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Long-term reduction of *Trypanosoma cruzi* infection in sylvatic mammals following deforestation and sustained vector surveillance in northwestern Argentina

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Abstract

Long-term variations in the dynamics and intensity of sylvatic transmission of *Trypanosoma cruzi* were investigated around eight rural villages in the semiarid Argentine Chaco in 2002–2004 and compared to data collected locally in 1984–1991. Of 501 wild mammals from 13 identified species examined by xenodiagnosis, only 3 (7.9%) of 38 *Didelphis albiventris* opossums and 1 (1.1%) of 91 *Conepatus chinga* skunks were infected by *T. cruzi*. The period prevalence in opossums was four-fold lower in 2002–2004 than in 1984–1991 (32–36%). The infection prevalence of skunks also decreased five-fold from 4.1–5.6% in 1984–1991 to 1.1% in 2002–2004. Infection in opossums increased with age and from summer to spring in both study periods. The force of infection per 100 opossum-months after weaning declined more than six-fold from 8.2 in 1988–1991 to 1.2 in 2002–2004. Opossums were mainly infected by *T. cruzi* lineage I and secondarily by lineage IId in 1984–1991, and only by *T. cruzi* I in 2002–2004; skunks were infected by *T. cruzi* IId in 1984–1991 and by IIc in 2002–2004. The striking decline of *T. cruzi* infection in opossums and skunks occurred in parallel to community-wide insecticide spraying followed by selective sprays leading to very low densities of infected *Triatoma infestans* in domestic and peridomestic habitats since 1992; to massive deforestation around one of the villages or selective extraction of older trees, and apparent reductions in opossum abundance jointly with increases in foxes and skunks. These factors may underlie the dramatic decrease of *T. cruzi* infection in wild reservoir hosts.
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Keywords: *Trypanosoma cruzi*; Reservoirs; *Didelphis*; *Conepatus*; Deforestation; Land use change; Skunks; Opossums; Force of infection

1. Introduction

Trypanosoma cruzi, the etiologic agent of Chagas disease, has been detected in some 180 species belonging to 25 families of mammals in the Americas, with marsupials, edentates, and rodents being the most fre-

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quent sylvatic hosts (World Health Organization, 2002). Domestic transmission cycles mainly include humans, dogs and cats, and several species of triatomine bugs adapted to human dwellings (Pinto Dias, 2000). Transmission cycles of *T. cruzi* display large spatial and structural heterogeneity (Diotaiuti et al., 1995).

The Gran Chaco, a natural landscape unit of about 1,000,000 km^2 crossing over northern Argentina, Bolivia, Paraguay and southwestern Brazil, is one of the most endemic regions for Chagas disease. Natural infection by *T. cruzi* has been reported for armadillos *Chaetophractus vellerosus*, *C. villosus*, *Cabassous unicinctus*, *Dasypus novemcinctus, Euphractus sexcinctus,* and *Tolypeutes matacus*; opossums *Didelphis albiventris* and *Lutreolina crassicaudata*; short-tailed opossums *Monodelphis domestica*; foxes *Lycalopex culpaeus* and *L. gymnocercus griseus*; coatis *Nasua nasua*, and mice *Calomys musculinus* and *C. laucha* (Carcavallo and Martínez, 1968; Yeo et al., 2005). In a well-defined area in the semiarid Argentine Chaco, the only wild mammals found infected with *T. cruzi* were *D. albiventris* opossums, a few *Conepatus chinga* skunks and one *Galictis cuja* ferret among 230 mammals from 20 species (Pietrokovsky et al., 1991; Wisnivesky-Colli et al., 1992). In the Bolivian Chaco, sylvatic *Triatoma infestans*, *Triatoma sordida* and *Triatoma guasayana* have been found infected with *T. cruzi* and may be the putative sylvatic vectors of *T. cruzi* (Noireau et al., 2000). In the Argentine Chaco, however, the sylvatic vector of *T. cruzi* has not been firmly established. Since the 1990's the Chaco has been undergoing accelerated deforestation and change of land use patterns which may have affected the relationship between the domestic and sylvatic transmission cycle of *T. cruzi* to an unknown extent.

T. cruzi has been classified into two major phylogenetic lineages, *T. cruzi* I (TCI) and *T. cruzi* II (TCII), and several sublineages within TCII designated as IIa, IIb, IIc, IId and IIe (Anon., 1999). These lineages appear to be distributed differentially between triatomine species and hosts throughout the Americas. TCI was originally described from sylvatic hosts and predominates in domestic transmission cycles to the north of the Amazon basin, whereas TCII predominates in domestic cycles but has sometimes been found in sylvatic mammals as well (Brisse et al., 2000; Yeo et al., 2005). In the Argentine and Paraguayan Chaco, TCI infects *D. albiventris* opossums and much less frequently humans and *T. infestans*, whereas TCII typically infects *T. infestans*, domestic dogs and cats, humans and skunks (Luca d'Oro et al., 1993; Diosque et al., 2003; Yeo et al., 2005; Marcet et al., 2006). Based on isoenzyme and molecular markers, two studies concluded that domestic and sylvatic transmission cycles of *T. cruzi* overlapped partially throughout Argentina and in two rural areas within the Chaco region (Wisnivesky-Colli et al., 1992; Luca d'Oro et al., 1993; Diosque et al., 2003). Opossums were suggested as a possible bridge between sylvatic and domestic transmission cycles (Schweigmann et al., 1999; Diosque et al., 2004). Temporal variations in the sylvatic cycle of transmission of *T. cruzi* in the presence of significant environmental changes have not been investigated.

As part of a longitudinal study on the eco-epidemiology of Chagas disease in a well-defined rural area in northwestern Argentina under sustained vector surveillance and selective insecticide sprays, the present study sought to assess the host range and prevalence of *T. cruzi* in a wide variety of wild mammals, and to identify the parasite sublineages circulating in them. Furthermore, to assess the existence of long-term variations in the dynamics and intensity of sylvatic transmission of *T. cruzi,* we compared our results with data collected in the same area between 1984 and 1991, before both massive deforestation around one of the villages and sustained vector surveillance in all villages was initiated in 1992.

2. Materials and methods

2.1. Study area

Field studies were carried out in the dry forest around Amamá (27°12′30″S, 63°02′30″W) and neighboring rural villages (Trinidad, Mercedes, Pampa Pozo, Villa Matilde, San Luis and La Curva) and in an isolated settlement (Lote S), situated in Moreno Department, Province of Santiago del Estero, Argentina (Fig. 1). The area is part of the semiarid southern Chaco, with a dry season from April to October. During 2002–2004 a weather station (Weather Monitor II, Davis Co., Baltimore, MD) located in Amamá measured mean annual precipitation (740 mm), relative humidity (55–68%), and mean annual temperature (22 °C), ranging from 28 °C in the warmest months (January–February) to 5 °C in the coldest month (July). The landscape is characterized by a secondary hardwood forest dominated by *Schinopsis lorentzii* and *Aspidosperma quebracho blanco*, and several *Prosopis* sp., which has been heavily exploited since the early 1920s' and especially since the 1990s'.

Amamá was the only rural village in the Moreno Department that had ever been treated with residual insecticides (in 1985), but the absence of a vector surveillance system resulted in an exponential increase of domestic reinfestation and in renewed transmission (Gürtler et al., 1991, 2005). A second insecticide treatment conducted in 1992 included other highly infested

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