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Chagas Disease in Free-Ranging Wildlife Populations in South Texas

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Introduction

Emerging diseases are of critical concern in the United States and around the world. This concern is now growing as diseases caused by avian influenza virus, West Nile virus, Zika virus, and others spread into new areas in North America. These diseases have significant impacts on human and ecological health, local and regional economies, and human safety and security.

Chagas disease in the southern United States is a relatively little known example of these spreading diseases but has received increased media attention and has caused health concerns with the public.

The purpose of this report is to describe the prevalence of Chagas disease in South Texas, and how free-ranging wildlife populations play a significant role in the life cycle of this disease in the natural environment. Results presented in the report are derived from an ongoing field research project conducted by the Texas A&M Institute of Renewable Natural Resources, and this serves as a final summary technical document.

What is Chagas disease?

Chagas disease, also known as American Trypanosomiasis, is caused by the protozoan *Trypanosoma cruzi* (*T. cruzi*). Brazilian physician Dr. Carlos Chagas first described the disease in 1909 (Barr 2009). Chagas disease is a chronic, incurable infection that causes cardiac and digestive problems in humans, canines, and many free-ranging mammals.

The disease is considered a significant human health problem in Central and South America where 8-11 million people are infected (Center for Disease Control and Prevention [CDC] 2016). Although there have been few reported cases in the United States, in 2009 the CDC estimated that as many as 300,000 humans in the United States may be infected.

Chagas disease is of growing concern, though the role of free-ranging wildlife populations in the United States as host species is poorly understood. Previous studies have reported that woodrats (*Neotoma micropus*) are the primary host of T. cruzi due to location preference of vectors (i.e., insects that transmits a disease) in the burrows of these mammals (Bern et al. 2011). Other host species include burrow- or cavity-dwelling species such as skunks (*Mephitis* spp.) and raccoons (*Procyon lotor*). Research suggests that animals living in and around human habitations and free-ranging mammal populations may be significant reservoirs for the disease.

Currently, preventative treatments for the disease are limited (Bern et al. 2007). There are two phases of Chagas disease — acute and chronic phases — though both phases can be symptom free. The acute phase is usually symptom free or with only mild symptoms (e.g., conjunctivitis, fever, rash, swelling of the eyelids near the bite wound (Romaña sign). Following the acute phase, the infection may be silent for decades during the chronic phase, which may result in cardiac (e.g., enlarged heart, heart failure, altered heart rate or rhythm) or intestinal (e.g., enlarged esophagus or colon) complications.

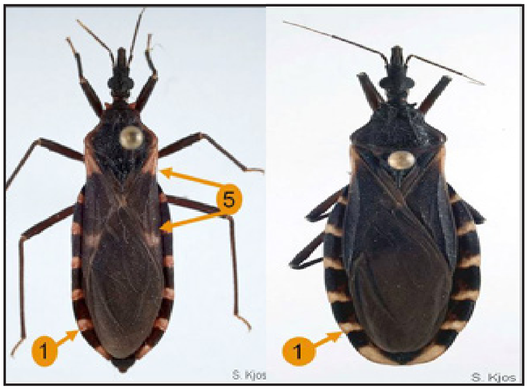

Figure 1. South Texas Triatomine species: *Triatoma sanguisuga* (left), and *Triatoma gerstaeckeri* (right). (Photo courtesy of Sonia Kjos).

Pathogen and Insect Biology

The primary vector of Chagas disease are triatomines (commonly known as kissing bugs but also known as reduviid bugs, assassin bugs, or blood suckers), found from South America through the mid-United States.

Eleven species of triatomines are known to occur in North America (Bern et al. 2011), with the most common vector species being *Triatoma rubida* and *Triatoma protracta* in Arizona and California and T*riatoma gerstaeckeri* and *Triatoma sanguisuga* in Texas and New Mexico (Fig. 1).

Kissing bugs are blood-feeding insects, which obtain the parasite from an infected host. The parasite carries out part of its life cycle in the insect's digestive tract. Parasite transmission occurs when fecal material from infected kissing bugs containing infective *T. cruzi* protozoa trypanosome is rubbed or introduced into the feeding bite wound or mucous membranes of the host or when infected feces contaminate food or water.

Triatomine insect species use both domestic and free-ranging mammal species as hosts. Free-ranging mammals are bitten typically on the ventral or belly side and feeding occurs for a few minutes typically unnoticed with no observed pain or discomfort. Additionally, the disease pathogen can be transmitted through contact with infected blood and tissue, transplacentally, through carnivory, and through direct consumption of infected triatomines by mammals (Fig. 2).

Blood-feeding triatomines live approximately two years and undergo five molts (shedding exoskeleton for growth) prior to reaching reproductive maturity and having the ability to fly (Fig. 3). Each molt stage and/or production of eggs requires a mammal blood meal for survival. In South Texas, triatomines are primarily found outdoors, living with burrowing- or cavity-dwelling meso-mammals or in and under decaying wood material or crevices near peridomestic animals. The insects can also be found in substandard housing where they will readily feed on humans or pets at night and retreat to a crack or crevice during the day, remaining there as long as a mammal blood meal is continuously available.

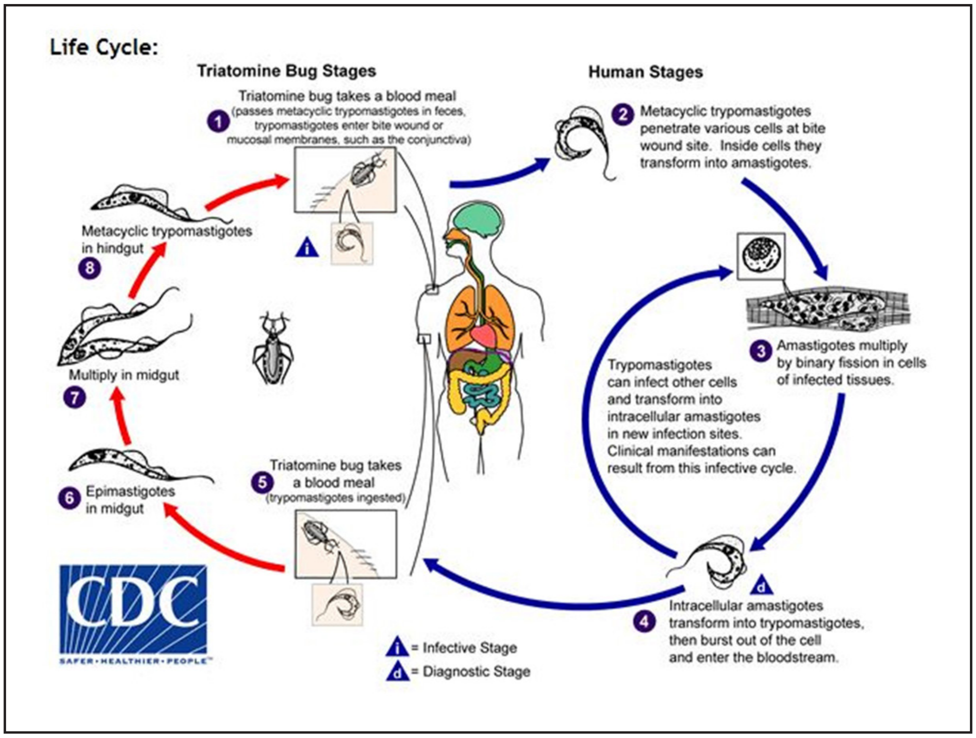

Figure 2. *Trypanosoma cruzi* (Chagas disease) life cycle (CDC 2016).

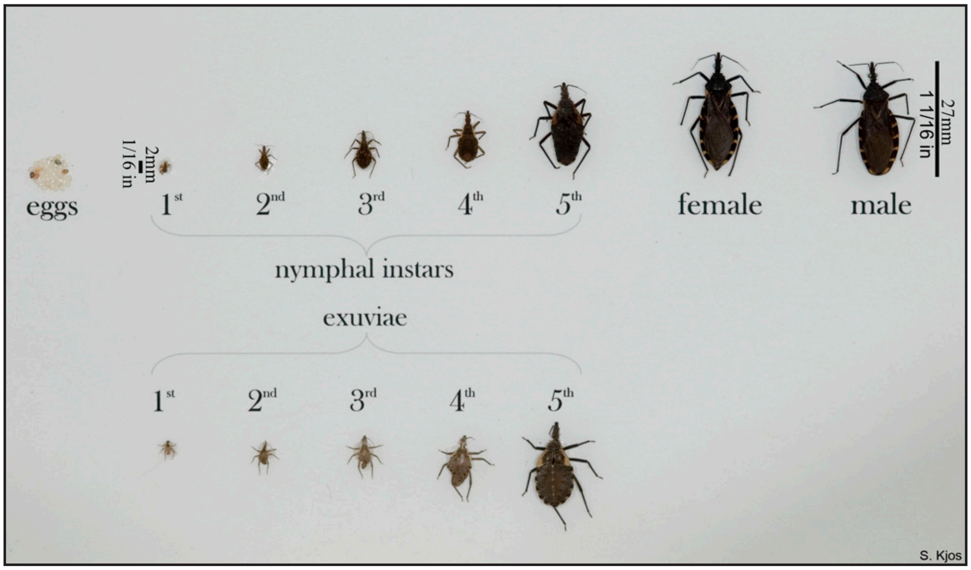

Figure 3. Triatomine instar growth stages. (Photo courtesy of Sonia Kjos).

Description of South Texas (Study Area)

We sampled free-ranging wildlife populations in two South Texas counties: Bexar and Val Verde. Bexar and Val Verde counties are biologically diverse counties that include deserts, grasslands, and forested areas. Bexar County includes the city of San Antonio and largely resides within the Texas Blacklands Prairie Ecoregion. Val Verde County is located along the Texas-Mexico border and is the intersection between the Chihuahuan Desert, Edwards Plateau, and Southern Texas Plains.

Herbaceous cover is highly diverse between the counties but includes King Ranch bluestem (*Bothriochloa ischaemum* var. *songarica*), buffalograss (*Buchloe dactyloides*), and Texas wintergrass (*Stipa leucotricha*). Woodland plant species include mesquite (*Prosopis glandulosa*), sugarberry (*Celtis laevigata*), cedar elm (*Ulmus crassifolia*), annual sunflower (*Helianthus annuus*), and ashy sunflower (*Helianthus mollis*). Riparian woodland plant species include black "swamp" willow (*Salix nigra*), green ash (*Fraxinus pennsylvanica*), basswood (*Tilia caroliniana*), sugarberry (*Celtis laevigata*), chinaberry (*Melia azedarach*), giant ragweed (*Ambrosia trifida*), and morning glory (*Ipomoea* sp.).

Role of Wildlife Populations

Most species of triatomines are associated with free-ranging vertebrates including mammals, which usually serve as reservoir hosts for *T. cruzi*. A recent study (Kramm, 2015) reported *T. cruzi* infection among four primary burrowing reservoir species in Bexar and Val Verde counties and detected a high incidence of infection in Virginia opossums (*Didelphis virginiana*), skunks (*Mephitis* spp.), raccoons (*Procyon lotor*), and other species. Blood and tissue samples (n = 392) were collected from small- and mid-sized mammals, in addition to samples from white-tailed deer (*Odocoileus virginianus*) and feral hogs (*Sus scrofa*) (Fig. 4). Molecular DNA techniques were used to determine *T. cruzi* infection from both blood and tissue samples (Kramm, 2015).

Research suggests that Chagas disease is more widespread in mid-sized mammal species found in south Texas than previously reported (Kramm, 2015). Prior to recent research, the role of free-ranging mammalian populations as host preference species for *T. cruzi* was poorly understood (Bosseno et al. 2009, Brown et al. 2010), particularly in other states. (Sarkar et al. 2010). Differences in reported research results suggest that control and risk management of *T. cruzi* requires a local understanding of the reservoir host species and their geographic distribution to aid in developing prevention programs (Noireau et al. 2009, Brown et al. 2010).

Parasite Prevalence

Kramm (2015) reported *T. cruzi* was prevalent in four species of wildlife, which served as carriers for the disease: (1) Virginia opossums, n=26 positive, 65% of sampled; (2) striped skunks, n=9 positives; 27% of sampled; (3) raccoons, n=14 positives; 45% of sampled; and (4) hispid cotton rats, n=2 positive; 12% of sampled (Fig. 4). Parasite prevalence differed significantly (P=0.001) based on vegetation community with grasslands demonstrating far fewer positive mammals (n=4 positives, 17% of total sampled) than semi-improved woodlands (n=11 positives, 61% of total sampled) and dense hardwoods (n=22 positives, 60% of total sampled).

Chagas Spatial Distribution

Raccoons, Virginia opossums, striped skunks, and focal rodents are typically generalists with the ability to live in human-dominated areas. These species act as localized primary *T. cruzi* mammal reservoirs, an indication that these common mammals help maintain and transmit these parasites in association with vector triatomines. In the Kramm (2015) study, these species were the primary hosts for the pathogen, and the low numbers of test-positive animals in grasslands is reflective of habitat preferences for these species.

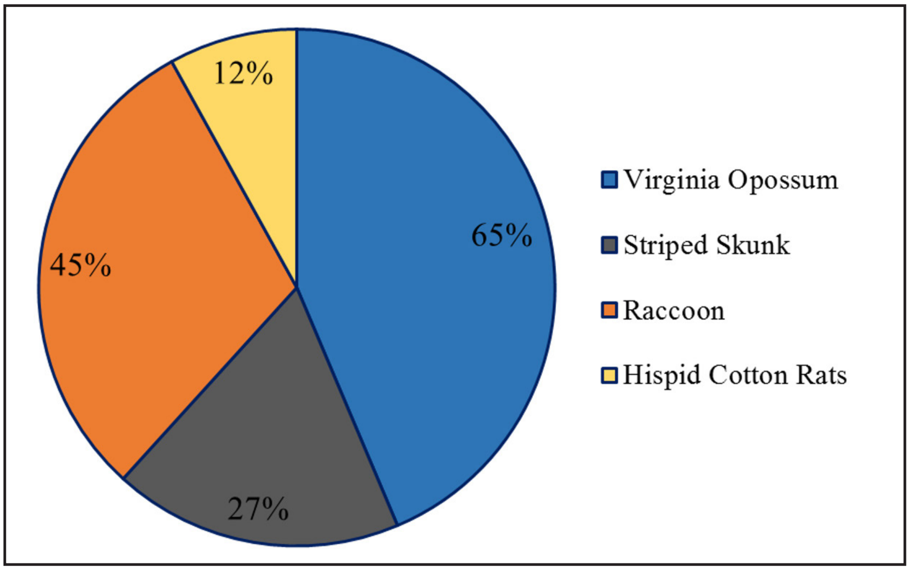

Figure 4. Infection rates for the four wildlife species most commonly testing positive for *Trypanosoma cruzi* in South Texas.

Research indicates triatomines are located in a variety of habitats including grasslands, woodlands, and human-dominated areas such as houses and often prey on mammals (Kjos et al. 2009, Bern et al. 2011, Kramm 2015). Furthermore, despite the different characteristics of the two types of woodlands studied, they still had significantly higher rates of mammal infection than grasslands, lending credence that these species (woodland generalists) are important in pathogen persistence.

The lack of evidence of *T. cruzi* in all rodents except in hispid cotton rats is contrary to the findings of Pinto et al. (2010) and may be attributed to phylogenetic lineage differences between the protozoan pathogen and diversified mammal assemblage found within specific vegetation communities. Similarly, no evidence supports white-tailed deer and feral hogs as major contributors to the disease's transmission in South Texas. This is probably because of the lack of burrowing activity (where insects are commonly found) and different resting locations.

Research largely supports much of the available evidence of mammal host roles in *T. cruzi* persistence. Beard et al. (2003) reported that *T. cruzi* infection of canine species in South Texas may be endemic. A recent study in Mexico identified the blood-meal origins of 47 triatomines and found that raccoons and armadillos (*Dasypus* spp.) were the main blood-meal hosts (Bosseno et al. 2009). Another study in the United States reported *T. cruzi* infection among 11 reservoir species from six southern states and detected a higher incidence of the infection in Virginia opossums and raccoons. These studies suggest that *T. cruzi* prevalence varies between host preference species and geographic regions.

Management Implications

The distribution of *T. cruzi* prevalence in mammal species is an important component in disease transmission to people. Research indicates triatomines are located in a variety of habitats including grasslands, woodlands, and human-dominated areas such as houses and often prey on mammals (Bern et al. 2011, Kramm 2015). In South Texas, preventative strategies should focus on minimizing exposure to raccoons, Virginia opossums, and skunks due to the high prevelance of the disease among those populations.

Strategies can include changing the habitat so it is not conducive to target host species or measures to minimize exposure of humans and domestic animals to areas where coexistence may occur. Simple removal of host species should be undertaken with caution because it could cause kissing bugs to displace and search for alternative blood meals including pets and humans. Management of wildlife diseases often requires a change in human behavior such as changes in human use of areas of high risk of transmission (Wobeser 2002). This might include suggesting humans limit their time in areas with high-triatomine presence during peaks in triatomine activity or take other measures to prevent contact with triatomines (see recommendations below). Managing vector and reservoir movement requires an integrated control approach that includes identifying harborage locations, spatial insecticide applications, mechanical or chemical vegetation management to discourage vectors and reservoirs, and Environmental Protection Agency-approved mammal bait formulations with systemic insecticide that kills the triatomines without negative effects on vertebrate hosts. Other strategies that can serve to minimize the potential disease risk transmission of Chagas in South Texas include the following:

General Management Recommendations

1. Reduce mid-sized mammal attractants such as open garbage cans around areas with human activities.
2. Manipulate the local vegetation structure to discourage both mammal hosts and triatomine insects.
3. Apply insecticide around areas with humans or domestic animals.
4. Apply DEET on exposed skin, treat clothing with permethrin, and use bed nets when sleeping when outdoors.
5. Weatherproof buildings to the extent possible with exterior and interior holes patched and fine mesh screens installed over openings.
6. Screen regularly for Chagas disease including mammal and invertebrate sampling. This is particularly important during peak triatomine activity periods in the spring.

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