PALEOECOLOGY AND TAPHONOMY OF A MASTODON POPULATION FROM ÁGUAS DE ARAXÁ, MINAS GERAIS, BRAZIL

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INTRODUCTION

The Pleistocene fossil assemblage from Águas de Araxá consists of a great concentration of dental and skeletal fragments of several sizes and it is associated to the mastodon *Stegomastodon waringi*. The fossils were deposited in a pothole of a Pleistocene stream. The uniqueness of this deposit drew the attention of Simpson & Paula-Couto (1957), which recognized the mastodon assemblage from Águas de Araxá as a single population.

Mothé et al (in prep), following the study of Simpson & Paula-Couto (1957), redefined the intermediate teeth wear classes proposed by these authors through a morphometric wear index. Also, Mothé et al (in prep) by the association of each recognized individual to an age group, based on previous studies of dental wear of current proboscideans (Moss, 1996), it was possible to establish the mastodont population structure from Araxá. These age classes follow socio-physiological aspects of proboscideans life and they are divided into five classes: 0-12 years (immature individuals), 13-24 years (subadult individuals), 25-36 years (adult individuals), 37-48 years (mature adult individuals) and 49-60 years or more (senile individuals). Considering these age classes, the mastodon population of Araxá is formed as follows: immature individuals (14,89%), subadults (23,04%), adults (27,65%), mature adults (17,21%) and senile (17,21%). Due the lack of age bias in this assemblage, with the fact the fossiliferous process is a casual event, it is accepted these fossil remains could be a random sample of mastodons local population. The current concepts of population do not consider the time like a limiting factor (Begon, Townsend & Harper, 2006; Odum & Barrett, 2007). About fossiliferous assemblage, the time is a very important variant because it may imply in the occurrence of a time-averaging. For the population studied here, it is argued that individuals are possibly contemporaneous and they passed together through the burying process, as said by Price (1944) and Simpson & Paula-Couto (1957), whereas there is no deposit stratification and the fossil remains have similar taphonomic signature.

Extant African savanna or bush elephants usually associate in a nuclear group (family unit) composed of an adult female with one to three immature offspring (Owen-Smith, 2000). Therefore, the number of individuals who compose this fossil assemblage may indicate that the occupied environment was an open formation (savannah-like), as suggested by other authors (Ledru, 1993; Sánchez et al, 2004). Also, we propose that the mastodon aggregation we describe here may have died together during a time of low environmental humidity. Loss of water sources caused by dry climatic conditions would have led to density-dependent deaths as a result of crowding around water sources, as well as overcrowding and overgrazing migration routes. In times of drought, proboscideans suffer mass deaths at water refuges (Haynes, 1991).

Paleoecology is one of the subjects of paleontology which concerns in the study of interactions of preterit organisms with each other and their environment (Dood & Stanton, 1990). However, the greatest part of paleoecological evidences reaches the present fragmented or damaged by stratinomic and fossil gaining processes. In this point, the use of other sciences (like taphonomy) to recover information is extremely necessary. Taphonomy studies the processes since the death of organisms up to preservation of organic remains in sediment record and the way they affect the fossil record quality (Behrensmeyer et al, 2000).

The objectives of this study are to infer about the feeding habits, mortality event and fossilization process of mastodons population from Águas de Araxá.

MATERIALS AND METHODS

The analyzed specimens are housed at the fossil collection of the Departamento Nacional de Produção Mineral (DNPM), Rio de Janeiro, Brazil.

The diet analysis involved the recognition of dental microwear patterns and the recuperation of microtraces in teeth calculus. The enamel scar patterns, the frequency of pits and scratches and the counting of gouges and cross scratches were obtained. A microwear index witch relates the pits and scratches frequencies were used to compare the mastodons of Águas de Araxá and other herbivorous mammals. From the teeth calculus of 54 molars, 142 samples were obtained. After the chemical processing of samples, some blades were prepared and observed under optical microscopy, in searching of food remains.

The *post-mortem* analysis involved the observation of taphonomic processes that the cervical vertebrae and the long bones (left humerus, left femur and three ulnas) were submitted. Thus, the main ichnofossils and marks were recognized with support of current literature.

RESULTS AND DISCUSSION

On relation to microwear pattern, 41 scratches and 19,5 pits were registered by cuspid and 41 gouges, 14 large pits and 35,7 cross scratches by molar. Higher values of scratches on the pits suggest the use of grass on diet of *S. waringi*. Furthermore, the presence of large and/or medium textures scratches, together with biggest gouges and pits, mat suggests the ingestion of leaves and lignified parts of plants to *S. waringi*. Comparing the logarithmical totals of pits and scratches of mastodons from Águas de Araxá with several known diet herbivorous mammals, *S. waringi* is close to those considered mixed feeders, but it has some tendency to grazing. Among the analyzed proboscideans, *S. waringi, Mammut americanum* (American mastodon) and *Loxodonta Africana* (African elephant) show the same pits pattern. It suggests these proboscideans ate lignified plants parts, like tree barks and branches. The Asian elephant (*Elephas maximus*) shows a pits pattern under its congeners, i.e., it does not eat as many lignified plant parts. According to distribution pattern of C3 and C4 vegetation and their climatic association during Pleistocene, the Araxá region probably had mixed pastures or a great dominance of C4 vegetation. The dental calculus analysis found several kinds of phitolits with varied morphology, plant fragments and spicules. Improved phitolit identification is necessary, in order to state correctly the *S. waringi* diet.

About the *post-mortem* aspect, the recognized borings on cervical vertebrae are identified as result of necrophagus insect action (Roberts et al, 2007; Britt et al, 2008). Roberts et al (2007) affirm the ichnospecies *Cubiculum ornatus* differs from all other oval-shaped borings for the reason it is the only found in continental sedimentary environments and bone substrates. Thus, the ichnofossils found here are attributed to *C. ornatus*, and it is associated to pupae chambers of dermestid beetles. These insects are the last carcasses consumers (Oliveira-Costa, 2003) and they usually act in the carcasses when the body fat is completely lost (Kulshrestha & Sapathy, 2001). For large mammals, as a proboscidean, the skin and body fat decomposition can happen in a period of 1 to 2 years. The presence of these beetles suggests that the bone fragments of mastodons from Araxá had a relatively long time of exposure, which was sufficient to allowed beetles posture, but not long enough to the weathering destroy them.

We found, on long bones, three types of cut marks: pittings, scratches and punctures. All of these marks are associated to carnivores action, produced during the consume of the carcass. The scratches are present mainly at diaphysis and they are associated to the action of gnawing, typical of canids action. The Brazilian Pleistocene registers the presence of a large canid (*Protocyon troglodytes*), with record on Minas Gerais. This hypercarnivorous could show the necrophagous habit, consuming the mastodons carcasses and creating the cutting marks, as actual canids, e.g. *Canis lupus*.

CONCLUSION

The age classes pattern suggests a fossil assemblage composed of aggregated family units situated in savannah-like vegetation, during a time interval (perhaps a season) of low humidity. It seems likely that this group of animals perished in a catastrophic event, and we further suggest that this population's disappearance is unrelated to the mass extinction of Pleistocene South American megamammals. About the diet, it is possible to infer that *S. waringi* from Águas de Araxá was mixed-feeder, but with a tendency for grazing. The *post-mortem* analysis found several unpublished marks and an ichnofossil for Brazilian Continental Quaternary and it is an important evidence for paleoecology aspects connected with necrophagy by canids and dermestids beetles in mastodons. Further studies on diet, ecological modeling and taphonomy will be conducted to shed more light on the paleoecology of the mastodons population from Águas de Araxá.

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