

3D Geometric Morphometrics and Sheep/Goat Breeds in the Early Bronze Age of Tell es-Safi/Gath

Goal: To be able to determine if there are different sheep and/or goat breeds present at Tell es-Safi/Gath during the (Early Bronze (EB) III (2850-2500 BCE) occupation in order to provide insights into the animal husbandry strategies at Tell es-Safi/Gath. Will use the ovicaprine remains from the EB occupation at Tell es-Safi/Gath, Israel.

Data: The site of Tell es-Safi, located in the Shephelah region in Israel, has yielded the remains of an EB neighbourhood with a rich assemblages of animal bones from several houses, courtyards and an adjacent alleyway. This neighbourhood is thought to be a merchant's quarter since it has evidence of extensive trade with the surrounding regions. Using ovicaprine astragali recovered from these deposits, geometric morphometric comparisons were conducted to determine the composition of and changes to sheep and goat breeds during this period.

EB III neighbourhood with four houses divided by an alleyway



Map of region showing location of Tell es-Safi/Gath

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Modern sheep and goat breeds, Ziyaret Tepe, SE Turkey

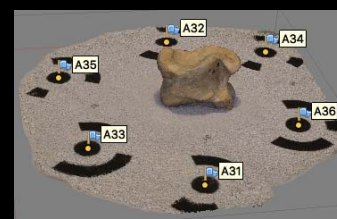
Methods: In order to identify the presence of different breeds of sheep (and goats) at Tell es-Safi/Gath, we chose to use 3D Geometric Morphometric (GMM) variation in the astragali. GMM is a far more detailed and precise technique to identify differences in the size and shape of bone elements to identify intra-species variation (breed). It is a computer-assisted system that measures distances between discrete anatomical landmarks. Photogrammetric modelling is used to create an accurate 3D digital model of each astragalus. A series of 250-300 photographs are taken of each astragalus using fixed markers and a turntable to ensure accurate measurements (Fig. A). These are assembled in AgiSoft PhotoScan to form a point cloud (Fig. B) which reproduces the location of each portion of the astragalus and its associated markers in three dimensions. Once the point cloud is built, a mesh is overlaid in Photoscan and the distance between the centre of each marker to its fellow markers is recorded (Fig. C). Landmarks are determined with the use of a statistical program "R" using the GMM package 'geomorph' (Fig. D). The landmark measurements are analysed in multivariate statistical programs to determine differences in size and shape between populations (e.g. Cucchi 2008; Duval et al. 2015; Evin et al. 2013). Measurements obtained from these landmarks are normalized to the same axis of orientation and gross size through a General Procrustes Analysis (GPA) and the shape-only geometry compared using Principal Components Analysis (PCA).



A: An example of one of the many photographs taken for photogrammetric modelling.



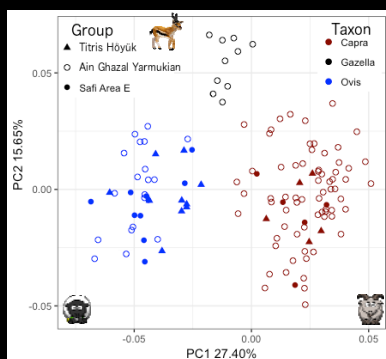
B: The 3D point cloud built in PhotoScan from the series photographs taken.



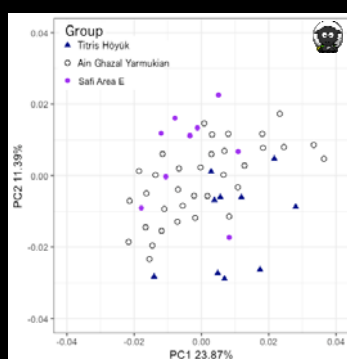
C: Mesh overlaid upon the 3D point cloud to form a model of the photographed astragalus. Measurements between the highlighted markers allow for the calculation of accurate scale (+/- 70 microns).



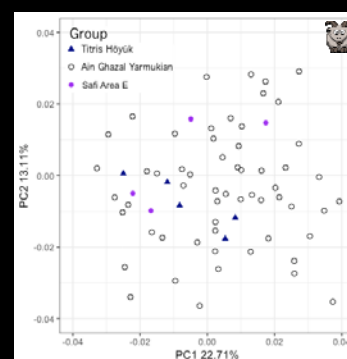
D: Landmarks being assigned to the 3D digital model of the astragalus using R package 'geomorph'.



E: As a control to ensure that the variability does not measure inter-species taxonomic variation, the Safi data are compared against gazelles (from Ain Ghazal) and from a N Euphrates drainage site (Tiris Höyük). It is clear that sheep, goat and gazelle can be distinguished and not confused with GMM.



F: The results suggest that EB sheep from Safi form a population distinct from those of EB Tiris Höyük. There are some morphometric 'outlier' sheep present from Tel es-Safi/Gath, which is suggestive of different populations to that of the main group of sheep present at the site.



G: The Yarmukian material shows a high level of morphological variability, which encompasses the both the Safi and Tiris Höyük assemblages. This suggests that there may well be no regional differences in breeds of goat between Safi and other sites.

Results: Given the small sample size from Safi, the astragali morphometrics (totality of all landmark measurements) are compared against those of other assemblages to determine the presence of breeds at the site. The initial results suggest that sheep from Safi form a distinct population from those of Tiris Höyük, and that there appear to be 'outlier' sheep present in the initial Safi sample, which may come from different populations to the main group of sheep present at the site. Goat populations do not appear to vary regionally, based upon these initial data. A much larger sample from Safi (currently under analysis) will eventually provide more detailed information about sheep and goat populations at the site.

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