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Review of the rodent paleoparasitological knowledge from South America

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A B S T R A C T

Rodents (Mammalia, Rodentia) are a key mammalian group with a worldwide distribution. The relevance of rodents as hosts in parasitic life-cycles, also in those of zoonotic impact, has been fully recognized. Parasites have been found in ancient remains throughout the world. Paleoparasitology is the study of ancient parasites recovered from archaeological and paleontological sites and materials. This paper reviews the major research activities carried out in rodent paleoparasitology from South America, aiming to integrate data and generate prospects in this field of research. The presence of rodent parasites in ancient times can provide useful and valuable information, as rodent paleoparasitological data can be used from diverse point of views. Anthropologists, biologists, archaeologists, and paleontologists can use this data to reconstruct ancient events based on the parasite life cycles and on the biological requirements to maintain the transmission from host to host. Rodent paleoparasitology may provide a picture of the biodiversity of parasites in ancient times. Although rodent remains are generally present in ancient times, their recovery from archaeological and paleontological contexts is still exceptional.

1. Introduction

Rodents (Mammalia, Rodentia) are a key mammalian group with a worldwide distribution, over 42% of all mammal species (Carleton and Musser, 2005). Their success is due to their small size, the short pregnancy and the ability to gnaw and to eat a wide variety of foods (Wilson and Reeder, 2005). Rodents are important in many ecosystems because they reproduce rapidly, and can function as food source for predators, as dispersors of seeds and as vectors of diseases. Some species are good ecological, climatological, and geographical indicators (i.e. Legendre et al., 2005; Hernández Fernández, 2006; Smith, 2012).

The relevance of rodents as hosts in parasitic life-cycles, also in those of zoonotic impact, has been fully recognized (Miyazaki, 1991; Perkins et al., 2005; Morand et al., 2006). Their role as reservoirs of zoonoses has long been known. Rodents are hosts to a number of ectoparasites such as lice, mites, and ticks, and can transmit viral, bacterial and protozoan parasites to humans and animals (Soliman et al., 2001). In addition, they can harbour many different protozoan and helmintic endoparasites (Morand et al., 2006).

Parasites have been found in ancient remains throughout the world (Reinhard, 1990; Bouchet et al., 2003; Gonçalves Carvalho et al., 2003; Araújo et al., 2011). Paleoparasitology is the study of ancient parasites recovered from archaeological and paleontological sites and materials (Ferreira et al., 1979; Gonçalves Carvalho et al., 2003). It aims to provide additional information on parasites themselves (origin, history, evolution), on human and animal populations (paleopathology, sanitary conditions, lifestyles), and also on relationships among hosts, parasites and their environment (Reinhard, 1992; Bouchet et al., 2003; Le Bailly and Bouchet, 2010, 2013).

At the end of the 1980s, paleoparasitology added rodents as important material to be studied. The first research started on coprolites of the Brazilian endemic rodent *Kerodon rupestris* (Rodentia, Caviidae). Eggs and larvae of *Strongyloides ferreirai* and eggs of *Trichuris* sp. (roundworms, nematodes) were found in samples collected from archaeological layers dated from 8000 to 2000 BP from Brazil (Araújo et al., 1989). This paper reviews the

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major research activities carried out in rodent paleoparasitology from South America, aiming to integrate data and generate prospects in this field of research.

2. Sources and techniques used in ancient rodent parasitic studies

In some paleontological and archaeological sites from South America, coprolites are the most common source of paleoparasitological data. In southern Patagonia and Northeasthern Brazil, coprolites are generally found by archaeologists and paleontologists dispersed in layers from rock-shelters and caves.

The study of coprolites presents some difficulties. When coprolites are collected from mummified bodies, their origin is clear. Commonly, coprolites are found free in sediment layers of archaeological and paleontological sites. The identification of the biological origin of the coprolites is mainly based on the knowledge of the feces of the local fauna and on morphometric characteristics associated with macro and microscopic examination (Chame, 2003).

In the 2000s, the study of raptor pellets and sediments opened up the possibility of new ancient rodent parasite sources of evidence (Fugassa, 2006a; Fugassa et al., 2007). Raptor pellets collected from archaeological sites are considered as good rodent material for parasitic studies (Beltrame et al., 2011).

Mummified bodies are rarely found in Brazilian and Argentinian archaeological sites. However, human and other animal mummies were recovered from archaeological sites from Perú. This allowed ectoparasite studies in rodent paleoparasitological data. The examination of mummies of the Guinea pig *Cavia porcellus* (Rodentia: Caviidae) from Perú enabled the recognition of mites, fleas, and lice from ancient samples (Dittmar, 2000).

Rodent organic remains are examined by parasitological regular techniques after rehydration using a trissodium phosphate aqueous solution 0.5% ($Na_3PO_4^-$) for 72 h (Callen and Cameron, 1960). Next, spontaneous sedimentation is recommended (Lutz, 1919; Araújo et al., 1998).

Technical improvements in Polymerase Chain Reaction (PCR) analysis added the possibility of studies with ancient DNA. Mitton (2012) achieved molecular detection of *Trichuris* spp. from samples of rodent coprolites from an archaeological site from Argentina from one egg. This technique has been also used with different tissues, offering a great spectrum of research for infectious diseases from archaeological samples. Bastos et al. (1996) used PCR to study the kinetoplast DNA (kDNA) of Chagas disease, *Trypanosoma cruzi*, from experimentally desiccated mouse tissue (heart, skeletal, muscle, spleen, and pancreas). The preliminary data suggest the application of this technique to detect *T. cruzi* in archaeological rodent material. On the other hand, the protozoan causative of toxoplasmosis (*Toxoplasma*) has not yet been detected in ancient remains, although successful recovery of its DNA has been accomplished from desiccated mousse tissues (Terra et al., 2004). The application of PCR to rodent paleoparasitological toxoplasmosis and Chagas disease research is a promising option.

3. Studies of ancient rodent parasites from South America

Records of ecto and endoparasites recovered from rodents from archaeological and paleontological sites of South America have been published chronologically (Table 1).

Table 1
Summary of South America rodent paleoparasitological findings.

Locality	Date (yr B.P.)	Sample	Host	Parasites	Measurements (μm)	References
Piauí, Brazil	8000–2000	Coprolites	*Kerodon rupestris*	*Strongyloides ferreirai* *Trichuris* sp.	61.96 × 31.65 (*N* = 10)	Araújo et al. (1989)
Pedra Furada, Brazil	30,000–8450	Coprolites	*K. rupestris*	*Trichuris*	60–65 × 30–33	Ferreira et al. (1991)
Sitio do Meio, Piauí, Brazil	9000 yr	Coprolites	*K. rupestris*	*Trichuris* sp.	59–66 × 33 (*N* = 20)	Araújo et al. (1993)
El Yaral, Moquegua Valley, Perú	Chiribaya Culture	Mummies	*Cavia porcellus* (guinea pigs)	*Trimenopon hispidum*, *Gliricola porcelli.* *Ornithonyssus* spp. *Pulex simulans*		Dittmar (2000)
Orejas de Burro 1, Santa Cruz, Argentina	3720–3978	Rodent coprolites	Unidentified	*Eimeria macusaniensis*		Fugassa and Barberena (2006)
Alero Mazquiarán, Chubut, Argentina	s. XIX	Coprolites and sediments	Unidentified	Anoplocephalid *Trichuris* sp. Ascaridid *Capillaria* sp.	55–60 × 57.5–61.25 (*N* = 4) 66.25 × 52.5 53 × 35 65 × 35	Fugassa (2006b)
Cerro Casa de Piedra, Santa Cruz, Argentina	6540 ± 110	Raptor pellet	Unidentified	*Capillaria* sp.	37.5–42.5 × 63.75–68.75	Fugassa et al. (2007)
Cerro Casa de Piedra 7, Santa Cruz, Argentina	7920 ± 130	Coprolites	*Ctenomys* sp.	*Trichuris* sp. *Paraspidodera uncinata* *Eucoleus* sp.	60–67.5 × 30–37.5 57.5–67.5 × 45–50 (*N* = 24) 60–62.5 × 37.5–40	Sardella and Fugassa (2009a)
Alero Mazquiarán, Chubut, Argentina	212 ± 35	Coprolites	Unidentified	*Monoecocestus* sp. *Pterygodermatites* sp. *Trichosomoides* sp.	50–62.5 × 50–62.5 (*N* = 30) 65–75 × 45–52.5 (*N* = 13) 62.5 × 62.5 (*N* = 5)	Sardella and Fugassa (2009b)
Alero Destacamento Guardaparque, Santa Cruz, Argentina	6700 ± 70–3440 ± 70	Coprolites		*Trichuris* sp. *Calodium* sp. *Eucoleus* sp. *Echinocoleus* sp. *Monoecocestus* sp.	57.5–70 × 30–35 57.5–70 × 33.75–47.5 50–55 × 22.5–35 (*N* = 85) 65 × 31.5 (*N* = 1) 48,75–70 × 47.5–70	Sardella et al. (2010)
Cerro Casa de Piedra, Santa Cruz, Argentina	2740 ± 100–3.990 ± 80	Raptor pellets	*Abrothrix* sp. and *Euneomys chinchilloides*	*Calodium* sp. *Trichuris* sp. taeniid	39.8 ± 2.2 × 67.2 ± 3.8 (*N* = 60) 60 × 35 (*N* = 1) 37.5 × 33.5 (*N* = 1)	Beltrame et al. (2011)
CCP 7	10,620 ± 40–9390 ± 40	Coprolites	Species of Caviomorpha	*Heteroxynema* sp. *Trichuris* sp.	87.5–107.5 × 45–62.5 (*N* = 30) 67.5–77.5 × 40–45 (*N* = 96)	Sardella and Fugassa (2011)

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