

# Canine heartworm: natural infection along remote coastal area of Rio de Janeiro

Dirofilariose canina: infecção natural ao longo de área costeira remota do Rio de Janeiro

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## Abstract

*Dirofilaria immitis* is a mosquito-borne nematode that often infects dogs worldwide and causes what is commonly referred to as heartworm disease. The infection is recognized as being more prevalent in tropical and subtropical coastal regions; however, due to recent climate changes, it has been detected in regions previously considered free of infection. The asymptomatic animals presented in this case report had their infections detected opportunistically. One was presented for a routine checkup and the other for pre-operative evaluation. In the checkup case, heartworm disease was suspected after auscultation. In the presurgical case, microfilariae were found when cytology was performed. Both dogs had *D. immitis* infection confirmed by antigen detection using an enzyme-linked immunosorbent assay (ELISA) test. The microfilariae were confirmed to be *D. immitis*. This report highlights the unsuspected finding of the infection in a region where canine heartworm disease has not been a concern. It throws light on the importance of constant surveillance of animal vector-borne diseases in areas of ecotone. Surveillance must be reinforced when natural resources are disturbed, especially in the face of global climate change.

**Keywords:** *Dirofilaria immitis*, heartworm, zoonosis, One Health.

## Resumo

*Dirofilaria immitis* é um nematoide transmitido por mosquitos que frequentemente infecta cães em todo o mundo. A infecção é reconhecida como sendo mais prevalente nas regiões costeiras tropicais e subtropicais, porém, devido às recentes mudanças climáticas, infecções foram detectadas em regiões antes consideradas livres de infecção. Os animais assintomáticos aqui apresentados tiveram sua infecção detectada por acaso. Um foi apresentado para exame de rotina e o outro para avaliação pré-operatória. Durante o *check-up*, suspeitou-se de dirofilariose devido ao resultado da ausculta e o outro apresentou microfílaras em citologia realizada. Ambos os cães tiveram infecção por *D. immitis* confirmada pelo teste ELISA ("enzyme-linked immunosorbent assay") para detectar antígenos e as microfílaras foram confirmadas como *D. immitis*. Este relato destaca o achado inesperado de dois cães infectados com *D. immitis* em uma região onde a "doença do verme do coração" canino não era uma preocupação. Ele lança luz sobre a importância da vigilância constante de doenças transmitidas por vetores animais em áreas de ecótono. A vigilância deve ser reforçada quando os recursos naturais são perturbados, especialmente em face das mudanças climáticas globais.

**Palavras-chave:** *Dirofilaria immitis*, verme do coração canino, zoonose, Saúde Única.

## Introduction

*Dirofilaria immitis* is a mosquito-borne nematode and an agent of canine heartworm disease. Dogs are the most adapted hosts; therefore, most dogs are asymptomatic when infected. When they do develop disease, it is marked by chronic and insidious cardiopulmonary abnormalities (American Heartworm Society, 2020). Other mammals can be infected (Magi et al., 2008; McCall 2005; Penezić et al., 2014; Trotti et al., 1997), including humans (Grapatsas et al., 2018; Milanez-de-Campos et al., 1997). This transmission may occur from different vector mosquito species (Labarthe et al., 1998a; Lourenço-de-Oliveira & Deane, 1995).



**How to cite:** Santos Filho, M., Alberigi, B., Balius, D. M. P., Lemos, N. M. O., Bendas, A. J. R., & Paiva, J. P. (2021). Canine heartworm: natural infection along remote coastal area of Rio de Janeiro. *Brazilian Journal of Veterinary Medicine*, 43, e000220. <https://doi.org/10.29374/2527-2179.bjvm000220>

**Received:** August 20, 2020.

**Accepted:** February 26, 2021.

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In Brazil, *D. immitis* is one of the most prevalent arthropod-borne disease in dogs, with an approximate prevalence of 23.1% (Labarthe et al., 2014). Rio de Janeiro is a coastal state and has a favorable climate for vector mosquitoes to develop (Bendas et al., 2019). The prevalence of infected dogs varies according to the region due to climate and population characteristics. Examples of this variation in prevalence can be seen in the following cities: Armação dos Búzios (62.2%), Niterói (58.6%), Cabo Frio (27.5%) and Mangaratiba (16.3%) (Labarthe et al., 2014).

Different mosquito species have been reported as heartworm disease vectors in Rio de Janeiro. *Ochletotatus taeniorhynchus* and *Ochletotatus scapularis* were identified as possible vectors in the coastal lowlands of Rio de Janeiro (Lourenço-de-Oliveira & Deane, 1995) and have been subsequently confirmed as primary heartworm vectors (Labarthe et al., 1998b). In the same area, *Culex quinquefasciatus* was considered as secondary vector (Labarthe et al., 1998b). *Aedes aegypti* from Rio de Janeiro presents vectorial competence for heartworm disease (Serrão et al., 2001). However, its epidemiological role in the transmission of the disease in Rio de Janeiro remains to be clarified.

Infected animals can be asymptomatic or demonstrate symptoms related to the presence of the parasites (Bowman & Atkins, 2009). These symptoms can be mild, such as coughing and reduced physical activity. When left untreated, symptoms may progress to dyspnea, syncope, congestive heart failure and even death (Atwell et al., 1988).

Heartworm infection is confirmed by the detection and identification of microfilariae or by the detection of the *D. immitis* antigen in blood samples (American Heartworm Society, 2020). The presence of *D. immitis* in infected dogs signals the presence of mosquito vectors. These mosquito species may vector heartworm or other pathogens to different host species, including humans. Therefore, a heartworm-infected dog may be a useful sentinel to warn of human mosquito-borne health hazards (Cancrini et al., 2003; Gratz, 2004; Mitchell, 1995). The concept of One Health in Veterinary Science represents more than just the impact of zoonoses on human health; it should be deeply considered and studied in a broader perspective. The presence of infected animals with pathogens vectored by eclectic mosquitoes that may vector human pathogens highlights this concept (Backer & Miller, 2016; Racloz et al., 2006; Schmidt, 2009).

In order to identify the presence of an infection where it is infrequent and neglected and to show the importance of canine heartworm surveillance, two autochthonous cases of canine heartworm disease occurred in Seropédica, Rio de Janeiro, Brazil, are described.

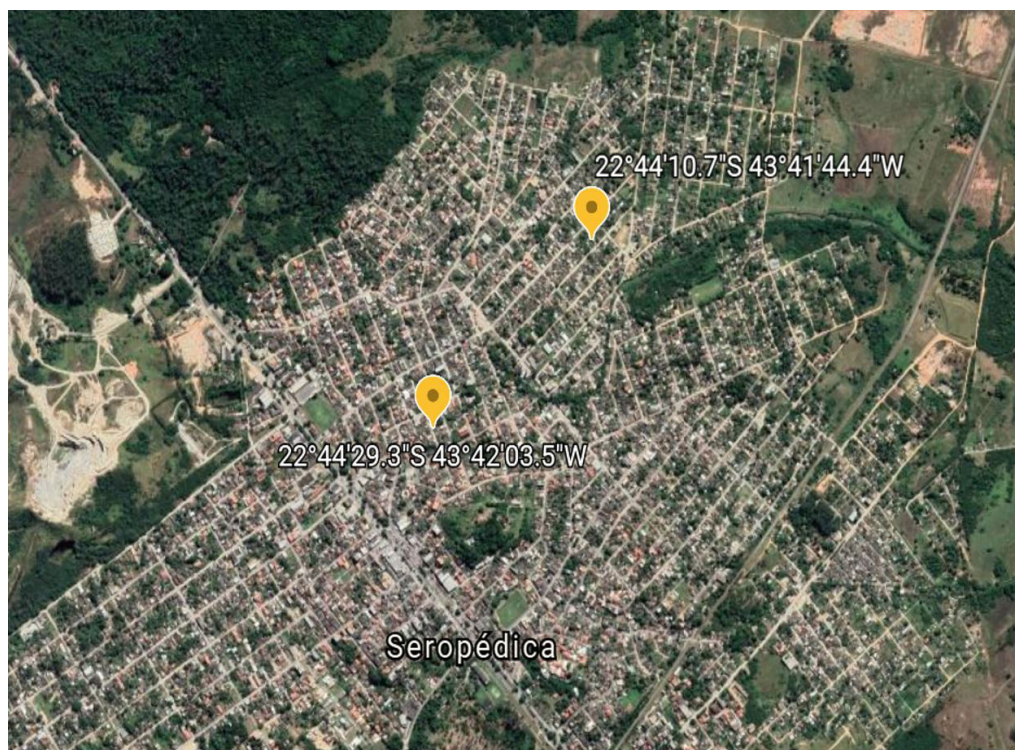
## Case reports

### Patient 1

A 2-year-old mixed breed intact male dog presented for clinical care at the small animal veterinary hospital of the Universidade Federal Rural do Rio de Janeiro in November 2016. The patient was presented for a routine check-up. The pet's owner reported that the animal had lived outdoors in Seropédica (22°44'29.3"S 43°42'03.5"W) (Figure 1), since he was born and had never traveled elsewhere. The dog was in good health. Upon pulmonary auscultation, harsh expiratory sounds were detected. Thoracic radiographs and blood work (complete blood cell counts, clinical biochemistry, microfilariae and heartworm antigen tests) were performed. The dog tested positive for microfilariae and heartworm antigens. No other changes were observed in blood work. X-rays showed slight bronchial and interstitial patterns suggesting bronchopathy. After diagnosis of the heartworm infection, echocardiography was performed, and it revealed the presence of parallel lines in the main pulmonary artery, further confirming infection with *D. immitis*.

### Patient 2

A 7-year-old German Shepherd intact male dog presented at the small animal veterinary hospital of the Universidade Federal Rural do Rio de Janeiro in October 2017 for preoperative evaluation of a lump in the paw. At this visit, microfilariae were detected as a result of cytology. The owner reported that the animal lived outdoors in Seropédica (22°44'10.7"S 43°41'44.4"W) (Figure 1), had contact with free-roaming dogs, and had never been taken elsewhere. During thoracic auscultation, a grade I/VI murmur in the mitral area and harsh respiratory sounds were detected. According to the pet's owner, the patient experienced sporadic episodes of coughing, but never showed signs



**Figure 1.** Map showing the home location of autochthonous cases reported in Seropédica, RJ, Brazil.

of dyspnea. The dog tested positive for *D. immitis* antigen, but no microfilariae were detected. A diffuse bronchial pattern was detected on radiography, and Doppler echocardiography showed the presence of parallel lines in the main pulmonary artery, which further confirmed infection with *D. immitis*.

## Discussion

The municipality of Seropédica is part of the Metropolitan region of Rio de Janeiro, RJ. Canine heartworm infection is known to occur in most districts of the city of Rio de Janeiro (Labarthe et al., 1997), although there are information gaps in other areas of the municipality. Seropédica is one of those areas where no survey has been conducted.

Seropédica shares a tropical climate with Rio de Janeiro city (Lohmann et al., 1993), is only 20 km away from the Atlantic Ocean, and is adjacent to Mário Xavier National Forest. Despite having similar environmental characteristics as the Rio de Janeiro lowlands, where canine infections are frequent (prevalence ranges from 2.7% to 58.6%) (Labarthe et al., 1997, 2014), and having a Veterinary School, canine heartworm infection has received little attention (Genchi & Kramer, 2020).

Many environmental changes, including urban improvements that have impacted the national forest, have taken place in the past 10 years (Farias et al., 2020). It is reasonable to expect that these impacts would have diminished the natural vector population density and, as a consequence, reduced heartworm prevalence (Clements, A. N., 1999). Paradoxically, the number of opportunistic heartworm cases reported here suggests that the canine infection rate has increased (Traversa, D. et al., 2010). Therefore, other factors may be important and must be identified.

Canine population mobility is part of the modern way of life. Therefore, it would not be surprising to learn that the students of the local university travel back and forth between Seropédica and endemic areas with their dogs unprotected (Alirol et al., 2011). This behavior is known to spread heartworm disease to naive neighborhoods (American Heartworm Society [AHS], 2020). Another factor to be considered is environmental disturbances in nearby forests. Since the most efficient heartworm vector mosquito species in Rio de Janeiro

lowlands are known to be the sylvatic *Ochlerotatus taeniorhynchus* and *Ochlerotatus scapularis* (Labarthe et al., 1998a; Macêdo et al., 1998), environmental changes that have occurred in the forest may have displaced those vectors, forcing them to colonize new areas.

In addition, global warming favors mosquitoes, allowing them to produce higher numbers of new generations over a given time, thereby increasing local population density (Campbell-Lendrum et al., 2015). As environmental temperatures rise, the heartworm extrinsic cycle is accelerated, resulting in more efficacious and faster transmission (Carvalho et al., 2002; Christensen & Hollander, 1978; Knight & Lok, 1998; Ferreira, A. F. et al., 1999).

Other mosquito synanthropic species that may play a vector role in this geographic area are *Aedes aegypti* and *Aedes albopictus*. Although their heartworm vector capacity throughout Brazil is unknown, both species are endemic in Seropédica (Sanavria et al., 2017), and they have been shown to naturally vector heartworm in different areas of the world (Ahid & Lourenço-de-Oliveira, 1999; Cancrini et al., 2003; Comiskey & Wesson, 1995; Ledesma & Harrington, 2011; Nayar & Knight, 1999; Serrão et al., 2001).

Once these variables are considered, the presence of microfilaremic dogs, high density of competent synanthropic vector mosquito populations, and unprotected dogs exposed to the mosquitoes, it can be suggested that heartworm is becoming native to the area.

In an area where canine heartworm disease is rare, clinical signs may be misinterpreted when they are unspecific. In Seropédica, where both dogs described above have lived all their lives, one was 2-year-old that had the infection detected because he was presented with harsh lung sounds. This finding is rare at such a young age (Rozanski, 2020), although frequent in canine heartworm infections (Alberigi et al., 2020; Bowman & Atkins, 2009). The older heartworm-infected dog presented would have gone undetected if microfilariae had not been present in the cytology, and his clinical signs could have been misinterpreted as senile bronchitis (Rozanski, 2020).

Considering that the socioeconomic condition of the residents of Seropédica is poor, resources there are focused mainly on human needs (Silva et al., 2020). Therefore, pet infection prophylaxis is often not maintained, leaving animals to become potential reservoirs of parasites that may be a threat to human health.

These factors highlight the need for continuous surveillance of canine infections, keeping in mind that biomes are mistreated constantly, and that pets may be good hazard sentinels. Nature changes as a reaction to insults, repeatedly eliciting new life cycle characteristics that may impact human and non-human animal well-being. Therefore, veterinarians need to be updated and diligently work to prevent and detect infections such as heartworm disease.

## Conclusion

These two case reports demonstrate that infection with *D. immitis* can occur even in places where it is not usually found, provided that there are favorable climatic conditions for the presence of vectors and hosts. In these environments, veterinarians must prioritize diagnosis and prevention of infections.

## Acknowledgements

Norma Labarthe for the critical analysis of the manuscript.

## Ethics statement

This study was authorized by the animals owners through formal consent for disclosure of data and images for academic purposes.

## Financial support

MSF - The present work was carried out with the support of the Coordination of Improvement of Higher Education Personnel - Brazil (CAPES - Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) - Financing Code 001. NMOL - received scholarship from FAPERJ (Fundação de Apóio a Ciência, Tecnologia e Inovação do Rio de Janeiro). BA, DMPB, AJRB, JPP - none.

## Conflict of interests

MSF, BA, DMPB, NMOL, AJRB - no conflict. JPP - deceased.

## Authors' contributions

MSF and NMOL assisted the reported patients and contributed to the writing of the manuscript. DMPB - Contributed to the writing of the manuscript and to the translation into English. BA - contributed to the idealization and writing of the manuscript. AJRB - contributed to the idealization and writing of the manuscript. JPP - contributed to the idealization of the manuscript.

## Availability of complementary results

All information obtained as a result of the study is included in the manuscript.

The animals reported were treated at the Veterinary Hospital of the Universidade Federal Rural do Rio de Janeiro.

## References

- Ahid, S. M. M., & Lourenço-de-Oliveira, R. (1999). Mosquitos vetores potenciais de dirofilariose canina na Região Nordeste do Brasil. *Revista de Saúde Pública*, 33(6), 560-565. <http://dx.doi.org/10.1590/S0034-89101999000600007>. PMID:10689372.
- Alberigi, B., Fernandes, J. I., Paiva, J. P., Mendes-de-Almeida, F., Knackfuss, F., Merlo, A., & Labarthe, N. (2020). Efficacy of semi-annual therapy of an extended-release injectable moxidectin suspension and oral doxycycline in *Dirofilaria immitis* naturally infected dogs. *Parasites & Vectors*, 13(1), 503. <http://dx.doi.org/10.1186/s13071-020-04380-z>. PMID:33023664.
- Alirol, E., Getaz, L., Stoll, B., Chappuis, F., & Loutan, L. (2011). Urbanisation and infectious diseases in a globalised world. *The Lancet. Infectious Diseases*, 11(2), 131-141. [http://dx.doi.org/10.1016/S1473-3099\(10\)70223-1](http://dx.doi.org/10.1016/S1473-3099(10)70223-1). PMID:21272793.
- American Heartworm Society. (2020). *Current Canine Guidelines for the Prevention, Diagnosis and Management of Heartworm (Dirofilaria immitis) Infection in Dogs*. [https://d3ft8sckhnqim2.cloudfront.net/images/pdf/2020\\_AHS\\_Canine\\_Guidelines.pdf?1580934824](https://d3ft8sckhnqim2.cloudfront.net/images/pdf/2020_AHS_Canine_Guidelines.pdf?1580934824)
- Atwell, R. B., Sutton, R. H., & Moodie, E. W. (1988). Pulmonary changes associated with dead filariae (*Dirofilaria immitis*) and concurrent antigenic exposure in dogs. *Journal of Comparative Pathology*, 98(3), 349-361. [http://dx.doi.org/10.1016/0021-9975\(88\)90043-6](http://dx.doi.org/10.1016/0021-9975(88)90043-6). PMID:3392249.
- Backer, L. C., & Miller, M. (2016). Sentinel animals in a one health approach to harmful cyanobacterial and algal blooms. *Veterinary Sciences*, 3(2), 8. <http://dx.doi.org/10.3390/vetsci3020008>. PMID:27152315.
- Bendas, A. J. R., Branco, A. S., da Silva, B. R. S. A., Paiva, J. P., de Miranda, M. G. N., Mendes-de-Almeida, F., & Labarthe, N. V. (2019). Mosquito abundance in a *Dirofilaria immitis* hotspot in the eastern state of Rio de Janeiro, Brazil. *Veterinary Parasitology. Regional Studies and Reports*, 18, 100320. <http://dx.doi.org/10.1016/j.vprsr.2019.100320>. PMID:31796177.
- Bowman, D. D., & Atkins, C. E. (2009). Heartworm biology, treatment, and control. *Veterinary Clinical Small Animal Practice*, 39(6), 1127-1158. <http://dx.doi.org/10.1016/j.cvsm.2009.06.003>. PMID:19932367.
- Campbell-Lendrum, D., Manga, L., Bagayoko, M., & Sommerfeld, J. (2015). Climate change and vector-borne diseases: What are the implications for public health research and policy? *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 370(1665), e20130552. <http://dx.doi.org/10.1098/rstb.2013.0552>. PMID:25688013.
- Cancrini, G., Di Regalbono, A. F., Ricci, I., Tessarin, C., Gabrielli, S., & Pietrobelli, M. (2003). *Aedes albopictus* is a natural vector of *Dirofilaria immitis* in Italy. *Veterinary Parasitology*, 118(3-4), 195-202. <http://dx.doi.org/10.1016/j.vetpar.2003.10.011>. PMID:14729167.
- Carvalho, S. C., Martins-Junior, A. J., Lima, J. B., & Valle, D. (2002). Temperature influence on embryonic development of *Anopheles albiparvus* and *Anopheles aquasalis*. *Memórias do Instituto Oswaldo Cruz*, 97(8), 1117-1120. <http://dx.doi.org/10.1590/S0074-02762002000800009>. PMID:12563476.
- Christensen, B. M., & Hollander, A. L. (1978). Effect of temperature on vector-parasite relationships of *Aedes trivittatus* and *Dirofilaria immitis*. *Proceedings of the Helminthological Society of Washington*, 45, 115-119.
- Comiskey, N & Wesson, D. M. (1995). *Dirofilaria* (Filarioidea: Onchocercidae) Infection in *Aedes albopictus* (Diptera: Culicidae) Collected in Louisiana. *Journal of Medical Entomology*, 32(5):734-737. <https://doi.org/10.1093/jmedent/32.5.734>.
- Farias, H. S., Vargas, K. B., Marino, T. B., Sousa, G. M., & Lucena, A. J. (2020). Vulnerabilidade socioambiental no Oeste Metropolitano do Rio de Janeiro: estratégias de prevenção a riscos. *Revista Brasileira de Geografia Econômica*, 9(19), e2020. <http://dx.doi.org/10.4000/espacoeconomia.14182>.
- Ferreira, A. F., Barbosa, F. C., & Mastrantonio, E. C. (1999). Ocorrência da dirofilariose canina na cidade de Uberlândia, MG, Brasil. *Veterinária Notícias*, 5(1), 57-61.

- Genchi, C., & Kramer, L. H. (2020). The prevalence of *Dirofilaria immitis* and *Dirofilaria repens* in the Old World. *Veterinary Parasitology*, 280, e108995. <http://dx.doi.org/10.1016/j.vetpar.2019.108995>. PMID:32155518.
- Grapatsas, K., Kayser, G., Passlick, B., & Wiesemann, S. (2018). Pulmonary coin lesion mimicking lung cancer reveals an unexpected finding: *Dirofilaria immitis*. *Journal of Thoracic Disease*, 10(6), 3879-3882. <http://dx.doi.org/10.21037/jtd.2018.05.137>. PMID:30069389.
- Gratz, N. G. (2004). Critical review of the vector status of *Aedes albopictus*. *Medical and Veterinary Entomology*, 18(3), 215-227. <http://dx.doi.org/10.1111/j.0269-283X.2004.00513.x>. PMID:15347388.
- Knight, D. H., & Lok, J. B. (1998). Seasonality of heartworm infection and implications for chemoprophylaxis. *Clinical Technology Small Animals*, 13(2), 77-82. [http://dx.doi.org/10.1016/S1096-2867\(98\)80010-8](http://dx.doi.org/10.1016/S1096-2867(98)80010-8). PMID:9753795.
- Labarthe, N. V., Almosny, N., Guerrero, J., & Duque-Araújo, A. M. (1997). Description of the occurrence of canine dirofilariasis in the State of Rio de Janeiro, Brazil. *Memórias do Instituto Oswaldo Cruz*, 92(1), 47-51. <http://dx.doi.org/10.1590/S0074-02761997000100010>. PMID:9302414.
- Labarthe, N. V., Paiva, J. P., Reifur, L., Mendes-de-Almeida, F., Merlo, A., Pinto, C. J. C., & Alves, L. C. (2014). Updated canine infection rates for *Dirofilaria immitis* in areas of Brazil previously identified as having a high incidence of heartworm-infected dogs. *Parasites & Vectors*, 7(1), 493. <http://dx.doi.org/10.1186/s13071-014-0493-7>. PMID:25376238.
- Labarthe, N. V., Serrão, M. L., Melo, Y. F., Oliveira, S. J., & Lourenço-de-Oliveira, R. (1998a). Potential vectors of *Dirofilaria immitis* (Leidy, 1856) in Itacoatiara, Oceanic Region of Niterói Municipality, State of Rio de Janeiro, Brazil. *Memórias do Instituto Oswaldo Cruz*, 93(4), 425-432. <http://dx.doi.org/10.1590/S0074-02761998000400001>. PMID:9711329.
- Labarthe, N. V., Serrão, M. L., Melo, Y. F., Oliveira, S. J., & Lourenço-de-Oliveira, R. (1998b). Mosquito frequency and feeding habits in an enzootic canine dirofilariasis area in Niterói, state of Rio de Janeiro, Brazil. *Memórias do Instituto Oswaldo Cruz*, 93(2), 145-154. <http://dx.doi.org/10.1590/S0074-02761998000200002>. PMID:9698883.
- Ledesma, N., & Harrington, L. (2011). Mosquito vectors of dog heartworm in the united states: vector status and factors influencing transmission efficiency. *Topics in Companion Animal Medicine*, 26(4), 178-185. <http://dx.doi.org/10.1053/j.tcam.2011.09.005>. PMID:22152605.
- Lohmann, U., Sausen, R., Bengtsson, L., Cubasch, U., Perlwitz, J., & Roeckner, E. (1993). The Köppen climate classification as a diagnostic tool for general circulation models. *Climate Research*, 3, 177-193. <http://dx.doi.org/10.3354/cr003177>.
- Lourenço-de-Oliveira, R., & Deane, L. M. (1995). Presumed *Dirofilaria immitis* Infections in Wild-Caught *Aedes taeniorhynchus* and *Aedes scapularis* in Rio de Janeiro, Brazil. *Memórias do Instituto Oswaldo Cruz*, 90(3), 387-388. <http://dx.doi.org/10.1590/S0074-02761995000300013>. PMID:8544737.
- Macêdo, F. C., Labarthe, N., & Lourenço-de-Oliveira, R. (1998). Susceptibility of *Aedes scapularis* (Rondani, 1848) to *Dirofilaria immitis* (Leidy, 1856), an Emerging Zoonosis. *Memórias do Instituto Oswaldo Cruz*, 93(4), 435-437. <http://dx.doi.org/10.1590/S0074-02761998000400003>. PMID:9711331.
- Magi, M., Calderini, P., Gabrielli, S., Dell'Omodarme, M., Macchioni, F., Prati, M. C., & Cancrini, G. (2008). *Vulpes vulpes*: A possible wild reservoir for zoonotic filariae. *Vector Borne and Zoonotic Diseases (Larchmont, N.Y.)*, 8(2), 249-252. <http://dx.doi.org/10.1089/vbz.2007.0207>. PMID:18260788.
- McCall, J. W. (2005). The safety-net story about macrocyclic lactone heartworm preventives: a review, an update, and recommendations. *Veterinary Parasitology*, 133(2-3), 197-206. <http://dx.doi.org/10.1016/j.vetpar.2005.04.005>. PMID:16198822.
- Milanez-de-Campos, J. R., Barbas, C. S., Filomeno, L. T., Fernandez, A., Minamoto, H., Filho, J. V., & Jatene, F. B. (1997). Human pulmonary dirofilariasis: Analysis of 24 cases from São Paulo, Brazil. *Chest*, 112(3), 729-733. <http://dx.doi.org/10.1378/chest.112.3.729>. PMID:9315807.
- Mitchell, C. J. (1995). Geographic spread of *Aedes albopictus* and potential for involvement in arbovirus cycles in the mediterranean basin. *Journal of Vector Ecology*, 20, 44-58.
- Nayar, J. K., & Knight, J. W. (1999). *Aedes albopictus* (Diptera: Culicidae): an experimental and natural host of *Dirofilaria immitis* (Filarioidea: Onchocercidae) in Florida, U.S.A. *Journal of Medical Entomology*, 36(4), 441-448. <http://dx.doi.org/10.1093/jmedent/36.4.441>. PMID:10467770.
- Penezić, A., Selakovic, S., Pavlovic, I., & Cirovic, D. (2014). First findings and prevalence of adult heartworms (*Dirofilaria immitis*) in wild carnivores from Serbia. *Parasitology Research*, 113(9), 3281-3285. <http://dx.doi.org/10.1007/s00436-014-3991-9>. PMID:24951168.
- Raclou, V., Griot, C., & Stärk, K. D. C. (2006). Sentinel surveillance systems with special focus on vector-borne diseases. *Animal Health Research Reviews*, 7(1-2), 71-79. <http://dx.doi.org/10.1017/S1466252307001120>. PMID:17389055.
- Rozanski, E. A. (2020). Canine Chronic Bronchitis: a update. *Veterinary Clinics: Small Animal Practice*, 44(1):107-116. <https://doi.org/10.1016/j.cvsm.2013.09.005>.
- Sanavria, A., Silva, C., Electo, É. H., Nogueira, L., Thomé, S., Angelo, I., Vita, G. F., Sanavria, T., Padua, E. D., & Gaiotte, D. G. (2017). Intelligent monitoring of *Aedes aegypti* in a rural area of Rio de Janeiro State, Brazil. *Revista do Instituto de Medicina Tropical de São Paulo*, 59(0), e51. <http://dx.doi.org/10.1590/s1678-9946201759051>. PMID:28793020.
- Schmidt, P. L. (2009). Companion animals as sentinels for public health. *The Veterinary Clinics of North America. Small Animal Practice*, 39(2), 241-250. <http://dx.doi.org/10.1016/j.cvsm.2008.10.010>. PMID:19185191.

- Serrão, M. L., Labarthe, N. V., & Lourenço-de-Oliveira, R. (2001). Vectorial Competente of *Aedes aegypti* (Linnaeus 1762) Rio de Janeiro Strain, to *Dirofilaria immitis* (Leidy 1856). *Memórias do Instituto Oswaldo Cruz*, 96(5), 593-598. <http://dx.doi.org/10.1590/S0074-02762001000500001>. PMID:11500754.
- Silva, P. C. B., Oliveira-Junior, R. R., & Borges, M. S. (2020). Scenarios of territorial inequalities in the Brazil: A study on Baixada Fluminense (RJ). *Brazilian Journal of Development*, 6(9), 72767-72779. <http://dx.doi.org/10.34117/bjdv6n9-648>.
- Traversa, D., Aste, G., Milillo, P., Capelli, G., Pampurini, F., Tunesi, C., Santori, D., Paoletti, B., & Boari, A. (2010). Autochthonous foci of canine and feline infections by *Dirofilaria immitis* and *Dirofilaria repens* in central Italy. *Veterinary Parasitology*, 169(1-2), 128-132. <http://dx.doi.org/10.1016/j.vetpar.2009.12.034>. PMID:20097479.
- Trotti, G. C., Pampiglione, S., & Rivasi, F. (1997). The species of the genus *Dirofilaria* Railliet & Henry, 1911. *Parasitologia*, 39(4), 369-374. PMID:9802094.