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# Chagas Disease in the Yucatan Peninsula, Mexico

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Carlos F. Ortega-Jimenez, Eugenia Guzman-Marin,  
Eduardo Gutierrez-Blanco,  
Antonio Ortega-Pacheco and  
Matilde Jimenez-Coello

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## Abstract

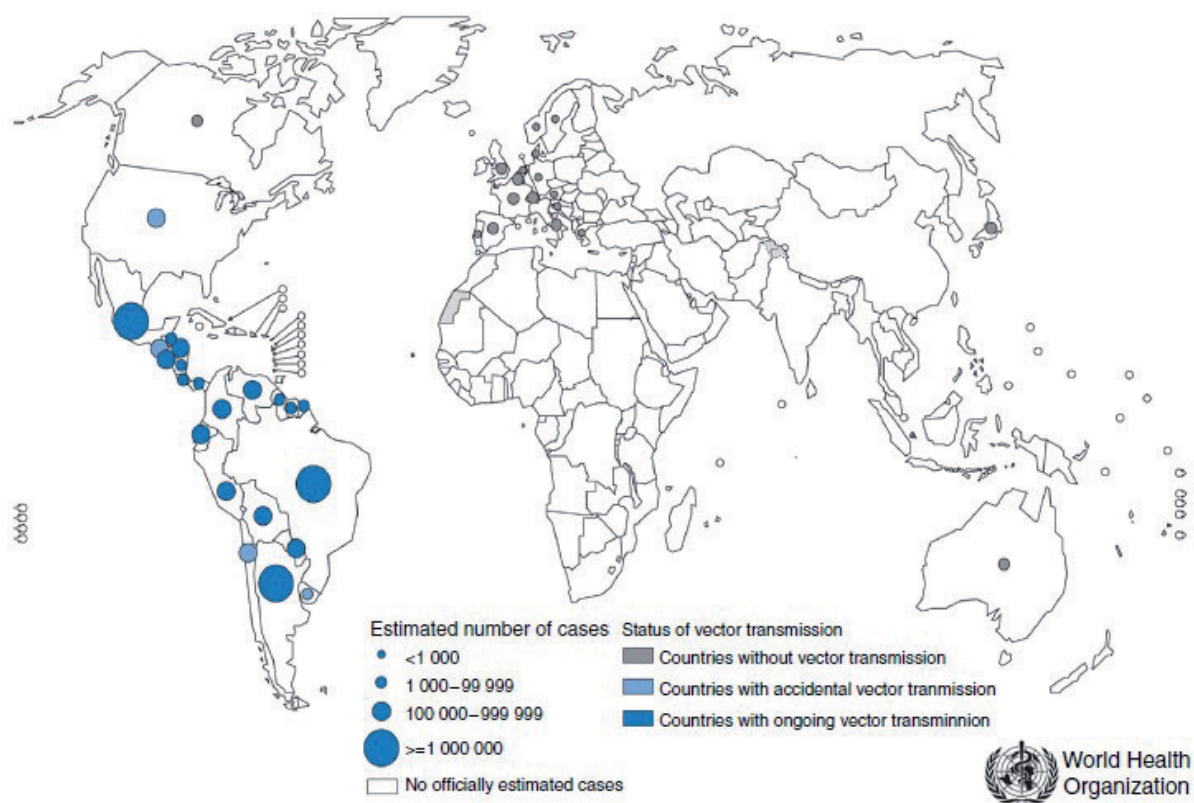
American trypanosomiasis or Chagas disease is caused by the protozoan *Trypanosoma cruzi*, which affects a wide variety of hosts including the man, until now treatment options or vaccines developed are not enough to control or prevent infected cases. The main way of transmission is vectorial, through insects of the *Reduviidae* family, as well by congenital transmission, blood/organ transplants or oral transmission. Chagas disease are considered as endemic in many areas due to the presence and lack of control of insect vectors. Many touristic places in Latin America are located in endemic areas; however, there is a nonexistence of knowledge by touristic service providers about the theme. For that reason, there is a latent risk that tourists who come to vacation in endemic areas are exposed get the infection. The risk factors are well identified, and this allows that well-defined prevention strategies can be established in order to avoid the presentation of cases in visitors to the tourist zones. This chapter aimed to describe the situation of Chagas disease in touristic areas of the Caribbean of America Latina as and to provide a brief review of information that allows visitors to know about the epidemiology and potential risks of this infection.

**Keywords:** American trypanosomiasis, tourism, endemic regions, vector transmission, Mexico

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## 1. Introduction

Nowadays, any destination can be reached from any other place around the world in 36 h of travel or less. This 36-h window fits well within the incubation period of most diseases,



**Figure 1.** Distribution of cases of *Trypanosoma cruzi* infection, based on official estimates and status of vector transmission, 2006–2009 [4].

affording ample opportunity for the unrecognized pathogen movement from place to place and for rapid global spread of microbial agents [1].

There are nearly 20 million seropositive persons with Chagas disease (CD) in the Americas, and 90 million persons, or about one-fifth of Latin America's population, are at risk of contract *Trypanosoma cruzi* (*T. cruzi*) infection [2]. The protozoan, known as the causative agent of CD, a neglected tropical disease, extends through North, Central, and South America, affecting 21 countries [3], with over eight million people across Mexico and Central and South America. In the United States, around 300,000 to over 1 million people are infected, mostly because of traveling and migration to Chagas disease-endemic regions (**Figure 1**) [5]. This disease has caused more deaths from parasitic disorders than from any other parasitic disease in Latin America and was responsible for the third highest number of parasitic infections in the world following malaria and schistosomiasis [6].

## 2. Presence of Chagas disease in the Yucatan Peninsula

Chagas disease transmission has been reported in the Yucatan Peninsula as early as 1941, but current information on its incidence is probably underestimated. Mexico is a leader in Latin American tourism, and the Yucatan Peninsula is one of the most important tourism destinations in Mexico; it has emerged as a major tourist destination for archeology, weddings and romance, rest, parties (spring breakers), ecotourism, diving in subterranean rivers in caves and cenotes, over the past several decades. Tourism numbers have increased during 2017 over 1,652,653 arrivals each year, that is, over 0.6% from previous years. As in January 2017,

the arrival of foreign air-coming visitors who reside in the United States represented 52.5% of all foreign arrivals, followed by Canada as 18.7% and other Latin American and Caribbean countries as Argentina and Colombia with 3.3 and 2.3% of total visitors, respectively [7].

Dumonteil and Goubrière [8] constructed a risk map for the natural transmission of Chagas disease in the Yucatan peninsula of Mexico, using geographic information systems to design predictive models of reduviid abundance (*T. dimidiata*) and infection rates. They described that there were (a) greater numbers of *T. dimidiata* in warmer and drier climates of the Yucatan, including coastal tourist areas; (b) higher reduviid infection rates in areas with lower temperatures and higher precipitation rates, specifically rain forests; and (c) greater reduviid abundance in areas of “perturbed” vegetation, defined in their study as agricultural fields and pastures.

In a study conducted by Reyes-Novelo [9], houses of a rural community in Yucatan were studied to identify intra or peridomiciliary infestation with *T. dimidiata*. It was found that 76.5% of the houses were infested, of those 27.7% colonized and 75% had infected triatomines, indicating that both habitats may contribute as sources of *T. dimidiata* house infestation.

## 2.1. Risk of travel

Travelers not only put themselves at risk by visiting areas where diseases are emerging, but they also run the risk of exposure to disease they do not usually encounter at home. After exposure, they may not manifest symptoms due to incubation period, until they return to their countries, risking the potential for spread of microbes to new areas [1]. Chagas disease is an autochthonous disease of many countries of the western hemisphere, travelers, including immigrants have been considered a potential source of introduction of diseases, and CD can pose increasing communicable disease risks to travelers in endemic regions of the Americas, including beachside resort regions and interior rural regions [2, 10].

The touristic areas in the Yucatan peninsula include coasts, colonial cities and Mayan ruins, most of them located in perturbed forested areas, and they are among the most scenic and popular destinations for historians, archeologists, ecotourists and cruise line passengers. The urban areas in the Yucatan Peninsula had/have a big rate of growing due to the migration even from other states of Mexico (caused by the insecurity levels in other states of the country) as well the presence of many other citizens coming mainly from Venezuela and Argentina. Therefore, many areas from the Yucatan Peninsula are still high-risk regions for Chagas disease and are the most frequently visited areas throughout the year by travelers, including Quintana Roo (where Cancun and Playa del Carmen are located) Campeche and Yucatan [8].

Human seroprevalence has been reported since the 1970s with a 11.2–18.8% prevalence infection, and more recent further studies have shown a prevalence in Mayan communities ranging from 1 to 4%, being similar in the city, over 0.6 and 1.7% in blood donors [11, 12].

Over the years, *T. cruzi* seroprevalence has been reported in several ways, and many population groups, which help us, have a general panorama of the situation represented in the Yucatan Peninsula. The few studies conducted in the region show the urban and rural prevalence that has changed among years, not differing much from each other, pointing out Chagas Disease its present, especially in cardiopathic patients, pregnant women and any population group, even domestic animals, such as cats and dogs, which humans generally coexist with. Seroprevalence found in diverse studies is shown in **Table 1**.

Study group	Area development	Seroprevalence (%)	Reference
Pregnant women	Rural	4.4	Gamboa-Leon et al. [11]
Mothers and newborns	Urban	0.8–1.2	Gamboa Leon et al. [13]
General	Rural	11.2	Zavala-Velázquez [12]
Pregnant women	Rural and urban	0.8	Sosa-Estrani et al. [14]
General	Rural and urban	3.7	Nouvellet et al. [15]
General	Rural	2.3	Monteon et al. [16]
Cardiopathics	Urban	15	Alducin-Tellez et al. [17]
General	Urban	8	Jiménez-Coello et al. [18]
Cardiopathics	Rural	4.8	Monteón et al. [19]
Other factors			
Dogs	Rural and urban	14.76	López-Céspedes et al. [20]
Dogs	Rural	29.9	Carrillo-Peraza et al. [21]
Cats	Urban	8.6	Jiménez-Coello et al. [22]

Data are obtained from [11–22].

**Table 1.** Prevalence reported in the Yucatan Peninsula.

A big number of tourists from non-endemic countries can become infected through the skin or mucous contact with the stool or urine of infected bloodsucking insects of the triatomine species when they visited endemic areas, were exposed, and almost never had previous knowledge about the pathogen or the Chagas disease. The acute phase is usually not diagnosed because it is characterized by an influenza-like illness acutely in adults. However, as *T. cruzi* can be presented in the blood of infected individuals, decades after infection took place; the infection can be also transmitted through blood transfusion and organ transplant, which is considered the second most common mode of transmission for *T. cruzi*. Indeterminate and chronic infections may be reactivated by immunosuppression, particularly human immunodeficiency virus (HIV) infection or acquired immunodeficiency syndrome (AIDS), and by pregnancy [23, 24].

On the acute infection, symptoms are suggestive of a nonspecific febrile illness, and these may occur between 1 and 4 weeks after infection; there also are severe forms that include myocarditis or meningoencephalitis, chagomas are indurated areas of erythema and swelling at the site of parasite penetration. Romaña's sign is the classic sign of acute Chagas disease; it is characterized by painless edema of the palpebrae and periocular tissues that appear when the conjunctiva was the parasites route of entry; not all patients with acute Chagas disease present with Romaña's sign (**Figure 2**) [26].

Immunocompromised travelers, such as advanced aged and people with chronic diseases, need to be concerned by their travel physicians of the potential risk for Chagas disease transmission by American Triatomines, due to coasts, colonial cities and ancient archeological ruins from Latin America are high endemic regions among the most popular touristic destination, these patients must be advised about the behavioral risk factors of the disease and take the appropriate steps to reduce risk [2, 27].



**Figure 2.** Romaña's sign and characteristic sign of acute Chagas disease [25].

Muñoz-Vilches et al. [28] recommended that tourists who travel for long periods through the tropics (endemic areas)—like the Yucatan Peninsula—are at risk for acquiring these endemic tropical diseases and should be screened similar to patients born in these areas, especially when they are symptomatic. Animals can also increase the risk of infection, acting as intermediate hosts of infection; the prevalence of stray dogs nearby plays an important role in CD prevalence of endemic places, such as Yucatan [29].

## 2.2. Presence of vectors

Natural landscapes of the Yucatan Peninsula (YP) have been modified since the expansion of Mayan groups at least until 900 A.D., and subsequently the Spanish conquest, mainly in the north and east region between Yucatan and Quintana Roo state [30].

Mexico is located in both the neotropical and Nearctic regions, having different demography, climates and vegetation, with over 19 vector species, Yucatan has the *Triatoma dimidiata* as its most abundant and epidemiologically relevant vector (**Figure 3**), although other triatomines are present and sporadically collected even in anthropic habitats: *Panstrongylus rufotuberculatus*, *Eratyrus cuspidatus*, *Triatoma nitida*, *Triatoma hegneri* with 88% of the population exposed to at least one of this competent vector species [31].



**Figure 3.** *Triatoma dimidiata* [25].

Previous reports show that there is a heterogenic distribution of the vector, identifying the north of the peninsula as the highest bug abundance area and a greater risk of natural transmission [8].

*T. cruzi* reduviids are hardy and ubiquitous vectors of Chagas disease among wild and domestic animals and humans in a variety of transmission cycles, from dense rain forest to packed cities and beaches [2]. The vector adapts quickly to houses, gardens and parks in the city and can spread quickly when urbanization is introduced in rural areas. The blood of dogs may be an important source of triatomine bugs and acts as sentinels of domestic and peridomestic vector-mediated transmission [32].

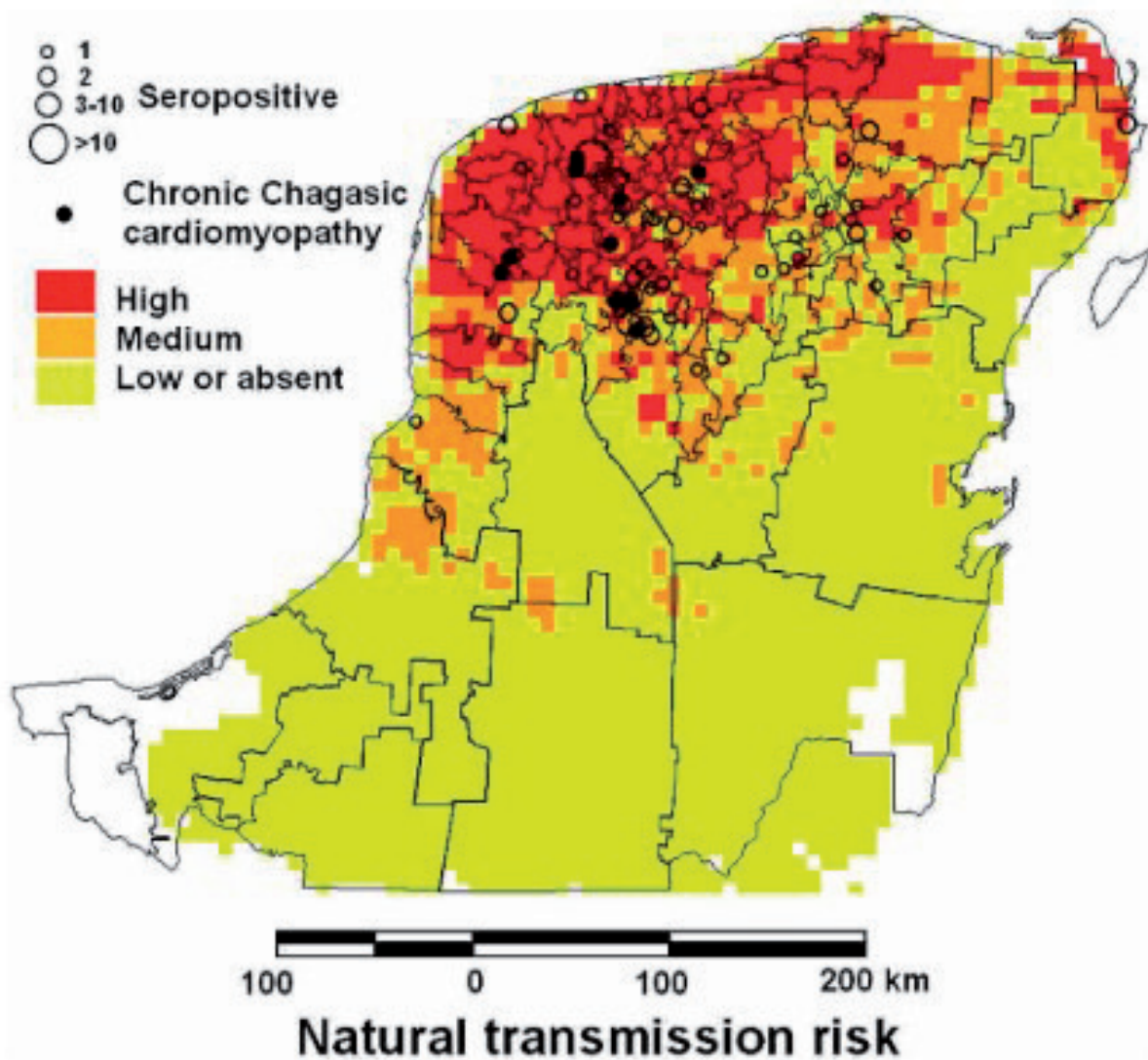
*T. cruzi* reduviids are recognized to be sylvatic, periurban and now urban agents of transmission cycles of Chagas disease; in the sylvatic cycle, the vector becomes infected with *T. cruzi* as either nymphs (the five juvenile stages or instars) or adults during rainy seasons by feeding on many nonspecific wild animal hosts. As humans begin to deforest and develop rural areas for agriculture, ranching, and housing, infected reduviids are attracted to more stable, peridomestic environments. Most often, the pathogenic agents are within the vector's saliva injected directly into the skin, but the metacyclic trypomastigotes of American trypanosomiasis, in contrast, are passed not in the saliva, but in the feces of their triatomine vectors. The host is infected when these protozoa are scratched or rubbed into the wound or mucus membranes. Triatomine bugs of tropical and subtropical Central and South America serve as vectors for the agent of Chagas Disease, and these burden people with more than their bites, as with bedbugs, conceal themselves during the day, often in thatched roofs and porous walls of logs and sticks, and glide down from roof crevices and cracked walls seeking blood from almost any available warm-blooded host at night, passing the infectious forms in their feces while feeding painlessly [33]. In heavily infested areas, residents may suffer dozens of bites each night, with individual adult bugs drawing up to 4 g of blood per meal (**Figure 4**).

### 2.3. Preventive recommendations

Travelers in endemic regions are wise to select accommodations with solid ceilings or roofs, no thatched palmetto or palm fronds which are the natural canopy homes for reduviids and with smooth walls without crevices. Cabanas and lodges that provide accommodations in rural or isolated settings for large numbers of tourists are also perfect accommodations for reduviid families, who will both blood-feed and breed while hiding in such dwellings, some of which may be very comfortable and elegant [34].

As clinicians usually consider, evaluate and recommend prophylactic treatments, vaccines and other travel-related issues, they must offer appropriate guidance on preventing vector borne illnesses they might encounter and their arthropods, focusing on their destinations, accommodations and the risks accompanying their planned activities.

Diaz [2] and Carter et al. [26] mentioned that the best preventive strategies of travelers to the Americas should be directed at (1) information about *T. cruzi* endemic areas and about the transmission risks of Chagas disease, (2) avoid residence in poorly constructed dwellings, (3) be advised to take precautions while engaging in outdoor activities, and (4) a recommendation for sleeping under pyrethroid-impregnated insect nets (taking care of tucking in the edges to



**Figure 4.** Natural transmission risk map for Chagas disease. The risk of natural transmission of Chagas disease, defined as proportional to the abundance of infected *Triatoma dimidiata* [25].

provide a physical barrier to the triatomine bugs). However, pyrethroid impregnated nets are not definitive or efficient, enough to avoid the insect nearby; also the exposition to chemical agents is not recommendable, mainly if their effect over the triatomines is not adequate.

Infection prevention requires travelers to avoid sleeping in hovels and mud dwells and checking in their hotel rooms and potential places where the triatomine vector could be hidden, using bed nets, and avoid potentially contaminated fruit or cane juices from street vendors [35]. Packing efficient insect repellents and properly applying them, if not purchasing them on the destination is an option, always keeping in mind that formulations based on DEET remain as the best available repellents, other methods as clothing cleaning with permethrin should be considered, clothing is more protective if it has a tight weave and it is loose and baggy. Window screens, bed nets and air conditioning can markedly reduce annoyance and risk from those biting insects that live or venture indoors [36].



The riskier blood or organ donors are those who come from areas where the prevalence of infection is high; there is also an increased risk in places with a great number of immigrants from Mexico, Chile, El Salvador, Colombia, Bolivia, and other Latin American countries. The most effective form of prevention is to avoid blood use from donors of countries where Chagas disease is endemic, or performing serological screening for *T. cruzi* exclusively on donors from these countries [37].

This lack of knowledge and awareness of Chagas disease and its relationship with triatomines can be considered a major barrier for vector control, as it likely results in communities having limited interest in and motivation for eliminating triatomines [38].

Concrete recommendations for preventive actions are needed for the national and international visitors from endemic and non-endemic countries, focusing on vector control, spreading information and screening in health procedures, all of this should be following a structure as listed:

1. Tourism providers and local government from traveler's country of origin must inform about the Chagas disease in this area, its changing nature of ecology, of where no formal measures to control or eradicate it have been taken.
2. Protect yourself and your pets from the vector, as they are also warm-blooded hosts and sentinels of this disease, they should be required to have a good insecticide or repellent.
3. Hotels and resorts should also have their own vector control plan, as they do with mosquitoes and other insects, keeping their green areas clean and not having palm roofs or other cracks and holes that could lead to unwanted triatomines.
4. Touristic areas such as ruins, colonial cities and other attractions in endemic zones must be fumigated regularly, as a control for the vector, which could be easily attacked.
5. If receiving medical attention, particularly blood transfusions after an accident, labor or any other conditions, screening for Chagas Disease is important, due to lots of donors could have been previously exposed, have history of CD or the receiver is a female on reproductive age, with a higher risk of vertical transmission.

Providing acute information and taking the corresponding recommendations could allow reduce the travel-associated risks of Chagas disease infections in this *T. cruzi* endemic region from southern of Mexico, and where the CD which is now extended and widely established as well in urban and rural areas.

### 3. Conclusions

Chagas disease is as a neglected tropical disease that must be considered by people willing to travel to endemic zones, such as the Yucatan Peninsula. Travelers must be aware of the potential risk that exist in the areas they will be interacting in, such as public or resort beaches, archeological places, parks, rural areas and even yards; it is crucial for everyone traveling to correctly identify the vector, and to use properly insecticides to prevent the

triatomines bite and probably infection. However, information about this and other vector transmitted diseases must be displayed in the touristic areas and written information given to everyone upon arriving, and tourists should take preventive measures such as a good quality repellent, checking window screens, holes or other places where the reduviids could hide and request bed nets that could be offered by the hosting accommodations, including hotels, archeological sites and ecotourism locations. Other measures can be also taken, as reduction of the stray dog population, limiting contact with them, and green areas fumigation for vector control; even when staying in previously fumigated areas, insecticides should be used, especially in exterior areas, when walking and even resting on the beach, but one of the most important things is to correctly identify the reduviid vector, so travelers can stay away from them.

Latin American immigrants represent an important segment in worldwide population; therefore, they must consider risks when arriving from their native countries and never lose sight of other forms of infection blood transmission possibilities, especially in immune-depressed patients and vertical transmission that is taking more importance nowadays.

## Conflict of interest

The authors declare no conflict of interests.

## Author details

Carlos F. Ortega-Jimenez<sup>1</sup>, Eugenia Guzman-Marin<sup>1</sup>, Eduardo Gutierrez-Blanco<sup>2</sup>, Antonio Ortega-Pacheco<sup>2</sup> and Matilde Jimenez-Coello<sup>1\*</sup>

\*Address all correspondence to: [mjcoello@correo.uady.mx](mailto:mjcoello@correo.uady.mx)

1 Autonomous University of Yucatan, Regional Research Center "Hideyo Noguchi", Mérida, Yucatán, Mexico

2 Autonomous University of Yucatan, Faculty of Veterinary Medicine and Animal Science, Yucatan, Mexico

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