

## **Risk of resident wildlife as the primary source of foot-and-mouth disease virus in Mato Grosso do Sul**

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Received: 05 Oct 2021,

Received in revised form: 01 Dec 2021,

Accepted: 09 Dec 2021,

Available online: 20 Dec 2021

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**Keywords**— *wildlife, foot-and-mouth disease, risk, source of infection.*

**Abstract**— *The state of Mato Grosso do Sul is part of the Midwest region, its strategic position, its borders and its borders with many states are characteristics that require the State to pay special attention to the introduction, dissemination and maintenance of emergency diseases. The state, in addition to climate, vegetation and hydrography has a rich wildlife, mainly in the Pantanal region. The municipality of Corumbá is the first municipality in cattle herd. In this region the cattle production system is almost exclusively extensive with the use of native pasture. This combination: the breeding of commercial herd and proximity to the various wild species and susceptible to foot-and-mouth disease was the object of study, at a time when the State did not share the status of "free area". Studies conducted in the State, Brazil, occasionally or experimentally, show that despite species susceptible to free living, the siids affected by the disease do not become carriers. The only species reported as carrier of foot-and-mouth disease is the African buffalo and does not exist in the country. Despite the need to develop other work with susceptible wild species, the effective control and eradication of foot-and-mouth disease began with the awareness of producers, emergency training given to the Official Service, vaccination campaign establishments, surveillance of properties, surveillance of events, surveillance in slaughter establishments and effective traffic control.*

## I. INTRODUCTION

Mato Grosso do Sul (MS) is the fifth largest cattle producer in the country with a herd of 17,206,260 cattle, representing 9.08% of the total in Brazil. Even with the reduction of 13.18% of the herd, the State still maintains a relevant position. The municipality of Corumbá, in Mato Grosso do Sul, is in second place with the highest number of cattle heads per municipality, with 1.8 million. It is located in the Midwest region in a privileged position close to the major consumer centers and distributors of the country; it has borders with the states of Mato Grosso, Goiás, Minas Gerais, São Paulo, Paraná and also with two countries, Paraguay and Bolivia. This international border strip has an extension of approximately 700 kilometers, of which 300 kilometers without water travel.

In the state of MS we find three important Brazilian biomes, the Cerrado, the Atlantic Forest and the Pantanal. They are biomes with rich biodiversity, resulting from influences from other forest formations and phytogeographies of other Brazilian regions, drained by important rivers such as Paraguay and Paraná [1]. It has two types of climate according to Koppen classification: semi-humid tropical climate, which is present throughout the northern part of the state, with the presence of rain in summer and drought in winter and the tropical climate of altitude, present in the southern part of the state, where summer rains are more intense due to the action of the Atlantic tropical mass, in winter, cold fronts originating in the Atlantic polar mass can cause frosts.

Due to its strategic territorial location, the MS is part of Block IV of the Strategic Plan of the National Surveillance Program for Foot-and-Mouth Disease - PNEFA (2017-2026) and has commercial interests in raising the health status of "foot-and-mouth disease-free area with vaccination" to "foot-and-mouth disease-free area without vaccination".

Foot-and-mouth disease is an acute infectious disease caused by a virus belonging to the picornaviridae family, with high potential for transmission among susceptible animals, and may, in about a week or less, affect all the components of an affected herd. It is the animal disease that has the greatest repercussion worldwide, due to its high infection and contagiousness among animals, such as cattle, sheep, goats, pigs and wild ruminants, among which we can mention buffaloes, cervix, tapirs, capybara, bush pig, cateto, queixada and wild boar, all present in the state of Mato Grosso do Sul. Most wild animals are concentrated in conservation areas, especially the Pantanal Matogrossense National Park.

In Brazil, especially in the state of Mato Grosso do Sul, there are several species of wild animals susceptible to

foot-and-mouth disease virus, but do not play the role of reservoir. Only the African buffalo (*Syncerus caffer*), nonexistent in Brazil, was considered a reservoir of the virus. Scientific studies show the presence of antibodies in wild animals, but there is no evidence that one population predominates as the origin of the infection for the other.

Thus, the objective of this work was to research and verify the level of risk that the wild fauna of Mato Grosso do Sul, being this source of natural infection of foot-and-mouth disease virus.

### a) Geographic Description of Mato Grosso do Sul

The State of Mato Grosso do Sul, in the Midwest region of Brazil, has an extension of 357,145 km<sup>2</sup>. The state extends from the international borders with Paraguay and Bolivia, to the borders with the states of Mato Grosso, Goiás, São Paulo and Paraná in Brazil. The state is bordered by the Paraguay River to the south, southwest and north and the Paraná River to the east. It consists of two continuous geographical areas, formed by the pantanal plain, a large humid area with lots of natural vegetation, (~89,000 km<sup>2</sup>), and a plateau, originally covered by neotropical savannah and dry forest.

The State has several macroecosystems and the peculiar location and vegetation types found in it result in a biological diversity. Many species occur in the country, exclusively or almost exclusively in the south-matogrossense territory, due to this peculiarity [5].

According to Koppen's classification, the climate of the State of Mato Grosso do Sul can be divided into two types: the semi-humid tropical climate and the tropical climate of altitude. The semi-humid tropical climate, predominant in the north of the State of Mato Grosso do Sul, has as a remarkable characteristic the presence of a rainy season in summer, in the period from November to April, and clear dry season in winter, from May to October (July is the driest month). The average temperature of the coldest month can exceed 18°C. With precipitations exceeding 750 mm in the period of one year, and can reach up to 1800 mm. Emphasizing that this climate is typical of the savanna and cerrado areas. The tropical altitude climate, predominant in the south of the state of Mato Grosso do Sul, has temperatures above 22°C in summer and with more than 30 mm of rain in the driest month. This climate has average temperatures between 18°C and 22°C and annual thermal amplitude between 7°C and 9°C [6].

The hydrographic basins, throughout their length, have ripe forests and are composed of a rich fauna of national and international prominence, being distributed throughout their territorial extension (Correntes, Taquari, Negro, Nabileque, Miranda, Apa, Apore, Sucuriu, Verde, Pardo, Invinhema, Amambai, Iguatemi, Santana and Quiteria) [7].

### **b) Main areas of concentration of wild animals**

Mato Grosso do Sul has conservation areas such as the Environmental Protection Area Islands and Floodplains of the Paraná River, Serra da Bodoquena National Park, Emas National Park, Ilha Grande National Park and the Pantanal Matogrossense National Park, with abundance in wildlife in quantity of species and number of specimens.

The history of the implementation in Mato Grosso do Sul (MS) of conservation instruments and tools is very recent, in Brazil the state was one of the last members of the federation that created conservation units. However, more than a decade was set up until the creation of the first conservation unit of integral protection in Mato Grosso do Sul, materialized with the creation of the Várzeas do Ivinhema State Park, in December 1998, with 73,000 hectares, in the forest formations of the Atlantic Forest domain and wetlands, created as environmental compensation for the construction of the Sérgio Motta HOU, on the Paraná River[4].

### **c) Characterization of the Pantanal of Mato Grosso**

The Pantanal is located in the Upper Paraguay Basin and has 138,183 km<sup>2</sup> in Brazilian territory – equivalent to 38.21% of the Paraguay River Basin area. In addition, it is widespread in Brazil (80%) between the states of Mato Grosso and Mato Grosso do Sul, with a small part in northern Bolivia (19%) and eastern Paraguay (1%) [9].

In the study of Allem and Valls (1987) the division of, which affirm that the Pantanal is traditionally divided into limited areas by its main watercourses and by the nature of its historical occupation. The only exception was the separation of the Pantanal of Aquidauana and Pantanal de Rio Negro. Thus, the regions studied were: Pantanal of Nhecolândia, Pantanal of Abobral, Pantanal of Rio Negro, Pantanal of Aquidauana, Pantanal de Miranda and Pantanal of Nabileque. Other studies such as that

conducted by Silva & Abdon (1998) considered aspects related to flooding, relief, soil and vegetation and defined the Pantanal region throughout the continuous area inserted in the Upper Paraguay basin, subject to periodic flooding, between years and within the same year (Fig. 1). The most recent study, by Mito et. al (2012) does the analysis by photointerpretation of satellite images, which captured the entire Pantanal in a single image[8][10][11].

According to Suçuarana (2021) the pantanal fauna is quite diverse. Surveys recorded approximately 263 species of fish, 41 species of amphibians, 113 species of reptiles, 463 species of birds and 133 species of mammals being 2 endemic. The pantanal is also characterized, because it is rich in water, in this large ecosystem that is a great differential of the pantanal biome favoring the fauna, mainly due to the existence of several species of aquatic animals. Livestock, tourism and fishing are the main economic activities of the Pantanal. Deforestation that has been occurring in the pantanal has been the main threat to this biome and inadequate land management for agriculture, the construction of hydroelectric plants and urban and population growth contribute to this threat[12].

Most of the Pantanal is formed by private farms (about 95%) that develop beef cattle. Cattle ranching has been in the Pantanal for more than 200 years, with this, the Pantanal has been shaping the landscape units of the region with little impact, because the food base of cattle are the native forage resources (native pastures) and the optimization of production in the Pantanal must respect the limits of the environment, ensuring the maintenance of biodiversity and resilience (recovery capacity) of ecosystems[13].

The pantanal fauna is very diverse, including wetland deer, monteiro pig, wild boar and wild buffalo.

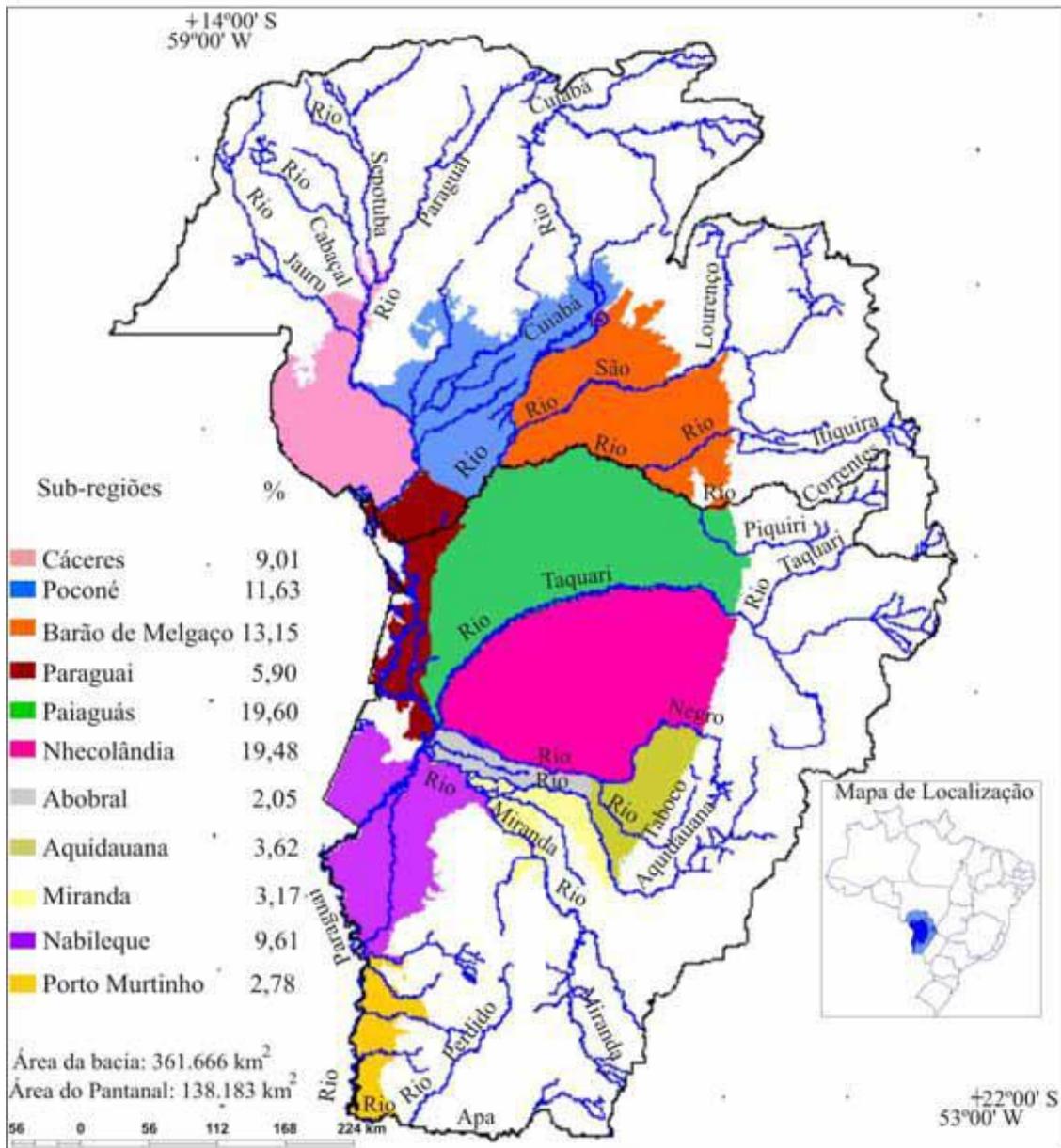


Fig. 1: Thematic map of the delimitation of the subregions of the Brazilian Pantanal. Upper Paraguay basin and Pantanal in Brazil, 1998. Source: SILVA & ABDON (1998)

**d) FebreAftosa (Etiology and epidemiology)**

Being considered as the main disease of mandatory notification foot-and-mouth disease is classified as a disease of list A of the International Health Code, it is a disease of high contagion rate, which puts agribusiness at risk, from countries where cattle ranching has economic importance[15].

Caused by the virus of the genus Aftovirus belonging to the family Picornaviridae, it has an envelopeless icosahedric capsid and by a ribonucleic acid (RNA) molecule of approximately 8,400 nucleotides [16].

Among the seven serotypes of the virus (A, O, C, Asia-1, SAT1, SAT2 and SAT-3), serotypes A, O and C were isolated in occurrences in Brazil. However, several serotypes with different degrees of virulence are described, especially between serotypes A and O [17].

After infection, the incubation period can be from 02 to 21 days (average three to eight) and large amounts of viruses are excreted by infected animals even before clinical signs are evident. Infected animals exhibit blisters and ulcers in the mouth, tongue, lips, feet and udders. Clinically, animals salivate excessively, have fever and sore feet, lose weight and stop producing milk. The losses caused by the disease reflect the fall in productivity and

loss of markets, in addition to embargoes and sanitary barriers applied by meat importers, increase in public and private costs of prevention, control and eradication and compensation when necessary the sacrifice of animals. The losses are also due to the expenses of all the work necessary to return the status of disease-free area according to The OIE rules [18].

Foot-and-mouth disease still occurs in large parts of the world. Its cross-border nature is becoming increasingly important due to the rapid development of international trade in animals and animal products and the increased movement of people around the world [19].

Foot-and-mouth disease is endemic in Africa, much of Asia, the Middle East and parts of South America (Fig. 2). Recently, clusters of foot-and-mouth disease viruses have been determined and seven virus pools have been identified (Fig. 3), where several serotypes occur, but within which there are topotypes that remain mostly confined to this pool. Three pools were defined covering Europe, the Middle East and Asia, three pools covering Africa and a pool covering the Americas. This classification allows a regional approach to be adopted to assist in the global control of foot-and-mouth disease (Fig. 4).

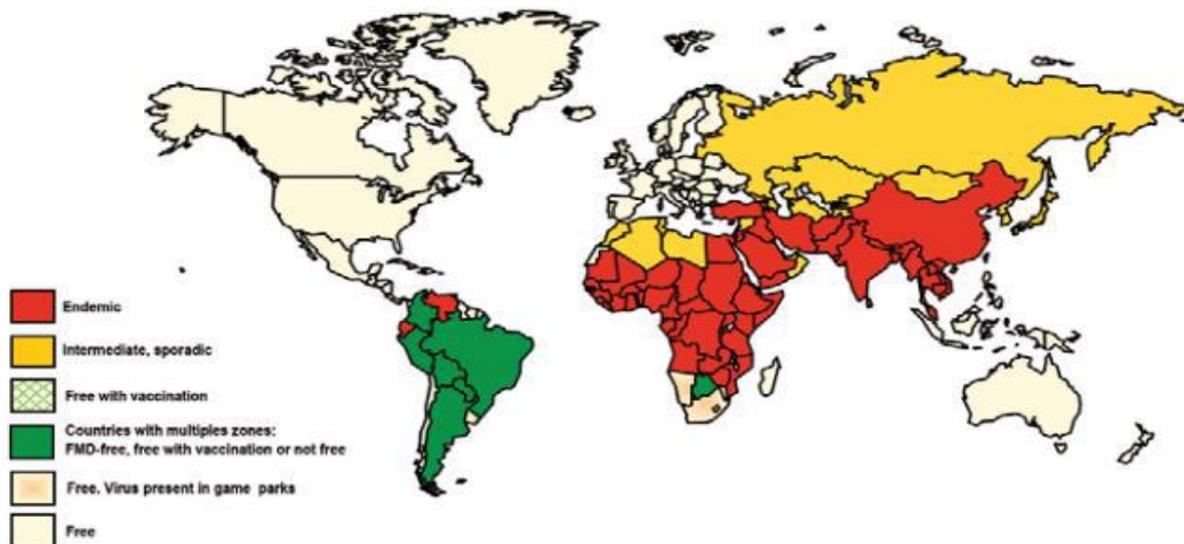


Fig. 2: The conjecture status of foot-and-mouth disease in the world (FAO/OIE, 2012).

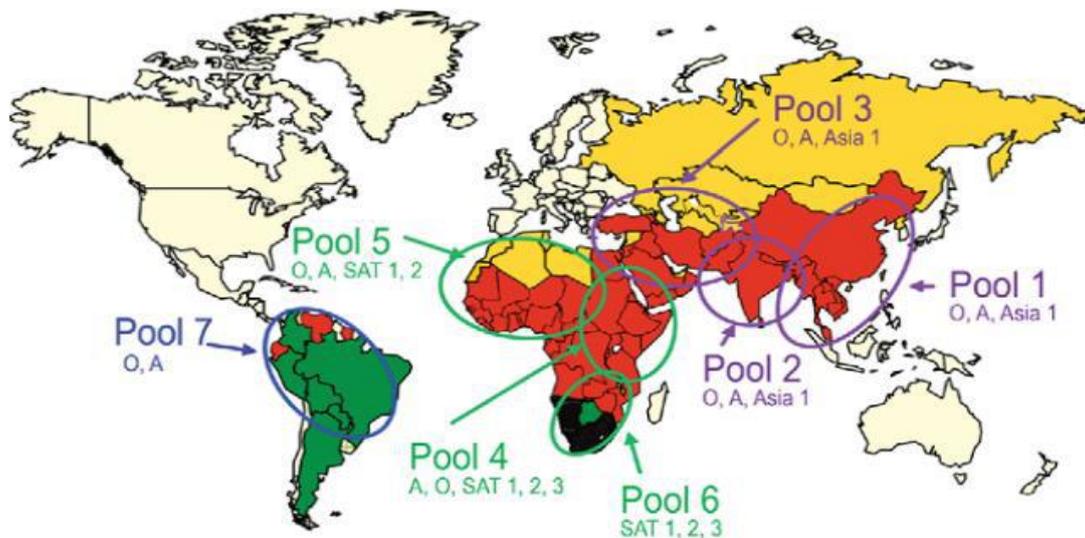


Fig. 3: The conjecture status of foot-and-mouth disease showing approximate distribution of regional virus pools. (FAO/OIE, 2012).

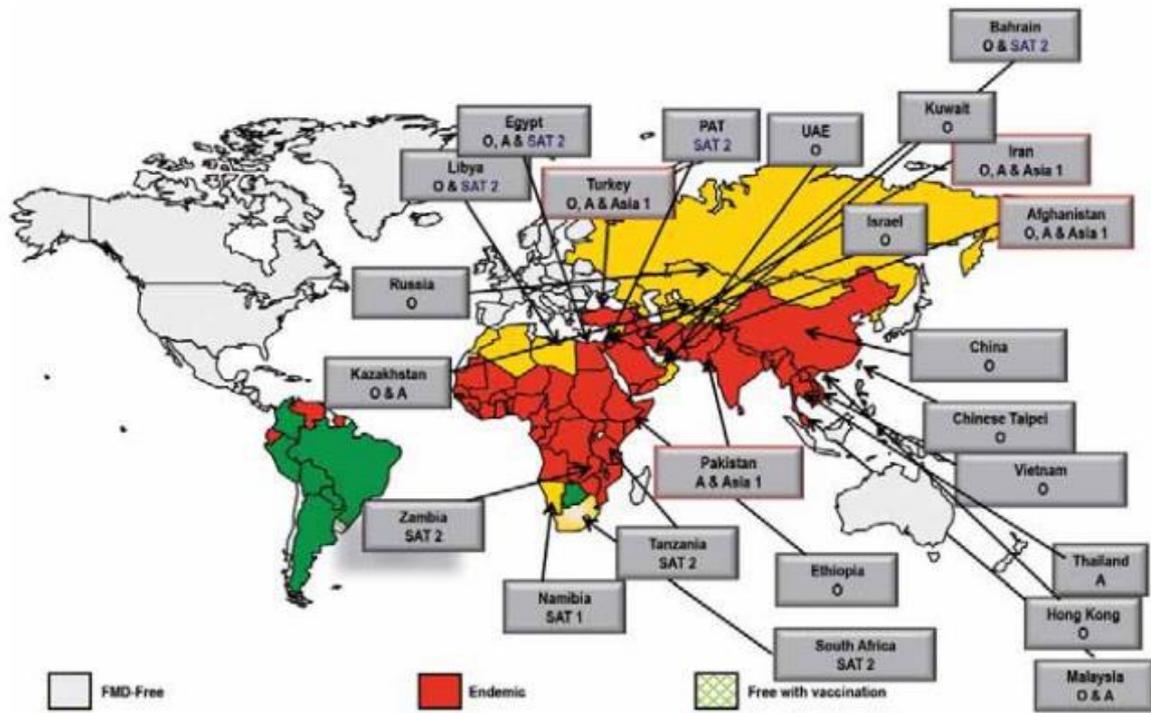


Fig. 4: Overall incidence of foot-and-mouth disease: serotypes identified in the first half of 2012 (FAO/OIE, 2012).

In Brazil, the occurrence of Foot-and-mouth disease was first recorded in 1895 after the description of the occurrence of the disease in Argentina and Uruguay, coinciding with the systematic importation of bovine breeders of European breeds in the emergence of the refrigeration industry[17].

Foot-and-mouth disease is the most significant animal disease and concern worldwide, due to its high infection and contagiousness among animals, bovine species, sheep, goats, swine and wild animals biungulates, causing economic damage throughout the production chain, especially in disabling meat exports, making the production chain unviable [20].

**e) Wildlife x Foot-and-Mouth Disease**

Studies involving epidemiological serum analyses for foot-and-mouth disease in wild animals are older studies or belonging to regions considered endemic, with frequent occurrence of foci.

Paes (2001) reports the scarcity of information about the problem of foot-and-mouth disease in the Pantanal of Mato Grosso do Sul in relation to viral circulation in wild animals and considers it important to control this disease[21].

In his master's thesis conducting a research of anti-virus antibodies of foot-and-mouth disease in susceptible and unvaccinated domestic and wild animal species, in the

pantanal of Mato Grosso do Sul, Paes considers the possibility of, in the specific cases of baguás and bubalinos cattle with older age, the specificity and titer of the antibodies against foot-and-mouth disease virus found, has been the result of an episode of infection that occurred in a distant period at the time of the collection of sera samples from these animals; it may be hypothesis that older individuals have undergone more than one infection caused by different serotypes, and in these cases the stimulus of memory immune response. This explains the non-predominance of a more specific and distinct serological reactivity profile capable of identifying the type of virus that was circulating in the field at the time the samples were obtained in 1998[21].

Paes (2001) also indicates the possibility of infection caused by foot-and-mouth disease virus in domestic and wild bi-ungulate species, a fact attested by sera samples with the presence of antibodies against the VIA antigen now detected in the BFL-ELISA test, although the sampled animals do not present clinical symptoms of the disease and concludethat although the domestic and wild animals studied may be carriers of the same virus and be able to infect the other, there is no evidence in their study that one population predominates as the origin of infection for the other [21].

Taiassusides (cateto and cumptives) are ungulates susceptible to foot-and-mouth disease virus, but no cases

of the disease have been reported in Brazil [22]. In another study conducted at Embrapa Amazônia Breeding, in order to identify the endoparasitosis and the most common parasitic flora in animals, they also collected caimitu material and complained for serological diagnoses of zoonoses such as brucellosis, leptospirosis, tuberculosis and foot-and-mouth disease. The results were all negative or with low titration [23].

Some fauna animals, present in the State, play an important role in the dissemination of other diseases, especially in flooded regions with flooded temperatures. Vieira et al. (2013) reported that mammals from the pantanal of Nhecolândia (wild dog and quatis) presented a potential risk of dissemination of leptospirosis. The analyses indicate that these species were reagents indicating that the antigen is circulating in the environment and suggesting that they are participating in their transmission chain, due to the high density and way of life of these species; other species of wild rodents have also been tested [24].

Among wild animals, the only reservoir of foot-and-mouth disease virus is the African buffalo (*Syncerus caffer*), a wild animal that does not exist in Brazil. It is important to differentiate it from domestic buffalo (*Bubalus bubalis*), an animal used in Brazil for milk, meat and labor production. The African buffalo remains for up to five years as a carrier of the virus, and is the only animal species proven capable of transmitting foot-and-mouth disease virus as a carrier. In Brazil, there are no wild animals that play the role of reservoir, although there are several susceptible species, such as capybaras, tapirs, cervids and taissuids, among others [3].

As demonstrated by Paes (2001), beef and buffalo cattle, which have not been vaccinated, keep the virus for a long period of time, as asymptomatic carrier, with the production of high serum levels of antibodies [21].

The control of wild boars is necessary for the health defense, because wild boar is a risk to crops and production animals, especially pigs from technical farms and subsistence, due to the possible transmission of diseases such as classical swine fever, African swine fever, reproductive and respiratory syndrome of pigs - PRRS, aujeszky disease, however, the boar, despite being an animal that is a susceptible foot-and-mouth disease, does not become a carrier. Semagro Resolution No. 657 of December 22, 2017 regulates the transport of wild boar carcasses slaughtered with authorization from IBAMA for the purpose of population control and monitoring of Classical Swine Fever. The Surveillance Plan of the National Program of Suid Sidae's Health, valid from August 1, 2021, provides for epidemiological surveillance

in technical and non-technical commercial farms, in subsistence farms and provides for monitoring for foot-and-mouth disease in assavage pigs carried out by the management registered in the Official Service of each State.

Although unvaccinated and wild domestic animals, studied in the pantanal of Mato Grosso do Sul, have presented antibodies to foot-and-mouth disease virus, there is no evidence that one population predominates as the origin of the infection for the other. There is a need for a planned complementary study, aiming at viral isolation and/or the detection of genes or gene segments of VFA, from esophageal-pharyngeal mucus of baguás cattle, Indian buffalo and sheep from this and other sub-regions of the Pantanal sulmatogrossense [21].

In addition to the African buffalo (*Syncerus caffer*) in sub-Saharan Africa, wildlife does not play a significant role in maintaining foot-and-mouth disease [25].

The reasons for the increase in the frequency of outbreaks in Zambia and nearby regions are not fully known, but it is suspected to be a consequence of the failure of control measures in the 1990s. The epidemiology of foot-and-mouth disease in this region is aggravated by the presence of a natural reservoir such as African buffalo; the presence of six or seven foot-and-mouth disease serotypes, especially SAT; the mutation of foot-and-mouth disease virus; the high concentration of wildlife; the movement of commercial herds and the knowledge, attitude and perception of small producers about the disease [26].

To date, scientific evidence indicates that outside the situation of sub-Saharan Africa, with types of Foot-and-mouth disease SAT adapted to the African buffalo, effective control of foot-and-mouth disease among domestic herds will result in the protection of both livestock and wildlife, without the need for direct management or intervention activities directed to wildlife [25]. Efforts to control the disease should be directed to vaccination, improved herd management practices, and use of disease control programs [25].

The aim of this study was to increase the risk of reintroduction of foot-and-mouth disease virus related to the coexistence of commercial herds in areas of high density of wild fauna.

## II. MATERIALS AND METHODS

This is a systematic literature review that includes a descriptive phase of data selection relating scientific productions, master's dissertations, doctoral theses, books and electronic data that addressed the researched theme.

Pubmed was used as an electronic database, and Google Scholar: the strategies for searching for computerized data were foot and mouth disease Brazil, foot and mouth disease virus Brazil, foot-and-mouth disease Brazil, foot-and-mouth disease virus in Brazil, wild fauna, risk criteria, pantanal sul-matogrossense, wild animals, biungulates and primary source of infection - resulting in articles published between 1986 and 2021 and which also resulted in more research articles ("articles related" to the search result in Google Scholar - articles present in Science Direct).

Books related to the objective to be researched, electronic data from the website of the Ministry of Agriculture, Livestock and Supply-MAPA, Brazilian Association of Meat Exporting Industries, World Organization for Animal Health-OIE and the Brazilian Agricultural Research Company-EMBRAPA were used. It is important to report that the articles were selected by title, abstract and availability.

### III. RESULTS AND DISCUSSION

All scientific papers selected for this publication were systematically analyzed. The works were separated by major themes such as geographic data from Mato Grosso do Sul, wild fauna and foot-and-mouth disease.

The geographic data and herd data from Mato Grosso do Sul used were the case reports and concepts used to establish climatic, vegetation and hydrography parameters, as well as statistical data from the last livestock census conducted in 2020.

Regarding the disease studied, foot-and-mouth disease, information on the etiology of the disease and epidemiological data published in various documents in various regions of the world were used. The difference in research methodologies was verified in endemic regions and regions that have some control of the commercial herd. In endemic areas, the studies are well detailed, with viral isolation and characterization of the serotype.

Considering the majority of the results of the studies conducted in the last 45 years, the object of this research, it was demonstrated that despite some commercial creations, especially those of extensive breeding and contact with free-living animals, it does not characterize imminent risk of introduction, dissemination and maintenance of foot-and-mouth disease virus. This situation may be related to the coexistence not always so close and constant of wild species and controlled herds.

It is clear in several results described that direct transmission occurs through contact between infected and susceptible animals by ingestion or inhalation of viral particles contained in secretions and excretions and

transmission may also occur indirectly by animated and inanimate vectors as described by Souza (2007) [27]. In areas considered endemic, the movement of infected animals by means of transport between different regions is one of the forms of dissemination of the disease. In addition, the virus remains viable in the form of aerosols and can be distributed by airways between long distances if subjected to favorable heat and humidity conditions [28].

Due to the difficulty of capturing and manipulating wild animals, respecting the physiology of the animal and the well-being of the species, the official monitoring has the experimental design considering all controlled production units, classified by the production purpose and production system adopted.

The National Surveillance Program for Foot-and-Mouth Disease maintains monitoring for the disease on a regular basis in all units of the federation, thus ensuring the absence of viral circulation in the south-mato-grossense territory. The animals reagent in the initial phases of the investigation are submitted to material collection for the use of a test of greater specificity.

As in the surveys for Newcastle disease and avian influenza in migratory bird sites, resident birds, chickens raised extensively, with direct and indirect contact with migratory birds are used. Thus, due to the specificity and sensitivity of the methods of diagnosis of choice, it is possible to monitor a certain disease safely. In the case of birds, there are in some of the established sites, serological and molecular diagnosis is made wild birds, also making it possible to catalog the migrant species and estimate the amount.

### IV. CONCLUSION

In the state of Mato Grosso do Sul, there has been no outbreak of foot-and-mouth disease for more than fifteen years. Despite being a very rich state in relation to fauna and flora, in the last three foci of foot-and-mouth disease there was no solution of continuity or there was no correlation with regard to the transmission of foot-and-mouth disease by wild animals. It is certain that there are margins for more scientific studies related to this theme, but what is concluded is that the risk of resident wildlife as the primary source of foot-and-mouth disease virus in the State of Mato Grosso do Sul, is considered almost nonexistent.

Believing that the conservation of environmental preservation areas and the socioeconomic development of the regions in Mato Grosso do Sul should coexist, especially in the Pantanal region, is that the need for

sanitary surveillance on properties and awareness to the producer is of paramount importance. Other actions such as: animal traffic control; sensitivity of producers to increase the notification of suspected occurrence of diseases or deaths; surveillance in agricultural events and surveillance in slaughterings, the final link in the production chain.

It is important to highlight that the risk of foot-and-mouth disease contamination is composed of several factors such as: the efficiency of surveillance or health control in the country, supervision of animal transport, existence of veterinary service (public and private), coverage of vaccination campaigns, cooperation and awareness of the government and producers regarding the importance of maintaining the health status of foot-and-mouth disease free with and without vaccination.

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