Ciências Agrárias
SEMINA

DOI: 10.5433/1679-0359.2023v44n6p2197

Utilization of the C7-LVC application in the georeferencing of canine visceral leishmaniasis cases

Uso do aplicativo C7-LVC no georreferenciamento de casos de leishmaniose visceral canina

Jaíne Soares de Paula Vasconcellos[1]; Fagner D'Ambroso Fernandes[2]*; Carlos Flávio Barbosa da Silva[3]; Ênio Giotto[4]; Sônia de Avila Botton[4]; Fernanda Silveira Flores Vogel[4]; Luís Antonio Sangioni[4]

Highlights

Geographic distribution of canine visceral leishmaniasis cases through C7-LVC.
Georeferencing cases of canine visceral leishmaniasis.
Geographic and environmental characteristics the proliferation of the vector.

Abstract

Georeferencing can also be used to reveal the spatial distribution of diseases. This study characterized the geographic locations of positive cases of canine visceral leishmaniasis (CVL) (n=21) using the C7-LVC application (App) in the city of Santa Maria, RS, Brazil. This technology is available for use on smartphone devices, making it the first tool for notifying CVL to public services, intending to assist in disease control efforts. In this study, we used the Municipal Environmental Surveillance Service database, which contains information about CVL notifications sent by veterinarians between April and December 2017. The prevalence of CVL was higher in the north (17/21, 80.93%) of the city. Positive cases were observed in seven neighborhoods, with the highest occurrence (9/21, 42.85%) in the Perpétuo Socorro neighborhood. The regions containing CVL-positive dogs exhibited native vegetation with humid shaded areas rich in organic matter, representing distinctive environmental characteristics. All the CVL cases were identified in nearby geographical regions. The municipality's environmental characteristics favor the proliferation and survival of the vector in urban and peri-urban perimeters and pose risks to human and animal health. The georeferencing data obtained by C7-LVC can aid in formulating health measures to mitigate the

[1] Veterinarian, Administration Assistant, Universidade Federal de Santa Maria, UFSM, Santa Maria, RS, Brazil. E-mail: jainevasconcellos@hotmail.com
[2] Prof., Veterinary Medicine Course, Centro Universitário Ritter dos Reis, UniRitter, Porto Alegre, RS, Brazil. E-mail: fagner.fernandes@acad.ufsm.br
[3] Veterinarian, Superintendência de Vigilância em Saúde do Município de Santa Maria, RS, Brazil. E-mail: cfbs.vet@ibest.com.br
[4] Profs. Drs., UFSM, Santa Maria, RS, Brazil. E-mail: enio.giotto@ufsm.br; sonia.botton@ufsm.br; fernanda.vogel@ufsm.br; luis.sangioni@ufsm.br
* Author for correspondence

Received: May 09, 2023 Approved: Jan. 16, 2023

transmission of the disease between humans and animals.
Key words: Control. Epidemiological surveillance. Georeferencing. *Leishmania.* Visceral leishmaniasis.

Resumo

O georreferenciamento pode revelar a distribuição espacial das doenças. Este estudo caracterizou a localização geográfica dos casos positivos de leishmaniose visceral canina (LVC) (n=21), por meio do aplicativo C7-LVC (App), na cidade de Santa Maria, RS, Brasil. Esta tecnologia está disponível para uso em dispositivos smartphones, sendo caracterizada como primeiro instrumento para a notificação de LVC ao serviço público, com o objetivo de auxiliar nas ações de controle da doença. Neste estudo, foi utilizado o banco de dados do Serviço Municipal de Vigilância Ambiental que continha informações de notificações sobre LVC anteriormente enviadas por médicos veterinários, entre abril e dezembro de 2017. Neste período, a prevalência de LVC foi maior na região Norte (17/21 - 80,93%) da cidade. Os casos positivos foram observados em sete bairros, com maior ocorrência (21/9 - 42,85%) no bairro Perpétuo Socorro. As regiões contendo cães positivos para LVC apresentavam como características ambientais a vegetação nativa com áreas úmidas, sombreadas e ricas em matéria orgânica. Todos os casos de LVC foram identificados em regiões geográficas próximas. As características ambientais do município favorecem a proliferação e sobrevivência do vetor no perímetro urbano e periurbano e acarretam riscos à saúde humana e animal. Os dados de georreferenciamento obtidos pelo C7-LVC podem auxiliar na formulação de medidas sanitárias para conter a propagação da doença entre humanos e animais.
Palavras-chave: Controle. Vigilância epidemiológica. Georreferenciamento. *Leishmania*. Leishmaniose Visceral.

Introduction

Visceral leishmaniasis (VL) is a chronic, systemic zoonotic disease. When left untreated, VL progresses to death in more than 90% of the cases. Canine enzootic infection has preceded the occurrence of human cases, and infection in dogs has been more prevalent than in humans (Guia de Vigilância em Saúde, 2016). In the United States of America (USA), the disease is primarily transmitted by vectors, particularly *Lutzomyia longipalpis* and the etiologic agents are protozoans belonging to the genus *Leishmania.* The main hosts in urban areas are domestic dogs (*Canis familiaris*), which constitute a susceptible population and are an important source of infection in the transmission of canine visceral leishmaniasis (CVL) to vertebrate and invertebrate hosts (Manual de Vigilância e Controle da Leishmaniose Visceral, 2006).

Despite the known circulation of the etiologic agent in the region of Santa Maria, Rio Grande do Sul, Brazil (Ratzlaff et al., 2018), it was not until 2018 to 2021 that CVL became an integral component of the municipal health planning (Santa Maria, 2018). CVL cases were detected by the Environmental Surveillance Service (Santa Maria, 2018). This notification prompted investigators to identify the areas of disease transmission. According to the Brazilian Ministry of Health (MH), areas of transmission are regions where there have been records of autochthonous

cases of human VL or CVL in the last three years. The municipalities are categorized into areas of VL transmission, stratified as sporadic, moderate, and intense, based on the intensity of transmission of the disease in humans. This classification varies by percentile, with the annual average ranging from 0 to 4.4 cases or more of VL (Guia de Vigilância em Saúde, 2016).

The field of health geography aims to assess the spatial distribution patterns of a disease within a specific geographic location. The use of geoprocessing technologies, including various applications, has proven invaluable in identifying risk factors, conditions, and determinants of diseases. Moreover, it enables the identification of disease-related disparities within a given geographic area (Ribeiro, 2014).

This study aims to highlight the use of the C7- LVC application (pp Canine Visceral Leishmaniasis Notification System) and determine the distribution of CVL in the municipality of Santa Maria, RS, Brazil, using information and communication technology. This application provides notifications to public authorities about CVL cases to facilitate the implementation of One Health measures, specific to health surveillance and protection.

Materials and Methods

The municipality of Santa Maria is situated in the Central region of the state of Rio Grande do Sul, in southern Brazil, at coordinates 29°41'02"S and 53°48'25"W, with an average elevation of approximately 113 meters above sea level. Spanning an area of 1,780.194 square kilometers, this region is inhabited by a population of 285,159 residents. Santa Maria has a subtropical climate characterized by four distinct seasons, influenced by its proximity to the Southern Atlantic Ocean and the region's varying topography. The city experiences warm summers, with average temperatures between 25–30°C (77–86 °F), and cold winters, with average temperatures between 5–15°C (41–59 °F). Precipitation was evenly distributed throughout the year, with an annual average of approximately 1,500–1,800 mm. The topography of the area is defined by rolling hills and plains, with the city located at an elevation of approximately 151 m above sea level. Santa Maria is situated in the Pampa biome, an extensive lowland grassland ecosystem that extends into Uruguay and Argentina. The natural vegetation in the Santa Maria region is indicative of the Pampa biome, characterized predominantly by grasslands featuring a variety of native grass species. Low scrub vegetation is also observed in hilly areas. Regarding basic sanitation, Santa Maria, similar to many other urban areas in Brazil, has actively improved its infrastructure. The city provides access to piped water and sewage systems to a significant portion of its population. However, the quality and coverage of sanitation services may vary across different areas within the city, with certain regions benefitting from better infrastructure. In addition, the city has established waste management and recycling programs to handle solid waste, which are typically overseen by municipal governments or contracted agencies (Instituto Brasileiro de Geografia e Estatística [IBGE], 2021).

The MH designates this particular municipality as a vulnerable area, despite the absence of reported autochthonous cases of human VL and/or CVL. However, it shares borders with municipalities that have reported VL cases, regions of intense migratory flow, and/or regions that are part of the same road axis as the municipalities with cases of VL (Manual de Vigilância e Controle da Leishmaniose Visceral, 2006). Due to its economic attributes, substantial population influx (especially students and military personnel from across the country), and its role as a regional health hub, Santa Maria is considered a strategic focal point for surveillance efforts aimed at preventing outbreaks in both humans and animals.

The first notification of positive CVL cases in the municipality occurred in 2017, which triggered MH-recommended surveillance in the form of an active search. Therefore, it was possible to characterize the distribution of the disease.

To conduct an active search for reported cases of LVC, the Environmental Surveillance teams collected 97 dog samples from 45 households located in various areas of Santa Maria, RS, Brazil. To determine the spatial distribution of CVL, the C7-LVC application for smartphone devices was used to notify the Public Health Manager in the municipality of the CVL cases, which allowed georeferencing of these cases (Vasconcellos et al., 2021). The development and formatting of this application were based on the CR Campeiro7® software (Santi et al., 2016).

The C7-CVL database contains information from notifications sent by veterinary professionals to the Municipal Environmental Surveillance Service between April and December 2017. The notifications were followed by an active search for reported cases, which included prompt blood collection for CVL laboratory testing. Individuals in contact with these dogs were also informed. In addition, dogs living in dwellings close to the residences of the positive animals were identified. The active search carried out in the urban area involved a radius of 30 m around the site of positive dogs.

During the active search, a form was developed for the case investigation. The collected information included the following important variables for environmental assessment: climate data; presence or absence of native forest; incidence in rural or urban areas; and presence of other domestic, synanthropic, and/or vector animals.

To identify antibodies against *Leishmania infantum* in the surveyed dogs, their sera were analyzed using the rapid immunochromatography test (TR-DPP® - Biomanguinhos), provided by the MH to the municipalities. Serum samples of the positive cases were sent to the Central Laboratory of Rio Grande do Sul (LACEN-RS), and MH-accredited facility, to confirm the infection through serology, using the enzyme-linked immunosorbent assay (EIE-LVC®- Biomanguinhos). This procedure has been adopted by the MH since July 2012 (Guia de Vigilância em Saúde, 2016).

The data of the positive dogs, including the owner's addresses, were registered by the "Registro de Notificações" interface of the smartphone C7-LVC application (Figure 1). Using the address data, including the municipality, the Global Positioning

System (GPS) tool filled in the latitude and longitude coordinates of the location using the Google Maps plug-in. The C7-LVC app uses technologies available on smartphone devices, such as GPS, and embodies several critical software quality attributes, including functionality, reliability, usability, efficiency, maintainability, and portability. Geographic databases have been increasingly developed because of their potential application value.

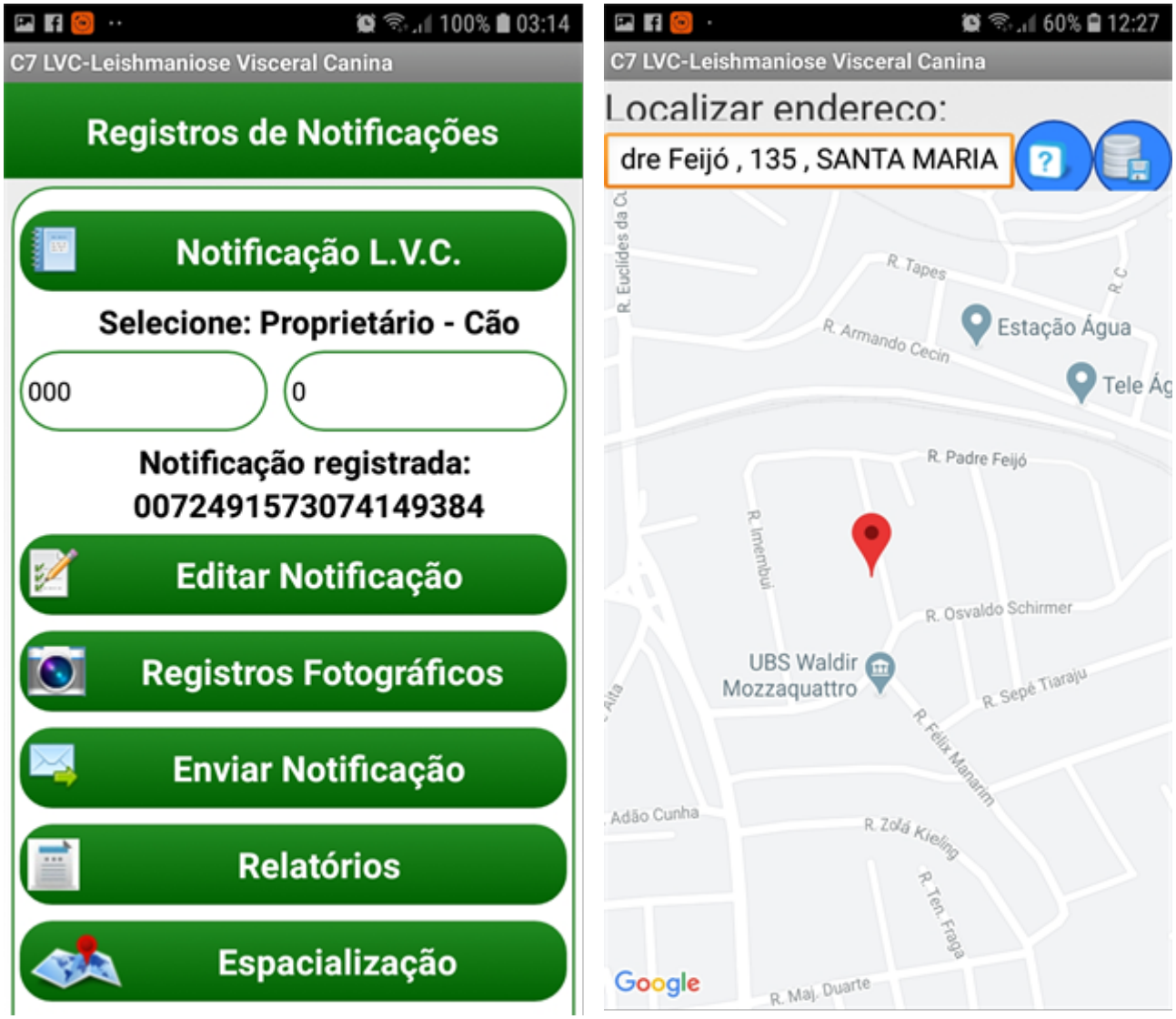

Figure 1. The initial smartphone application menu and geospatialization through addresses.

Detecting silent outbreaks of CVL-positive animals, which pose a risk of disease transmission to humans, is crucial for health services to implement appropriate control measures for each epidemiological situation. Therefore, the utilization of C7-LVC will enable the documentation of suspected cases of LVC and the generation of notifications to the Municipal Health Service, facilitating supplementary and relevant actions in compliance with legislation that can further enhance the control of canine leishmaniasis.

This study was authorized by the Permanent Education Centre (Núcleo de Educação Permanente, NEPES) of the Municipality of Santa Maria to collect and publish the data generated by the research.

Results and Discussion

In the past two decades, epidemiological studies applied to health surveillance have initiated the adoption of new technologies for investigating outbreaks, monitoring trends in infectious diseases, and facilitating the early identification of outbreaks and communicable diseases. Despite its recognition as a hub for computational health development, Brazil has yielded modest results in scientific production concerning the digital communication of diseases (Leal et al., 2016).

Brazil has one of the largest global disease registration systems, the Notifiable Diseases Information System (SINAN), which provides notifications of predominant diseases occurring in Brazil (Instrução normativa n.º 02/SVS/MS, de 22 de novembro de 2005, 2005). In addition, there are the "Observatory of Dengue" and "Dengue on the Web" applications that use websites as platforms for interaction and spatialization of information (Wójcik et al., 2014). In the healthcare sector, Brazil has seen the development of significant digital platforms, including "Saúde na Copa," created in 2014 in conjunction with the World Cup, and "Guardians of Health," established in 2016 in association with the Olympic Games. These platforms employ both websites and Apps to serve their purposes. Additionally, several digital platforms, such as HealthMap, Google Flu Trends, and Flu Near You, allow visualization of the distribution of diseases worldwide, providing data on diseases to the population, travelers, and health authorities (Leal et al., 2016).

Using the C7-LVC app, we observed that all 21 CVL-positive cases occurred in the northern (80.93%), northeastern, and central-western administrative regions of Santa Maria. Positive cases were observed in seven neighborhoods in the city, with the highest occurrence (9/21, 42.85%) in the northern region of Bairro Perpétuo Socorro. The CVL cases were concentrated in close proximity (Figure 2).

The mapping tool within the C7-LVC application, along with assessments of the local environment, identified areas of vegetation characterized as being humid, shaded, and abundant in organic matter. These characteristics favor the oviposition and survival of VL vectors (Penha et al., 2013). Costa (2008) reported the appearance of the vector that transmitted CVL (sandflies of the *Lutzomyia* genus) in regions with characteristics similar to those observed in this study. Marcondes and Rossi (2013) demonstrated the ability of the vector to adapt and urbanize, which favors the dispersion of CVL.

Several vector characteristics, including its limited flight capacity, confine its dispersal to a specific region and its boundaries. In this study, we observed that the reported cases were in close proximity to each other (Figure 2).

Drastic changes in the environment that are occurring nowadays are damaging to environmental health. These changes are, in part, related to the loss of biodiversity, which leads to the elimination of natural predators of disease vectors and favors new infestations (Casagrande & Guimarães, 2019). Another point to be considered regarding the prevalence of CVL cases, especially those outside the regions where studies on canine species as a reservoir predominate, is that some wild animals are also reservoirs for VL contributing to the maintenance of the agent in these environments (Manual de Vigilância e Controle da Leishmaniose Visceral, 2006; Marcondes & Rossi, 2013).

Figure 2. Images (generated by the smartphone application) of positive cases with locations marked with geographic coordinates.

It is noteworthy that environmental issues related to CVL need to be broadly analyzed because there are other important variables (including socioeconomic characteristics of the population and even the articulation of government public policies) linked to the environment. One variable observed in this study was the occurrence of CVL in socially vulnerable areas. The determination of socially deprived territories in Santa Maria was previously characterized by Faria et al. (2019). Additionally, the presence of other species of domestic animals, including chickens and pigs, in the peridomicile of dogs was observed.

Once notifications of cases are sent to public authorities, one of the initiatives consistently practiced in the Municipal Health Plan of Santa Maria since 2018, is the collection of biological material samples from dogs suspected of having CVL (Santa Maria, 2018). Monitoring the occurrence of CVL cases using municipal health services through early notification is a vital step for developing public health policies for VL.

With the advancement in technologies, public health managers should seek innovative and effective solutions for detecting and controlling the disease, including a combination of strategies, including case georeferencing and portable technology, to enable spatial contextualization. These measures will promote CVL control at locations where CVL is prevalent.

Conclusions

The mobile communication technology described in this study provides epidemiological data in an integrated manner, which allows for effective, rapid, and agile monitoring of CVL through georeferencing. This approach offers substantial public health advantages by enabling the implementation of prophylactic measures in the identified areas, continuous monitoring of CVL cases, and deployment of proactive efforts to prevent the emergence of autochthonous CVL cases in humans. This technology facilitates the execution of active searches and enhancement of sanitary measures, including health education initiatives, environmental and vector control planning, and the utilization of insecticide collars for dogs in the spatial regions identified in the notifications.

Acknowledgements

Coordination for the Improvement of Higher Education Personnel (CAPES) - Financial code 001 and National Council for Scientific and Technological Development (CNPq) for the financial support.

References

Casagrande, B., & Guimarães, R. B. (2019). Vetores das Leishmanioses no Parque Estadual do Morro do Diabo (PEMD), Município de Teodoro Sampaio - SP, Brasil. *Geografia, 28*(1), 225-238. doi: 10.5433/ 2447-1747.2019v28n1p225

Costa, C. H. N. (2008). Characterization and speculations on the urbanization of visceral leishmaniasis in Brazil. *Cadernos de Saúde Pública, 24*(12), 2959-2963. doi: 10.1590/S0102-311X2008001200027

Faria, R. M., Savian, P., & Vargas, D. (2019). Territórios da privação social na cidade de Santa Maria, Rio Grande do Sul. *Boletim de Geografia, 37*(1), 234-250. doi: 10.4025/bolgeogr.v37i1.39208

Guia de Vigilância em Saúde. Ministério da Saúde. Secretaria de Vigilância em Saúde. Coordenação-Geral de Desenvolvimento da Epidemiologia em Serviços. Secretaria de Vigilância em Saúde, Coordenação-Geral de Desenvolvimento da Epidemiologia em Serviços. (2016). Brasília: Ministério da Saúde. https://portalarquivos2.saude.gov.br/images/pdf/2016/novembro/18/Guia-LV-2016.pdf

Instituto Brasileiro de Geografia e Estatística (2021). *Cidades e estados.* https://www.ibge.gov.br/cidades-e-estados/rs/santa-maria.html

Instrução normativa n.º 02/SVS/MS, de 22 de novembro de 2005. (2005). Ministério da Saúde. Regulamenta as atividades de vigilância epidemiológica com relação à coleta, fluxo, periodicidade de envio de dados da notificação compulsória de doenças por meio do Sistema de Informação de Agravos de Notificação – Sinan. Diário Oficial da União, Poder Executivo, Brasília, DF, 23 nov. 2005. Seção 1. p. 46. http://portalsinan.saude.gov.br/images/documentos/Legislacoes/IN_2_2005.pdf

Leal, O. B., Neto, Dimech, G. S., Libel, M., Oliveira, W., & Ferreira, J. P. (2016). Digital disease detection and participatory surveillance: overview and perspectives for *Brazil. Revista de Saúde Pública, 50*, 1-5. doi: 10.1590/S1518-8787.2016050006201

Manual de Vigilância e Controle da Leishmaniose Visceral. (2006). Ministério da Saúde. Departamento de Vigilância Epidemiológica. Secretaria de Vigilância em Saúde. Secretaria de Vigilância em Saúde. Brasília: Ministério da Saúde, 2006. http://bvsms.saude.gov.br/bvs/publicacoes/manual_vigilancia_controle_leishmaniose_visceral.pdf

Marcondes, M., & Rossi, C. N. (2013). Leishmaniose visceral no Brasil. *Brazilian Journal Veterinary Research and Animal Science, 50*(5), 341-352. doi: 10.11606/issn.2318-3659.v50i5p341-352

Penha, T. A., Santos, A. C. G., Rebêlo, J. M. M., Moraes, J. L. P., & Guerra, R. M. S. N. C. (2013). Fauna de flebotomíneos (Diptera: Psychodidae) em área endêmica de leishmaniose visceral canina na região metropolitana de São Luis–MA, Brasil. *Biotemas, 26*(2), 121-127. doi: 10.5007/2175-7925.2013v26n2 p121

Ratzlaff, F. R., Engelmann, A. M., Luz, F. S., Braunig, P., Andrade, C. M., Fighera, R. A., Botton, S. A., Vogel, F. S. F., Pötter, L., & Sangioni, L. A. (2018). Coinfecções por *Leishmania infantum, Neospora caninum* e *Toxoplasma gondii* em cães necropsiados da região central do Rio Grande do Sul, Brasil. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 70*(01), 109-116. doi: 10.1590/1678-4162-9412

Ribeiro, H. (2014). Health geography in knowledge crossover. *Saúde e Sociedade, 23*(4), 1123-1126. doi: 10.1590/S0104-12902014000400200

Santa Maria (2018). *Plano municipal de saúde 2018 - 2021.* Prefeitura Municipal de Santa Maria, Secretaria Municipal

de Saúde. https://www.santamaria.rs.gov.br/inc/view_doc.php?arquivo_dir=2018&dir_mes=08&arquivo_nome=D21-598.pdf&doc_gc=1

Santi, A. L., Sebem, E., Giotto, E., & Amado, T. J. C. (2016). *Agricultura de precisão no Rio Grande do Sul.* CESPOL.

Vasconcellos, J. S. P., Ratzlaff, F. R., Vogel, F. S. F., Giotto, Ê., Veiga, H. G. C., Botton, S. A., & Sangioni, L. A. (2021). Information technology by mobile communication for the notification of canine visceral leishmaniasis. *Pesquisa Veterinária Brasileira, 41*, e06671. doi: 10.1590/1678-5150-PVB-6671

Wójcik, O. P., Brownstein, J. S., Chunar, R., & Johansson, M. A. (2014). Public health for the people: participatory infectious disease surveillance in the digital age. *Emerging Themes Epidemiology, 11*(1), 7. doi: 10.1186/1742-7622-11-7