First forensic records of termite activity on non-fossilized human bones in Brazil

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Abstract

The aim of this study was to describe the first records of termite activity on non-fossilized human bones in Brazil. The cases reported in this study resulted from forensic analysis of six human skeletons found in northeastern Brazil between 2012 and 2014. Traces of tunnels and nests commonly produced by termites were found on several human bone surfaces as well as the specimens and characteristic signs of osteophagic activity. In four cases, the species were identified: *Amitermes amifer* Silvestri, 1901, *Nasutitermes corniger* (Motschulsky, 1855) (on two skeletons), and *Microcerotermes indistinctus* Mathews, 1977. In two other cases, the activity of termites on bone surfaces was evidenced by remains of nests and tunnels produced by these insects. At least in the samples of human remains available for this report, the number of termites collected was greater on bones found during autumn, the rainy season in the Northeast of Brazil. The human bones examined showed termites like insects with lots of strength at bone degradation, capable of continuing the process of decomposition of human remains even in completely skeletonized bodies.

Keywords: Entomology, *Isoptera*, bone and bones, Forensic Anthropology.

Primeiros relatos forenses de atividade de térmitas em ossos humanos não fossilizados no Brasil

Resumo

O objetivo deste estudo foi descrever os primeiros relatos de atividade de térmitas em ossos humanos não fossilizados, no Brasil. Os casos relatados neste estudo resultaram da análise pericial de seis esqueletos humanos encontrados no Nordeste do Brasil, entre os anos de 2012 e 2014. Vestígios de túneis e ninhos comumente produzidos por cupins foram encontrados em várias superfícies dos ossos humanos, bem como a presença de espécimes e característicos sinais de atividade osteofágica. Em quatro casos, foram identificadas as espécies: *Amitermes amifer* Silvestri, 1901, *Nasutitermes corniger* (Motschulsky, 1855) – em duas ossadas, e *Microcerotermes indistinctus* Mathews, 1977. Em dois outros casos, a atividade de cupins sobre superfícies ósseas foi evidenciada pelos restos de ninhos e túneis produzidos por esses insetos. Pelo menos nas amostras de restos humanos disponíveis para o presente estudo, o número de térmitas recolhido foi maior em ossos encontrados durante o outono, a estação chuvosa no Nordeste do Brasil. Os ossos humanos analisados apresentaram cupins como insetos com muita força na degradação óssea, com capacidade de prosseguir o processo de decomposição de restos humanos, mesmo em corpos completamente esqueletizados.

Palavras-chave: Entomologia, *Isoptera*, osso e ossos, Antropologia Forense.

1. Introduction

The human decomposition starts quickly, approximately four minutes after death. In general, the initial step of the decomposition is the autolysis in which the bodily cells deprived of oxygen increase the concentration of carbon dioxide in blood with the consequent decrease of pH. At the same time, the disintegration of cellular organelles occurs while several existing enzymes are released, which completely dissolve the cells from inside to outside resulting in cell lysis and liberation of nutrients (Vass et al., 2002).

Additionally, a link between decaying bodies and the presence of various types of arthropods, especially insects (flies, beetles, moths) and arachnids (mites) has been

reported. As a result of extensive biomass of arthropods and their adaptation to different types of environments, these animals can be found in a wide variety of locations, even at crime scenes (Benecke et al., 2004).

No matter what the records say about the decomposition of the bodies and entomological role in this process, the insects' activities on cadaverous remains does not cease concurrently with that of body fluids and the destruction of soft tissue.

In order to establish and objectively link macroscopic and microscopic characteristics of marks and actions caused on fossils caused by termites, Backwell et al. (2012) conducted an experiment of inserting bones ranging from fresh to fossilized stages in nests of termites. After analysis, star-shaped marks attributed to termites' activity were observed on bone surfaces.

In his very first record of such activities, Derry (1911) was able to establish a link between a bone degradation phenomenon, specifically osteophagic activity on remains of human bodies and its relationship with the presence of termites. More recently, the association between the carcass of a rat and the osteophagic activity of termites was reported. Because this happened at the end of the rainy season in March, it was suggested that this behavior might be related to termites' nutritional deficiencies (Prestes et al., 2014).

A study on archaeological burials in Huaca in Peru, conducted by Huchet et al. (2011), was the first in South America to record osteophagic activity of subterranean termites on a female skeleton. In this case, they performed a macroscopic study of the resulting bone degradation and could deductively link their findings to the action of termites by examining their nest remains and characteristic materials of this type of insect. Despite active search and careful sifting for termite micro-remains, they could not identify the species involved.

As can be inferred, the records previously reported referring to necrophagia or osteophagic activity of termites were related either to animal carcasses or when in humans, solely to archeology. This study, however, is intended to report the first six cases so far known of colonization and osteophagic activity of termites on non-fossilized human bones in a forensic context.

2. Material and Methods

The Institute of Forensic Police of the State of Paraíba/Brazil previously authorized this study. The information on the cases reported in this study were obtained through forensic examinations on six human skeletons found in northeastern Brazil, between 2012 and 2014. The description will follow the chronological order in which the bones were received for anthropological expert analysis.

Termites were collected *in loco* and preserved in 70% alcohol solution. In cases where only nests and tunnels of termites were observed, photographs were taken. Specimens were collected according to permits granted by appropriate agencies to AV (SISBIO # 12688-2). All specimens are deposited at *Isoptera* Collection of the Federal University of Paraíba (CIUFPB # 7193).

2.1. Case reports

The first skeleton was examined in April 2012. At that time, it was only possible was to take photographs of the termites' colonies on the bones. Still, based on the images obtained, the colonizing species were identified as *Amitermes amifer* Silvestri, 1901. Traces of tunnels and nests were found on the skull in the intracranial region, temporal region, orbital cavity, ear canal, palate (Figure 1), nasal fossae, pterygopalatine fossa, and also on vertebrae, tibia and foot bones. There were also signs of bone degradation in the orbital cavity, in the L5 vertebral body, one rib, scapula, iliac, calcaneus and on articular surfaces of a metatarsal bone.

The second skeleton was examined in October 2012. In this case, the analysis and linking of the osteophagic activity of termites to the bone surfaces were performed through the observation of remains of nests and tunnels produced by these insects. Thus, the individualization of termite species involved was not possible, but the color and width of the tunnels are typical of the *Nasutitermes* (*Isoptera: Termitidae*) species. We found signs of nests and tunnels in the jaw (an open socket of the lower right second premolar), orbital cavity and nasal passages. Signs of osteophagic activity on cervical, thoracic, and lumbar vertebrae, on five ribs, scapula, and also on the humerus and femoral epiphysis were observed.

In 2014, four human skeletons showing signs of colonization by termites were received for forensic examination, three of them in March and one more in September. In this case, colonization was confirmed by the presence of tunnels and nests without the detection of on-site specimens.

The first skeleton examined in March of 2014 was colonized by *Microcerotermes indistinctus* Mathews, 1977. Osteophagic activity promoted by termites was observed in anatomical sites with predominance of thin cortical bone

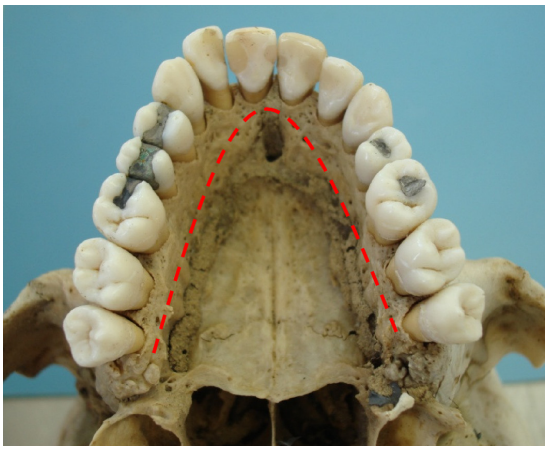

Figure 1. Photographic record of tunnels of *Amitermes amifer* Silvestri, 1901 on palate.

and abundant spongy bone, namely: vertebrae, articular surface of the sacrum and epiphysis of the tibia, fibula and femur. There were only a few traces of typical termites nest on the sacrum and iliac. The other two cases in which termites were observed on site were from the same global geographical position. The two skeletons were colonized by termites known as *Nasutitermes corniger* (Motschulsky, 1855), which left signs of osteophagic activity on the jaw bones, vertebrae of all segments, including sacral (Figure 2), scapulae, proximal humeral epiphysis, iliac (auricular surface), symphysis pubis and manubrium of the sternum. In this case, a central nest was found within the cranium. Other vestiges of termites nest were found in the skull base and fractured jaw region with exposure of the cancellous bone.

Finally, in September 2014, another skeleton with signs of colonization by termites in various anatomic segments was found. Only traces of termite nests and tunnels were identified on bone surfaces, as well as osteophagic activity. No termite specimens were found in this case, but the tunnels were similar to those of the *Nasutitermes* species. The remains of nests and tunnels were found on skullcap (externally), orbital cavity, nasal passages, skull base (Figure 3), jaw, pterygopalatine fossae, palate, open dental alveoli, temporal region (externally), sacrum, iliac (acetabulum, ileum, obturator foramen and auricular surface). On the macroscopic level, characteristic signs of osteophagic activity promoted by termites were observed on vertebrae, sacrum (atrial face) and iliac bones (auricular surface and iliac tuberosity).

3. Discussion

In general, it can be said that a significant variety of physical, chemical, or biological agents can affect bone surfaces after death. Even if one just takes the biological agent into consideration, it is clear that carnivores and scavengers such as canines, big cats, reptiles (crocodilians) and even insects can promote severe damage to the bone structure with the aim to dispose of nutrients that remain in these structures (Backwell et al., 2012).

The criteria for identifying the changes on bones produced by termites were established through an experiment which aimed to identify the causal agent of various star-shaped marks and subparallel lines found on fossil bones, as well as to check the possibility of these findings be a result of the osteophagic activity carried out by termites. So, Backwell et al. (2012), put bones in different stages of preservation into colonies of *Trinervitermes trinervoides* (Sjöstedt, 1911). The results indicated that termites were capable of destroying bone preservation at any stage. There was, however, positive tropism for fresh bones,

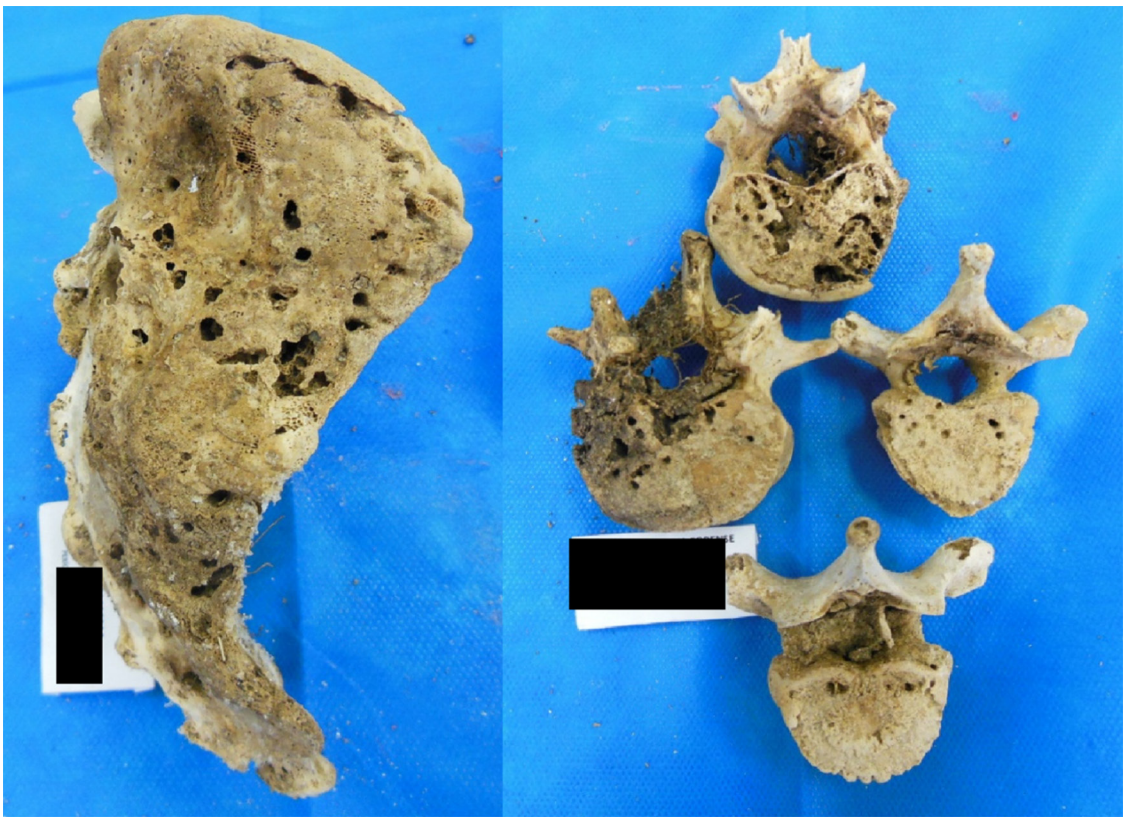

Figure 2. Photographic record of the osteophagic activity of *Nasutitermes corniger* (Motschulsky, 1855) on sacrum and vertebrae.

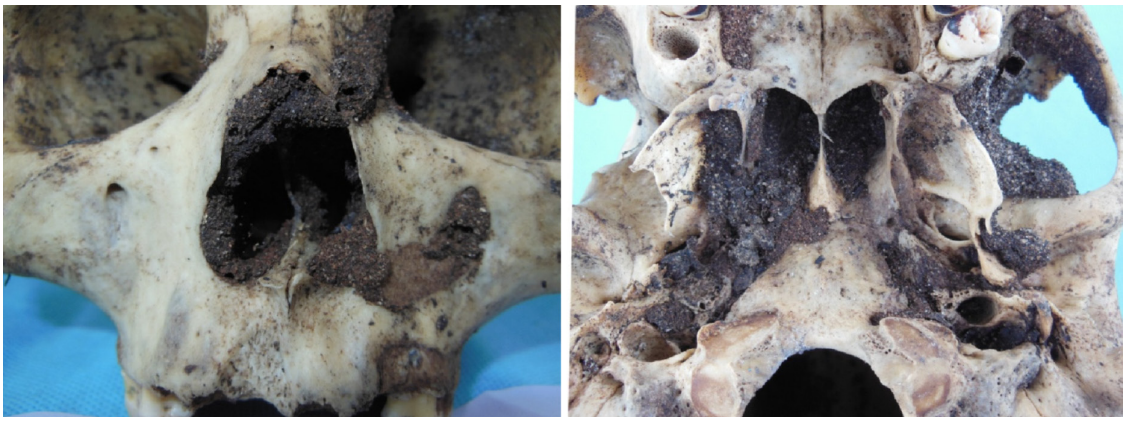

Figure 3. Photographic record of termites' tunnels in orbital cavity, nasal passages, and skull base.

mainly those with thin cortical bone, cancellous bone of epiphysis containing flesh, and marrow. Thus, the authors noted that the main signs of termites' osteophagia were tiny holes and tunnels, star-shaped superficial marks on the bone surface, and clusters of subparallel lines. In the cases presented in our report, these aspects were found mainly near termite tunneling present on the examined human bones.

Huchet et al. (2011) observed greater damage on the outer portion of the parietal and frontal bones. In other body segments, they observed bone degradation in scapulae, ulna, ribs, iliac, sacrum, and calcaneus. The information on Figure 1 and the descriptions made during the analysis of the bones showed that the vertebrae, and in particular the vertebral bodies that are mainly composed of cancellous bone, were the most attractive structures to the osteophagic activity of termites which left marks in all cases. Scapula and iliac were affected in half of the reported cases. The auricular surfaces of iliacs and the pubic symphysis suffered greater osteophagic activity. Two cases of bone degradation in humeral epiphysis were registered. Overall, the findings in this study agree with reports in the literature that have shown termites' predilection for bone sites with cancellous bone, bone marrow or thin cortical bone.

Termites are usually labeled as social insects that live in communities (Buschini et al., 2008). Despite they have been initially described as higher plants decomposers, they also feed on other types of diet. Their osteophagic behavior on human bones, for example, was first reported on archeological studies of graves in ancient Nubia (Huchet et al., 2011). Notwithstanding this record, scarce are the references to this fact in the archeological literature. These authors reported the discovery of a human skeleton excavated in Moche Huaca La Luna (Peru). They found evidence of degradation on bone surfaces and attributed them to subterranean termites.

Termites' seasonal attraction for carcasses takes place after the dry season, and it is hard to guess precisely the period of the year when an abandoned carcass was colonized (Thorne and Kimsey, 1983). References to the periods of the seasons used in this study were based on information provided by the National Institute for Space Research (NISR) and the Weather Forecast and Climate Studies Center (WFCSC), official institutes of the Brazilian government (Table 1).

As can be seen, the skeletons received for forensic examinations in September and October, which correspond to spring, did not present specimens of termites on-site. According to information from NISR, spring corresponds to the dry season in the northeast of Brazil. So, the findings regarding the presence or the absence of termites *in situ* are in accordance with the literature, since during periods of dryness no termites were detected on the bones, but only traces of their characteristic nests and tunnels. Nevertheless, during autumn (rainy season), we observed active colonization with the presence of termites on all bones received for examination. These aspects are consistent with those reported by Prestes et al. (2014).

Further investigation should be performed in order to study the great contribution of termites to chronotanatognosis. According to Anderson (2015), after three days, insect evidence is often the most accurate and sometimes the only method of determining elapsed time since death. Since different stages of the decomposition are attractive to different species of insects, the determination of the relationship between elapsed time since death and bone degradation became possible even if one has to keep in mind termite seasonal demand for carcasses. The human bones found in northeastern Brazil presenting characteristic termite tunnels and nests remains, as well as particular signs of bone degradation, show termites like insects with lots of strength at bone degradation, which continue the process of decomposition of human remains even in completely skeletonized bodies.

Studies on termites' osteophagic activity are very relevant and must be more often conducted. Additionally, these first Brazilian cases reported in this study are extremely useful to forensic experts' practice, once Entomology is one of the most important scientific contributors to Forensic Anthropology regarding investigations on time and place of death. Moreover, the description of bone lesions patterns caused by termites' osteophagic activity

Table 1. Species identified, sex and estimated age of the skeletons, geographical location, month, and season in which they were found.

Global Location - Gps	Sex	Estimated Age (Years)	Month/Year In Wich The Bones Were Found	Season – Nisr / Wfcsc	Species
Not available	Male	20 to 50	April/2012	Autumn/Rainy period in the Northeast of Brazil	*Amitermes amifer*
Not available	Male	11 to 20	October/2012	Spring / Dry season in the Northeast of Brazil	No specimens *in loco*
Not available	Male	15 to 25	Mach/2014	Autumn/Rainy period in the Northeast of Brazil	*Nasutitermes corniger*
Lat.: 07.35° Long.: 34.92°	Male	16 to 19.5	March/2014	Autumn/Rainy period in the Northeast of Brazil	*Nasutitermes corniger*
Lat.: 07.29° Long.: 34.94°	Male	23 to 40	March/2014	Autumn/Rainy period in the Northeast of Brazil	*Microcerotermes indistinctus*
Lat.: 06.73° Long.: 35.18°	Male	30 to 50	September/2014	Spring / Dry season in the Northeast of Brazil	No specimens *in loco*

may aid the forensic experts on differentiation between lesions caused by these insects from those caused by other agent, energy or instrument.

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