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# Fluvial dispersal potential of guanaco bones (*Lama guanicoe*) under controlled experimental conditions: the influence of age classes to the hydrodynamic behavior

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ABSTRACT

Hydrodynamic sorting is a taphonomic process able to transport and scatter bones deposited in archaeological and paleontological sites. This study presents the results of experimentation performed in an artificial flume with guanaco (*Lama guanicoe*) bones of different ontogenetic development, dry and saturated in water, in hydric flows velocities of 15 and 30 cm/s. The obtained results show that bone global density, the age of the individual, the dry or wet bone state, and the hydric flow velocity influence significantly bone dispersion. In this way, bones from immature individuals with unfused secondary growth centers and relatively low bulk density have better possibility of being transported than fused bones from adult individuals. Taking into account the results obtained in this experimentation and the feasibility of discriminating age categories in fossil assemblages, two bone groups with differential potential transport are presented in this paper. These transport groups constitute a methodological tool to evaluate the role hydric current may had played in the formation of a fossil assemblage.



## 1. Introduction

Once an animal dies and its bone remains are deposited, a great variety of natural processes begin to act which may condition the skeletal survival and original positions of the elements. Among these processes, the role of fluvial transport is remarkable because it is able to scatter and select the bones (Behrensmeyer, 1975; Boaz and Behrensmeyer, 1976; Voorhies, 1969). When performing cultural and paleoecological interpretations of archaeological and paleontological bone assemblages recovered in fluvial environments, it is appropriate to know the degree to which the taxonomic, anatomic and age representation may be biased by this natural process. Several sets of experiments are presented in this work conducted with disarticulated bones of guanaco (*Lama guanicoe*) in a flume. The main objective of this research is to contribute to the knowledge of variables intervening in hydric transport of skeletal elements of guanaco and propose a model of its differential transport. A particular objective in this study is to evaluate if the bone element dispersion is different in relation to the age of the individuals, an aspect that has not been considered in previous fluvial transport taphonomic experiments. In order to reach these objectives, elements corresponding to three guanacos with different ages, namely, newborn, juvenile and adult, were used in the experiments. The choice of this species to perform these experiments was due to the fact that the guanaco was a major resource for the hunter–gatherer groups that inhabited the different regions of the Southern Cone during the Late Pleistocene and Holocene. Consequently, it is common to find abundant remains of this ungulate in the archaeological sites of these regions (De Nigris, 2004; Madrazo, 1979; Martínez and Gutiérrez, 2004; Mengoni Goñalons, 1999; Miotti, 1998; Miotti and Salemme, 1999; Politis, 1984; Politis and Salemme, 1990; Salemme, 1987). The knowledge attained in this paper will be of particular interest to archaeologist and paleontologists studying this taxon's bone assemblages. Moreover, due to the lack of information on hydrodynamic sorting related to age, this paper will also contribute to the formation process studies in other geographic regions where *taxa* with similar characteristics to guanaco are involved.

Laboratory experiments and observations in natural environments have been made by several researchers with the aim of evaluating the consequences of water action on bone assemblages. The first studies explored the differential potential of bone hydric transport considering different variables such as hydric flow velocity and channel depth (Behrensmeyer, 1975; Boaz and

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Behrensmeyer, 1976; Dodson, 1973; Hanson, 1980; Voorhies, 1969). These studies indicated that the different intrinsic properties bone have, such as global density, shape, and size influence significantly their hydric transport potential. In later experimental studies additional variables were added such as bones in articulated state, fractured, saturated in water, and variation of the channel bed (Aslan and Behrensmeyer, 1996; Coard, 1999; Coard and Dennell, 1995; Pante and Blumenschine, 2010; Trapani, 1998); and later on, the number of *taxa* studied was increased (Frison and Todd, 1986; Kaufmann and Gutiérrez, 2004; Trapani, 1998). The most used fluvial transport model is still the one proposed by Voorhies (1969), who evaluated the potential hydric transport of different disarticulated bones of domestic sheep (*Ovis aries*) and coyote (*Canis latrans*) and proposed three skeletal groups with differential behavior.

## 2. Materials and methods

For this experimental study, bones corresponding to three guanaco skeletons with different fusion bone state were used; namely, newborn (0.5–3 months old) with all bone centers unfused (Fig. 1); a juvenile individual (12–19 months old) with some unfused and some fused centers and an adult individual (120–132 months old) with all its bones fused. All right elements of the appendicular skeleton were selected and for the axial, the cranium, the mandible, pelvis, atlas, axis, a cervical vertebra, a thoracic vertebra, a lumbar vertebra, the sacrum, a caudal vertebra, and a rib were considered. The total number of bone elements used in the experiment was 153, 63 of which corresponded to the newborn, 53 to the juvenile, and 37 to the adult skeletons.

To conduct the experiments, a smooth bottomed without mobility recirculating flume 0.3 m wide with a channel length of 8 m was used, with a water depth of 0.16 m. The flume was positioned horizontally and flow velocities were acquired by a pump. Each bone was placed on the surface of the water at the start of the test section (3 m long) oriented with long axes parallel to the current. Four series of three trials each were performed for each skeleton. The series included: (1) dry bones at a flow velocity of 15 cm/s; (2) dry bones at a flow velocity of 30 cm/s; (3) wet bones at a flow velocity of 15 cm/s, and (4) wet bones at a flow velocity of 30 cm/s. The total number of trials performed for the three skeletons was 36. During each trial the mode of transport of the bone was noted; *i.e.*, rolling, sliding and/or saltation along the bed, and/or floating in the water surface.

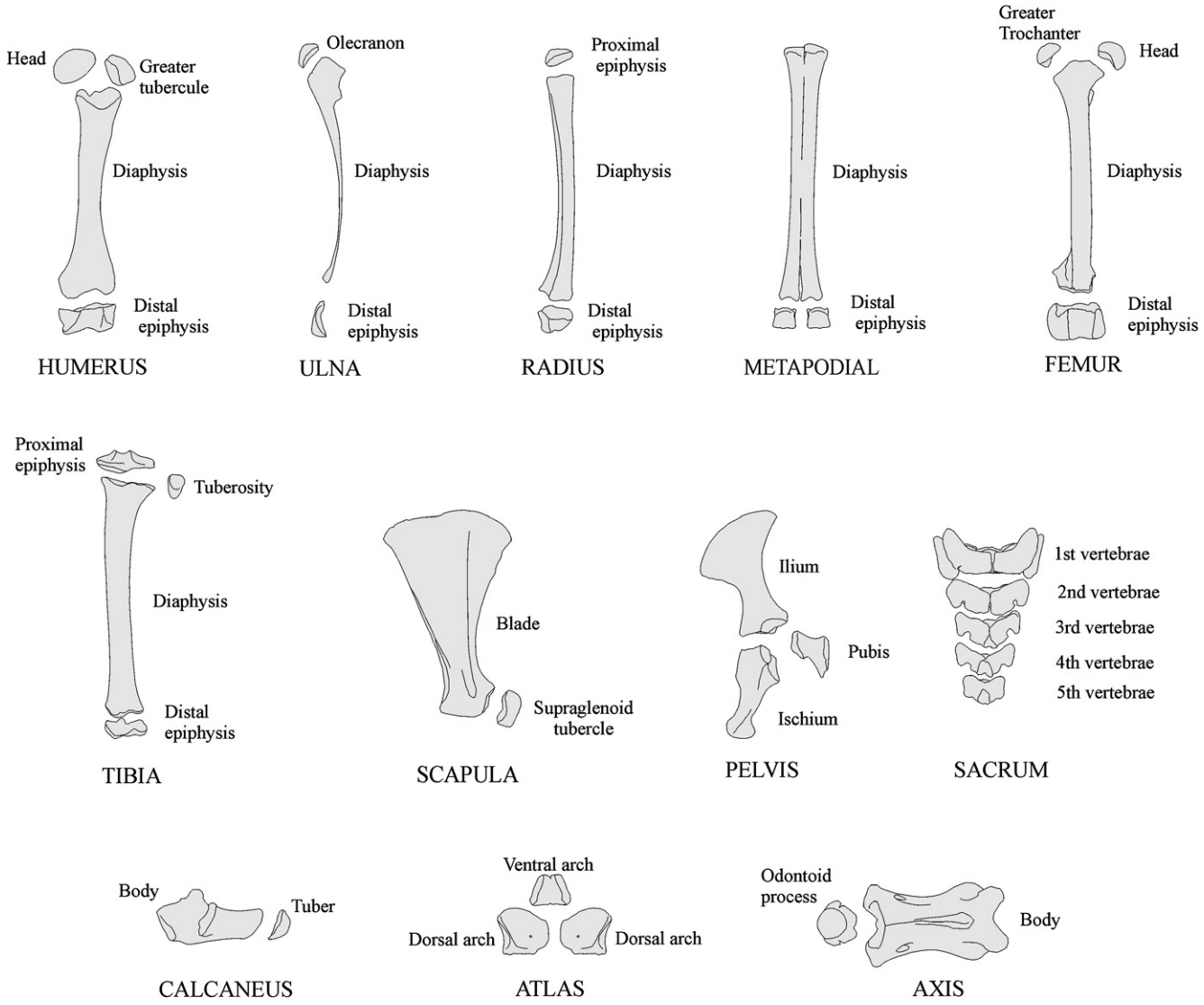


**Fig. 1.** Guanaco's bones showing center of fusion considered in this experiment.