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Research Article

Epidemiological Indicators of Classical Swine Fever that Occurred in Brazil in 2019 and Implications for Global Porcine Market

Renata Vieira Chaves Gabriel[1], Isabela Gonçalves da Silva[1], Lara Ellen Correa Nogueira Silva[1], Alexandra Cristina Silva[1], Alcione da Silva Fernandes Dinato[1], Eduardo Souza Dinato[1], Lindomar Pereira da Silva Filho[2] and Sérgio Eustáquio Lemos da Silva[1]*

[1]Centro Universitário do Triângulo, UNITRI, Brazil

[2]Faculdade Presidente Antônio Carlos, UNIPAC, Brazil

***Corresponding Author:** Sérgio Eustáquio Lemos da Silva, Centro Universitário do Triângulo, UNITRI, Brazil.

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Abstract

Classical Swine Fever (CSF) is an infectious disease, caused by the Pestivirus and highly contagious, being considered of mandatory notification by the OIE. Considering the cases of CSF that occurred in Brazil in 2019, this article sought to correlate the epidemiological indicators recorded in the national territory with risk factors that predispose to the incidence of this disease, as well as with the components of the epidemiological chain that are associated with prevention and the consequences for the economy of the sector. The study revealed that in the first half of 2019, 667 cases were confirmed. On the other hand, in the second half of the year, 79 cases were confirmed, with the states of Piauí, Ceará, and Alagoas registering the highest prevalence of the disease. In the period analyzed, in the regions of incidence of the disease, 1303 and 336 pigs were susceptible to the virus in the first semester and second semester, respectively; that is, they were exposed to the risk of getting sick. Therefore, analyzing and understanding the health indicators of CSF in the Brazilian territory (in space) and in the year 2019 (in time), means a way to ensure that the Brazilian pork market continues to grow, in addition to developing and improving plans for the control, prevention and eradication of the disease.

Keywords: Pestivirus; Pig farming; Incidence; Prevalence

Introduction

Pork is the most consumed source of animal protein worldwide. Brazil has an organized and quality pork production chain capable of offering this animal protein to all Brazilians – on average, 16 kilos per person – and also exporting to all continents. Brazil's performance is significant when compared to the world average [1].

Currently, Brazil ranks 4th in the world as a pork producer, with approximately 4.436 million tons produced in 2020. Of all this production, 77% is destined for the domestic market, and 23% is exported. Around 1.024 million tons were exported that same year, placing the country in 4th place in the world in the international market ranking based on data from the Poultry and Swine Intelligence Center of the Brazilian Agricultural Research Corporation [7].

Pig farming is an important economic activity for Brazil. In recent years, this activity has undergone improvements, as a result of technological advances in agribusiness, with increases in productivity and a decrease in production costs. Brazilian pig production stands out for the large extension of the geographical spaces, allowing the expansion of the herd and also aspects such as the ease of access to grains for feed production, the presence of water and the favorable climate [7]. According to the Food and Agriculture Organization of the United Nations [8], the availability of agricultural areas is concentrated in a few countries; about 90% of the

land for agricultural expansion is in Latin America and sub-Saharan Africa. In addition, countries such as China and the United States no longer have new areas available for agricultural exploitation, which makes the costs of Brazilian pork production lower compared to the costs of these same countries.

In Latin America, Brazil is an important world food producer, with great potential for expanding supply. In 2012, there were 246,629 hectares in agricultural production, 28% in agricultural production, 69% in livestock production and 3% in forest planting, according to data from the Agricultural Census [11].

Concomitant with the increase in production, the demands of the consumer market also grow with the required food safety parameters, whether at a national or international level. Food safety has been widely discussed by countries that import meat, which are concerned about having safe, healthy food, free of contaminating microorganisms and of good origin. In the international context, institutional arrangements dealing with traceability in the food supply chain are developing rapidly due to concerns related to animal health, the threat of bioterrorism, food safety, international trade, consumer demand, and the scalar management of the supply chain [32].

Classical Swine Fever (CSF), also known as Swine Fever, Swine Cholera or Classical Swine Fever is a highly contagious infectious disease caused by an RNA virus, with cosmopolitan distribution, belonging to the family Flaviviridae and the genus Pestivirus, which affects domestic and wild pigs. It is not a zoonosis. CSF is characterized by a wide variety of clinical signs and lesions with a predominance of the hemorrhagic type [20].

The disease has worldwide distribution, but some countries are free or have free zones. Currently, the occurrence of foci of the disease in Brazil is limited to the non-free zone. The country has about 95% of the industrial production of pigs in an area recognized as free of the disease by the World Organization for Animal Health (OIE), which includes a large part of the national territory [9].

The main route of transmission of the virus is through direct contact between infected and susceptible pigs, or through the ingestion of meat products of porcine origin contaminated with viruses from human food remains. Such a virus is able to survive cold environments and some types of processing, such as in cured and smoked meats. The movement and introduction of infected pigs into the herd are the main ways of spreading the disease, for which there is no treatment. Therefore, the affected pigs must be slaughtered and the carcasses must be buried or incinerated [9].

The increase in production allows animals to be more susceptible to diseases, which can generate a great economic loss in the sector. In this sense, prevention measures aim to minimize the possibilities of CSF entry, favoring the Brazilian scenario. Understanding biosecurity and its importance in this process is essential to maintain the development of the activity in a sustainable and profitable way. This is a tool of increasing importance in agribusiness, proving to be essential for the survival of technified farms [2].

However, in order to continue to be internationally recognized for its production, Brazil seeks to eradicate the disease throughout its territory. This is a challenge for pig farming in Brazil, as ensuring total or partial control throughout the territory depends on inspection and, mainly, on knowledge about the disease, in addition to attention to all epidemiological issues. Given this scenario, the emergence of diseases such as Classical Swine Fever and African Swine Fever in Brazilian pig herds may hinder the country's performance in the export market.

The objective of this study was to survey the epidemiological indicators of incidence, morbidity, lethality and mortality of Classical Swine Fever in Brazil in the first and second semester of 2019, in addition to correlating these indicators of disease measurements with the risk factors that predispose the emergence of this disease with the epidemiological chain and its consequences for the economy of the sector.

Methodology

The present study was carried out based on an exploratory bibliographic research with the scientific databases Scielo, Google Scholar, Medline and Lilacs, with a time frame of publication between the years 2003 and 2020. The database of the website of the Ministry of Agriculture, Livestock and Supply was also used, detailing the records of CSF cases that occurred in the first and second half of 2019 in Brazil that were reported to the World Organization for Animal Health. For the search, the following keywords were used: classical swine fever, epidemiology, pig farming, world market, pork and biosecurity.

The study included reports, plans to combat swine fever, technical notes, manuals, tables, graphs and panels of statistical indicators from the Ministry of Agriculture, Livestock and Supply. Based on the material collected, a qualitative analysis of the selected articles and documents was carried out, seeking to evidence

the incidence, morbidity, lethality, and mortality of CSF in Brazil in the first and second semester of 2019, correlating these indicators of disease measurements with the risk factors that predispose the emergence of this disease with the epidemiological chain and its consequences for the sector's economy.

Results and Discussion

CSF is a highly infectious disease with a high rate of contamination and is often fatal to pigs. Also known as Swine Fever or Cholera, it affects both domestic and feral pigs. The reservoir of the disease is domestic pigs and wild pigs, which are like natural reservoirs of the virus [12].

This disease is serious in pigs, but it is not transmitted to humans or other species. It is a notifiable disease for the World Organization for Animal Health, with high morbidity and mortality, which has significant consequences for animal welfare and socioeconomic, health and environmental losses [20].

CSF is caused by RNA viruses of the family Flaviviridae, genus Pestivirus, and three genotypes are currently described. The disease has worldwide distribution, but some countries are free of it [10]. A large part of the Brazilian territory, where pig farming is technified, is considered a CSF-free zone without vaccination [35]. CSF is characterized by a wide variety of clinical signs and lesions with a predominance of the hemorrhagic type. The infection causes great destruction of monocytes, lymphocytes, and mature neutrophils, causing immunosuppression. There is also a severe reduction in the number of platelets, leading to increased clotting time and generalized hemorrhages, typical of the classic manifestation of the disease [19].

The disease presents differently in the acute, chronic and congenital forms. In the acute form, pigs are affected with a strain of high pathogenicity and virulence that can be acquired or congenital. Clinical signs are high fever, anorexia, lethargy, occasional vomiting, dyspnea, cough, and crowding of piglets. The chronic form is caused by a strain of lower pathogenicity and virulence, and in partially immune herds. Signs are listlessness, intermittent fever, diarrhoea, bristling hair, seemingly eventual recovery, and death at approximately three months. In the congenital form, which occurs in fetuses and piglets, maternal infection occurs early in gestation and causes fetal death, fetal resorption, birth of piglets with malformation, or neonatal mortality [12].

A preventive measure applied to the source of infection is to identify the herds and then adopt the sacrifice and, subsequently, perform emergency vaccination (official needle) depending on the sero-epidemiological condition. Vaccination against CSF will only be carried out if the emergency use of the official vaccine is authorized through a specific plan approved by the Ministry of Agriculture, Livestock and Supply, which includes extension and delimitation of the geographical area in which the vaccination will be carried out [12].

Actions aimed at preventing, minimizing or even eliminating the risks of contamination by CSF, inherent to pig production activities, involve care with feeding, cleaning and disinfection of objects and trucks, prohibiting the use of food waste, and correct handling of the destination of waste, corpses and garbage [4,24].

Transmission of the disease occurs mainly through direct contact between infected and susceptible animals via the oronasal route. It can also occur indirectly, through people, vehicles, contaminated and undercooked meat fed to piglets, or even by aerogenous route over short distances, such as up to 1 kilometer [4,24].

According to Ishizuka., *et al*. [12], pigs infected with virus strains of low pathogenicity and virulence eliminate it continuously for months in the absence of clinical signs. Therefore, for the safety of the swine herd, attention is needed with regard to biosecurity, hygiene and active immunization of the herd.

The diagnosis of the disease is based on its signs, history, and epidemiological indicators. Thus, the clinical diagnosis is probable, and its confirmation by means of official laboratory tests is essential, since CSF is a disease of great economic impact, with no treatment available. It is important to emphasize that, in the case of detection of outbreaks, the sanitary sacrifice of sick animals and their animals is carried out direct and indirect contacts, in addition to other health defense measures provided for in legislation [15,17].

CSF is a disease of importance for domestic pigs, and is part of the "A" list of the World Organization for Animal Health whose diseases are notifiable, even though they do not pose a risk to human health. The "A" list includes communicable diseases that have the potential for rapid and serious spread, regardless of national borders. In addition to these, this list includes diseases that have serious socioeconomic or public health consequences and that are of great importance for the export of animals and products of animal origin [33].

The World Organization for Animal Health is responsible for certifying the health status of all countries that export animal pro-

tein. Therefore, in the occurrence of these diseases, notification is mandatory. The sanitary condition of the country is given according to the type of infectious agent present or not. Countries are considered to be free, endemic or with the presence of the disease in all or part of the territory. This sanitary condition is the main reference for the safe trade of animals and their products between countries [10]. According to the occurrence of CSF cases in Brazil, the infection was endemic in several regions until the 1980s, a period in which the Ministry of Agriculture's Official Programs for Combat and Eradication were implemented [20].

According to the CSF-free Brazil Strategic Plan, the infection is in the process of being eradicated, and the country can be divided into two distinct areas: an area free of the disease and which concentrates more than 80% of the national herd with the main pig farms and industries; and a region where isolated foci of the disease still occur [26]. In recent years, outbreaks of the disease have occurred in some states in the Northeast and North regions of Brazil. However, efforts are being made to make the entire territory disease-free [20].

In Brazil, there are two zones with different animal health situations regarding CSF: a free zone where there are no records of cases of the disease, which corresponds to the states of Rio Grande do Sul, Santa Catarina, Acre, Bahia, Espírito Santo, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Paraná, Rio de Janeiro, Rondônia, São Paulo, Sergipe, Tocantins, the Federal District and the municipalities of Guajará and Boca do Acre, the southern part of the municipality of Canutama and the southwestern part of the municipality of Lábrea and the state of Amazonas; and another non-free or infected zone, with the presence of the disease in the states of Alagoas, Amapá, Amazonas, Ceará, Maranhão, Pará, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Roraima.

Since October 2018, with the intensification of surveillance in the zone not recognized as free of CSF in Brazil, the detection of suspected and confirmed outbreaks of CSF in the state of Ceará and Piauí in 2019 increased. Surveillance for the detection of suspected CSF continues throughout the country, and the mobilization of animals and products at risk from the infected zone to the free zone is prohibited [21,22].

Much of Brazil's pig production is located in the free zone of CSF without vaccination. The most recent outbreaks have occurred in the Northeast region and are located in the area considered endemic for the disease. In 2019, according to data from the official website of the coordination of information and epidemiology in animal health of the Ministry of Agriculture, Livestock and Supply [16,17], outbreaks of the disease were detected in the states of Ceará, Piauí and Alagoas. However, it is considered that the national pig herd has a very good health, and that the control measures used guarantee high productivity. Even so, it is necessary to prioritize rapid and efficient diagnostic systems, as well as to support health defense [35].

In contrast to the states where the health status is positive, pig farming is intensified and actively participates in the economy, making Brazil an important country in pig production. The North and Northeast regions of Brazil face difficulties in eradicating the disease, given that some cultural practices in the region leave the health focus aside [20]. These regions have precarious sanitary conditions, with small herds. Commonly, there is production of different species in the same area. In addition, the loan and contact of animals between properties are common practices, and there is no registration/control [29,30].

Based on this "health status" in Brazil regarding pig farming, the importance of an epidemiological study on CSF is understood. Epidemiology can be defined as the science that studies the health--disease process in human collectivities, analyzing the distribution and determining factors of diseases, damage to health, and events associated with public health, proposing specific measures for the prevention, control, or eradication of diseases, and providing indicators that support the planning, administration, and evaluation of health actions [27].

Based on epidemiological indicators, the occurrence of diseases can be evaluated under three aspects: who is affected (animal category, type of farm), when the disease occurs (temporal relationship, if there is a period of greater occurrence, for example) and where (spatial relationship, if the disease occurs more in a certain region, for example). After this initial description, the association of the occurrence of diseases with some previously determined risk factor can be evaluated [6].

There were 667 confirmed cases of CSF in Brazil in the first half of 2019. In the state of Ceará, 85 cases were recorded in January, 97 in February, 176 in March and 21 in April. In Piauí, there were 20 cases in February, 116 in May, 63 in April and 89 in March [21].

In the second half of 2019, 79 confirmed cases of CSF were recorded in Brazil. In the state of Ceará, 10 cases were recorded in

July and 22 in August. In the state of Alagoas, there were 32 cases in September and 4 in October. In Piauí, there were 11 cases in October. In the same period in the regions where these cases were recorded, 1303 pigs were susceptible in the first half of the year, and 336 pigs were susceptible in the second half of the year, i.e., they were exposed to the risk of becoming ill with CSF [22], as shown in table 1.

Locality	Nº Susceptible		Nº Cases		Deaths	
	1st Semester	2st Semester	1st Semester	2st Semester	1st Semester	2st Semester
Alagoas	---	38	---	36	---	02**
Ceara	673	269	379	32	270**	25**
Piaui	630	29	288	11	244**	10**
Total	1303	336	667	79	514**	37**

Table 1: Distribution of Classical Swine Fever Foci in Brazil in 2019.

Note. Information such as location, susceptible animals, number of cases and deaths were taken from the World Organization for Animal Health [21,22]. **Animals that have died from the disease. All susceptible animals that did not die from the disease were culled.

The general health situation of the pig herd in Brazil is very good compared to the situation in other producing countries [31]. However, in these regions, infections occur in small farms with non-technified productions, where there are usually subsistence farms without a structure for the meat trade. Small-scale pig production can play an important role in the spread of diseases, mainly due to the lack of information about diseases and their clinical signs, procedures for offering meal waste to animals, and biosecurity measures [28]. Extensive pig farms are common in the Northeast region of Brazil, where CSF outbreaks have occurred. According to Oliveira., *et al*. [20], subsistence farms should receive particular attention, prioritizing serological surveys.

It is known that extensive pig farming systems may be more likely to suffer from CSF infections, as outbreaks of the disease are commonly initiated when a domestic pig comes into contact with infected material originating from wild pigs. Subsistence producers usually have low productivity and little technology (both genetics, nutrition and management techniques) on the properties. Usually, they use family labor and carry out various agricultural and livestock activities [18].

The feeding of domestic or wild pigs with leftovers of human food is typical of this type of pig farming. In addition, there is a risk of feral pigs having access to contaminated pork products improperly disposed of in landfills. Since the early days of pig farming, it has been known that most diseases can be avoided by simple management practices, provision of adequate feed, hygiene, and disease prevention practices [5].

Therefore, the care with the feeding of domestic and wild pigs, preventing them from having access to human food remains, is a relevant factor to avoid infection by swine fever. This risk is exacerbated in the population of this region, where a significant portion of pig slaughters are carried out clandestinely under precarious hygienic conditions, and whose meat reaches the consumer without any sanitary inspection [3].

Knowledge of CSF case records in Brazil is extremely important not only for the economy, but also for public health, since it can direct and enable the adoption of control and prophylaxis measures, reducing the financial losses and the risk of zoonotic transmission caused by these diseases [3].

The imposition of trade barriers to pork exports has led to an intensification of measures aimed at improving the health profile of herds [25]. The pig farming market in the country has been increasingly concerned with the health status of the national pig herd. However, the use of biosecurity measures can avoid major economic losses.

In view of the above data, which were consulted in the Semiannual Report for the Notification of the Presence of Diseases of the World Organization for Animal Health List in 2019, provided by the website of the Ministry of Agriculture, Livestock and Supply, it is possible to calculate the rates of Prevalence, Incidence, Mortality, Morbidity and Lethality of CSF in Brazil in 2019, as shown in Table 2.

Rates	Alagoas		Ceara		Piaui	
	1st Semester	2st Semester	1st Semester	2st Semester	1st Semester	2st Semester
Prevalence	---	94,73%	56,31%	11,89%	45,71%	37,93%
Incidence	---	94,7%	56,31%	11,89%	45,71%	37,93%
Morbidity	---	94,73%	56,31%	11,89%	45,71%	37,93%
Lethality	---	5,55%	71,24%	78,12%	84,72%	90,90%
Mortality	---	5,26%	40,11%	9,29%	38,73%	34,48%

Table 2: Prevalence, Incidence, Morbidity, Lethality, and Mortality Rates of CSF in Brazil in 2019.

Note. Information such as location, susceptible animals, number of cases and deaths were taken from the documents: World Organization for Animal Health (2019a; 2019b).

When analyzing Table 2 prepared with data from the Biannual Report for the Notification of the Presence of Diseases on the World Organization for Animal Health List in 2019, it is noted that CSF has high morbidity and mortality, which has significant consequences for animal welfare and socioeconomic, health, and environmental losses. All animals in the herd should be euthanized, even if they do not have the disease. Confirmed cases and pigs that have had contact should be euthanized, and protective measures for other groups should be adopted, such as: slaughtering infected animals, restricting the transport of pigs, or vaccination, depending on the disease control regulations in place [14,23].

Frequency measures, i.e., prevalence rates and incidence rates, are essential for the study of the occurrence and frequency of diseases. Prevalence is understood as the proportion of individuals who have the disease at a given time. Of the cases that occurred in the first half of 2019, it can be said that there was a high prevalence of the disease in the period: around 56.31% in the state of Ceará and 45.71% in Piauí. However, there were records of a decrease from the first to the second semester, which may be related to the prevention and eradication measures adopted to contain the disease in these regions [21,22].

Incidence refers to the number of new cases of a healthy individual developing the disease in a population over a period of time. Thus, the data show a decrease in the incidence of CSF in the states of Ceará and Piauí. On the other hand, in the second half of the year, there were outbreaks in Alagoas, increasing the incidence rate of the disease in this region. Alagoas had no records of CSF cases in the first half of the year, and in the second half of the year it recorded 36 cases. One of the factors that may have facilitated the entry of the disease into herds is mainly caused by their geographical location.

Lethality is the ratio of the number of deaths caused by a disease to the total number of individuals affected by it in a given area and over a given period of time. According to the data in table 2, the case fatality rate is quite high, exceeding 70% in the second half of the year in the state of Ceará and 80% in Piauí. This means that the disease is severe and kills many individuals.

In addition, the morbidity, mortality, and lethality rates of CSF are high in non-immunized pigs and in acute infections, with a lethality rate approaching 100%. This rate is lower in subacute cases and chronic infections, as it affects a smaller number of animals in the herd. Some variations can be observed if the disease is endemic in the herd or the animals are previously vaccinated [19,34].

Because it is a highly contagious disease that is difficult to control in regions with a high concentration of pigs and areas with a population of wild pigs, it is necessary to pay attention to the predisposing factors that favor the spread: the existence of non-technified breeding; high stocking density; farms very close by; lack of sanitary management; lack of control or discipline in the marketing system; agglomerations (fairs, auctions, exhibitions); mixture of animals of different ages or origins; feeding with kitchen waste or garbage; lack of active surveillance actions, such as serological monitoring, which favors the presence of permanently infected sows or immunotolerant piglets (carriers); lack of a system for the rapid notification of suspected cases; lack of biosecurity; lack of health education programs for breeders and intermediaries, among others [13,24]. In this way, pig producers who live with the presence of CSF in their farms suffer irreversible losses, hence the importance of strategies to eradicate the disease throughout the territory. In this sense, health education is an instrument of preventive veterinary medicine that aims to change the attitude of social actors in the production chain towards the prevention, control and eradication of animal health problems [17].

In addition to losses in the field of exports, the losses also affect, mainly, sectors of society in which pig farming represents the only source of animal protein or the main source of family income. To this end, attentive animal health surveillance is essential, and the awareness of all actors involved in pig farming is extremely important. According to the Standardization Manual of the National Swine Health Program [17], This awareness of the socioeconomic aspects, clinical signs, transmission, damages, prevention and risks caused by diseases can be carried out through the media, lectures, educational material, leaflets, booklets and posters. These resources should be aimed at the target audience in clear and objective language. All of this will contribute to early detection and rapid reaction to CSF outbreaks.

In view of this scenario, according to the Strategic Plan Brazil free of CSF [15], which aims to eradicate CSF in the non-free zone of Brazil, the eradication of this disease in the country will also contribute to improving the image and access to markets of national livestock products, considering that it is a disease eradicated in most developed countries. including all major pork exporters.

Thus, effective programs are needed to eradicate CSF, since control in large territorial areas is complex, the diffusion of the disease is aggravated by transport, and it is possible to consider that the real incidence of the disease exceeds the notifications [20].

Final Considerations

In Brazil, the CSF-free zone has states that actively participate in the economy through intensified pig farming. To this end, these states constantly develop prophylactic measures, following norms that enable positive health status. On the other hand, in the non-CSF-free zone, health aspects are left aside due to the cultural practices of the region, which makes it difficult to eradicate the disease. Eradicating the disease throughout the Brazilian territory means ensuring that the Brazilian pork market continues to grow, and the production of pigs is increasingly intense, since, today, the country has a good sanitary level, being internationally recognized for its production.

It should be noted that, with this increase in production, animals are more susceptible to different diseases, which can generate a great economic loss in the sector. In this sense, biosecurity measures aim to minimize the possibilities of CSF entry, favoring the Brazilian scenario with a good health status of the swine herd around the world. In addition, small pig farms can hinder the control of CSF, since they usually have a low level of biosecurity and commonly report the presence of wild pigs on the farms, which are considered reservoirs of diseases. Therefore, it is extremely important that information about diseases and prevention measures reach these small producers in order to prevent them from being the gateway to the CSF virus, since they have difficulty accessing information or even ignore the necessary information essential to prevent an outbreak of the disease.

Therefore, CSF is a challenge for pig farming in Brazil, as the guarantee of total or partial control throughout the territory depends on inspection, accurate diagnoses, laboratory support, knowledge about the disease, qualified labor and agility in notifications, avoiding underreporting. All these measures should be improved consecutively in the face of epidemiological issues. Particular attention should be paid to subsistence farming, prioritizing serological surveys in order to ensure the safety of the CSF-free zone, in order to make Brazil free of the disease.

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