












Flea parasitism in wild mammals in the metropolitan region of Sorocaba, São Paulo, Brazil

Parasitismo por sifonápteros em mamíferos silvestres na região metropolitana de Sorocaba, São Paulo, Brasil

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Abstract

Fleas are eurixenous ectoparasites that can parasitize different species of warm-blooded animals, including humans, with the possibility of causing irritation and blood spoliation. They are vectors responsible for the transmission of numerous pathogens and have a wide geographical distribution, more frequently in warm regions. Domestic animals (dogs and cats) are preferred hosts, but parasitism can also occur in wild hosts, with a greater variety of parasitic species and strong interaction between these siphonapteres and their hosts. During the period from January 2021 to June 2023, flea specimens were collected from wild animals coming from the metropolitan region of Sorocaba, São Paulo. Some of these animals were animals from the zoo's own stock, which were diagnosed with parasitism during routine examinations and others were rescued from the natural environment and sent to the zoo. The flea specimens collected were packed in alcohol 700 GL and sent for microscopic diagnosis. Four groups were diagnosed at the specific level: *Ctenocephalides felis*, *Rhopalopsyllus lutzi*, *R. lugrubis* and *Tunga penetrans*, and two groups as unidentified species, belonging to the genera *Rhopalopsyllus* and *Polygenis*. The parasitized animals were all mammals, belonging to eleven different species, distributed in the Orders Carnivora, Didelphimorphia, Rodentia and Cingulata. Studies on the parasitofauna of wild animals contribute to a greater knowledge about the distribution of parasitic agents and their relationships with the host species.

Keywords: ectoparasite, siphonaptera, zoological.

Resumo

As pulgas são ectoparasitos eurixenos que podem parasitar diferentes espécies de animais de sangue quente, incluindo seres humanos, com possibilidade de causar irritação e espoliação sanguínea. São vetores responsáveis pela transmissão de inúmeros patógenos e apresentam ampla distribuição geográfica, com maior frequência em regiões quentes. Os animais domésticos (cães e gatos) são hospedeiros preferenciais, mas o parasitismo pode ocorrer também em hospedeiros selvagens, com maior variedade de espécies parasitas e forte interação entre esses sifonápteros e seus hospedeiros. Durante o período de janeiro de 2021 a junho de 2023, espécimes de pulgas foram coletados de animais selvagens provenientes da região metropolitana de Sorocaba, São Paulo. Alguns destes animais eram animais do plantel do próprio zoológico, que foram diagnosticados com o parasitismo durante exames de rotina e outros foram resgatados do ambiente natural e encaminhados ao zoológico. Os espécimes de pulgas coletadas foram acondicionados em álcool 70° GL e enviados para diagnóstico microscópico. Foram diagnosticados quatro grupos a nível específico: *Ctenocephalides felis*, *Rhopalopsyllus lutzi*, *R. lugrubis* e *Tunga penetrans*, e dois grupos como espécies não identificadas, pertencentes aos gêneros *Rhopalopsyllus* e *Polygenis*. Os animais parasitados eram todos mamíferos, pertencentes a onze espécies diferentes, distribuídas nas Ordens Carnivora, Didelphimorphia, Rodentia e Cingulata. Estudos sobre a parasitofauna de animais selvagens contribuem para um maior conhecimento sobre a distribuição de agentes parasitários e suas relações com as espécies hospedeiras.

Palavras-chave: ectoparasito, siphonaptera, zoológico.




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Introduction

Fleas are small wingless insects with dark brown coloration, flattened laterally, and hind legs adapted for long jumps. They act as obligatory hematophagous parasites in their adult life stage and can parasitize wild animals, domestic animals, and humans. They have bristles covering their bodies, which serve the purpose of attachment and aid in movement among the host's fur. These structures are also important for taxonomic identification. Fleas are classified in the order Siphonaptera, which comprises approximately 3,000 species distributed among 240 genera and 15 families. The state of São Paulo has the highest variety of cataloged flea species, totaling 38 species compared to other Brazilian states. Regarding hosts, studies indicate that rodents are the main mammalian hosts parasitized by fleas, followed by carnivores, marsupials, bats, armadillos, primates, artiodactyls, lagomorphs, and perissodactyls (Linardi, 2011).

Among the various species of Siphonaptera, four families are of special veterinary importance due to their high capacity for spreading diseases to humans and domestic animals: Pulicidae, Ceratophyllidae, Leptopsyllidae, and Vermipsyllidae (Dobler & Pfeffer, 2011). Several species of fleas have been reported in wild animals, but the most common ones in Brazil are *Ctenocephalides felis*, *Pulex irritans*, *Tunga penetrans*, and *Xenopsylla cheopis*. The genus *Ctenocephalides*, represented by the species *C. felis* and *C. canis*, is considered a genus with a wide geographic distribution and has been reported to parasitize various species of wild mammals in the orders Artiodactyla, Carnivora, Didelphimorphia, Lagomorpha, Primates, Rodentia, and Xenarthra (Linardi & Santos, 2012; Santos et al., 2015).

Among flea species, *C. felis* is the most generalist, exhibiting low host specificity (Clark et al., 2018). This characteristic is shared by many siphonaptera species and allows for the sharing of parasitism between domestic and wild animals, particularly in situations where wild animals access urban and peri-urban areas, or domestic animals invade protected areas or natural landscapes. Fleas of the species *P. irritans* and *C. felis* have been reported in free-ranging wild canids in Brazil, such as the crab-eating fox (*Cerdocyon thous*) and the maned wolf (*Chrysocyon brachyurus*) (Almeida et al., 2010).

Fleas of the species *C. felis*, *C. canis*, *P. irritans*, *Rhopalopsyllus lutzi*, and *Xenopsylla cheopis* have been collected from crab-eating fox specimens (*Cerdocyon thous*) (Cerqueira et al., 2000; Rodrigues and Daemon, 2004; Santos et al., 2012).

Skin lesions caused by *Tunga penetrans* have been diagnosed in free-ranging jaguars (*Panthera onca*) found dead on roads in the state of Mato Grosso (Tancredi et al., 2021). In a free-ranging margay cat (*Leopardus wiedii*) in Peru, *C. felis* was identified parasitizing a rescued wild-born kitten that had been kept in the same environment as domestic animals for a period of time prior to flea collection (Quevedo et al., 2014). Other species of wild felids, both free-ranging and under human care, have been identified as flea hosts in Brazil, including *Adoratopsylla antiquorum*, *A. intermedia*, *C. felis*, *Polygenis tripus*, *P. occidentalis*, *Pulex irritans*, *Rhopalopsyllus lutzi*, and *X. cheopis* in species such as the jaguarundi (*Herpailurus yagouaroundi*), southern tiger cat (*Leopardus guttulus*), margay cat (*Leopardus wiedii*), geoffroy's cat (*Leopardus geoffroyi*), ocelot (*Leopardus pardalis*), and puma (*Puma concolor*) (Grossmann et al., 2018; Pinto et al., 2009; Souza et al., 2021).

Rodents constitute a diverse and numerous group of animals in terms of species and individuals, and as a result, they are the main hosts for fleas in natural environments. Parasitism by fleas has been described in rodents, including species such as *Adoratopsylla antiquorum*, *Craneopsylla minerva*, *Ctenocephalides felis*, *Hechtiella lakoi*, *Polygenis atopus*, *P. dentei*, *P. frustratus*, *P. pygaerus*, *P. pradoi*, *P. rimatus*, *P. roberti*, *P. tripus*, *Pulex irritans*, *Rhopalopsyllus australis*, *R. lugubris*, *R. lutzi*, *Tunga caecata*, and *X. cheopis* (Carvalho et al., 2001; Linardi, 2017; Moraes et al., 2003; Sales et al., 2021). Fleas of the species *Polygenis occidentalis*, *P. rimatus*, and *P. tripus* have been collected from free-ranging squirrels (*Sciurus aestuans*) (Barros-Battesti et al., 1998; Bittencourt & Rocha 2003).

Marsupials of the *Didelphis* genus are known hosts for numerous siphonaptera species, possibly due to their wide geographic distribution, adaptability to different biomes, and proximity to domestic animals. In Brazil, approximately 30 flea species parasitizing marsupials have been reported, distributed among 11 genera and five families. The family Rhopalopsyllidae has the highest number of flea representatives parasitizing marsupials, followed by Ctenophthalmidae, Stephanocircidae, and Pulicidae. A new flea family, Leptopsyllidae, with a single species

Leptopsylla segnis parasitizing common opossums (*Didelphis aurita*), has recently been described (Linardi & Santos, 2012; Santos et al., 2015).

Fleas of the species *A. antiquorum*, *A. intermedia*, *C. felis*, *P. atopus*, *P. occidentalis*, *P. roberti*, *P. rimatus*, and *X. cheopis* have been identified in common opossums (*D. aurita*) captured in the wild (Bezerra-Santos et al., 2021; Cordeiro et al., 2022; Moraes et al., 2003; Nogueira et al., 2023; Oliveira et al., 2007, 2010; Pinto et al., 2009). The presence of *T. penetrans* has been reported in common opossums (*D. albiventris*) in free-ranging populations (Barros-Battesti & Arzua, 1997; Saraiva et al., 2012). In a study conducted in southern Brazil, fleas of the species *C. minerva*, *C. felis*, *P. atopus*, *P. rimatus*, *P. roberti*, *Polygenis* sp., and *Rhopalopsyllus lutzi* were collected from white-eared opossums (*D. albiventris*) (Antunes et al., 2006; Bezerra-Santos et al., 2021). Among armadillos, the most prevalent flea species is *Tunga terasma*, found mainly on nine-banded armadillos (*Dasyurus novemcinctus*) (Antunes et al., 2006).

Ectoparasites play an important role in the transmission of pathogens that cause diseases in animals and humans. Flea infestations can lead to irritation, dermatitis, anemia, and skin lesions caused by penetrating flea species. As vectors or intermediate hosts, fleas are involved in the transmission of viruses, bacteria, protozoa, and helminths (Linardi, 2011).

In wild animals kept under human care, fleas are recognized as significant parasites, particularly *C. felis*, which can cause severe anemia and even fatalities in severe cases. Controlling these ectoparasites is a major challenge since synanthropic animals can act as vectors, transmitting the infestation to wild animals (Costa et al., 2019). Clinical examinations involving inspection and collection of ectoparasites from wild animals under human care should be a constant and routine activity, aiming for accurate diagnosis and control, which is not always a simple task due to various factors. Actions targeting the host and the environment are necessary for successful control (Dantas-Torres & Otranto, 2014).

The objective of this research was to taxonomically diagnose Siphonaptera parasites of wild mammals in the Metropolitan Region of Sorocaba (RMS), São Paulo, both in wild animals rescued from their natural habitat and in animals kept under human care at the Sorocaba's Zoo.

Materials and methods

The Sorocaba's Zoo has the number of CTF (Federal Technical Registration) 39291.

From January of 2021 to June of 2023, wild mammals kept under human care or rescued from their natural habitat and brought to the Sorocaba's Zoo, SP, were examined for clinical evaluation and ectoparasite collection.

Collections took place in the wild animal population of the zoological during routine management and preventive examinations, as well as during the quarantine period of rescued wild animals before their transfer to the zoo. The collected specimens of Siphonaptera were stored in plastic bottles with screw caps, containing 70% ethanol. The bottles with the ectoparasites were labeled with information about the hosts, date, and location of host origin. They were then sent to the Laboratory for Diagnostic Support in Parasitic Diseases (UFF) in the city of Niterói, RJ, and examined using optical microscopy techniques for taxonomic diagnosis following the methods described by Linardi & Guimarães (2000), Linardi (2011) and Linardi & Santos (2012). The specimens were clarified in creosote and mounted between slide and coverslip in Canadian Balsam (Consoli & Oliveira, 1994). The photographed records were made of specimens in 70% ethyl alcohol in a Leica M205c stereomicroscope and images captured by the Leica Application Suite (LAS) v4.7.

Results

Eleven species of wild mammals were diagnosed with flea infestation, representing 11 species from the orders Carnivora, Didelphimorphia, Rodentia, and Cingulata (Table 1). No severe clinical cases or clinical signs of pruritus, skin erythema, or anemia were detected. The analyzed fleas were identified as belonging to the species *Ctenocephalides felis*, *Rhopalopsyllus lutzi*, *R. lugrubi*, and *Tunga penetrans*. Two samples were identified as unidentified species, belonging to the genera *Rhopalopsyllus* sp. and *Polygenis* sp. (Figure 1).

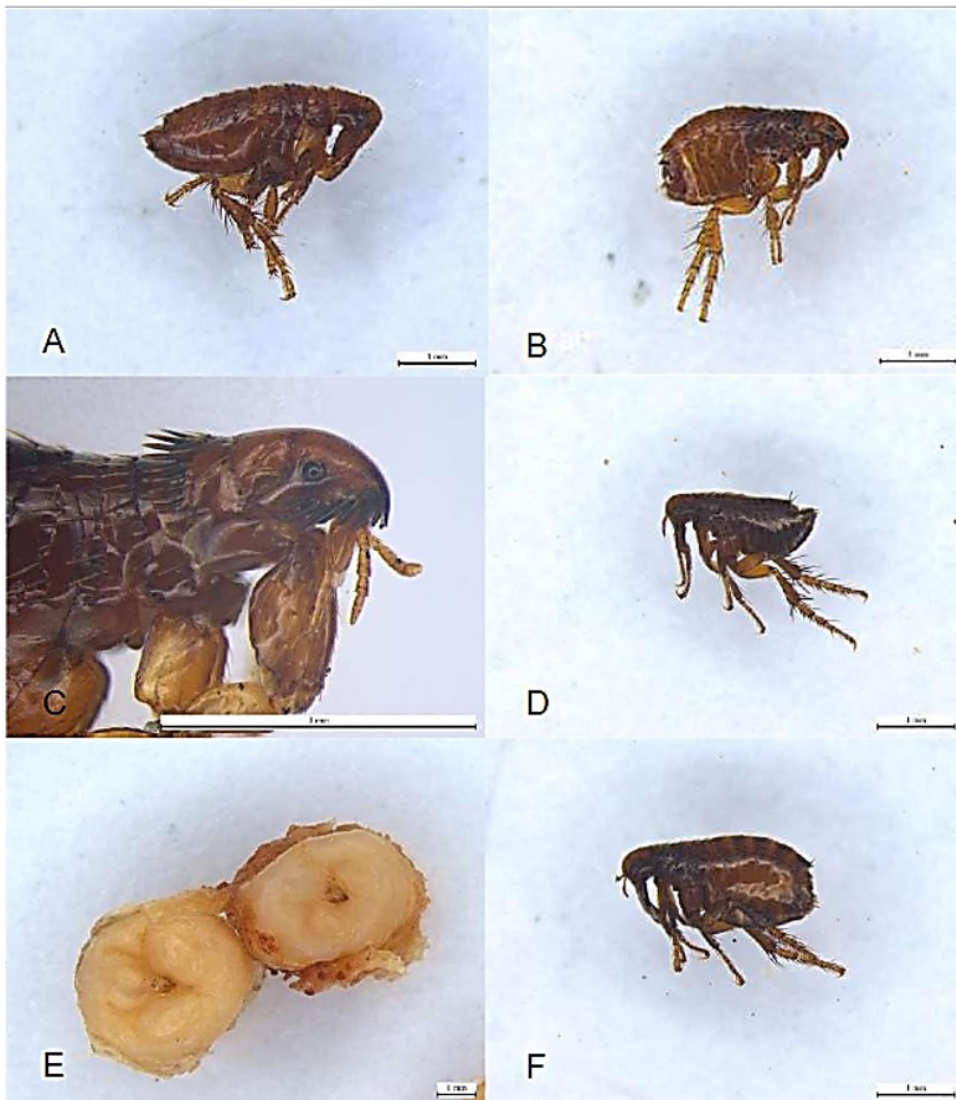


Figure 1. Siphonaptera specimens collected from wild animals from the metropolitan region of Sorocaba, SP: (A) *Rhopalopsyllus lutzi*, (B) *Ctenocephalides felis*, (C) *Ctenocephalides felis* (D) *Rhopalopsyllus* sp., (E) *Tunga penetrans* (nodular lesions), (F) *Polygenis* sp.

Table 1. List of wild hosts infested with Siphonaptera in the metropolitan region of Sorocaba between January of 2021 and June of 2023.

Host	Fleas species	Origin / local
<i>Sciurus aestuans</i> (Guianan Squirrel)	<i>Polygenis</i> sp.	wild / Sorocaba
<i>Dasyprocta azarae</i> (Azara´s Agouti)	<i>Rhopalopsyllus lutzi</i>	zoo / Sorocaba
<i>Cuniculus paca</i> (Agouti)	<i>Rhopalopsyllus lugrubi</i>	zoo / Sorocaba
<i>Cerdocyon thous</i> (Crab-eating fox)	<i>Ctenocephalides felis</i>	wild / Sorocaba
<i>Leopardus pardalis</i> (Ocelot)	<i>Ctenocephalides felis</i>	zoo / Sorocaba
	<i>Rhopalopsyllus</i> sp.	wild / Itapetininga
<i>Herpailurus yagouaroundi</i> (Jaguarundi)	<i>Ctenocephalides felis</i>	zoo / Sorocaba
<i>Leopardus guttulus</i> (Southern tiger cat)	<i>Ctenocephalides felis</i>	zoo / Sorocaba
<i>Leopardus wiedii</i> (Margay cat)	<i>Ctenocephalides felis</i>	zoo / Sorocaba
<i>Chrysocyon brachyurus</i> (Maned wolf)	<i>Ctenocephalides felis</i>	zoo / Sorocaba
<i>Didelphis albiventris</i> (White-eared opossum)	<i>Ctenocephalides felis</i>	wild / Sorocaba
<i>Dasybus novemcinctus</i> (Nine-banded armadillo)	<i>Tunga penetrans</i>	wild / Sorocaba

Family Pulicidae

Subfamily Pulicina

Tribe Pulicini

Subfamily Archaepsyllinae

Genus *Ctenocephalides* Stiles & Collins, 1930

Ctenocephalides felis (Bouché, 1835) (Figure 1B)

Description: Pulicini, Archaepsyllinae. Based on fifteen specimens mounted in toto. Integracypite head, prominent occipital sulcus, oblique forehead, presence of eight genal ctenids on each side, the first being longer than the eye. Dorsal margin of the posterior tibia with only a long bristle between the median and apical notches. Average size: 2.20mm females and 1.75mm males.

Taxonomic Review:

Hosts: 1 Bush dog (*Cerdocyon thous*), 2 Ocelot (*Leopardus pardalis*), 2 Moorish cats (*Herpailurus yagouaroundi*), 1 Lesser bush cat (*Leopardus tigrinus*), 1 Margay cat (*Leopardus wieddi*), 1 Maned wolf (*Chrysocyon brachyurus*), 8 White-eared opossums (*Didelphis albiventris*).

Origin: Sorocaba, SP (Bush dog, Moorish cats, Lesser bush cat, Margay cat, Maned wolf, White-eared opossums), Itapetininga, SP (Ocelot).

Family Rhopalopsyllidae

Subfamily Rhopalopsyllinae

Tribe Rhopalopsyllini

SubTribe Rhopalopsyllina

Genus *Rhopalopsyllus* Baker, 1905

Rhopalopsyllus lutzi (Baker, 1904) (Figure 1A).

Description: Rhopalopsyllini, Rhopalopsyllina. Based on five specimens assembled in toto. Lip palps with six segments. Nails of the first pairs of asymmetrical paws. Prominent occipital groove. Sternite VII with truncated posterior margin and with a row of larger bristles arranged in a non-decreasing manner in length.

Taxonomic Review:

Host: 1 Paca, *Cuniculus paca* Origin: Sorocaba, SP.

Family Rhopalopsyllidae

Subfamily Rhopalopsyllinae

Tribe Polygenini

Subtribe Polygenina

Genus *Polygenis* Jordan, 1930 (Figure 1F).

Description: Polygenini, Polygenin. Based on three specimens mounted in toto. Frontal tubercle situated below the middle of the frontal margin. Well-developed eyes. Club with nine flagelomeres. Lip palps with five segments do not extend to the base of the trochanter. Absent prenotal ctenids. Mesopleura longer than high. Symmetrical nails.

Taxonomic Review:

Host: 1 Serelepe, *Scirius aestuans*

Origin: Sorocaba, SP.

Family Tungidae

Genus *Tunga* Jarocki, 1838

Tunga penetrans (Linnaeus, 1758) (Figure 1E)

Description: Siphonaptera, Tungidae. Based on four penetrating female specimens. The head is quadrangular and has a glabrous forehead and occiput. The three thoracic tergites gathered shorter than the first abdominal tergite.

Taxonomic Review:

Host: 2 Nine-banded armadillo, *Dasypus novencinctus* Origin: Sorocaba, SP.

Discussion

The flea species described in this study depict a reality regarding the parasite-host interaction in natural and urban environments. We cannot assert that there are flea species with a higher aptitude for urban, peri-urban, or wild environments. However, some fleas are species-specific, exhibiting preferences for certain host groups. In the routine of Sorocaba's Zoo, the reception of wild carnivore cubs, kept, for some time, under the care of human guardians, is very frequent. These animals usually test positive for flea infestation by *C. felis*. This species was also described by Linardi (2011, 2017), Linardi and Santos (2012), as the most common flea in domestic dogs and cats.

Clark et al. (2018) indicates that *C. felis* is the most prevalent flea species, with low host specificity. The results obtained in this study corroborate this information since *C. felis* was the most frequency flea among the examined mammals, being present in seven out of the eleven host species examined.

The presence of domestic animals as invaders in natural areas is undoubtedly a factor that interferes with the sharing of pathogens between domestic and wild species. In studies conducted in natural reserve areas, Almeida et al. (2010) reported that the most frequency parasite species were those traditionally described as parasites of domestic animals.

Zoos are artificial environments that are highly favorable for flea infestations as they house various species of wild animals, which are usually grouped in a restricted area where synanthropic animals (rodents and birds) and domestic animals may also coexist. Clark et al. (2018) reported that wild animals kept in artificial environments are potential accidental hosts for flea infestations. In the specific case of Sorocaba's Zoo, the park area is located in a residential neighborhood where many domestic animals reside. Furthermore, the contact of animals kept in the zoo's collection with migratory species or free-living animals can also be considered an important factor in the dispersion of parasite species to other environments and hosts.

In this study, fleas from three different taxonomic families were collected and identified, based on the analysis of samples collected during the clinical examinations of the hosts, but the size of the flea infrapopulations in each host was not estimated and the absolute prevalence was not even calculated in the total number of animals already examined at the Sorocaba's Zoo. However, Marshall (1981) describes that 74% of siphonapteran specimens are found infesting rodents, 8% insectivores, 5% marsupials, 5% batsoptera, 3% lagomorphs, 3% carnivores and about 2% in mammals of other orders.

Collecting ectoparasites in wild animals is a routine and cost-effective activity in Sorocaba's Zoo, which generates valuable knowledge about the parasite-host interaction. Ectoparasite collection and diagnosis are activities that need to be performed more frequently in institutions that house wild animals, especially during the quarantine period, as the results provide important information not only for implementing sanitary control programs but also for a better understanding of these parasites and their relationships with host species.

Conclusion

Wild mammals at the Sorocaba Zoo presented fleas but were not see any clinical or behavior change in the hosts. Studies about the relationship between fleas and domestic animals are well documented, however, between fleas and wild hosts requires further studies and is still scarce.

The presence of fleas in wild animals was observed during routine physical examinations, confirming the importance of the search of ectoparasites in the quarentine time.

Ctenocephalides felis proved to be an ectoparasite without specificity because the species was found parasitizing different groups of carnivores in the Sorocaba Zoo (Canidae, Felidae and Didelphidae).

Ethics statement

The Sorocaba Zoo holds a license to keep the wild animals (host) from the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) under number 1/35/95/0432-7 and a Management Authorization (AM) from the State Secretary of the Environment, Infrastructure, and Logistics (SEMIL) under number 8040/2011.

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Conflict of interests

RHFT, ALMC, CRRG, FNM, MAM, SFS, RVM, MAB, BFL, CAMS, LAB. No conflict of interest

Authors' contributions

RHFT - design the experiment and wrote the paper; RVM, MBFL, BFL, CAMS and LAB - contributed materials/ analysis tools; ALMC, CRRG, FNM, MAM and SFSL - data collection.

Availability of complementary results

None.

The wild mammals kept under human care to the Sorocaba Zoo, SP, were examined for clinical evaluation and ectoparasite collection. The fleas were then sent to the Laboratory for Diagnostic Support in Parasitic Diseases (UFF) in the city of Niterói, RJ.

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