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Contextual Taphonomy: Superficial Bone Alterations as Contextual Indicators

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Introduction

Taphonomy is the study of changes that a body undergoes during the gradual transition from the biosphere to the lithosphere. Archaeologically (Canci and Minozzi, 2005; Mallegni, 2005; Duday, 2005) it is generally referred to as the study of the maintenance of anatomical articulation and the position of bones in buried skeletons in order to reconstruct the type of burial (primary, secondary, reduction) as well as the original deceased's position. Under the forensic point of view, taphonomy has been developed to answer several questions about the methods of concealment (Roksandic, 2002), the time since death and the environmental conditions that are faced by the skeletal remains (i.e. exposure to the weather, landing on surface, burial, contact with water). According to international experience, the authors propose the integration of the Duday's taphonomy axiom (2005) "A decomposing body always interacts with the shape of the support in which it's contained" identifying two areas of taphonomy: a more general one, focused to the skeleton as a structure which modifies its disposal in relation to the type of burial (depositional taphonomy), and a more specific analysis of macroscopic changes detectable on the bones surface as a result of the interaction between the remains and environmental components (contextual taphonomy).

Materials and Methods

Below are presented some of the most common alterations attributable to different taphonomic agents, which can be divided by their nature into biotic and abiotic agents. Atmospheric phenomena, sun's rays, mineral, soil and water are abiotic taphonomic agents, while biotic ones can describe Bio-Taphonomy and Cultural-Taphonomy. In the first class there are plants and animal activity, while in the second human action must be ascribed, as the ritual deposition of grave goods, practices such as burning or cremation, burial or dismemberment and other acts performed by gravedigger or perpetrator.

Staining

Differently from a physiological yellowish color, the bone surface may present different colors and spots, as traces left by the interaction with metals and their oxides (i.e. from objects in the immediate proximity or in contact with the remains): copper causes a greenish color at which the bone's surface is usually smoother and glossy; the rust of iron, instead, leaves brownish-red traces, sometimes associated with an incrustation of the same oxide. The soil burial gives a general darker and slightly brown color to the bones, which may not look uniform on the surface; the presence of minerals in the soil, such as manganese (black) or calcium (white), can create stains ranging in size, recognizable by a margin rather irregular than mold presence, generally evidenced by blackish brown spots variable in size with a continuous margin profile.
The presence of percolating water into the ground can originate peculiar streaks of different colors, which often allow the reconstruction of the water direction. A very dark brown and peculiar patina classified as "chocolate brown", sometimes slightly glossy and spread throughout the bone, is found on remains from old coffins; this coloration, resulting by stagnation in purge fluids and by the tannins of the wooden case, it is often associated with erosion of bone protrusions on the back side, corresponding to laying plane in dorsal recumbency.

Bleaching (Daly, 2010)

Following a prolonged exposure to sunlight, bone and teeth can appear unnaturally white; this discoloration is often associated with a marked loss of weight and fragility of the sample.
The presence of such an alteration only on a side of the district suggests a preferential exposure of the bleached surface than the other, which can be reasonably considered as the bearing surface of the specimen itself.

Adhesions

Depending on the laying context, adhesions of different origins can be formed on the surface, within fractures or the medullary cavity. In buried bones deposits of soil or sand are common; sand incrustation associated with aquatic taxa deposits are typical of marine/river environments. The presence of metallic materials, especially irony, can leave incrustation from their oxides, as well as materials melted by fire.

Circumferential staining

A color change that runs circumferential along long bones or skull perimeter, or a line of demarcation between one color and another, or between an area characterized by algal growth and a free once, or a zone with soil or aquatic taxa adhesions and a clean one, can indicate the boundary between areas continuously exposed to different taphonomic agents.

Warping

The combined pressure of sediments (or other constraints) and changes in the environmental moisture concentration can cause plastic deformations, particularly at the cephalic district where it is not uncommon to find post-depositional plagiocephaly or post-mortem cranial sutures separation. If fragments of the same district are subject to this type of taphonomic alteration, their reassembly can be compromised: it is recommended not to intervene at these changes in order to document the phenomena to which the bones have been subjected.

Surface Erosion

A long period of time in water or in high moisture concentrations environments can lead to a progressive loss of cortical bone, which breaks out in chips. In the aquatic environment the current may also gradually round the bone's edges compromising the anatomical analysis.

Post Mortem Fractures (Ubelaker and Adams, 1995)

Generally fractures of the bone surface classified as taphonomic are due to the loss of moisture from the sample: they run longitudinally along the axis of the bone, sometimes deepening to traversing the entire cortex. Fractures associated with fire action are attributable to a sudden dehydration. These may occur in the form of crisscross cracking, longitudinal fractures intersected by short transverse fractures similar to those on old paintings and lacquers (crackle), or as shrinkage fractures. These are usually multiple curved transverse fractures on the diaphysis of long bones: the concave side corresponds to direction of the progressive retraction of burning tissues and consequent bone exposure. In areas where the tissues burn becoming a compact mass fractures have a concentric morphology (bulls-eye fracture).

Weathering (Beary, 2010; Behrensmeyer, 1978; Hill, 1976)
The interaction with the weather (i.e. temperature and moisture changes, sunlight action) results in a set of changes grouped as "weathering" composed by the whitening of the surface, which is rough to the touch and furrowed by longitudinal fractures (parallel to the axis of the bone); delamination and surface flaking (the outer part of cortical breaks off as thin chip); weight loss.

Damages by animal activity (Willey and Snyder, 1989; Haglund, 1992; Haglund et al., 1988)

Several species may attack a human. Carnivores are directed preferentially to fresh remains and feed onon the soft tissue and bone. Tooth marks are classified into sub-circular loss of substance that can traverse the entire cortical bone (punctures), or defects which are limited to small depressions (pits). Generally these marks are concentrated in long bones epiphysis and may be accompanied by streaks left by the tooth; especially the most fragile epiphysis margins which may appear rounded, smooth and irregular until as they expose the medullary cavity. Differently from carnivores, rodents are attracted to human remains for with both nutritional purposes and to sharpening teeth that grow continuously. Alimentary activity is generally restricted to protruding areas such as the orbital rim, nasal edge, and phalanges which are reached after gnawing the overlying tissues; the teeth sharpening is preferentially directed to more compact bones. Rodents activity is recognized by short parallel streaks (gnawing marks) that run continuously along the bone margin: the presence of a single printed side or both sides that converge to create a sharpened profile describes the use of the mandibular incisors only or both jaws.

Damage from root activity

The permanence of a sample in an environment with vegetation is inferred from the damage that the roots cause on its surface: it is generally distinguishable, as well as by colors and markings that reflect the roots'shape, modest depth and length "filigree" incisions, arranged in a serpentine chaotic and multidirectional pattern, in contrast to the damage left by micro or macrofauna activity. Not uncommon is the possibility of a root infestation in nutritional foramina or in medullary cavity.

Algal growth

Different varieties of green algae can proliferate on bones surface; depending on the species only a stain (green, dark green, blackish), or a more complex formation with distinguishable morphology are observed. Since algae are prototrophic organisms, their growth tends toward the light, allowing the identification of the exposed portion of the sample (especially when they are present on only one side of the remains).

Thermal alterations (Symes et al., 2005; Symes, 2010)

The fire action can be distinguished by different stages of alteration, also in relation to the state of the sample (if still covered with tissues or already defleshed and dry) and by fire temperature. Generally ash will accumulate within any fractures and cavities.
The bone surface can present a simple washable soot or an indelible alteration: the bone is charred when it is black, with a still recognizable morphology and possible microscopic residual soft tissues. A heat line and a border

between the burned and unburned areas that run as a opaque off-whitish margin along the charred zone perimeter. Fractures may be present. Longer exposure to high temperatures can result in the calcination of the sample, with total dehydration and organic components loss; the bone becomes very brittle and subjected to fractures even with a considerable distortion of tiny fragments. The bone color ranges from gray to white ash. Calcification and carbonization may be present on the same skeletal sites based on which area is more exposed to the fire action even after the tissue retraction, related also to typical pugilist posture of the corpse.

Results and Discussion

Contextual taphonomy emerges as an essential tool to identify what kind of environment may have preserved the remains during their history, and thus reconstruct the events which have undergone both the perspective of a more complete analysis of the "culture of dying "of ancient populations, and in terms of forensic investigative reconstruction of a crime-dynamic. The identification of a combination of different taphonomic markers allows the identification of the "taphonomic syndromes" corresponding to different possible paths that the remains have been underwent from the moment of death until their recovery.

To facilitate the reading of taphonomic changes and create a valuable aid to forensic and archaeological investigation, the open source software TaphonomyReader has been developed (Borrini and Tumbarello, 2011) as a free downloadable program from www.restiumani.it.

In conclusion, this dual approach to taphonomy (depositional and contextual) contributes to skeletal analysis beyond the traditional biological profile important contextual, cultural and ecological information allowing the reconstruction of events in which the remains have been subjected.

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