the MS. Dentro do Estado, this important waterway has the ports of Bataguassu (border with the State of São Paulo), with that of Mundo Novo (border with Paraná), and also with the overflow terminals in Aparecida do Taboado (also border with the State of São Paulo). This portal also mentions that, in the stretch that cuts the State of the MS, the Paraguay-Paraná waterway, the ports of Corumbá-Ladário (on the border with Bolivia) and

Porto Murtinho (on the border with Paraguay) are in operation[6].

b) Brief history of foot-and-mouth disease in South America

The first documented records of foot-and-mouth disease on the American continent begin in 1870. This year, outbreaks were recorded, almost simultaneously in the United States, Argentina and Uruguay, associated with the first imports of cattle from Europe, where the disease occurred endemically [7]. In the case of Brazil, probably, the outbreaks recorded in the same year have reached the Southern Region of the country, a hypothesis also considered by Olascoaga (2003) and Rosenberg and Goic (1973); however, the first official recognition of the disease was dated 1895[8][9][10].

Foot-and-mouth disease spread to the other regions of the country, considering the epidemiological characteristics of the disease and the process of occupation and expansion of the national territory, named by Figueiredo (1994) as "colonization by the ox's paw", since cattle ranching has always been a key tool for colonization of the "Novo Continente" [11].

In 1951, through the continuous efforts between the Government of Brazil and the Organization of American States (OAS) and due to the outbreaks of foot-and-mouth disease at the time, the Pan American Foot-and-Mouth Disease Center (PANAFTOSA) was formed under the responsibility of the Pan American Health Organization (PAHO) and in 1972, by the action of both PAHO-Panaftosa, the South American Commission for the Fight against Foot-And-Mouth Disease (COSALFA) was created [12].

In 1988, paho and the first Action Plan of the Hemispheric Program for the Eradication of Foot-and-Mouth Disease (PHEFA) was established by PAHO, the Hemispheric Committee for the Eradication of Foot-and-Mouth Disease (COHEFA), constituted through the effort of the official veterinary services (SVO) and the collaboration of the private sector. Its main objective is to eradicate foot-and-mouth disease until 2009, with the design of strategies and the political support of countries that were considered extremely necessary [12].

The eradication of foot-and-mouth disease in South American countries until 2009 has not been obtained, so a new programme was developed for the 2011-2020 management. Then, in 2012, the World Organization for Animal Health (OIE) approved a plan to control the disease globally, with the OIE and the Food and Agriculture Organization (FAO) as managers. Thus, the PHEFA was named as the program of the American continent for the control and eradication of the disease [12]. Since then, for these territories, the plan is to carry out a passage of free status without vaccination, eradicating the disease and enhancing prevention, diagnosis and early response [13].

According to Brazil (2019), Rio Grande do Sul and Santa Catarina became the first foot-and-mouth disease-free zone with vaccination in Brazil, a fact that occurred in 1998, gradually starting a process of implantation of free zones in the rest of The Brazilian territory[14]. In 2007, Santa Catarina was recognized as the first foot-and-mouth disease-free zone without vaccination, and there was also an expansion of the foot-and-mouth disease-free zone with vaccination in 2014 and later encompassing the entire Brazilian territory [14].

Specifically in Mato Grosso do Sul, 21 outbreaks of foot-and-mouth disease were recorded in 1994, two in 1998 and two in 1999, in the municipalities of Porto Murtinho and Naviraí [15]. According to Amaral et al. (2016), this State was classified by the OIE as an foot-and-mouth disease-free zone in 2001. However, in September 2005, there was a reintroduction of foot-and-mouth disease virus, involving municipalities located on the border with Paraguay. This reintroduction led to the suspension of the classification of foot-and-mouth disease free in Mato Grosso do Sul and also in other states of Brazil [15].

c) The work of health defense carried out by Brazil

The actions against foot-and-mouth disease in Brazil are shown to be a beautiful history of our animal health defense system. Especially since 2006, after the last occurrences of the disease in Brazil, the National Surveillance Program for Foot-and-Mouth Disease (PNEFA) entered the phase of consolidation of the eradication process, with evolution and maintenance of foot-and-mouth disease-free areas. Preventing the reintroduction of the virus, demonstrating its absence in the national territory, preparing for early detection in the face of possible viral agent tickets and its rapid elimination are important challenges currently imposed on the Brazilian animal health defense system [16].

According to Brazil (2021), the Strategic Plan 2017-2026 was created with the objective of maintaining and creating sustainable conditions to ensure the status of country free of foot-and-mouth disease and expand the zones free of foot-and-mouth disease without vaccination, protect livestock assets and generate benefits to Brazilian society, organized to be executed in a period of 10 years, beginning in 2017 and ending in 2026[12].

According to Brazil (2019), the Strategic Plan was provided in 16 operations, assembled into four components: strengthening the animal health surveillance system, expanding the capacities of SVs, transitioning from free with vaccination to vaccination-free zone throughout the

country and interaction with stakeholders in the foot-and-mouth disease prevention program[14].

The first version of the Strategic Plan was based on animal movement and spatial distribution analyses of herds susceptible to foot-and-mouth disease during the period 2014 and 2015. After two years of implementation of the plan, the current scenario and regional peculiarities have been adjusted (Ibid).

Also according to Brazil (2019), the federative units were separated into blocks, according to the following sequence, block I, Amazon region, being Acre, Rondônia, part of amazonas and part of Mato Grosso; block II, the Amazon region, with the Amazon, Amapá, Pará and Roraima; block III, Northeast region with Alagoas, Ceará, Maranhão, Paraíba, Pernambuco, Piauí and Rio Grande do Norte; block IV, the central region, with Bahia, Distrito Federal, Espírito Santo, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Rio de Janeiro, São Paulo, Sergipe and Tocantins; block V, the southern region, with Paraná, Rio Grande do Sul and Santa Catarina[14].

According to Brazil (2017), the Program for Quality Assessment and Improvement of Official Veterinary Services (Quali-SV) will be composed of evaluations through audits with the objective of verifying the available structures and procedures conducted by the SVs and evaluation by quality indicators[14].

In The Brazilian territory since 2005, according to Brazil (2021), the State Veterinary Services (SVEs), under the coordination of the Department of Animal Health of the Ministry of Agriculture, Livestock and Supply (DSA/MAPA) and the support of PANAFTOSA, carry out seroepidemiological studies, aiming to estimate the percentage of immune coverage of the bovine population achieved by vaccination campaigns against foot-and-mouth disease. This study is carried out in the bovine population of the area qualified for the export of fresh meat to the EU (European Union), an area composed of the States of Espírito Santo, Minas Gerais, Mato Grosso, Mato Grosso do Sul, São Paulo and Goiás[12].

In December 2006, the areas called the High Surveillance Zone (ZAV) were defined in the border region of each of the countries and common actions to be adopted in this area were implemented, comprising a range of approximately 15 km wide on both sides of the border with neighboring countries, affecting specific areas of Argentina, Brazil, Bolivia and Paraguay [17].

d) Work protocol carried out in the foci of foot-and-mouth disease in the border region of Mato Grosso do Sul.

In the national territory, the notification of suspected vesicular disease is compulsory and should be informed immediately to the SVO, within a maximum of 24 hours, and the SVO has a deadline of 12 hours for the first surveillance. Notification can be made by any citizen, through communication channels available to the public [3].

The direction and procedures for the investigation of suspected cases of vesicular disease and in probable cases of foot-and-mouth disease are established in manuals and the prohibition of property is one of the immediate procedures. If there is confirmation of the suspicion of foot-and-mouth disease, the actions should follow the contingency plan for foot-and-mouth disease [3].

Upon receipt of a notification the veterinarian performs the following procedures [18], as follows.

1ª Record of the notification

The first record of the notification of suspicion immediately in the book of sanitary occurrences with at least, with the guarantee of confidentiality if requested by the notifier, such as date and time of notification, type of notifier (owner, third party or surveillance), name of the notifier (where relevant, include surname), telephone to contact of that notifier; identification of the place where the animals with suspected vesicular disease are located, identification of the public person service who received the notification, brief description of the notification (including species involved), other observations considered relevant, and the date and time of departure for the service.

Remembering that guidance should be made on the biosafety procedures necessary to prevent the spread of the possible infectious agent, especially regarding not moving sick animals and their direct contacts and not entering any other property with susceptible animals until the result of the care to be performed by the official veterinary service [18].

2ª Initial survey of information

Evaluations of the information available in the registration system or in the health record of the state veterinary service, such as the existing herd, intensity of movement of animals (entry and discharge in the last 30 days), date of the last vaccination, geographical location and access routes. It is also important to collect information and identification of bordering properties and related properties (with ties in the last 30 days, be it their admission and/or

their graduate) with the property with animals under investigation. Also obtaining information from other properties belonging to the same owner. It is searched for its approximate location (Fig. 2) and identification of nearby properties. All this without compromising reaction time. The priority is to arrange the visit [18].

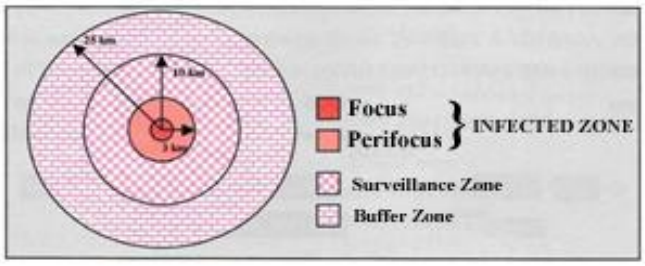

Fig. 2: Schematic representation of the risk areas established around the outbreaks

3ª displacement to the service to the notification received.

In parallel to the survey of the initial information, it is provided the preparation of the vehicle for travel and kit to meet suspected vesicular disease. The staff and the immediate superior were informed of the time and reason for the departure. The FORM-IN (today we have the e-Sisbravet) is filled in, with completion of the final version after returning to the office [18].

4ª Shares in the property.

Arriving at the property with suspicious animals, with care related to biosafety and attention to research, interview and clinical inspection of animals [18].

Confirming the possibility of vesicular disease, the veterinarian should pay special attention to the activities of harvesting material for diagnosis, gathering information and biosafety, the time interval between the confirmation of suspicion and the result of laboratory tests of paramount importance that should be administered considering the possibility of being foot-and-mouth disease. Depending on the quality of the material collected, after entering the laboratory, the initial result can be presented in less than 24 hours [18].

In the collection of diagnostic material, the impossibility of making a differential clinical diagnosis of vesicular diseases, associated with the frequent lack of epidemiological information at the beginning of investigations, requires laboratory support to confirm the diagnosis [18].

Considering, the possibility of being foot-and-mouth disease in biosafety activities, the period between the confirmation of clinical suspicion and the waiting for laboratory results is extremely important. In areas where vaccination is not performed, the disease can spread rapidly horizontally among susceptible animals. In most cases, transmission occurs after direct contact between infected and susceptible; a large amount of virus is found in all secretions as well as in aerosols for 1 to 3 days before and 7 to 14 days after the appearance of lesions and, in vaccinated animals, the elimination of the viral agent has not been recorded before the appearance of lesions [18].

Less frequently, the virus is mechanically diffused between infected and susceptible animals through animal products, instruments (fômites), vehicles and people. Biosafety measures are part of the set of activities used to avoid or minimize the risks of spreading the disease, and several procedures are still being used in the property where suspicion has been confirmed:

In the issue of biosafety, special attention should be given to disinfectants to be used in different situations. Based on the Manual of Procedures for The Care of Occurrences of Foot-and-Mouth Disease and other Vesicular Diseases of PANAFTOSA, where information is presented regarding the procedures to be used in cleaning and disinfection work in different phases of veterinary emergency actions and list of chemicals that can be used in disinfection [18].

Biosafety measures are part of the set of activities used to a void or minimize the risks of spreading the disease, and several procedures to be used, even on the property where suspicion was confirmed, after the collection of samples, all disposable material should be collected by placing them in plastic bags and providing the cleaning and disinfection of the rest of the material, which should also be properly packaged, go to the place where the interview with the owner or direct responsible for the management of the animals will be complemented; change clothes, also keeping the overalls and boots in appropriate plastic bags, tilling interdiction term and pass, clearly and objectively, the guidelines in relation to the care to be taken to avoid the diffusion or aggravation of the health problem. Local veterinary units should have interdiction and disinterdication forms for ready use. The interdiction term should contain the reason for its application, its legal basis, space for signature of the owner or responsible for the herd and the main prohibitions established [18].

The main guidelines and prohibitions that should be applied, especially to issues such as property size and predominant livestock production system, stand out to prohibit the sale of property of animals and products at risk for the spread of foot-and-mouth disease. Also included are non-susceptible animals, in view of the risk of mechanical

transmission of the disease, products not directly associated with risk of spreading the disease may spread it mechanically, and all measures should be taken to disinfect the means of transport and packaging material of these products, and work with tractors and machinery that may increase the chances of mechanical dissemination of the disease should be suspended, leave the lot with cases of the disease under the responsibility only of a small group of workers who will not be able to have access and contact with other susceptible animals of the property, guide those present who do not visit other properties with susceptible animals and do not maintain contact with other people who also deal with susceptible animals (this conduct should be more rigorous for those people who have maintained direct contact with sick animals).

Visits by any person without authorization, including veterinarians, technicians working with artificial insemination and other professionals and producers, especially those who have contact with susceptible animals, are also forsauly, as to whether milk production should be retained on the property. Do not use this product and dairy products in the feeding of susceptible animals (especially calves and pigs). The issue of milk is very important, not only because of the risk directly represented by the product, but mainly because of the risk of mechanical diffusion through the transporter truck and the people dealing with its harvest. Regardless of the quantity produced, the removal of the property may not be authorized as long as the risks of spreading the disease persist.

Even knowing that it is a measure that involves several economic and social issues, it should be considered that milk has low unit value and it is often safer to recommend its destruction, with compensation to the producer. Alternatives to be used and recommended in relation to this product include the destination for the manufacture of products subjected to thermal processing (mozzarella, curd, among others) within the property, the consumption of milk of healthy animals, after boiling for at least 5 minutes and destruction, using chemicals that lead to pH change (e.g.: vinegar or caustic soda), discarding the product in open ditch for this purpose. Do not spill the product into rivers or other water collections [18].

Basic cleaning and disinfection measures for entry and exit from sites with suspected infectious vesicular disease [18].

For the team of professionals (fig. 3) these measures are, at the entrance of the supposedly infected site, wear the appropriate clothing, prepare disinfectant solution, bathe the boots with the disinfectant solution (fig. 4). When leaving the premises, wash and disinfect the boots, remove the used clothes and put them in a plastic bag. Like the material used in animal inspection and sampling activities, disposable materials should be placed in other plastic bags for further destruction [18].

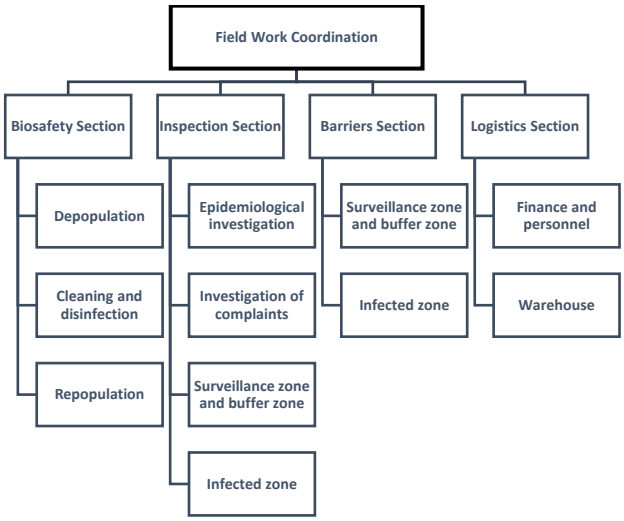

Fig. 3: Field Work Coordination

Fig. 4: People disinfection work

For the vehicles used (fig. 5), you must clean and disinfect pedals and floors, wash the tires with disinfectant solution and go directly to the local veterinary unit [18].

Fig. 5: Vehicle disinfection work

In each identified focus, independent risk and safety areas, represented by the infected, surveillance and buffer zones, should be delimited. After defined actions, with the objective of the complete elimination of the disease, activities of depopulation, cleaning/disinfection, sanitary void, introduction of sentinels and restocking were carried out [18].

In the areas of focus, the sick animals of direct contact, are destroyed using the sanitary rifle method, inside the property and obeying the legal rules. The animals with indirect contact were sacrificed using the Sanitary Slaughter method in refrigerators with federal inspection service (SIF), not eligible for export [18].

Actions were taken in the 1998 focus (fig. 6), according to archives of the Agency for Animal and Plant Sanitary Defense- IAGRO.

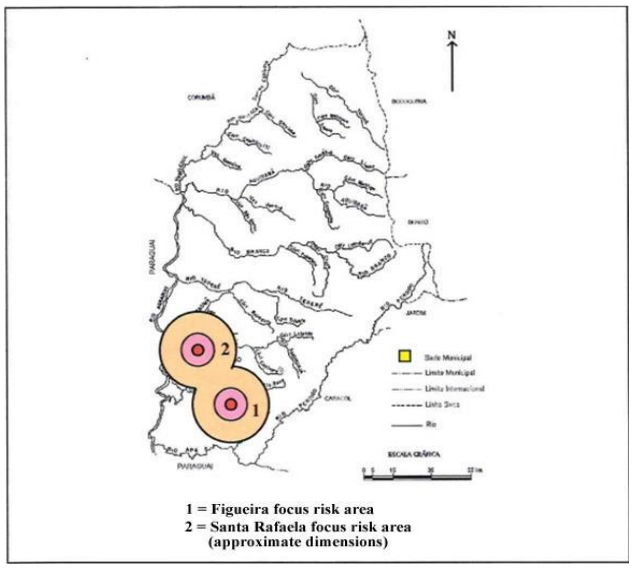

Fig. 6: Schematic representation of risk areas for each identified focus in Porto Murtinho, MS, 1998.

In the Focus (fig. 7 and fig. 8), signs were placed "FORBIDDEN ENTRY - FOCUS OF AFTOSA FEVER...", depopulation, cleaning/ disinfection, sanitary void, introduction of sentinels and repopulation, cleaning and disinfection of all material used in the work, such as vehicles and clothing, specific clothing was used to enter the properties, being used, baged, washed in a washing plant, with the acquisition of washing machines, access to outbreaks was limited, and focus workers were prevented for 72 hours of visiting other properties with susceptible animals.

Fig. 7: Door of the Figeira's farm (index focus)

Fig. 8: Door of the Santa Rafaela farm (Second index focus)

In the Perifoco, clinical inspection was carried out, avoiding the movement of animals, remaining in quarantine, the evaluation of the vaccination history, compulsory vaccination, the collection of blood serum samples in bovines under the age of two years to evaluate the viral activity were carried out. , the re-registration of all properties using the GPS, preventing the transit of susceptible animals, their products and by-products, clarification to owners and pedestrians about the symptoms of the disease, procedure and care necessary to reduce the risk of infection in their herd and the epidemiological survey in search of information for clarification.

In the Buffer Zone and Surveillance Zone, the actions taken were the inspection of susceptible animals with evaluation of the vaccination history, compulsory vaccination in the Surveillance Zone, the collection of blood serum samples in cattle aged less than two years to verify viral activity, the reregistration of all properties using GPS, the impediment of the transit susceptible animals, their products and by-products, the clarification to owners and

pedestrians about the symptoms of the disease, procedure and care necessary to reduce risks of infection of their herd and also conducted epidemiological survey in search of information for clarification.

The actions carried out in the 1999 focus, according to iagro archives of 2000 (fig. 9 until fig 19), are similar to those of 1998, differentiating only the geographical space.

Fig. 9: Photos of lesions characteristic of vesicular disease of cattle in the 1999 focus.

Fig. 10: Photos of lesions characteristic of vesicular disease of cattle in the 1999 focus.

Fig. 11: Animals sacrificed with a positive diagnosis for vesicular disease

Fig. 12: Raising cows for disposal of contaminated carcasses.

Fig. 13: Burial of contaminated carcasses

Fig. 14: Preparation of disinfectant solution

Fig. 15: Vehicle with disinfection solution

Fig. 16: Corral disinfection on one of the properties

Fig. 17: Agents of the State Agency for Animal and Plant Sanitary Defense of Mato Grosso do Sul in field work

Fig. 18: Sanitary education work with rural producers

Fig. 19: Animal captured for material collection

The figures below show the map containing the delimitations (fig. 20 and fig. 21) and regions worked in the 1999 focus, contained in the Archives of IAGRO[19].

Fig. 20: Map with area boundaries

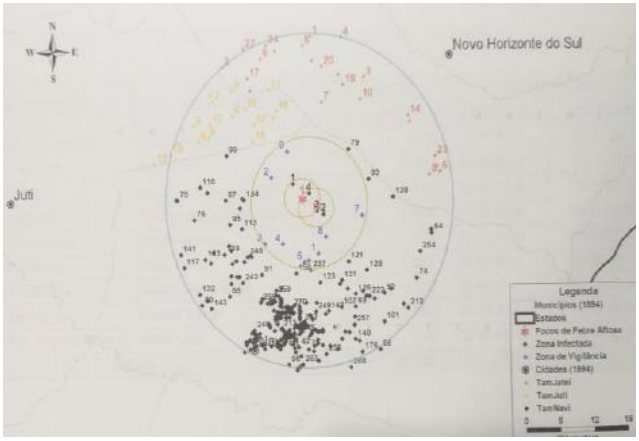

Fig. 21: Map with area boundaries

Among the actions already listed in the previous focuses, the actions of 2005-2006, where there were 33 outbreaks, according to IAGRO archives of 2006, were the interdiction of the Infected Zone, depriving animal owners of their right of free administration of the goods that are in the infected zone, isolation, quarantine, restriction of the movement of animals - no animal left, in the Perifocal Area susceptible animals, were in complete quarantine for up to 30 days, after the elimination of the animals from the focus, the concentration of animals were prohibited fairs and the like, there were various restrictions, of animals destined to refrigerators (30 days without symptoms, have remained on the property for 3 months, 10 km around the origin, for 3 months without foot-and-mouth disease, accompanied boarding), washed vehicles, non-export of meat, meat treatment in accordance with the OIE Animal Health Code; the prohibition of the departure of animal remains, hay, bed, manure, objects, vehicle, etc., the exit of tubers, fruits and vegetables would only occur with special authorization, live birds could not be marketed, only dead, plucked, without viscera, without head and paws, and the eggs could only leave the said area, in packages that allowed disinfection.

Sanitary measures carried out in the outbreaks of 2005-2006, sanitary barriers, sanitary rifle (fig. 22), burial.

Fig. 22: Animals sacrificed with the disease

Due to the number of outbreaks, restrictive factors and sanitation time, animosities (fig. 23 until fig. 25) were recorded from the local population of the affected municipalities in the 2005-2006 outbreaks.

Fig. 23: Popular surround health inspection vehicle

Fig. 24: Popular people overturn IAGRO vehicle as a form of protest

Fig. 25: Popular people interdict access road to the city

e) The Agency for Animal and Plant Sanitary Defense - IAGRO.

IAGRO is the Animal and Plant Sanitary Defense Agency of the State of Mato Grosso do Sul, responsible for performing the Official State Service, being subordinated to the Federal Official Service of the Ministry of Agriculture, Livestock and Supply [20]. It has a Central Unit, located in the municipality of Campo Grande, seventy-eight Local Units, distributed in the seventy-nine municipalities of the State (Corumbá and Ladário divide the same Local Unit), which are divided among eleven Regional Units [21].

The Agency was created under the qualification of The Department of Agricultural Inspection and Defense of Mato Grosso do Sul (IAGRO), by Decree-Law No. 9, of 01/01/1979, already on 10/26/2000 received the current name, State Agency of Animal and Plant Sanitary Defense. And on 12/24/2014 the Government of the State of Mato Grosso do Sul sanctioned State Law Nº. 4,640, defining in the organizational structure of the State The IAGRO as an autarchy, with the purpose of implementing public policies of inspection and inspection, complying with and complying with the obligations of the laws in force, with the objective of safeguarding agricultural health and the economy of the State [21].

This work was carried out with the objective of conducting a study on the actions performed by IAGRO in emergency care for the elimination of outbreaks of Foot-and-Mouth Disease in the State of Mato Grosso do Sul, considering the importance of the geographical characterization of the state border region in the study of the epidemiology of the disease.

II. MATERIALS AND METHODS

a) Research Design

The survey carried out in this study regarding its nature has a qualitative approach, since a bibliographic survey of all information regarding the outbreaks of Foot-and-Mouth Disease in the border region of the State of Mato Grosso do Sul was made.

The research was delineated through a case study, making a survey with depth, related to a given case or human group in all its aspects. However, this may be limited because it is restricted to the case studied, which cannot be generalized [22].

The research is characterized as exploratory and explanatory, providing greater familiarity with the problem and identifying the factors that determine or contribute to the occurrence of phenomena [23].

To develop this work, articles, regulations, public archives and official reports were researched, in short, a compile of materials related to the subject was carried out for retrospective study of foot-and-mouth disease virus in regions of international borders of the state of Mato Grosso do Sul, the object of this study.

b) Collection and analysis of documents

The data collected from the outbreaks of Foot-and-Mouth Disease that occurred in the State of Mato Grosso do Sul were produced through records in case books and official reports of public person service that were in the coordination of the actions of the teams that acted directly in the foci. All material cited is filed with the Division of Animal Sanitary Defense, in IAGRO Central. Its content includes all the records of the actions in the outbreaks, as well as the guidelines and activities carried out throughout the State until 2006.

In the period established between June 2006 and April 2007, the Animal Health Surveillance System (VISAN) was responsible for recording animal movement, through the issuance of the Animal Transport Guide (GTA), and also for vaccination records of the state herd. This computerization system was internally accessible, that is, only from IAGRO's public persons service.

The data published in the 2008 PNEFA/DSA/MAPA Annual Report were extracted from IAGRO's monthly reports and, provided every six months to MAPA for the preparation of the Annual Report pertinent to this Department.

III. RESULTS AND DISCUSSION

In 2005, the State of Mato Grosso do Sul (MS) suffered a great economic and social impact when the presence of foot-and-mouth disease virus, serotype O, by IAGRO was detected in the municipalities located in the south of the state (Japorã, Eldorado and Mundo Novo), a region with an international dry border with Paraguay, and there is also a reflection in five municipalities of the State of Paraná (PR).

As described in the Ebook MAPA 2021, after the detection of outbreaks in MS and PR, there was the suspension of the condition of Free Zone in these two States and in ten other Units of the Federation that were part of the Free Zone of Foot-and-Mouth Disease with Vaccination, which were the States of the Federal District, Goiás, Espírito Santo, Bahia, São Paulo, Rio de Janeiro, Sergipe, Tocantins, Minas Gerais and Mato Grosso, which resulted in the closure of cattle trade with OIE member countries [24].

The method used to eliminate outbreaks was based on the elimination of animals susceptible to Foot-and-mouth disease existing in the foci and herds related to them by direct or indirect contact, and on the prohibition of trade and movement of susceptible animals and products at risk for foot-and-mouth disease according to the Annual Report 2008 PNEFA/DSA/MAPA, with indemnification to animal owners eliminated.

According to the Partial Report of the actions adopted for the elimination of outbreaks of foot-and-mouth disease in the municipalities of Eldorado and Mundo Novo - MS/Period: October 2005 - October 2006, prepared by GEASE (2006), initially the safety zone with a radius of 25 km was created around the foci. These zones were divided into three sanitary areas, being: Infected Area (3 km from the focus); Surveillance Area (7 km from the infected area) and Buffer Area (15 km from the surveillance area). In the study by Goulart (2014) mentions that the municipalities of Eldorado, Mundo Novo, Japorã, Itaquiraí and Iguatemi were banned because they had properties within the safety zone, as an area of health risk; and the transit of animals was prohibited in these municipalities mentioned, authorizing only animals for slaughter aiming at internal consumption.

The transport and marketing of products and by-products of animal origin, in addition to the movement of animals, within a radius of 25 km of the foci properties was prohibited. Subsequently, these measures were prolonged for two years.

In addition to the transit of live animals, the activities to control the state's health emergency for the eradication of foot-and-mouth disease virus in the safety zone, was described by Goulart (2014) in five stages, initially: depopulation (herd slaughter); cleaning/disinfection; sanitary void (established a period of thirty days without animals); introduction of sentinel animals and repopulate (gradually the animals were reintroduced) [25].

After the depopulation work, a population-based serological study and sampling methodology in the remaining herds of the banned municipalities was carried out, as presented in the 2008/PNEFA/DSA/MAPA Annual Report, in order to verify the absence of foot-and-mouth disease virus circulation in the herd. From March to August 2006 and from October 2006 to January 2007, two seroepidemiological studies were conducted covering 826 properties and 21.396 samples, according to the guidelines established by the OIE.

The results of the study did not allow to rule out the occurrence of viral circulation in the restricted area: Eldorado, Japorã and Mundo Novo. It was concluded that the zoosanitary measures were sufficient to prevent the diffusion of the viral agent out of the three interdicted municipalities, but were not effective to contain its circulation between the properties within the affected municipalities. In this context, and because it is a serological study involving random sampling, the 2008 PNEFA/DSA/Mapa Annual Report shows that the final result referred to the entire target population of the epidemiological survey and not only to the properties that were part of the sample. As a course, these municipalities remained closed due to existing viral circulation.

A number of cattle were preemptively sacrificed from 118 properties. The owners of the animals were compensated for the difference between the value of the animals and the amount paid by the refrigerator, totaling US$ 7.966.050.00. This preventive slaughter was finalized on June 21, 2007, according to the 2008 PNEFA/DSA/MAPA Annual Report.

The Annual Report 2008 PNEFA/DSA/MAPA shows that in 2007 a seroepidemiological survey was conducted with the objective of evaluating the circulation of foot-and-mouth disease virus in the state. For this, the State was subdivided into four subpopulations. Restricted Area, in the Regions of the Plateau, Pantanal and Border. The study was conducted in 2.046 rural farms in cattle between 6 and 12 months of age, totaling 34.699 cattle. Of these properties, 1.150 primary sampling units were constituted, and in each of them, an average of 30 blood serum samples were collected, in addition to clinical inspections in mouths and paws of all animals.

Also in this same document, the 2008 PNEFA/DSA/MAPA Annual Report, the results of the complementary investigations and the evaluations that were conducted in the primary units, with seropositive cattle, were satisfactory to, based on the established decision criteria and sample parameters used, to demonstrate the absence of viral circulation of foot-and-mouth disease virus in the State of Mato Grosso do Sul. On November 6, 2007, MAPA considered closed the sanitation work of the foci of Foot-and-Mouth Disease registered in the State of Mato Grosso do Sul, based on the official results obtained through the serological survey.

These actions resulting from Iagro's actions were paramount for the subsequent creation of the High

Surveillance Zone (ZAV), in the regions of international border between Brazil and Paraguay and, Brazil and Bolivia, to maintain and protect the health of the herds as well as the economy of the State of MS, through ORDINANCE/IAGRO/MS Nº1,420, of 21/01/2008, amended by Portaria/IAGRO/MS Nº 1.758, DE 03/03/2009 [26][27]. ZAV obtained its recognition as an area free of Foot-and-Mouth Disease with vaccination, through Normative Instruction of the Ministry of Agriculture No. 13, of 03/21/2011[28].

According to Goulart (2014) the main measures of ZAV were the identification with numerical earrings of all sheep and goat herds; the issuance of Animal Transport Guides (GTAs) to accompanied shipments, as well as the supervision of fixed barriers and steering wheels, resulting in total control in animal traffic; the quarantine requirement for animals carried over and to be carried; vaccination against foot-and-mouth, by means of the official needle, carried out by the official organ IAGRO and; serological surveys[25].

The Agency has reformed the surveillance methodology by intensifying surveillance in strategic locations and deploying surveillance in "quadrants". The quadrants contributed to the resizing of health surveillance actions, which were carried out by quadrants directly meeting the two demands coming from the federal sphere (MAPA), with a certain degree of correlation between them, being the first pertinent to the attendance to the PNEFA - Strategic Plan (2017-2026) that aims to lead states to change the health status of free of Foot-and-mouth disease with vaccination, for the free of Foot-and-mouth disease without vaccination and the second, to attend to the fundamental components of QUALI-SV, complying with Normative Instruction Nº. 27, of 07/17/2017[29].

There is another redesigned and intensified system, animal traffic surveillance and animal products. In 2020 mobile surveillance data, according to the e-Saniagro/IAGRO database, show that 91.098 cattle and 336 buffaloes were inspected throughout the state of Mato Grosso do Sul, distributed in 3068 surveillances. Of the tax actions applied, including all species of production animals, 59 records of infractions were drawn up and a fine for transit without GTA.

IV. CONCLUSION

The outbreaks of foot-and-mouth disease in Porto Murtinho in 1998, in Naviraí in 1999 and in the years 2005 and 2006 in the municipalities of Eldorado, Japorã and Mundo Novo, expose three moments lived in an interval of 8 years, which allowed a transformation in the productive system of the State of Mato Grosso do Sul and also, structuring of animal health institutions. Such situations have changed the awareness of the producing class, that the work is not only the responsibility of IAGRO, but also of the entire meat production chain, culminating in the economic success of this market. The State of Mato Grosso do Sul has been without a foot-and-mouth disease outbreak for more than 15 years and the international border region has been vaccinated for more than 99.2 years, including in the South Mato Grosso pantanal region.

Conducting a study on the foci of foot-and-mouth disease and characterizing the border region of the State of Mato Grosso do Sul is the objective of this study, which serves as a reference to maintain and improve health surveillance measures substantially in these regions. These inspections take place throughout the state, however, in the border region must be optimized every year, so that Mato Grosso do Sul achieves the goal desired by IAGRO and also throughout the production chain, the status of foot-and-mouth disease-free area without vaccination.

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