

Chagas disease Occurrence in Texas and others USA States an Undiagnosed and unappreciated entity

Chagas disease, caused by the protozoan parasite *Trypanosoma cruzi*, continues to make inroads in the United States and physicians are both unprepared to diagnose and under equipped to treat cases of the disease in their patients. A multidisciplinary research team based in Texas A&M University create a website is to feature of public health education and citizen science efforts focused on kissing bug collections. In this website information about Chagas disease, kissing bugs, and how you can help research efforts in Texas and beyond. See some of the citizen science results from bugs collected in 2013-2014.

OVERVIEW Eco-Epidemiology and Chagas Disease Basics

Many diseases have their origins in nature. Eco-epidemiology examines the relationship between health and ecology: how animal and human health are affected by ecological factors in the environment. Studying the eco-epidemiology of Chagas disease in the United States allows these reserches to take a broad approach to better understand the relationships among many different parts of the system, Chagas disease emerges at the intersection of wildlife, domestic animals, humans, and vector populations.

THE VECTOR Kissing Bugs

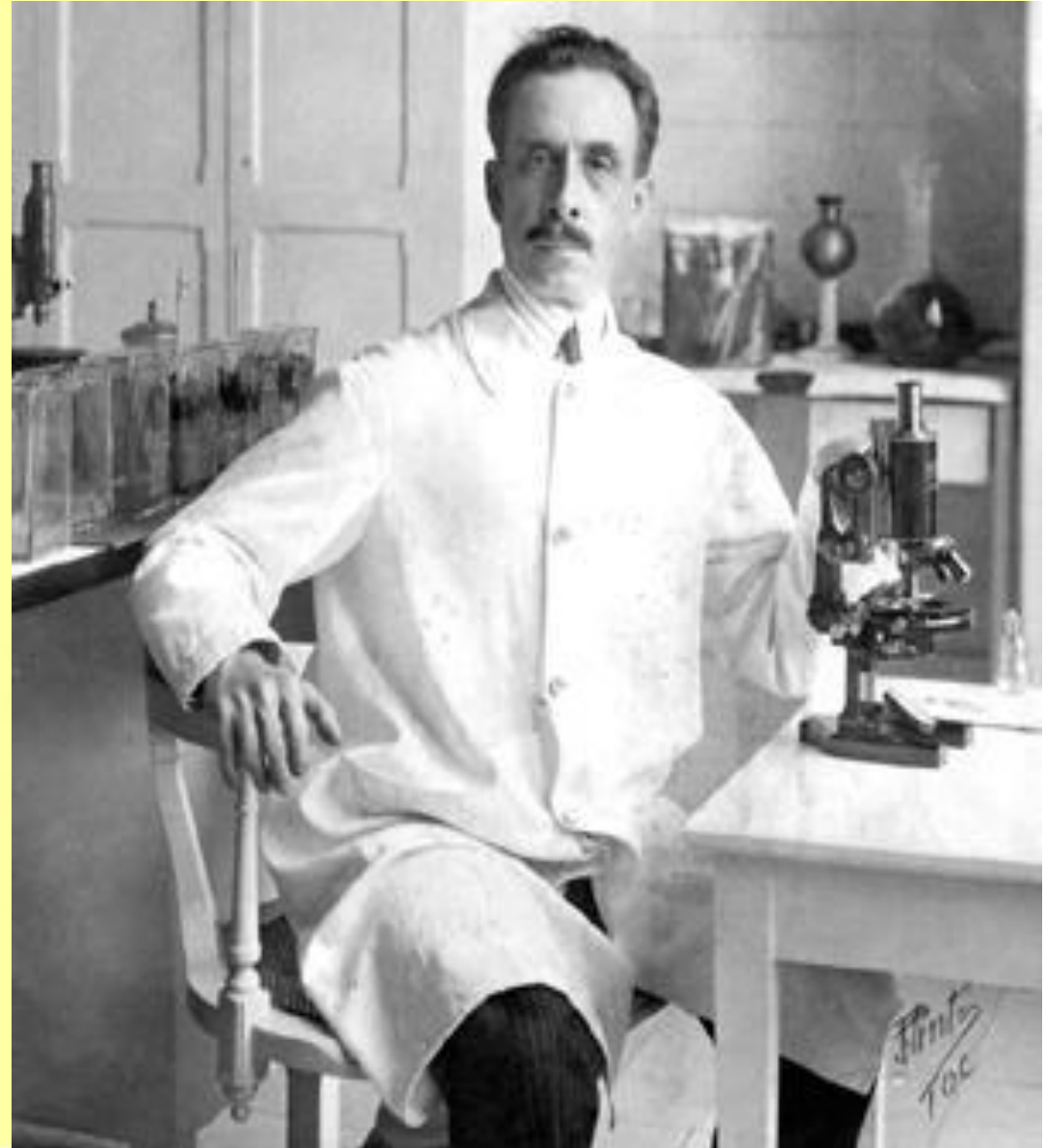
Kissing bugs are nocturnal, blood-feeding insects that are members of the Reduviidae family.



Three species of kissing bugs that can be found in Texas. Left to right: *Triatoma sanguisuga*, *Triatoma gerstaeckeri*, *Triatoma protracta*

BACKGROUND & DISCOVERY

- Chagas disease, also known as American trypanosomiasis, is caused by infection with the protozoan parasite *T. cruzi*.
- The organism *T. cruzi* and infection in humans were first described in 1909 by the Brazilian physician Carlos R. J. Chagas.



Pinto J Carlos Chagas in his laboratory at the Manguinhos Institute, Rio de Janeiro Fundação Oswaldo Cruz Biblioteca

Carlos Chagas was born on 9 July 1878 in the farm "Bon Retiro" located close to the City of Oliveira in the interior of the State of Minas Gerais, Brazil. He started his medical studies in 1897 at the School of Medicine of Rio de Janeiro. In the late XIX century, the works by Louis Pasteur and Robert Koch induced a change in the medical paradigm with emphasis in experimental demonstrations of the causal link between microbes and disease. During the same years in Germany appeared the pathological concept of disease, linking organic lesions with symptoms. All these innovations were adopted by the reforms of the medical schools in Brazil and influenced the scientific formation of Chagas. Chagas completed his medical studies between 1897 and 1903 and his examinations during these years were always ranked with high grades. Oswaldo Cruz accepted Chagas as a doctoral candidate and directed his thesis on "Hematological studies of Malaria" which was received with honors by the examiners. In 1903 the director appointed Chagas as research assistant at the Institute. In those years, the Institute of Manguinhos, under the direction of Oswaldo Cruz, initiated a process of institutional growth and gathered a distinguished group of Brazilian and foreign scientists. In 1907, he was requested to investigate and control a malaria outbreak in Lassance, Minas Gerais. In this moment Chagas could not have imagined that this field research was the beginning of one of the most notable medical discoveries. Chagas was, at the age of 28, a Research Assistant at the Institute of Manguinhos and was studying a new flagellate parasite isolated from triatomine insects captured in the State of Minas Gerais. Chagas made his discoveries in this order: First the causal agent, then the vector and finally the human cases. These notable discoveries were carried out by Chagas in twenty months. At the age of 33 Chagas had completed his discoveries and published the scientific articles that gave him world recognition and a deserved high place in medical history. After the publication of his classic article the world paid homage to Chagas who was elected member of the National Academy of Medicine of Brazil on 26 October 1910, and at the age of 31, of other National Academies of the continent. The Committee of Hygiene of the Society of Nations, precursor of the World Health Organization, was created in Chagas was elected member of this Committee from its inception until 1933. The example of Chagas' life can be summarized in his interest that medical research should be translated into concrete benefits for human beings because he was convinced that disease had not only biological but social determinants as well. Carlos Chagas was a laboratory researcher, a clinician and a health administrator. For all these accomplishments he deserves our respect and admiration. In the above mentioned conference before the National Academy of Medicine in 1910, he said: **“Could we find public health procedures to alleviate this situation? I am convinced that this is a humane and also a state problem and that the scientifically well oriented statesman who launches such a public program with successful results, will win the recognition of my compatriots and the future generations of Minas Gerais” (Chagas, 1910).** This fervent desire, so eloquently expressed by Carlos Chagas in 1910, was accomplished in his own country in 2006 when Brazil was certified free of vectorial transmission by *Triatoma infestans* by an International Commission convened by the Pan American Health Organization (Pan American Health Organization, 2006, World Health Organization, 2007). Likewise, the interruption of transmission by *T. infestans* was also certified in Uruguay in 1997 and in Chile in 1999 (World Health Organization, 2002).





Instituto Oswaldo Cruz (Manguinhos)

Eclético, o castelo mescla duas ou mais tendências de estilo e decoração, sendo um dos poucos edifícios neomouriscos ainda existentes no Rio de Janeiro. É o principal componente do núcleo arquitetônico histórico de Manguinhos, e começou a ser construído em 1905, quando as obras do Prédio do Relógio e da Cavalaria já estavam concluídas. O projeto foi encomendado a Luiz Moraes Júnior por Oswaldo Cruz, depois de se conhecerem em uma das muitas viagens que fizeram juntos nos vagões do trem da Leopoldina, quando o arquiteto coordenava obras de reforma da Igreja da Penha. Português, ele imigrou para o Brasil em 1900, a convite do vigário-geral, padre Ricardo, e cuidou da reestruturação e embelezamento das fachadas, concluídas em 1902. Morreu no Rio de Janeiro em 1955, aos 87 anos.

WHY DIDN'T HE WIN THE NOBLE PRIZE?



It has been accepted that the reason why the prize was not awarded to this brilliant scientist may have been the strong opposition that he faced in Brazil, from some physicians and researchers of that time. They went as far as questioning the existence of Chagas disease, thereby possibly influencing the decision of the Nobel Committee not to award the prize to him. Analysis of the database of the Nobel prize archives, with the revelation of the names of nominators, nominees and prize winners spanning the years 1901-1951, brought information not only about what was considered to be a scientific achievement at that time, but also about who the important scientists were and what the relationships between them were. The connections of the members of the Nobel Committee with the international scientific community, almost exclusively centered in European and North American scientists, also influenced their choices.

In 1909, Carlos Chagas (1878-1934) discovered a new protozoon, *Trypanosoma cruzi*, and the (previously unknown) disease that it causes. Within a few months, virtually single-handed, he described the pathogen, its vector, and the clinical features of American trypanosomiasis (Chagas disease), a feat unique in medical history. He headed the Oswaldo Cruz Institute after the death of its founder (1917) until his own death; and from 1920 until 1926 he also directed the Brazilian Department of Public Health. His discovery brought him worldwide acclaim, but at home antagonism against Chagas, muted for years, finally flared up in a campaign that was acted out in the 1921-22 plenary sessions of the National Academy of Medicine. Chagas's name was repeatedly proposed for the Nobel Prize but he never received it; this hostile campaign may have been instrumental in costing him the award.

Other reduviids that are similar in appearance feed on plants and other insects and can inflict a painful bite when disturbed, however only kissing bugs are known to transmit the Chagas parasite. Kissing bugs are found throughout the Americas. In the US, kissing bugs are established in 28 states. A total of 11 different species of kissing bugs have been documented in the US, with the highest diversity and density in Texas, New Mexico, and Arizona. Previous studies have found that, on average, 50% of kissing bugs are infected with the Chagas parasite. Kissing bugs develop into adults after a series of five immature life stages called nymphs, and both nymphs and adults engage in blood feeding behavior.

Bugs can feed on diverse wild and domestic animals including wild rodents, other wild mammals, domestic dogs, and humans.

THE PARASITE *Trypanosoma cruzi*

Infection with *Trypanosoma cruzi* can cause Chagas disease in humans, dogs, and other mammals. Kissing bugs can transmit the parasite to hosts by biting and subsequently defecating near the site of the bite. The parasites live in the digestive tract of the bugs and are shed in the bug feces. When infectious bug fecal material contaminates the mucous membranes or the site of a bug bite on a mammal, transmission of the parasite can occur. Alternately, dogs can also become infected through the consumption of infected bugs. The parasite can be transmitted congenitally, through blood transfusion, and through transplantation of infected organs. Chagas disease is endemic throughout central and South America, and is increasingly recognized as both a human and veterinary health concern in the southern United States. Chagas disease became a reportable disease in Texas in 2013.

HUMAN HEALTH *Impacts*

The public health burden of Chagas disease in the US is largely unknown, because most states are not required to keep track of the number of confirmed human cases. Estimates of human cases of Chagas disease in the US range from 300,000 to over 1 million, with particular concern for those living in the US/Mexico border regions. In addition to documented cases in immigrants who were infected in central and South America, there are increasing reports of human cases of Chagas disease acquired in the US.

In humans, Chagas disease manifests in two phases: acute phase and chronic phase. After becoming infected with the parasite, the acute phase can last for a few weeks or months. Some people may never develop acute disease. Acute phase Chagas disease may be difficult to diagnose because the symptoms are common for many types of sicknesses, including fever, fatigue, body aches, headache, rash, loss of appetite, diarrhea, and vomiting. Of those who are infected with the parasite, approximately 30% are at risk of developing chronic Chagas disease. Chronic Chagas disease includes cardiac complications and/or intestinal complications, and these signs may not be apparent until decades after the initial infection. Cardiac signs include enlarged heart, heart failure, altered heart rate, and/or cardiac arrest. Intestinal signs include an enlarged esophagus or colon, which can cause difficulties with digestion. Concerned individuals should discuss testing options with their physicians. Treatment of Chagas disease can be difficult, and drugs are available only through the CDC after consultation with a physician.

WILDLIFE AND DOMESTIC ANIMALS *Impacts*

Wildlife and Domestic Animals-Many different wildlife species are infected with the *T. cruzi* parasite in nature, and can serve as a source of parasite infection to kissing bugs. Infected animals in the US include domestic dogs, non-human primates, opossums, woodrats, armadillos, coyotes, mice, raccoons, skunks, and foxes. Studies have not been conducted to determine if all these species actually suffer from disease when infected, or if they can be silent, unaffected carriers of the parasite.

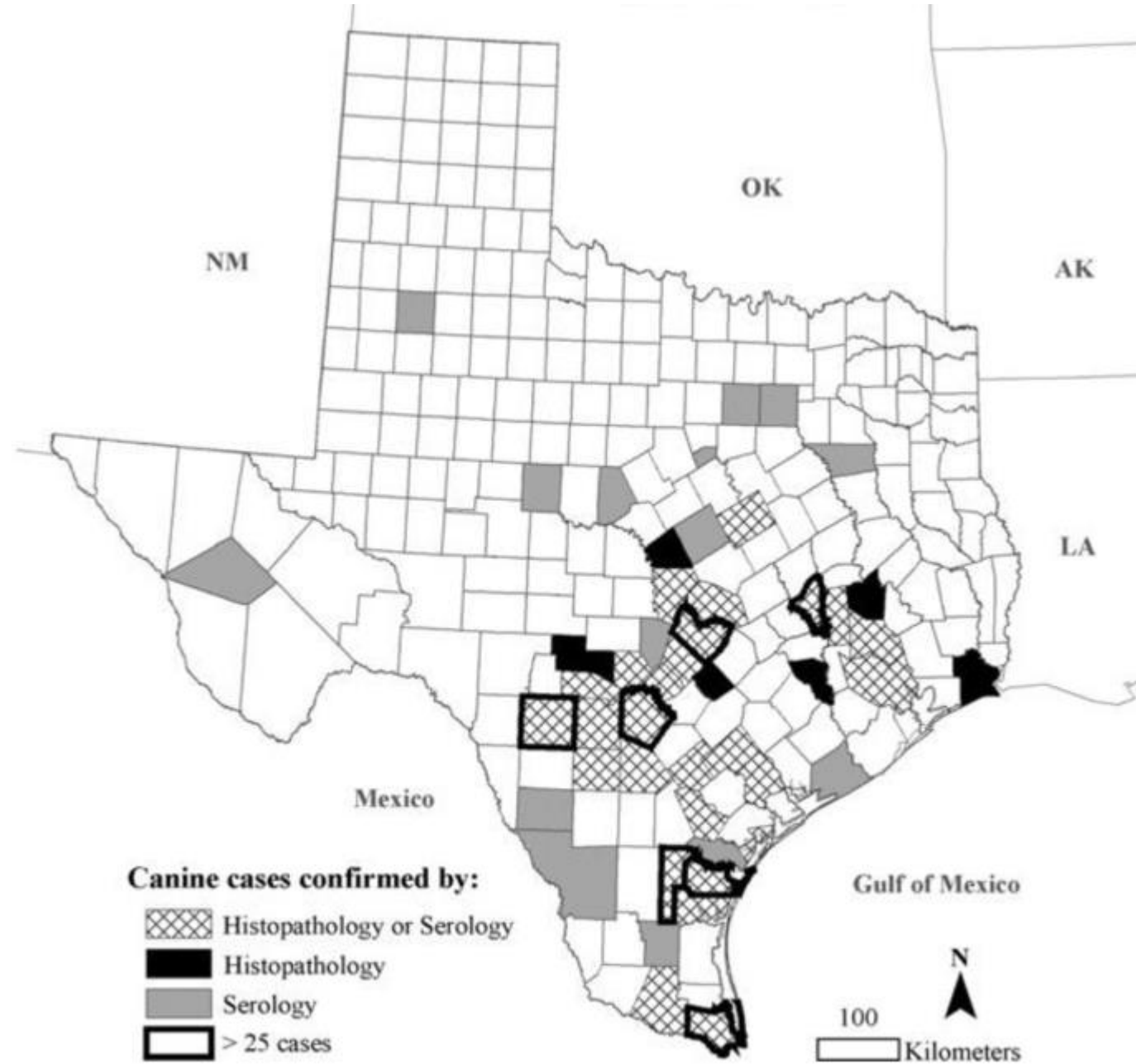
You can see some of the results of studies we have done to determine *T. cruzi* infection in feral hogs, carnivores, and a horse.

CANINE HEALTH *Impacts*

In dogs, infection with the Chagas parasite can cause severe heart disease, however many infected dogs may remain asymptomatic. There is variation in the degree of complications from Chagas disease that likely relate to the age of the dog, the activity level of the dog, and the genetic strain of the parasite. Cardiac rhythm abnormalities and sudden death may occur, as well as bloat due to reduced cardiac function and inability to properly pump fluids throughout the body. The most common test for canine Chagas disease is a blood test called the indirect fluorescent antibody (IFA) test. IFA does not test for infection with the parasite, but rather tests for antibodies to the *T. cruzi* parasite. A positive result indicates that the dog has been exposed at some time in past. Testing for canine Chagas disease is available through the Texas Veterinary Medical Diagnostic Laboratory. Unfortunately, treatment options are not readily available, although some research teams are developing new treatment approaches that are promising. There is currently no vaccination that protects against Chagas disease for either dogs or humans. Researchers at Texas A&M University documented Chagas disease in domestic dogs throughout many counties in Texas.

ENVIRONMENT *The Importance of Surroundings*

The local environment is important to the Chagas disease system. In order for the parasite to be maintained in nature, the environment must support the reservoir, vector, and parasite, and allow interactions among them. Dog kennels are environments that may be particularly suitable for the establishment of Chagas disease transmission cycles. High densities of dogs in confined areas are associated with heat and carbon dioxide that attract kissing bugs that seek bloodmeals. Furthermore, dogs may easily consume kissing bugs in kennels. Kissing bug control can be difficult in kennels, particularly in areas where human development is relatively recent and kennels are surrounded by natural habitats where wildlife occur. Adult kissing bugs engage in nocturnal flights to search for mates and mammals for blood-feeding. Because adult bugs fly towards lights, we recommend that lights be turned off at night around kennels. Some insecticides are effective against kissing bugs when sprayed around the kennel area. However, because kissing bugs can fly in from many yards away or from nearby wildlife habitats, new colonization of treated areas can easily occur.



This study documented 537 cases of canine Chagas disease in 48 counties in Texas, from 1993-2007. As from Kjos et al., 2008, *Veterinary Parasitology*, 152: 249-256.

Countries where Chagas' disease is endemic and estimates of the seroprevalence and number of infected inhabitants			
Region	Country where Chagas' disease is endemic ^a	Estimated seroprevalence (%) ^b	Estimated no. of infected individuals
North America	United States	NDA	300,167 ^c
	Mexico	1.03	1,100,000
Central America	Belize	0.74	2,000
	Costa Rica	0.53	23,000
	El Salvador	3.37	232,000
	Honduras	3.05	220,000
	Guatemala	1.98	250,000
	Nicaragua	1.14	58,600
	Panama	0.01	21,000
South America	Argentina	4.13	1,600,000
	Bolivia	6.75	620,000
	Brazil	1.02	1,900,000
	Chile	0.99	160,200
	Colombia	0.96	436,000
	Ecuador	1.74	230,000
	Guyana	1.29	18,000

Region	a Country where Chagas' disease is endemic ^a	b Estimated seroprevalence (%) ^b	c Estimated no. of infected individuals
Suriname	NDA	NDA	
	French Guiana	NDA	NDA
	Paraguay	2.54	150,000
	Peru	0.69	192,000
	Uruguay	0.66	21,700
	Venezuela	1.16	310,000

^aVector-borne *T. cruzi* transmission occurs, or occurred until recently, in parts of these countries.

^bDisease burden estimates are for the year 2005, based on references (**Bern 2009**)and(**Organización Panamericana de la Salud 2006**). NDA, No data available.

^cThe number for the United States reflects the estimated number of infected immigrants from countries in Latin America where the disease is endemic. No estimate of the number of locally acquired infections is currently available

Associated Signs & Symptoms in the Acute Stage of Infection

Romana's Sign

- Is a classic finding in acute Chagas's disease, which consist of unilateral painless edema of the palpebrae and periocular tissue
- It can result when the conjunctiva is the portal of entry.



STATISTIC ACCORDING TO CDC (2013)

➤ Chagas disease in the United States

The impact of Chagas disease, once thought to be limited to Latin America (where an estimated 8 million people are infected), has moved to the United States, through immigration of persons from Chagas-endemic areas of Mexico, Central America, and South America. The estimated number of infected persons living in the United States is 300,000 or more, based on estimated disease rates by country of origin.

➤ Blood screening for Chagas disease

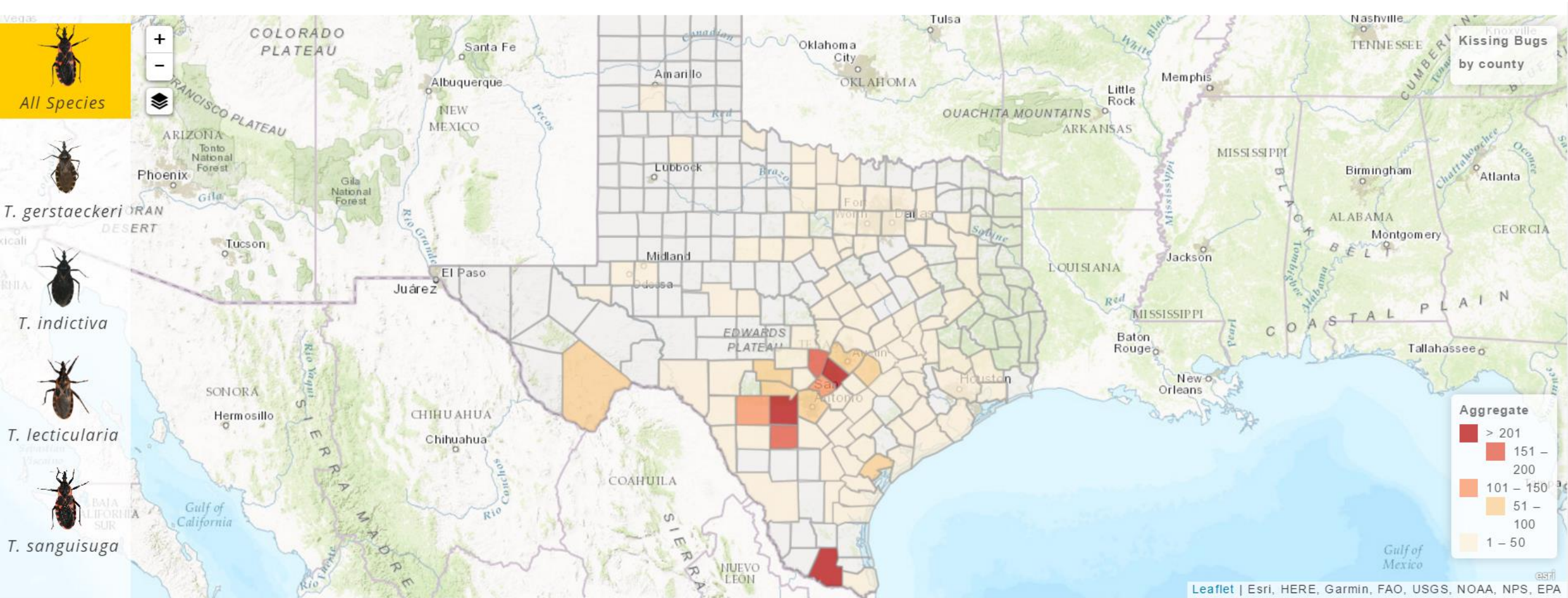
National screening of the blood supply was instituted in early 2007. More than 500 donors with *T. cruzi* infection were identified within the first 18 months of testing.

ENVIRONMENT *The Importance of Surroundings*

The local environment is important to the Chagas disease system. In order for the parasite to be maintained in nature, the environment must support the reservoir, vector, and parasite, and allow interactions among them. Dog kennels are environments that may be particularly suitable for the establishment of Chagas disease transmission cycles. High densities of dogs in confined areas are associated with heat and carbon dioxide that attract kissing bugs that seek bloodmeals. Furthermore, dogs may easily consume kissing bugs in kennels. Kissing bug control can be difficult in kennels, particularly in areas where human development is relatively recent and kennels are surrounded by natural habitats where wildlife occur. Adult kissing bugs engage in nocturnal flights to search for mates and mammals for blood-feeding. Because adult bugs fly towards lights, we recommend that lights be turned off at night around kennels. Some insecticides are effective against kissing bugs when sprayed around the kennel area. However, because kissing bugs can fly in from many yards away or from nearby wildlife habitats, new colonization of treated areas can easily occur.

Chagas disease is a parasitic infection, caused by *Trypanosoma cruzi*, endemic in Latin America. Sylvatic *T. cruzi*-infected triatomine vectors are present in rural and urban areas in the southern USA and may transmit *T. cruzi* infection to at-risk populations, such as homeless individuals. Ingber et al evaluate Chagas disease knowledge and behaviors potentially associated with transmission risk of Chagas disease among Houston, Texas' homeless population by performing interviews with 212 homeless individuals. The majority of the 212 surveyed homeless individuals were male (79%), African-American (43%), American-born individuals (96%). About 30% of the individuals reported having seen triatomines in Houston, and 25% had evidence of blood-borne transmission risk (IV drug use and/or unregulated tattoos). The median total time homeless was significantly associated with recognition of the triatomine vector. Their survey responses indicate that the homeless populations in Houston, Texas may exhibit potential risks for Chagas disease, due to increased vector exposure, and participation in blood-borne pathogen risk behaviors. These findings warrant additional research to quantify the prevalence of Chagas disease among homeless populations. (Ingberg 2017)

Select a bug species from the layers drawer and month using the slider to filter bug activity/submissions.

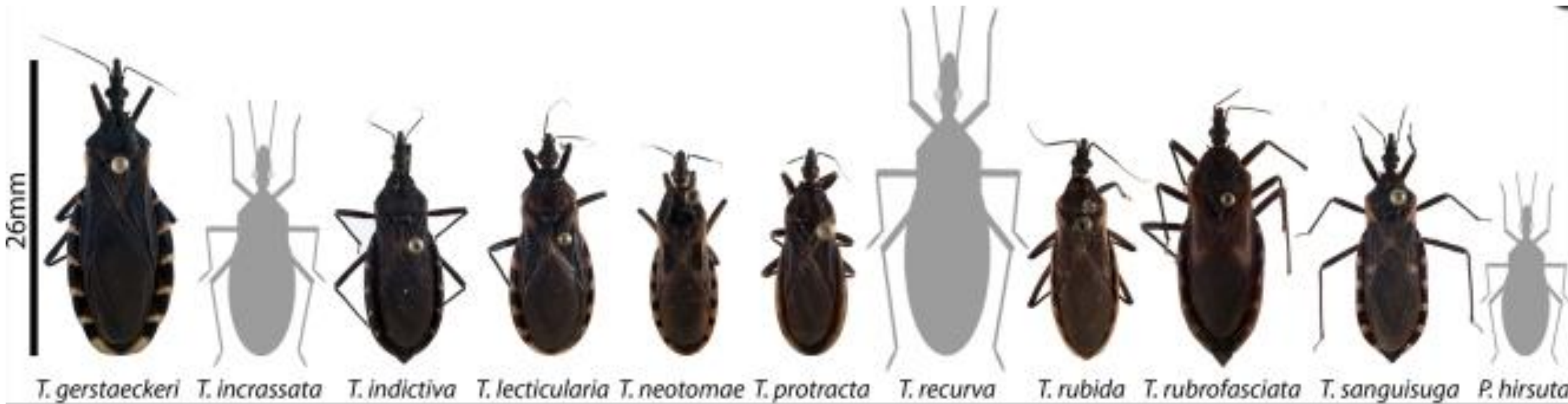


INTERACTIVE MAP *Occurrences in Texas*

Many citizen scientists and a dedicated team of student helpers. They are able to map the submissions of kissing bugs from across the state. Explore the locations and seasonality of kissing bugs in Texas. Please note that this map reflects only bugs submitted to this research lab by the public, and this is not a perfect method of sampling for assessing disease risk. The absence of submission from a given area **does not imply** that kissing bugs do not occur there.

Triatomine Distribution in the United States

Eleven species of triatomine bugs have been reported from the United States: *Triatoma gerstaeckeri*, *T. incrassata*, *T. indictiva*, *T. lecticularia*, *T. neotomae*, *T. protracta*, *T. recurva*, *T. rubida*, *T. rubrofasciata*, *T. sanguisuga*, and *Paratriatoma hirsuta* (Figure below). Triatomines are present across the southern half of the country, distributed from the Pacific to Atlantic coasts (Figure below). One species (*T. rubrofasciata*) is found in Hawaii. A high degree of polymorphism has been noted in several species across their geographic ranges, particularly *T. protracta*, *T. rubida*, and *T. sanguisuga*, resulting in proposed subspecies classifications(**Ryckman 1962; 1971; 1984; Usinger1994**). However, due to the recognition of morphological intermediates across some subspecies groups and the absence of supporting data (e.g., paired molecular and morphological studies), these subspecies have not been universally accepted as valid taxonomic groups. (**Galvao 2003;Lent 1979**)



Beware the

KISSING BUG

The parasite from a kissing bug can infect dogs and humans.

Long needle-like mouthpart tucked under the head used to pierce prey.

Cone shaped head

Some kissing bugs have a solid yellow, orange or red band of color around the outer body. Some may look striped as shown above.



The feces of the bug contains a parasite that can cause the potentially life-threatening Chagas Disease. The parasite is not transmitted by the bite directly.

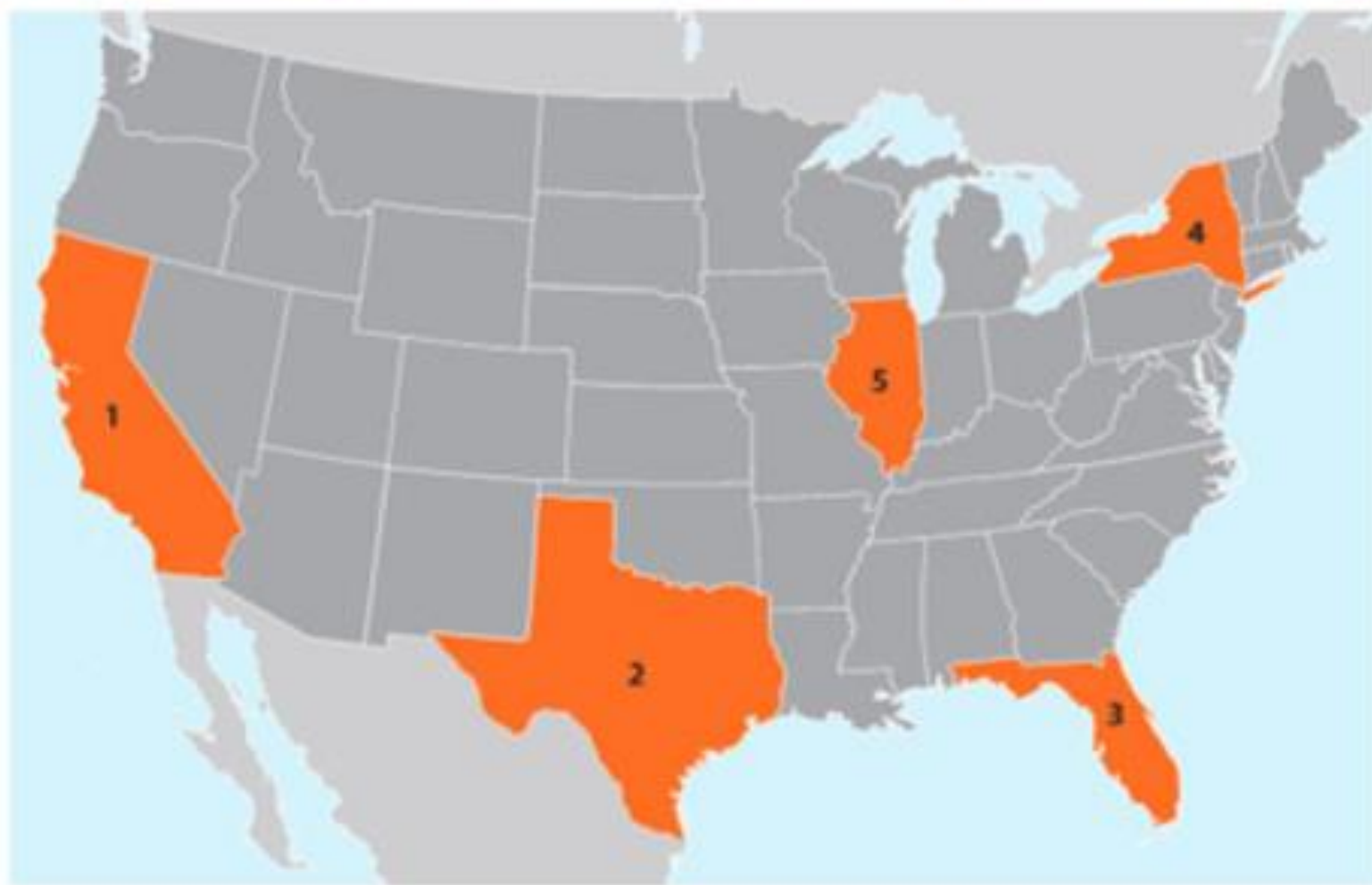
TAXONOMÍA

- Dominio: Eucariota
- Reino: Protozoa
- Subreino: Biciliata
- Infrareino: Excavata
- Filo : Euglenozoa
- Subfilo: Saccostoma
- Clase: kinetoplastea
- Orden: Trypanosomatida
- Familia: Trypanosomatidae
- Genero: Trypanosoma

ESPECIES

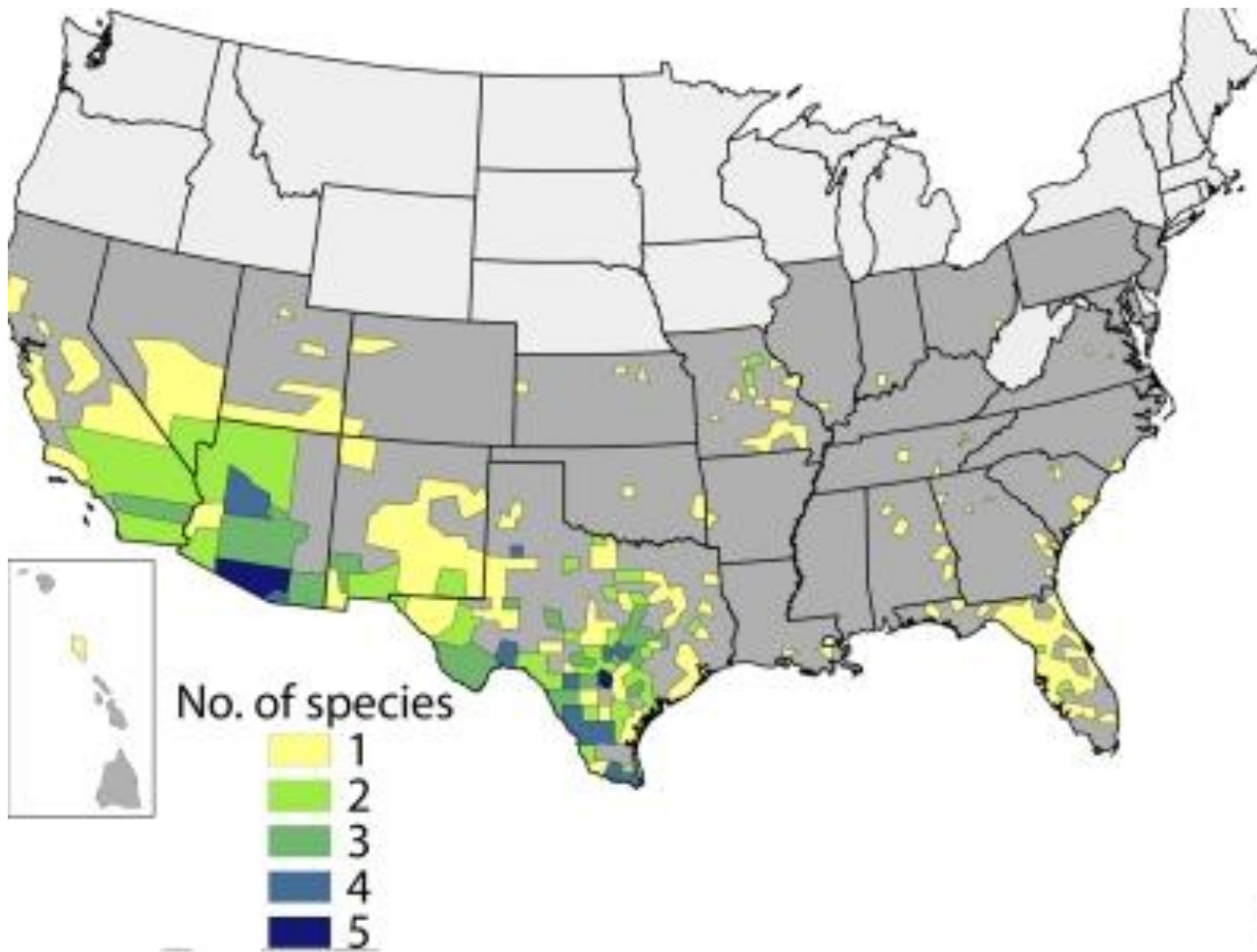
- *T. avium*, causa tripanosomiasis en aves.
 - *T. boissoni*, en tiburones, rayas.
 - *T. brucei*, causa la enfermedad del sueño en personas y nagana en el ganado vacuno.
 - *T. cruzi*, causa la enfermedad de Chagas en humanos.
 - *T. congolense*, causa nagana en vacuno, caballos y camélidos.
 - *T. equiperdum*, causa durina o enfermedad cubierta en caballos y otros Equidae.
 - *T. evansi*, causa una forma de la enfermedad, surra, en ciertas especies (sólo se ha informado de un caso de infección humana en 2005 en India y fue tratado con éxito con suramina).
 - *T. lewisi*, en ratas.
 - *T. melophagium*, en ovejas infectadas por *Melophagus ovinus*.
 - *T. percae*, en peces: *Perca fluviatilis*.
 - *T. rangeli*, se considera inocua para los seres humanos.
 - *T. rotatorium*, en anfibios.
 - *T. simiae*, causa nagana en animales.
 - *T. suis*, causa una forma diferente de surra.
 - *T. theileri*, un gran tripanosoma que afecta a rumiantes.
 - *T. triglae*, en peces marinos teleósteos.
 - *T. vivax*, causa la enfermedad nagana.
-

TOP FIVE STATES IN THE U.S. WITH REPORTED ESTIMATED CASES OF CHAGAS DISEASE



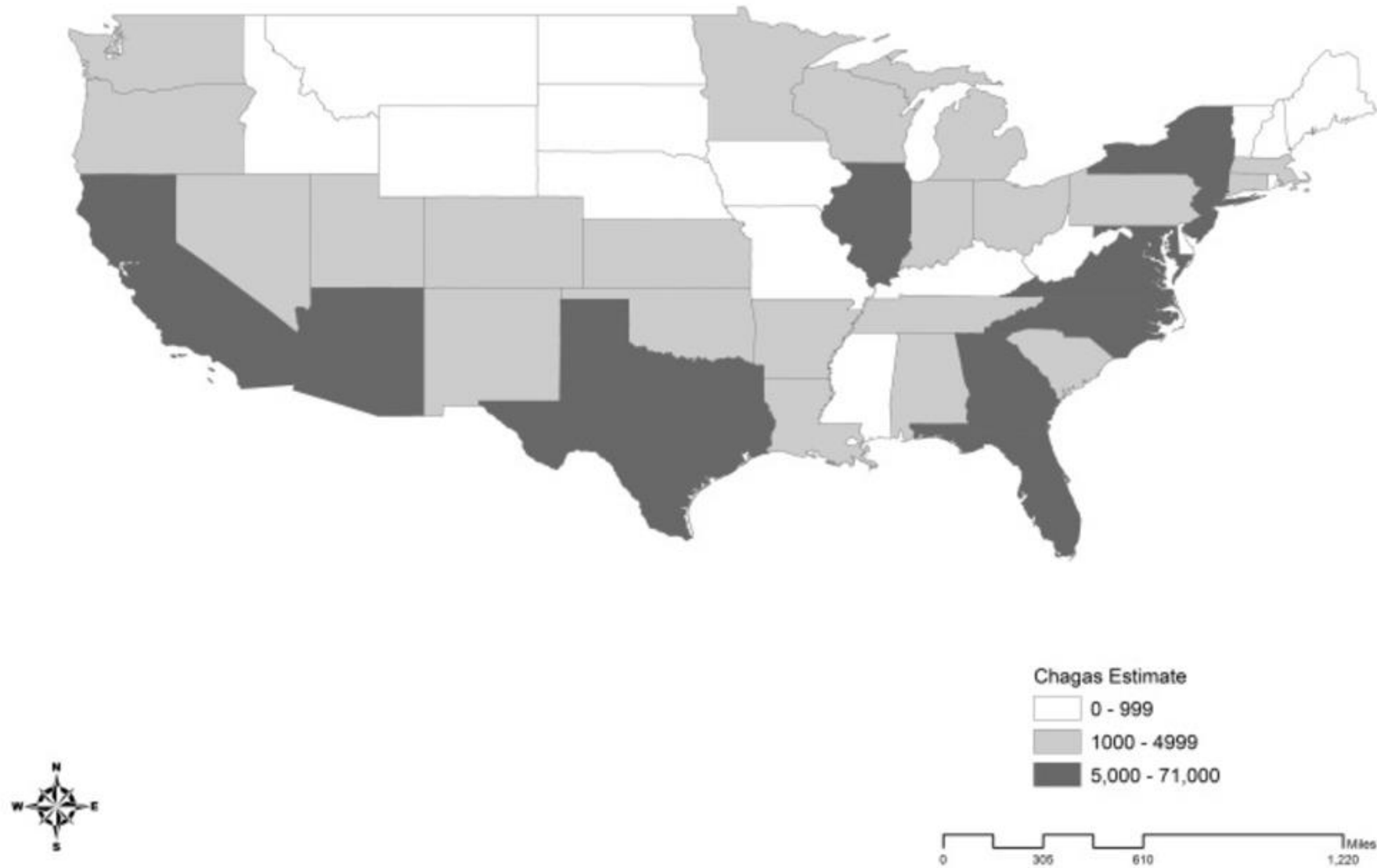
	States	Cases	Population (in millions)
1	California	71,000	38.4
2	Texas	37,200	26.5
3	Florida	18,200	19.6
4	New York	17,500	19.7
5	Illinois	9,200	12.9

SOURCE Estimated cases based on data from 2007–2013 from Jennifer Manne-Goehler, et al. "Access to care for Chagas." Population data from US Census Bureau.



Triatomine species diversity in the continental United States and Hawaii by county. States shaded gray have reported at least one species. The states of Kentucky, Maryland, Mississippi, New Jersey, and Pennsylvania have each reported one species but with no locality specified.

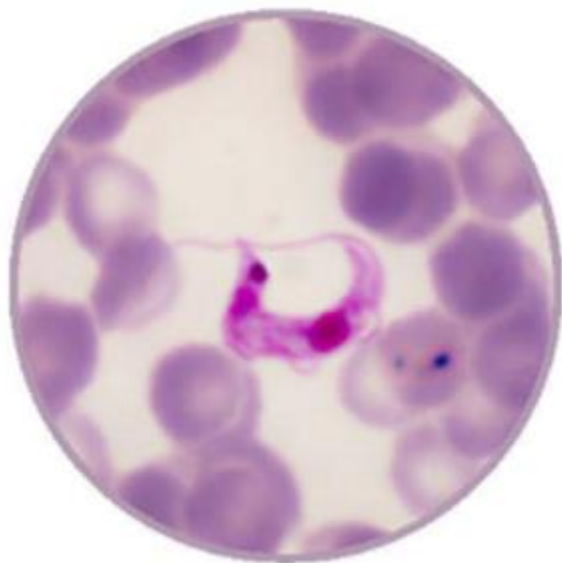
Estimated Cases of Chagas Disease in the United States, 2012



Map of estimated cases of Chagas disease in the United States, 2012

NEGLECTED PARASITIC INFECTION:

Chagas Disease



More than **300,000 people** in the United States are infected with *Trypanosoma cruzi*, the parasite that causes Chagas disease—and most don't know it.



Estimated *T. cruzi* cases in the United States in 2012 and confirmed cases of *T. cruzi* infection in donated blood per AABB from 2007–2013, by state.

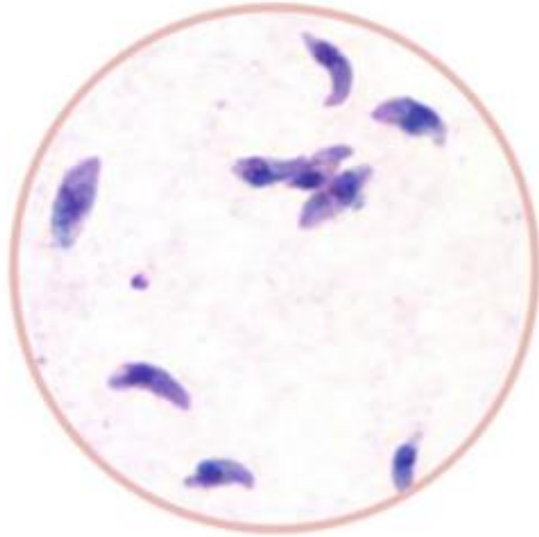
State	Est. Cases	AABB Cases	State	Est. Cases	AABB Cases
Alabama	1,116	8	Montana	46	1
Alaska	110	----	Nebraska	855	3
Arizona	6,440	28	Nevada	3,712	25
Arkansas	1,161	25	New Hampshire	159	3
California	70,860	707	New Jersey	8,686	32
Colorado	3,219	4	New Mexico	1,752	4
Connecticut	1,924	8	New York	17,403	160
Delaware	339	----	North Carolina	5,408	41
D.C.	745	2	North Dakota	23	1
Florida	18,096	260	Ohio	1,142	9
Georgia	5,681	37	Oklahoma	1,407	17
Hawaii	139	----	Oregon	1,995	13
Idaho	611	----	Pennsylvania	1,804	7
Illinois	9,316	22	Rhode Island	641	1
Indiana	1,705	12	South Carolina	1,486	15
Iowa	716	5	South Dakota	82	----

State	Est. Cases	AABB Cases	State	Est. Cases	AABB Cases
Kansas	1,273	9	Tennessee	1,900	14
Kentucky	618	9	Texas	36,977	176
Louisiana	1,427	15	Utah	1,767	24
Maine	49	1	Vermont	36	----
Maryland	5,926	29	Virginia	7,346	103
Massachusetts	3,346	9	Washington	3,144	18
Michigan	1,258	7	West Virginia	88	1
Minnesota	1,443	2	Wisconsin	1,239	3
Mississippi	434	11	Wyoming	112	----
Missouri	927	17	TOTAL	238,091	1,908

The AABB data included 6 confirmed infections whose state was unknown and 4 confirmed infections in Puerto Rico, not included in Table

NEGLECTED PARASITIC INFECTION:

Toxoplasmosis

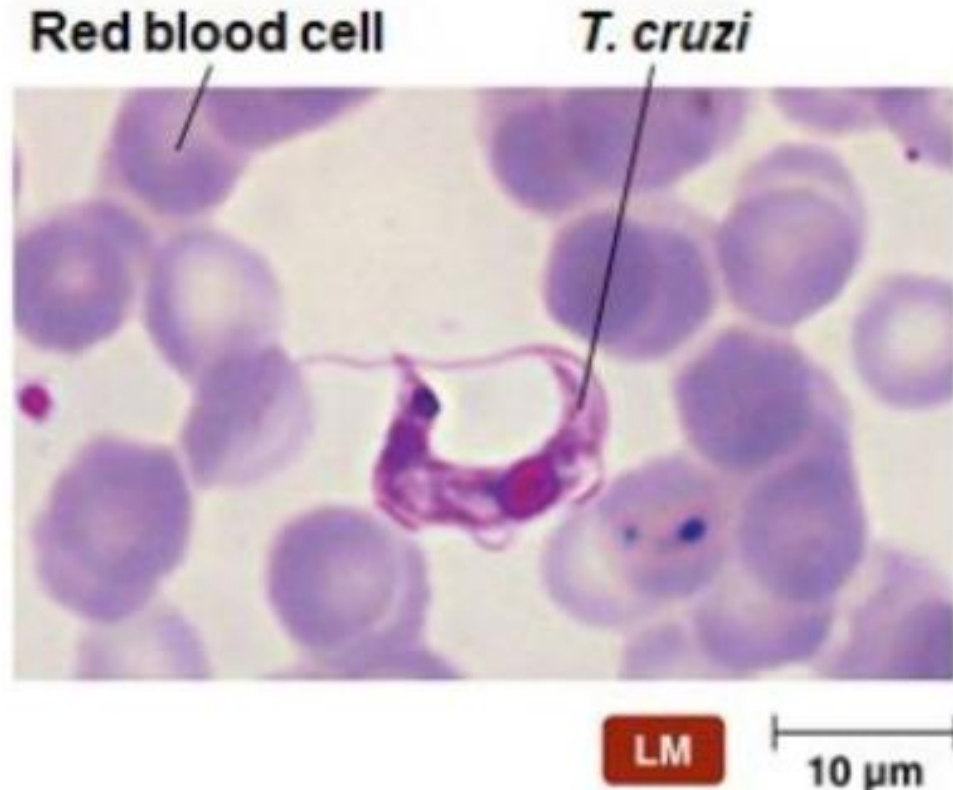


Toxoplasmosis is the **2nd leading cause of death** from foodborne illness in the United States.



Chagas' disease – American trypanosomiasis

- The disease is **endemic in Central and South America**



- Affects 8-15 million people
 - Thousands die each year, including children
- **Early stages can be treated but not late stages**
- No vaccine exists for Chagas's disease
- **Prevention involves** measures that protect against bugs: mud replaced with concrete/brick, insecticides

References

1. Bern C., Montgomery S. P. 2009. An estimate of the burden of Chagas disease in the United States. Clin. Infect. Dis. 49:e52–54
2. Galvao C., Carcavallo R., Rocha Dda S., Jurberg J. 2003. A checklist of the current valid species of the subfamily Triatominae Jeannel, 1919 (Hemiptera, Reduviidae, Triatominae) and their geographical distribution with nomenclatural and taxonomic notes. Zootaxa 202:1–36,
3. Ingber A, Garcia MN, Leon J, Murray KO. Chagas Disease Knowledge and Risk Behaviors of the Homeless Population in Houston, TX.J Racial Ethn Health Disparities. 2017 May 31. doi: 10.1007/s40615-017-0362-0.
4. Lent H., Wygodzinsky P. 1979. Revision of the Triatominae (Hemiptera, Reduviidae), and their significance as vectors of Chagas' disease. Bull. Am. Museum Nat. History 63:123–520
5. Organización Panamericana de la Salud 2006. Estimación cuantitativa de la enfermedad de Chagas en las Americas OPS/HDM/CD/425-06. Organización Panamericana de la Salud, Washington, DC
6. Ryckman R. E. 1962. Biosystematics and hosts of the Triatoma protracta complex in North America (Hemiptera: Reduviidae) (Rodentia: Cricetidae). Univ. Calif. Publ. Entomol. 27:93–240.
7. Ryckman R. E. 1971. The genus Paratriatoma in western North America. J. Med. Entomol. 8:87–97.
8. Ryckman R. E. 1984. The Triatominae of North and Central America and the West Indies: a checklist with synonymy (Hemiptera: Reduviidae: Triatominae). Bull. Soc. Vector Ecol. 9:71–83.
9. Usinger R. L. 1944. The Triatominae of North and Central America and the West Indies and their public health significance. U.S. Government Printing Office, Washington, DC.