Evaluating Cleaning Strategies for Zooarchaeological Remains at Makounta-Voules

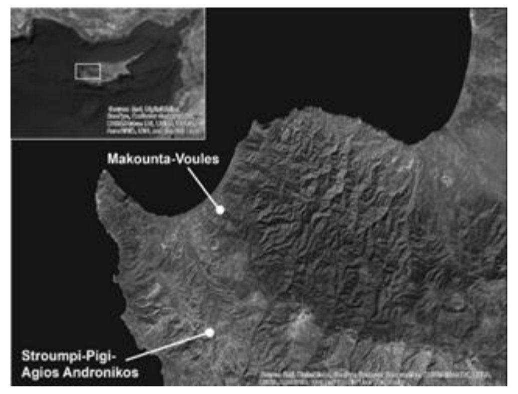
Gabrielle Puckett, Kathryn Grossman

Acknowledgements

The authors would like to thank the American Society for Overseas Research, the University of Tennessee Office of Undergraduate Research and Fellowships, Department of Religious Studies, Department of Classics, and Fern and Manfred Steinfeld Program in Judaic Studies for their financial support of this research. Materials for this study come from the Makounta-Voules Archaeological Project of North Carolina State University.

Introduction

During the Bronze Age, Cyprus was characterized by interlinked agricultural communities whose economies relied heavily on managed herds and diversified animal exploitation strategies (Albarella 2021). Zooarchaeological research from Bronze Age contexts across the island demonstrates that sheep and goats formed the dominant component of animal husbandry, with cattle and pigs also present in smaller numbers. Alongside these domestic taxa, the hunting of Mesopotamian fallow deer (*Dama mesopotamica*) remained a consistent feature of Cypriot subsistence into the Bronze Age. Deer were never domesticated but instead were selectively hunted as free-living game animals within controlled, sustainable systems of resource use (Berthon et al. 2017).



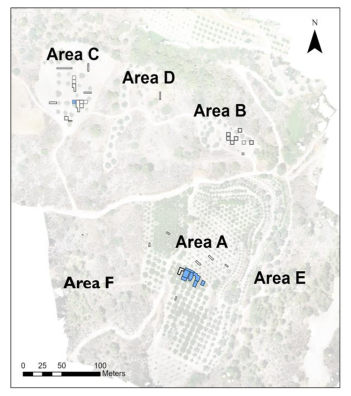


Fig. 1a: Map depicting Makounta-Voules within Cyprus (Grossman et al. 2020)

Fig. 1b: Site map of Makounta-Voules (Grossman et al. 2020)

These patterns reflect broader social and economic developments on the island during this period. Bronze Age Cyprus saw increasing copper exploitation, the adoption of secondary products (especially wool and milk), and new forms of labor specialization within agrarian communities. Because animal products became tied to textile production, metallurgy, and emerging social differentiation, faunal assemblages have become key datasets for interpreting changing practices in subsistence, production, and communal activity. In this context, faunal remains are not merely dietary refuse. They are primary evidence for how Bronze Age Cypriots organized herding, hunting, craft production, food distribution, and social interaction (Berthon et al. 2017).

To understand this picture of daily life, zooarchaeology becomes vitally important. However, accessing this information is not without challenges. Across Cyprus, one persistent issue is the island's calcareous soil composition, which promotes the formation of dense calcium accretions (Fig.2). These accretions build up as a hard crust on archaeological materials, including bone and pottery, obscuring surface detail. For zooarchaeologists, this creates a significant obstacle, as the very marks that carry information about past behaviors are often concealed beneath this layer.

Fig. 2: Makounta-Voules Archaeological Project samples

2a: Proximal femoral epiphysis

2b: Distal femoral epiphysis

2c: Antler fragment

Overcoming this challenge requires methodological innovation. The research must find ways to remove or reduce calcium accretions without damaging the fragile surfaces of bones, which are themselves already vulnerable after millennia of burial. A combination of mechanical approaches, such as careful abrasion or micro-tools, alongside chemical treatments designed to soften or dissolve accretions, has been employed in attempts to improve visibility. Each approach, however, carries risks, and the ultimate goal is to enhance the readability of the specimen while preserving as much of its integrity as possible.

Procedures and Methods

As a case study, I focused on the site of Makounta-Voules in northwest Cyprus (Fig. 1a). This prehistoric settlement provided an ideal opportunity to investigate how calcium accretions affect the analysis of faunal remains. Many of the bones from the site were heavily encrusted, making it difficult to identify surface modifications such as butchery or burning marks. By applying and comparing different cleaning methods on this assemblage, Makounta-Voules became both a source of insight into prehistoric life and a testing ground for developing techniques that improve the readability of zooarchaeological material.

Materials

- 44 Faunal specimens from Makounta-Voules

Mechanical

- Dry Brushing
- Wet Brushing
- Rotary Tool

Chemical

- Vinegar at 10%, 25%, 50%, and 100% for 1 hour to fully submerge the bone
- Formic Acid at 2%, 5%, and 10% for a duration of 15 minutes, accompanied for some samples by a 15-minute water bath and wet brush

Results

Mechanical

Dry brushing left the specimens with no change. Wet brushing was more effective than dry brushing but still concluded with a negligible difference to the starting point. The use of the rotary tool was met with success but was not worth the damage done to the bone surface (Fig.3). It also possibly obstructed the markings by removing them.

Fig. 3: Makounta-Voules specimens used in the rotary tool method

Chemical

While vinegar is usually used in situations of thick accretions, due to the nature of Cypriot soil, it had little impact. More visible results came with the use of a 100% solution for 1 hour. This yielded the removal of some accretions but not all and left the bone surface disproportionately covered in the accretions. The formic acid provided the most immediate and clear results, as almost all accretions were removed. The results from 2% formic acid for 15 minutes with a 15-minute water bath and that of 10% for 15 minutes with no water bath were comparable in removing accretions but differed in their impact on bone preservation. The safety of the osseous material must be considered. It is vital to the understanding of these remains that the acid being employed does not hurt the bone composition. With a negligible difference between the two formic acid techniques, the smaller percentage is preferable for the sake of preserving bone structure.

Fig. 4: Makounta-Voules Archaeological Project samples

4a: Proximal femoral epiphysis after exposure

4b: Distal femoral epiphysis after exposure

4c: Antler fragment after exposure

Discussion and Conclusions

These experiments at Makounta-Voules demonstrate the advantages and drawbacks of both mechanical and chemical approaches to cleaning calcium accretions. Mechanical methods were largely unsuccessful, either producing no measurable results or causing excessive damage to the bone surface (Fig. 3). The use of a rotary tool showed some promise, but it was ultimately determined to be a method best reserved for extreme circumstances where other options are unavailable. In contrast, chemical cleaning provided more consistent and controlled outcomes.

Of the two chemical treatments tested, vinegar was less effective but offered the benefit of being comparatively gentle, leaving little observable damage to the specimens. Formic acid, on the other hand, produced immediate and favorable results, quickly revealing surface details such as potential working marks and other modifications (Fig. 4). However, its strength also introduced significant risks. While the bones appeared visually clearer, there remains a high likelihood that the formic acid altered the chemical composition of the specimens. This raises concerns about its long-term effects, particularly for bones intended for future analyses such as stable isotope studies or radiocarbon dating. For cases where visualization alone is the primary goal, formic acid can serve as a rapid and effective method, but it cannot yet be considered a universally safe solution without further testing of its long-term impacts.

One factor that became especially clear during this study is the importance of considering the concentration, or percentage, of formic acid being used. Higher concentrations remove accretions more quickly but are also more likely to compromise the structural and chemical integrity of the bone. Even when bones appear visually undamaged, subtle alterations at the chemical level could interfere with subsequent analyses, making high concentrations a high-risk option. Conversely, weaker solutions may act more slowly and require repeated applications, but they reduce the chances of irreversible damage. This balance between efficiency and preservation highlights the need for careful calibration depending on the specific research goals.

Future Work

Further research into the effectiveness of different concentrations may be important to the efficacy of this method. Variances in condition of assemblage may correspond with the need to adapt concentrations of the solution. Bones that are heavily encrusted might require a stronger initial treatment to make progress, while better-preserved specimens could be adequately cleaned with lower concentrations. This variability may suggest that there is not a single formula or "best practice" for all contexts. Instead, concentrations must be tailored to the unique conditions of each assemblage and the intended scope of analysis. Future research that systematically tests multiple concentrations across diverse assemblages could help establish clearer guidelines, ensuring that formic acid remains a valuable tool without becoming a destructive one.

Another line of research could be focused on the possible unknown chemical effects the formic acid may have on the bone. This includes the ways in which isotopic analysis, Zooarchaeology by Mass Spectrometry (ZooMS), and radio-carbon dating may be altered due to molecular changes within the bone makeup. A comprehensive example of this kind of research may include sampling the accretions before exposure, using a rotary tool to expose the bone surface and sampling there, and finally sampling after exposure to the solution. Methods like this would ensure that the chemical composition of the accretions is not altering the readings pre-exposure, as well as assessing the level of harm to which the bone may be exposed in this invasive process.

Works Cited

Albarella, Umberto, Catarina Ginja, Sónia Gabriel, and Cleia Detry. "Themes in Old World zooarchaeology: from the Mediterranean to the Atlantic." (2021): 1-224; Berthon, Remi, Angelos Hadjikoumis, and Julie Daujat. "Archaeozoology of Southwest Asia and Adjacent Areas XIII: Proceedings of the Thirteenth International Symposium, University of Cyprus, Nicosia, Cyprus, June 7-10, 2017." (2021): 1-312; Grossman, Kathryn, Tate Paulette, Lisa Graham, and Andrew McCarthy. "2017 Survey of Two Prehistoric Sites in Western Cyprus: Stroumpi-Pigi-Agios Andronikos and Makounta-Voules-Mersinoudia." (2020)