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Animal sporotrichosis in two municipalities in Mato Grosso do Sul - Brazil: epidemiological aspects from a One Health perspective

Esporotricose animal em dois municípios de Mato Grosso do Sul - Brasil: aspectos epidemiológicos sob a perspectiva de uma só saúde

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Abstract: Human and animal sporotrichosis has been observed in Corumbá and Ladário, Mato Grosso do Sul (MS), Brazil, since 2011. The unique characteristics of border areas and the human-environment-animal interface necessitate the development of health policies and programs that incorporate One Health concepts, fostering advances in health research and management. This article examines the epidemiological aspects of feline sporotrichosis with the aim of supporting decisions pertinent to its prevention, control, and public health management. Data were collected from veterinary records between 2011 and 2018, encompassing 315 cases (five dogs and 310 cats). Mapping of compatible or confirmed cases of animal sporotrichosis was conducted using QGis, though data loss posed a significant limitation. Descriptive statistics assessed the frequency of variables, geo-statistical analysis methods, and disease occurrence rates. This study represents the first investigation of sporotrichosis in the state. The occurrence rate in felines varied from 0.04% to 3.50% between 2015 and 2018. The typical profile of infected cats was young adults that were not neutered. The euthanasia rate was 76.50%, while the cure rate for treated animals stood at 64.90%. A higher number of cases was associated with more populous neighborhoods, indicating these as higher-risk areas. The findings were crucial in engaging public authorities and the community to address sporotrichosis. However, improvements are needed in areas such as case notification, laboratory diagnosis, treatment monitoring, health education, responsible pet ownership, and population control of felines.

Keywords: mycosis; public health; spillover; zoonosis.

Resumo: A esporotricose humana e animal têm sido observadas em Corumbá e Ladário, Mato Grosso do Sul (MS), desde 2011. Em razão das especificidades das áreas fronteiriças e da interface humano-ambiente-animais o desenvolvimento de políticas e programas de saúde, considerando conceitos de "uma só saúde", é um caminho para a pesquisa e a gestão da saúde. O artigo discute sobre aspectos epidemiológicos da esporotricose felina com o objetivo de dar suporte às decisões pertinentes a sua

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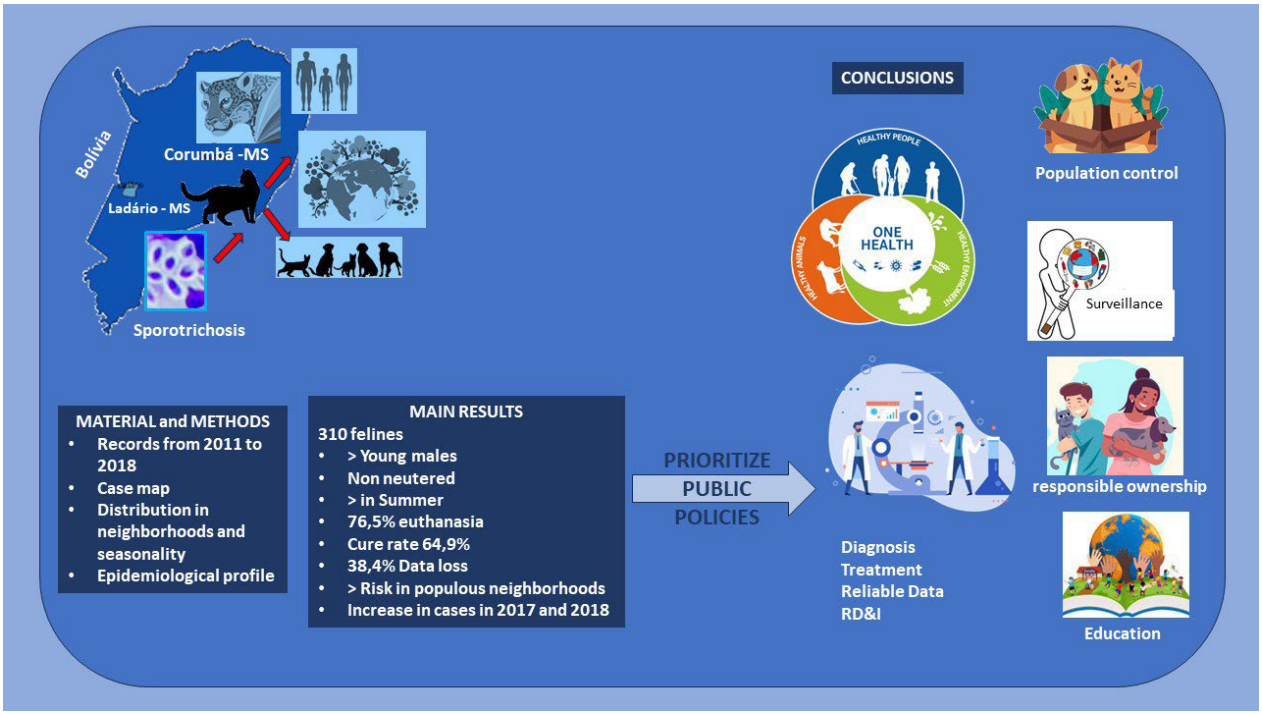
prevenção, controle e gestão da saúde pública. Coletou-se informações em prontuários veterinários, entre 2011 e 2018, totalizando 315 casos (5 cães e 310 gatos). Realizou-se o mapeamento dos casos compatíveis ou confirmados de esporotricose animal, utilizando o QGis, entretanto a perda de dados foi um aspecto limitante. Foram realizadas estatística descritiva para frequência das variáveis, métodos de análise geo-estatística e taxas de ocorrência da doença. Este é o primeiro estudo sobre esporotricose no estado, a taxa de ocorrência, em felinos, variou de 0,04% a 3,50% entre os anos de 2015 e 2018. O perfil dos gatos infectados foi: adultos jovens, machos não-castrados. Taxa de eutanásia foi 76,50%, a taxa de cura em animais tratados foi 64,90%. O maior número de casos relacionou-se a bairros mais populosos, indicando que essas seriam áreas sob maior risco. Os resultados foram fundamentais para mobilizar o poder público e a sociedade em atenção à esporotricose, mas é preciso melhorar aspectos relacionados a notificação de casos, diagnóstico laboratorial, a acompanhamento do tratamento, educação sanitária, guarda responsável e controle populacional de felinos.

Palavras-chave: micose; saúde pública; transbordamento; zoonose.



Graphical abstract

1. Introduction

Sporotrichosis, a disease caused by the dimorphic fungus of the genus *Sporothrix*, is widely distributed worldwide, particularly in tropical and subtropical regions. It is recognized as the most common subcutaneous mycosis in South America[1, 2].

The disease typically has an occupational nature, associated with activities involving soil cultivation and handling. Transmission occurs through the inoculation of the fungus into the skin and subcutaneous tissue via traumatic injuries with contaminated material. The domestic cat is the principal vector for the transmission of *Sporothrix* sp. among animals and to humans, attributed to the high fungal load in its lesions and behaviors that facilitate the inoculation of the agent into both domestic and wild animals through scratches or bites from infected cats[3, 4, 5].

The species *S. brasiliensis* and *S. schenckii* are related to both zoonotic transmission and horizontal animal transmission, but the increase in the number of urban cases is associated with *S. brasiliensis*[6].

Zoonotic transmission of *S. brasiliensis* began in the late 1990s in the state of Rio de Janeiro, which today faces a hyperendemic situation concerning sporotrichosis. Persistent epizootics have been detected in the south and southeast regions of Brazil, with additional reports of outbreaks in various municipalities across the country. Factors such as the absence of mandatory notification and delayed diagnosis and treatment contribute to the spread of this disease to at least 25 Brazilian states and neighboring countries, including Argentina[5, 6].

The first cases of human sporotrichosis in Corumbá and Ladário were reported in the media in 2016, although an incident involving an animal and a human had been described in 2011. The Regional Council of Veterinary Medicine of Mato Grosso do Sul has since released information measures regarding this zoonosis[7].

The lack of official information and scientific evidence concerning sporotrichosis in these municipalities has motivated researchers to investigate its occurrence, supported by public health management and veterinarians.

The location of these municipalities on the Brazil-Bolivia border was considered a critical factor in investigating the epidemiological situation of sporotrichosis, as there was no information available on human or animal cases of sporotrichosis in Bolivia.

Consequently, it was recognized that the absence of awareness about this disease directly interferes with the effectiveness of prevention and control strategies for this zoonosis, potentially posing a significant risk to the public health of local populations[8].

In this context, this study aimed to provide insights into animal sporotrichosis to aid in the development of a comprehensive work plan that addresses the issues of epidemiological surveillance, diagnosis, treatment, prophylaxis, and disease control. This plan is intended to enable informed decision-making that enhances health care quality in this Brazil-Bolivia border region of Mato Grosso do Sul.

Moreover, it is hypothesized that the implementation of health programs with a One Health approach will enhance the management of sporotrichosis. This approach includes educational initiatives, promoting responsible pet ownership, waste management, and other strategies that effectively contain the environmental spread of the pathogen and subsequent infection of humans and animals[9].

2. Material and Methods

The study was conducted in Corumbá and Ladário, municipalities located on the Brazilian border, with a territorial relationship to the east (Figure 1). To the west, Corumbá borders the district of Puerto Quijarro, part of the Germán Busch province in Santa Cruz department, Bolivia.

Fifteen veterinarians, constituting 83% of the total professionals working in the area, were contacted. These professionals provided care to small animals in private veterinary clinics and/

or homes, and also offered services to municipal bodies responsible for the epidemiological surveillance of zoonoses in the two municipalities. They made available records of feline sporotrichosis cases from 2011 to July 2018, which included information such as the address of the animal's owner or the location where the animal was found, approximate age, species and sex of the animal, clinical-laboratory diagnosis results, treatment, clinical progression, and outcome of each case.

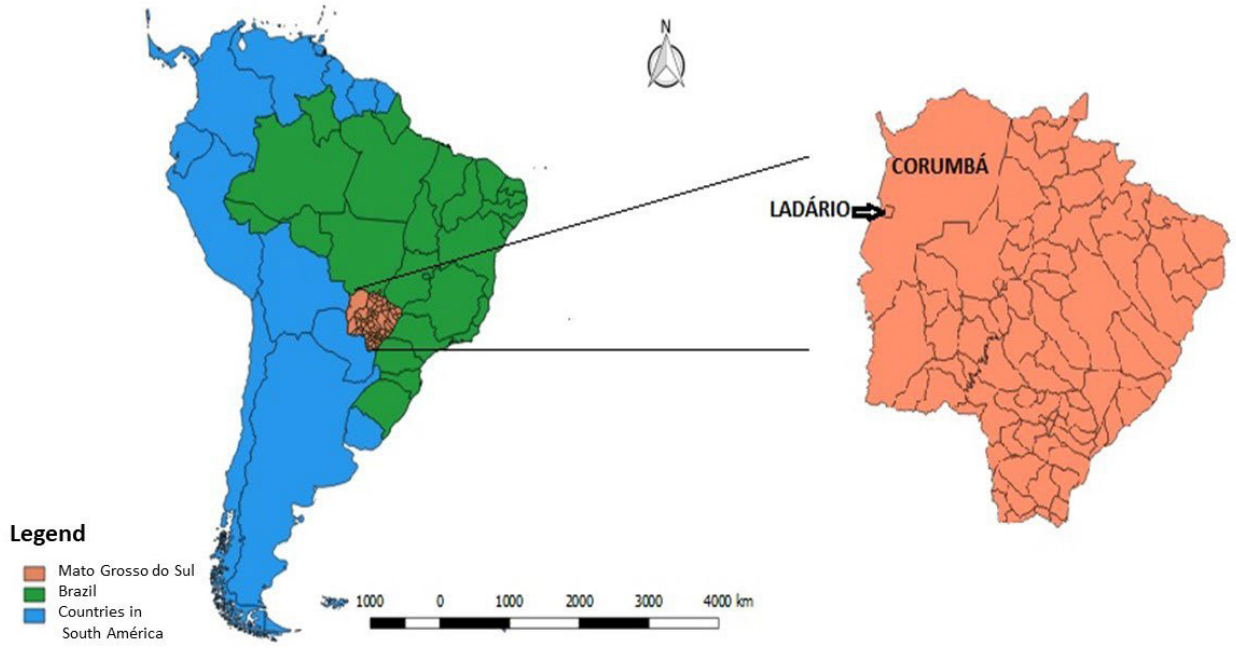


Figure 1. Map of South America highlighting Brazil and the state of Mato Grosso do Sul, with detailed views of the municipalities of Corumbá and Ladário.

The diagnostic criteria used in the clinical records to confirm a case of animal sporotrichosis were: (I) clinical diagnosis, based on the observation of lesions consistent with sporotrichosis; and/or (II) laboratory diagnosis involving the growth of *Sporothrix* sp. in culture medium or the detection of yeast cells in cytological examinations from the exudate or skin lesion samples.

Data collection was followed by mapping the cases in three stages: (I) construction of the database using Excel® 2010 software (Microsoft, Washington, USA), (II) determination of case coordinates using Google Maps, and (III) on-site verification of coordinates with a GPS (Global Positioning System).

Addresses lacking specific numbers were pinpointed using the midpoints of the aforementioned public places. If not found, these were considered primary losses.

Addresses that could not be located with the application (primary losses) were verified on-site using a GPS device (Etrex Garmin® model). Addresses that remained unidentified after the in-person search were deemed definitive losses and were excluded from the geospatial analysis but included in other analyses.

Once coordinate locations were finalized, they were entered into a free Geographic Information System (GIS) software, QGIS version 3.4.2 (Open-Source Geospatial Foundation), which facilitated the visualization of the distribution of sporotrichosis cases.

Service record data were analyzed using descriptive statistics to present the frequency of variables such as species, sex, age, occurrence or absence of neutering, treatment, and case evolution[10].

Given the zoonotic nature of sporotrichosis and the lack of reported human cases, statistical analyses were chosen that could potentially elucidate the relationship between the spaces inhabited by infected animals and nearby residents.

Pearson's linear correlation test was performed to measure the linear association between two variables: I - the number of inhabitants per neighborhood in the municipalities of Corumbá and Ladário[11] (independent variable); and II - the number of recorded cases of sporotrichosis in the studied municipalities (dependent variable) during 2017 and 2018, years which recorded the highest incidence.

The results of Pearson's linear correlation analysis were classified according to criteria proposed by Dancey & Reidy[12]: weak (r values from 0.10 to 0.30), moderate (0.40 to 0.60), and strong (0.70 to 1.0).

A least-squares regression analysis was conducted to estimate trends in disease occurrence relative to changes in the total population[13], resulting in the best-fit model being a linear model.

Cluster analysis was applied to stratified data based on the neighborhood locations of sporotrichosis cases, aiming to group the sampling objects into homogeneous clusters.

The occurrence rate of sporotrichosis in felines was determined based on the number of registered animals with suspected or confirmed diagnoses and georeferenced, relative to the estimated total feline population derived from the number of animals vaccinated door-to-door by CCZ in the urban area of Corumbá from 2015 to July 2018 (Table 1). Exclusions from this calculation included cases of canine sporotrichosis, neighborhoods lacking vaccination data, cases without georeferencing, and neighborhoods without recorded disease cases.

Table 1. Number of felines vaccinated against rabies in neighborhoods in the municipality of Corumbá, MS, from the year 2015 to 2018 (1st semester).

NEIGHBORHOOD	YEAR			
	2015	2016	2017	2018 (1st sem)
Aeroporto	406	360	430	188
Arthur Marinho	86	181	152	74
Beira-Rio	56	36	61	23
Centro	911	943	933	386
Centro-América	290	339	168	101
Cervejaria	68	105	101	48
Cristo Redentor	949	994	967	384
Dom Bosco	219	269	276	23
Generoso	129	170	126	64
Guarani	119	132	149	80
Guatós	465	410	419	205

Industrial	22	20	240	10
Jardim dos Estados	464	451	456	166
Maria Leite	521	665	468	291
Nª Srª Fátima	164	195	154	69
Nova Corumbá	672	677	793	305
Popular Nova	392	347	269	124
Popular Velha	740	690	715	300
Previsul	148	130	63	39
Universitário	318	288	441	133
TOTAL	7139	7402	7381	3013

Due to insufficient data on the feline population and inconsistent epidemiological records of sporotrichosis cases provided by the NCZ of Ladário, the occurrence rate in this municipality was not calculated.

3. Results and Discussion

Consultations of clinical records identified 315 registered cases (five dogs and 310 cats) of sporotrichosis in animals, diagnosed clinically based on lesions consistent with the disease (multiple skin ulcers on the head, chest, and extremities, facial deformity), or confirmed through laboratory tests (cytology and microbiological isolation).

It was observed that epidemiological surveillance bodies (Zoonosis Control Center [CCZ] and Zoonosis Control Unit [NCZ]), along with most veterinarians, only carry out clinical diagnoses. Only two veterinarians submitted clinical samples from animals suspected of sporotrichosis for laboratory diagnosis, which was conducted in a private laboratory in the state of Minas Gerais.

The laboratory diagnosis of sporotrichosis in animals is necessary to establish procedures that prevent its spread to other animals and humans, and to promptly initiate appropriate treatment for the infected patients. Cytology can be a rapid method for a presumptive diagnosis when associated with clinical signs, but it should be followed by confirmatory microbiological diagnosis[13].

The data contained in medical-veterinary care records and from zoonosis centers was often incomplete or absent, complicating the creation of a database for epidemiological studies. Of the total number of animals described (n=315), 121 (38.4%) had incomplete or entirely missing data (n=108).

This lack of information about cases of sporotrichosis occurred exclusively with animals handled by the NCZ of Ladário that were slated for euthanasia. The decision was made to utilize the incomplete records for descriptive analyses of variables (species, sex, age, occurrence or absence of neutering, treatment, and evolution of cases) and geolocation, which will be presented and discussed subsequently.

The data loss reported in the case registry underscored the precarious state of epidemiological surveillance in this municipality. Only four dogs were included in the descriptive analyses and mapping because they had sufficient information in the clinical records; one was located in Ladário and the others in the Popular Nova, Guanã, and Centro neighborhoods of Corumbá.

The lack of standardized data collection among professionals in the studied municipalities has diminished the accuracy of understanding the status of animal sporotrichosis. This deficiency hampers efforts to address health issues and to grasp the true epidemiological status of this zoonosis, adversely affecting the development and success of health programs. In São Paulo-SP, protocols have been established for clinicians to notify municipal zoonosis services, which work to identify cases and provide laboratory diagnoses for referred cases[14].

It is crucial to emphasize the need for standardized protocols for data collection on animal healthcare across different professional sectors, which would facilitate the acquisition of data for studies that also contribute to public health.

This zoonosis exemplifies the One Health approach, highlighting the vital role of veterinarians in detecting, preventing transmission, and notifying zoonosis surveillance bodies[14].

Improving the diagnostic network at CCZ or NCZ and involving health agents in active surveillance and health education may serve as an effective alternative for monitoring sporotrichosis in municipalities experiencing epizootics.

Veterinarians are integral to public health and epidemiological surveillance, especially in detecting, preventing, and controlling zoonoses, due to their ability to assess the health-disease process and its interconnections[15].

The effective collection of public health data is crucial for the optimal programming and overall performance of surveillance bodies, including CCZs and NCZs. These health units are tasked with preventing and controlling zoonoses through the development of sanitary, epidemiological, and environmental health surveillance systems[16].

Geolocation using the Google Maps application was performed based on the 194 cases with complete addresses in the clinical records. There was a and loss of 12 cases; subsequently, 10 cases were located on-site using GPS, resulting in a definitive loss of 1.03% (2/194).

The identified coordinates of the 192 cases were mapped. Each yellow circle on the map represents an address with a geographic coordinate, potentially linked to one or more detected animals. In Ladário, out of 121 detected cases, only 12 had complete data and were included on the map (Figure 2).

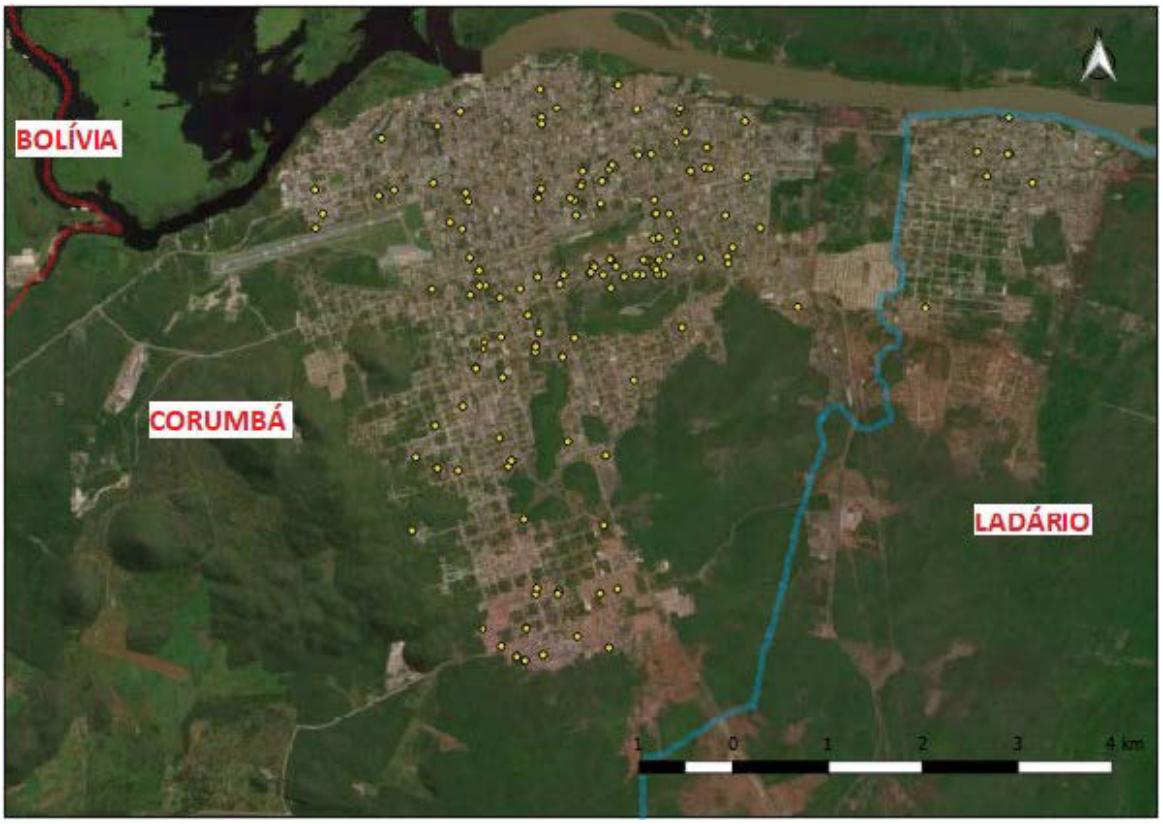


Figure 2. Georeferenced sporotrichosis cases in dogs (n=2) and cats (n=190) in Corumbá and Ladário, MS, 2011–2018. Red line indicates the international boundary between Brazil and Bolivia; Blue line marks the Corumbá-Ladário intermunicipal boundary.

The on-site verification of case coordinates was found to be effective in utilizing addresses that could not be identified by the online application. However, this approach incurred higher costs and required more time for implementation, along with challenges in locating public spaces due to inconsistent or nonexistent residential numbering. Enhancing the cartographic and Geographic Information System (GIS) structure of these municipalities, as well as improving the collection and documentation of data on identified cases, would expedite epidemiological studies and the decision-making process for interventions in health programs.

These observations support the findings of Gondim et al.[17], who described challenges in georeferencing and pointed out the absence of structured municipal Geographic Information Systems (GIS), the lack of digital cartographic bases, and official address records. They also noted the complexity of urban infrastructure, particularly in areas with irregular settlements and *favelas*, where non-standardized addresses prevail.

The municipality of Corumbá has a geoprocessing sector that manages real estate and could provide updated property coordinates and addresses. This support would facilitate disease mapping and monitoring in collaboration with the health department.

In Corumbá, the neighborhoods with the highest case concentrations were Centro, Popular Velha, and Nova Corumbá (Figure 3). Centro had a reported population of 18,400; and Nova Corumbá, 7,900, ranking among the most populous neighborhoods[18].

An association was found between the population size and the frequency of detected cases in each location, with a correlation coefficient of 0.75 and a significance level of p≥0.05. The coefficient of determination was 0.57, indicating that 57.00% of the dependent variable (infection cases) could be explained by the by the independent variable (population size of the neighborhoods). The least squares regression analysis indicated a potential increase of 20 new cases of animal sporotrichosis for every 10,000 people in population change.

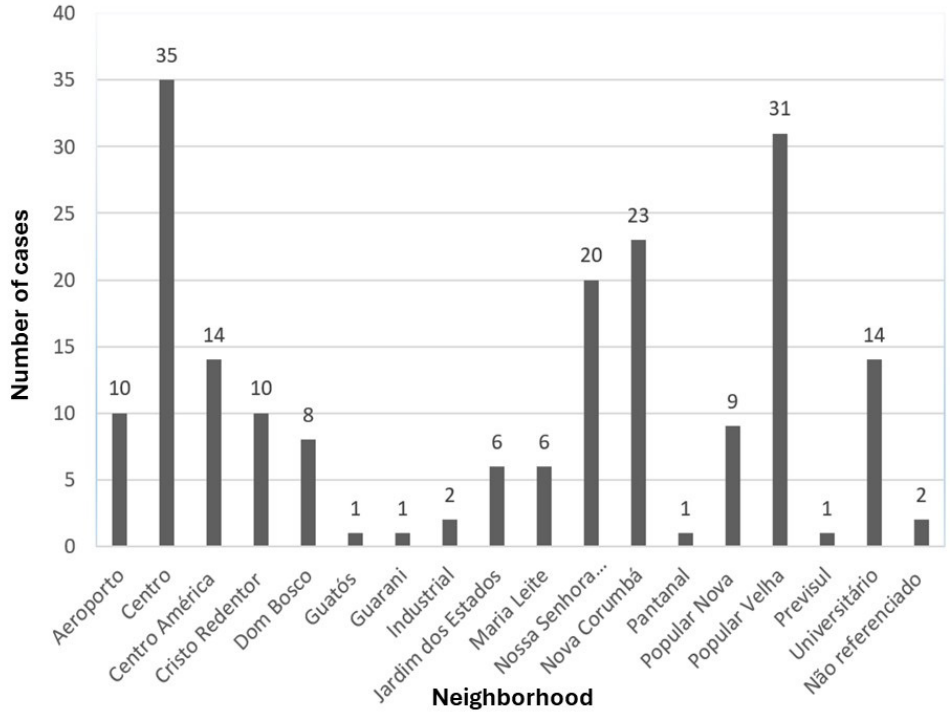


Figure 3. Distribution of sporotrichosis cases in clinical records by neighborhood in Corumbá, MS, 2011–2018. Cases of canine sporotrichosis (n=2) were included in the Centro and Popular Nova neighborhoods.

These results may indicate priority areas for active surveillance to monitor case registration in both animals and humans, while also raising hypotheses about the role of human behavior in disease spread.

From the cluster analysis, the formation of two groups was observed: Group I, comprising neighborhoods with the highest population density (Nova Corumbá, Popular Velha, Cristo Redentor, and Centro); and Group II, consisting of neighborhoods with lower population density. The clustering of infection occurrences was related to the number of inhabitants per neighborhood, corroborating the findings from the linear correlation analysis.

The relationship between cases of feline sporotrichosis and population density can be explained by the direct correlation between the growth of the human population in urban areas and the increase in the number of non-domesticated cats, which have access to anthropogenic food sources. This shift in population dynamics reflects the risk of transmission of etiological agents, with or without zoonotic potential, and also significantly impacts local biodiversity due to the predatory behavior of cats[19].

In this context, reflecting on the One Health concepts becomes crucial. The ecological aspects of the studied region must be considered: in Corumbá, the appearance of large felines in urban settings is a common occurrence during periods of flooding when these wild animals cross the Paraguay River into the city in search of shelter and food.

Disruption of traditional wildlife habitats due to climate events, demographic changes, and human behaviors can expose populations to various pathogens[20].

The emergence and spread of a disease are influenced by several factors, including the mode of transmission, survival of the infecting agent, amplification potential, and host transmission. The interaction of these risk factors increases the likelihood of spillover events [21]. In this context, the described situation could be a significant factor in the dispersal and spillover of *Sporothrix* sp.

In the temporal distribution of the total number of sporotrichosis cases in both municipalities (Figure 4), a notable increase was observed in the years 2017 (n=146) and 2018 (n=147), with a similar monthly case distribution from January to April. However, in 2018, there was an increase in cases in May.

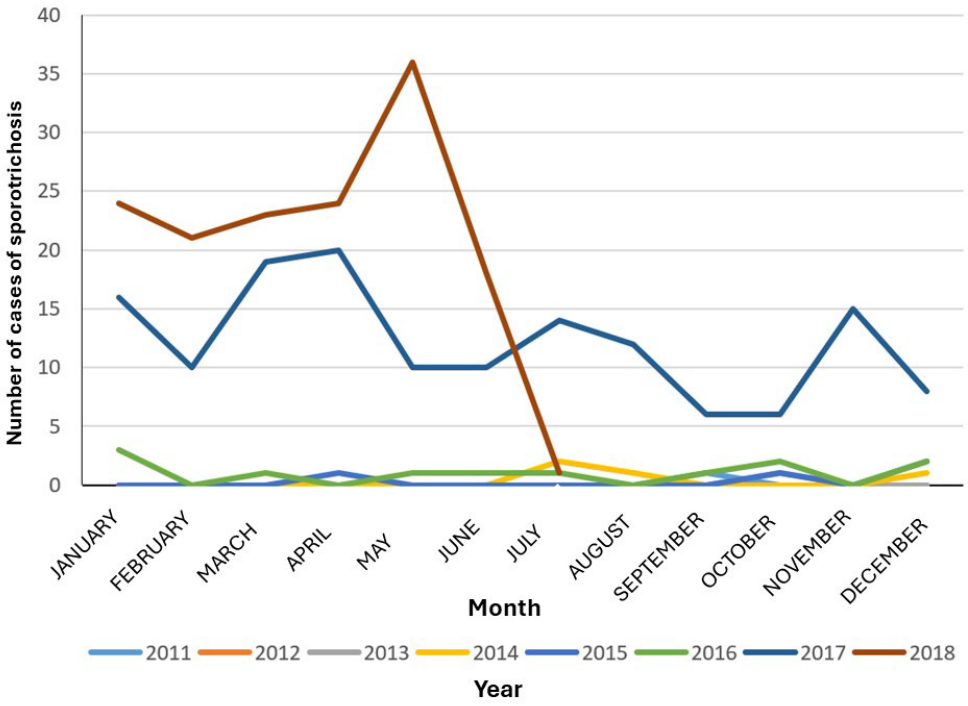


Figure 4. Monthly distribution of the number of suspected and confirmed cases of animal sporotrichosis in Corumbá and Ladário, MS, 2011–2018.

The monthly distribution of sporotrichosis cases does not definitively indicate seasonality, as underreporting and the recognition of the disease significantly impact this analysis. However, given an estimated period of 80 days—from infection to the manifestation of clinical signs, and until the animal receives clinical care[22]—, it is suggested that the infections occurred during the summer months. During this time, temperatures and humidity levels are conducive to the growth of the pathogen in the environment, and the photoperiod (12 to 14 h of light/day) stimulates the estrous cycle in cats and increases male aggression related to mating[23].

By utilizing the number of georeferenced cases along with the number of felines vaccinated against rabies, it was possible to estimate the occurrence rate by location from 2015 to 2018 (Table 2).

Table 2. Occurrence rate of feline sporotrichosis in neighborhoods in the municipality of Corumbá, MS, from 2015 to 2018 (1st semester).

Sporotrichosis occurrence rate (N of cases/N of cats vaccinated against rabies)				
			YEAR	
NEIGHBORHOOD	2015	2016	2017	2018
Aeroporto	0	0	1.86% (8/430)	1.06% (2/188)
Centro	0.22% (2/911)	0.21% (2/943)	0.32% (3/933)	6.99% (27/386)
Centro América	0	0	2.98% (5/168)	7.92% (8/101)
Cristo Redentor	0	0	0.21% (2/967)	2.08% (8/384)
Dom Bosco	0	0	1.45% (4/276)	17.39% (4/23)
Guarani	0	0	0.67% (1/149)	0
Guatós	0	0	0	0.49% (1/205)
Industrial	0	0	0.83% (2/240)	0
Jardim dos Estados	0	0	1.10% (5/456)	0.60% (1/166)
Maria Leite	0	0	0.43% (2/468)	0.69% (2/291)
Nª Srª de Fátima	0	0	7.14% (11/154)	13.04% (9/69)
Nova Corumbá	0	0.15% (1/677)	1.51% (12/793)	2.95% (9/305)
Popular Nova	0	0	1.12% (3/269)	4.84% (6/124)
Popular Velha	0	0.29% (2/690)	1.26% (9/715)	6.67% (20/300)
Previsul	0	0	0	2.56% (1/39)
Universitário	0.31% (1/318)	0.35% (1/288)	1.36% (6/441)	3.76% (5/133)

When stratifying the occurrence rates of sporotrichosis by neighborhood, certain areas emerged as significant that were not previously noted when considering only the absolute number of cases. The neighborhoods of Dom Bosco, Nossa Senhora de Fátima, Centro América, Centro, Popular Velha, and Popular Nova showed the highest frequencies, in descending order.

Overlaying data on neighborhoods with the highest absolute number of cases against those with the highest occurrence rates (Figure 4) highlights a high-risk zone for feline sporotrichosis in Corumbá. This zone includes neighborhoods like Centro, Centro América, Nossa Senhora de Fátima, and Popular Velha, where both high numbers of cases and high occurrence rates coincide.

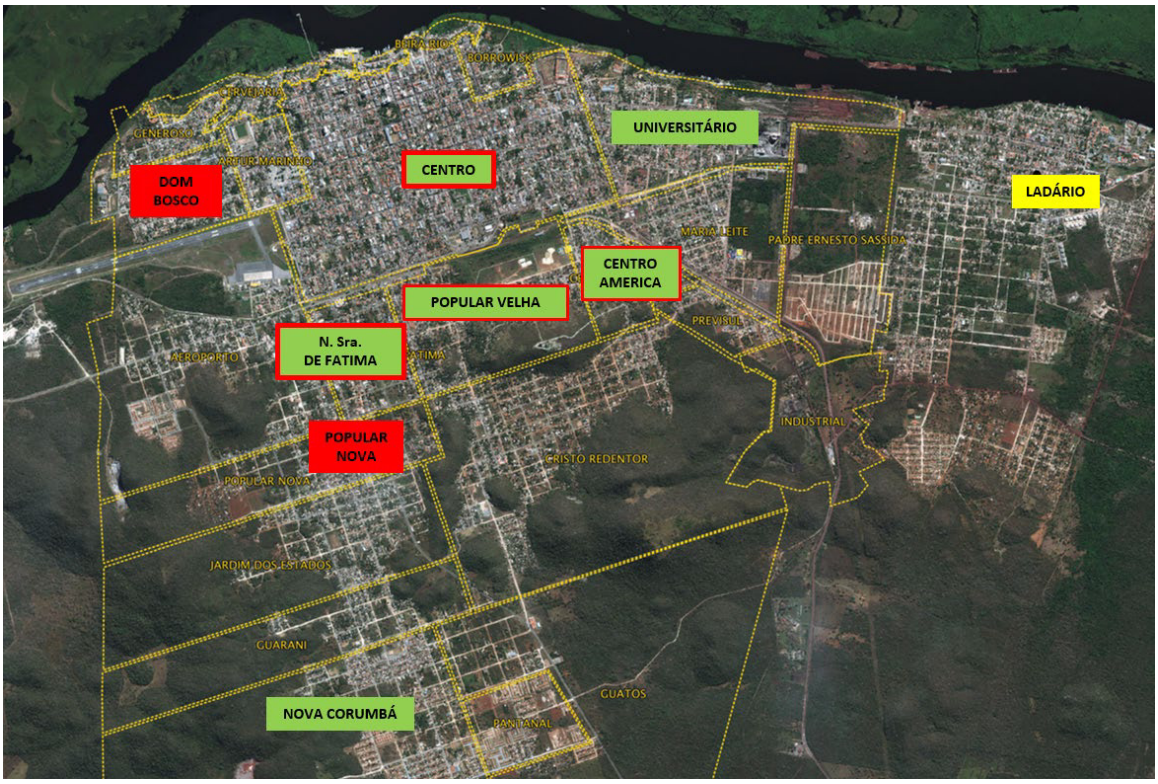


Figure 5. Location of neighborhoods in Corumbá, MS, which separately displayed elevated feline sporotrichosis cases and rates, 2015-2018 (1st Semester). Neighborhoods with higher case numbers are marked in green, higher occurrence rates in red, and those with both characteristics in green and red.

These locations should be prioritized for actions aimed at controlling feline sporotrichosis. These include actively searching for cases in both animals and humans, alongside implementing health education, promoting responsible pet ownership, and controlling animal populations.

Of the 315 initially identified cases, 98.40% (310) were in felines, with only five dogs suspected of having the disease. In 159 cases (50.50%), the age of the animals was not specified; however, 73.10% (114/156) of the reported cases occurred in animals aged one to five years. Sex was recorded in 206 cases (65.40%), with 146 (70.90%) males and 60 (29.10%) females. Among these, 6.30% of males and 3.80% of females were neutered.

The profile of animals affected by sporotrichosis corroborates findings from other researchers[24, 25, 26], who noted a higher disease predisposition in unneutered male felines. These animals often have increased exposure to the outdoors and are more likely to engage in territorial fights or encounters during the mating season.

Laboratory confirmation of sporotrichosis was obtained in 21.30% (67/315) of cases, confirmed through cytology and culture tests for the fungus *Sporothrix* sp.

Laboratory diagnosis to confirm the disease is crucial for implementing effective prevention and control measures, applying targeted therapies, and avoiding transmission to other animals and humans. It also reduces unnecessary treatment costs and potential side effects, in addition to constituting a fundamental step to promptly identify and alert public health authorities, preventing zoonotic spread[27].

Euthanasia was performed in 76.50% (241) of cases, managed by public zoonosis control bodies. The remaining cases (74; 23.50%) underwent treatment with itraconazole and/or potassium iodide. Of these treated animals, 64.90% (48) were cured; 21 died naturally, and five underwent euthanasia post-treatment.

The cure rates and lethality among treated animals in this study surpassed those reported by Rabello et al.[28], which were 56.72% and 24.32%, respectively. However, their study identified factors not assessed here, including 13.07% treatment abandonment and 5.89% treatment failure.

The epidemiological profile of feline sporotrichosis in São Paulo, described by Maia et al.[25], showed variability in lethality rates from 1.10% to 20.50%, depending on the neighborhood in which the animals were located. The cure rate hovered around 50.00%.

Collaboration among various institutions and professionals to undertake this work led to the publication of Resolution 047/2019 and Technical Note 01/2019. These documents provide guidelines on managing sporotrichosis based on local epidemiological data[29]. Additionally, the 1st Workshop of Sporotrichosis in August 2019 facilitated a critical dialogue among doctors, nurses, veterinarians, students, and NGOs involved in animal protection. This event was decisive for enhancing reporting procedures for sporotrichosis in animals and humans, mobilizing epidemiological surveillance, facilitating sample submission to the Central Laboratory (LACEN-MS), and ensuring the availability of treatments through the Brazilian Public Health System (SUS).

5. Conclusion

The findings confirm the presence of feline sporotrichosis in the municipalities of Corumbá and Ladário, with higher case numbers in more populous neighborhoods and a significant increase noted since 2017. The majority of the affected animals are young adult, non-neutered male felines. Most cases were directed towards euthanasia without a prior laboratory diagnosis or treatment attempt; however, most of the animals that were treated showed satisfactory evolution and recovery.

Continued research into feline sporotrichosis is essential to develop a robust database that can support a prevention and control program based on One Health principles. Future studies are suggested to identify the *Sporothrix* sp. species involved in human and animal cases, monitor the temporal patterns of cases, and explore associations between these variables and socioeconomic and environmental factors.

Conflicts of interest

The authors declare no conflicts of interest, whether personal, commercial, political, academic, financial, or other.

Author contributions

Conceptualization: L.T.R. Araújo and R.S. Juliano. Data curation: L.T.R. Araújo and W.A. da Silva. Formal analysis: U.G.P de Abreu. Funding acquisition: R.S. Juliano and C.R.B. Leal. Project management: L.T.R. Araújo and

R.S. Juliano. Methodology: R.S. Juliano, C.R.B. Leal and L.E. Pereira. Supervision:R.S. Juliano. Investigation:L.T.R. Araújo. Writing (original draft): L.T.R. Araújo. Writing (proofreading and editing):R.S. Juliano, C. R. B Leal and A. O. Pellegrin

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