# 13TH ANNUAL MEETING OF THE EUROPEAN SOCIETY FOR THE STUDY OF HUMAN EVOLUTION ABSTRACTS AARHUS, 21-22 SEPTEMBER 2023

Poster Presentation Number 1, Session 1, Thursday 17:45-19:15

## A new EEG approach for exploring the cognitive underpinnings of early stone tool use

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Technological innovation has played a key role in the evolution of our lineage. The emergence of the first lithic technology represents one of the most debated topics in evolutionary sciences. For decades now, the Oldowan tradition (dating back to ~2.6 million years ago) has been widely considered the earliest stone tool industry, hypothesized to reflect the emergence of habitual human-like precision grasping and skilled object manipulation. The Oldowan also marks the introduction of the earliest cutting behaviors (using flakes), whereas the earlier proposed industries have been predominantly associated with hammerstone percussion (e.g., for nut-cracking). While hammerstone percussion is known to be practiced by both human and non-human primates, the purposeful use of cutting flakes appears to be a behavior that is exclusive to hominins and their subsistence strategies [e.g., 1]. Nevertheless, even though previous neurological studies have focused on the cognitive demands of early stone toolmaking [2-3], no previous experimental approach has directly addressed the neurocognitive underpinnings of the earliest modes of stone tool use.

Here, we put forth a novel experimental approach to explore brain activation patterns during hammerstone percussion and flake cutting behaviours. To achieve this, we relied on electroencephalography (EEG) to record brain activation data from 23 healthy, right-handed subjects during the performance of two stone-tool using tasks. In the first task, participants were instructed to use a power grip to crack a nut with a hammerstone, while in the second task, they were asked to use a precision grip to cut a pre-marked pattern on a pleather square using Oldowan flake replicas. To distinguish the brain activation patterns associated with each cognitive step of these two processes, we divided each task into three phases/steps: holding the tool, aiming at the target, and cracking the nut (task 1) or cutting the pleather (task 2). An additional manual task was included as a control. Our results highlighted the higher cognitive demands of flake cutting behaviors, which showed significantly greater EEG activity (in the beta frequency range) in the left frontal cortex, with the "aiming" step showing distinctive frontal lobe activation. The left frontal cortex is known to be critical for the control of fine motor movements and grip execution, involving the planning and selection of appropriate grasping strategies based on the task demands. Overall, these findings support the value of our new EEG-based approach for exploring the cognitive demands of early stone tool use, encouraging further research on its neural mechanisms and potential implications for language evolution.

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Poster Presentation Number 2, Session 1, Thursday 17:45-19:15

# Counteracting fragmentation in the human fossil record; a new approach to the reconstruction of fossil hominin long bones using *Homo naledi* as an example

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Our knowledge of human evolution is limited by several factors, one of them being the fragmentary nature of the fossil record. One of the possibilities in overcoming the limitations imposed by the discovery of fossil fragments in an increasingly complex evolutionary picture, relies on the reconstruction of said fragments with the help of modern anatomical data or analogous fossil specimens. Unfortunately, these techniques have raised several methodological questions, as they might introduce different types of biases.

Here we present the preliminary results of a novel approach aimed at reconstructing hominin long bones through the combination of 3D geometric morphometrics and advanced computational, mathematical, and artificially intelligent tools. For this preliminary trial, we have used the 3D meshes of the *Homo naledi* humeri, radii, femora and tibiae available in MorphoSource, which present different degrees of fragmentation. In addition, we have also collected a series of 3D models on the upper and lower limb long bones of anatomically modern humans, chimpanzees, orangutans and gorillas. On one hand, the external morphology of the modern sample was described with the aid of anatomical landmarks and a net made of 160 semilandmarks. On the other hand, the *Homo naledi* specimens were first aligned and mirrored, when necessary, using the modern sample as reference to establish the correspondence between each fossil specimen and complete long bones. Different numbers of landmarks and semilandmarks were then collected on the *Homo naledi* sample based on the preserved bone portion. Finally, landmark data were subjected to a new methodological approach for the estimation of missing landmarks, called the 'Reverse Engineering' method. This method leverages geometric morphometric information after being processed using dimensionality reduction, so as to establish a mathematical relationship between the portions of preserved bone represented by each fossil fragment, and the complete bones found in the reference collection. Using a number of different regression algorithms, including some derived from metalearning in artificial intelligence, this approach reverse-engineers dimensionality reduction to predict the morphology of the entire bone corresponding to each fossil specimen.

When tested on modern individuals, our results reveal that the present technique reduces the reconstruction error of estimated missing landmarks considerably in comparison with other approaches. This is especially relevant when estimating the position of a very large number of landmarks, i.e., the number of landmarks in the fossil fragments are considerably lower than the number of landmarks available in the reference collection. Using this novel methodology, we have been able to successfully reconstruct all the available *Homo naledi* long bone specimens. The promising results obtained here have important implications for paleoanthropological studies, particularly for the analysis of fragmentary hominin fossils. Overall, these findings demonstrate the potential for our approach to significantly enhance our understanding of human evolution and contribute to ongoing efforts to reconstruct the evolutionary history of our clade.

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Pecha Kucha Presentation Session 3, Saturday 16:40-17:55

## Modelling the conditions in which externally-stimulated cultural behaviours will likely be lost by hominin groups

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Sandgathe and colleagues [1-3] have highlighted an intriguing pattern at several Neanderthal-linked archaeological sites in Europe -namely, that evidence for fire was plentiful in the sites' lower layers but sparse in their upper layers even though the latter were deposited in colder conditions than the former. This pattern is intriguing because, as Sandgathe and colleagues have pointed out, it is the reverse of what we expect to see. Given that we use fire to keep warm, the expectation is that we should have found more fire evidence in the cold period layers than in the warm period layers. Sandgathe and colleagues have investigated whether taphonomy, excavation bias, a change in site use, or seasonality can explain the pattern and concluded they cannot. Based on this, Sandgathe and colleagues have proposed that some Neanderthal groups may not have been able to make fire on demand and simply collected it from the environment when it was available as a result of wildfires.

In this paper, we report a modelling study that was inspired by Sandgathe and colleagues' [1-3] hypothesis. We were interested in the feasibility of a group of hominins maintaining a set of cultural behaviours such as those involved in the use of naturally-occurring fire when the group only engages in the behaviours intermittently because the relevant stimulus occurs irregularly, as is the case with wildfire. Learned behaviours are constantly threatened by the decay of memory, so we reasoned that the probability of an externally-stimulated cultural behaviour being maintained by a group must be influenced by both the frequency of occurrence of the external stimulus and the rate of decay of memory. The goal of the study was to clarify how these two variables interact in determining the probability of survival of a culturally-learned behaviour.

The model focused on the probability of survival of a culturally-learned behaviour over 1,000 years and had just four parameters. We deliberately kept the model simple in order to be able to fully explore the effects of varying the parameters. The parameters were:

$\partial$ = The rate of decay of the memory of the culturally-learned behaviour.

T = The period of time between enactments of the culturally-learned behaviour.

$k\varepsilon$ = The error associated with the enactment of the culturally-learned behaviour.

$T\varepsilon$ = The error associated with the time between enactments of the culturally-learned behaviour.

The first of these parameters was assumed to be a negative exponential. We obtained values for the second variable from published empirical work on the occurrence of wildfires. The two errors were assumed to be normally distributed. For each combination of values for the four parameters, we created hundreds of stochastic time-series, each of which was 1,000 years long. Then, we calculated the percentage of the time-series that preserved the cultural behaviour at the end of 1,000 years.

We have yet to fully analyse the results of the model, but it is already clear that the impact of the four parameters on the probability of the survival of a culturally-learned behaviour is non-linear. For a memory decay rate of 1% per year and a 10% enactment error, the cultural behaviour has a high probability of surviving when it is enacted at least once every two years. However, if the time period between enactments exceeds 18 years, the probability of the behaviour surviving drops to <5% unless the error associated with the length of time between enactments, $T\varepsilon$, is low (<0.14). Enactment periodicities above 35 years basically guarantee that the cultural behaviour will disappear. An obvious implication of these findings for Neanderthal use of naturally-occurring fire is that many groups would have completely lost the relevant behaviours from their cultural repertoires as the frequency of occurrence of wildfires due to the climate becoming colder and drier.

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Pecha Kucha Presentation Session 2, Friday 16:40-17:55

## Towards determining human skeletal proteome variation

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As the palaeoproteomic study of human evolution is an emerging research field, methodology and baseline information constantly emerges and develops. This relates to many aspects of the palaeoproteomic workflow. One such thing is the important question of what location in the skeleton gives the greatest proteomic information. The spatial preservation of DNA has been well characterised for aDNA research where the petrous bone and the cementum constitute the best environment for the preservation of DNA [1-2]. The spatial preservation in proteome composition has not been extensively studied in archaeological human material, however, especially in connection with the biological processes that form the skeleton.

The human skeleton, like in other mammals, is largely formed through two different processes, endochondral and intramembranous ossification. Intramembranous ossification is the process of direct ossification within soft tissues, while endochondral ossification is the process of ossification replacing a cartilage template of the forming bone. During the ossification process these two processes have different proteome composition, i.e., the endochondral ossification containing cartilage-related proteins while the intramembranous ossification does not [3-4]. Additionally, bones are composed of two types of bones, cortical and trabecular, which have differences in function and in structure. Moreover, trabecular bone is metabolically more active, with much higher turnover rate per year than what is observed in cortical bone [5]. As a result, the human skeleton is heterogeneous in terms of ossification, composition, and maintenance, while in contrast skeletal proteomes are generally supposed to be homogenous across the skeleton.

Here we present the preliminary results of proteome variation within a single human skeleton. The proteins were extracted from one post-Medieval individual from the Netherlands and analysed using liquid chromatography tandem mass spectrometry (LC-MS/MS). The cortical and trabecular bone proteomes vary in terms of composition, e.g., different protein groups identified, and size, e.g., the number of peptides and proteins identified. Furthermore, our analysis allows comparison of rates of protein degradation between cortical and trabecular bone. The results presented here give unique insights into the skeletal biology of archaeological human remains as well as aid in optimising sampling strategies to get the most information from highly precious specimens, which has major implications when sampling Pleistocene skeletal material.

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Poster Presentation Number 3, Session 1, Thursday 17:45-19:15

## BaTEx: A Methodological Framework for Analysing Wear Traces on Basalt Tools

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Basalt is often the primary or the only raw material utilized in lithic tool manufacture in certain geographic and chronological contexts. The manufacture of basalt tools was a widespread practice in prehistory, and as such, it is an important material for archaeological research. However, despite its prevalence, there is currently no unified methodology for examining the use of basalt tools by hominins in prehistory. This is particularly problematic for older sites where basalt is often the primary source of information about the behaviour of early humans and for insight into hominin socioeconomic strategies and lifeways.

To address this gap in knowledge, the BaTEx project was created to develop a comprehensive methodological framework for the functional analysis of basalt tools. The project involves an important methodological component consisting of systematic experimentation involving the production and utilization of basalt tools, next to systematic wear analysis. For the latter, different qualitative approaches are combined with newly developed quantitative analysis to measure wear on both experimental and archaeological basalt assemblages.

Here we present the preliminary results of this project and specifically focus on the experimental component. Through sequential experiments and comprehensive functional analysis using optical and scanning electron microscopes, we have identified the minimum use duration required for diagnostic wear to form, as well as the characteristics of edge damage, polish, and other types of wear on basalt tools. Additionally, we discuss the role of intra-raw material variability in the formation process of use-wear on basalt.

The project is anticipated to have a significant impact by generating functional data on basalt tools, which will enable comprehensive analysis and interpretation of human activities at crucial archaeological sites. For the first time, it will be possible to mobilise data obtained on basalt assemblages to address questions on technology, subsistence patterns, and even behavioural and cognitive aspects, which remained beyond the scope of research until now.

Poster Presentation Number 4, Session 1, Thursday 17:45-19:15

## Age, sex, and ancestry-related variation in cortical bone and dentine thickness in modern humans and relevance to evolutionary anthropology

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Cortical bone and dentine share an embryological origin, a development, and a genetic background, that are not shared with enamel [1]. Knowing how these tissues relate in individuals is of great importance to decipher the factors acting on their morphogenesis, and ultimately to understand the mechanisms responsible for the different patterns of tissue proportions shown by hominins. However, only a few studies have analyzed bone and tooth structures in combination [2], and no study has investigated a possible correlation between the volumes of cortical bone and dentine relative to endogenous and exogenous factors. The aims of our study are to examine age-, sex-, and ancestry-related variation in cortical bone and dentine volumes, and to preliminary assess the possible covariation between these tissues in modern humans. The analytical sample includes 12 immature individuals and 17 adults from French medieval cemeteries, as well as 32 adults of African and European ancestries from South African contemporary osteological collections. Variables describing three-dimensional tissue proportions were assessed from microtomographic records of radii and permanent maxillary canines. Results suggest an age-related pattern in bone development and important sex differences in cortical bone and dentine thickness. The developmental pattern of dentine also seems to vary according to individual's ancestry. In addition, preliminary results have outlined a covariation trend between volumes of cortical bone and dentine that does not exist with enamel nor pulp. However, when splitting the sample by age, sex, and ancestry, no signal of covariation is found in the immature subsample, while the adults of South African and European ancestry show a covariation between cortical bone and either radicular or crown dentine, respectively. Thus, accessing the genetic-related morphological variation may be complexified by the impact of environmental factors, particularly mechanical ones, which play an important role in structuring the mechanosensitive tissues throughout life. To identify variations in degree of bone and dentine functional sensitivity, and thus disentangle genetic and environmental factors, we also documented the local variation of cortical bone and dentine distribution along the bone shaft and the dental remains by using morphometric maps [3,4]. More research on the cortical bone-dentine covariation would provide a better understanding of the impact of endogenous and exogenous factors on the development of the mineralized tissues. Ultimately, this may shed light on the pattern of joint tissue thickening observed in the palaeoanthropological record, and especially in the majority of Neandertal specimens [5].

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Pecha Kucha Presentation (Virtual) Session 1, Thursday 11:30-12:45

## A new face for an old species: Virtual reconstruction of the DAN5/P1 *Homo erectus* cranium

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The ~1.6-1.5 Myr DAN5/P1 fossil, from Gona, Ethiopia, comprises a relatively complete calvaria, and fragments of a face and isolated maxillary dentition. DAN5/P1 was initially described in 2020 and attributed to African *Homo erectus* [1]. Here we present a reconstruction of the face that, in combination with the calvaria, yields the first early Pleistocene *Homo* cranium from Ethiopia.

The virtual reconstruction of the DAN5/P1 face was performed in Geomagic Wrap using three-dimensional models generated from micro computed tomographic (μ-CT) scans of the left and right maxillae (hemi-palates), left infraorbital fragment of the maxilla, left zygomatic fragment containing the frontal process, right maxillary P3 (previously identified as a P4) and left maxillary P4-M3. First, the left maxillary zygomatic process was isolated and relocated to its anatomical position. Next, the pieces were joined together along natural breaks (e.g., left zygomatic root and infraorbital piece) and sutures (e.g., infraorbital and zygomatic fragments) and refined based on alignment with the supraorbital torus superiorly. The P4 and M1 were positioned in their alveoli, and the remaining teeth were added based on interdental wear facets and root orientation. Pieces were reflected across the midline to create a maximally complete face.

DAN5/P1 presents a relatively long and sloping face with a round orbit, transversely flat midface, squared-off and prognathic subnasal clivus, and anteriorly positioned zygomatic process of the maxilla. Shape analysis of facial architecture groups DAN5/P1 with classic *H. habilis* and basal Georgian *H. erectus* fossils more so than Kenyan *H. erectus*. Additionally, it does not show the widening of the nasal aperture typical of Kenyan *H. erectus* and later mid-Pleistocene *Homo* fossils [2]. Comparative analysis of the teeth confirms similarity of DAN5/P1 to early *Homo* and some Georgian *H. erectus* in its tooth proportions, including a mesio-distally elongated P4 and large M3. Yet, some derived traits align DAN5/P1 taxonomically with *H. erectus*, including an angular torus, projecting browridge and post-toral sulcus, well-developed maxillary sulcus, deep palate, and small premolars [3-4]. The combination of 'classic' *H. erectus* traits with a small brain (598 cm3) and plesiomorphic facial architecture provides a retrospective glimpse of the basal African *H. erectus* cranium, and signals high intraspecific variation in east African *H. erectus* circa 1.6-1.5 Myr.

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Poster Presentation Number 5, Session 1, Thursday 17:45-19:15

## Jackie: Anthropogenic hybridization, de-novo mutations, or incipient stages of self-domestication?

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Phenotypic variation in natural populations brings about a debate relating to the phenotype and occurrence of domestication features. Mammalian domestication is a widely researched process, and theories discussing its mechanism are copious. Whether wild mammals were actively caught by humans to exploit their beneficial traits, or did they approach the emerging human settlements, taking advantage of this proximity to acquire food, and becoming passively domesticated, is still unsettled.

The golden jackal (*Canis aureus*), is a widespread medium sized canid, prospering in various habitats from semi-deserts and forests to agricultural and urban areas. In Israel, golden jackals were nearly extirpated in the 1960's as part of an eradication program to control rabies. Since then, they have repopulated Israel with numbers rapidly increasing in many regions across the country, particularly in the Golan Heights.

Here we report the case of four golden jackals (*Canis aureus*), that were observed during a camera-trapping wildlife survey in Northern Israel, displaying anomalous morphological traits, such as white patches, an upturned tail, and long thick fur which resemble features of domesticated mammals. Another individual was culled under permit and was genetically and morphologically examined.

Methods: To disprove hybridization, the following analyses were performed: ZFY intron and Mitochondrial DNA were sequenced and genetic population structure and potential signs of inter-taxon admixture in the Israeli Canids were assessed by genotyping 43 collected DNA samples at 38 autosomal microsatellite markers (STRs). Geometric morphometrics shape analysis was carried out using 30 key osteometric landmarks, and 300 semi-landmarks placed on the cranium of different canids for comparison (jackals n=19; wolves n=11; foxes n=9).

Results: Paternal, maternal and nuclear genetic profiles, as well as geometric morphometric data, identified this individual as a golden jackal rather than a recent dog/wolf-jackal hybrid. Its maternal haplotype suggested past introgression of African wolf (*Canis lupaster*) mitochondrial DNA, as previously documented in other jackals from Israel. When viewed in the context of the jackal as an overabundant species in Israel, the rural nature of the surveyed area, the abundance of anthropogenic waste, and molecular and morphological findings, the possibility of an individual presenting incipient stages of domestication should be considered.

Pecha Kucha Presentation, Session 2, Friday 16:40-17:55

## Investigating directional asymmetry in the first metacarpals of an extensively documented modern human sample

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Handedness (i.e., hand preference) is thought to have played an important role in the lateralization of the human brain for language and the emergence of other complex cognitive functions [1]. Given that only hard tissue is preserved in hominin fossil records, the identification of directional asymmetry in arm bones can allow a better understanding of the development of this trait during human evolution [2]. However, while directional asymmetries in arm bones can be due to different factors such as differences in mechanical stress and strain due to different occupational activities, this effect is not well understood on finger bones. This study aims to investigate how different occupational activities can affect the first metacarpals (Mc1) external shape directional asymmetry in *Homo sapiens*. We analyzed shape variation and covariation in associated Mc1s in 22 extensively documented male modern humans from the Basel-Spitalfriedhof collection [3-4] using a 3D geometric morphometric approach, involving both 3D anatomical landmarks and 3D sliding semi-landmarks on curves and surfaces [5]. We explored shape variation by occupational trend using Principal Component Analyses (PCAs), and Two-Block Partial Least Squares (2B-PLS) analysis on Procrustes co-ordinates was used to investigate patterns of shape covariation between right and left Mc1s. PCAs revealed a trend of shape variation on both sides of Mc1s that varied between individuals associated with finer (more "precise") occupational activities (i.e., less strenuous and/or highly mechanized occupations) and individuals involved in intense manual labor during their lifetime (mainly long-term construction workers). Precision workers showed proportionally smaller distal and proximal joints of their Mc1s than heavy manual laborers, who presented relatively larger joints and palmar epicondyles, consistent with the application of high grip force on both hands. The 2B-PLS analysis showed statistically significant patterns of asymmetric shape covariation (based on permutational MANOVA) in MC1s between precision and powerful workers, revealing a trend of a more marked directional asymmetry in individuals classified as precision workers. In the future, these results will help to infer functional morphology in fossil hominins, setting the basis for further research on directional asymmetry in finger bones in relation to functional constraints.

We are thankful to all volunteers of the "Citizen Science Basel" (University of Basel) and the staff of the City Hall Archive Basel-Stadt.

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Podium Presentation, Session 6, Saturday 9:15 -10:35

## Neanderthal life and death in Shanidar Cave, Iraqi Kurdistan

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Shanidar Cave is iconic in Palaeolithic archaeology following Ralph Solecki's 1951-1960 excavations [1]. His discoveries, including the remains of 10 Neanderthals, have played a central role in debates about Neanderthal behaviour. New excavations began in 2015, concentrating on the centre of Solecki's 14 m-deep trench. As reported at ESHE 2020 further Neanderthal skeletal remains found include part of Solecki's Shanidar 5 individual [2] and, immediately adjacent to Shanidar 4 (the famous 'flower burial'), the largely complete upper body of an adult currently designated Shanidar Z [3]. Here we report the discovery of further Neanderthal skeletal remains below Shanidar Z and their relationship to adjacent occupation deposits.

Approximately 15 cm directly below Shanidar Z we have found further adult hominin remains including a right hand, two lower left ribs, a left scapula, and several loose, heavily worn incisors. The remains plausibly belong to a single, heavily disturbed skeleton whose head was orientated to the east and right hand crossed over their waist. Sedimentary studies, microfaunal analyses and in-progress OSL dating suggest that the Shanidar Z/4 bone cluster (including the new remains) was deposited in relatively warm and humid conditions probably within Marine Isotope Stage 5a.

Shanidar 4, Shanidar Z and the new remains all lay within the scour-and-fill bedded and laminated sediments of an ancient watercourse. Solecki's Shanidar 6, 8 and 9 remains possibly also lay within this watercourse, since they were found within a small ~1 x 1 x 0.5 m volume block of sediment containing Shanidar 4 removed for excavation in Baghdad, losing their precise stratigraphic location. The heads of the three Neanderthals whose position is documented (4, Z and the new finds below it) were orientated upstream. The position of the watercourse was controlled by the diversion of ephemeral floodwaters around a very large boulder standing over 3 m above the cave floor at that time, that would have provided a topographic marker.

Shanidar Z lay in an anthropogenically modified depression within the watercourse [3] and was rapidly covered including by gently aggrading sediments; decomposition occurred in a covered state. Subsequently, more energetic flows led to the erosion of parts of the channel floor and may have displaced some skeletal material. It is likely that similar erosion following burial and skeletonization led to the displacement of the majority of the skeletal material of the new Neanderthal remains, before Shanidar Z was deposited.

The layering of the sediments in the watercourse can be followed stratigraphically into the deposits of the adjacent cave floor, where we found hearths, ash dumps, lithics and fragments of animal bone in layers contemporary with Shanidar 4, Z and the new remains. Whilst absolute contemporaneity cannot be demonstrated, the evidence increasingly suggests that these Neanderthals used the cave for both habitation and for body deposition and that these activities were intimately entangled.

The deposition of at least 4 Neanderthal individuals clustered in a small area and depth of the cave, and demonstrating a similar orientation and flexed position, suggest patterning in Neanderthal mortuary behaviour around 75,000 years ago at Shanidar Cave. The sedimentary separation of the Neanderthal Z and new remains, and of Shanidar 4 in sediments above Shanidar Z, indicates multiple deposition events adjacent to the 'marker' stone. While the time-span in which these events took place cannot be precisely determined, sediment accumulation rates suggest a period of at least several hundred years. These findings have implications for understanding the nature of Neanderthals' mortuary behaviour and use and conception of the landscape, including possible 'special places' for mortuary and daily living activities.

We wish to thank the Kurdistan Regional Government for the original invitation to G.B. to plan new excavations at Shanidar Cave and the Kurdistan General Directorate of Antiquities for permission to conduct them. We gratefully acknowledge the financial support of the British Academy, the Leverhulme Trust (Research Grant RPG-2013-105), the McDonald Institute for Archaeological Research (University of Cambridge), the Natural Environment Research Council Oxford Radiocarbon Dating Facility (grant NF/2016/2/14), the Rust Family Foundation, the Society of Antiquaries, the Templeton Foundation and the Wenner-Gren Foundation.

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Podium Presentation, Session 4, Friday 9:30-11:10

## Thinking outside the rift: exploring the limitations of hominin habitat reconstructions based on spatially restricted species occurrences

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The Eastern African Rift System (the rift) preserves a very large percentage of the early hominin fossil record, but reflects less than 2% of the spatial area of the continent. Our understanding of hominin habitat use is likely impaired by the overabundance of fossils coming from this thin sliver of eastern Africa. To better understand potential biases in hominin environmental reconstructions, this study asks: how would our understanding of rift-dwelling extant mammal habitats be different if all we knew about was their occurrence within the rift? In short, we use modern mammals as models for determining the potential for biases in early human paleoenvironmental reconstructions.

Using species range maps from IUCN, we compared each rift-dwelling terrestrial mammal range (range_full) to the subset of the range occurring within the rift (range_rift). We characterized range_full and range_rift in terms of percent grass cover and percent tree cover (from the Copernicus Global Land Cover service) and annual precipitation and annual temperature (from BIOCLIM). The median spatial overlap between range_rift and range_full is only 2.8%. Using repeated measures ANOVA, tree cover was significantly lower in range_rift ($F=96.4$, $df=1,146$, $p<0.001$, range_full mean = 33.4%, range_rift mean= 15.9%), as was annual precipitation ($F=29.2$, $df=1,146$, $p<0.001$, range_full mean = 1010.46 mm, range_rift mean = 887.94 mm). Grass cover and mean temperature showed no significant differences.

Our results show that, for modern rift-dwelling mammals the rift comprises a tiny and environmentally unrepresentative fraction of most species ranges. To the extent the environmental differences between the rift and the rest of Africa were present in the Plio-Pleistocene, reconstructions of early hominin paleoenvironments are likely biased towards less wooded and drier portions of actual hominin ranges. We call for a more formal consideration of the spatial limitations of the early human fossil record in environmental reconstructions.

Poster Presentation Number 6, Session 1, Thursday 17:45-19:15

## FAIR sharing is caring: insights into the data sharing mindset in paleoanthropology

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Open Science is a term used to describe practices in scientific research that aim to make the process of knowledge acquisition and communication more equitable, accessible, and transparent. These practices also actively invite the evaluation of results through reproducibility and replicability, which enhance science by ascertaining the validity of scientific knowledge. Especially open data are key to ensuring validity of published studies and promoting large-scale collaborations and syntheses.

A recent survey on data sharing was conducted on various fields within biological anthropology [1], and included respondents from paleoanthropology (n=154). While 81% of respondents benefitted from data shared by others, only 56% shared their own data. The most common reasons not to publish were a lack of acknowledgement, misuse/misrepresentation of the data, and being scooped. While a number of respondents reported negative experiences from data sharing (n=19), more researchers experienced benefits (n=55), citing knowledge accumulation, new collaborations, and increased impact as the most common benefits.

Many of the fears surrounding data sharing, both perceived and experienced, can be solved by improving knowledge of data publishing and FAIR (Findability, Accessibility, Interoperability, Reusability) data principles [2], especially Reusability. For example, acknowledgement can be ensured by associating a dataset with a license and a citation statement, and appropriate use of data can be improved through detailed documentation. In addition, informed data sharing can increase a researcher's impact if the data are readily Findable and Accessible.

We present data from the aforementioned survey from respondents who reported paleoanthropology as their field of research, allowing us to assess specific needs and experiences relevant to the ESHE community. We provide guidelines for data sharing according to FAIR principles, such as choosing an appropriate repository and license, and provide some solutions to the fears of negative repercussions from sharing data. Finally, we aim to extend the discussion of data sharing practices beyond paleoanthropology, incorporating the ESHE community as a whole, to learn more about the sharing practices, experiences, and concerns of researchers, as well as the needs of the community to practice science more openly (journal and funder requirements, trainings, etc).

Promoting Open Sciences practices within paleoanthropology, especially open data, can further democratise the field by allowing people without access to fossil material to contribute to knowledge accumulation, and promote a mentality of collaboration rather than competition.

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Pecha Kucha Presentation, Session 1, Thursday 11:30-12:45

## Positional behavior in African Miocene hominoids: new insights from the first cervical vertebrae of *Otavipithecus* and *Nacholapithecus*

**Amélie Beaudet[1,2,3], Fredrick Kyalo Manthi[4], Helke Mocke[5], Emmanuel Ndiema[4], Dominic Stratford[3], Bernhard Zipfel[6]**

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Despite ongoing debates on the phylogenetic relationships of Miocene apes, fossil hominoids are crucial to understand the selection pressures that played a role in the emergence of modern hominoid positional behaviors [1]. In particular, the nature of the ancestral model for the *Pan-Homo* last common ancestor, and the evolutionary context of hominin bipedalism, remain largely questioned. The first cervical vertebra (atlas) acts as the main interface between the head and the axial skeleton, and plays a critical role in directing and stabilizing head movements. As such, previous studies have emphasized the functional link between the morphology of the atlas, head mobility, and postural and locomotor repertoires in catarrhines [2]. Here we quantitatively investigate the morphology of the atlas of *Otavipithecus namibiensis* and *Nacholapithecus kerioi* for identifying locomotor-related functional signals and discussing possible implications for the phylogenetic, evolutionary and geographic origins of modern hominoid behaviours.

The sample includes the two Miocene ape specimens GSN BA 104'91 (Berg Aukas, Namibia) and KNM-BG 35250BE (Nachola, Kenya), respectively attributed to *Otavipithecus namibiensis* and *Nacholapithecus kerioi* and dated to 12-13 and 15 Ma, respectively [3-4]. GSN BA 104'91 is a virtually complete atlas curated at the Geological Survey of Namibia. KNM-BG 35250BE only preserves the right lateral mass and base of the posterior arch of the atlas and is housed at the National Museums of Kenya. 3D models were generated using photogrammetry and an Artec Space Spider 3D scanner. For comparative material, 38 atlases of extant non-pathological adult *Gorilla*, *Homo*, *Hylobates*, *Pan*, *Papio*, and *Pongo* were included, as well as the *Australopithecus* specimens StW 573 and StW 679. In addition to standard linear measurements, the morphology of the two specimens was investigated by landmark-based geometric morphometric method and statistical analyses [2].

The overall dimensions of GSN BA 104'91 and KNM-BG 35250BE fall within or closely approximate the range of variation of extant *Pan* and *Hylobates*. Our geometric morphometric analyses indicate that the overall morphology of BA 104'91 is more similar to *Pan* and StW 573. When the right side only is considered, the morphology of KNM-BG 35250BE is intermediate between the extant catarrhine groups included in our sample while GSN BA 104'91 approximates the condition seen in *Pan*. Overall, our study supports the mosaic morphology of Miocene apes previously described in the literature [3,5]. Similarities between *Otavipithecus* and *Australopithecus* as identified in our study would deserve further attention, including testing the hypothesis of parallel evolution.

This study is funded by the Centre National de la Recherche Scientifique (CPJ-Hominines), the French Institute for South Africa, the National Research Foundation of South Africa (#129336) and the University of Cambridge.

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Poster Presentation Number 7, Session 1, Thursday 17:45-19:15

## Reconstructing the trunk muscles of the Kebara Neanderthal

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Kebara 2, unearthed in 1983, is one of the most complete Neanderthal skeletons ever to be found. Since its discovery, it has been studied extensively, and in recent years, the spine, pelvis, and thorax were virtually reconstructed. These reconstructions give us exceptional opportunity to accurately measure the dimensions of its axial skeleton, enabling us to gain unique understating of the trunk muscles of Neanderthals.

Thus, the aim of this study is to reconstruct the Neanderthal's trunk muscles, measure their length and torque (moment arm) and compare them to a sample of contemporary *H. sapiens*.

Using Horos software, we measured muscle length and moment arms on the virtual reconstruction of Kebara 2, and CT scans of the fifty modern humans. Fascicular length and torque arm of the muscles of the abdominal anterolateral wall, erector spine, and deep posterior abdominal muscles were measured in the sagittal, coronal, and horizontal planes. These measurements are based on well-established kinesiological methods, making them easy to repeat.

The results of the study show that muscle fibers length of the longissimus, quadratus lumborum, and external oblique muscles were shorter in the Kebara Neanderthal. This is because the position of the sacrum in the Kebara neanderthal is placed much lower within the pelvic girdle, and the lower ribs are longer, compared to modern humans. However, the moment arm of the lateral abdominal muscles is considerably longer than that of modern humans. This was probably due to a wider pelvis and thorax in Kebara. There were no significant differences in the length and moment arm of the rest of the trunk muscles that were measured.

The skeletal morphology of the Neanderthal from Kebara, manifests differences in the length of the fascicles and the torque arm of spinal and abdominal muscles, compared to modern humans. While the reason for this unique morphology requires further study, it does imply differences in muscle function and movement pattern between the two species, that might have occurred due to distinct habitat or food selection.

Poster Presentation Number 9, Session 1, Thursday 17:45-19:15

## Fish bones used as tools by Early Humans in Tabun Cave (Israel)

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Three fish bones from Tabun Cave (Israel) were recovered among the faunal collections at the Natural History Museum (London, UK). Details associated with these three specimens are sparse, but the information found within their original boxes suggests a provenance within 'level C' for NHMUK PV P 76388 and NHMUK PV P 76389 and from 'level D' for NHMUK PV P 76387. Given the depth and extent of sediments excavated from levels C and D at Tabun, it is unfortunately not possible to say whether these fish bones might be associated with occupations by early *H. sapiens* or *H. neanderthalensis*.

Anatomical comparisons (visual and CT scan) with modern fish specimens suggest that the three Tabun fish bones are all tilapine 1st anal pterygiophores, and they most likely belong to the species *Tilapia nilotica*. The Nile tilapia is a cichlid fish native to the northern half of Africa and the Levant, including Israel and Lebanon, which can be found in most types of freshwater habitats, such as rivers, streams, canals, lakes, and ponds, and has a range distribution from sea level to an altitude of about 1,830m.

We analysed the bone surfaces of the Tabun specimens through scanning electron microscopy (SEM) and 3-dimensional focus variation microscopy. All three Tabun specimens are covered by concreted sediments that obscure the proximal articulations of NHMUK PV P 76387 and NHMUK PV P 76388, and cover the entire surface of NHMUK PV P 76389. All three specimens have their proximal and distal epiphysis partially broken. Microscopic analyses of the visible bone surfaces of NHMUK PV P 76387 and NHMUK PV P 76388 show several clusters of fine sub-parallel striations of different widths. In the case of the wider striations, it is possible to observe internal micro striations and partial flaking of the bone surface, consistent with the morphology of scraping marks produced by a stone tool. On NHMUK PV P 76387, these marks are accompanied by clusters of small sub-triangular pits.

Our interpretation of the taphonomic history of these three specimens suggests that, although some of the scratches can be attributed to natural causes, the majority of the modifications were anthropogenic. We suggest that the combination of the different types of modifications observed on NHMUK PV P 76387 and NHMUK PV P 76388 is more likely consistent with scraping to clean or shape the spines and the use of these bones as tools, perhaps for piercing.

These finds are so far unique and therefore it is difficult to determine the exact nature of their use. We will present and interpret the modifications observed on the fish bones, discuss how these artefacts could have been used, and explore the significance of their rediscovery for the evolution of behavioural complexity in our lineage.

This study was made possible thanks to the generosity of the Calleva Foundation.

Podium Presentation Session 1 (Virtual), Thursday 9:20-11:00

## Variation in the fusion of the pubic symphysis by sex and age in five primate species and implications for obstetric adaptations

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The openness and flexibility of the pubic symphysis is a key obstetric adaptation in *Homo sapiens*, facilitating the passage of a large foetus through a relatively small birth canal. There is limited information on the frequency and degree of openness of the pubic symphysis in other primates, although there is evidence of some variation across the order: the maroon leaf monkey (*Presbytis rubicunda*) and some gibbons (e.g., *Hylobates lar*) show frequent fusion of the two pubic bodies [1], while the common marmoset (*Callithrix jacchus*) and the silvery lutung (*Tachypithecus cristatus*) are consistently unfused [1-2]. These differences have been suggested to reflect locomotor and obstetric adaptations, but to understand the evolutionary significance of an open pubic symphysis it is essential to know the range of variation across the order, including variation by sex and age.

To characterised the degree of pubic fusion, 114 primates from five different species were examined: *Pan troglodytes*, *Macaca mulatta*, *Microcebus murinus*, *Eulemur fulvus* and *Galago moholi*. The presence of an open or fused pubic joint was determined via computed tomography scans of adult individuals of known sex and age, either as skeletal remains or full bodies (cadaveric or living). Each individual was assigned to an age stage based on their chronological age and the timing of key life history events in each species. For each species, five age stages were defined: four stages equally distributed between the age at first female reproduction and the age of female reproductive senescence, plus a fifth stage of post-reproductive life. Then the proportion of individuals with a fused pubic joint by sex and age stage in each species was calculated.

Substantial variation exists across the five primate species sampled. Like humans, *Galago moholi* presents an open pubic symphysis in both sexes across the entire life history. At the other extreme, *Macaca mulatta* shows a high frequency of symphyseal closure in both sexes by the middle of their reproductive life period (i.e., stage 3, 12.5-17.5 years) and well before reproductive senescence. In species with some degree of symphyseal fusion, the frequency of fusions increases with age and the symphysis closes much earlier in males than females; this is despite females reaching skeletal maturity earlier than males in other skeletal – including pelvic – regions.

The results clearly show that humans are not unique in maintaining an open symphysis throughout life, but that symphyseal fusion is more common than a persistent open symphysis across primates, including our closest relatives. In species where symphyseal fusion occurs, females tend to maintain an open symphysis for longer, often beyond reproductive senescence, while males tend to show early pubic fusion. The fact that this pattern is the opposite in general skeletal maturity, with females completing overall skeletal development earlier, suggests that a delay in symphyseal fusion is a female-specific adaptation, which is likely related to obstetric pressures.

For the access to primate CT scans and life-history data, we wish to thank the California National Primate Research Center (University of California Davis), Steven Heritage and Amanda Mazza at the Duke Lemur Centre, Dr. Kate Kaya at the Center for Academic Research and Training in Anthropology (CARTA), Dr Yuki Kinoshita at Kyoto University, and Morphosource. The study was only possible thanks to funding from the Kyoto University Primate Research Institute Cooperative Research Programme (project title: Positional, dimorphic and obstetric influences on pelvic shape in primates), the Sasakawa Foundation Butterfield Awards for UK-Japan collaboration in medical research and public health practice (grant B130 - Positional, dimorphic and obstetric influences on human pelvic shape) and the Leverhulme Trust (Project grant RPG-2021-130 - Solving the evolutionary puzzle of human childbirth)

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Pecha Kucha Presentation Session 2, Friday 16:40-17:55

## Reconstructing the occupational history of El Castillo Cave using sediment DNA

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The Middle-to-Upper Paleolithic transition is associated with a strong shift in the complexity and sophistication of tools and ornaments in the archaeological record. Yet, whether the makers of specific transitional industries were Neandertals and/or Anatomically Modern Humans (AMH) often remains a subject of debate. One example for this is the transitional levels 18b and 18c in El Castillo (Puente Viesgo, Spain). Recently, three juvenile molars from level 18B, dated to >42 kya, were assigned to Neandertals based on their morphology [1]. Unfortunately, the teeth are currently not available for ancient DNA (aDNA) analysis to infer their genetic ancestry.

In the present study we take advantage of the potential of sedimentary aDNA analysis for reconstructing the occupational histories of Palaeolithic archaeological sites [2-4]. For this purpose, we collected 385 sediment samples from El Castillo, spanning from unit 16 (dated to >41 kya) to unit XXV (dated to >89 kya) [5]. In an initial screening for aDNA preservation we analyzed 170 samples. In brief, sub-samples of 40-90 mg sediment were removed using sterile spatulas and the DNA extracted using an automated silica-based method. Subsequently, single-stranded DNA libraries were prepared, with library preparation efficiency monitored using a synthetic oligonucleotide spike-in. Negative controls were processed alongside the samples. Finally, the libraries were barcoded with sample-specific indices and enriched for mitochondrial (mt) DNA sequences using two rounds of hybridization capture [4]. A subset of libraries was further enriched for 377,046 informative positions in the human nuclear genome [3]. Following a previously described bioinformatic pipeline [2], reads were assigned to mammalian families using BLAST and MEGAN, and classified as endogenous or contaminant based on the frequency of damage-induced substitution at their ends.

Of the 170 sediment samples analyzed, 42 yielded ancient hominin DNA. The analysis of diagnostic positions in the mtDNA genome that distinguish different groups of hominins [2] revealed significant support for AMH in unit 17 and Neandertals in units 18b, 18c, XXab, XXc, XXd, XXe, XXf and XXh. No ancient hominin DNA was found in unit XIX, which is archaeologically sterile, and below unit XX. In addition to a lack of ancient hominin DNA, no evidence for the presence of ancient faunal DNA was found in the lower layers, with the exception of small traces of hyaena and cervid DNA in unit XXIII, indicating that DNA preservation is poor in layers >70 ka.

Using the software Kallisto to compare the hominin mtDNA fragments to published mtDNA genomes of Neandertals [3] we found significant similarities to Mezmaiskaya 2, a late Neandertal from the Caucasus, in samples from units 18b to XXc, and significant similarities to Mezmaiskaya 1, a Neandertal dated to 70-60 kya, in samples between units XXf and XXh. Preliminary nuclear DNA analyses from units 18b and XXab show more genetic affinity to Vindija 33.19 than to other Neandertals from which high-coverage genomes are available, with estimated population split times of 86-73 kya and 78-56 kya, respectively. However, more data is needed to determine if this indicates a population turnover in Neandertals at the site.

In summary, our data provide a time transect of Neandertal genetic history in northern Iberia between ~70-41 kya (represented by levels 18b to XXh), covering the occupation history of El Castillo from the Mousterian to the Middle-to-Upper Palaeolithic transition. This complements previous sediment DNA analyses at Galería de las Estatuas 112 km further south, which had revealed aspects of Neandertal population history between ~112-79 kya. As more sediment DNA data continues to emerge from El Castillo and other sites, we expect to further increase the resolution at which Neandertal population history can be studied on the Iberian Peninsula and elsewhere.

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Poster Presentation Number 10, Session 1, Thursday 17:45-19:15

## Classification of partially observed curves with applications to the fossils and paleoenvironment of the hominin bearing site of Gladysvale, South Africa

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Animals in the Family Bovidae (antelopes and buffalo) are frequently the most common fossil found at a site in South Africa. When associated with hominins, they are useful for reconstructing past environments. However, due to age and degree of attrition, fossil bovid teeth can be difficult to identify. In addition, taphonomic issues can lead to breakages which makes their identification even more difficult. We addressed this missing data problem by investigating whether we could classify the occlusal surface of tooth curves when they are partially observed. To test this, we virtually broke extant teeth from known specimens and used a hot-deck type imputation method to complete the partially observed shapes and then classified the completed shapes using simple classification algorithms. In addition, we also considered classification of the partial observed shapes without completion through imputation. In both cases, we demonstrate that reasonable classification performance can be achieved with and without imputation.

Gladysvale is a hominin bearing site located in the Bloubank Valley in the Cradle of Humankind World Heritage Area, approximately 13 km northeast of Sterkfontein. The deroofed Gladysvale External deposit (GVED) dates to approximately 578-780 ka [1]. Previous analyses of GVED fauna identified a group of bovids as medium sized alcelaphines. We used the B.O.V.I.D. database [2] and a novel application of the statistic support vector machine with a radial kernel to reclassify thirty-two, unbroken teeth to their genera/species. The newly identified specimens increase the number of individuals and diversity of fossils recovered from Gladysvale. This research helps refine the paleoenvironmental reconstruction. However, some of the medium sized alcelaphine teeth were broken. We applied the aforementioned missing data research to a sample of medium sized alcelaphine fossil teeth from Gladysvale and reclassified them. This method allows us to use even more of the recovered fossils to generate a more precise paleoenvironmental reconstruction. While multiple habitats may have been sampled [1], the bovid identifications suggest the paleoenvironment likely consisted of open edaphic and secondary grasslands that grade into bush cover with a nearby water source.

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Poster Presentation Number 11, Session 1, Thursday 17:45-19:15

## Steinheim: first digitization and digital alignment of additional fragments from the left cranial side

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The cranium from Steinheim an der Murr (Baden-Württemberg, Germany) is one of the most important specimens in the European human fossil record. It is an almost complete cranium that was discovered in 1933 in a gravel pit and roughly dated to OIS 9 (i.e., 300–320 ka to 250 ka) by biochronology. Despite overall good preservation, it lacks a great part of its left side comprising the facial skeleton and the anteriormost portion of the neurocranium. The cranium SMNS-P-17230, known simply as Steinheim, shows also significant signs of taphonomic deformation which affects its morphology and led to different taxonomic attributions in the past. A new species *Homo steinheimensis* [1] was first proposed, followed by different attributions to either an intermediate form between *Homo erectus* and *Homo sapiens*, or to the Neanderthal lineage, among others. Nowadays the association with the Neanderthal lineage and the possible attribution to the species *Homo heidelbergensis* are more accepted. The main focus of the underlying debate is the peculiar morphology of the preserved portion of the facial skeleton. This morphology is however highly influenced by an ensemble of distortions of taphonomic origin [2]. The cranium is familiar to scholars in its broken form and has been shown without the missing part of the left side throughout its history. Fragments of the upper left side of the face were found at the same time as the cranium but described only in a rather recent review in German, by Wahl and colleagues [3]. In general, the existence of these portions of the facial skeleton of Steinheim has been mostly overlooked by the scientific community. The five bigger fragments are labeled T1-T5, while 5 additional smaller fragments (around 1 cm) have no individual labels and are of difficult assemblage. T1-T5 vary in size, between 2 and 6 cm in maximum length. T1-T3 are possibly part of the left orbit, while T4 seems to be part of the zygomatic arch and T5 is more difficult to identify. Here we present the first digitization by computed tomography of the fragments, and an attempt at the integration of these fragments in a digital reconstruction of the cranium. Two methods were tested: the Digital Alignment Tool (DTA), a protocol developed in R for the alignment of separated fragments of the same specimens based on the morphological data from a reference sample [4], and a manual alignment within the software environment of Avizo. The fragments were integrated into a previous cranial reconstruction in which the majority of the effects of taphonomic deformation were corrected [2]. The possibility to appreciate an unknown missing portion of the Steinheim face contributes to better identifying the similarities of this specimen with penecontemporaneous populations of the European Middle Pleistocene. The obtained reconstruction can also represent an occasion for increasing the general knowledge of this specimen by the possible 3d printing and exhibition along the original specimen.

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Poster Presentation Number 12, Session 1, Thursday 17:45-19:15

## Environmental change and human adaptation in the Sicilian Upper Paleolithic

**Peyton Carroll[1], Ilaria Patania[2], Christian Tryon[1], Robert Thorson[1]**

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This poster reports the findings of a systematic petrographic sampling of the stream valley near the Upper Paleolithic site of Pedagaggi, the first attempt at raw material sourcing in southeastern Sicily, and a technological reanalysis of the site's previously excavated stone tool assemblage. These analyses will determine how climate-driven changes in the stream altered the site's occupants' access to local toolstone and identify resulting behavioral modifications. This research has implications for understanding the deeply rooted relationships between human behavior and fragile island ecosystems.

As the largest island in the Mediterranean (25,711 km$^2$) and with land bridge connections to both the Italian mainland and Malta during periods of lowered sea level [1], Sicily is the most likely candidate for hosting the first human populations entering the Mediterranean islands. Archaeological and environmental evidence gathered thus far suggests that humans first reached the island approximately 16 thousand years ago [2], as populations associated with the Epigravettian techno-complex in southern Italy moved into Sicily, possibly by way of the land bridge exposed during the last glaciation. However, despite much research focused on the later occupations of Sicily, the prehistoric archaeological record and early environmental context of the island are largely unknown.

Island ecosystems are extremely sensitive to change. Thus, the prehistoric archaeological and environmental records of Sicily can be considered a 'natural laboratory' for understanding both the impact of humans on fragile ecosystems and human behavioral change relative to environmental shifts. Chipped stone tools used by hunters and gatherers (HG) are one of the most direct proxies for prehistoric human behavior, representing environmental exploitation strategies. Studies suggest that the availability and distribution of toolstone on the landscape mediates how foraging populations adapt to their environments [3]. Changes in basin-scale fluvial systems, the dominant Paleolithic sources of toolstone, caused by fluctuations in climate and a rapidly rising sea level during the Late Glacial period (~18 to 11 thousand years ago) [4] would have altered Sicilian foragers' access to toolstone, necessitating population-wide behavioral adaptation. The transitional Late Glacial (~14 thousand years ago) site of Pedagaggi in southeastern Sicily, is geographically and temporally situated to be a strategic case study for examining human behavioral responses to climatically-driven landscape change in a closed ecosystem.

The Pedagaggi cave, located 320 m.a.s.l. in southeastern Sicily, opens to the East over a narrow gully cut by the Gelso River. In the 1980s, archaeologists recovered a lithic assemblage dominated by flint and typologically consistent with the Epigravettian of southern Italy. Thus far, study of the Pedagaggi assemblage has been minimal and limited to a typological analysis [5], and as is the case for most of the Sicilian stone tools, raw material sourcing has not been attempted. Current evidence suggests that prior to the Neolithic period, cobbles in streams and rivers were the primary source of raw material. The Gelso stream, which originates from a spring in the Hyblaean Mountains, is a likely source of the various toolstone present in the lithic assemblage. The depth of the Gelso stream gully (>320m deep, 800m wide) suggests that the stream has been subjected to climatically-influenced geomorphic processes since the Last Glacial Maximum, likely altering Pedagaggi's occupants' access to local raw material through time. Understanding how the Gelso stream responded to environmental change resulting from the post-glacial climatic shift, and the source(s) of the toolstone represented in the Pedagaggi stone tool assemblage will provide insight into how Sicilian HG adapted their mobility and foraging strategies to fit the evolving landscape of the Late Glacial period.

Special thanks to the entire EOS team for their hard work to make this project possible! Thanks also to CESE – IoE for funding this project.

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Poster Presentation Number 13, Session 1, Thursday 17:45-19:15

## Neanderthals and early modern humans in western Iberia: taphonomy and diet at Lapa do Picareiro (central Portugal)

**Milena Carvalho[1], Michael Benedetti[2], João Cascalheira[1], Lukas Friedl[3], Joanthan Haws[1,4]**

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In Iberia, potentially the last place where Neanderthals survived, the demographic breakdown of small, loosely connected populations seems to have been a significant driver for their demise [e.g., 1]. Human responses to the climatic fluctuations of the Late Pleistocene, particularly Marine Isotope Stage (MIS) 3, could be an explanation for the decreases in Neanderthal population size during this time; it may be that habitat fragmentation and environmental instability contributed to a demographic breakdown, resulting in small, secluded Neanderthal populations that remained for some time in refugia, even after the arrival of anatomically modern humans in Europe some 40,000 years ago. Thus, understanding human responses to climate change during the Middle to Upper Paleolithic Transition is critical. Lapa do Picareiro (Portugal), one of a handful of sites on the Iberian Peninsula with end-dates for the Middle Paleolithic (~45-42ka cal BP), and a rare early Aurignacian occupation (~41.1-38.1ka cal BP) [2], yielded a large zooarchaeological assemblage from highly stratified and well-dated deposits corresponding to various stadial and interstadial phases, rendering it a good location to study human responses to climate change during the Middle to Upper Paleolithic transition [see 3]. Given that caves are home to numerous fauna, taphonomic analyses are critical for teasing out the non-human depositional agents of faunal assemblages accumulated in caves. Preliminary analyses from Picareiro suggests both human and non-human inputs in the faunal assemblages. Anthropogenically modified bones with evidence of cutmarks, burning, and percussion marks have all been identified. In this poster, we present taphonomic and zooarchaeological data from Levels JJ and GG from Picareiro, which correspond to the Middle to Upper Paleolithic transition. These data will contribute to a limited but growing [e.g., 4] number of studies on Neanderthal and early modern human behavior, particularly subsistence, in westernmost Iberia.

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Pecha Kucha Presentation Session 2, Friday 16:40-17:55

## More than a cutting tool? An experimental examination of flakes produced in Early Acheulean handaxe manufacture

**James Clark[1], Marta Mirazón-Lahr[1]**

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The Acheulean covers a crucial period of cognitive and behavioural change within the hominin lineage, and yet the initial relationship between its characteristic large, usually bifacial, tool forms and hominin behaviour is unclear. As implied by the term "Large Cutting Tool", it has long been assumed that bifacial implements evolved for use in specific heavy-duty cutting tasks, particularly (large) animal butchery and woodworking, and their effectiveness in these tasks is confirmed by a number of experimental investigations [1]. Nonetheless, the limited number of use-wear studies looking at bifaces from the Early Pleistocene have indicated their isolated use in distinct tasks in different localities (including butchery at Konso Gardula, woodworking at Peninj, and pounding of an unknown substance at Olduvai), or their lack of use at all [3]. Other authors have instead argued that bifaces evolved for use as cores in their own right, and simply reflect an allometric extension of cores that existed in the Oldowan [4]. However, no data exists on the potential advantages or disadvantages of producing flakes a) using a large flake as a blank for core reduction, and b) reducing them in a way that produces characteristic Acheulean forms, such as handaxes. This is in spite of a growing body of literature that emphasise that the choices of the knapper can have a profound impact on the morphology and economisation of stone flakes [5].

The present study marks an attempt to address this issue through experimental manufacture of flakes from cobble and flake blanks, using Oldowan-like core and Early Acheulean-like handaxe reduction sequences. In this presentation, we first outline the development of a standardised methodology for the production of 20 flakes each from 120 cores covering the two blank types and four reduction methods, producing a total sample of more than 2000 flakes. We then examine differences in flake morphology by blank type, reduction strategy, and changes across the knapping sequence, demonstrating the effectiveness of Early Acheulean handaxes at producing usable flakes. We further argue that the selection of blank type and reduction strategy reflects a complex set of trade-offs between flake size, flake utility, and hominin mobility across individual landscapes, and therefore that different core forms may have been chosen in different environmental or functional contexts. We discuss the implications of our results for the origins of the Acheulean.

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Podium Presentation Session 5, Friday 14:30-16:10

## Do paleogeographic changes from MIS 6 to MIS 3 explain the timing of Neanderthal expansions in Eurasia?

**Emily Coco[1], Radu Iovita[1]**

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The advances during the last few decades of research have revealed that Neanderthals colonized a vast territory that stretched from Spain to Siberia. The earliest Neanderthals in Asia likely arrived there from the west shortly before MIS 6 [1] and were probably separated from European Neanderthals until glaciers retreated. From MIS 5d-a, we continuously find genetic and archaeological connections between European and Siberian Neanderthals [2-3].

Despite our current understanding of population history across Eurasia, we still have limited knowledge about the routes taken to get to Siberia and the behavioral adaptations required for that journey. Dramatic paleogeographic changes occurred in Eurasia during the period of hypothesized Neanderthal dispersals. These changes are well-known to geologists but have never been utilized to generate hypotheses about hominin dispersals. Specifically, the formation of ice-dammed lakes in Siberia during cooling phases prior to MIS 3 led to re-routing of river drainage systems and the formation of new rivers due to outburst flow [4-5]. Considering pioneers colonizing new landscapes often use landmarks such as rivers to enable dispersal, these new watercourses formed before MIS 3 may facilitated the long-distance movements of Neanderthals suggested by the genetic and archaeological records.

We created paleogeographically realistic agent-based model to simulate dispersal of Neanderthal populations between MIS 6 and MIS 3. Using cost surfaces derived from elevation, climate, hydrological, and glacier data, we explore possible paths that mobile populations may have taken in Eurasia under different paleogeographic and climatic scenarios. This allows us to test hypotheses about when and how dispersal eastward across Eurasia occurred leading up to the Last Glacial Maximum.

Our results demonstrate that rivers were indeed likely conduits for dispersal across Central Asia between MIS 6 and MIS 3. We are also able to model the relatively restricted movement of mobile agents during cooling phases when paleolakes and glacial outbursts would have been at their peak. This is contrasted by significant eastward movement during periods of lower lake levels. By running the simulations many times, we identify those routes that are most common. Additionally, given the relative freedom of the mobile agents to move in any direction, the model produces areas characterized by a lot of redundant movement during each climatic scenario. These findings could help direct archaeological survey to find new Paleolithic sites, allowing us to document important information about the behaviors and adaptations required by hominins to disperse across Eurasia.

The current study was performed within the PALAEOSILKROAD project and all field research was conducted under license No. 15008746 (12.05.2015) of the National Museum of the Republic of Kazakhstan based on the collaboration protocol between the Eberhard-Karls University of Tübingen and the National Museum. This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement n° 714842; PALAEOSILKROAD project). This work was also supported in part through the NYU IT High Performance Computer resources and services.

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Pecha Kucha Presentation Session 1, Thursday 11:30-12:45

## Partial infant skeleton illuminates growth and development in *Homo naledi*

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*Homo naledi* lived alongside the ancestors of modern humans in South Africa over 200,000 years ago. Despite its relatively recent date, the species retained many primitive characteristics including a brain size within the range of *Australopithecus* and early *Homo*. While small brain size is generally associated with a rapid life history, juvenile jaws of *H. naledi* indicate a pattern of tooth emergence common in modern humans and associated with our slower life history strategy. The overall pattern of growth and development in our extinct cousin has been largely obfuscated by the fragmentary and commingled nature of the large *H. naledi* assemblage. Here, we present undescribed infant remains which were recovered from the 2013 excavations of the Dinaledi Chamber. Representing much of the postcranial skeleton, these remains are developmentally consistent with modern humans aged 1–3 years, and are spatially consistent with coming from the "DH6" individual previously known only by the infant mandible U.W. 101-1400. The absolute sizes of a right scapular glenoid fossa, a right pubic symphysis, and vertebral neural arches are most similar to recent humans under six months of age. These infant dimensions are approximately 45% of adult *H. naledi* sizes, whereas the homologous dimensions of human infants 1–3 years are around 35–40% adult size. We estimated body size of the *H. naledi* infant using multiple regression based off a recent human comparative sample. Body mass estimates for this infant average 6.5 kg (75% prediction interval of 2.6–10.3 kg), and height of 58.4 cm (75% prediction interval = 52.9–63.8 cm). We used a simulation-based approach to estimate body mass growth rates from birth through infancy in *H. naledi*, taking into account the uncertainty in neonatal body size and the infant's age and body size at death. We compared these simulated distributions with empirical data from humans and captive chimpanzees of known age at death. Among human infants age 1–3 years, average annual growth rates (median=5.3 kg/year, interquartile range=4.2–7.0 kg/year) are higher than those of chimpanzee infants (median=2.8 kg/year, interquartile range=2.5–3.2 kg/year). Simulated *H. naledi* rates envelope the chimpanzee range but are lower on average (median=2.6 kg/year, interquartile range=1.7–3.8 kg/year). In contrast to these absolute size changes, simulations indicate the *H. naledi* infant body size was around 3.8 times larger than at birth, more similar to humans (median=3.9, interquartile range=3.15–5.0) than to chimpanzees (median=4.4, interquartile range=3.5–5.9). Despite the many uncertainties of a fragmentary fossil record, our results build toward reconstructing life history of the late-surviving, small-brained *Homo naledi*.

This research was supported by Vassar College; fieldwork was supported by the National Geographic Society, the Lyda Hill Foundation, the South African National Research Foundation, the South African Centre for Excellence in Palaeosciences and the LRB Foundation for Exploration. We wish to thank the Jacobs Family and the LRB Foundation for Exploration, for access to the Rising Star site, and the South African Heritage Resource Agency and Cradle of Humankind UNESCO World Heritage Site Management Authority for issuing the various permits required for this work, including the excavation permit (PermitID: 952).

Podium Presentation, Session 7, Saturday 16:00-17:20

## Religious sacrifice in the Ice Age? On ritual finger amputation as a potential explanation for the Gravettian hand images with incomplete fingers

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Over 200 hand images with incomplete fingers (HIIFs) have been found among Europe's Ice Age cave paintings. Currently, the significance of these images, which are all thought to be associated with the Gravettian archaeological culture (27,000-22,000 BP), is unclear. Some authors have argued the individuals who produced the images had all their fingers and simply manipulated their hands so that certain finger segments were invisible. Others have argued the images were produced by individuals who had undergone finger amputation.

In 2018 we reported a study designed to shed light on the possibility that the Gravettian HIIFs reflect finger amputation [1]. We identified 121 recent societies that practised finger amputation and distinguished ten motivations for engaging in the custom, nine of which did not involve a medical goal. We concluded that the hypothesis that best fits the Gravettian HIIFs is that they were produced by individuals who had undergone amputation in religious rituals.

Some colleagues have dismissed our study. Most notably, Prof. Paul Pettitt has argued that amputation cannot account for the Gravettian HIIFs because many are missing more than just the little finger and removing multiple fingers is "idiotic" [2]. A similar argument has been made by Dr. Alison George. She noted that the most common HIIF pattern at the sites of Gargas and Cosquer in France is an extended thumb with all other fingers incomplete and she argued that this "extreme mutilation…would have been catastrophic for the recipient" [3].

The present paper is a response to these criticisms. First, drawing an expanded cross-cultural survey, we show that the claim that amputation cannot explain the Gravettian HIIFs because the amputation of multiple fingers is "idiotic" and "catastrophic" does not hold water. A number of ethnographic groups are known to have removed multiple finger segments for cultural reasons and their members clearly survived.

Next, we outline four reasons why the Ritual Amputation Hypothesis deserves to be taken seriously as a potential explanation for the Gravettian HIIFs. The first is that amputation of finger segments from living people for cultural reasons was surprisingly common in the recent past. The second is that there is other evidence of finger amputation associated with the Gravettian. The third is that HIIFs are not limited to Europe, which is consistent with the fact that in the recent past finger amputation was practised on all inhabited continents. The fourth and final reason for taking seriously the possibility that the Gravettian HIIFs reflect finger amputation is that the inter-site variation in incomplete finger segments is reminiscent of the inter-group variation in the finger segments that were amputated in our cross-cultural sample.

In the third part of the paper, we highlight some implications of the Ritual Amputation Hypothesis. Specifically, we suggest it is worth considering whether finger amputation and other 'dysphoric rituals' [4] might help explain not only the ability of Upper Palaeolithic groups to outcompete non-modern hominins like the Neanderthals but also the emergence of the ethnolinguistic groups that appear to be reflected in the personal ornaments of the European Upper Palaeolithic [5]. Another interesting possibility, we suggest, is that dysphoric rituals played a role in the evolution of what seems to be our psychological propensity for tribalism.

Our work on this paper was supported by the Social Sciences and Humanities Research Council of Canada, the Canada Research Chairs Program, the Canada Foundation for Innovation, the British Columbia Knowledge Development Fund, and Simon Fraser University.

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Pecha Kucha Presentation, Session 1, Thursday 11:30-12:45

## A 3D geometric morphometrics reconstruction of the KNM-ER 3228 os coxae

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Fossil hominin pelves are important sources of evidence regarding locomotion, childbirth, thermodynamics, and support of viscera in hominin species. However, the structure of the pelvis makes it prone to taphonomic damage, and therefore the infrequency with which complete pelves are discovered in the fossil record make functional interpretations uncertain or impossible. The early Pleistocene is especially lacking in complete hominin pelvic fossils. While partial hominin ossa coxae have been discovered, complete or reconstructed pelves may provide better evidence for behavioral adaptations hypothesized to have played a key role in the evolution of *Homo*.

KNM-ER 3228 is an isolated and incomplete os coxae originally discovered in East Lake Turkana, Kenya in the 1974-1975 field season and described by MD Rose in 1984. Based on its similarity to the OH 28 os coxae, it was originally assigned to *H. erectus* [1], though more recent evaluations have challenged its assignment in favor of a more ambiguous designation of early *Homo* [2-3]. This 1.9 Ma partial os coxae displays traits that seem consistent with a pattern of mechanical reinforcement of load-bearing regions about the hip and larger and rougher insertion scars for ligaments that stabilize the pelvic joints [1]. Though damaged in the gluteal region and missing the rami and pubis, it is still clear that its morphology differs from most other *Homo* specimens, and it has variously been used as representation of a more robust early *Homo* species [2-3]. The variation in early *Homo* postcrania suggests differences in weight transmission from trunk to thigh, and therefore possibly locomotion [3]. A reconstruction of the isolated os coxae KNM-ER 3228 would allow for a more extensive biomechanical evaluation to test this hypothesis.

Here we present the first ever reconstruction of KNM-ER 3228 using 3D geometric morphometrics. MicroCT scans were used to evaluate the extent of the damage to the gluteal region, which was removed and repaired. Homologous landmarks and semilandmarks were digitally placed on KNM-ER 3228 and a sample of complete hominin pelves. Landmarks and semilandmarks on the incomplete regions of KNM-ER 3228 were deemed missing. Using thin plate spline interpolation [4], the missing landmarks were imputed using the hominin sample as reference. After a mesh was generated using the new coordinate values of the landmarks and semilandmarks, the right os coxae was mirrored, and the two ossa coxae were aligned with the E. 688 Broken Hill sacrum. While this sacrum is often grouped with *H. heidelbergensis*, it is similar in size and morphology to KNM-ER 3228, and the auricular surfaces closely match.

The anterior portion of the reconstructed pelvis is strongly morphologically influenced by modern humans, and therefore uncertainty is still strong as to the true morphology of KNM-ER 3228. Future research will include larger numbers of hominin species in the comparison sample to create several versions of the reconstruction. Still, the resulting full reconstruction presented here allows for more extensive biomechanical evaluations that require a complete structure, such as finite element analysis. Reconstructions of fragmentary fossils like KNM-ER 3228 may help to clarify the taxonomic uncertainty of early *Homo*.

For access to microCT scans of KNM-ER 3228 we thank Job Kibii, the National Museums of Kenya, and the Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology. For technical assistance we thank Matthew Skinner. For access to E. 688 we thank the Natural History Museum, London.

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Pecha Kucha Presentation, Session 3, Saturday 16:40-17:55

## Growth of the fetal energy requirement during pregnancy and its role in birth timing

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Compared to non-human primates, human newborns are uniquely helpless and neurologically immature. This so called "secondary altriciality" has been proposed as the solution to the obstetrical dilemma. According to this hypothesis, secondary altriciality helps to mitigate the consequences of a twisted birth canal and a tight cephalopelvic fit that are corollary to an anteroposteriorly shortened human pelvis adapted for bipedal locomotion [1]. In contrast, the "Energetics of Gestation and Growth" (EGG) hypothesis suggests that the neurological immaturity of human newborns results exclusively from limitations to the maternal energetic capacity during pregnancy and particularly from a presumed inefficient transfer of essential fatty acids across the placenta to the fetus [2]. The EGG hypothesis further assumes that fetal energy requirements grow exponentially during pregnancy, and labour is initiated when they exceed the maximum sustained maternal metabolic capacity [2]. However, it has been shown that the maternal metabolic scope during pregnancy is highly variable, which in turn is not reflected by a corresponding variability in birth timing [1,3]. Furthermore, recent research revealed a multitude of factors that might control birth timing in modern humans in addition to the suggested metabolic ceiling during pregnancy [see 4]. Here, we investigate the growth of fetal energy requirements during pregnancy. Since the fetal energy requirements mainly depend on weight gain, we calculated the fetal energy requirements for the 10th, 50th and 90th percentiles based on the fetal weight data from 13 studies. We found that fetal energy requirements increase rapidly only until pregnancy week 35, whereafter fetal growth slows down and stagnates. This implies that fetal energy requirements decrease towards the end of pregnancy. However, it is unlikely that this reflects starvation of the fetus as suggested by the EGG hypothesis since fatty acid transportation through the placenta is now known to occur rapidly and efficiently [5], and the mother often accumulates plenty of fat reserves until the very end of the third trimester, which she only depletes during lactation. Further, considering fetal weights at the 90th percentile, fetal energy requirements peak at approximately 500 kcal/d, which is well below the suggested maternal metabolic ceiling at approximately 700 kcal/d during pregnancy according to the EGG hypothesis. Fetal energy requirements only approach the suggested maternal metabolic ceiling above the 97th percentile of fetal weights. This indicates that the supposed maternal metabolic ceiling generally may not be reached nor exceeded during pregnancy. Consequently, the timepoint of birth seems to be determined by other factors than fetal energy requirements and the maternal metabolic capacity. These might particularly include various genetic factors on the timing of parturition and birth weight as well as redundant and synergetic biological clocks like the endocrine, fetal membrane or decidual clocks [4]. Although no direct, specific link between pelvic capacity and fetus size and thus birth timing has been described so far, our findings contribute to the notion that human pregnancy and childbirth have evolved to highly complex biological processes that go beyond simplistic energetic explanations.

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Podium Presentation, Session 4, Friday 9:30-11:10

## The technological behaviour in the Lower Palaeolithic site of Marathousa 1 (Megalopolis basin, Greece)

**Dalila De Caro[1], Moritz Kuhn [2], Eleni Panagopoulou[3], Katerina Harvati[1,4], Vangelis Tourloukis[1]**

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Marathousa 1, dated to MIS 12, is an open-air site situated in a lignite mine, where systematic excavations have unearthed a Middle Pleistocene archaeological sequence associated with a paleolake setting. The site represents the oldest-known Lower Palaeolithic butchering site in the Southern Balkans, discovered during a target-oriented survey campaign in the Megalopolis Basin [1].

Its favourable location in proximity to a paleolake shore contributed to the preservation of different taxa in a paleoenvironment that acted as a *refugium*, preserving fresh-water bodies during glacial stages [2]. The artefacts were found in spatial and stratigraphic association with remains of an almost complete straight-tusked elephant skeleton (*Paleoloxodon antiquus*), as well as elephant and other faunal elements bearing bone surface modifications [3,4].

The flake-based lithic assemblage, constituted of 2046 pieces, presents a "small tools" component with an average length of 20 mm for the flakes and 24 mm for the tools. We investigated the industry from the perspective of the *chaîne opératoire* approach, namely the modality of raw material procurement, the technique(s) adopted, and the reduction sequences. To integrate and test the results of the macroscopic lithic analysis, we relied on a controlled knapping experiment using radiolarite pebbles and cobbles collected in the Megalopolis basin, as a raw material. The aim was to investigate how the small-tool industry was produced. The results allowed the acquisition of new information regarding the technological behaviour of the early hominins in Marathousa. The technique mainly adopted is freehand on radiolarite cores from cobbles collected in secondary outcrops. The raw material was likely tested at the source locations, and only knappable pieces were carried into Marathousa 1, where the production of flakes and blanks suitable for a secondary modification took place until the cores did not permit further flake production and were sometimes reconfigured into tools. The thicker and more coarse-grained flakes from the first phases of the reduction sequence were retouched, while the fine-grained flakes derived from a full production phase, were used without any further modification, mainly to process animal tissue, according to the preliminary results of the functional analysis [5]. For both categories (initial cortical flakes, and non-cortical flakes from later-stage production), we note the presence, although not systematic, of a central ridge/crest useful to guide the propagation wave. These two macro-categories are juxtaposed to a third one, less represented, eminently opportunistic, where slabs, angular pieces and pebbles with an already natural suitable shape were retouched to obtain ready-to-use tools. The way in which the hominins from Marathousa 1 dealt with the raw material constraints implies a technological savoir-faire and a good knowledge of the territory, despite the fact that the abundant radiolarite often lacks the mechanical qualities suitable for knapping. From this, the maximisation of the production, seldom accompanied by ready-to-use tools, with the aim to take advantage of all the possible resources surrounding the paleolake is an important component that intersects and trespasses the dichotomy of curation and expediency.

D. De Caro, V. Tourloukis and the Marathousa 1 lithic assemblage analysis are supported by the Deutsche Forschungsgemeinschaft (DFG TO 1474/1-1; "MEGALOPOLIS", Project no. 463225251) awarded to V. Tourloukis and K. Harvati. Research at Marathousa 1 was conducted under the auspices of the Ephorate of Paleoanthropology-Speleology and was funded by the ERC StG no 283503 "PaGE" and the ERC CoG no 724703 CROSSROADS awarded to K. Harvati.

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Pecha Kucha Presentation, Session 1, Thursday 11:30-12:45

## Cracking the nut of the Nut-Cracker: revisiting the *Paranthropus* endocasts from eastern Africa

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One of the primary questions in hominin brain evolution pertains to the emergence of derived brain features within the hominin lineage. The endocast of *Paranthropus*, an understudied hominin in terms of cortical evolution, has been challenging to study due to the fragmentary nature of its hypodigm [1]. Consequently, many questions still remain unresolved regarding the brain of this robust hominin and possible related evolutionary pressure. In particular, the study of the brain of *Paranthropus* may enhance our understanding of how this early hominin taxon interacted with its environment approximately 1.4 to 2.5 million years ago, including tool making and usage [2]. In order to shed light on the cortical evolution of *Paranthropus* and address these questions, in this study we use imaging techniques and 3D modelling to extract data from some of the most fragmentary specimens, revealing previously unnoticed details.

We analysed cortical imprints from the endocasts of Paranthropus from eastern Africa attributed to *Paranthropus boisei* (KNM-ER 407; KNM-ER 23000 and KGA 10-525) and *Paranthropus aethiopicus* (KNM-WT 17000 and KNM-WT 17400). The endocasts were generated and initially studied by R. Holloway [3], and digitized using the Artec Space Spider 3D scanner. After reconstructing the endocasts using the Artec software, an algorithm was applied to automatically detect cortical imprints [4]. The imprints were then labelled and analysed using a program in MATLAB, focusing specifically on the sulcal imprints [4]. The imprints of *Paranthropus* specimens were compared to the density maps of extant humans (N=20) and chimpanzees (N=21) that represent the pattern of distribution of the main sulci in the endocasts [5], as well as published descriptions of fossil hominin endocasts of *Australopithecus* and *Homo*. Using the same method, for the first time we generated a mean endocast for *Paranthropus* and mapped the distribution of the imprints using the most complete specimens investigated in this study.

By using this approach, we were able to identify cortical imprints which are central to discussions in early hominin brain evolution, such as the lunate sulcus and sulci of the frontal lobe. More specifically, the lunate sulcus in *Paranthropus* is positioned relatively anteriorly on the occipital lobe and thus approximates the condition seen in extant *Pan* and *Australopithecus*. The configuration of the frontal lobe approximates the condition of *Pan*, where there is a clear fronto-orbital sulcus and a middle frontal convolution occupied by a horizontal ramus leading to the sulcus rectus rostrally. Accordingly, the findings of this study provide new insights into the cortical expansion and intra-taxic variation in the east African *Paranthropus* fossil record.

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Poster Presentation Number 14, Session 1, Thursday 17:45-19:15

## Unravelling sexual dimorphism in human crania: in-depth exploration using Neural Networks

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In recent years, novel approaches leveraging advancements in neural network architectures have flourished in biological anthropology applications and human evolution studies, especially to aid in the identification of human remains [1]. However, the reliability of such methods has been hindered by severe limitations, such as small training/testing sample sizes, data relatedness between training and test sets, limited population inclusiveness, and lack of attention to the issue of overfitting. Here, we present a neural network-based estimation of sex from human crania built to overcome the aforementioned issues. In fact, the accurate estimation of individual sex from cranial morphology plays a crucial role in various fields, including physical anthropology.

We present a population-inclusive protocol for estimating sex using a limited set of cranial metric traits consisting of only 10 measurements. Howell's dataset (82 craniometric measurements on 2524 human crania from 30 populations) is utilised for training and validation, while the UT Forensic dataset (36 craniomandibular variables on 1396 individuals of mixed ancestry) is employed for testing [2-3]. Our approach employs a neural network architecture designed to mitigate overfitting, and to maximise the individual probability of class attribution (through the Log Loss measure) rather than sample percent accuracy. Our model achieved an accuracy of 86.7% ± 0.02% through rigorous cross-validation and a Log Loss of 0.34 ± 0.03 (lower than the upper non-informative limit of 0.693, reference value for a binary classification problem).

Furthermore, we evaluated the performance of our protocol on data sets unrelated to the training and validation phases. The estimated accuracy on these external data sets was 84.3%, with a log loss of 0.348. To promote reproducibility and wider adoption, we have made our model freely available [4].

This research contributes to the development of a robust and reliable method for sex estimation based on cranial metric traits. By addressing key limitations of previous approaches, our population-inclusive protocol provides a valuable resource for anthropologists seeking to accurately determine an individual's sex based on cranial morphology.

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Poster Presentation Number 15, Session 1, Thursday 17:45-19:15

## Testing the validity of a theoretical model for Galician Palaeolithic settlement patterns: a statistical approach in Monforte de Lemos basin

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The settlement patterns of the Galician Palaeolithic have long been a subject of theoretical exploration. However, despite the proposed theoretical model, a statistical verification of its accuracy has been lacking. The objective of this paper is to address this gap by investigating whether the previous theoretical model can be supported by statistical analysis. To achieve this goal, we employ a method based on the generation of a predictive model. By analysing the main environmental variables and statistically evaluating their suitability for predicting the location of Palaeolithic sites, we aim to shed light on the validity of the theoretical framework.

From a methodological point of view, we first identify the key environmental variables that are likely to influence the settlement patterns of the Galician Palaeolithic. By considering these factors, we can create a predictive model that serves as a statistical tool for verifying the theoretical model. Using geospatial data and advanced analytical techniques, we analyse the distribution of Palaeolithic sites across the Monforte de Lemos basin.

The results obtained not only contribute to the understanding of Galician Palaeolithic settlement patterns but also open new possibilities for analysis in the study of Palaeolithic sites in Northwestern Iberia. The statistical tool reveals that elevation, slope, the cost to potential hydrology, the cost to wetland areas, and visual prominence are the most reliable variables for predicting the location of Palaeolithic sites. This finding supports the theoretical model proposed in previous decades, suggesting that they indeed play a significant role in determining settlement patterns. The fulfilment of the theoretical model in some of the proposed variables demonstrates the usefulness of the predictive model approach in testing hypotheses. The predictive model developed in this study can serve as a valuable tool for archaeologists and historians working on similar topics. To facilitate the democratization of science and open science, all the analyses conducted in this study are reproducible using the statistical software R. Therefore, they can be adapted to other archaeological problems by other researchers.

Poster Presentation Number 16, Session 1, Thursday 17:45-19:15

## The latest frontier: a Metaverse tool can support archaeology to interpret Palaeolithic excavations

**Miguel Ángel Dilena[1], David Álvarez-Alonso[1], Enrique Cerillo-Cuenca[1]**

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Archaeological excavations are destructive processes where few elements survive after the extractive tasks [1]. Although these operations can deliver a significant amount of data, they cause the blatant loss of a volumetric reference in the site. Hence, such subtraction can hinder the exhaustive analysis of the entire spatial context in which the artefacts were located, namely, distances, dimensions, positions, inclinations and orientations. This problem becomes particularly evident in cases where sedimentation can bury human occupations which are consecutive and chronologically close. As it often occurs during the Palaeolithic, and in particular, as it happens at the Spanish shelter used herein as a case study. The Abrigo del Molino (Segovia) is a late Mousterian site located in the central part of the Iberian Peninsula [2].

To sort this spatial problem out, researchers tried to implement: two-dimensional (2D) projections on different planes; and also 2.5D technologies, which cut two-dimensionally the three-dimensional (3D) space. However, the nature of each archaeological excavation develops integrally in a third dimension.

The Metaverse concept can help resolve this dilemma since it embraces an immersive, shared, 3D virtual space where humans experience life in ways they could not in the physical world [3]. Thus, to meet the 3D paradox, we apply innovative Metaverse methodologies in three steps: reconstruction, visualisation and analysis of the digital 3D excavation. Concerning the first step - the re-creation - the techniques allow for a spatial database generation. Such a database contains one 3D virtual model for each extracted artefact, whose shape and form can be restored using the original spatial context in which it was recovered. Furthermore, the automatic processes make possible the volumetric reconstruction of the stratigraphic and archaeological surfaces found during the unearthing. Therefore, using specific colours, the different strata can be represented chronologically, as well as the finds contained therein.

Regarding the second step - site visualisation - these methods create mixed reality (MR) computational applications. Such programmes employ the aforementioned three-dimensional models to locate and display them interactively through a mobile device (i.e., tablets, smartphones) on the mere excavation (they can also show the models elsewhere). This action allows us at the site to associate the virtual finds with the tangible context from which they were extracted (digital and physical reality coexist and melt each other, creating a fusion of mixed reality) [4].

Finally, the third step -the exhaustive statistical analysis- manages to group the archaeological finds using mathematical techniques -clustering methods- [5]. This examination to encounter associations by using the discernible attributes of each artefact and their spatial distributions in the digital excavation, which allows for the classification of the buried elements. The result includes bunches of archaeological finds aggregated in 'clusters' or conglomerates, which statistically show a high level of correlation between the objects they contain. Therefore, such clusters could delineate a single occupation or a series of chronologically close human settlements with significantly similar characteristics.

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Poster Presentation Number 17, Session 1, Thursday 17:45-19:15

## First insights into trabecular bone distribution in the first metacarpal of *Homo naledi*

**Christopher J. Dunmore[1], Sebastian Bachmann[2], Alexander Synek[2], Tracy L. Kivell[3,4], Matthew M. Skinner[1,3,4]**

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Modern human dexterity is thought to be facilitated by our distinctive pollical (thumb) morphology. The shape of the first metacarpal (Mc1), including the robusticity of the shaft and disto-radial flange as well as the articular surfaces of the first metacarpophalangeal and trapeziometacarpal joints, have been used to infer the degree of dexterity in several hominin species [1-4]. The *Homo naledi* Mc1 has a unique external morphology among known fossil hominins with no direct analogue in extant primates, possessing a small proximal articular surface, a flat radio-palmarly extended distal articular surface, and both radial as well as ulnar diaphyseal flanges [3-4]. As trabecular bone can (re)model in response to mechanical loading over an individual's lifetime and is located beneath both epiphyseal and diaphyseal Mc1 external morphology, it may provide additional functional information about *H. naledi* thumb use. Compared to other living great apes, humans have significantly more trabecular bone directly beneath the radial aspect of both the distal and proximal articulations of the first metacarpal, as well as beneath the disto-radial flange. These differences are consistent with differences in both external Mc1 morphology and observed manipulative capabilities [5].

Here, we use canonical holistic morphometric analysis (cHMA) to statistically compare the distribution of relative trabecular bone density (rBV/TV) in largely complete H. naledi Mc1s (U.W. 101-1321 and U.W. 101-270) to a sample of living great apes including: modern humans (*Homo sapiens*, n=10), bonobos (*Pan paniscus*, n=10), chimpanzees (*Pan troglodytes*, n=11), gorillas (*Gorilla gorilla*, n=10) and orangutans (*Pongo* sp., n=7). Run in Medtool 4.5 (www.medtool.at), this method uses a statistical deformation model to create a canonical Mc1, to which all Mc1s are subsequently deformed. This controls for shape differences before statistical volumetric comparison of trabecular distribution. The trabecular distribution of the whole bone, the proximal epiphysis, the distal epiphysis, and the diaphyseal medullary cavity of the fossils, were each separately compared to the homologous region of the comparative sample.

*H. naledi* Mc1s demonstrate some intraspecific variation in trabecular distribution. We find evidence for radial concentration of trabecular bone beneath the proximal and distal articular surfaces of U.W. 101-1321 consistent with the modern human pattern, thought to reflect thumb loading during forceful opposition. U.W. 101-270 does not show this signal as clearly. However, both fossils show trabecular concentrations beneath both the ulnar and radial diaphyseal flanges, suggesting a plastic response to strong first dorsal interosseous and opponens pollicis muscle action. We hypothesize that the antagonistic actions of these muscles assisted in the maintenance of stability at the small proximal articulation of the Mc1 in *H. naledi*, but ongoing analysis of the large hypodigm available for this species is needed to properly support this supposition.

We thank the following researchers or curators for access to specimens in their care: I. Livne and R. Jennings (Powell-Cotton Museum), A. vanHeteren and M. Hiermeier (Zoologische Staatssammlung München), C. Boesch and U. Schwarz (Max Planck Institute for Evolutionary Anthropology), A. Ragni (Smithsonian Institution, National Museum of Natural History); M. Teschler-Nicola and R. Muehl (Natural History Museum, Vienna), J. Moggi-Cecchi and S. Bortoluzzi (University of Florence), F. Mayer (Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science, Berlin), B. Großkopf (Johann-Friedrich-Blumenbach-Institut für Zoologie und Anthropologie der Georg-August-Universität Göttingen), E. Gilissen and W. Wendelen (Musée Royal de l'Afrique Centrale), V. Volpato (Senckenberg Museum of Frankfurt), B. Zipfel and L. Berger (University of the Witwatersrand), E. Gilissen and W. Wendelen (Musée Royal de l'Afrique Centrale), V. Volpato (Senckenberg Museum of Frankfurt. This research was supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant no. 819960).

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Podium Presentation, Session 0, day 00:00-00:00

## The hominin footprints from the Late Pleistocene site of Larache (Morocco)

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In the last decades, the study of hominin footprints has grown exponentially with the discoveries of many important sites. The discoveries and analyses of these footprints provides complementary information to the more common skeletal remains or archaeological artifacts. Indeed, by representing snapshots of life, footprints give direct access not only to the biological and biomechanical characteristics of individuals but also to their behaviours. Despite the increase in the number of discoveries in recent years, footprints remain relatively rare and have a very heterogeneous geographical distribution. Indeed, no footprints have been discovered in certain regions such as North Africa, which is well known for its numerous archaeological or paleoanthropological discoveries.

It is in this context that we report the discovery and the first study of human footprints left during the Late Pleistocene at the Larache site in Morocco.

The Larache site is located in a coastal environment between Rabat and Tangier. It is on this site devoid of human skeletal remains or archaeological artifacts that 85 human footprints have been discovered since July 2022. These footprints are distributed within a surface of 4,000 m² composed of fine to medium sand dated to MIS 5c. The Larache ichnological assemblage includes trackways and isolated footprints that are preferentially oriented in the WNW-ESE direction, which is perpendicular to the current shoreline. Their morphology is variable but clearly shows the anatomical characteristics of the human foot: a rounded heel, a plantar vault, relatively short toes including an adducted hallux.

The statures and age classes of the individuals who left these footprints were estimated from their length and experimental regressions. The Larache footprints whose length varies from 12.7 to 30.0 cm (mean: 22.7 cm) correspond to statures between 120.8 and 189.0 cm (average: 160.0 cm) and to the different age classes: children, adolescents and adults.

The discovery of the footprints in Larache is important. Indeed, no other site has yielded footprints in North Africa and the Larache footprints are among the oldest attributed to Homo sapiens in the world. Their study provided new information on human occupations in North Africa during the Late Pleistocene and will give the opportunity to learn more about the behaviours of the individuals who left them.

Poster Presentation Number 18, Session 1, Thursday 17:45-19:15

## Analysis of tooth size in the transition from hunter-gatherer to agriculture in the Near East populations

**Albert E. Dyowe Roig[1], Laura M Martínez[2,3], Alejandro Pérez-Pérez[2,3], Miquel Molist[1], Eric Coqueugniot[4], Ferran Estebaranz-Sánchez[3,5]**

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The process of neolithization was a major event in human history that led to a change in subsistence strategies, i.e., a shift from hunting and gathering to agriculture and pastoralism. Agriculture was adopted in several regions of the world during a period of global warming known as the Holocene, around 12000 cal BP. Several changes in the way people lived, such as subsistence methods and settlement patterns, occurred at the beginning of the Neolithic in the Near East. Tooth size and enamel thickness have been widely used as indicators of food type availability and are considered key data for tracing dietary and ecological adaptations in the Hominini lineage. Evidence suggests that dental size has decreased over evolutionary time [1]; e.g., hunter-gatherers had larger dentitions than agricultural populations [2]. Some authors have suggested that this dental size reduction from the Paleolithic to the Neolithic was due to a process of gracilization caused by the necessity to sustain the masticatory pressure under the reduction of muscle mass [3]. On the other hand, other authors concluded that the change in tooth size was due to multiple factors such as dietary changes, new technologies and biological functional requirements, all important for the relaxation of the selective pressures towards large teeth. This study aims to determine whether dietary change favoured the evolution of dental morphology, using tooth size as an indicator of morphological affinities between populations. Biodistance is a measure of relatedness or divergence among groups separated by time and/or geography based on morphological variation and represents a non-invasive analytical technique alternative to aDNA studies for population affinities. The studied sample (N=2046) corresponds to premolars and molars from 28 different sites and different periods of the early Neolithic in the Near East and the Anatolian Peninsula (Tell Halula, Abu Hureyra, Dja'de el Mughara, El Wad, Jerf el Ahmar, Kebara, Shukba, Tell Aswad, Tell Ramad, Ain Mallaha, Areq el Ahmar, Hayonim, Nahal Oren, Hatoula, Jericho, Yiftahel, Kefar Hahoresh, Abu Gosh, Atlit Yam, Rakefet, Nahal Betzet, Abu Madi, Basta, Banana, Tell Roim West, Lod, Neve Yam, Tepecik Ciftlik). Tooth casts were made from the originals using polyvinylsiloxane President MicroSystem Regular Body (Coltène), a standard procedure in microwear studies due to its stable physical properties and high detail resolution. Buccolingual and mesiodistal diameters of the tooth crown were measured with a digital calliper [4], [5]. Results suggest that there are significant differences ($p<0.05$) in the area of dentition between different prehistorical periods. Similarly, buccolingual measurements also show a higher rate of difference than mesiodistal measurements.

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Pecha Kucha Presentation, Session 3, Saturday 16:40-17:55

## Results from recent archaeological fieldwork near Tsabong, Kgalagadi district, south-western Botswana

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The importance of the arid interior of southern Africa for the study of human evolution has become a growing research topic in recent years. Several research teams have shown that the Kalahari was not devoid of human occupation in the Pleistocene [e.g., 1-3]. However, the current distribution of published excavated archaeological sites in the interior is limited to the southern margin of the Kalahari sediments in South Africa and to the northern part of Botswana. Surface scatters of archaeological artefacts in other parts of the Kalahari have not been studied systematically despite their potential to test human adaptation to marginal environments in the past. With striking differences in lithic technology and raw material selection between the southern and northern Kalahari sites, the aim of our project is to determine the extent of these industries and potential contact zones in between.

In a landscape with no caves and little relief, we developed a mobile Geographical Information System (GIS) setup that allows us to record the archaeological potential of the south-western Kgalagadi district in a rapid and standardised manner. This talk describes five previously unknown archaeological sites (Itireleng, Letlhakane pan, Okwane pan, Maralaleng pan and Maleshe dune 2) that were identified through our survey. Four of these sites, as well as the majority of identified surface archaeology, belong to the Fauresmith or the early Middle Stone Age based on a first assessment of their lithic typology. They show most affinity with the Fauresmith sites of the neighbouring Northern Cape Province, South Africa. We report the results from our survey as well as six archaeological test pits and the first systematic excavation from the 2022 and 2023 field seasons. A pattern is emerging of particular concentration of these sites on or near quartzite outcrops that are located next to pans. The local quartzite was used to manufacture the lithics, with other raw materials not present. Our research highlights the high potential for further archaeological investigations in this under-researched area using an interdisciplinary landscape approach.

These investigations were carried out under research permit ENT 8/36/4 L (56), issued August 26, 2021 by the Botswana Ministry of Environment, Wildlife and Tourism. This project was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under grant number 455851250. We wish to acknowledge the continued logistical support of the University of Botswana, the Department of Monuments and National Museum of Botswana and the McGregor Museum Kimberley.

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Poster Presentation Number 19, Session 1, Thursday 17:45-19:15

## Craniovascular morphology of the early Upper Palaeolithic skull from Zlatý Kůň, Czech Republic

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The craniovascular system is part of the vascular network of the head, and includes the middle meningeal vessels, the dural venous sinuses, the emissary veins, and the diploic veins. These vascular networks leave marks in the skull in form of imprints, channels, and foramina. In palaeoanthropology, craniovascular traits provide the only available information about vascular networks. They inform on physiological processes associated with blood circulation, and provide an opportunity to investigate metabolic features, possibly associated with phylogenetic or demographic factors, in extinct hominins and past populations. Craniovascular features can supply information about evolutionary adaptations, inter- and intra-population differences, and individual life history [1]. Here we present an analysis of the craniovascular morphology of the early Upper Palaeolithic skull from Zlatý Kůň (Koněprusy caves, Czech Republic) [2]. The human remains from Zlatý Kůň belonged to an adult female and include fragmentary cranial and postcranial bones. Recently, a study revealed that this individual might be a representative of the earliest Eurasian inhabitants following the expansion out of Africa. Based on a genome analyses, it has been suggested that this female lived at least 45 000 years ago. Interestingly, her genome carries ~3% Neanderthal ancestry, which is similar to other Upper Palaeolithic hunter-gatherers [3]. It has been also shown that the cranium from Zlatý Kůň display a morphological affinity with pre-LGM (Last Glacial Maximum) population [4]. The skull consists of a partial neurocranium with better preserved right part (fragmentary parietal bones, a squama of the occipital bone, a large part of the frontal bone, and part of the right temporal bone) and several bones from the facial skeleton (zygomatic bones, the intact mandible and the right maxillary fragment). Although some parts of the cranium are missing, several craniovascular features can be observed and analysed. The traces of middle meningeal vessels seem to have a posterior dominance, at least on the right side, where the posterior branches are more numerous than the anterior ones. However, the main posterior branch runs antero-superiorly. The superior sagittal sinus runs into the right transverse sinus above the internal occipital protuberance. There is also a visible imprint of the occipital sinus. The tomographic scan of the cranium revealed well preserved and quite complex network of diploic channels. There is one large diploic channel within the frontal bone on the right side (the left part of the bone is not preserved). The diploe of the right parietal bone contains two large crossing channels, and several smaller branches originates from both. The left parietal bone contains only small fragments of the upper region, but there has been at least one large channel present as well. The occipital bone contains two vertical channels bilaterally. Three mastoid foramina are present at the right temporal bone and one occipital foramen is present at the inferior part of the occipital bone (parietal foramina are absent). When compared with the craniovascular patterns in modern humans, this individual display infrequent features, namely the posterior dominance of middle meningeal vessels (which may be due to the rather dolichocephalic proportions of the cranium), the imprint of the occipital sinus and an atypical confluence pattern, and the occipital foramen [5]. The results of this study may be useful for future research of craniovascular morphology in Upper Palaeolithic individuals.

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Pech Kucha Presentation Session 2, Friday 16:40-17:55

## Enhancing palaeoproteomic study of hominin evolution through decontamination

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Analysis of ancient proteins preserved in hominin remains has in recent years proved to be a useful resource for both taxonomic assignment [1] and phylogenetic study [2] of archaeological skeletal elements. However, the methods used in this relatively young scientific field still need thorough testing and evaluation, as reliable data forms the foundation of achieving robust results. Over time, archaeological materials will be contaminated from sources such as the burial environments, excavation, and handling. These contaminants may bias subsequent biomolecular analyses, as their abundance and more intact state may cause them to overpower endogenous molecules, and they may introduce modern sequence variation into the dataset. Several different decontamination methods have been previously used in palaeoproteomic analyses, however, thus far no study has compared their efficiency or the amount of fragmentation and modification they induce in the endogenous proteome, which is already damaged through diagenetic processes. In this study, we evaluate five methods that are commonly used for decontamination in palaeoproteomics. Pleistocene herbivore skeletal elements that have been artificially contaminated by a modern dog salivary proteome are used for the comparison, in order to ensure that endogenous and contaminating biomolecules can be bioinformatically separated and quantified. The proteins are analysed through LC-MS/MS, and the methods are compared by quantifying differences in proteome size and composition, protein coverage, and post-translational modifications of amino acids. Our results show that the tested methods have significant differences in the amount of contaminating proteins that are removed, as well as the damage that they cause to the ancient endogenous proteome. This study thereby clearly shows the necessity of performing decontamination prior to palaeoproteomic analyses, as well as thoroughly evaluating each method that is used when analysing ancient biomolecules, in order to maximise information gain from each analysis.

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Poster Presentation Number 20, Session 1, Thursday 17:45-19:15

## A geoarchaeological investigation on the formation processes and palaeoenvironmental context of archaeological sites in the Kgalagadi district, Botswana

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The Kalahari of Southern Africa is a semi-desert that extends across the bulk of Botswana's land surface. This region's most prominent geomorphological features include pans and lunette dunes occurring on the southern side of each pan. The pans are the main focus of this research, as they would likely have provided an occasional water source for groups of hominins during the Quaternary. Previous research suggests that pans are likely of deflation origin [1]. Calcrete formations are visible inside the pans and are often associated with more arid conditions. Past research has been conducted on pans and calcretes on the Southern African interior, especially in the 20th century [1-3]. New research on the Makgadikgadi Pans has established hominin presence and determined palaeoenvironmental conditions during the late Pleistocene in the north of Botswana [4]. However, less attention has been given to the pans, lunette dunes, and calcrete formations in south-western Botswana, especially in geoarchaeological contexts. During January, July and August 2022, the Kgalagadi Human Origins project surveyed the area around the town of Tsabong to establish the presence of lithic surface scatters. The surveys identified surface scatters belonging mainly to Early-to-Middle Stone Age typologies located in close proximity to pans at different sites. A geoarchaeological investigation was undertaken near the villages of Maralaleng and Maleshe to identify the pan and dune formation processes and give a palaeoenvironmental context. Sediments from 4 archaeological test pits (ITI-T1, ITI-T2, MAR-T1, MAR-T2), 3 exposed quarrying profiles (Maleshe Quarry, Letlhakane Quarry, and Maralalaeng Pan), and 3 geotrenches (MLD 1, MLD 2, and Maralaleng Mud Pit) were taken for analysis. Preliminary luminescence age estimates for the lowermost layer of Maralalaeng Mud Pit, suggest a deposition during Marine Isotope Stage 5, an interglacial. Loss-On-Ignition (LOI), particle size by laser diffraction (Mastersizer 2000), portable energy dispersive X-ray fluorescence (p-ed XRF), microscopic analysis and microfossil analysis were systematically applied to the sampled sediments from the Maleshe and Maralaleng areas. The LOI and p-ed XRF results from Maralaleng Mud Pit show that carbonate content decreases with depth. Particle size analysis from the base of the mud pit suggests that the samples are poorly sorted, very coarse silty fine sand. In the Maleshe area (Maleshe Quarry, outer part of the pan), the granulometry data shows poorly sorted, very coarse silty fine sand throughout the sequence. Bioturbation is noted at Maralaleng Mud Pit and Maleshe Quarry, which could result in poorly sorted particles. The innermost dune section close to the pan at Maleshe (MLD 1) has poorly sorted medium sand more consistent with the sediment from the pan, albeit with higher sand content. These results might reflect a mixture of Aeolian, runoff and bioturbation processes. In contrast, the dune sediments from MLD 2, ITI-T1, ITI-T2, and MAR-T2 are moderately sorted, likely due to Aeolian processes and have high sand content. A microfossil analysis revealed that diatoms and ostracods are present at Maralaleng Mud Pit. The same ostracod taxa occur throughout the sequence and likely belong to fresh-to brackish water genera (*Zonocypris* cf. or *Sarscypridopsis* cf*).* Ostracod valves are badly preserved and therefore limited interpretations are made. No microfossils were noted in samples from the sites in the Maleshe area. This research contributes to the discussion on depositional contexts and palaeoenvironments during the Middle to Late Pleistocene on the under researched semi-arid Southern African interior by combining a wide range of geoarchaeological techniques with OSL dating and microfossil analysis in a single study.

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Pecha Kucha Presentation, Session 3, Saturday 16:40-17:55

## The puppet method: new experimental insights into imposed form and cultural transmission

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Modern humans' capacity to adapt to diverse environments around the globe is due, in large part, to our uniquely powerful types of culture. Human culture's qualitative and quantitative aspects derive from cultural cumulation. As generations come and go, specialized knowledge does not necessarily vanish but may be transmitted, and even further built up through time. Culturally transmitted knowledge can thus cumulate, enabling adaptive solutions to evolve quickly. In this way, each generation does not have to 'reinvent the (main) wheel', as seems to be the case in more minimal cultures, which are typical among most animals. The potential for cultural knowledge to cumulate, in turn, depends on the ability to faithfully transmit it-in particular, forms of behaviors and artifacts. This ability is dramatically enhanced in humans relative to our closest living relatives, the other great apes.

Cumulative culture's origins are thus an important topic in human evolution. Answers here can only be triangulated from indirect evidence, which include the study of culture in non-humans, the traces of hominin behavior offered by the archaeological record, and modern experimentation. In archaeology, imposed form in stone artifacts *per se* is often taken to imply modern human-like cultural capacities. In certain periods, some artifact forms appear to become standardized across vast ranges of time and space, leading to the belief that these forms were intentionally imposed. In this regard, the Acheulean handaxe form has seen the most explicit discussion. The ability to impose this form is claimed to be a behavior so complex that it must have been transmitted culturally—i.e., that the form cannot be produced in the absence of such transmission. If true, handaxes would be the earliest evidence of the type of learning enabling human cumulative culture today.

Imposing form onto stone involves several skills. First is "knapping know-how"-the perceptual-motor skills needed to predictably remove flakes. Second is "knapping knowledge"-the spatial reasoning and abstract thinking needed to organize flake-removals towards imposing form. Here, we specifically tested the claim that the latter requires cultural transmission using a new experimental methodology: the puppet method. Four knapping-naïve "puppeteers" were tasked with imposing 12 arbitrary target forms onto glass blanks by merely guiding a "puppet" expert knapper where to remove material from the blank, with the puppet then applying her existing knapping know-how. Crucially, the targets forms remained unknown to the puppet at all times. The experiment disentangled knapping knowledge from knapping know-how by artificially providing "borrowed" knapping know-how to the knapping-naïve subjects. In this way, we could test whether knapping-naïve individuals are spontaneously capable of imposing form onto cores by way of knapping-via a puppet knapper.

Two analyses of the finished cores evaluated whether the puppeteers successfully imposed the target forms: a sorting task, and geometric morphometric analyses of form and shape. In each analysis, an attempt was only considered successful if the finished core was most similar to the target form that was actually used among all 12 targets. The null hypothesis was evaluated that no more attempts were successful than would be expected by chance.

The results of both analyses converged in showing that the puppeteers successfully imposed the target forms. These findings prove that knapping-naïve humans can spontaneously impose form, thereby providing evidence that knapping knowledge can occur in the absence of any direct demonstration. Given these results, imposed form can no longer be associated with a necessity for cultural transmission in the archaeological record *per se*. To show such a connection would require additional data. Additionally, our study introduces the puppet method as a productive new methodology in experimental archaeology.

We thank Gregor Bader and Alexander Janas for their assistance printing the target forms, and David Boysen for his insightful discussion regarding their design. We are also grateful to Dominik Göldner for his help exploring different geometric morphometric approaches.

Poster Presentation Number 21, Session 1, Thursday 17:45-19:15

## The developing morphology of a juvenile Neanderthal: preliminary morphometric results of the Roc de Marsal infant talus

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The development of the human talus is a complex process that implies the interplay of both genetic and environmental influences. The talus undergoes significant (re)modeling as the child begins to stand and walk. These changes continue throughout childhood and adolescence until the bone reaches its final adult morphology. The differences between adult and infant morphology well reflect the changes that occur during growth and development.

Among species, the tali of *Homo sapiens* and Neanderthals show significant differences in their adult morphologies as well, reflecting plesiomorphic, autapomorphic, and functional modifications [1]. The ontogenetic trajectories of these two human groups are thought to be similar or slightly different, with Neanderthal infants that appear to have reached skeletal maturity faster than humans [2-3].

We used Geometric Morphometrics to investigate the morphology of the Mousterian juvenile talus of Roc de Marsal (RdM, 2.5-4 years old) [4]. The comparative sample is composed of modern human tali aged between birth and 15 years and a small sample of human and Neanderthal adults. Juvenile individuals were grouped into 5 age groups (0-1 years, 1.1-3 years, 3.1-6 years, 6.1-10 years, 10.1-15 years). A template of 228 (semi)landmarks (8 anatomical landmarks, 45 curve semilandmarks, and 175 surface semilandmarks) [5] was created in Viewbox 4 (dHAL Software) on a female individual (BO-14-F, 1 year and 9 months). Statistical analyses were performed in R.

A shape space Principal Component Analysis (PCA) shows that the first three PCs explain 55.9% of the total variance. Most of the variance is explained by PC1 (37.3%), while PC2 and PC3 explain 11.3 and 7.3% of the variance, respectively.

A Kruskal-Wallis test revealed significant differences along PC1 ($p<0.001$) and PC3 ($p<0.001$). Dunn's tests highlight significant differences between individuals aged between 1 and 3 years and individuals older than 3 years, revealing a more marked morphological difference between these two macro-groups, and between the adult Neandertals and all the individuals younger than 6 years old. RdM talus plots in an overlapping area that comprises individuals ranging from 1.5 years and 4.5 years, which is consistent with the estimated age-at-death of RdM.

The talus displays an immature morphology with a more triangular posterior calcaneal facet, a well-defined, deep neck, and a slightly convex trochlea, with posterior margins not yet defined, i.e., suggestive of stable-but-not adult-like locomotion.

These preliminary results show that the talar morphology of RdM is similar to that seen in *H. sapiens* individuals of similar age. Nevertheless, further studies are needed employing more juveniles at different age stages to better understand the Neanderthal developmental pattern.

We would like to thank: Professor Graeme Barker, Professor Chris Hunt, and Dr Tim Reynolds, directors of the Shanidar Cave Project; J. Stock and J. Saers; The Kurdistan Regional Government for inviting Professor Barker to plan and direct new excavations at Shanidar Cave, and the Kurdistan General Directorate of Antiquities for granting excavation permits and permission to analyse the finds. Access to the Krapina sample was made possible by the NESPOS (Neanderthal Studies Professional Online Service) Database (https://www.nespos.org/display/openspace/Home). We also thank D. Hervé, A. Balzeau, P. Mennecier, and A. Froment (Museum National d'Histoire Naturelle, Département Hommes, Natures, Sociétés) for providing digital models of La Ferrassie 1 and 2, and La Chapelle, R. Macchiarelli, A. Mazurier, and V. Volpato (University of Poitiers) for the microCT scan of Regourdou talus performed at the European Synchrotron Radiation Facility, Grenoble, France. This study is based upon work from COST Action "Integrating Neandertal Legacy: From Past to Present" – iNEAL (CA19141), supported by COST (European Cooperation in Science and Technology).

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Poster Presentation Number 22, Session 1, Thursday 17:45-19:15

## The Lomekwian and Oldowan are likely culturally related

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The temporal relationship between the Lomekwi 3 archaeological site and the Oldowan stone tool industry is not well explored. Lomekwi 3 dates to 3.3 million years ago (Ma). Until recently, the Lomekwian pre-dated the oldest known Oldowan site, Ledi-Geraru, by 719 thousand years (ka). The publication of 2.9 Ma Oldowan artefacts at Nyayanga indicates that the Lomekwian pre-dates the earliest known Oldowan by just 400 ka. Here, we update our investigation of the temporal relationship between Lomekwi 3 and early Oldowan occurrences considering this new data. We apply the 'surprise test', a statistical technique to assess cultural occurrences' temporal cohesion. It evaluates the null hypothesis that Lomekwi 3 was produced by the same cultural process responsible for the Oldowan and does so by determining the temporal exceptionality of an outlying occurrence (i.e., Lomekwi 3) relative to a larger sample of earlier or later occurrences (in this case early Oldowan sites, now including Nyayanga). Results indicate that the null hypothesis cannot be rejected, suggesting Lomekwi 3 to potentially be from the same cultural process responsible for the Oldowan. This lack of temporal distinction means the former cannot reliably be inferred to be outside of the temporal range of the latter, increasing the feasibility of a cultural evolutionary relationship between Lomekwi 3 and the Oldowan and emphasising the need for a more widely evidenced technological distinction between the two. The inclusion of Nyayanga in our analysis only reinforced our conclusions. Additionally, we examine the impact of a less porous Oldowan record on these results by simulating the discovery of additional early Oldowan sites, bounded between 2.9-2 Ma. The addition of 26 or more sites was required to guarantee a significant result. Thus, updated temporal evidence suggests Lomekwi 3 and the Oldowan should currently be considered part of the same cultural process (i.e., not to result from technological convergence), but this scenario may change through additional site discoveries.

Pecha Kucha Presentation Session 3, Saturday 16:40-17:55

## Quantifying heterogeneity of hominin environments in and out of Africa

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To understand *Homo sapiens* expansion we need to investigate the plasticity which has enabled our species' rapid dispersal. By investigating the environments which hominins adapted to throughout time we can better understand the origins of plasticity. By conducting a systematic review of published environmental reconstruction of hominin sites in the early Pleistocene, we have found that during this period *Homo* was occupying heterogeneous environments ranging from fully open to fully forested habitats across Africa and Eurasia [1]. The results of the review also suggest that humans started to use a wider range of different habitat types when they expanded out of Africa for the first time. To better understand the width of the niche *Homo* occupied in this period, we need to further investigate this habitat variability and validate these findings.

To validate our finding of between locality heterogeneity out of Africa we have utilised mean ordinated hypsodonty of large plant eating mammals to investigate the environmental variability of the regions occupied by *Homo* during the early Pleistocene. We use the mean ordinated hypsodonty of large mammal communities as this is a proxy for environmental aridity [2]. Hypsodonty is a measure of tooth height and is an evolutionary response to increased dental wear. The increased wear associated with hypsodonty arises from several interrelated factors such as the proportion of grass in the food ingested, the occlusal pressure required to break the plant tissues and the dust load on the vegetation. The higher the mean hypsodonty of a herbivore community, the more open, grass-dominated, and seasonal the environment tends to be [2-4]. Our preliminary results show that the variance of mean hypsodonty across sites occupied by early *Homo* increased out of Africa, with the highest variance displayed in Asia. This supports the burgeoning hypothesis that *Homo* in this period was not constrained to the environmental limits of its African niche, but was increasingly able to exploit a wider range of environments.

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Poster Presentation Number 23, Session 1, Thursday 17:45-19:15

## Middle to Late Pleistocene sedimentary deposits on the southwestern shore of Lake Turkana, Kenya

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The Turkana Basin in Kenya preserves an exceptional fossil and archaeological record and features prominently in models explaining hominin diversification and adaptation, many of which posit a causal link to changing climatic conditions [1]. The Koobi Fora Formation, situated east of Lake Turkana in northern Kenya, represents a 560-meter thick succession of lithostratigraphic units separated by more than twenty volcanic tuffs dated by argon-argon and ranging from 4 Ma to 0.75 Ma [2-3]. This formation has contributed much to our understanding of human and mammalian evolution. Significant concentrations of hominin fossils and stone tools are also preserved in sediments on the northwestern side of Lake Turkana in the Nachukui Formation [e.g., 4]. However, the southwestern shore of the lake has been historically less intensively studied because it was formed by a succession of beach and lacustrine sedimentary deposits, which are chronologically poorly constrained due to the absence of datable volcanic tuffs. As a result, and despite decades of palaeoanthropological investigations in Kenya, many sites lack reliable chronology. The inability to directly determine the age of most non-tuffaceous sedimentary deposits remains a fundamental limitation in human origins studies. This limitation can be addressed using luminescence dating, a powerful tool that directly dates fossil-bearing sediment up to 500,000 years or more in some situations.

Our investigation focused on the Lobolo camp, ~15 km north of the village of Eliye Springs, on the western shore of Lake Turkana. This area was made famous by the discovery of a nearly complete hominin cranium in 1985 protruding from the mud and gravel of the beach. The cranium, cataloged as KNM-ES 11693, is a rare specimen of archaic *Homo sapiens* [5]. However, since the cranium was not found in situ, only an age estimate of 300,000 to 100,000 years was proposed based on its morphology.

During our 2022 field survey, we relocated the area where KNM-ES 11693 was found using published GPS coordinates, site descriptions, and photos. A series of outcrops along the shore exposed well-preserved successions of tilted sand, silt, and gravel. To help understand the stratigraphic correlation between these discontinuous exposures, we used a shallow geophysical imaging technique known as Ground-Penetrating Radar (GPR). In addition, we described six stratigraphic sections, from which we collected fifteen sediment samples for luminescence dating and forty-seven samples for radiogenic isotopic analyses. The luminescence measurements were done at the new luminescence dating research laboratory at Stony Brook University (SBU). The results show that the currently exposed sedimentary deposits at Lobolo are Middle to Late Pleistocene and suggest that the area has been subject to significant transgression-regression followed by intense tectonic activity in the Late Pleistocene. The radiogenic isotope analyses were done at the FIRST laboratory at SBU. $^{87}Sr/^{86}Sr$ versus $\varepsilon Nd$ isotopic signatures show a relationship recognized as a climate signal. At the symposium, we will present (i) the GPR images, (ii) the luminescence age estimates, and (iii) the radiogenic isotope results. Finally, we will discuss a model for the evolution of the southwestern shore of Lake Turkana.

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Podium Presentation Session 6, Saturday 9:15 -10:35

## Spatial consideration of Neanderthal fire through burned bone distribution at Pech de l'Azé IV (Layer 8) and Roc de Marsal (Layer 9)

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The presence of anthropogenic fire in the Middle Paleolithic (MP) of southwest France in relatively temperate periods indicates that pyrotechnology was a part of the behavioral repertoire of at least some Neanderthal populations. This study expands upon our knowledge of the presence of Neanderthal fire to document specific properties and general locations of combustion features, inferred by accumulations of burned bone. Bones are a useful proxy for the study of fire properties (including temperature inferences) as the chemical composition and structure of bone mineral is permanently changed when thermally altered. The high degree of burned bone fragmentation can also provide in-situ residue of fire locations in contexts without a large degree of post-depositional alteration or which have not been purposefully cleaned.

Here we use faunal remains from Pech de l'Azé IV (Pech IV) Layer 8 and Roc de Marsal (RDM) Layer 9 to visualize the density and distribution of burnt fauna by weight (g) with kernel density estimations following established methodologies [1]. Both sites have excellent preservation, are from roughly contemporaneous periods with temperate climates, are found within 25 km of each other, and have prevalent evidence for anthropogenic fire. Both piece-plotted (>25 mm) and coarse screened (6-25 mm) fauna were considered to draw inferences regarding Neanderthal fire organization and temperature thresholds at both sites. Temperature inferences and burning stages were validated by spectroscopic analyses (FTIR-ATR and XRD).

Spatial analyses indicate that the distribution of burnt bone at RDM reflects with high fidelity the placement of hearths in Layer 9 which were delineated during excavation [2-3], with the exception of two features that likely did not have bone burned as a major component. Fire evidence at Pech IV Layer 8 was so prevalent that the identification of discrete features in-situ was difficult [3], and the spatial distribution of burnt bone also supports multiple clusters of burned bone, separated primarily by temperature thresholds. Both RDM Layer 9 and Pech IV Layer 8 provide evidence for the highest temperature fires in loci that are under the Pleistocene drip line. RDM also has multiple lower temperature fires outside of the cave extent. Within the cave interior Pech IV preserves fire features exhibiting a pattern of carbonized bone clusters adjacent to the higher temperature calcined bone concentrations.

Our study highlights bone as a powerful fire proxy and the importance of the coarse screens for recovering zooarchaeological evidence of burning. The spatial distribution of the burnt faunal remains associated with combustion features and the properties of those fires support multiple fire events within these layers and show anthropogenic organization of fire placement in reference to the different cave morphologies. This project will support future research which aims to further contextualize the functions and properties of these fires and the broader role fire held in Neanderthal populations.

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Poster Presentation Number 24, Session 1, Thursday 17:45-19:15

## Natural or anthropogenic? Using lithic taphonomy to assess site formation processes at UEE-PA (Lisboa, Portugal)

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In the scope of a preventive archaeological excavation, during 2021/2022 at the Unidade de Execução de Entrecampos - Parcela A (UEE-PA) in central Lisbon, Portugal, a sedimentary succession containing evidence going from Prehistory to the XX century was identified. The depositional dynamics consist of aggradation related to a high dynamic discharge recorded at the base of the alluvial deposits, with a progressive reduction of the transport flux capacity to the top, resulting in a sandy to silt loam floodplain deposit. The latter contained stone features with well-selected clasts (pavements?), pit features, charcoal concentration areas and preserved an assemblage of 10 706 lithic artefacts and faunal remains (including *Capreolus capreolus* – roe deer; *Cervus elaphus* - red deer and *Equus caballus*. – horse), pointing to a late Pleistocene or early Holocene chronology. This situation suggests the occurrence of subsequent intermittent depositions that marked the initial stage of an energy-reduced courseload, followed by the activation of soil formation processes which slightly affected the underlying sandy deposits as well [1].

This paper aims, to present the preliminary results of lithic taphonomy [2-3] and spatial analysis [4] to discuss the impact of natural agents on site formation: are the identified stone features attributable to human activity, or should they be accounted as natural factors? How can we explain the three stone clusters detected?

The excavation was carried out respecting sedimentary variations, subdivided by artificial levels. At the base of each level, a photogrammetric survey was conducted. All the bones, as well as a total of 7962 lithic artefacts, were plotted; the orientation and dip of those larger than 2 cm, with a longer axis in comparison to their width, were documented. Unfortunately, water sieving on the site was not feasible, and therefore sediment samples were collected from alternate squares. These samples were processed for floatation, using a 2mm sieve for the heavy fraction and a 0.25mm sieve for the light fraction, allowing for the retrieval of, charcoal, chips, and micro-faunal remains.

The ongoing study embraces an interdisciplinary approach combining geoarchaeology, lithic techno-typological studies and faunal and charcoal analysis. [1]. The lithic techno-typological study is currently in progress and refitting attempts have not yet been undertaken. The inventory includes data on different types of raw materials, the degree of lithic edge rolling (fresh, slightly, or severely rounded), the presence or absence of thermal alteration, and granulometry (classified into seven size classes) [2-4]. Based on these attributes, artifact distribution maps can then be plotted.

Regarding the lithic artefacts recovered. fresh edges are predominant, thermal alteration is frequent, and chips represent 19% of the total artefact number. Most of the stone tools were produced using local Cenomanian flint, accounting for 69% of the total number of pieces. All the phases of the chaîne opératoire are represented and debitage suggests the use of simple and expeditive techniques to produce flakes which were scarcely transformed into scrapers, notches or denticulates. Endscrapers, borers and splintered pieces are present in small amounts. Bladelet reduction sequences are simple, with little investment in preparation, often taking advantage of the natural shape of the volumes or using cores-on-flake. Nevertheless, bladelets are extremely rare and no microliths were retrieved. These characteristics point to a late Magdalenian or early Mesolithic ascription [5]. Overall, the clustering of artefacts shows correspondence with depressed areas, and despite little post-deposition disturbance, there is evidence of material rearrangement due to water action.

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Poster Presentation Number 25, Session 1, Thursday 17:45-19:15

## New human fossil remains and contextual information about the Sima I of the Polvorín cave (Karrantza, Biscay, Northern Iberian Peninsula)

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The first stages of the evolution of the Neandertal lineage are still not well understood, thus, multiple models have been proposed [1]. The c. 430 ka fossil record from the Sima de los Huesos (SH) site provides the first clear evidence of the Neandertal lineage, but it does not present the full suite of Neandertal-derived features [2-3]. Otherwise, the MIS 12-7 human fossil record is relatively scarce, especially in postcranial remains, and the tempo and mode of evolution is unknown for certain anatomical features present in "classic" Neandertals but not yet present in SH.

We recently identified human fossil remains among the faunal record from the Sima I of El Polvorín cave extracted by speleologists in 1983 and 2000. We have also found more human fossils during our own excavations in 2021. The human remains show Neandertal-like features, though some (e.g., the radial tuberosity orientation) are primitive, similar to SH [4]. They were found mixed with faunal bones, mostly composed by cave bears (*Ursus spelaeus*) and spotted hyaenas in a sediment in a secondary position. The hyaena remains show morphometric affinities with the MIS 9-8 *Crocuta intermedia* from Lunel Viel [5] and a few bear remains show a morphology consistent with *U. deningeri*, which suggests a diachronic accumulation. The taphonomic analysis of the fossil remains from the old excavations rules out anthropogenic or carnivore activities as the cause of the bear accumulation at the site, but we are not certain yet whether it was the result of a natural trap or deaths occurred during hibernation.

The excavations in 2022 have yielded four additional human fossil remains: a cranial fragment that represents part of the right portion of a frontal bone (preserving the lateral supraorbital region, including the zygomatic process, the *trigonum supraorbitalis*, the temporal line and the right lateral part of a relatively complete well-developed right frontal torus), a partial right scapula that preserves the glenoid cavity, a nearly complete coracoid process, and part of the axillary border, the sternal end of a lower rib, likely an 11th from the right side, and a complete intermediate hand phalanx. These new human remains do not replicate and are consistent (in terms of age-at-death and general size) with the fossil remains identified at the Arkeologi Museoa and recovered at the site in 2021. The preliminary observations on the frontal bone and the radius suggest that the Polvorín-Sima I individual is gracile similar to La Ferrassie 2, La Quina H5 and Cranium 7 from SH.

The 2022 excavations revealed the presence of in situ faunal fossils, composed by cave bears and hyaenas. One bear and one hyaena remains were directly dated using AMS radiocarbon and an ultrafiltration protocol, yielding results between 37485 and 34539 cal BP. These remains are located on the most recent layer of a complex sedimentary sequence that alternates siliciclastic sediments with speleothem formation, in which different fossil accumulations have been observed. Our working hypothesis is that the recovered human fossil remains likely derive from the partially dismantled lower layers of these sequence, which have been mixed with more recent sediments. This adds to previous observations of the general geology of the gallery that contains the paleontological site, with different phases of infilling and erosion, with perched sediment remnants (with fossil remains) at different heights of the gallery. In parallel, we have recovered several stalagmites that show a chronological record that spams MIS5-3 and that will help to contextualize climatically, at least, the Late Pleistocene fossil record from this site.

In summary, despite its geological complexity, the Sima I from El Polvorín cave is providing an interesting human fossil assemblage to delve into the Neandertal evolution and the Middle and Late Pleistocene paleoecology of the Northern Iberian Peninsula.

The excavations at Polvorín-Sima I are funded by the Diputación Foral de Bizkaia-Bizkaiko Foru Aldundia and the Ayuntamiento de Karrantza-Karrantzako Udala. Thanks to Esparta, ADES and Haitzulo speleological groups for all their work that has helped improve the access to the site. AGO and NS are supported by a Ramón y Cajal fellowship RYC-2017-22558 and RYC2020-029656-I respectively. AP is financed by a research grant from Junta de Andalucía, Spain (EMERGIA20_00403). This project is also supported by the Basque Country Government (research group IT418-19), the Ministerio de Ciencia e Innovación-Agencia Estatal de Investigación, Grant Number: PGC2018-093925-B-C33 (MCI/AEI/FEDER, UE) and the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (Grant agreement No. 949330). JA is supported by a Newton International Fellowship (NIF22\220310). MVA is supported by a Margarita Salas Fellowship CT18/22.

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Poster Presentation Number 26, Session 1, Thursday 17:45-19:15

## The evolution of the respiratory kinematics of the human torso. An approach through Procrustes Motion Analysis

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The human torso is a complex, dynamic structure. Its superior part, the thorax, houses the major respiratory structures. During evolution the primitive condition of deep and wide thoraces with low rib torsion and declination in early *Homo* changed into the narrow, flat thorax (derived condition) of modern humans [1]. Yet the functional implications of these changes remain unclear. Studies in modern humans suggest that rib torsion and declination affect not only thorax morphology, but also respiratory kinematics [2-3]. Consequently, the deep and wide thorax in primitive *Homo* was suggested to show less thoracic contribution to respiratory motion than the flat, narrow thorax of modern humans [1]. Here, we address this hypothesis through an experimental approach using stereophotogrammetric motion capture (MOCAP) and geometric morphometrics (GM) to study the relationship between torso shape and respiratory kinematics during exercise, which allows us to explore the biomechanical limits of breathing.

Seventeen male volunteers (ages 19-30, BMI 26.35±4.56) performed an incremental exercise (Steep Ramp Test) on a cycle-ergometer. A VICON 612 system (14 cameras, 100 Hz), recorded breathing motion of 89 3D-markers on the torso surface in standing position immediately after the exercise during the recovery breathing period. This facilitates capturing exercise breathing kinematics without the influence of locomotion and sitting posture. We analyzed MOCAP data through Procrustes Motion Analysis (PMA) [4], which allows for the quantitative separate study of shape and motion by GM. Principal components analysis (PCA) was used to analyse principal patterns of shape kinematics and two-block partial least squares (2B-PLS) analyses were used to test associations between kinematic trajectories and torso shape.

PMA generated inspiratory kinematic trajectories specific to each subject. PCA detected major features of respiratory shape kinematics. Specifically, more than half of the variance was explained by torso extension (PC1: 57.46%). 2B-PLS analysis suggested greater torso extension in deep, wide and short torsos than in flat, narrow and tall torsos (PLS1: 68.26%%, $p<0.05$). This suggests that torso shape and function are strongly integrated in modern human males and that torso biomechanics depend on its depth, width and height.

Flatter, narrower and higher torsos need less extension to achieve maximal inspiratory motion than deeper, wider and shorter torsos, suggesting more efficient thoracic mechanics as less muscle groups are recruited for inspiration. In turn, deeper thoraces express a limited cranial thoracic expansion during intense exercise inspiration. Thus, greater extension and recruitment of spine extensor muscles would increase their inspiratory capacity and lung volume. A different study showed that higher running velocity in males was associated to flatter thoraces, narrower pelvis and taller trunks, as well as a reduced kyphosis and pronounced lordosis [5], features almost identical to the ones detected here by 2B-PLS analysis and related to different respiratory kinematics.

Assuming similar biomechanical relations in fossil hominins, we could speculate that deeper (plesiomorphic) torsos showed different respiratory kinematics than flatter (derived) ones. If biomechanically more efficient, a derived breathing mode could confer energetic advantages or posture and locomotion tradeoffs with impact on hominin ecological evolution, affecting subsistence strategies such as persistence hunting or running performance [1,5]. However, our preliminary results warrant caution. We assume that the selected landmarks on external torso anatomy are reflecting internal musculoskeletal aspects. On the other hand, sexual dimorphism and BMI variation may affect interpretations, as they influence breathing physiology. Considering this factors, future research will provide a more holistic understanding of the evolution of hominin respiratory kinematics.

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Poster Presentation Number 27, Session 1, Thursday 17:45-19:15

## Phylogenetic analysis of recent *Homo* species

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The phylogeny of Middle and Upper Pleistocene hominins is a hotly debated topic. For instance, the phylogenetic affinities of *Homo floresiensis* and the recently described species *Homo longi* are not yet fully resolved [1-3]. Based on a literature review, we identify different potential improvements that we believe will greatly increase the quality of phylogenetic reconstructions and tests of paleoanthropological evolutionary scenarios.

First, some morphological regions have rarely been incorporated into character-taxon matrices, despite having demonstrated phylogenetic signals. For example, the endocrania were extensively described but only scarcely used in phylogenetic studies, though successfully. Such an observation also applies to postcranial characters, despite being part of some species' description and an increasing amount of data. Though attribution of some postcranial bones is not certain, enough is known from several taxa to attempt using them in phylogenetic analyses. Some anatomical regions are intensively studied for non-phylogenetic purposes and thus little is known of the potential signal they carry. For instance, we may take advantage of the cross-sectional properties of long bones that have been mainly used to investigate locomotor patterns.

Additionally, morphological integration and variability are not sufficiently considered to select and/or weight characters. Recently gained knowledge on morphological modularity in primates and hominins and efficient statistical tests may help solving these issues.

Besides, the vast majority of methods developed for phylogeny outside the hominin tribe have seldomly been applied to recent *Homo* species. These include truly continuous (i.e., not discretized) characters and incorporation of data from geometric morphometrics. Both are now successfully implemented in current software (e.g., TNT) and routinely used in empirical analyses. Phylogenetic networks were also applied to hominin-wide data [4] but no analysis at the individual or populational level were applied to recent *Homo* species, even though introgression events are now well documented by genetic and paleogenetic data for these species [5].

The merging of the huge amount of data available for hominins regarding all these issues and the variety of methods developed to address them outside the hominin tribe should greatly benefit to our understanding of human evolution.

We are grateful to Valéry Zeitoun for bibliographic orientations and access to old articles and books and to Miguel Caparros for providing additionial information on data analyses.

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Pecha Kucha Presentation Session 2, Friday 16:40-17:55

## New Neanderthal remains from the Grotte du Bison (Arcy-sur-Cure, France)

**Juliette Henrion[1], Maurice Hardy[2], Cédric Beauval[3], Nicolas Vanderesse[1,4], Maryelle Bessou[1], Jean-Jacques Hublin[5], Bruno Maureille[1]**

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The prehistoric caves of Arcy-sur-Cure (Yonne, France) contain rich levels of occupations associated with the Middle Paleolithic and the Upper Paleolithic. Among them, the Grotte du Bison is the second richest Arcy-sur-Cure cave in terms of Neandertal fossils, with 50 human remains. While, two remains were discovered during the first excavations, directed by Leroi-Gourhan (1961-1963), the rest of the human remains was excavated during the subsequent investigations directed by F. David from 1995-2010 and the recently completed ones directed by M. Hardy from 2011-2020. Furthermore, the inspection of the faunal collection by B. Maureille and C. Beauval, allowed the re-discovery of 17 human remains, from 2020 to 2021.

The Grotte du Bison has seven Paleolithic layers (D to J, from the top to the base of the stratigraphy). Most of the Neanderthals remains were discovered within the two Mousterian layers I and J (respectively Denticulate and Charentien). Only one find, a deciduous canine, was discovered in the layer G (Typical Mousterian). Among these three layers, only faunal remains from the layer I were dated to 46,534 ±1,838 BP and 43,571 ±1,354 BP, with a 95.4% probability (AMS datations, in Erlangen laboratory [1]).

The Grotte du Bison yielded a diverse collection of Neanderthal remains including two infracranial remains (a rib fragment and a fibula fragment), six skull fragments, two maxillary fragments and 40 isolated teeth (n=30 permanent and n=10 deciduous). In addition, four isolated teeth (modified due to taphonomic alterations) could be human. Only a fragmented left hemi-maxilla (including teeth from C to M3) and 13 teeth were previously published in 2009 and 2013 [1-3].

In this study, we present a comprehensive analysis of the Grotte du Bison's complete collection of Neanderthal remains. This sample represents a valuable resource for investigating the biological diversity of Neanderthals, in terms of morphology, age distribution and some of their behavioural traits.

First, we address questions related to potential matching of specimens using dental traits, developmental criteria (such as the developmental state of the tissues, the perikimata, hypoplasia and enamel defects), the degree of occlusal wear, as well as the taphonomic alterations. We found a total of 6 pairing, which is not a common result for a collection of Neanderthal isolated teeth. This allows us to discuss the minimal number of individuals, the horizontal dispersion of the remains within their stratigraphic units and the loss of other skeletal parts.

Secondly, we note that the Neandertal individuals from the Grotte du Bison are rather young adults, as most of the teeth are unworn. However, some teeth have wear surfaces that cannot be the result of a regular occlusal mechanic, but rather non- or para-masticatory activities. These wear surfaces could be associated, for example, to the other indicators of hide preparation materials (scrapers, pebbles, ochre) found in the Mousterian layers.

Lastly, we studied the morphological variation of the dental traits at the outer enamel surface and at the enamel-dentine junction, and especially the morphological variability of maxillary and mandibular premolar (crowns and roots).

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Poster Presentation Number 28, Session 1, Thursday 17:45-19:15

## A volumetric analysis of handaxe symmetry referencing a known symmetrical ideal

**James Hicks**[1,2]

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This presentation outlines a novel volumetric approach to simultaneously analyzing bifacial and bilateral symmetry in Acheulean handaxes. It begins with a focus on the archaeological discussion and evolutionary importance of symmetry in Acheulean handaxes (e.g., [1]) and offers a concise review of previous analytical methods covering both qualitative and quantitative approaches to analyses of Acheulean handaxe symmetry. These include the Index of Symmetry [2], the Flip Test [3], the Continuous Symmetry Measurement [4], and the Index of Deviation from Symmetry [5] as well as recent volumetric approaches to handaxe symmetry. It will outline the constraints and limitations of these traditional approaches to artifact symmetry, discussing their bias toward measures of bilateral symmetry, before introducing a novel approach. This method employs a custom Python script to compare the volume of the largest possible bifacially and bilaterally symmetrical 'Ideal' — a high-resolution complex polygon with a roughly equivalent number of vertices as the 3D model of interest — that can occupy the internal topology of the 3D model of interest without exceeding its boundary. The Omega (ω) Coefficient of Symmetry will be introduced as a ratio describing the quotient of 1) the volume of the largest Ideal that can occupy the internal topology of a digitized handaxe as the numerator, and 2) the volume of the digitized handaxe as the denominator. Can archaeologists gain novel insights by employing this approach to simultaneously analyze the contributions of both bilateral and bifacial symmetry represented as a simple ratio of lithic symmetry robust to variations in size, orientation, and morphology? Might this volumetric morphometric approach not only provide high-resolution analyses of 3D bilateral symmetry, but insights into questions regarding the underserved analyses of 3D bifacial symmetry? Could this coefficient of symmetry be employed to eventually answer previously unexplored questions regarding the emergence of overdetermination in the archaeological record? The presentation will conclude by discussing the limitations and future applications of this volumetric method for simultaneously analyzing bifacial and bilateral symmetry and its possible applications to other unresolved debates in the field of evolutionary cognitive archaeology and beyond..

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Podium Presentation Session 4, Friday 9:30-11:10

## Something old, something new, what is reworked, what is true? A new chronostratigraphic model and provenance assessment for the hominin fossils from Trinil (Java, Indonesia)

**Sander Hilgen[1,2], Eduard Pop[1], Sofwan Noerwidi[3], Shinatria Adhityatama[4], Ni Luh Gde Dyah Mega Hafsari[5], Harold Berghuis[6], Tom Veldkamp[7], Indra Sutisna[8], Dida Yurnaldi[8], Klaudia Kuiper[2], Guillaume Dupont-Nivet[9,10], Tony Reimann[11], Norbert Nowaczyk[10], Wout Krijgsman[12], Hubert Vonhof[13], Dian Rahayu Ekowati[5], Gerrit Alink[6], Olafianto Drespriputra[14], Alexander Verpoorte[6], Remco Bos[12], Thijs van Kolfschoten1[5], Truman Simanjuntak[5], Wil Roebroeks[6], Josephine Joordens[1,2,6,16]**

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In the early 1890s, under supervision of Eugène Dubois a hominin skullcap and femur were found at Trinil, in deposits situated at the same horizontal level ca. 10-15 m apart. He interpreted these fossils as representing one species, *Pithecanthropus erectus* (now *Homo erectus*) which he inferred to be a transitional form between apes and humans. As the skullcap looked archaic and the femur surprisingly modern, this interpretation has been questioned since their discovery. More than a century later these doubts surrounding the skullcap and femur continue to exist, with (bio)stratigraphic arguments gaining importance–thereby raising the stakes to not only the association between the hominin fossils, but also the homogeneity of the complete Trinil fossil assemblage. However, evidence on the provenance and the age of the Trinil hominin fossils remains inconclusive.

Here we present a new chronostratigraphic model for the Trinil site that is based on our geoarchaeological fieldwork from 2016 till 2019 at and around Trinil, including new stratigraphic sections and testpits, and geochronological analyses (40Ar/39Ar, paleomagnetic, and pIRIR290) on samples from freshly exposed deposits [1-2]. This chronostratigraphic model [2] was subsequently connected to an analysis of the historical excavation documentation, i.e., the stratigraphy as documented by Dubois and Selenka, the position of the historical excavation pits, and the hominin fossils found in these pits [3].

At Trinil, no less than five strata can be identified at the same low water level within the area of the historical excavation site, ranging in age from the Early to Late Pleistocene. Cutting into a late Early Pleistocene lahar breccia (BGL-51) are two similarly oriented, but asynchronous fossiliferous fluvial channels: Bone-Bearing Channel 1 (BBC-1) dated to 830-773 ka, and BBC-2 dated to 560-380 ka [2]. Their fossil-rich infills can be identified as the primary targets of the historical excavations (the 'Hauptknochenschicht' -H.K.) and yielded most of the hominin fossils [3]. It is likely that during historical excavations material from both units was collected, and that the Dubois and Selenka collections from Trinil therefore represent mixed assemblages. Furthermore, evidence for reworking [1] indicates that both BBC-1 and BBC-2 may contain fossils from older deposits. Moreover, within the historical excavation area the BBC-1 and BBC-2 were incised by terrace-related fluvial channels of terminal Middle or Late Pleistocene age, introducing an additional source of temporal heterogeneity in the Trinil fossil assemblage. Critically, these younger channels most likely intersected the reconstructed discovery location of Femur I.

These findings have important implications for Pleistocene studies on Java, particularly for the biostratigraphy of Java and for the current framework of human evolution. First of all, these findings raise serious concerns regarding the use of the 'Trinil H.K. fauna', the fauna collected by Dubois from fossil-rich deposits near low-water level at Trinil, as a biostratigraphic unit. Although the majority of the fauna may potentially derive from a single older source (e.g., being of equivalent age as the ca. 900 ka old Trinil H.K. fauna from Sangiran), it is difficult to quantify fossil supplements contemporaneous with the age of the younger deposits exposed at Trinil. Secondly, our observations provide a plausible explanation for the modern human-like morphology of Femur I–the "bone of contention", relative to the skullcap that shows more similarities with late Early Pleistocene specimens from Sangiran, and to femora II-V–for which the attribution to Homo erectus is undisputed. But if Femur I is not early or middle Pleistocene *Homo erectus*, then, what is it? We will explore several options for its taxonomic identity, including a late *Homo erectus* as e.g., found at Ngandong, early *Homo sapiens*, and Denisovan.

This study was carried out with the permission of the Indonesian Ministry of Research, Technology and Higher Education, under the project 'Studying Human Origin in East Java'. We thank Arkenas (Pusat Penelitian Arkeologi Nasional) and in particular Dr. I Made Geria, Priyatno Hadi Sulistyarto, and Marlon Ririmasse for facilitating and supporting our collaborative research. We would also like to thank BPCB Jawa Timur and the Government Regency of Ngawi for giving us support and permission to do research in Trinil. The research was funded by the Treub Foundation (Maatschappij voor Wetenschappelijk Onderzoek in de Tropen), SNMAP (Stichting Nederlands Museum voor Anthropologie en Praehistorie), the Faculty of Archaeology, Leiden University, and the Dutch Research Council NWO (Grant number 016. Vidi.171.049 to Joordens).

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Poster Presentation Number 29, Session 1, Thursday 17:45-19:15

## Lithic microwear analysis of the Baradostian (Zagros Aurignacian) material from the recent excavations of Shanidar Cave, Iraqi-Kurdistan

**Michael Hitchcock**[1]

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The Baradostian culture, named for its discovery at Shanidar Cave on the Baradost Mountain (Zagros Mountain range, Iraqi-Kurdistan), is an Early-Upper Palaeolithic industry typified by burins, bladelets, and scrapers [1-2]. It is one of the earliest tool typologies associated with anatomically modern humans (*Homo sapiens*) outside of Africa and may have originally developed in this region before spreading into Europe [3]. Recent excavations at Shanidar Cave have unearthed over 300 lithics attributed to the Baradostian industry which were assessed for microwear analysis and for any notable residues.

Analysis was conducted using a Nikon SMZ1270 stereomicroscope as well as a Huwvits HRM-300 3D microscope at magnifications between 12-80x. Edges were assessed for traces of possible wear, with features such as rounding, striations and fracture scars being recorded. Additionally, the presence of any residues was noted when present. The tool type, raw material, measurements and colour were also recorded for each individual lithic. When edge modifications were noted, they were photographed on both microscopes and were compared to a purpose made experimental programme, as well as published literature in order to determine the function [4].

The category which preserved the highest levels of use-wear was unretouched flakes, which appear to have been used primarily as butchery tools, with evidence for contact with meat/skin and in some instances fresh bone. Burins show heavy work attributed to crafting (shell or bone working); this is also reflected in the archaeological material recovered from the site [5]. Multiple scrapers suggesting regular hide-working practices at the site, likely on fresh or wet hide. Blades and some instances of bladelets appear to have been used both for wood and bone working. A number of pieces have been found with ochre on them, with other forms of residue being noted possibly relating to hafting. Some pieces present heavy retouching associated with the Zagros region, with overlapping layers of use present between layers of scars. The preliminary results for the Baradostian use-wear of Shanidar cave shows that people were conducting regular activities such as hunting and the processing of animals as well as wood-working but also had time for perhaps less essential and more creative pursuits as shown by the presence of ochre and the crafting of decorative shell and bone pieces.

I would like to thank my supervisors Laura Bishop and Chris Hunt, for their continued guidance and assistance throughout my project. I am grateful to the rest of the Shanidar Cave project team for helping me to become a better researcher. I would also like to thank my parents for their love and affection throughout this thesis and the entirety of my life. Finally, this work could not have been made possible without the constant support and care provided by partner Natalie, her belief in me kept me going even when I found it hard to. Thank you all.

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Pecha Kucha Presentation Session 3, Saturday 16:40-17:55

## A new multi-approach method for taxonomically identifying isolated hominin teeth from the Omo, Ethiopia

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One of the longest-studied hominin-bearing fossil sites in eastern Africa is the Omo Basin of Ethiopia, prominently investigated from 1967-1976 [1] and more recently since 2006 [2]. Sediments exposed by the Omo River produce an abundant fossil record of ca. 3.5 to 1 million-year-old terrestrial faunas. These 2.5-million years represent a particularly interesting time in human evolution because they capture the early evolution of the genus *Homo* and the first appearance of the eastern African robust hominins. However, fossils from the Omo tend to be highly fragmentary, with isolated teeth being among the most common elements recovered.

While teeth are often the most diagnostic element for vertebrate paleontological taxonomy, teeth in isolation are much less informative. Previous studies have taken on the challenge of identifying the taxonomic affinities of isolated teeth from the Omo [e.g., 3]. We revisited the taxonomic identification of isolated teeth from the Omo for two reasons. First, there have been discoveries that dramatically alter and improve our understanding of hominid evolution since those previous studies were conducted, such as *Ardipithecus ramidus*, *Australopithecus garhi*, *Au. deyiremeda*, *Homo erectus* from Dmanisi, and *Au. sediba*. And second, with the Omo Group Research Expedition's renewed fieldwork in the Omo [2], dozens of new hominin specimens have been recovered, demonstrating that the Omo localities (and their proclivity to yield isolated teeth) will continue to contribute evidence of human evolution during this particularly intriguing time period. Consequently, we need to continue to improve our ability to infer taxonomy from isolated teeth.

We developed a four-pronged approach that produces most-likely taxonomic identifications based on the external crown morphology of postcanine hominid teeth. For the first component, we ran linear discriminant analyses of linear crown dimensions on a comparative dataset of 464 hominid teeth (with well-established taxonomic identifications) that were then used to predict the classification of 114 crowns from 94 specimens from the Omo (including 22 new specimens). For the second and third components, we ran a cluster analysis on the morphological scores and on the 2-dimensional cusp areas for subsets of the study sample. The fourth part of our approach was a comparison of the three analytical methods to reach a final decision on taxonomic identification.

Our results demonstrate a significant amount of overlap in size and morphology between the isolated postcanine teeth of *Au. afarensis* and *H. habilis*. This *afarensis/habilis* group dominates the dental assemblage in the earliest part of the Omo stratigraphic sequence, with the robust lineage gradually increasing in proportion. By 2.27 million years ago, we see clear evidence of teeth from genus *Homo* alongside those from the robust lineage. Near the top of the sequence, between 1.38 and 1.09 million years ago, we only find isolated teeth of *Homo*. This tooth-by-tooth analysis also offers insight to the modularity of hominid dental evolution, which will be discussed in the presentation.

This laboratory research was supported with funding from the European Research Council within the European Union's Horizon Europe (ERC-2021-ADG, Tied2Teeth, project number 101054659), a grant from the Spanish Ministerio de Ciencia e Innovación (Project PID2021-122355NB-C33 financed by MCIN/ AEI/10.13039/501100011033/ FEDER, UE), and support from the France-Berkeley Fund (2018 to JRB and LJH). Access to collection and OGRE fieldwork permit were granted by the Ethiopian Heritage Authority. This research benefited from the work of hundreds of people who participated to fieldwork missions, collection management, and preparation within the International Omo Research Expedition and the Omo Group Research Expedition. OGRE fieldwork was principally funded by the Ministry of Europe and Foreign Affairs, the National Research Agency, the Région Nouvelle-Aquitaine, CNRS INEE, PALEVOPRIM, and the Fyssen Foundation.

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Podium Presentation Session 1, Thursday 9:20-11:00

## 3D spatial analyses of the hominin, primate and carnivore fossil assemblages from M4 at the Sterkfontein Caves, South Africa: implications for Plio-Pleistocene ecology, taphonomy and hominin evolution

**Maryke Horn[1], Markos Katsianis[2], Kathleen Kuman[1], Stefania Merlo[3], Dominic Stratford[1]**

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Over the last eighty years, the fossil- and artefact-bearing deposits of the Sterkfontein Caves, South Africa, have yielded remarkable fossils of both hominins and the diverse range of fauna that lived on the landscape over the last 3.67 million years [1]. Member 4 of the Sterkfontein Cave sequence has yielded one of richest the Plio-Pleistocene faunal records in southern Africa and one of the most significant *Australopithecus* assemblages in the world. Due to their close ecological association, hominins, non-hominin primates and carnivores have received the greatest research analytical attention, with specialist studies focusing on their respective biochronology, taxonomy, and taphonomy in order to provide greater chronological, taphonomic and ecological context to the hominin fossil assemblage. Ecological studies suggest a range of environments existed during the formation of Member 4. Similarly, taphonomic studies have identified multiple active accumulation agents of fauna during Member 4 formation. Taxonomically and morphologically, Member 4 is renowned for its hominin and non-hominin primate variability, with the bulk of the fossil assemblage deriving from a nine-meter-thick sequence of the Member 4 deposit exposed on the landscape surface. No internal stratigraphy was documented during excavations prior to the 1990s, and assemblages have by many researchers been considered as a whole despite representing hundreds of thousands of years of deposition. The cause of the mosaicism and variability observed in the fauna may be a result of geogenic time-averaging [2] or a lack of stratigraphic resolution, but the intra- and inter-assemblage spatial relationships have never been analysed to test these. Dedicated research has in recent years established an intra-Member 4 stratigraphic framework [3]. When combined with the recent development of a three-dimensional spatial framework at Sterkfontein [4], it is possible to more effectively associate hominins with their coeval mammal community through time. By conducting intra- and inter-assemblage three-dimensional vector and raster spatial analyses that can test for clustering and spatial patterns, this research will quantitatively and qualitatively explore their associations within Member 4 and clarify their ecological relationships on the Plio-Pleistocene landscape.

We thank the National Research Foundation (NRF), the Palaeontological Scientific Trust (PAST Africa), and the French Institute of South Africa (IFAS-Research) that have made this research possible through their financial support.

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Podium Presentation Session 3, Thursday 16:30-17:30

## Stabilizing selection in the evolution of *Homo* cranial morphology

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The complex evolution of our lineage is observed in the great diversity of cranial morphology in the fossil record of the genus *Homo*. This evolution was the outcome of a balance between maintaining the functionality of anatomical and developmental modules that define the skull and external environmental pressures acting on individuals' fitness over time. Therefore, the myriad of intrinsic and extrinsic evolutionary forces acting on cranial morphology can result in several different outcomes, which ultimately produced the speciation events in our lineage. Despite the complex nature of the evolution of cranial morphology, few studies have explored the possible evolutionary pathways that led to the diversity of shapes seen in the genus *Homo*, especially when it comes to the role of stabilizing selection and non-linear evolutionary forces like punctuated equilibrium. In this study we evaluate the maximum likelihood estimates of several competing evolutionary models (diversifying selection, stabilizing selection, unbiased random walks, punctuated equilibria) to explain the cranial morphological changes across *Homo*. The analyses were based on linear measurements and principal components extracted from the coordinates of 28 neurocranial landmarks that are commonly represented in fossils of the genus *Homo*. The sample includes 61 fossils and 308 modern human skulls grouped into 8 Operational Taxonomic Units (OTUs) that represent *Homo habilis*, *H. erectus*, *H. heidelbergensis*, *H. neanderthalensis*, and *H. sapiens*. The maximum likelihood estimates for the models were calculated for three possible lineages: one that assumes direct ancestral-descendant relationships between all OTUs, a second one assuming Neandertals are the terminal lineage (and excluding all OTUs representing *H. sapiens*), and a third lineage that assumes Neandertals are not ancestral to modern humans. The results show that stabilizing selection has the highest fit likelihood in 64.0% of the variables tested, and random walks are the best fit for 25.5% of the variables. Directional selection is only the best fit in 1.3% of the variables. When the fit of the evolutionary models is tested for the PC dimensions that best separate the OTUS in each lineage, the *Homo sapiens* lineage shows strongest fit to linear diversifying selection, but the Neandertal lineage and the lineage considering all OTUs show stronger fits to stasis and unbiased random walk models. These results suggest that, despite the changes observed in the genus *Homo*, the constraints acting on the accumulation of variance are possibly the most important baseline in the evolution of the cranial morphology of *Homo*. Therefore, developmental, functional, and evolutionary constraints must be taken into account in discussions about the evolution of our genus.

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Podium Presentation Session 7, Saturday 11:00-12:40

## Who were the makers of the Lincombian-Ranisian-Jerzmanowician? New evidence from the site of Ilsenhöhle in Ranis (Germany)

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Lincombian-Ranisian-Jerzmanowician (LRJ) is a technocomplex from the period of transition between Middle and Upper Paleolithic. It covers the northern European plain from the UK to Poland. Based mainly on techno-typological arguments, it has been attributed to either Neanderthals [1] or *Homo sapiens* [2]. What we lack are LRJ assemblages with associated hominin fossils, but unfortunately most LRJ sites were excavated before the middle of the 20th century and only a handful of them still have intact archeological deposits or well provenanced bone assemblages.

One of the eponym sites of the LRJ, the cave site of Ilsenhöhle in Ranis (hereafter "Ranis") located in the Orla River valley (Thuringia), was mainly excavated by W.M. Hülle3 between 1932-1938. Here intact deposits remain, and in 2016, the Thuringian State Office for the Preservation of Historical Monuments and Archaeology and the Department of Human Evolution at the Max Planck Institute for Evolutionary Anthropology started a project to clarify its chronology and to identify the makers of the LRJ. The site has a complex stratigraphy almost 8 m thick that includes massive limestone blocks resulting from the collapse of the cave roof during the last Pleistocene glacial phase. This situation made the excavation of the site technically very problematic but also preserved in situ layers that were untouched by earlier excavators. Using an extensive set of radiocarbon dates, sedimentological analysis, and an analysis of archeological material from both our excavations and the previous excavations, we have correlated the stratigraphy observed during our excavations with that recorded by Hülle. The LRJ occupations from two thin layers at the bottom of the site can be securely dated to 47,490-45,770 cal BP and 46,830-43,260 cal BP, respectively (modelled ranges at 95.4% probability).

We performed a combination of proteomic screening on 1,322 bones from the 2016-2022 and the 1932-1938 excavations, morphological screening of all of the LRJ related bones from the 1932-1938 excavation, and morphological screening of 756 bones from the 2016-2022 excavation from Ranis. Among the LRJ associated material, we were able to identify 13 hominin bones. Four hominin bones from the 2016-2022 excavation could be directly dated. The other 9 hominin bones come from Hülle's excavation, and six of these could be directly dated. All of our radiocarbon dates on these hominins fit within the date ranges for the LRJ reported above. We extracted mtDNA from 11 of these hominin remains, all of which were identified as *Homo sapiens*. Identified sequences were part of Haplogroup N and had molecular dates of 44,646 years ago (95% highest posterior density: 32,200-55,700) consistent with their direct radiocarbon dates.

Our results present reliable evidence that, at Ranis, hominins with *H. sapiens* mtDNA are directly associated with the LRJ. This indicates a very rapid expansion of pioneer groups of *H. sapiens* into the higher mid-latitudes of Europe, possibly as far as the British Isles, much earlier than previously thought. It contrasts with the later persistence of Neandertals further south.

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Poster Presentation Number 30, Session 1, Thursday 17:45-19:15

## Looking inside the skull: the internal cranial features of Maba 1 (Guangdong, China)

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The Maba 1 hominin remain is a key and the most controversial specimen in the study of East Asian human evolution. The Maba 1 fossil is a partially complete cranium discovered in Guangdong Province, China, in 1958. The dating of the Maba 1 fossil remains controversial, but most studies suggest it can be dated to between 300 and 130 ka. Since its initial unearthing, the Maba 1 cranium has garnered considerable attention due to its unique composite morphological characteristics, exhibiting a remarkable amalgamation of traits shared by both Asian *Homo erectus* and *Homo neanderthalensis*. Notably, the facial morphology of the Maba 1 cranium, including the presence of circular orbits and robust supraorbital ridges, bears resemblance to the anatomical features observed in *Homo neanderthalensis*.

Recent studies employing geometric morphometric analyses have further shed light on the facial morphology of the Maba 1 fossil, establishing its position within the range of African and European Middle Pleistocene hominins and highlighting its closer affinity to the Neanderthal lineage. However, the facial preservation of the Maba 1 fossil is incomplete. We still need further evidence to discuss the taxonomic position of Maba 1. Consequently, it becomes imperative to redirect our attention towards the internal cranial structures that have received relatively limited scrutiny.

In our study, by applying high-resolution Micro-CT imaging (slice thickness = 0.05 mm), we examined the internal microstructures of the Maba 1 cranium and reconstruct various anatomical features, including the diploic venous system (DVS), emissary venous system (EVS), frontal sinuses, as well as the endocast. For the DVS and EVS, qualitative observations were conducted, while linear measurements were performed on the frontal sinuses. Concerning the endocast, three-dimensional geometric morphometric analyses were employed. The data on Maba 1 were compared with Asian, European, and African middle & late Pleistocene hominins, as well as fossil and extent *Homo sapiens*.

The results show that the frontal sinus measurements of the Maba 1, as well as the morphology of the endocast, exhibit Neanderthal affinities and are distinct from *Homo sapiens*. The drainage pathway of the DVS includes an anastomosis with the frontal sinus, which is relatively rare in *Homo sapiens*. Additionally, the EVS contains the parietal foramina, a feature that occurs less frequently in Homo neanderthalensis but has been recorded in another Neanderthal-like fossil (Xujiayao) from China. Overall, the evidence from internal structures is consistent with previous studies on external morphology, all of which have identified Neanderthal affinities in Maba 1.

Poster Presentation Number 31, Session 1, Thursday 17:45-19:15

## Revisiting the Last Glacial-Interglacial Transition in Europe: a new expert-sourced macro-archaeological dataset and some first results

**Shumon T. Hussain[1], David N. Matzig[1], Miguel Biard[2], Philippe Crombé[3], Federica Fontana[4], Daniel Groß[5], Thomas Hess[1], Mathieu Langlais[6], Javier Fernández-Lopéz de Pablo[7], Ludovic Mevel[8], William Mills[9], Martin Moník[10], Nicolas Naudinot[11], Caroline Posch[12], Tomas Rimkus[13], Damian Stefański[14], Hans Vandendriessche[3], Felix Riede[1]**

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We here present a newly compiled database designed to revisit continental-scale questions of cultural taxonomy and lithic technological evolution between ca. 15,000 and 11,000 years ago. This database presents the fruits of a collaborative effort undertaken in the framework of the ERC-CoG project CLIOARCH, pulling together expert-sourced state-of-the-art data on 16 macroregions across Europe featuring a total of 86 unique entries of named archaeological cultures (NACs) spanning the Late Upper Palaeolithic, Final Palaeolithic and earliest Mesolithic. Each NAC composes information on lithic technological organization (mainly blank production) and toolkit structure, and hosts a library of key 2D artefact shapes. The dataset promotes the pan-European investigation of taxon-level variability and consistency in naming practices and offers some important new insights into the nonlinear dynamics of lithic technological evolution across the Last Glacial-Interglacial transition. The open-source, macro-archaeological dataset notably facilitates the quantification of modes and rates of lithic technological change across different technical domains (laminar reduction technology, toolkit structure and whole-outlines of tools) and highlights previously underestimated asynchronies and decoupled rhythms of change as well as key moments of technological diversification with important inter-domain trade-offs. The compiled data further demonstrate the complex landscape of cultural taxonomic denominations currently framing archaeological research of the Last Glacial-Interglacial transition. While some NAC-groupings such as those related to the Magdalenian sensu lato, the Tanged Point Complex and to some extent the Arch-Backed Complex (Azilian and Federmesser-related NACs) perform surprisingly well and exhibit higher within-group similarity than randomized similarity with other NACs in the dataset, other affinities as signaled by current naming conventions are more difficult to recover. These initial results are promising and showcase the profound potential of collaboratively collated pan-European datasets on lithic technological evolution, even though the quality of such data requires ongoing attention.

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Poster Presentation Number 32, Session 1, Thursday 17:45-19:15

## Developing methodologies for understanding the interaction between culture and environment: a case study from Southern Africa using the ROAD database

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This contribution aims to develop a methodology that examines the interaction between culture and environment during the Late Pleistocene. We will focus on the well documented archaeological record of Southern Africa and use available climatic proxies and simulations to understand how human settlement may have been constrained by the environment and to what degree hunter-gatherer groups were interconnected beyond ecozones.

Methodologically, our study will be based on two approaches. The first will analyze cultural networks based on material evidence from diverse technocomplexes. The second will employ ecological niche modeling to characterize the suitability of the landscape for human occupation. By merging these methods, we hope to validate whether cultural connectivity among assemblages through time and space is also reflected in ecological connectivity, for example through natural barriers, corridors or refugia in the landscape.

From the cultural side, we plan to use datasets from the ROCEEH Out of Africa Database (ROAD) (https://www.roceeh.uni-tuebingen.de/roadweb/) combined with new results from our ongoing research to gain information about sites in Southern Africa spanning from 130,000 to 20,000 years ago. The datasets will provide detailed information about localities (sites), stratigraphy, technocomplexes and dating, as well as the specific assemblages (finds) contained therein. We will attempt to constrain the datasets by chronometric ages and not necessarily by technocomplexes to avoid issues with sample bias and time averaging. For environmental data we will combine published climate model simulations [1-3] with proxy-based climate reconstructions [4-5] and assess their suitability through correlation and collinearity, thus avoiding problems arising from relationships among environmental predictor variables.

While the study has just begun, we hope to test some of the following ideas. First, the extent to which human behavior and material culture responded to environmental changes and whether range expansions are also reflected within cultural innovations. Second, whether or not the makers of different material culture inhabited different ecological niches, and consequently what variables shape the spatio-temporal relationships between hominin habitats. Third, whether we can confirm that the cultural record reflects a pattern of coalescence and fragmentation. Fourth, whether or not we observe regularities in the environmental signal related to the less well known technocomplexes of MIS 5 and MIS 3.

Although a natural influence of environmental factors on human behavior is generally assumed, in the majority of cases the resolution of underlying data is weak. By combining the strength of ROAD with ongoing research conducted by different collaborating teams in several parts of Southern Africa, we are optimistic that we can provide a coherent synthesis using state of the art data.

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Poster Presentation Number 33, Session 1, Thursday 17:45-19:150

## Taxonomic identification of worked bone from the Middle-Upper Palaeolithic Transition: testing non-destructive methods

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We have recently begun to uncover a new, previously hidden source of information; the species choice of material for worked bone from the Middle-Upper Palaeolithic. Worked bone artefacts are an intriguing part of the Middle-Upper Palaeolithic record, as we know very little about the faunal species they are made from due to the degree of modification they undergo. Previous studies that assessed manufactured bone tools were restricted to material that could only be identified due to minimal alterations on the worked bone. Frustratingly, most bone artefacts have undergone significant amounts of anthropogenic surface modification. The transformation process from animal resource to cognitively meaningful bone artefact thereby removes the visible species identity of the source material and the bone artefact becomes unidentifiable based on morphological observations. Previous studies focusing on the materiality of bone artefacts are therefore severely limited in their taxonomic and *chaîne opératoire* conclusions. As a response to these investigative limitations, new methods such as ZooMS – Zooarchaeology by Mass Spectrometry, have been pivotal in bridging the gap within research where unidentifiable faunal material is ignored and deemed uninformative. This study addresses these limitations by applying ZooMS to unidentified worked bone from the Middle-Upper Palaeolithic of Europe. As part of a case study from the pilot project, we present the methodological approach that will establish the sampling technique(s) that causes minimal/no destruction to the bone. This study has the potential to alter the way researchers choose to sample rare archaeological bone artefacts in the future. Moreover, this approach will shed light on bone tool manufacture and what the human-environment interaction entailed. Finally, the application of ZooMS will assist in understanding if and how resource acquisition and modes of procurement compare throughout the Middle-Upper Palaeolithic, as Neanderthals become extinct, and *Homo sapiens* thrive as the single species in Europe.

Poster Presentation Number 34, Session 1, Thursday 17:45-19:15

## Foods from the forest: a nutritional analysis of wild plant foods used by the Baka forager-horticulturalists in Southeastern Cameroon

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An important anthropological field of enquiry is that of the dietary practice of our ancestors. Past diet has been crucial to the evolution of our lineage, as changes in dietary practice have been associated with brain expansion, cooperation, tool-making, and family formation. Moreover, it is implied that hunter-gatherer diet can be recruited as a reference standard for the evolution of human nutrition [1]. Given that foragers live a lifestyle most similar to that of our ancestors, some researchers have argued that the average diets of hunter-gatherers could represent an ideal human diet [2]. However, the variability among hunter-gatherer diets remains undervalued in these studies and the predominant part of investigation has focused on African populations from open grasslands and savannahs [3]. On the other hand, groups from rainforest-type environments have been largely understudied [4].

Currently, one of the societies occupying the Congo Basin rainforest is that of the Baka forager-horticulturalists, of which some 40,000 individuals live in Cameroon [5]. The Baka provide an excellent opportunity for investigating subsistence behaviour within groups that forage in an African rainforest-type environment. Our main goal is to present new data on the macronutrient composition of wild, edible plant taxa foraged by the Baka in southeastern Cameroon, and to elucidate the variability within hunter-

gatherer diets. We present a nutritional analysis on 30 samples of Baka wild edible plant foods that were collected during fieldwork in four villages in southeastern Cameroon, in 2018 and 2019. Nutritional analysis of the samples was conducted at Food and Quality design department of Wageningen University & Research.

We found that tubers are the main suppliers of plant-based carbohydrates. Nuts and seeds are high in fat relatively to all other food types. Total dietary fiber is highest in leaves, followed by fruits. Fruits are significantly higher in carbohydrate content in comparison to leaves. However, leaves are the main plant-based protein source, alongside Arctium lappa tubers and Panda oleosa nuts. Interestingly, the main starchy tubers from the genus Dioscorea show high values of within-species variation, likely caused by maturity of the individual plant specimens.

Combined with other studies on the average diets of the Baka, our data allow us to compare dietary composition and nutritional qualities of a rainforest diet to those from other foraging societies. Our preliminary results suggest considerable differences between groups. These results suggest that the notion of an ideal human diet should be approached with caution.

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Poster Presentation Number 35, Session 1, Thursday 17:45-19:15

## A biomechanical and shape assessment of the mandibular corpus in the Banyoles mandible

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The Banyoles mandible, from the northeast of the Iberian Peninsula, has generally been considered to show affinities to the Neandertals or to represent a Middle Pleistocene hominin. Uranium-series and electron spin resonance dating suggest the mandible dates to the Late Pleistocene (Tarantian), approximately 40-70 ka, excluding the possibility of a Middle Pleistocene age for the specimen. We recently performed a reassessment of the Banyoles mandible through an evaluation of the frequencies of anatomical traits on the mandible as well as through an external 3D geometric morphometric analysis. Our results ruled out Neandertal affinities and, instead, showed closer shape resemblances to *Homo sapiens*. The present study examines potential relationships between aspects of bone shape and the underlying biomechanical properties at key masticatory regions of the mandibular corpus in Neandertals and *H. sapiens* to further elucidate the taxonomic affinities of the Banyoles mandible.

We compared Banyoles to a sample of 42 CT or micro-CT scans of human mandibles representing 20 recent *H. sapiens*, 8 Upper Paleolithic *H. sapiens*, 3 early *H. sapiens* and 11 Neandertals. We generated 2D cross-sectional images of the mandibular corpus between the central incisors, between the right and left third and fourth premolars, and right and left first and second molars. We placed semilandmarks along the external and internal cortical bone and subjected them to a 2D Geometric Morphometric analysis. Standardized biomechanical variables were estimated from the cross-sections. Group membership based on biomechanical and shape variables were quantitatively assessed through Principal Component Analyses and predicted by Canonical Variate Analyses and Support Vector machines.

The results of our shape analysis demonstrated that, despite some overlap between the shapes of Neandertals and *H. sapiens*, there are clear differences in the corpus shape at all cross-sections. Group differences in the symphysis are associated with the prominence of a chin as well as an eversion of the bone surrounding the genioglossal fossa. For the premolar region, we found that Neandertals tended to have a wider and more everted lingual basal corpus than did *H. sapiens*, who tended to have longer and narrower cross-sections. In the molar region, *H. sapiens* show a narrower cross-section with a greater prominence of bone on the external buccal side. Banyoles expressed cross-sectional shapes most similar to Upper Paleolithic and recent *H. sapiens* but had a wider basal symphyseal corpus and a thicker basal corpus between the premolars. Canonical variate analyses of each cross-sectional shape presented a mixed signal and had low to moderate total predictive accuracy (<75%); grouping Banyoles with Neandertals at the symphysis and in the molar region but with *H. sapiens* in the premolars, which overall showed the highest predictive accuracy. When implementing support vector machines, we found greater overall predictive accuracy (85–100%), and each cross-section showed the shape of Banyoles to more closely resemble *H. sapiens* than Neandertals.

The mandibles of Neandertals, on average, show higher bending rigidity and breaking strength than do *H. sapiens*. Generally, Banyoles had lower bending and breaking resistances as well as relative cortical area than Neandertals and instead resembled *H. sapiens* in nearly all cross-sections. Uniquely, Banyoles had the one of the lowest absolute and relative cortical area values for each cross-section in our entire sample, but also had some of the highest bending resistances in the entire sample at the molar junction.

In conclusion, Banyoles shows close affinities with *H. sapiens* in both corpus shape and biomechanical properties. However, Banyoles also expresses an unusual combination of biomechanical signals which may shed light on human mandibular diversity.

We would like to express our gratitude to the Alsius family for giving us permission to study the Banyoles mandible and for providing us access to the CT scan to conduct this study. We would also like to express our gratitude to the institutions that have provided us with CT and Micro-CT scan data to conduct this analysis. Specifically we would like to thank the University of Pretoria (Bakeng se Afrika digital skeletal repository) and the University of Kent for access to microCT scans of recent human mandibles. Additionally, we would like to thank Musée de L'Homme, Tel Aviv University, Université de Bordeaux, ANR project "Big Dry" (ANR-14-CE31), Natural History Museum, and NESPOS for access to fossil mandible CT and Micro-CT scans. This study is in part funded by Binghamton University and forms part of Project PID2021-122355NB-C31 supported by MCIN/AEI/10.13039/501100011033/FEDER, UE of the Government of Spain.

Podium Presentation Session 1, Thursday 9:20-11:00

## Signatures of incomplete lineage sorting in the phenotypes of great apes

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Advancements in whole genome sequencing reveal that up to 15% of the modern human genome is more closely shared with gorillas, despite chimpanzees being our closest living relatives [1]. This pattern can arise from incomplete lineage sorting, or ILS, in which ancestral gene copies fail to segregate accordingly during rapid speciation events with large effective population sizes ($N_e$). This process results in discordance among species trees and gene trees in many taxa, including in hominids [2]. Identifying the impacts of ILS affected genes on hominid phenotypes requires genotype-phenotype mapping, which has so far been hampered by the lack of studies linking phenotypic variation with underlying genetic mechanisms across these species. Additionally, despite centuries of morphological comparisons among hominids, systematic comparisons of phenotypic variation among these species remain few. To understand the impact of ILS affected genes on hominid phenotypes, we reviewed literature comparing extant hominid (*Gorilla* sp., *Pan* sp., *Homo sapiens*) morphologies to identify traits that are more similar between human and gorilla than between human and chimp. Forty-eight out of 493 studies suggest signs of morphological hemiplasy, in which phenotypic similarities contradict the speciation process. For example, thumb-to-digits proportions of modern humans more closely resemble gorillas than those of chimpanzees or orangutans, which appears independent of locomotory adaptations [3]. The scapula is also repeatedly considered taxonomically controversial, as humans and gorillas share superoinferiorly broad scapulae and similarities in the associated muscles, distinct from that of chimpanzees [4]. Papers comparing only humans and gorillas demonstrate that they additionally share several ocular characteristics, such as globe dimensions, iridoscleral contrasts, and thickness of the cornea and lens [5]. Morphological comparisons were generally biased towards solid tissues (66.7% of the papers, while 30.6% focused on soft tissues and 2.6% on both), particularly the craniofacial and appendicular skeleton, and sample sizes were typically small (<50 individuals/species). First, to gain a more complete picture of hominid phenotypic similarities, future studies should focus on other body regions, for example the axial skeleton and soft tissues using advanced bioimaging such as CT and MRI. Second, transgenic mouse models are able to link identified ILS affected gene variants to phenotypic expression, and can thereby be used to determine if phenotypic similarities are caused by ILS or other evolutionary mechanisms, such as symplesiomorphy or convergent evolution. Third, the increasing application of digital morphology now allows for improved data sharing among biological anthropologists, which will be needed to fill gaps in species sampling, particularly for gorillas which are often missing or poorly represented in morphological comparisons. Finally, interdisciplinary research between phenotypic and genetic disciplines is crucial to explain observed discordances between hominid species trees and gene trees, and ultimately gain a clearer understanding of the evolutionary history of hominids. As such, our literature survey highlights potential avenues of future research on this topic using targeted experimental and digital methods, and provides preliminary evidence of ILS affected phenotypes among hominids.

I am deeply grateful for the guidance and support both my supervisors, Prof. Guojie Zhang and Prof. Christy Anna Hipsley, have provided during the preparation of my first chapter of my PhD, resulting in this perspectives paper. I would not have been able to comprehend the combination of two distant disciplines without their experience and knowledge in both fields. Furthermore, a special thanks to Prof. Søren Rosendahl (Ecology & Evolution, Department of Biology, University of Copenhagen), for discussing ILS, hybridization, and symplesiomorphy with me. I am also deeply thankful for the numerous researchers publishing great morphological studies and providing available hominid data in online databases (e.g., MorphoSource).

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Poster Presentation Number 36, Session 2, Friday 11:40-13:00

## Acheulean handaxes in Medieval France: an earlier social history for bifaces

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Handaxes have a uniquely prominent role in the history of Palaeolithic archaeology, and their early study provides crucial information concerning the epistemology of the field. We have little conclusive evidence, however, of their investigation or societal value prior to the mid-17th century. For such information we often rely on the early oral histories of European populations, as recorded in 17th to 19th century works by King [1], Evans [2] and others. From these texts, it is widely stated that handaxes – or 'ceraunia' and 'thunderstones' – were considered to be natural in origin and "shot from the clouds" when lightning struck the ground [1:77]. To our knowledge, the mid-1500s provide the earliest recorded (written or otherwise) instances of ceraunia or 'thunderstones' which likely include handaxes.

Here we investigate the shape, colour, and potential flake scarring on a handaxe-like stone object seen in the Melun Diptych, an oil painting on wood created by the French 15th century artist Jean Fouquet in c.1455. We compare its features with artefacts from diverse Acheulean handaxe assemblages, including several French assemblages from close to the city of Tours where Fouquet was born and undertook much of his work. Commissioned by a high-status individual, Étienne Chevalier, Fouquet's work ('Étienne Chevalier with Saint Stephen') depicts an important religious context, while the handaxe-like object points to the stoning to death of an important Christian saint. Our results strongly support the interpretation that the painted stone object represents a flint Acheulean handaxe, likely sourced from northern France where Fouquet lived. Identifying a 15th century painting of a handaxe does not change what we know about Acheulean individuals, but it does push back the evidence for when handaxes became a prominent part of the 'modern' social and cultural world. Indeed, out results support the inference that handaxe artefacts could potentially have played important social or religious roles in 15th century France – be it for a very limited period or even only in Fouquet's regional social sphere.

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Poster Presentation Number 37, Session 2, Friday 11:40-13:00

## Identifying Palaeolithic birch tar production techniques: challenges from an experimental biomolecular approach

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The intentional production of birch bark tar by European Neanderthals as early as 190,000 years ago plays an important role in discussions about the technological and behavioural complexity of Pleistocene hominins. However, research is hampered because it is currently unknown how Neanderthals were producing birch tar. Unlike resins and gums that are exuded from trees in a naturally sticky state, birch bark tar must be intentionally manufactured. There are a number of different ways that this can be done. Each method varies in apparent complexity, but all require some degree of knowledge about the use of fire to transform white bark into sticky black tar [1]. Identifying tar production processes in the archaeological record is therefore paramount for furthering research on the technical behavioural repertoire of Neanderthals. Organic biomarkers present in tar are altered in specific ways depending on the different physical, chemical, and biological forces that act on them [2-3]. Changes to the biomolecular composition of tar can result from natural processes, but can also be caused by anthropogenic forces, such as thermal degradation due to heating temperatures, oxygen abundance, or chemical interactions during manufacture. These types of alterations therefore have the potential to provide direct insight to the original production and manipulation of the material by those who made it. Gas Chromatograph-Mass Spectrometry (GC-MS), has been used to identify possible production processes during the Neolithic. Depending on whether tar is produced in a single ceramic container, or with a second, separate container to collect the tar, patterns emerge based on the presence or absence of certain fatty acids and diacids [4]. Here we test whether these same biomarkers can also distinguish Palaeolithic (aceramic) tar production methods. We produced tar using five different methods and analysed their biomolecular composition with GC-MS. Our results show that with small sample sizes, the biomarkers used to distinguish Neolithic/ceramic tar production strategies cannot be reliably used to distinguish Palaeolithic/aceramic tar production processes. Significant intra-method variation exists, making it difficult to clearly differentiate production methods. The problem is likely compounded with archaeological remains due to raw material variation and natural decay. More experimentation is therefore required to produce a larger reference library of different tars for statistically valid comparisons. To achieve this, complete GC-MS datasets of experimental and archaeological material must also be made publicly available. The open sharing of data will be essential in future endeavours to illuminate ancient methods of birch bark tar production.

This research was supported as part of the Ancient Adhesives project, funded by the European Research Council (https://erc.europa.eu/) under the European Union's Horizon 2020 research and innovation programme grant agreement No. 678 804151 (grant holder G.H.J.L.). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. We thank the educational archaeological site Masamuda in Vlaardingen (the Netherlands) for their generous use of space for the experiments and Rivka Chasan for assisting with the final GC-MS peak identification.

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Poster Presentation Number 38, Session 2, Friday 11:40-13:00

## Excessive asymmetry of the human endocast in the context of evolutionary changes in hominids

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The human brain reveals a high level of asymmetry that has increased from earlier to later hominids and may favour the appearance of specialized cognitive abilities. Unfortunately, the factors influencing brain asymmetry are still unclear. Given that brain development and function depend on a constant blood supply (i.e., the brain receives approximately 15-20% of cardiac output), we assume that differences in blood flow rates between hemispheres may have an effect on brain asymmetry. Especially that dimensions of the carotid foramen disproportionately increased from *Australopithecus* to archaic *Homo sapiens*, which influenced brain reorganization. Therefore, the following hypothesis will be tested: the increase in brain asymmetry during the hominid evolution is associated with the increasing differences in blood flow rate between the hemispheres that are restricted by the cranial foramina. If that hypothesis is confirmed, the increase in endocast asymmetry should be preceded by an increase in the asymmetry of the cranial foramina and hence a greater asymmetry of the blood flow and the middle meningeal system during hominid evolution.

To test the above hypothesis, specimens from various species, geographical areas, and chronological periods will be analysed. The analyzed material included CT scans of 800 skulls with preserved brain case and cranial base of non-human primates, extinct hominins, Upper Palaeolithic *H. sapiens*, Late Palaeolithic *H. sapiens*, prehistoric and historical human populations, and modern human populations.

3D skull models from all CTs were performed using Avizo software, and a reconstruction of the endocast and its volume were prepared using the Arothron R package. The endocast asymmetry will be analysed by the location of the most protruding points on, respectively, the right and left frontal and occipital lobes (i.e., the frontal and occipital poles, namely the petalias). The complexity of the middle meningeal system will be assessed on both sides using the following features: number of ramifications (branches), absence/presence of the sinuses, and type of the torcular Herophili. The blood flow rate will be calculated for each hemisphere separately using the equation $Q=155ri2.49$, where ri is the lumen radius of the carotid canal. Other parameters of the carotid canal will also be measured bilaterally: area, circuit, minimum, and maximum lengths.

All 3D models of skulls and endocast are prepared; however, the statistical analysis of the proposed study is still ongoing. The obtained results will show whether the increase in brain asymmetry during the hominid evolution is associated with the increasing differences in blood flow rate and the middle meningeal system between the hemispheres. In addition, the research will show if the variation in endocranial shape and structure in human evolution is related to variation in blood flow.

The authors thank the Morphosource, the New Mexico Decedent Image Database, and the Museum of the First Piasts for sharing the data.

Podium Presentation (Virtual) Session 2, Thursday 14:20-16:00

## Human-like manual activities in hominins predating the genus *Homo*

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The human hand is uniquely dexterous and versatile. Previous research suggested that this high biomechanical efficiency, which is specifically evident in the thumb, might have emerged in the hominin lineage around 2 mya [1]. While the hands of hominins prior to this biomechanical adaptation might not have been as dexterous as ours, they nonetheless engaged in various activities, including tool production and use. Analyzing behaviourally plastic morphologies, such as muscle attachment sites, can help us better understand how these early hominins used their hands in their everyday lives.

We investigated the entheseal patterns of *Australopithecus afarensis*, *Australopithecus africanus*, and *Australopithecus sediba* to reconstruct their habitual manual activities compared to a sample of later *Homo* (*Homo sapiens* and *Homo neanderthalensis*) and three species of non-human great apes. The analysis, following the Validated Entheses-based Reconstruction of Activity (V.E.R.A.) method [2-3], included the entheseal proportions of muscles attaching to the first, second, and fifth rays. The results show that entheseal patterns clearly differentiate between later *Homo* and non-human great apes. In concordance with a previous study [4], later *Homo* presents a relatively large attachment site of the first *dorsal interosseous* (DI1), a muscle heavily used during tool production and use. Additionally, the pattern is characterized by proportionately large entheses of muscles attaching to the fifth digit (*extensor carpi ulnaris*, *abductor* and *flexor digiti minimi*). The fifth digit plays a fundamental role in human-like hand use, including manipulating and stabilizing objects within one hand. These movements would, for example, be carried out by the non-dominant hand during hard hammer percussion or while handling large stone tool industries. However, they are also essential to more general human-like manual activities involving power grasping.

Both *A. sediba* and *A. afarensis* present entheseal patterns concordant with human-like hand use. Unlike the great apes analyzed here, they present large entheseal proportions of the DI1 and muscles of the fifth ray, indicating that they frequently engaged in human-like manual activities involving power grasping and in-hand manipulation. These results disagree with a previous assessment of the *A. afarensis* hand that suggested limited opposability and grip force of the fifth finger, leading the authors to exclude *A. afarensis* as a potential producer of the Lomekwian stone tools. [5]. While our results do not present specific evidence for the production of stone tools, they suggest that the fifth digit played a more important role in the habitual manual activities of *A. afarensis* than previously thought. In contrast to the other australopiths, *A. africanus* presents an entheseal pattern intermediate between later *Homo* and great apes, indicating unique manipulative behaviors in this individual.

Our study highlights the importance of the fifth digit in human-like manipulation. Additionally, it provides evidence for manual activities resembling human-like power grasping and in-hand manipulation in *A. sediba* and *A. afarensis* long before the adaptation to increased manual dexterity [1,4] and the genus *Homo*.

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Poster Presentation 39, Session 2, Friday 11:40-13:00

## Traditional and cluster cranial integration: comparing methods of morphological covariation

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In anatomical structures, the ability of morphological traits to change in a coordinated fashion is a process defined as integration [1-2]. When a region (module) possesses a significantly higher level of within-region integration compared to between-regions, this region behaves in a modular way. Often, modularity and integration are used to investigate the relation among cranial regions during growth and development, to give insights into the driving forces and hierarchies of interactions underlying adult cranial variation. Although numerous studies of integration and modularity have been published, it is surprisingly difficult to use this information to make comparisons or develop generalisations. This occurs because the definition of a priori modules, even though derived from knowledge of their developmental, structural and/or functional differences, is partially arbitrary. Indeed, in literature, the same cranial modules have been defined in a variety of ways in terms of their boundaries and structure [3].

This work aims to test if significant differences arise when comparing analyses deriving from the a priori choice of anatomical modules VS the use of cluster analysis [4] during ontogeny. To address it, we first divided the cranium (with a set of 88 landmarks and 250 semilandmarks) into the three a-priori modules of the cranial vault, face and base, following literature. We applied this division to an ontogenetic dataset of 70 individuals from 0 to 15 years old (3D surfaces reconstructed from CT-scans, New Mexico Deceased Database). We tested and visualised their integration using Partial Least Squares (PLS) and identified the variance/covariance ratios [5], comparing covariations patterns among the 3 cranial regions at different age stages. Then, following a cluster approach to overcome the use of a-priori anatomical modules, for each semilandmark we selected a cluster of 20 closest semilandmarks and performed a 2-block-PLS against the rest of the semilandmark configuration, by first running an individual Generalised Procrustes Analysis (GPA) for each block. This was repeated for all semilandmarks, and a colourmap was plotted, representing the average covariation strength for each semilandmark. We repeated the operation at several age stages and compared the results.

Our PLS results when using a-priori modules indicate that the cranial vault-cranial base pair shows the highest degree of covariation in the early postnatal stages, which decreases significantly after 2-3 years of age. However, all covariation values converge progressively for the vault-base vault-face and face-base pairs during later development. Variance/covariance ratios indicate that a smaller percentage of the cranial vault and base is explained by their covariation with the face in the early stages, further supporting the idea of a modular behaviour of the neurocranium in early phases. The cluster analysis using colourmap at different age stages seems to suggest different modules from those classically defined: the nasal cavity among all others, behaves in a strongly modular way throughout all development, particularly during adolescence. The neurocranium, after initial modularity, behave progressively in a more integrated fashion, with the exception of some possibly dimorphic traits, such as the mastoids and glabellar region, which in adolescence seem to retain a certain degree of modularity.

Future work, by increasing the number of specimens and age range, will allow us to gain more detailed knowledge of the growth and developmental patterns of covariation from infancy to adulthood.

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Pecha Kucha Presentation Session 2, Friday 16:40-17:55

## Towards sustainability in palaeoproteomics? A digestion time comparison for cost and electricity reduction in palaeoproteomic analyses

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The ongoing climate crisis is a major threat to human societies worldwide, and addressing this crisis has therefore become an important part of government, economic, and scientific policies worldwide. The scientific community can take an active part in this challenge by, among other aspects, building sustainable approaches to conducting science. One way of transitioning to a more sustainable science is by reducing electricity and plastic consumption in the laboratory context. This can be achieved by re-thinking steps in existing protocols. In human evolution research, palaeoproteomic applications such as ZooMS (Zooarchaeology by Mass Spectrometry [1]) and SPIN (Species by Proteome INvestigation [2]) allow for the retrieval of biological information from archaeological material, and are increasingly performed on hundreds or thousands of bone specimens in individual studies [3–5]. Traditionally, these applications involve the hydrolysis of proteins into peptides using trypsin during overnight digestions at 37°C. Here we explored the effects of reducing digestion time from 18 hours (overnight digestion) to 3 hours on herbivore skeletal elements from Baiyisha Karst Cave (China) and La Draga (Spain), covering a chronological range from the Middle Pleistocene to the Early Holocene. These two localities also represent a range of preservation environments of broad relevance to archaeology and palaeoanthropology. Each sample was powdered, homogenized, and split between digestion conditions (3, 6 and 18 hour digestions). To each extract, both MALDI-TOF MS (ZooMS) and LC-MS/MS (SPIN) were applied. Our results indicate no statistical changes in terms of attained proteomic species identifications for either proteomic method. However, we do observe minor differences in proteome complexity, collagen type I sequence coverage, peptide composition, and proteome degradation, some of them favourable to obtained proteomic data at shorter digestion times. Thus, our analyses show that the environmental impact of our research can be reduced without affecting data quality, thereby taking an important step towards more sustainable scientific practices.

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Poster Presentation Number 40, Session 2, Friday 11:40-13:00

## Contextualizing the cultural stratigraphy and chronostratigraphy of the Blattspitzen horizon at Hohle Fels Cave, SW Germany

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The biocultural and chronostratigraphic contexts of artifact assemblages of the latest Middle Paleolithic and earliest Upper Paleolithic represent key topics for research in Eurasian prehistory and human evolution. This time of gradually disappearing Neanderthals and occurring of the first *Homo sapiens* populations has always drawn the attention of scientists, especially in terms of lithic studies. In much of Central Europe, the focus was on *Blattspitzengruppe*, which is characterized by bifacial technology and the presence of leaf points and has long been viewed as the main so-called "transitional industry" between the Middle and Upper Paleolithic [1-2,3-4]. The exact status and chronological position of the *Blattspitzengruppe* have been subject to considerable debate and speculation because of the extreme scarcity of reliable chronostratigraphic information from modern excavations and the rarity of inventory finds with leaf points [1,3-4].

In Europe, the Swabian Jura located in southwestern Germany is one of the most critical regions documenting the Middle and Upper Paleolithic sequence. Among the paleolithic sites in the Swabian Jura, Hohle Fels Cave located in Ach Valley is one of the very few that have been excavated using modern techniques. During archaeological excavations in 2020 at this site, the leaf point from Jurassic chert was discovered from archaeological horizons X, which is one of the few cases of leaf points found in stratified sites in Central Europe [3-5]. Here we present new results from the Hohle Fels Cave demonstrating the presence of *Blattspitzen* assemblages long before the beginnings of the Upper Paleolithic and predating 60 ka BP [5]. The observations from Hohle Fels raise important issues about the status of the *Blattspiztengruppe* in Central Europe and question the concept that this cultural taxonomic unit is directly related to the last Neanderthals or a hypothesized transition between the Middle Paleolithic and Upper Paleolithic.

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Poster Presentation Number 41, Session 2, Friday 11:40-13:00

## Trophic structure of the faunal assemblage at Middle Palaeolithic Neanderthal site Neumark-Nord, Germany

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Stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios are a well-established geochemical tool for investigating diet and reconstructing the trophic structure of ancient food webs. While $\delta^{13}C$ is frequently measured in collagen and in the bioapatite of tooth enamel, measurement of $\delta^{15}N$ in the fossil record is significantly limited by poor preservation of collagen in skeletal material (bone/dentine) and the very low organic matter content of tooth enamel.

Here we use stable isotope ratios of fossil tooth enamel ($\delta^{13}C$ and $\delta$15N) to evaluate the trophic structure of fossil fauna from the 120,000-year-old Middle Paleolithic Neanderthal occupation site of Neumark Nord (NN), Germany. Neumark-Nord is a well-preserved Pleistocene interglacial (Eemian) site that offers a rare, high-resolution faunal, floral, and archaeological record for studying Neanderthal adaptation to forested environments on the North European Plain. In contrast to the open mammoth steppe environments often associated with Neanderthals, the interglacial deciduous forests characterizing Neumark Nord would have had high primary productivity but relatively fewer dispersed prey for meat procurement, making it a challenging environment for Neanderthals to live in [1]. Recent evidence for close-range hunting as well as systematic exploitation of megafauna (i.e., adult male straight-tusked elephants weighing up to 13 tons), have major implications for range of adaptive behaviors exhibited by Neanderthals (e.g., cultural knowledge regarding butchery and storage of large amounts of meat) [2]. Thus, clarifying the trophic structure of this ancient food web at Neumark Nord using stable isotopes can provide additional insight into Neanderthal ecology.

In this study, we measured $\delta^{13}$Cenamel [after 3] and $\delta^{15}$Nenamel [after 4] values in the tooth enamel of all available herbivore (fallow deer, red deer, giant deer, auroch, rhino, and straight-tusked forest elephant; n=43), omnivore (bear; n=2), and carnivore taxa (lion, wolf, hyena; n=6) to reconstruct the paleoecology of the fauna at Neumark Nord. Our results show that herbivores have, on average, lower mean $\delta^{15}$Nenamel values (x=5.3 ±1.3‰) than omnivores (x=7.4 ±1.5‰) and carnivores (x=7.5 ±1.9‰). Further, $\delta^{13}$Cenamel values confirm that most of the Neumark Nord fauna foraged predominantly in forested environments, but suggest that some taxa (i.e., aurochs) also grazed, indicating the presence of somewhat open environments at Neumark Nord as well.

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Poster Presentation Number 42, Session 2, Friday 11:40-13:00

## First steps in the reconstruction of the hand of KNM-WT 15000

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Despite the well preserved cranial and post-cranial elements of the fossil KNM-WT 15000 (~1.5 Ma), its hand anatomy is still largely unknown [1]. Only a partial proximal phalanx (KNM-WT 15000-BQ), an intermediate phalanx (KNM-WT 15000-BO) and two potential first metacarpals (KNM-WT 15000-BU and -BV) were recovered. Moreover, in all of them the proximal epiphyses are missing, likely in relation to its juvenile status.

KNM-WT 15000, as a *Homo erectus* [1], chronologically, archaeologically and ecologically has been related to the appearance and expansion of the first complex and standardized human technology, the Acheulean [2]. Therefore, its upper limbs anatomy and manipulative abilities are a main topic of discussion for palaeoanthropologists.

Previous study has argued that KNM-WT 15000-BQ and -BO are a proximal pollical phalanx and one of the second to fifth intermedial phalanges [1]. However, no quantitative assessment with current morphological methodologies has yet been carried out. Hence, to characterise *H. erectus* hand bone anatomy, in this investigation we use Geometric Morphometrics (3DGM) and seriality approaches to address previous hypothetic assignations, while identifying and reconstructing, via 3D, the two phalanges preserved of KNM-WT 15000. In addition, we present a proof of concept for the estimation of specific missing phalanges based on previous methods of serial anatomical elements estimation [3].

We used 3D surface scans of right proximal and intermediate phalanges (n=61) of seven different primate taxa of adult individuals, in which researchers [4] have argued cultural use and production: *Pan troglodytes*, *Macaca fascicularis*, *Australopithecus sediba*, *H. erectus*, *H. naledi*, *H. neanderthalensis* and *H. sapiens*. On these meshes, we measured 27 fixed landmarks and 128 curve semilandmarks. The missing landmarks of the fossil specimens were estimated by TPS method, based on the grand mean of the sample, after General Procrustes Analysis. In order to quantify and understand the specimen total morphological variability we used Principal Component Analysis (PCA). The morphological identifications were based on the Procrustes Distances (PD) within the sample. Once the seriality of KNM-WT 15000-BO and its specific affinities was identified we applied a TPS serial shape deformation vector [3] to model shape change between the intermediate and proximal phalanx. Original data and shape predictions were compared by PCA. All analysis were made with the R software and the packages Morpho and geomorph.

PD matrix analysis highlighted that KNM-WT 15000 phalanges were not only closer to one of the *H. sapiens* individuals, but 3DGM also confirmed that KNM-WT 15000-BQ is a proximal pollical phalanx, while KNM-WT 15000-BO is identified as a third intermediate phalanx. Consequently, we used the deformation of the 3rd human digit to predict its corresponding proximal phalanx shape and size.

PCA revealed that both reconstructions are flat and "bottle-shaped"; the shaft is notably broad at the proximal and mid-sections but becomes narrower towards the distal end. They are dorsally canted, which has been related to increased passive dorsiflexion range during tool use or other manipulative bahaviours that experience higher than normal forces in a palmar to dorsal direction [5]. We propose that part of the preserved anatomy of KNM-WT 15000-BO, the deep bilateral gutters for the insertion of the tendons of flexor digitorum superficialis, could explain why the proximal phalanx estimated shows a wide base compared to a thin head and a curved distal shaft.

Our study indicates that 3DGM and seriality methods can successfully reconstruct elements of the hand of KNM-WT 15000, proving itself as an important tool for future research. Furthermore, it allows a better understanding of the manipulative anatomy of the taxon who developed the longest-lasting technology of hominins.

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Poster Presentation Number 43, Session 2, Friday 11:40-13:00

## Reconstructing the ribcage of Nazlet Khater 2

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The events that took place during the OIS 3 (~60–30 ky BP) are considered crucial in the framework of the evolution and migrations of *Homo sapiens*. This period witnesses the dispersal of African early modern *H. sapiens* into portions of Africa and Eurasia previously occupied by late archaic *H. sapiens*, who were apparently assimilated by them [1]. In this context, Nazlet Khater 2 (38 ±6 ky BP) is the only complete adult male skeleton from the OIS 3 found in North Africa. Its post-cranial skeleton presents discrete characters shared with archaic *H. sapiens* and coupled with biomechanical adaptations to intense physical activity, possibly due to mining work [1-2]. However, there are no current publications studying the potential 3D configuration of its ribcage (or that of any other fossil *H. sapiens*) although it plays an important role in body proportions, breathing kinematics and locomotion [3]. Therefore, the aim of this research is reconstructing the ribcage of Nazlet Khater 2 from its extant costo-vertebral material and, subsequently, making functional interpretations.

To carry out this study, we first sorted the digitized ribs and thoracic vertebrae of Nazlet Khater 2 and then 3D reconstructed its ribcage using LhpFusionbox (lhpfusionbox.org). Given the particularities of this specimen, we chose a preliminary recent human reference sample according to eco-geographical proximity and a potential common post-cranial *Bauplan*. All these individuals were adult, healthy males CT-scanned in supine position at thoracic muscle relaxation, divided according to their ancestry in Sub-Saharan (8), Western (19) and Eastern Mediterranean (16). The size and shape of the reference ribcage sample was quantified using Viewbox 4 (www.dhal.com/viewbox.htm) by a template of 526 (semi)landmarks [4]. Related to Nazlet Khater 2, we only took into consideration those (semi)landmarks present in the extant skeleton. Next, we carried out three PLS analyses, one for each reference sample, and then we estimated the missing data of Nazlet Khater 2 through the mean shape of the three obtained configurations. Shape differences among the fossil and recent humans were explored by permutations test and PCA. All these statistical analyses were performed in R [5].

Permutations tests show that the general shape of the ribcage is not significantly different among the fossil and recent *H. sapiens*. Hence, specific shape differences were explored by PCA. On the one hand, no population specific differences were detected along PC1, which represents sagittal costal declination. This is indicating a variation related to skeletal thorax morphology (e.g., rib torsion, length) that could be slightly affected by the quantity of air retained in the lungs during the scanning process. On the other hand, PC2 and PC3 are informative about the curvature of the rib corpus and coronal costal declination, respectively. Although we neither found significant differences among the reference populations, Nazlet Khater 2 was statistically different to all of them since its estimated ribcage is more slender because of the greater curvature and coronal declination of its ribs. The thoracic proportions estimated for Nazlet Khater 2 match those of its sternum, which is particularly long. Although our results could potentially confirm the effects of habitat in body proportions, it has been proposed that the long sternum of Nazlet Khater 2 (within its slender ribcage) would be a biomechanical adaptation to extreme physical activity [2]. In terms of functional interpretations, the estimated ribcage of Nazlet Khater 2 is flat and globular (therefore, anatomically modern in shape) [3] and its breathing kinematics would have been potentially similar to that of recent humans. However, more ribcage reconstructions of fossil *H. sapiens* are necessary to determine whether the globular ribcage of recent humans was also present in late archaic ones.

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Poster Presentation Number 44, Session 2, Friday 11:40-13:00

## Trabecular distribution of proximal tibia in extant apes

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Extant apes are characterized by a wide range of locomotor, postural and manipulative behaviours that require each to use their limbs in different ways. In addition to external bone morphology, comparative investigation of trabecular bone can provide novel insights into bone functional adaptation. Two previous studies [1-2] have examined trabecular bone structure in the hominoid knee joint, but have focused on the distal femur only. We build upon these previous studies to characterize trabecular structure of the proximal tibia in extant apes. Here we analyze the trabecular morphology of proximal tibial epiphysis of *Homo sapiens* (N=25), *Gorilla gorilla* (N=13), *Pan troglodytes verus* (N=15), and *Pongo* spp. (N=7) to determine how variation in trabecular structure reflects differences in locomotor behaviour and to establish patterns of proximal tibia loading in extant taxa. Trabecular bone was imaged using microtomography with an isometric voxel resolution of 25-63 microns. Bone tissues were segmented using the medical image analysis (MIA) clustering method [3]. Canonical holistic morphometric analysis (cHMA) [4] was used to analyze relative bone volume fraction (rBV/TV) and patterns of rBV/TV distribution within and between taxa were investigated via principal component analysis (PCA).

A PCA of rBV/TV shows clear separation between extant ape taxa. In humans, trabecular density is similarly concentrated in circular regions in the middle of both the medial and lateral condyles, which distinguishes them from all other apes on PC1. In African apes, the trabecular bone is denser on the medial side (penetrating the entire condyle) suggesting differential loading of the tibia plateau. *Pongo* also exhibits greater density on the medial side but differs from African apes in having less rBV/TV at the margins of the condyles. Values of rBV/TV under the articulation with proximal tibia (and on the thibial plateau) are significantly higher compared to rest of the lateral condyle in all taxa. *Pongo* (positive PC2) separates from *Gorilla* (negative PC2) due to the higher rBV/TV concentration in the middle of both tibial condyles on tibial plateau. Additionally, rBV/TV concentration is the lowest in orangutans, which separates them from gorillas (PC2) as well as from chimpanzees (PC3).

Trabecular distribution in humans is consistent with an extended knee position and bipedal locomotion where the load is spread more equally between both tibial condyles. However, trabecular distribution in non-human apes is consistent with flexed knee positions compared to humans and with primarily medial loading due to the higher knee adduction moment, varus angle and ground reaction forces. The pattern of trabecular distribution in orangutans reflects their more variable knee joint postures during locomotion. These results provide the comparative context to interpret knee posture and, in turn, locomotor behaviours in fossil hominins.

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Podium Presentation Session 7, Saturday 16:00-17:20

## Settlement processes in the Nile Valley at the beginning of the Holocene: new dental evidence supporting population discontinuity

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The middle Holocene Nile Valley saw dramatic cultural and climate changes. This turning point between the last hunter-gatherers and first agro-pastoralists is also defined by significant changes in craniofacial morphology, going from robust masticatory apparatuses and complex dental morphologies to gracile and simpler ones [1]. Many studies have hypothesized on whether these dissimilarities were the result of population discontinuity or rather of a morpho-functional adaptation [2-3]. The discontinuity hypothesis argues that such morphological shift is related to population replacement or significant gene influx during the transition to agro-pastoralism. The continuity hypothesis assumes that the Neolithic lifestyle implied substantial changes in dietary habits; this would have led to selective pressure towards smaller and simpler teeth to prevent caries or conversely a relaxation of selective pressure resulting in natural derivation towards simpler morphologies.

During the past decade, excavations were led on early Holocene sites throughout Sudan, providing wide and novel samples dating prior to the Neolithic transition. To date, only the El-Barga assemblage (Nubia), dated to both Mesolithic and Neolithic periods, was analysed. Using 3D imaging and morphometric analyses of dental and cranial remains, evidence was found supporting the discontinuity hypothesis [4-5].

The present work is in line with these studies and focuses on a large and chronologically quasi-continuous sample of maxillary central incisors, and maxillary first and second molars dated from the Mesolithic (N=94; Nubia: El-Barga; Central Sudan: Sabaloka West – Sphinx and Fox Hill) to the Neolithic period (N=132; Nubia: El-Barga, Affad, Letti and Kadruka; Central Sudan: Fox Hill and Ghaba). Our sample also includes late Palaeolithic individuals from Jebel Sahaba (N= 27; Nubia). Analyses were based on 3D imaging and the characterization of both the outer (crown size and non-metric traits) and inner crown morphologies (dental tissue proportions).

Our results highlight various affinities between sites and significant differences between samples and periods. These include variation of the crown dimensions and shape index, but also a significant shift in dental tissue proportions, enamel thickness and enamel distribution patterns. First, despite exhibiting overall large teeth with thin enamel, the late Palaeolithic assemblage of Jebel Sahaba also shows affinities with the Mesolithic samples, especially with the site of Sphinx. Second, significant differences were found between the hunter-gatherers and mid-Holocene agro-pastoralists. When compared with earlier groups, Neolithic samples display obvious enamel thickening of the second molars, while central incisors and first molars tend to have thinner enamel. Their thickness patterns show substantial variation as well, with a lack of an enamel reinforcement in the buccal surface of central incisors and a significant enamel thickening of the lingual aspect of molars. Finally, significant dissimilarities are also seen within the Neolithic sample, allowing us to distinguish between the Nubian and Central Sudanese groups for both outer and inner morphologies.

We suggest that these data do not fit in any functional adaptation models. Rather, they support population discontinuity hypotheses, as such variation would have happened in an extremely short time (a few centuries at most) and in a context that did not see a drastic change in dietary habits, according to the archaeological records. The proximity of Jebel Sahaba with early Holocene groups is also indicative of some biological continuity throughout hunter-gatherer populations, that differ from mid-Holocene groups. Therefore, we suggest that the differences observed between Central Sudanese and Nubian Neolithic populations could reflect greater biological diversity and complex settlement processes that saw the arrival of the first agro-pastoralists along the Nile river.

The authors thank the National Corporation for Antiquities and Museums of the Sudan for their long-term support. We thank the curators and researchers who allowed us to examine the comparative original collections in their care at the time of the study: M. Maillot and J. Reinold (SFDAS), M. Besse (Université de Genève). We thank R. Lebrun (Institut des Sciences de l'Evolution, Université Montpellier 2) for the µ-CT acquisitions of the El-Barga dental material; B. Clark (Imaging and Analysis Centre, Natural History Museum, London) for the µ-CT acquisitions of the Jebel Sahaba remains; the PLACAMAT platform (UAR 3626, University of Bordeaux) for the µ-CT acquisitions of the rest of the remains. We thank also A.S. Benoiston and Y. Merigeaud for participating in the data acquisition in the framework of their Masters theses. This study was supported by the International Research Project (IRP) ABASC funded by the CNRS-INEE; the French government in the framework of the University of Bordeaux's IdEx "Investments for the Future" program / GPR "Human Past"; the French National Research Agency (ANR-14-CE31, project BIG DRY); The Czech Science Foundation

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Poster Presentation Number 45, Session 2, Friday 11:40-13:00

## Multiproxy analysis to reconstruct the feeding behavior of *Theropithecus* from the Middle Pleistocene site of Grotte à Hominidés (Western Morocco)

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*Theropithecus gelada* is a large-bodied Papionini primate that exploit the high-altitude graminoids ecosystems of the Ethiopia Plateau. It is the only extant species of a diverse genus as documented by the fossil evidence of the Late Pliocene to Early and Middle Pleistocene deposits, mostly from East and South Africa. Several remains have also been found in North Africa, Asia and Europe suggesting intra-African and out of Africa radiations co-occurred with the evolution and dispersal of the hominins. Interpreting the evolution of the *Theropithecus* lineage and niche partitioning with the hominins, therefore, could provide some clues to interpret the evolution of our lineage.

Isotopic analyses showed that the earliest *Theropithecus* from Africa at 4 Ma had a diet dominated by C4 resources and the proportion of these items progressively increased by 1 Ma achieving a nearly 100% C4-derived diet. Recent studied of undisturbed habitats have suggested a more varied diet for the extant geladas in Ethiopia, incorporating large quantities of forbs with the ingestion of grasses too, but also seeds and USOs [1]. The unique combination of craniodental and postcranial characters of *T. gelada* among extant primates, such as high-crowned molars, with thick enamel and particular wear, suggest that the selective feeding behavior started early in the lineage. Around 2.8 Ma *Theropithecus* had already shifted to diets more strongly dominated by C4 graminoids in East Africa, however little is known from the North African fossils. Recent studies indicate a domain of C3 signal in diet of *Theropithecus atlanticus* from Ahl al Oughlam dated about 2.5 Ma [2] but we have no evidence of the abrasiveness of the items that they ate.

The aim of this work is to characterize the diet and habitat of *T. oswaldi* from a moroccan cave [3] in an area shared with specimens of the genus *Homo*. These data will be related to those of other *Theropithecus* from North, East and South Africa in order to compare the diachronic evolution of their ecological behaviour.

Grotte à Hominidés is an archaeological site located in the south-west of Casablanca city (Morocco), in the locality called Thomas Quarry I [4]. This site is known for its early Middle Pleistocene fossil hominins considered representatives of archaic *Homo* sp. The *T. oswaldi* teeth analyzed in the present study were recovered in Unit 4 of this cave, dated to circa 0.6/0.7 Ma and associated with Acheulean artefacts and a rich mammalian fauna mostly accumulated by carnivores. Dental casts were obtained from the original specimens and occlusal microwear and buccal microtexture pattern were analyzed and compared with an extant Cercopithecoidea sample [5]. Both occlusal and buccal microwear pattern of the *T. oswaldi* samples from Grotte à Hominidés, suggest that these primates had a diet similar to that of the extant *T. gelada*, including a high proportion of grasses that were abundant in the North Africa ecosystems. Occlusal microwear suggest the ingestion of hard items too, similar to open savanna-dwellers. The results obtained in the present study suggest that *T. oswaldi* selected similar items in east, south and north Africa ecosystems. Thus, the specialized nature and high abrasiveness of geladas diet is already present in these *T. oswaldi*, showing that these extinct primates exploited open grasslands ecosystems, as extant geladas do, relying on tough and abrasive grasses, and occupied a different niche than the hominins.

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Romero, A., Ibáñez, J.J., Hidalgo-Trujillo, L., Avià, Y., Pérez-Pérez, A., 2022. Effectiveness of buccal dental-microwear texture in African Cercopithecoidea dietary discrimination. American Journal of Biological Anthropology 179(4), 678-686.

Pecha Kucha Presentation Session 1, Thursday 11:30-12:45

## Plio-Pleistocene deciduous hominid teeth from the Omo Valley (Ethiopia)

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The sediments from the Shungura Formation, in Omo (Ethiopia) date back to the Plio-Pleistocene, spanning a time period of approximately 3.5 to 1 Ma, providing an important window to the origin and evolution of early *Homo* and the eastern African robust lineage [1]. Teeth are the most common of the hominid fossils recovered from the Shungura Formation. Even though the dentition is typically the most taxonomically informative skeletal element, the dental remains from the Omo tend to be isolated teeth. In 1996, Suwa and colleagues [2] described 48 isolated permanent postcanine teeth and compared them with other hominins, concluding that multiple hominin taxa were preserved in the Omo dental remains.

Compared to the adult dentitions of hominins, there is a paucity of deciduous teeth available in the fossil record [3-5]. Consequently, little is known about the evolution of the juvenile stage of dental development compared to the permanent one. In this study, we focus attention on the isolated hominin deciduous dental remains from the Shungura Formation and compare these results to the conclusions of Suwa et al. [2] and our more recent analysis of the permanent dental specimens. Regarding dental terminology, there is debate as to how to refer to the two most posterior deciduous teeth. As the permanent molars have no predecessors in the deciduous dentition, some authors call them deciduous premolars, while others refer to them as deciduous molars because of their shape. Here, we use the latter terminology.

In this study, we describe the external morphology of the upper and lower deciduous molars (n=16) recovered from the Omo and compare them with other specimens found in the fossil record in an attempt to make taxonomic classifications and infer potential evolutionary relationships. Although we only have a few isolated deciduous teeth from the Shungura Formation, our preliminary results show that they exhibit some similarities with other early hominins, particularly with *Australopithecus* species.

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Poster Presentation Number 46, Session 2, Friday 11:40-13:00

## Middle Pleistocene hominin teeth from Biache-Saint-Vaast, France

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Providing new evidence on the diversity of the European Middle Pleistocene (MP) populations is relevant to the discussion on the origin of the Neanderthal clade. The great morphological variability in the combination of dental and cranial features in the European fossil record suggests a non-linear evolutionary scenario characterized by genetic drift, founder effect, isolation, and hybridization of the populations. Within this framework, the sink and source model with a central area of dispersal in Eurasia (CADE) has been proposed as a more parsimonious explanation for the non-linear evolution of the MP groups towards the late Neanderthals [1]. In this model, the geographical and climatic constraints of Europe constituted a driving force in the demographic dynamics [2]. Among European fossils, the Atapuerca-SH (Spain), Steinheim (Germany), Montmaurin (France), Swanscombe and Pontnewyyd (U.K.), and Fontana Ranuccio and Visogliano (Italy) exhibit in their dentitions a suite of features characteristic of the Neanderthal clade. On the contrary, in other European MP specimens, such as those of Ceprano (Italy), Aroeira (Portugal), Mala-Balanica (Serbia), and Arago (France), the Neanderthal affinities are less clear, attesting for the possible coexistence of at least two hominin lineages in the European MP [e.g., 2-3].

This work presents the outer and inner description of the remains from Biache-Saint-Vaast (BSV) and its comparison with other MP European fossils. The BSV site is located 17 km east of the city of Arras (Pas-de-Calais Department), in northern France. The total recovered hominin assemblage includes a hominin skull, cranial fragments, and dental remains. The hominin remains were associated with a rich lithic and faunal context. A recent ESR/U-series analysis of several faunal remains associated to the paleoanthropological and archaeological remains provided a mean age of ca. 240 ka [5], correlating the human occupation to MIS 7c.

High-resolution µCT images and 3D reconstruction (Amira) were employed to describe the morphological traits of the enamel and dentine, to perform geometric morphometrics of the EDJ as well as to calculate enamel thickness. In addition, we also measured the MD and BL diameters, the crown index, the total computed crown base area, and the relative occlusal polygon area.

The morphological and metric analyses place the BSV hominins within the group that shows greater affinities with Neanderthals, together with SH, Montmaurin, Fontana Ranuccio, and Visogliano. The results support the coexistence of two or more populations in Europe at this period, with this group representing the basal population of late Neanderthals, which reflects the population and settlement of human groups suggested by the CADE and sink and source model.

We are very grateful to Catherine Schwab, Curator at the Musée d'Archéologie Nationale in Saint-Germain-en-Laye, who welcomed us to study the BSV teeth stored under her responsibility and who facilitated the procedure to carry out the µCT acquisition. For this later step, we thank Marta Bellato at the Ast-Rx (MNHN, Paris) who kindly found the best technical solutions. The comparative samples, including SH and modern humans, were scanned at CENIEH-ICTS facilities with the collaboration of the CENIEH staff. Partial financial support was received from the DRAC Occitanie, Ministry of Culture, France, in the context of the Montmaurin prehistoric caves project (Dir. by A. Vialet) and Projects PID2021-122355NB-C31-C33 financed by MCIN/AEI/10.13039/501100011033/ FEDER, UE. M-MT has received support from the Leakey Foundation through the personal support of Gordon Getty (2013) and Dub Crook (2014-2022). LM-F research is funded by the project IJC2020-043979-I financed by the MCIN/AEI/10.13039/501100011033, and NextGenerationEU/PRTR.

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Podium Presentation Session 2, Thursday 14:20-16:00

## Assessment of Pleistocene *Homo sapiens* dental remains from the Middle Awash study area of Ethiopia

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The emergence of *Homo sapiens* represents one of the most fundamental questions in human evolutionary studies. Given its abundance, location and established chronostratigraphic context, the hominin fossil record from the Middle Awash (Ethiopia) plays a critical role in exploring the anatomy of the populations ancestral to modern humans. Here, we present for the first time a preliminary detailed morphological assessment of the dental samples recovered from the Herto Member of the Bouri Formation and the Halibee Member of the Upper Dawatoli Formation, both in the Middle Awash. The outer enamel surface (OES) and enamel dentine junction (EDJ) of these teeth are compared to a large sample of early and recent *H. sapiens* and Neanderthals by means of classic and geometric morphometric techniques. The small Herto sample (~160 ka) is characterized by the preservation of cingular features that are commonly lost in recent and early modern humans, although in shape and cusp configuration it falls within *H. sapiens* variation. The primitive traits comprise the expression of a protoconal cingulum; cinglum-protocone and trigonal-hypocone crests; extensive crenulations; and several distoconules that are commonly absent in *H. sapiens* and more typically found in Middle Pleistocene teeth. The primitive character of the Lower Halibee's Chai Baro's dentition (>158 ka; likely older than Herto) is even more pronounced than in Herto, with a combination of discrete traits more typical of Middle Pleistocene *Homo*, and a general shape conformation of molars and premolars that falls peripheral to the *H. sapiens* distribution. The younger Faro Daba fossils (~100 ka) are comparatively more derived than Herto and Chai Baro in lacking cingular derivates, and in the shape and spatial cusp arrangement. However, their massive and column-like roots approach morphologies more typically seen in Middle Pleistocene specimens. The Herto and Halibee dentitions represent a unique opportunity to begin to understand a spatially and geochronologically constrained succession of hominin populations approaching anatomical modernity. The integration of the dental evidence with the data derived from other skeletal parts, as well as its contextualization in the archaeological, ecological and environmental settings of the Middle Awash region, can contribute with critical information to understanding the biological and cultural emergence of our species.

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Podium Presentation Session 2, Thursday 14:20-16:00

## What comes next? Acheulean Large Cutting Tool production at Olduvai Gorge Beds III-IV, Tanzania

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Stone toolmaking has proven to be essential in the study of human evolution. The project presented here studied at *Homo erectus* technological behaviour through a first-hand assessment of the Acheulean Large Cutting Tools (LCTs) excavated between 1969 and 1971 by Mary Leakey and colleagues [1] at Olduvai Beds III and IV (Tanzania).

Traditionally, at Olduvai Gorge, studies on Large Cutting Tools have mostly focused on the Oldowan/Acheulean transition [2], so that the Acheulean evidence from Beds III-IV has commonly been overlooked. Although fieldwork has recently resumed at Bed IV [3], so far only part of the fossil and lithic collections from Beds III-IV (~1.3-0.6 Mya) have been examined [4-5] This project is therefore the first re-evaluation of such lithic remains since they were first reported in 1994 [1].

The analysis presented here found a sudden increase in the number of LCTs from Olduvai Beds III and IV, particularly from the Lower of Bed IV onwards. The general increase in the number of LCTs, especially marked among cleavers, is parallel to the increase in the use of flake blanks from the Base of Bed IV onwards, and to the progressive development of newly, diversified and standardised core preparation techniques across Lower and Upper Bed IV. Whereas in older Acheulean sites at this area, LCTs are mostly manufactured in local raw materials, the analysis of the technological sequences of LCTs reveals new, more complex and hierarchised knapping strategies, specifically adapted to the shape and size of the local raw material boulders. LCTs are most often produced in large flake blanks detached from previously prepared cores, resulting in relatively predetermined shapes and acute edges that do not require extensive secondary shaping. Ultimately, this research found substantial diachronic changes in technological complexity, which are thought to have occurred as an adaptive response to the isotropy, shape and size of the local raw material boulders. This visible technical innovation and enhanced knapping skill, together with the use of soft percussors from the Base of Bed IV upwards suggests that the cognitive skills of hominins within Bed III were similar to those at Bed II, but that a considerable and likely progressive increase in working memory capacity might have taken place throughout Bed IV.

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Podium Presentation Session 1, Thursday 9:20-11:00

## The compromises of being bipedal

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The transition to bipedal locomotion was a fundamental milestone in human evolution. This transition involved significant morphological adaptations to the human skeleton, specifically to the proximal femur, to balance the trunk over a single supporting limb during locomotion with minimal energy consumption [1-2]. The adaptation of the proximal femur included an increase in the size of the femoral head, a shortening and an increase in the height of the femoral neck, and narrowing of its anteroposterior dimension, an increase in the lateral projection of the greater trochanter, a more medially oriented lesser trochanter, and an increase in the neck shaft angle [e.g., 3-5]. While the transition to bipedal locomotion probably resulted from a positive selective pressure, the morphological adaptation required to withstand the forces applied to the hip is suspected to involve compromises, such as an increased fracture risk to the femoral neck (henceforth, hip fracture). Recognizing the elementary risk factors for hip fractures, among the most prevalent and economically burdensome pathologies nowadays, is valuable for improving our ability to predict the risk of fractures and develop new preventive measures.

This study aimed to follow changes in the three-dimensional shape of the proximal femur throughout human evolution and reveal whether morphological adaptations continue over time with lifestyle changes (e.g., hunter-gatherers and recent humans). Finally, to examine whether the morphological changes in the proximal femur during human evolution increased the risk of hip fracture in present-day populations. Using the landmark-based Geometric Morphometric method, we followed shape changes in the proximal femur over time and examined their relationships with hip fracture. The sample of this study included *Pan troglodytes* (N=18), early hominins (N=4), early *Homo* (N=3), Neanderthals (N=3), and archaic and recent humans (N=25 and N=307, respectively). The recent sample was divided according to bone health (i.e., normal, osteopenia, and osteoporosis) and hip fracture presence. Multivariate statistical analyses and visualizations were obtained based on the 3D landmark configurations. We found changes in proximal femoral shape over time and between populations that practiced different lifestyles. Neanderthals' proximal femoral shape fell within the prehistoric hunter-gatherers' shape variation. We showed that the proximal femur morphology is a risk factor for hip fracture, independent of osteoporosis. Individuals with a non-osteoporotic fracture had a proximal femoral shape most distant from earlier populations and at the edge of the recent human variation. During human evolution, changes in the proximal femur, such as shortening and an enlarged convexity of the femoral neck and an increased anterolateral expansion of the greater trochanter, were associated with an increased risk for hip fracture. The most common mechanism for hip fractures is a sideways fall. The morphological adaptation of the proximal femur identified in recent humans, especially in those with a higher risk of hip fracture, is characterized by reduced resistance to the reverse forces applied to the femoral neck due to the fall. We concluded that hip fracture is a trade-off for efficient bipedal walking in modern humans and is intensified by reduced physical activity.

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Podium Presentation Session 4, Friday 9:30-11:10

## Extracting ancient human DNA from Palaeolithic artefacts

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Artefacts made from stones, bones, and teeth are fundamental to our understanding of human subsistence strategies, behavior, and culture in the Pleistocene. Although these resources are abundant, it is impossible to associate artefacts to specific human individuals who can be morphologically or genetically characterized, unless they are found within burials, which are rare in this time period. Therefore, our ability to discern the societal roles of Pleistocene individuals based on their biological sex or genetic ancestry is limited.

It is conceivable in principle that hominins also left their DNA on the surface of artefacts that they made and used. However, the prospects of recovering hominin DNA from stone tools seem low due to the limited surface area available for DNA binding and the potential contamination with DNA from surrounding sediments. We therefore set out to test whether traces of hominin DNA could be recovered from bone tools and artefacts, which are open systems that allow DNA to penetrate below the surface.

Building on a method initially developed for decontamination of ancient bones [1], we developed a non-destructive DNA isolation method for the stepwise release of DNA from the bone/tooth matrix using serial incubations in sodium phosphate buffer at 21, 37, 60 and 90°C, with three incubations per temperature. The DNA obtained in each fraction was purified using a silica-based DNA extraction method, converted into single-stranded DNA libraries, and enriched for human and mammalian mitochondrial DNA. In addition, shotgun sequencing and capture of human nuclear DNA were performed with some of the libraries.

Application of the method to eleven objects from museum collections recovered large quantities of contaminant DNA from their surfaces, mainly human DNA introduced during or after excavation. However, two of the objects also yielded ancient mammalian DNA from the animals from which the objects had been made. To reduce the impact of contamination, we next applied the method to four cleanly excavated Palaeolithic tooth pendants, three from Bacho Kiro Cave in Bulgaria and one from Denisova Cave in Russia. All four pendant yielded ancient DNA from the animals to which the teeth belonged. In addition, from the Denisova Cave pendant, a deer tooth, we recovered large quantities of ancient human mitochondrial and nuclear DNA, especially in the 90°C fractions. Based on near-complete deer and human mitochondrial genomes we estimate the age of the pendant at approximately 19,000 to 25,000 years. Nuclear DNA analysis identifies the presumed maker or wearer of the pendant as a female individual with strong genetic affinities to a group of Ancient North Eurasian individuals who lived around the same time but were previously found only further east in Siberia [2-3].

In summary, our work opens new possibilities for linking cultural and genetic records in prehistoric archaeology.

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Poster Presentation Number 47, Session 2, Friday 11:40-13:00

## Hafted technologies likely reduced stone tool-related selective pressures acting on the hominin hand

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The evolution of the hominin hand has been linked to the use and production of flaked stone tool technologies. After the earliest handheld flake tools emerged, shifts in hominin manual anatomy allowing for greater precision and forceful manipulation during tool manufacture and use are observed in the fossil record. Previous research has demonstrated how biometric traits, such as hand and digit lengths, and precision gripping strengths, significantly impact functional performance and ergonomic relationships in handheld flake and core technologies. These studies are consistent with the idea that evolutionary selective pressures would have favoured individuals who were better able to efficiently and effectively produce and use flaked stone technologies. After the advent of composite technologies during the Middle Stone Age (MSA) and Middle Palaeolithic (MP), fossil evidence does reveal differences in how hands were used between populations, but there is minimal evidence of increasing precision gripping capabilities. Furthermore, there is little research investigating the selective pressures, if any, impacting manual anatomy after the introduction of composite stone technologies ('handles'). Here we investigated the influence of tool-user biometric variation on the functional performance of 420 replica hafted Clovis knives. Biometric data, including hand length, digit lengths, and three gripping (precision and power) strengths, were recorded from 30 participants. Modern *Homo sapiens* were used as proxies for MSA and MP hominin populations. Each participant was presented with fourteen different knife forms, and were tasked with two distinct cutting tasks, one consisting of twisted sisal rope and the other red ceramic clay. Cutting times and stroke count were used to measure tool use efficiency. Our results show there to be no statistically significant relationships between biometric variables (precision-pinch strengths, power grip strength, or hand and digit lengths) and the cutting efficiency of the replica hafted knives. Unlike handheld flake technologies, greater gripping strength, hand length, and digit lengths do not appear to significantly increase the efficiency with which hafted knife technologies can be used. We argue that the advent of hafted stone technologies could have acted as a 'performance equaliser' within populations, which in turn, may have increased the relative importance of cultural evolutionary selective pressures in the determination of a stone tool's performance.

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Poster Presentation Number 48, Session 2, Friday 11:40-13:00

## teethR: a new R package to reconstruct crown heights and estimate perikymata counts on worn teeth

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Dental studies are key to understanding the evolution of the growth and developmental processes of extinct hominins. Central to these studies is the intrinsic nature of dental tissues (enamel and dentin), as they record periodicity lines in their histological structure, enabling us to calculate very accurately their formation times. In this regard, the total number of long growth markers present in the tooth crown surface (known as perikymata) is an essential variable for assessing enamel formation times [1].

Many teeth in the fossil record are naturally worn due to masticatory forces during the life of the individual, and the part of the crown preserving the perikymata lines on the surface of the crown are lost. This wear complicates studies of dental development in two ways: 1) the crown height that disappeared due to wear is unknown, and 2) the existing perikymata of that missing enamel is unknown. These two hurdles significantly reduce the available sample sizes of teeth in dental anthropological analyses and the inferences about paleobiology that can be extracted.

In order to address these two hurdles, we developed a new package in R named *teeth*R. Its name means *teeth aRe wonderful*, and it is released under GPL v3.0 license and hosted in GitHub (https://github.com/paleomariomm/teethR). *teeth*R contains, to date, two functions that address the two potential problems abovementioned.

The first function is named as *crown_height_recons_2d()*. The aim of this function is to reconstruct the cusp areas to locate the cusp tips of the different tooth types. With these cusp tips, crown height is now able to be estimated, and therefore, we can calculate the percentage of crown height that has been worn. This function significantly improves the method to reconstruct this part of the enamel based on polynomial regressions [2-3] with an easy straightforward two-step process.

The second function is named *predict_perikymata()*. The aim of this function is to predict the number of perikymata in the first three deciles of the crown height (crown heights can be divided in ten equal segments named as deciles) by using already-trained artificial neural networks.

The combination of the two functions allows the estimation either of the percentage of crown height lost or the estimation of the perikymata that existed in that part of the enamel that is no longer present. This user-friendly R package provides future studies with a statistically validated high level of accuracy, enabling the use of increased sample sizes, and, consequently, more robust insight to the paleobiology of our ancestors.

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Poster Presentation Number 49, Session 2, Friday 11:40-13:00

## Evaluating the hypothesis of artificial cranial modification in Arene Candide 12: a virtual anthropology approach

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AC12, a fragmented skull recovered from the Epigravettian levels of Arene Candide cave, holds significant archaeological importance. Its restoration and subsequent publication by Piero Messeri in 1979 [1] proposed that the skull was intentionally modified, classifying the type of Artificial Cranial Modification (ACM) as "circular oblique". However, alternative perspectives challenging Messeri's conclusions arose within the scholarly community. In 1987, Formicola and Scarsini [2] disputed the presence of sufficient evidence to support the hypothesis of ACM in AC12.

To address the lingering question of intentional cranial modification in AC12, this study employs a virtual anthropology approach. The skull underwent digitization through medical CT-scan imaging, allowing for virtual reconstruction through segmentation and semiautomatic realignment of bone fragments. In order to compare AC12 with relevant reference samples, a collection of 20 landmarks and 150 semilandmarks was performed on the preserved portion of AC12, alongside a comparative sample consisting of 15 Paleolithic and Neolithic Italian individuals, as well as 17 artificially modified skulls from the Museum of Anthropology of Florence.

The selected landmarks and semilandmarks were carefully employed to explore the morphospace and examine the relationship between AC12 and the reference specimens. The dataset was employed to produce different analyses. The first analysis only used the landmarks configuration, the second added the patch of 150 surface semilandmarks. A sequence of statistical methods was employed, including a sliding procedure, generalized Procrustes analysis, and principal component analysis (PCA) to investigate and visualize morphological variations. Canonical variate analysis (CVA) was also applied in the analysis using landmarks and semilandmarks to classify AC12 within the two groups of interest.

Results derived from the PCA and CVA analyses present intriguing insights into the cranial morphology of AC12. In all analyses, modified and unmodified specimens are clearly separated and AC12 falls within the cluster of specimens displaying characteristics associated with ACM. CVA classifies AC 12 as artificially modified. This observation opens up the possibility that artificial cranial modification was a practiced phenomenon in Europe during the final period of the Paleolithic. Furthermore, AC12 represents the earliest current known evidence of ACM in the European fossil record, emphasizing its significance in understanding the antiquity, evolution, and geographical distribution of this cultural practice.

Moreover, delving deeper into the implications of AC12's artificially modified cranial morphology, a noteworthy aspect emerges. The practice of Artificial Cranial Modification (ACM) is characterized by intentional alteration of the cranial shape, carried out by adults on infants and young children. This aspect renders ACM a form of body modification that is representative of a birth (rather than acquired) status. This notable finding underscores the socio-cultural significance surrounding ACM, shedding light on the intricate dynamics of past communities and expanding our knowledge of human history and the diverse range of cultural traditions.

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Podium Presentation Session 4, Friday 9:30-11:10

## Comparing extraction method efficiency for high-throughput palaeoproteomic bone species identification

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High-throughput proteomic analysis of archaeological skeletal remains provides information about past fauna community compositions and species dispersals in time and space. Archaeological skeletal remains are, however, a finite resource, and therefore it is essential to optimize methods of skeletal proteome extraction. Ancient proteins in bone specimens can be highly degraded, and consequently, extraction methods for well-preserved or modern bones might be unsuitable for the processing of highly-degraded skeletal remains.

In this study, we present a comparison of destructive proteomic extraction approaches [1–5] on Late Pleistocene skeletal remains with variable preservation, for species identification by LC-MS/MS. We assessed two simple methods broadly used for ZooMS, which use ammonium bicarbonate [1] and a conventional acid demineralization extraction method [2]. Additionally, two EDTA-based methods with modifications in the digestion enzyme [3] were tested. Finally, a PAC extraction method [4] and an EDTA-based method that combines demineralization and denaturation steps followed by protein digestion in situ [5] were compared. We randomly selected twelve morphologically unidentified bone specimens; six from Gruta da Companheira (Portugal, hereafter: GdC) and six from the cave site Ilsenhöhle Ranis (Germany, hereafter: Ranis). Both sets of archaeological specimens date to the Late Pleistocene, with those from GdC expected to be older (>50 kya) with comparatively high, Mediterranean temperature conditions, compared to those from Ranis (40-50 ka) with comparatively low, central European temperature conditions. Specimens from GdC displayed variable but generally poor proteome recovery in previous SPIN analysis [4], while collagen preservation and ZooMS identification rates at Ranis indicate well-preserved skeletal proteomes (unpublished results). These prior analyses also provided some taxonomic information for each specimen, despite all 12 bone specimens being unidentifiable based on morphological characteristics.

We compared the accuracy of species identification, protein sequence coverage, deamidation, and the number of post translational modifications between the proteomic extraction methods. We demonstrated that the acid protein extraction method produces high-quality peptide spectra for bone proteome analysis by LC-MS/MS for highly degraded samples. This method would allow for an easy scale-up and could be preceded by the ammonium bicarbonate buffer extraction method, as performed in several ZooMS studies. Our results show that the preservation of the archaeological material is crucial when designing a proteomic extraction approach. Therefore, a pilot study that compares potentially suitable extraction approaches based on sample preservation is advised for optimal proteomic recovery. Moreover, especially in challenging contexts such as the Late Pleistocene, our study showed that it is necessary to adjust data analysis approaches when studying archaeological bone specimens. A thorough understanding of the impacts of laboratory processing protocols and data analysis approaches on the reconstructed proteome is thereby essential, in order to retrieve a maximum amount of unbiased proteomic information from archaeological specimens.

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Podium Presentation Session 6, Saturday 9:15 -10:35

## High altitude adaptation in the Middle Palaeolithic of the Zagros Mountains, Iran

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The Middle Palaeolithic of the Zagros Mountains of Iran and Iraq languished for most of the 20th Century as a sort of intellectual backwaters of knowledge production on human origins research due to fragile political climates. Models of Middle Palaeolithic hominin behavioural evolution and environmental adaptations in southwest Asia, therefore, historically have been grounded in research based on fieldwork in the Levant. Consequently, lithic technological adaptation within the Middle Palaeolithic of the Zagros, gauged through production variability, raw material preferences, and functional decision-making through use, have been lacking behind the better-known industries of the Levantine Mousterian [1]. Intensification of fieldwork in the Zagros Mountains over the past two decades have provided crucial new insights into the region, and revealed a much more complex patchwork of Middle Palaeolithic lithic industrial variability than hitherto appreciated [2]. The Zagros Middle Palaeolithic historically has been associated – or even equated – with the so-called 'Zagros Mousterian' [3], an industry featuring pointed and heavily-retouched tools, in particular Mousterian points and scrapers. The Zagros Mousterian has been explained as a techno-behavioural expression of hominin summer-seasonal adaptation, specifically designed to manage lithic raw material scarcity within lowland to highland mobility strategies of high-altitude land-use [3]. This talk will present findings from a new series of studies on the high-altitude Middle Palaeolithic rockshelter of Houmian in the Iranian Zagros [4], posited to be one of the oldest, as well as highest-lying, Middle Palaeolithic sites in Southwest Asia [5]. The talk will focus on a re-analysis of the stone tool and pollen records, making the claim for multi-seasonal occupation at ca. 2000 m.a.sl. A lithic techno-functional study identifying separate – and non-Mousterian Middle Palaeolithic – technological strategies of production within different layers of the stratigraphy. A use-wear study revealing evidence of specific materials and resources targeted by Middle Palaeolithic hominins in the surrounding landscape. These findings serve to confirm and refuse previous behavioural and environmental interpretations surrounding Middle Palaeolithic land-use in the Zagros. The resulting evidence contribute to a re-appreciation of the Middle Palaeolithic of the Zagros as a dynamic region of hominin complexity.

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Poster Presentation Number 50, Session 2, Friday 11:40-13:00

## A new distal pedal phalanx from the Late Pleistocene Pinnacle Point 5-6N rockshelter (Western Cape, South Africa)

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With the exception of *Homo neanderthalensis*, fossil foot bones that are attributable to the genus *Homo* are extremely rare [1]. Most of the (scarce) fossils associated with the Middle Stone Age (MSA) in Africa consist of craniodental remains, with comparatively few postcranial bones [1-2]. In this paper, we describe and comparatively analyze a new human foot phalanx from Pinnacle Point 5-6N (PP5-6N) rockshelter (Western Cape, South Africa).

Pinnacle Point is a rocky headland on the southern Indian Ocean coast of South Africa that preserves an abundance of caves and rockshelters. These sites have gained scientific notoriety from their rich, well-preserved archaeological records that date to the origins of modern humans. The caves and rockshelters occur in quartzite of the Table Mountain Sandstone Formation. Extending off the south coast is a wide, gradually sloping continental shelf (the Agulhas Bank), which would have been variably exposed during the lower sea levels of the Pleistocene, exposing an entirely novel ecosystem (the Paleo-Agulhas Plain) [3].

PP5-6N is a rockshelter with ~15 vertical meters of excavated archaeological sediment that represents nearly continuous human occupation from ~110-50 ka [4]. In 2017, a human distal pedal phalanx was excavated from near the base of the vertically thick LBSR Stratigraphic Aggregate, which dates to around 91-86 ka. The specimen, with inventory number 683795, was found in a combustion feature and is burned black. It was found in association with stone tools, animal bones, mollusks and fire modified rock. To date, it is the only human remain that has been recovered in situ in a Middle Stone Age context at PP5-6N.

We provide here a complete metric and morphological study of this foot phalanx within a global comparative framework in relation to other Pleistocene fossils and recent human samples. Due to the near absence of well-identified distal foot phalanges in the MSA of South Africa [5], we include Neandertals, Middle Palaeolithic modern humans (MPMH), Upper Palaeolithic modern humans (UPMH) and several recent modern human samples as comparative samples for the study of the PP5-6N phalanx. The age at death for this specimen is adult, based on its completely fused proximal epiphysis. The bone is compressed in its dorsoplantar (DP) dimension, and the proximal articular facet is slightly bi-concave. The distal tuberosity exhibits a slight medial cant. The bone's size and morphology correspond to a right distal pedal phalanx that probably derived from the second or third toe (digit).

Although most of the metrical variables of 683795 fall comfortably within the ranges of variation of distal phalanges of Neandertals, and both the fossil and recent modern human samples, our metrical comparisons conclude that the Pinnacle Point phalanx differs from all the comparative sample averages in at least some of the variables. In general, the 683795 phalanx is longer, narrower and less robust than those of Neandertals. When compared with the meagre samples of UPMH and MPMH human toes, and the moderate samples of recent human homologues, 683795 is seen to be comparatively long and broad. Unfortunately, the small UPMH and MPMH samples preclude a firm conclusion regarding its affinities. More well-identified fossils are needed in order to substantiate the affinities of the 683795 toe bone.

We would like to thank the Pinnacle Point excavation and research team for providing new insights into the context of human evolution in South Africa. We are indebted to many people who have allowed access to some important skeletal collections.C. Marean recognizes the support of a grant from the National Science Foundation (BCS-0524087, BCS-1138073 and BCS-1460376), Hyde Family Foundations, the Institute of Human Origins (IHO) at Arizona State University, and the John Templeton Foundation to the Institute of Human Origins at Arizona State University. The opinions expressed in this publication are those of the author(s) and do not necessarily reflect the views of any of these funding organizations. Part of this research was supported by the Spanish project PID2021-122355NB-C31 funded by MCIN/AEI/10.13039/501100011033/ FEDER, UE. A. Pablos was financed by a research grant from Junta de Andalucía, Spain (EMERGIA20_00403).

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Podium Presentation Session 7, Saturday 11:00-12:40

## Procrustes Motion Analysis applied to the upper cervical spine flexo-extension of La Ferrassie 1

**Carlos A. Palancar[1], Marta Gómez-Recio[1], Markus Bastir[1], Benoit Beyer[2]**

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Several inferences have been made about neck mobility and stability in Neanderthals [1]. However, the hypothesis of decreased mobility of the cervical spine in this species was based on interpretations of a few morphometric measurements without directly linked functional data. Thus, experimental analyses are required to test whether Neanderthals had a lower neck mobility than modern humans.

Procrustes Motion Analysis (PMA) [2] is the study of motion through geometric morphometric methods. PMA is based on the principle that "any motion can be represented by an ordered sequence of postures exhibited throughout the course of a motion". Our experimental approach to mobility consists in measuring five discrete postures of flexion-extension of the upper cervical spine (UCS, i.e., Occiput, Atlas, Axis) in seven unembalmed modern human cadavers obtained from previous work [3]. In addition, the morphology of the UCS was also determined using geometric morphometrics, following the digitization template stablished by Palancar [4].

Firstly, neutral position of La Ferrassie 1 Neanderthal was estimated from the averaged modern human neutral position. Secondly, a two-blocs partial least square (2B-PLS) analysis demonstrated a significant relation between the neutral position of the UCS and its flexo-extension motion trajectory. Eventually, the UCS flexion-extension trajectory of La Ferrassie 1 Neanderthal was predicted according to the results of the 2B-PLS in modern humans, thanks to "predictPLSfromData" function in RStudio (package Morpho v. 2.9) [5].

Present results suggest a potential higher range of motion in this species when compared to the modern human mean. Additionally, the present study demonstrates the feasibility and usefulness of PMA for translational research from clinical field to Paleoanthropological applications. Further research will explore the overall cervical spine in various movements to enhance our understanding of the functional significance of fossil morphology.

Philippe Mennecier and Antoine Balzeau provided access to fossil data. Pierre-Michel Dugailly provided access to modern human motion data. Funding: PID2020-115854GB-I00 to MB is funded by MCIN/AEI/10.13039/501100011033 of the Spanish Ministry of Science and Innovation and the European Union. CAP is funded by the Spanish Ministry of Science and Innovation and the European Union via technician grant (PTA2020-018205-I).

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Poster Presentation Number 51, Session 2, Friday 11:40-13:00

## New potential case of Paleolithic interpersonal violence: First taphonomic approach from Qafzeh-25, Israel

**Ana Pantoja-Pérez[1,2], Laura Martín-Francés[2,1], Hila May[3,4], Israel Hershkovitz[3,4], Nohemi Sala[1,2]**

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The Qafzeh *Homo* fossils are among the best-known Middle Paleolithic prehistoric populations worldwide (120-90 ka). Their large number (n=25), their demographical structure (many young individuals), and the presence of formal burials testify to the existence of a complex society [1]. Although this population was identified as *H. sapiens* (anatomically modern humans), large morphological variations between the fossils exist. To date, various pathologies have been identified [2] and one individual (Q-11) was recognized with trauma.

A new taphonomic study of the Qafzeh collection revealed an additional, interesting case of trauma, i.e., on the mandible of Qafzeh 25 (Q-25). Qafzeh 25 (Q-25) is a partial skeleton of a young adult, probably male that was excavated in 1979 at level XV of the Terrace [3]. It was embedded in consolidated sediments that made excavation and reconstruction of its skeleton particularly difficult [5]. This individual is represented by a very flattened and deformed skull, a mandible and some postcranial bones mainly from the torso and the upper limbs. Of the lower postcranial skeleton, only a distal fragment of the left femur and a proximal fragment of the tibia on the same side were recovered. Based on the anatomical articulation of the bones, Q-25 burial was interpreted as intentional [1]. For its taphonomic study it was necessary to use computed tomography images to characterize all fractures present in the skeleton, especially in the skull and mandible.

The long bones exhibit a fracture pattern characterized mainly by the dominance of transverse fractures of the long axis, complete circumferences, and fracture edges with right angles and jagged surfaces. In the cranium and mandible, the fracture pattern is similar. There are no signs of carnivore or human activity on the skeleton. These findings indicate a rapid burial of the body, which is compatible with funerary practices. The new trauma identified here consists of an incision, on the left side of the mandible between the first premolar and the lower canine, on the interalveolar surface. We identified a transversally oriented chop mark affecting not only the mandibular bone but also the root of the premolar. This V-shaped incision is 13 mm long, 1.5 mm wide, and 2 mm deep. Furthermore, it penetrates about 1 mm into the root of the premolar. The affected mandibular bone shows signs of regeneration, and the incision in the premolar root has rounded edges, indicating an active healing process and use of the tooth after the trauma. Therefore, the blow probably occurred antemortem. The absence of bone resorption or abscess holes indicate that this lesion did not involve an infectious process. This fact probably favored the survival of this individual to the wound. The type of injury was produced by a sharp object, and its location on the left side of the facial skeleton may suggest it resulted from an interpersonal violence attack. Q-25 would join the few Paleolithic individuals affected by a sharp force trauma possibly of violent origin. Finally, we evaluate the possibility that other pathologies, such as tooth rotation, are secondary to the traumatic event.

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Podium Presentation (Virtual) Session 5, Friday 14:30-16:10

## Linking old and new data to reconstruct and contextualize the earliest dispersal and occupation of Sicily

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Despite the long history of research on the Mediterranean, many questions regarding the early human dispersal and occupation of its islands remain unanswered. Because of its size (25,711 km2) and proximity to the mainland, Sicily is considered to potentially be the first Mediterranean island to be colonized by humans [1]. At the moment, the earliest secure dates for human occupation in Sicily are set at ~16 kya [2]. This date appears to be broadly coincident with a period of major faunal turnover as European taxa, including European wild ass (Equus hydruntinus) and red deer (Cervus elaphus), replaced large and middle-sized Pleistocene mammals such as the elephant Elephas mnaidriensis, and cave hyena (Crocuta crocuta spelaea). Bathymetric studies of the Sicily Strait, the short stretch of sea that separates Sicily from Italy, have proven that a land bridge connected the two shores during the Last Glacial Maximum (LGM) (26-19 ka) facilitating animal and human migrations onto Sicily [3]. Simulation of sea-level retreat suggests that the Sicilian landmass was drastically increased during the LGM with the paleo-coast line at several tens of meters distance from the current one and a second land-bridge connecting it to Malta. If true, the late date of human arrival on Sicily suggests that despite the early ability to colonize new areas by boat (as demonstrated by Australia 65-45kya), initial human colonization in Europe was primarily overland, with opportunistic island occupation via land bridges occurring much later. However, there are still large gaps in our understanding of dispersal, occupation, and subsistence patterns on the island as only a handful of sites, mostly concentrated on the northern shore of Sicily, have been systematically analyzed. Most of the island is dotted by sites lacking professional studies, the majority of which are noted only in self-published avocational reports. In addition, the now-submerged palaeocoast remains still largely unexplored. Here, we report on the results of our 2022 and 2023 field surveys, on land and underwater, to identify and assess sites in the provinces of Siracusa and Ragusa. We were able to relocate ~25 sites between caves and rockshelters that were excavated partially or completely between the 1870s and 1960s. Of these, we highlight our re-examination of the cave of Campolato A [4], where we carried out GPR work and one test excavation; and the sampling and analyses of Grotta della Seggia, a partially submerged cave containing a continuous sedimentary palimpsest from the mid-Pleistocene to the medieval times that will allow us to reconstruct paleoenvironments and address questions of site preservation in marine caves. Additionally, we located and sampled the inland river valley of Pedagaggi where the homonymous site, considered typologically Upper Paleolithic [5], contained a complete assemblage re-examined in detail by our team. Finally, we surveyed the southern coastline of the island to locate paleosols that contain environmental and possibly anthropogenic records that can contextualize the Sicily-Malta bridge. The work presented here is the first step in collecting the necessary data to reassess and contextualize minimally studied sites across Sicily and eventually reconstruct the mobility patterns and environmental impact of humans on the island.

We acknowledge the local communities of Augusta, Brucoli, and Pedagaggi that have hosted us and shares with us their knowledge of the landscape and local history. In particular we would like to thank Mr. Russo and Mr. Patania. We thank our local collaborators: the Siracusa Superintendence for Archaeological and Environmental Heritage, the Sicilian Superintendence of the Sea, and the Paleontology Museum of the University of Catania. Funding for this project was provided by the Leakey Foundation, the UConn CLAS Summer Research Initiative, The American Institute of Archaeology, and the Rust Family Foundation.

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Podium Presentation Session 5, Friday 14:30-16:10

## An early dispersal of *Homo sapiens* into cold-arid steppes of the North European Plain

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The spread of *Homo sapiens* into new habitats across Eurasia and the concurrent disappearance of Neanderthals from the archaeological record during the Middle to Upper Palaeolithic transition represents a critical evolutionary turnover in our species' history. This biological transformation occurred in the framework of the dramatic and rapid climatic oscillations of the Late Pleistocene. Those climatic shifts are thought to have had major impacts on hunter-gatherer groups navigating the changing environments of Eurasia. 'Transitional' technocomplexes, such as the Lincombian-Ranisian-Jerzmanowician (LRJ), characterise the European record during this period. However, it has long remained unclear which hominin produced these assemblages and how they can be interpreted in the context of human evolution. New evidence from the LRJ type-site of Ilsenhöhle Ranis (hereafter "Ranis"), Germany, now demonstrates a secure connection of the LRJ with *H. sapiens* remains dated to ~45 ka ago, making it one of the earliest forays of our species into the North European Plain.

Using a multi-isotope (O, C, N, Zn, Sr) analysis of 16 equid teeth and 24 teeth from taxa across the food web, we present a record of palaeoclimatic conditions for the LRJ and Upper Palaeolithic human occupation at Ranis and review the ability of Late Pleistocene *Homo sapiens* to adapt to different climates and habitats. Equid teeth were directly radiocarbon dated and provide climatic and environmental data spanning ~12,500 years from 48.8 to 36.3 ka cal BP. Results show that cold climates prevailed across LRJ occupations even in early phases coinciding with the first *Homo sapiens* remains found at the site. During the LRJ occupations, temperatures further decreased, culminating in a pronounced cold-arid excursion at ~45-43 ka with temperatures 7-15°C below modern-day conditions. Directly dated *Homo sapiens* remains confirm that humans used the site even during these cold phases. Together with recent evidence from the Initial Upper Palaeolithic, this demonstrates that *Homo sapiens* groups lived in severe cold conditions during multiple distinct early dispersals into Europe and suggests pronounced climate resilience. Indeed, cold-steppe environments that supported large herds of prey animals in open landscapes may have actively supported rapid dispersals of *Homo sapiens* groups across the North European Plain during the LRJ.

Podium Presentation Session 3, Thursday 16:30-17:30

## Unravelling the elusive age-at-death estimation in hominins

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The mathematical model derived to estimate molar dentine exposure rates may contribute to the understanding of the long-term evolutionary strategies within hominins in relation to molar morphology and dietary habits. The model predicts that the overall dentine exposure is a nonlinear function of age, with the rearmost molar wearing away faster than the anterior molars in all species considered as evolutionary strategies to ensure chewing efficiency during the reproductive life span. Additionally, the proposed model provides an age-at-death estimation of individual fossil specimens or even isolated teeth, provided that the regression models of dentine exposure are known. Here, we provide preliminary equations for estimating age-at-death for hominin specimens. Since none of the analysed hominin specimens had previous age estimations, neither biological nor chronological, other than that derived from dental eruption patterns when available, the tentative ages provided, based on dentine exposure rates, would be of great relevance, especially because a continuous age variable can be derived for population comparisons. On a population basis, we show that the contributions of molars to the overall exposure of dentine follow a stable pace that depends on molar eruption ages and, eventually, on life expectancy. The cumulative exposure of dentine is faster on later erupting teeth. Equal dentine exposure areas are attained by adjacent molars at an age related to the life expectancy of the species. Molar wear rates are neither constant through time nor faster on M1 compared to later erupting teeth. In contrast, faster wear rates were observed on the rearmost molars which ensure maximum efficiency of the secondary morphology of molars [1]. Evolutionary strategies to extend the functional life of the posterior molars [2] can be the backwards increase in molar size, retention of the Y5 cusp pattern in all the lower molars, greater enamel thickness when an abrasive diet cannot be precluded, or a dietary shift to softer dietary habits to reduce overall molar wear rates. The evolutionary advantage of a fast wear model when tough and abrasive diets are required is to ensure the maximum functional efficiency within an individual's life span and an optimal topography of worn-out molars. However, if longer life expectancies are selected, a slow wear model, retaining faster wear rates on the posterior molars, would be more advantageous, followed by a slow model when the posterior molars hardly contribute to the overall dentine exposure. *Paranthropus*, *Australopithecus*, and *Gorilla* show fast wear rates consistent with strategies based on large molar sizes and enamel thickness on the posterior molars to allow an increase in life expectancy, as evidenced by their delayed molar eruption ages. These taxa would heavily rely on tough and hard food items retaining high overall molar wear rates. Early *Homo* showed a transitional model, with reduced overall wear rates, though still retaining fast wear rates on the posterior dentitions, with M1 and M2 matching their dentine exposures clearly later than their hominin ancestors; this was especially marked on *H. habilis* compared to *H. ergaster*. The reduced wear rates observed in *Pan* and modern humans would be consistent with softer dietary habits. A shift towards soft dietary habits would render less relevant a delay in weaning ages [3] in relation to life expectancy compared to the hominoidea primates studied.

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Poster Presentation Number 52, Session 2, Friday 11:40-13:00

## New human teeth from the Neanderthal site of Guattari Cave (San Felice Circeo, Latium, Italy)

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Guattari Cave is a pivotal site for the study of Neanderthal in Italy during the Late Pleistocene. Located on the Circeo promontory (San Felice Circeo, southern Latium, Italy), it was discovered in 1939, when a Neanderthal cranium (Guattari 1) and a mandible (Guattari 2) were recovered. Then, in 1950, a second Neanderthal mandible (Guattari 3) was found just outside the cave [1-2]. New excavations were conducted from 2019 to 2022 by the Soprintendenza of Frosinone and Latina in collaboration with the University of Tor Vergata, Rome, leading to the discovery of a rich sample of human skeletal remains, including fragmentary cranial, dental, and postcranial elements.

Here we present the results of the morphological analysis of the human teeth and the ongoing digital analyses aimed at investigating their taxonomy and variability. MicroCT scans of the seven teeth were acquired via non-destructive 3D X-ray Microscopy performed at CNIS, and 3D digital models were obtained through semi-automatic segmentation using Avizo v.9.2. The 3D models were optimized and spatially oriented using Geomagic Design X.

The 3D digital models were useful to improve the morphological description of the teeth from Guattari Cave by unveiling non-metric dental traits on the enamel-dentine junction and the morphology of the pulp chamber, as well as by allowing digital morphometric analysis (e.g., crown outlines by geometric morphometrics methods [3], quantification of 2D and 3D enamel thickness [4] and root volume [5]) and then comparing the results with a large sample of Neanderthal and *H. sapiens* teeth.

The dental specimen set includes seven permanent teeth, identified as follows: upper right canine (URC), upper right fourth premolar (URP4), upper right first molar (URM1), lower right third molar (LRM3), lower left third molar (LLM3), upper right third molar (URM3), and upper right second molar (URM2), the latter retrieved still *in situ* within a fragment of the maxillary bone. We suggest that URM2 and URM3 may belong to the same individual since their interproximal facets match as well as for the presence of a compatible alveolus fragment in the bone.

The non-metric dental traits (highly expressed hypocone in UMs and mid-trigonid crest and anterior fovea in LMs) align these teeth with Neanderthal morphology, as well as the buccolingual and mesiodistal crown diameters fall within the range of Neanderthal variability.

During the microCT segmentation, we observed the possible presence of pulp stones inside the pulp chamber and root canals of the URM1, URM2, URM3 and LLM3. Hypercementosis – common among Neanderthals – was observed on the roots of URC, URP4, and LMs. Taurodontism – also typical of Neanderthal teeth – was detected on LMs. Signs of caries are absent. Calculus is present in small amounts on every crown. Very faint evidence of linear enamel hypoplasia is present on URC and LLM3, whereas URM2 and URM3 are affected by pitting enamel hypoplasia.

Further digital analyses are ongoing on the Neanderthal dental remains from Guattari Cave, and are expected to broaden our knowledge on Neanderthals in the Italian peninsula.

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Poster Presentation Number 53, Session 2, Friday 11:40-13:00-00:00

## Comparing the trabecular structure of distal tibiae in extant hominid taxa: potential for inferring locomotor behaviour

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The ankle joint, given its proximity to the substrate and its contribution to the dissipation of ground reaction forces, is potentially a functionally informative site for analysis of internal bone structure. As trabecular bone (re)models during an individual's lifetime in response to mechanical loading, the internal structure of the skeleton has the potential to reveal how an individual behaved. A relationship between cortical and trabecular bone structure and habitual loading in humans and chimpanzees has previously been found at the ankle joint [1], potentially yielding valuable insights for reconstructing locomotor behaviour in fossil hominins. In this study we extend this work to examine trabecular bone structure in *Gorilla* and *Pongo*, to improve our understanding of the relationship between loading and trabecular structure at the ankle in extant taxa.

We analyse distal tibia trabecular structure in extant hominids with different locomotor repertoires, to investigate the link between internal bone structure and habitual loading: *P. troglodytes verus* (N=22), *G. gorilla gorilla* (N=11), *Pongo* spp. (N=6), and *H. sapiens* (N=6), scanned using micro-CT and segmented with the MIA-clustering algorithm [2].

To analyse the trabecular structure of the distal tibiae, we adopted a holistic morphometric approach using an in-house script for medtool, which segments the cortex, trabecular bone, and the internal bone cavity and air by applying several morphological filters and arithmetic operations [3]. Mean trabecular values of bone volume fraction (BV/TV), degree of anisotropy (DA), and other standard trabecular parameters were quantified throughout the entire distal epiphysis. Morphometric maps of the distribution of BV/TV and DA throughout the distal tibia were generated.

Modern humans were found to have lower BV/TV values compared to great apes, which generally had a more robust trabecular bone structure. Mean values and distribution patterns of DA were comparable among all taxa. Gorillas and humans have lower Tb.N values and higher Tb.Sp and Tb.Th values than chimpanzees and orangutans. Supporting the results of the previous study, bipedal human specimens exhibited a higher concentration of trabecular bone at the tibiotalar subarticular centre and on the medial malleolar surface, suggesting a neutrally-loaded ankle, perpendicular to the substrate [1]. In comparison, knuckle-walking chimpanzees and gorillas had higher concentrations of trabeculae at the anterolateral, anteromedial and posterocentral regions of the subarticular surface, as well as on the anteromedial malleolar surface, consistent with an ankle loaded in dorsal and plantar flexion that would occur during both knuckle-walking and arboreal climbing. Orangutans, although displaying greater trabecular bone concentration towards the anterior margin, the highest BV/TV was located anterolaterally, towards the fibular incisura, and distributed more evenly throughout the entire subarticular surface. This difference between orangutans and African apes is consistent with the more diverse postural behaviours of orangutans, and potentially higher loading at the ankle while the foot is inverted. These results demonstrate that variation in trabecular structure of the hominid distal tibia can discriminate habitual ankle posture consistent with differences in positional behaviours. These results provide the comparative background necessary for the analysis of the fossil hominin ankle posture and addressing questions on the evolution of bipedality and arboreality.

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Pecha Kucha Presentation (Virtual) Session 1, Thursday 11:30-12:45

## Digging Trinil's hominin backyard: Sogen, a promising Middle Pleistocene archaeological site along the Solo River

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As Java (Indonesia) has yielded a remarkably high number of Pleistocene hominin fossils, notably *Homo erectus*, it is a good testing ground for hominin adaptations to highly variable, lower latitude environments, both from a physical and from a behavioral point of view. Particularly, the Middle Pleistocene holds special interest as it is characterized by high-amplitude climatic fluctuations and from ~400 ka onwards by increased maritime conditions and insularity.

Whereas insights on the timing and palaeoenvironmental context of the first (Sangiran) and last (Ngandong) appearance of *Homo erectus* on the island have recently been updated, the archaeological and palaeoenvironmental record for the Middle Pleistocene on Java remains less well-understood. At the Trinil site, rich fossiliferous deposits of Early, Middle and Late Pleistocene age can be found, but due to uncertain provenance and the effects of reworking, the exact age of the (hominin) fossils remains difficult to assess [1-2]; a problem that similarly affects palaeoenvironmental proxies and cultural remains. Based on a recent re-assessment of Mojokerto, the hominin skull as well as the associated palynological evidence may be of Middle Pleistocene age [3], although this requires further testing with geochronological methods. Other potential Middle Pleistocene sites on Java have not been dated with absolute methods, have not (yet) been published in detail, or the artefactual nature of finds has not been established beyond reasonable doubt.

Here we present a new Pleistocene locality, Sogen, situated along the Solo River 8 km east of Trinil and 8 km south of Ngandong. The well-exposed section was documented in detail over a distance of ~300 m. At the base of the exposure lie a clay with palaeosoil formation and a >7 m thick lahar that can both be correlated with similar inclined units at Trinil (BGC-5; BGL-5, dated to ~780 ka) where they underlie the fossil-rich deposits thought to represent Dubois' Hauptknochenschicht [1-2,4]. After a relatively coarse-grained channel fill, several cycles follow, each consisting of thin layers of reworked carbonate nodules, cross-bedded sands, and silts/clays with palaeosoil formation, including in situ soil carbonates. Excavations within several units yielded mostly in situ, Pleistocene fossils (bovids, cervids, suids, crocodile, gharial, turtle, stegodon, shark, freshwater gastropods and bivalves). Moreover, the deposits yielded in situ stone (andesite, quartzite) and bone artifacts. These inclined deposits, attributed to the lower part of the Middle Pleistocene Trinil Formation (Trinil Member 1) [4] and probably constituting a delta terminating in the larger Ngawi palaeobasin, are locally capped by horizontal gravels and coarse sands most likely representing the T2 terrace of the Solo Formation [4]. Further downstream from Sogen, the inclined Trinil Formation is visible in outcrops again, including lacustrine beds.

These findings hold great (bio)stratigraphic, palaeoenvironmental, and archaeological potential; not only as a new Middle Pleistocene locality, but also for a better understanding of nearby sites like Trinil and Ngandong. Further fieldwork is employed to strengthen the archaeological and archaeozoological record, while chronological and palaeoenvironmental analyses are employed to improve and expand the chronostratigraphic framework and to study the palaeoenvironment from a diachronic perspective.

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Poster Presentation Number 54, Session 2, Friday 11:40-13:00

# When physical activity is not the reason: exploring great male variability in resting metabolic rate from an evolutionary perspective

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The evaluation of sex differences in body size and shape has a long history in evolutionary and anthropological studies. Similarly, behavioral differences between women and men have been attributed to anisogamy-related sex roles, promoted by sex differences in reproductive investment [1]. A recent publication has shown great male variability (GMV) in morphological and physiological traits affecting human resting and daily energy requirements [2]. These authors hypothesized that women may have been under selective pressures that would have reduced their metabolic variability, maximizing the energy available for reproduction. In addition, "considerably greater male variation in energy expenditure could be explained by greater male variation in levels of daily activity" was also suggested [2]. However, due to the characteristics of the population analyzed, this possibility was not explored.

As part of a larger study approved by the Virginia Tech Institutional Review Board (IRB #21-567), we recruited 50 healthy adults (26 female, 24 male; 19-58 yrs) evenly distributed from sedentary to ultra-endurance training levels. Body weight and height were measured with a stand-on scale and a stadiometer. Fat mass (FM) and fat-free mass (FFM) were obtained by dual-energy x-ray absorptiometry (DXA scan), and Resting Metabolic Rate (RMR) by indirect calorimetry. A VO2Max test was performed with indirect calorimetry to quantify the aerobic fitness levels of our participants. Participants self-reported their physical activity levels as miles walked or run per week. Physical activity was objectively measured for two weeks with a wearable tri-axial accelerometer and expressed as counts per minute per day (CPM/d) and steps per day. These parameters had a good correspondence with self-reported activity levels (miles/week). Body parameters, RMR, fitness levels, and activity levels were compared by sex with T-tests. W of Mann-Whitney tests were used to compare VO2Max levels and miles/week in men and women. RMR was adjusted by differences in FFM and CPM/d (AdjRMR) by adding residuals from the RMR~FFM+CPM/d regression to mean RMR. Variance was evaluated (with 95% Confidence Intervals) by sex in the different parameters we measured, an F test was used to compare standard deviations, and a ratio of the variance between males and females was calculated.

The results show that our participants had the expected sexual dimorphism regarding body size, body composition, fitness levels, and RMR (higher values for males). However, despite a similar distribution in fitness and activity levels, we found greater male variability in most of the parameters we evaluated (except for FM). Interestingly, after adjusting the RMR by FFM and activity levels (CPM/d), males still had greater variability (2.55 times higher) than females, with a significantly higher AdjRMR standard deviation ($F = 0.3918$; P-value = 0.0245).

Although our sample size was smaller than the population included in Halsey et al. [2] paper, we found similar results regarding male variability in biological and physiological traits. In addition, we controlled for differences by sex in physical activity levels which could have driven GMV. However, GMV was still evident. Our results provide support for possible sexual selection behind GMV in energy expenditure and selective pressures against female variability in metabolic traits that could enhance their capacity to keep energy balance and to allocate energy to reproduction [3].

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Pecha Kucha Presentation Session 3, Saturday 16:40-17:55

## Within-species encephalization drove the increase in hominin brain size

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One of the most evident evolutionary changes during human evolution has been an increase in brain size. Many studies have focused on this phenomenon, as it is considered a crucial aspect in our own evolutionary history. These studies have proposed various explanations for the underlying evolutionary patterns and processes. There has been a long-standing debate regarding the patterns of cranial capacity increase over time in human evolution. Some argue that cranial capacity increased gradually across species, while others propose that it underwent short periods of rapid growth followed by long periods of stasis, known as punctuated equilibrium. Some studies also suggest a combination of both punctuated equilibrium and gradualism, while others argue that it is not possible to distinguish between these two models. However, none of the previous studies have effectively differentiated between changes occurring within hominin species over time versus changes at the interspecific level, while also considering the effects of body size and phylogeny. To solve this issue, here we apply a novel phylogenetic comparative approach to paleoanthropological data spanning ~7 million years of hominin evolution that allowed us to model cranial capacity evolution trough time, by explicitly considering a) body mass, b) within- and between-species variability, as well as c) phylogenetic relatedness and uncertainty. This enabled us to effectively disentangle the levels (intra- vs. inter-specific) at which encephalization occurred in our own lineage. Our results show that hominin brain expansion primarily resulted from gradual increases at the intraspecific level. These within-species changes fully account for the overall increase in relative brain size. Furthermore, we also show that the variation in brain size between species, after accounting for this effect, is associated with differences in body mass rather than time. These results challenge the punctuated equilibrium theory and suggest that the evolution of relative brain size in hominins aligns more closely with a gradualistic model, with macro-evolutionary changes explained by trends observed at the micro-evolutionary level. Additionally, our analysis reveals that the within-species trend of brain size increase has accelerated in more recent lineages, indicating an overall pattern of gradual yet increasingly rapid brain size growth over time.

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Poster Presentation Number 55, Session 2, Friday 11:40-13:00

## Testing the utility of cranial and dental metric and non-metric data for inferring human population structure and history

**Hannes Rathmann[1,2], Silvia Perretti[3], Valentina Porcu[3], Tsunehiko Hanihara[4], G. Richard Scott[5], Joel D. Irish[6,7], Hugo Reyes-Centeno[8,9,10], Silvia Ghirotto[3], Katerina Harvati[1,2,10]**

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There is a broad consensus that global patterns of modern human cranial and dental phenotypic variation have evolved, to a large extent, through neutral evolutionary processes. As a result, craniodental features are widely used as proxies for reconstructing population structure and history. This is particularly relevant for the study of human skeletal remains from archaeological and paleoanthropological contexts, where DNA analyses are often limited due to poor molecular preservation, especially in deep fossil records and warmer climates, or when destructive DNA sampling of fragile and rare specimens is not possible. However, it remains unclear whether certain craniodental data types preserve neutral genomic signatures to a greater degree than others. This is problematic because investigations based on different craniodental data types may arrive at markedly disparate conclusions.

In this study [1], we aim to address this research gap and systematically test the relative utility of four standard metric and non-metric craniodental data types typically used for inferring neutral genetic variation. These include cranial linear measurements, cranial non-metric traits, dental linear measurements, and dental non-metric traits. Additionally, we explore the utility of a mixed-type dataset combining all four types of data together. To test the utility of each craniodental data type, we first estimated pairwise phenotypic Mahalanobis' $D^2$ distances among worldwide modern human population samples, drawing on the largest existing phenotypic datasets currently available. We then quantified the correlation of $D^2$ with pairwise genetic Weir and Cockerham's $F_{ST}$ distances estimated among the same set of populations using single nucleotide polymorphisms. Our computation accounted for geographically structured environmental variation, population sampling uncertainty, disparate numbers of phenotypic variables, and stochastic variation inherent to a neutral model of evolution.

Our results demonstrate that the four data types capture varying degrees of neutral genomic variation, with the highest signals preserved in dental non-metric traits and cranial linear measurements, followed by cranial non-metric traits and dental linear measurements. Importantly, our results show that combining the four data types together maximizes genotypic coverage compared to using them separately, even with a limited number of phenotypic variables. We hypothesize that this may reflect a lower level of genetic integration through pleiotropy between, compared to within, the four data types, effectively forming four different modules associated with relatively independent sets of loci. Consequently, we recommend that future craniodental investigations should strive for more holistic combined data approaches, allowing for more robust inferences about underlying neutral genetic variation.

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Pecha Kucha Presentation Session 2, Friday 16:40-17:55

## An experimental approach on dynamic Occlusal Fingerprint Analysis to simulate use-wear development and localisation on stone tools

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Stone tool-based technologies were a main component in the toolkit of humans since the origin of the genus *Homo*. Studying how hominins acted in the distant past through the study of evidence left on stone tools is key to understanding the evolution of human behaviour. Information about the use of stone tools is encoded in the wear patterns left on the tool's surface after its use. Post-depositional processes are known to modify or overwrite these wear traces. Differentiating between these traces is therefore fundamental in making accurate inferences about the function of tools.

Occlusal Fingerprint Analysis (OFA) is a well-established method in dental wear studies [1] to virtually simulate dental occlusal stroke movements and thus to locate and quantify the sequential contacts between opposing tooth crowns.

In a pilot study, we applied, for the first time, the OFA approach to a set of experimentally produced stone tools. The study aims to investigate whether contact areas calculated from the software correspond to use-wear traces we observe microscopically. The overarching goal is directed at building expectations as to where wear traces should develop on knapped tools based on their morphology, raw material, contact material and the type of action (i.e., movement) performed.

A series of controlled mechanised cutting experiments [2] with four experimental sample sets was performed: Two samples had a standard, saw-cut morphology, while the other two were knapped and retouched. One sample of each type was used on a synthetic bone plate [3] while the other was used to cut wood.

All samples were scanned with a high-resolution 3D scanner. The 3D scans were loaded into the OFA software and the trajectory, identical to that of the experimental setup, was simulated. During this trajectory, OFA recorded and quantified all contact areas by collision detection algorithms occurring between the 3D models of the tool and its contact material. In parallel, the experimentally produced micro use-wear (i.e., polish) was documented with various imaging equipment such as digital-, and light microscopes. Macro use-wear (i.e., edge reduction) was recorded using the cloud-to-mesh comparison software CloudCompare [4].

Results show that experimentally produced use-wear overlaps with contact areas calculated in the OFA software. Further, experimental data demonstrates that the saw-cut flakes abrade contact material more consistently than knapped blades, implying that tools with a simpler geometry cut contact material in a more regular way. In comparison to the knapped samples, these tools also generated larger contact areas in OFA simulation, suggesting that for these tools, a larger surface area is involved in the cutting process.

This proof-of-concept study demonstrates that the OFA method can be used to predict where multiscale use-wear develops on stone tools depending on their morphology and contact material. By incorporating other types of raw- and contact materials as well as other movements, this method will be further developed and may prove important for answering larger research questions. By formulating predictions as to where human-made use-wear should develop, this method can contribute to addressing the challenge of differentiating between surface alterations from human use and those stemming from post-depositional processes. In addition, this method may answer questions on tool performance based on contact areas simulated in the software.

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Poster Presentation Number 56, Session 2, Friday 11:40-13:00

## Distal ulnar morphology of the Miocene small-bodied catarrhine Pliobates cataloniae

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The holotype partial skeleton of the small-bodied catarrhine *Pliobates cataloniae*, from Abocador de Can Mata Miocene locality ACM/C8-A4 (~11.6 Ma), includes craniodental and postcranial elements. The skeleton of *Pliobates*, including its forelimb, display a combination of both primitive stem catarrhine and derived hominoid-like traits that hinders elucidating its phylogenetic relationships. From a morphofunctional viewpoint, the ulna plays a critical role in forearm flexion–extension and pronation–supination movements. The humeroulnar joint of *Pliobates* is more plesiomorphic than in crown hominoids, indicating a limited flexion–extension range at the elbow and lacking features related to elbow stabilization in extant apes. In contrast, its proximal radioulnar joint exhibits characters related to enhanced pronation–supination capabilities, closely approaching the condition of crown hominoids, Ateles, and Loris. The distal ulna also resembles the condition of extant hominoids regarding its incipiently expanded ulnar head (indicative of a diarthrodial distal radioulnar joint) and the incompletely developed ulnar fovea (suggestive of a triangular ligament and intra-articular meniscus). As in extant hominoids, the ulnar styloid process lacks articular surfaces for the pisiform or the triquetrum, although the latter shows a small articular facet, indicative of some (albeit reduced) ulnocarpal contact. Using 3D geometric morphometrics, we evaluated the morphometric affinities of the distal ulna of *P. cataloniae* to that of other primates to assess its positional behavior. The distal ulnar shape was quantified using 11 landmarks in *Pliobates* and a comparative sample of 138 individuals comprising 33 species from 20 anthropoid genera plus a lorisid, along with two fossil specimens corresponding to the stem hominoid *Ekembo nyanzae* and the pliopithecoid *Epipliopithecus vindobonensis*. The distal ulna of *Pliobates* does not overlap with any extant group or the other fossils analyzed, but more closely resembles that of hylobatids and lorises due to its incipiently expanded ulnar head and its reduced and hook-like styloid process. The former is related to enhanced pronation–supination capabilities, while the latter is related to an increased range of ulnar deviation. The morphology of the distal ulna thus suggests that *Pliobates* may have engaged in non-stereotypical postures in combination with eclectic climbing and/or non-acrobatic suspension, which necessitate enhanced mobility at the wrist. However, other forelimb elements must also be considered to complement this interpretation since the overall morphology of the ulna (both proximal and distal) suggests that *Pliobates* frequently engaged in both slow above-branch quadrupedalism and cautious climbing.

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Pecha Kucha Presentation Session 3, Saturday 16:40-17:55

## Copper-based pigments in the Palaeolithic? Identifying colour traces and revisiting the function of a Final Palaeolithic sandstone artefact from Mülheim-Dietesheim (Central Germany)

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Ongoing archaeometric investigations into a sandstone object from the Final Palaeolithic open-air site of Mülheim-Dietesheim [1] have initially identified it as a possible lamp. Excavations from 1976 on the southern bank of the Main River (east of Frankfurt) yielded an assemblage of lithics belonging to the Arch-Backed Point group, stratigraphically positioned under trace tephra from the ~13 ka BP Laacher See eruption. Re-investigations of the assemblage have identified both charcoal, ochre as well as a possible lamp. The rough oval bowl-shaped piece of sandstone is reminiscent of Late Magdalenian lamps [2] and preserves a crustal feature consistent with burning. Significantly, further examination of the lamp identified uncharacteristic blue spots across the object, with a concentration isolated in a worn/smoothed area of the upper rim. A comprehensive program of archaeometric analyses aims to characterise and identify the blue spots as well as the stone itself, with a view to help identify more precisely the function of the object. Petrographic analyses are underway to compare the object with lithic raw materials available in the locality, such as the silicified sandstone sources available in the nearby sedimentary rocks from the Taunus (Rhenish Massif). In-situ micro-X-ray fluorescence (μ-XRF) analyses of the blue inclusions confirm them to be copper-based. Further analyses in the form of micro-X-ray diffraction (μ-XRD), fourier-transform infrared spectroscopy (FTIR) and energy-dispersive X-ray spectroscopy (SEM-EDS) are being undertaken to further characterise the chemical composition and crystalline structure of the blue material with a view to confirming its mineral identification. Lead isotope analyses of the blue material, almost certainly a copper oxide pigment, may provide clues to the provenance of the mineral when compared to existing databases. The research may support a revised interpretation of the artefact, possibly a lamp with signs of a secondary function for pigment processing. Pigment processing at the site may be further supported by the presence of charcoal and ochre as well as the residue analysis of the apparent burnt crust, which may have served as binder. Whilst the use of red pigment (mostly ochre) and quartzite stone grinders are well attested from the Middle Stone Age onwards [e.g., 3], the use of natural blue pigments (i.e., azurite) only really appear from the Neolithic onwards [4], with few rare examples from the Palaeolithic [5]. The implications of such findings here, therefore, may be significant for understanding the evolution of art, body ornamentation, and the chronology of pigment usage in human prehistory.

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Podium Presentation (Virtual) Session 7, Saturday 16:00-17:20

## Dental Evidence from Mugharet el'Aliya, Morocco, and the Aterian

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The view of the Aterian lithic industry from Northwest Africa has changed drastically over the last decades. It has shifted from an industry supposedly associated with a Neanderthal-like population producing a delayed MSA between 40-20 ka to that of early *Homo sapiens* producing an MSA between ca. 145-20 ka, that also included features like personal ornaments and potentially overlapped with an earlier MSA now associated with the earliest known members of the *H. sapiens* lineage [e.g., 1-2]. Furthermore, Aterian skeletal remains are characterized by a mix of derived and archaic features, which motivate ongoing investigations into the origin of their archaic morphology for understanding evolutionary processes underlying modern human origins in the region. A recent reanalysis of the maxillary fragment from Mugharet el'Aliya, Morocco, showed that size played a significant role in the expression of archaic-like morphology, which had resulted in previous assignments of this specimen to the Neanderthal lineage [3]. Here, we explore the role of size on the Aterian dental morphology and growth, with special emphasis on the teeth from Mugharet el'Aliya.

Mugharet al'Aliya is a cave site located on the Moroccan Atlantic coast. A total of 6 fossil teeth have been found at the site since the 1930s. Three of these are associated with the Aterian layers of the site dated to ca. 60-35 ka [4] and available for our study: the so far poorly studied upper left permanent canine and third premolar as well as the so far undescribed fourth premolar. Casts of the upper canine were made to analyze perikymata counts per decile in this individual compared to a sample of Neanderthals, *Homo heidelbergensis*, and *Homo sapiens*. In addition, all three teeth were integrated into a comparative framework comprising data from CT scans as well as published metric and non-metric data of Neanderthals and early and later *Homo sapiens*, including three other Aterian teeth from two individuals (Contrebandiers T5, Dar es-Soltan II – H6). The toolkit of landmark-based geometric morphometrics was used to study the internal morphology of the enamel-dentine junction in all three tooth types. Multivariate statistics were applied to Procrustes superimposed coordinates derived from these three datasets. Summary statistics were calculated based on the metric and non-metric datasets.

As hypothesized, size is the main factor aligning Mugharet el'Aliya with Neanderthals and Middle Pleistocene groups. The dental metrics of Mugharet al'Aliya and the other Aterian teeth show high levels of megadonty similar to our Neanderthal sample from Krapina and our Middle Pleistocene samples. Dental non-metrics do not clearly distinguish between groups in our sample. However, Perikymata distribution in key regions of the upper canine of Mugharet el'Aliya showed tendencies toward a *H. sapiens* like growth pattern, falling outside the Neanderthal variation of our sample. Further, Mugharet el'Aliya shows a simplified crown morphology in all three teeth that is more similar to the dental morphology of *Homo sapiens* than to that of Neanderthals or Middle Pleistocene individuals. The enamel-dentine junction morphology of Mugharet el'Aliya, especially of its upper third and fourth premolar, aligns best with our *Homo sapiens* sample and is unlike any Neanderthal individual in our sample. The other Aterian individuals included in this study show a more intermediate enamel-dentine junction morphology, which is most similar to our early *Homo sapiens* sample.

Thereby, our results add further to the growing evidence connecting cranio-dental morphology from the Northwest African Middle Stone Age and western Asia, especially Qafzeh and Skhul [e.g., 5]. Furthermore, Mugharet el'Aliya adds to our knowledge about dental morphology within the Aterian fossil record, which spans an important time period in modern human evolution.

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Poster Presentation Number 58, Session 2, Friday 11:40-13:00

## Integrating ZooMS and zooarchaeology to assess the Châtelperronian and carnivore occupations at Cassenade (Dordogne, France)

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Across the Palaeolithic, humans and carnivores repeatedly occupied the same caves and rock shelters. At some of these sites, carnivores were the main accumulators of the bone material and traces of human occupation are sparse. Understanding these types of low-density archaeological sites is of importance to fully understand certain aspects of human subsistence behaviour, such as mobility patterns, duration of occupation, and human-carnivore interactions.

At these carnivore-dominated archaeological sites, the recovered animal bones are often highly fragmented and for over 70% of the recovered bone fragments we do not know what animal (or human) species they belonged to. Zooarchaeology by Mass Spectrometry (ZooMS) uses variations in collagen protein to taxonomically identify these types of morphologically undiagnostic bone fragments [1]. Therefore, ZooMS can be a useful tool in providing additional insights into the role of carnivores and humans in bone accumulation processes.

In this paper, we apply ZooMS to all morphologically unidentifiable bone fragments larger than 2 cm (n = 817) recovered from the 2012-2013 excavated Châtelperronian layer at Cassenade (Dordogne, France). This layer is characterised by a strong signature of carnivore activity and a low signal of human presence (227 lithics, [2]). Collagen was extracted using the ammonium-bicarbonate (AmBic) extraction method [3] and over 99% of the sampled bone fragments could be taxonomically identified. While the proportion of Equidae is similar in the ZooMS and zooarchaeological collections, Bos/Bison is represented at a threefold increase in the ZooMS fraction (50.8 vs 16.7%). Conversely, Ursidae, the dominant taxa in the morphologically identifiable remains (36.6%), only formed 7.3% of the ZooMS fragments. Carnivores are also present, but in low numbers (0-2%), and include Hyaenidae, Panthera and Canidae.

In the ZooMS fraction only one fragment (identified as a Bos/Bison) shows traces of human activity, but these numbers are most likely an underestimation due to the low surface readability. Conversely, traces of carnivore activity are much higher and we were able to taxonomically identify 334 bone fragments that were digested by carnivores (as indicated by acid etching). While large proportions of the Rhinocerotidae (63.79%), Elephantidae (52%), Equidae (48%) and Bos/Bison (45%) remains have been digested by carnivores, this is only the case for 1.7% of the Ursidae ZooMS fragments.

Three-dimensional data is available for all the ZooM-identified fragments, allowing a more detailed assessment of the vertical and horizontal distribution of the finds. Integration with the existing spatial site model further illustrates the added value of ZooMS to further define assemblage boundaries and test their integrity within a palimpsestual context of both carnivore and human activities.

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Poster Presentation Number 59, Session 2, Friday 11:40-13:00

## Musculo-skeletal stress markers of the right tibia from Las Estalactitas cave: insights into the mobility during the Chalcolithic in Northern Spain

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To understand the biological changes shaped on human bones that the emergence of the first farming societies and the end of the hunter-gatherer lifestyle produced is of high interest. In the case of Northern Spain, despite the thousand funerary structures found in the Cantabrian region, few human remains have been recovered due to alkaline and acidic soils [1]. A recent study on two burial caves in the area integrating different methodologies [1] shows that the $\delta^{13}C$ and $\delta^{15}N$ isotope analysis indicates a predominantly C3 terrestrial diet, including animal protein (meat and likely dairy products) and $\delta^{34}S$ results show that not great distances were covered by these human groups, depending on locally mobility for their daily activities [1].

In this study we present the description of musculo-skeletal stress markers of the right tibia of a Chalcolithic (3,955 ±75 BP) skeleton from Las Estalactitas cave, intending to deepen into the mobility patterns of the first farmers during this crucial period. Las Estalactitas cave is located in Cantabria (Northern Spain), and the human remains were first discovered in 1928, and first studied in 1991 [2]. The skeleton is almost complete, and it belongs to a middle-aged adult male individual, characterized by advanced dental wear and an oral pathology [2]. Some bones are covered with a fine layer of calcrete, which makes it difficult for the proper study of bone surface.

To quantify the external shape of the tibia, we measured the Platycnemic Index of the tibial shaft according to Bass [3], and musculo-skeletal markers were recorded according to the *Standardised Scoring Method* proposed by Mariotti and collaborators [4]. Our results indicate that the right tibia is hyperplatycnemic (Platycnemic Index of 49.74), the quadriceps tendon has a medium development (1c), and the soleal line of the tibia (*musculus soleus*) has a high development (2) with the line of insertion marked and with rugosity. Besides, we found vascular grooves (the imprints of some lateral branches of the anterior tibial artery), that are more frequent in individuals with high levels of physical activity [5].

Our results support that these groups had a predominantly continuous movement in the region and maybe seasonal mobility related to animal transhumance could have increased the mobility of this Chalcolithic individual, developing the features analyzed. Further research will be carried out to shed some light to the daily activities of the first farmers in the Northern Iberian Peninsula.

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Poster Presentation Number 60, Session 2, Friday 11:40-13:00

## Integrating computational fluid dynamics and 3D geometric morphometrics for a comprehensive analysis of nasal soft-tissue form and function in the context of human evolution

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Climatic adaptation has historically been considered one of the primary factors influencing morphological variation in the evolution of human nasal anatomy. Numerous craniofacial studies on dry skulls have found correlations between bony nasal cavity (NC) morphology and ecogeographic factors such as environmental temperature and humidity [1]. These correlations support the theoretical link between nasal morphology and a climatically mediated air-conditioning function. Thus, populations inhabiting colder and/or drier environments display longer, taller, narrower NC. This morphology would enhance the air-conditioning efficiency by increasing the ratio of mucosal surface area relative to air volume, as well as the residence time and turbulence of the airflow [2]. Additionally, climatic factors may influence metabolic requirements: humans living in colder environments tend to display larger NC to increase inhaled volumes of oxygen in order to meet their higher metabolic demands [3].

It is worth noting that despite the established associations between ecogeographic factors and NC morphology, this "correlational" approach only offers indirect evidences and may not be sufficient to fully address assertions of climatic adaptation. Indeed, the nasal airways (NA), i.e., the passageways delimited by the soft-tissue within the NC, plays a crucial role in respiratory physiology. The highly vascularized mucosa is the primary tissue involved in air-conditioning and its volume ultimately determines the actual intake of oxygen [4]. Furthermore, recent articles have revealed significant but low correlations between the NA and NC morphologies, urging caution in extrapolating climatic explanations from bony morphology to soft tissue [5]. In this context, applying experimental methods such as computational fluid dynamics (CFD) and 3D geometric morphometrics (3D-GM) on NA can enhance the empirical understanding of nasal anatomy and function.

Here, we conducted a preliminary analysis with a sex-balanced sample of 40 *in vivo* CT scans of adult individuals from diverse geographical regions (Cambodia, Chile, Russia, and Spain). 3D models of the NA were reconstructed and measured with 460 landmarks and semilandmarks for 3D-GM analyses to test morphological differences between populations. The airflow within the NA during inspiration was simulated under three environmental conditions (cold-dry, hot-dry, and hot-humid) to obtain two dimensionless parameters representing bilateral nasal resistance and nasal flow asymmetry (R and $\phi$), as well as the temperature and absolute humidity at the end of the nasopharynx, the posterior boundary of the NA. The covariation between shape (Procrustes coordinates) and function (dynamic airflow variables) was explored via Two-block Partial Least Squares.

3D GM analyses suggest subtle but statistically significant morphological differences between populations, with the Cambodians being the most morphologically distinct sample. However, our statistical analyses of CFD airflow simulations suggest no differences in air-conditioning capacities among populations, i.e., all geographic groups were able to adjust their airflow to meet internal body requirements regardless of external conditions. Correlations between the NA morphology and the dynamic airflow variables (R and $\phi$) were not significant. If our simulations provide functionally more informative and biologically more accurate results, these findings may suggest that differences in nasal soft tissue morphology may not be driven by a functional purpose linked to air conditioning, contrary to the widely documented but purely osteological evidence. Improving our understanding of the causal factors and functional significance underlying nasal morphological variation in modern humans could yield more accurate reconstructions of form and function of the NA in fossil hominins.

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Poster Presentation Number 61, Session 2, Friday 11:40-13:00

## Counting fragments: a new holistic approach to quantifying ZooMS-Identified bone fragments for analysis

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The application of ZooMS to Pleistocene-aged osseous assemblages has allowed for novel insights into human evolution and behavior. Recent ZooMS research suggests that there may be significant data "hidden" within the fragmentary, morphologically-unidentifiable portions of faunal assemblages which traditional zooarchaeological methods are unable to access. One of the most significant concerns with the integration of ZooMS identifications, however, is that the quantification of these fragments is currently restricted to NISP counts, which bring up obvious issues with double-counting that standard zooarchaeological quantification methods (e.g., MNI, MNE, DZ, etc.) have worked to excise.

This project has therefore sought to develop a new bone weight-based statistical method for quantifying ZooMS-identified fragments, abstracted from Kubasiewicz's "Wiegemethode", which the authors have termed Relative Abundance (RA). Since RA incorporates fragmentation rates, total expected weight per species, and utilizes data that is already commonly recorded during data collection for faunal assemblages, it can be variably applied for comparisons between species, sites, time periods, and even between the morphologically identifiable and unidentifiable portions of an assemblage. To test the reliability, biases, and limitations of the approach, we conducted an actualistic bone fragmentation experiment, quantifying the fragmented elements using RA and comparing these results with the original, known assemblage as well as the actual fragmentation patterns, counts, and sizes.

To explore the applicability and pragmatic potential for faunal assemblages quantified by RA, we have also applied this method to both the ZooMS- and morphologically-identified specimens from the Middle Paleolithic layers from two sites in Germany's Swabian Jura: Geißenklösterle Cave in the Ach Valley and Hohlenstein-Stadel in the Lone Valley. These sites each have long occupation histories that encapsulate the Epipaleolithic demographic change from Neanderthal to Anatomically Modern Human (AMH) populations in the Swabian Jura. This change in particular is defined by a culturally sterile layer separating the Middle and Upper Paleolithic layers within the Swabian Jura that suggests a lack of occupation overlap in the area. This is especially important as the location of the Swabian Jura itself would have been an important corridor for AMH populations moving progressively northward. While the Swabian Jura has been extensively studied, these studies mark some of the first explorations of the highly fragmented portions of these assemblages. Initial results indicate predictable correlations between traditional quantification methods and RA ratios within both the morphologically- and ZooMS-identified assemblages. With additional work, RA will ideally be expanded to allow for more thorough, holistic analyses of entire faunal assemblages and help ZooMS reveal clues "hidden in plain sight".

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Poster Presentation Number 62, Session 2, Friday 11:40-13:00

## Finding the haystack: utilisation of private-actor borehole data in the search of Danish interglacial deposits

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Looking for traces of Neanderthals can be like looking for a needle in a haystack. The South-Western region of Jutland, Denmark, is situated between the maximum extents of the Salian and the subsequent Weichselian ice sheets, resulting in the prospect of undisturbed deposits and surfaces from the intervening Eemian Interglacial preserved in the geological record. Preserved Eemian deposits in Denmark are considered rare. In contrast to similar deposits from Northern Germany, which contain rich open-air archaeological sites, the Danish Eemian and Early Weichselian deposits currently lack any traces of human occupation [1-2]. Besides differences in the sheer quantity of interglacial deposits, we believe the difference likely stems from the difficulty in finding and identifying accessible Eemian deposits in Denmark [3]. To search for novel occurrences of Eemian deposits in Denmark, we utilise privately-owned borehole data to locate previously unknown interglacial deposits.

In Denmark, most geotechnical boreholes have been digitised since the late 1990s. The boreholes are described following a common standard, are of good quality, and are capable of detecting organic-rich layers of 10 cm or less. An inferred age is attributed by the geotechnical companies to every sample with a code (e.g., "Ig" for interglacial) which allows the samples to be subset with a simple search. We currently have access to the borehole databases of six private companies, comprised of more than 72,000 projects, and with more than 420,000 boreholes covering all of Denmark. We identified 555 projects with interglacial or -stadial deposits. Through filtering and manual validation, we attribute interglacial deposits with a) significance, b) inferred interglacial age, c) depositional environment, d) accessibility, and e) geography. The resulting locations are crosschecked with already reported interglacial deposits.

This first-ever application combining privately owned geotechnical and public geological data is already providing new insights into the distribution and accessibility of interglacial deposits across Denmark. However, geotechnical encounters are spatially correlated with strong sampling bias towards areas with intense development, commonly located outside of our area of interest. Preliminary results suggest that shallow-buried Eemian deposits are often erroneously attributed to a postglacial age, as the local stratigraphy is the main argument for inferring a depositional age when geotechnical samples are described. The ongoing identification of interglacial and interstadial deposits presented in this project will serve as a framework for future ground-truthing activities with the potential for making novel discoveries of archaeological and paleoenvironmental significance.

We acknowledge all the data contributors.

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Podium Presentation Session 7, Saturday 11:00-12:40

## Ontogeny and evolution of midfacial gracilization in humans

**Alexandra Schuh[1,2], Philipp Gunz[1], Chiara Villa[3], Bruno Maureille[2], Michel Toussaint[4], Gregory Abrams[5,6], Dominique Bonjean[5], Jean-Jacques Hublin[7,1], Sarah E. Freidline[8,1]**

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Our species is characterized by a small and retracted, or gracile, midface compared to our living and extinct relatives, chimpanzees and Neanderthals [1]. However, the processes underlying this unique morphology remain elusive. Differences observed in adult morphology arise throughout ontogeny, i.e., through evolutionary changes in developmental and growth patterns and/or their timing [2]. Understanding the emergence and timing of ontogenetic differences can therefore provide insights into the underlying biological mechanisms of facial evolution.

Here we compared maxillary growth and development in present-day humans (represented by three populations from different geographic areas; N=128), Neanderthals (N=12) and chimpanzees (N=33) using two complementary approaches. Bone surfaces were analyzed using microscopic techniques to assess the cellular pattern of bone growth, (i.e., bone modeling [3]). We created digital maps to represent the pattern of bone modeling for each individual and computed the average pattern for each age group (according to dental development). In parallel, geometric morphometric techniques were used to capture changes in maxillary ontogeny from birth to adulthood. The results of both the microscopic and macroscopic approaches were visualized together, by projecting average bone modeling maps onto the respective average forms.

We found that postnatal growth is truncated in present-day humans compared to Neanderthals. Indeed, midfacial growth is greatly reduced towards the end of ontogeny (i.e., "adolescence"). This is reflected in reduced cellular activity, as we observed a decrease in bone resorption towards adolescence and adulthood. In Neanderthals, bone formation is predominant in the infraorbital and nasal regions. This is associated with pronounced growth throughout ontogeny and suggests more rapid growth rates.

Our results show that midfacial gracilization in present-day humans is acquired through unique ontogenetic mechanisms, and emphasize the significance of the late stages of growth in shaping the facial evolution of *Homo sapiens*. We find that the facial growth patterns of Khoe-San, Inuit, and Europeans differ consistently from those of Neanderthals and chimpanzees. This suggests that factors such as climate and diet, which differ in these populations, are not the main drivers of facial gracilization in present-day *H. sapiens*. Instead, our results point to differential expression of growth and sexual hormones between humans and Neanderthals [4].

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Poster Presentation Number 62, Session 2, Friday 11:40-13:00

## Network analysis, functional craniology, and the evolution of the human brain

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Craniocerebral morphology is influenced by constraints due to the spatial arrangement of its anatomical components [1]. Network theory can be applied in this context to perform analyses regarding the spatial arrangement of the human brain and skull, a methodology known as anatomical network analysis [2]. This approach can be used to reveal the basic architecture of the human head, which can influence or channel its ontogeny and phylogeny.

We generated a network model of the whole brain, based on its traditional macroanatomical division, and of the skull, based on its bone components at birth [3-4]. The model of the human head designed here consists of a set of 133 brain and skull elements, and 550 physical interactions.

Locally, the ethmoid and the body of the sphenoid bone are cranial elements with very high topological complexity, while the parahippocampal gyrus and the anterior lobe of the cerebellum are the brain elements with the highest spatial burden. This complexity, associated with geometric limitations due to spatial co-dependencies among craniocerebral elements, signals morphological significance and is likely to constrain regions' evolutionary plasticity [2-3,5]. Many of the craniocerebral elements with the highest topological load in the present anatomical network model are positioned in the head's inferior-medial regions, a result that is in agreement with previous studies [2-3,5]. Globally, the network model shows a clear topological compartmentalization of regions. Bilateral regions such as the frontal lobes are separated in their left and right sides. Isolated regions such as the viscerocranium or the cerebellum form separated and integrated topological blocks. This compartmentalization, or modularity, is interesting because it highlights groups of elements that undergo morphological evolution in a concerted way.

These results should be considered properly in ontogenetic and phylogenetic studies of morphological diversity in the human brain and skull.

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Poster Presentation Number 64, Session 2, Friday 11:40-13:00

## Taxonomic assessment of permanent and deciduous teeth from Uluzzo C rock shelter

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The Uluzzo C rock shelter was discovered and excavated in the 1960s by the Italian Institute of Prehistory and Protohistory led by Edoardo Borzatti von Löwerstern. This site is located in the Uluzzo Bay (Parco Naturale di Porto Selvaggio, Nardò, Puglia, south-eastern Italy), along with Grotta del Cavallo where the Uluzzian techno-complex was identified and described for the first time. Since 2015, the shelter has been the subject of new archaeological excavations, involving the Universities of Bologna and Roma "La Sapienza". The Uluzzo C shows a long stratigraphic sequence spanning from the Mousterian to the Bronze Age, including the Uluzzian and Romanellian, therefore it is crucial for our understanding of the Middle to the Upper Paleolithic transition [1].

Here we aim to investigate the taxonomic attribution of seven human dental casts recently rediscovered at the Museo Civico di Paleontologia e Paletnologia "Decio de Lorentiis" of Maglie (Lecce, Italy) and coming from Uluzzo C according to bibliographic sources. Unfortunately, the actual location in which the original teeth are stored is still unknown, but further research is underway to find them by analyzing existing literature and excavation diaries.

The sample consists of five permanent and two deciduous teeth: upper right second incisor (URI2), upper right canine (URC), upper left canine (ULC), lower right first molar (LRM1), lower left first molar (LLM1), lower right second deciduous molar (LRdm2), upper right first deciduous molar (URdm1).

The dental plaster casts were 3D captured with a high-resolution 3D blue light scanner (Artec Space Spider), and the 3D models were then optimized using Geomagic Design X software. Each tooth was morphologically described, including the non-metric dental traits, considering both 3D models and photographs of the casts [2]. Linear measurements (e.g., mesio-distal and bucco-lingual diameters) were obtained directly from the 3D models. For molars (LRM1, LLM1, LRdm2, URdm1) the crown outline was investigated using geometric morphometrics methods (Geomagic Design X, Rhinoceros 5 and R studio software were used) [3-4].

The non-metric dental traits identified are: distal trigonid and mid-trigonid crest and highly expressed anterior fovea in LRdm2, LRM1, LLM1; labial convexity in URI2; shoveling in URI2 and ULC; tuberculum dentale and distal accessory ridge in URC and ULC. Additionally, a highly expressed hypoconulid is present in LRM1 and LLM1. All the molars show a swollen buccal face, with internally compressed cusps.

In terms of morphology, the teeth of Uluzzo C present typical Neanderthal features, as also suggested by some preliminary morphometric analyses.

The study allows us to provide a taxonomic assessment from dental casts and adds further information on the peopling of Uluzzo Bay during the Late Pleistocene.

Acknowledgments: I would like to add this part: We thank the Soprintendenza Archeologia, Belle Arti e Paesaggio per le Province di Brindisi e Lecce for permission to study the materials and the Museo Civico di Paleontologia e Paletnologia "Decio de Lorentiis" of Maglie (Lecce, Italy) for access to teeth casts.

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Pecha Kucha Presentation Session 2, Friday 16:40-17:55

## Functional analysis of the late Lower Palaeolithic lithic assemblage from Schöningen 12 II-1, Lower Saxony, Germany

**Natasha T. Singh[1], Bárbara Rodríguez-Álvarez[2], Jordi Serangeli[2], Nicholas J. Conard[1,2,3], Flavia Venditti[1]**

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The site of Schöningen in Lower Saxony, Germany is an archaeological complex with MIS 9 deposits characterised by lakeshore sediments that favour the preservation of organic and faunal remains. They capture information on the sporadic visits of both animals and hominins that were drawn to this ancient lake ca. 300,000 years ago. Archaeological excavations have been undertaken at two main localities, Schö 12 and Schö 13, and notable finds include bones with hominin-induced cut and percussion marks, bone tools, and wooden implements [1].

Identifying the activities of hominins that frequented this lakeshore environment can lay the foundations for interpretations of economic and subsistence strategies during the Middle Pleistocene of Central Europe. Articulation of the faunal, lithic, and organic artefact assemblages unearthed at Schöningen is necessary to reliably interpret hominin lakeshore activities, one element of which includes the investigation of stone tool function. Previous functional studies of the lithic assemblages at Schöningen have provided insights into the behavioural and technological choices of Schöningen hominins, like the existence of both curational and expedient behaviours, the suggestive evidence of hafting, and interpretations of woodworking and animal processing [2-3].

This study aims to contribute to the functional analyses of Schöningen lithics by investigating the anthropogenic lithic assemblage from the site of Schö 12 II-1. Through optical microscopy at low and high magnifications, we assess the state of preservation of 179 specimens and, where possible, document the use-related macro- and microtraces on the lithic artefacts, discussing interpretations of use and handling. We also document any surface residues that might contribute to our understanding of tool function and manipulation.

The investigation of stone tool function, including the results of our use-wear and residue analysis of the Schö 12 II-1 lithic assemblage, supports the ongoing contextualistion of the other finds in this horizon, and offers valuable clues to the role of stone tools in the exploitation of lakeshore resources by Middle Pleistocene hominins in Central Europe.

The authors would like to thank Rudolf Walter in the Department of Early Prehistory and Quaternary Ecology at the University of Tübingen for his assistance with experimentation.

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Poster Presentation Number 65, Session 2, Friday 11:40-13:00

# The ecology, subsistence and diet of ca. 45,000-year-old *Homo sapiens* at Ilsenhöhle in Ranis, Germany

**Geoff M Smith[1,2], Karen Ruebens[3,2], Virginie Sinet-Mathiot[4,2], Elena Irene Zavala[5,2], Helen Fewlass[6,2], Dorothea Mylopotamitaki[7,2], Sarah Pederzani[8,2], Klervia Jaouen[9], Matthias Meyer[2], Mareike Stahlschmidt[10,2], Shannon P. McPherron[2], Johannes Krause[2], Hélène Rougier[11], Harald Meller[12], Jörg Orschiedt[12], Holger Dietl[12], Tim Schüler[13], Marcel Weiss[14,2], Jean-Jacques Hublin[3,2], Frido Welker[15]**

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The timing and spread of *Homo sapiens* into Europe and their role in the disappearance of Neanderthals remains a topic of much debate. The recent discoveries of new, well dated *Homo sapiens* fossils indicate an earlier arrival of these groups in Europe. In addition, isotope data suggests that some of these early occupations occurred during extremely cold phases, contrasting with previous models of *Homo sapiens* expansion [1]. Further, genetic evidence suggests that individuals from these early expansions of *Homo sapiens* did not contribute, genetically, to later Upper Palaeolithic populations [2-3]. Finally, the status of the makers of several transitional complexes, such as the Lincombian-Ranisian-Jerzmanowician (LRJ), remain unknown or highly debated.

Recent excavations at Ilsenhöhle in Ranis (Germany) the type-site for the LRJ, have provided evidence that the LRJ was produced by early groups of *Homo sapiens* ~45ka ago and represent one of the earliest entries of our species into central Europe. These new excavations have produced a wealth of archaeological and biomolecular datasets. Here we integrate results from zooarchaeology, peptide mass fingerprinting, and ancient sediment DNA to characterize the ecology, subsistence and diet of human groups at Ranis. All recovered bone remains (n=1764) were assessed through either morphology (n=1229) or palaeoproteomics zooarchaeology by mass spectrometry (ZooMS) and species by proteome investigation (SPIN) (n=536). The fauna is dominated by reindeer, cave bear, woolly rhinoceros and horse, indicating cold climatic conditions. A high proportion of carnivore modified bones, alongside the low occurrence of cut-marked and burnt bone, indicates the site was primarily used by large carnivores. This pattern is confirmed by animal DNA recovered from 26 sediment samples providing novel insights into the faunal community. Finally, the analysis of bulk carbon and nitrogen stable isotopes (n=44) provides a direct dietary signal for *Homo sapiens* individuals (n=10) and associated fauna. Results indicate a high trophic position for the Ranis individuals, though values are similar to what we usually see among Neanderthals and lower than that of Upper Palaeolithic *Homo sapiens*. Comparing the $\delta^{15}N$ and $\delta^{13}C$ of hominins over time in Europe as well as the associated fauna, it seems to be more a baseline effect related to climate changes, and that when *Homo sapiens* arrived they might have had similar subsistence strategies compared to Neanderthals.

Overall, the ephemeral involvement of humans with the faunal accumulation at Ranis contrasts with other early *Homo sapiens* sites, such as Bacho Kiro Cave [4], and suggests either small group sizes or task-specific functions of short duration. The study demonstrates the potential of combining archaeological and biomolecular datasets to provide a more in depth understanding of human site use, subsistence and diet.

The excavations and analyses at Ranis were funded by the Max Planck Society and the Landersamt fur Thüringia. We would like to thank the Landesmuseum in Halle for access to the Ranis collection and facilitating the sampling of specimens. We thank Stefan Kalkhof, and Johannes Schmidt (IZI Fraunhofer, Leipzig, Germany), Joelle Vinh and Emmanuelle Demey (ESPCI, Paris, France) for providing assistance with their MALDI-TOF MS instruments. We would like to thank Anna Chapin, Ayinuer Aximu-Petri, and Benjamin Vernot for help with sample collection and the Max Planck Institute for Evolutionary Anthropology Core Unit for support with data generation and DNA sequencing. F.W. received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement no. 948365). G.M.S. is funded by the European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie scheme (grant agreement No. 101027850).

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Podium Presentation Session 2, Thursday 14:20-16:00

## Morphological variation of the hominin navicular bone from past to present: implications for the evolution of the medial longitudinal arch of the foot

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The evolution of the medial longitudinal arch (MLA) of the foot is a hallmark of the evolution of human bipedalism, although it is still unresolved whether this derived characteristic arose within *Australopithecus* or *Homo* [1-3]. The navicular bone acts as the keystone of the MLA that uniquely characterizes the foot of *H. sapiens* among extant taxa [4]. However, *H. sapiens* may still present one of the multiple conditions of flatfoot (rigid or flexible flatfoot) from childhood (congenital) or developed during adulthood (acquired) [5]. In particular, there is no consensus on the clinical classification of congenital flexible flatfoot as pathological, as it is generally pain-free and presents a normal (but low) arch when the foot is not loaded. Complicating the issue, other factors such as footwear, lifestyles, and subsistence strategies are assumed to contribute to variation in *H. sapiens* MLA. This work aims to identify hominin navicular morphological features that may be related to the presence of the MLA and locomotor modes. Navicular shapes of 21 *Pongo*, 35 *Gorilla*, 46 *Pan*, 255 *H. sapiens* and 14 fossil hominins were captured using a 3D template of 85 (semi)landmarks and analyzed through geometric morphometrics. Navicular features purportedly related to the MLA were assessed by comparing living *H. sapiens* with clinically normal MLAs to individuals diagnosed with a flatfoot condition (i.e., congenital flexible flatfoot or adult acquired flexible flatfoot). Potential impact of footwear, lifestyle and subsistence strategies on navicular morphology was explored by analysing different archaeological *H. sapiens* samples (hunter-gatherers, agriculturalists, post-industrials) and living *H. sapiens* groups. Finally, fossil hominins (representing *Australopithecus* and *Homo*), *H. sapiens* groups (archaeological and living) and extant great apes were compared to identify traits linked to bipedalism and the presence of the MLA. Results show that human navicular shape differs significantly between clinically assessed normal arched feet and adult acquired flexible flatfoot, with the latter showing a 'hypertrophy' of the tuberosity that may be related to the (dys)function of the *m. tibialis posterior*. The congenital flexible flatfoot group, by comparison, does not differ from the normal arched group, suggesting that their navicular bony shape should not be identified as a pathological form. Interestingly, the naviculars of hunter-gatherers resemble those of the congenital flexible flatfoot group, while diverging from other *H. sapiens* groups characterized by a comparatively lower mobility level (e.g., agriculturalists and post-industrials). The naviculars of hunter-gatherers show traits that may reflect a larger range of motion at the talonavicular joint to adapt the midfoot to different substrates and likely a relatively low MLA when the foot is loaded, as seen in congenital flexible flatfoot. Whitin the entire extant comparative sample of hominids, navicular shape differentiates all *H. sapiens* groups from great apes primarily likely due to bipedalism since the phylogenetic signal is low. Among fossils, OH 8 (*H. habilis* or *P. boisei*?) and all fossil *Homo* specimens plot inside the range of living *H. sapiens* variation including congenital flexible flatfoot and normal arched groups. In contrast, *Australopithecus*, *H. naledi*, and *H. floresiensis* naviculars plot closer to African great apes, suggesting a certain degree of arboreality and likely an absent

human-like MLA. Our study suggests that known morphological differences between living human groups (i.e., clinically assessed as normal arched or flatfeet) can be used as a proxy to investigate navicular features presumably related to the MLA in fossils hominins.

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Pecha Kucha Presentation Session 3, Saturday 16:40-17:55

## Impact of lower limb length on human core temperature during endurance running

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Endurance running is used during persistence hunting which is a hunting technique likely used by individuals of the genus *Homo* since the Pleistocene. The success of persistence hunting is limited by the ability to maintain stable core body temperature and to avoid overheating during the hunt [1]. Endurance running could therefore create selective pressure on heat dissipation adaptations, which are observed in equatorial *Homo* sp., such as long limbs relative to body size. Longer lower limbs relative to body size have been previously shown to increase heat dissipation during sitting [2], but the impact of long lower limbs on heat dissipation could be even more critical during running due to the movement of the lower limb which increases heat dissipation by convection. The positive relationship between heat dissipation and relative lower limb length during running was previously inferred from results of ultramarathon events [3], but has not been tested in laboratory setting. Here we experimentally test the hypothesis that relatively long lower limbs reduce the increase of core temperature during endurance running.

We measured the length of lower limbs of 34 adult males and recorded their core temperature during running. Participants ran on a motorized treadmill wearing only shorts, socks, and shoes. Running was studied in a laboratory with controlled air temperature (25.15 ±0.24°C) and relative humidity (41.02 ±5.13%). The participants ran for 40 minutes at a speed of 2.78 m/s (10 km/h) and then rested in a standing position for ten minutes. Core temperature was measured using an ingestible temperature sensor. For the analysis we selected 20 individuals with the shortest and longest lower limb for their stature and separated them into short-limbed and long-limbed groups. We tested the effect of time and relative lower limb length on core temperature during running and during resting using linear mixed effects models.

Our results showed that core temperature during running increased significantly less ($p=0.011$) in the long-limbed group (by 0.69°C; from 37.27 to 37.96°C) than in the short-limbed group (by 0.93°C; from 37.44 to 38.37°C). During resting, the decrease in core temperature was not significantly different ($p=0.424$) between long- and short-limbed groups (decrease by 0.15°C in long-limbed group and decrease by 0.24°C in short-limbed group).

Our results therefore show that lower limb length has an advantageous effect on maintaining core temperature during running. This finding corroborates previous research which showed that individuals with longer lower limbs relative to stature have an advantage during running events in hot environment against individuals with relatively shorter lower limbs [3]. On the other hand, our results didn't show higher heat dissipation in longer- than shorter-limbed individuals during the resting, as would be expected from previous measurements on sitting people [2]. This difference could be caused by a different environmental temperature, which was around 3°C higher in our study, by a different resting position, which was standing in our study but sitting in the study of Tilkens et al. [2], or because in our study participants ran prior to the resting, while in the previous study they did not. Relatively longer lower limbs have been also previously shown to decrease the energetic cost of running [4]. Our results therefore support thermoregulatory advantage of relatively long lower limbs during endurance running, which in combination with energetic advantages of relatively long lower limbs might have created selective pressures driving the elongation of lower limbs in equatorial *Homo* sp. who engaged in persistence hunting.

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Podium Presentation Session 7, Saturday 11:00-12:40

## High coverage genomes of two of the earliest *Homo sapiens* in Europe

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To date there is little genetic data available to characterize *Homo sapiens* spanning the Middle to Upper Paleolithic transition in Eurasia, and only one genome, that of the ~44,000-year-old Ust'-Ishim individual from Siberia, has been sequenced to high coverage [1]. We present two high-coverage genomes from individuals found at two sites in central Europe that are approximately 230 km apart: one from the cave Ilsenhöhle at Ranis (hereafter, 'Ranis') in Germany, and one from Zlatý kůň in Czechia [2]. These individuals are among the oldest *Homo sapiens* known from Europe, and are likely older than Ust'-Ishim based on radiocarbon and molecular dating. We also sequenced low coverage genomes from seven individuals from Ranis, dated to between 49,160 and 42,200 years ago (95% cal BP), and detected second degree relatedness among three of the individuals.

All Ranis genomes show the highest genetic similarity to the genome of Zlatý kůň rather than to any other individual from ancient or present-day populations. Interestingly, the two high-coverage genomes share long identical-by-descent (IBD) regions, indicating that these individuals were distant relatives and lived at most 15 generations apart from one another. The high genetic similarity of Zlatý kůň to the Ranis individuals and the IBD sharing suggest that Zlatý kůň is either also associated with the Lincombian-Ranisian-Jerzmanowician (LRJ) technocomplex, or belonged to a different cultural group that was biologically similar to the LRJ population in Ranis.

Despite having genome-wide heterozygosity levels similar to present-day Europeans, we detect long runs of homozygosity in the two high coverage genomes, suggesting that there was a recent reduction in population size and/or recent inbreeding among their close ancestors. We also detected long tracts of Neandertal ancestry in both genomes that are best explained by a single pulse of Neandertal introgression, which is likely the major Neandertal introgression event shared among all non-Africans. We used the length distribution of these fragments to estimate when this introgression occurred.

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Podium Presentation Session 2, Thursday 14:20-16:00

## Hand use in fossil hominins: reconstruction of manual behaviours via phalangeal cortical bone morphology

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Throughout the fossil hominin record, the external morphology of manual phalanges presents mosaic features that indicate a transition in hand use from arboreal behaviours, combined with manipulative capabilities, to primarily dexterous manipulation in later *Homo* [1]. These mosaics of human- and ape-like features make it challenging to understand when the transition occurred from hands primarily used for locomotion to those being used primarily for manipulation. Here we investigate the cortical bone morphology of proximal and intermediate manual phalanges (digits 1–5) of several fossil hominins, as well as extant hominids (i.e., great apes and humans), as variation in phalangeal cortical bone distribution is thought to reflect differences in locomotion and manipulative behaviours [2].

We assessed cortical bone distribution patterns and thickness in the phalangeal shaft of *Australopithecus afarensis*, *Australopithecus africanus*, *Australopithecus sediba*, *Homo naledi*, Neandertals, *Homo floresiensis*, and fossil *Homo sapiens* alongside a comparative extant sample *Pongo* spp. (N=12 individuals), *Gorilla gorilla* (N=27), *Pan* spp. (N=29), and *H. sapiens* (N=40). Cortical bone structure was analysed in R package Morphomap [3], using surfaces created from high resolution micro-CT scans.

In the non-pollical proximal and intermediate phalanges, extant great apes generally had thick cortical bone on the palmar flexor sheath ridges (FSRs) with a low-to-intermediately thick shaft, whereas extant human cortical bone was thickest distodorsally in the phalangeal shaft. *A. afarensis*, *A. africanus*, *A. sediba* and *H. habilis* showed maximum cortical thickness on the palmar FSRs with an intermediately thick dorsal surface, which was more similar to that of great apes than to humans. Phalangeal cortical distribution in *H. naledi* and *H. floresiensis* showed a pattern intermediate between great apes and humans, with thick FSRs on the palmar surface combined with thick cortical bone on the dorsal surface of the phalanges. Neandertals displayed robust cortices with a thick dorsal surface like *H. sapiens*, as well as thick FSRs.

Within the first proximal phalanx, great apes varied from each other in the thickness of the shaft but shared a pattern of thick cortical bone on the distopalmar radial and ulnar surfaces. *H. sapiens* had the thickest cortical bone on the midshaft-to-distal dorsal shaft as well as along the distopalmar surface. Among fossil hominins, *A. africanus*, *A. sediba*, and *H. floresiensis* closely resembled the extant great ape pattern while *H. naledi* and Neandertals were most similar to the human pattern.

Overall, our results are consistent with diversity in hominin hand use behaviours. *Australopithecus* fossils were most similar to extant great apes across digits 1–5, suggesting digits that demonstrate functional signals for use during locomotion, which may 'override' any signals of manipulation. In contrast, the cortical bone distribution pattern of *H. naledi* digits 1–5 suggests a strong functional signal for manipulation, despite external morphology of the fingers and upper limb that would facilitate climbing [4]. The unique cortical bone distribution pattern in digits 1–5 of *H. floresiensis* may suggest the digits were used for both locomotion and manipulation, but in a way differing from that of extant great apes and other hominins in our sample. Variation in external morphology coupled with the variation in cortical bone distribution patterns indicate that the fossil hominins included in our study were using their hands in ways that were distinct from each other and from extant hominids.

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Poster Presentation Number 66, Session 2, Friday 11:40-13:00

## A protocol to test the reliability of the rearticulation of osteological primate pelves in comparative morphological studies

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The form of the pelvis is of outstanding importance to understand the evolution of locomotion, posture and parturition in the human lineage. The evolution of its unique shape has been elucidated primarily via disarticulated osteological material of primate species, including extinct hominins. The dry osteological pelvis, however, is composed of two ossa coxae and the sacrum; these individual bones need to be rearticulated to properly characterise pelvic form and this process is subject to uncertainty. Consequently, inaccuracy in the reconstruction of a fossil hominin pelvis may lead to erroneous sex determination and invalid interpretation of its functional and evolutionary significance.

To test whether the process of rearticulation of separated osteological pelvic bones introduces errors that may obscure inter- and intra-specific biological signals, CT scans of the body of one female and one male individual of *Homo sapiens*, *Pan troglodytes*, *Macaca mulatta*, *Lepilemur mustelinus*, *Galago senegalensis* and *Nycticebus pygmaeus* were used. For each specimen, the pelvic bones were segmented and analysed together in anatomical position ('connected') to serve as a reference for their shape *in situ*. Next, the 3D pelvic bones of the same individual were scattered intentionally and then rearticulated virtually three times on different days ('rearticulated) to test for error. Landmarks and semi-landmarks (n=268) characterising the overall shape of the pelvis were placed on the virtual 'connected' pelves three times on three different days to determine the extent of landmarking-only error. Each of the three 'rearticulated' models were also landmarked, to determine the amount of error introduced by rearticulation. Principal component analysis was used to explore the morphological variation of the sample and a Procrustes MANOVA (shape ~species/sex) was performed in the connected and rearticulated sample to disentangle the inter-specific, intra-specific, and residual variation (i.e., error). Mean Procrustes distance was used to assess the shape differences between groups in the connected and rearticulated samples to test for equivalence.

The first three PCs (~82% of the total variation) show that the connected and the rearticulated pelves are not identical, but a clear separation between species and between males and females within each species is observed in both groups. The Procrustes MANOVAs show that species differences are reflected in substantial differences in pelvic shape, with mean square of inter-specific differences ($MS_{connected}$=0.2624; $MS_{rearticulated}$=0.2741) an order of magnitude higher than for intra-specific sex differences ($MS_{connected}$ =0.0222; $MS_{rearticulated}$=0.0206) which is about ten-times higher than for landmarking error in the cadaveric individuals ($MS_{connected}$ =0.0010) or landmarking/rearticulation error in the rearticulated pelves ($MS_{rearticulated}$=0.0024). Furthermore, the mean Procrustes distance between the male and the female connected pelves within each species was higher than that between the landmarked connected and rearticulated pelves, demonstrating that the intra-specific sexual dimorphic signal is stronger than the morphological variation introduced by landmarking and/or and rearticulation error. In addition, the probability distributions of the Procrustes distances in the connected and rearticulated samples show no statistical differences in any of the species, supporting the interpretation that the intra - specific variation is comparable between the samples.

The present study thus statistically supports the previously assumed postulation that variation introduced by rearticulation of the separate dry osteological pelvic bones does not substantially affect the inter - specific or sexual dimorphic signal in comparative 3D morphological studies. This in turn justifies the continued use of dry osteological material in the study of the evolution and functional morphology of extant and extinct primates.

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Pecha Kucha Presentation Session 1, Thursday 11:30-12:45

## Pitting enamel defects offer novel phylogenetic interpretations for early hominins

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Pitting enamel defects described commonly on the post-canine teeth of *Paranthropus robustus* have been considered to have a genetic component to their formation [1]. Similar defects are not found in other hominin taxa in South Africa, and, as yet, have not been described in other hominins or primates more generally. In this study, we assess pitting enamel hypoplasia (PEH) in isolated dental remains from the Omo in present day Ethiopia [2], and compare these results to the pattern and frequency of PEH in other hominin taxa in eastern and southern Africa. PEH was scored for 83 isolated Omo teeth with complete crowns and not showing substantial post-mortem damage. No anterior teeth (incisors or canines) show PEH, and therefore frequencies are compared for posterior teeth only.

The results show PEH was relatively common in the posterior teeth (premolars and molars) of the Omo hominins, although they were not evenly distributed across the stratigraphic deposits or species/genera represented. Eight permanent teeth (8 of 29) assigned to robust species (*P. boisei* and *P. aethiopicus*) show PEH, spread over a wide range of Omo stratigraphic units in which they are represented in (teeth with PEH range from ~2.9 Ma to 1.9 Ma). Additionally, seven Omo deciduous teeth also display PEH, with at least three belonging to the robust lineage, and the others at present not assigned to a particular hominin taxa/group, giving a minimum of 11 Omo teeth with PEH attributed to *Paranthropus*. Unexpectedly, in the earliest deposits (Omo stratigraphic level B, approximately 3.0 Ma), the non-robust hominin material (likely representative of *Australopithecus afarensis*), also show PEH (5 of 15 permanent posterior teeth). Specimens assigned to later non-robust hominins (including early *Homo* and potentially different species) do not show pitting (Omo stratigraphic levels C to L: 2.9 Ma – 1.1 Ma; N=32 permanent posterior teeth).

The PEH observed in these 20 Omo samples (both in robust and non-robust specimens) is remarkably similar to those observed in *P. robustus*, and effects the same crown locations, and same teeth at similar severity and prevalence. Given the uniform nature of these defects across these taxa, and lack of defects in other groups, our results strongly suggest a shared aetiology. Interestingly, no PEH resembling these have been found in any extant primate sample, or specimens belonging to the genus *Homo*. We therefore hypothesize that, given the uniform nature of defects among post-canine teeth (including permanent premolars and molars, and deciduous molars), and lack of PEH on incisors and canines in both eastern and southern African samples, a common genetic effect is the cause. An environmental factor may still be required to initiate PEH formation, and therefore further research is required to asses this possibility. If the genetic hypothesis is supported through further investigation, these pitting enamel defects may offer novel phylogenetic insights into the hominin family tree, since it seems unlikely a potentially deleterious and unique phenotype may evolve independently multiple times solely within the hominin lineage. Therefore, our results offer support to the hypothesis that the robust hominin species in eastern and southern Africa evolved from *A. afarensis*. Given that we observed no pitting defects in the large sample of *A. africanus*, these data do not support the interpretation that the robust hominin species in southern Africa derived from *A. africanus*. Given the presence of PEH in the posterior teeth of *A. afarensis*, which are relatively small in size, these defects likely do not relate to the rapid evolution of hyper-thick enamel and large posterior teeth in *Paranthropus*, as previously proposed. Other pleiotropic effects should instead be considered to explain why these pitting defects remained common over such a long period.

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Podium Presentation Session 7, Saturday 11:00-12:40

## Further insights into the evolution of the Neanderthal semicircular canals

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Ancient DNA analyses [1] have provided key insights into the phylogenetic relationships of our closest hominin relatives and paleoproteomic research is promising to do the same for our ape ancestors. Nevertheless, several aspects of our evolutionary history remain contentious due to the fragmentary nature of the fossil record, the recurrent independent acquisition of morphological features, and the mosaic nature of evolution. Recent analyses have demonstrated that the morphology of the semicircular canals of the inner ear represents a good proxy for assessing phylogenetic relatedness in extinct species2, thus being a viable alternative when molecular data is not available.

Here we employed a deformation-based geometric morphometric method (diffeomorphic surface matching [DSM]) to analyze the semicircular canal morphology of a large sample of fossil hominins including two early *Homo* individuals (SK 27 and SK 847), the Sima de los Huesos hominins (n=11), the Aroeira 3 individual from Portugal, MIS7-5 Neanderthals from Western and Central Europe (n=7), and Eurasian Late Pleistocene Neanderthals (n=9), using recent and Upper Paleolithic (Cro-Magnon 1) modern humans (n=18) as a comparative sample. Relative to landmark-based geometric morphometrics, DSM has the advantage of allowing the direct comparison of continuous surfaces-thus reducing the uncertainties related with landmark placement-and is also sensitive to changes in volume proportions.

The results show the closest similarities between early Homo and modern humans, thus confirming that the latter retain the plesiomorphic condition (narrow lumen diameter, large vertical canals, and a somewhat smaller lateral canal) for the genus *Homo*. Furthermore, our results have identified a new derived feature for the Neanderthal lineage-a very wide diameter of the semicircular canal lumen, particularly in the common crus. Both fossil and extant great apes possess similarly "thick" canals, suggesting this likely represents the plesiomorphic condition for hominins [2]. In contrast, the genus *Homo* (as demonstrated by the morphology found in early *Homo*) is characterized by a narrower lumen of the semicircular canals. The Neanderthal condition, then, appears to be secondarily derived and may best be interpreted as a reversal. Among the European Pleistocene specimens, Aroeira 3 shows the most plesiomorphic condition [3], resembling Neanderthals only in the wide lumen diameter. The Middle Pleistocene Sima de los Huesos hominins are Neanderthal-like in their wide canal and common crus lumen, but lack an inferiorly positioned posterior canal [4], and show a uniquely derived (autapomorphic) rhomboid-shaped posterior canal. We suggest that the Sima de los Huesos hominins are best interpreted as a distinct paleodeme close to the base of the Neandertal lineage. Later in time MIS 7-5 individuals are morphologically diverse in the posterior canal shape, possibly as a consequence of genetic drift caused by group isolation related to paleoenvironmental factors. Both the Ehringsdorf and Abri Suard specimens have been previously reported to show a full set of "classic Neanderthal" features [4-5], whereas some Krapina individuals appear more primitive in the more inferiorly positioned lateral canal.

DSM analysis highlights greater morphological variability in Neanderthals than previously suggested using linear measurements and shape indices, comparable to that shown by extant modern humans. The present study has revealed that all members of the Neanderthal lineage share a newly identified derived feature in the wide diameter of the semicircular canal lumens. The evidence further suggests that a linear evolutionary model cannot be reconciled with the evidence provided by the fossil record in the Middle Pleistocene. Rather, it is suggestive of the presence of paleodemes [3] that locally evolved distinctive features, some of which may not have contributed directly to the later Neanderthal gene pool.

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Poster Presentation Number 67, Session 2, Friday 11:40-13:00

## Beyond diet and food properties: niche-driven evolutionary patterns in the study of jaw morphology and mastication

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The study of jaw morphology is naturally bound to diet because of the prominent masticatory function. Hominins and other primates are no exception, and the evolution of their jaws is analysed for their adaptation, or lack thereof, to the physical properties of food items. This perspective provides insights on the biomechanical capabilities of the primate jaw [1]. It also provides the framework to explain dental and mandibular reduction in *Homo*: extra-oral food processing (e.g. slicing, pounding, cooking) softens food texture, thus lowering the selective pressures to chew on biomechanically demanding foods [2]. Nevertheless, this approach bears severe limitations:

(i) it assumes a link between dietary and morphological similarities in the jaws [3], yet primate species with similar jaws may exhibit different diets and vice versa;

(ii) it assumes an optimum or near-optimum adaptation to one food source or a limited spectrum of food properties, which is undermined by the observation that several primates have varied diets and live in environments with high seasonal variations, conditions limiting the reach of an optimum [4];

(iii) it discretizes dietary and food profiles (e.g., frugivory/folivory, hard/soft foods), thus offering only a static and limited picture of a species' ecology.

In this work, we adopt a different approach by accounting for environmental change as an evolutionary driver of the primate jaw morphology. We analyse the pattern of evolutionary change in the catarrhine mandible and its association to shifts in the ecological niche. Morphology is represented by mandibular 3D landmark data collected on Cercopithecinae (35 species), Colobinae (8 species), Hominidae (5 species) and Hylobatidae (9 species). We estimate species' environmental niches via Maxent trained and evaluated on occurrence data from the 'Global Biodiversity Information Facility' (GBIF) and on six bioclimatic variables from the 'Worldclim database' (v2.1). We analyse the rate of change in shape and niche via Phylogenetic Ridge Regression. We aim to test that the environment can offer a suitable substitute to the limited proxies traditionally used, and want to set the focus on ecological changes, rather than adaptive optimums. In addition, we hypothesize that the catarrhine mandible is responsive to ecological changes despite the large and overlapping morphological variability across extant catarrhine clades.

Our analysis shows that the phylogenetic signals of niche (K: 0.23) and shape (K: 0.40) are different from what is expected under a Brownian Motion (BM) model of evolution (KBM = 1), while the difference is small and, likely, negligible for size (K: 1.05). Niche evolutionary rates are positively correlated to shape rates (Kendall's $\tau$: 0.47, $p < 0.001$), but the mangabeys appear to lie outside of the trend, with *Cercocebus* species exhibiting extreme evolutionary rates in both niche and shape.

The results confirm that using niche as a proxy for the species' ecological boundaries is suited to study the phenotype. Also, the correlation between niche and shape evolutionary rates suggest that the catarrhine mandible has responded to changes in the environmental niche, which could have played a crucial role in the masticatory evolution of the group. Notably, the durophagous and thick-enameled mangabeys [5] experienced an uncommonly rapid change in niche and correspondingly rapid change in shape, which suggests that peculiar masticatory adaptations in Catarrhini could be detected with the present approach. Our findings open new research opportunities to develop our understanding of the influence of climate and environmental change on the phenotypic evolution of hominins.

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Podium Presentation Session 5, Friday 14:30-16:10

## Spatiotemporal patterns of Neanderthal disappearance and coexistence with modern humans in Europe were affected by herbivore abundance

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Climatic shifts during the Marine Isotope Stage (MIS) 3 and the arrival of modern humans in Europe have been proposed to have influenced the trophic resource availability for Neanderthal populations. Nevertheless, quantifying the effect of these factors and their linkage has remained challenging. To address this gap, in this study, we integrate archaeological, paleontological and paleoclimatic data gathered over the last decades into new in silico models to assess whether the regional differences in the timing of the Neanderthal disappearance, the spread patterns of modern humans, and the temporal overlap between both human species, were affected by the carrying capacity of ecosystems they inhabit across Europe. Firstly, we use Bayesian age models and optimal linear estimations to establish an updated chronology of the Neanderthal's disappearance and their replacement by modern humans in each European region. Additionally, we validated an atmospheric circulation model with pollen-based reconstructions and used these data as driver inputs into a generalized dynamic vegetation model to compute the Net Primary Productivity in the surrounding areas of each archaeo-paleontological site between 55 and 30 kyr BP. Lastly, we developed and validated a macroecological model to compute herbivore carrying capacity according. We show that in the European regions where the ecosystem productivity was low or unstable, Neanderthals disappeared before or shortly after the arrival of modern humans. In contrast, in regions with high and more stable productivity, Neanderthals persisted longer and modern humans arrived earlier. Moreover, the observed temporal overlap between Neanderthals and modern humans is significantly correlated with the carrying capacity of small and medium-sized herbivores. These findings suggest that herbivore carrying capacity played a key role in releasing trophic pressure on the secondary consumers guild, which could have influenced the coexistence likelihood between both human species. These results suggest that resource availability was an important driver in shaping the spatiotemporal replacement patterns of Neanderthals by modern humans in Europe.

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Podium Presentation Session 6, Saturday 9:15 -10:35

## Intra-tooth variation of stable carbon, nitrogen, and oxygen isotopes in fossil tooth enamel of equids from the Middle Paleolithic site of Neumark-Nord 2, Germany

**Marissa Vink[1,2], Jennifer Leichliter[1], Sven Brömme[1], Théo Tacail[3], Lutz Kindler[3,4], Wil Roebroeks[2], Sabine Gaudzinski-Windheuser[3,4], Thomas Tütken[3], Hubert Vonhof[5], Alfredo Martínez-García[5], Amanda Henry[2], Tina Lüdecke[1]**

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Stable carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$), and oxygen ($\delta^{18}O$) isotopes are well-established proxies for dietary and environmental reconstruction in the fossil record. $\delta^{13}C$ and $\delta^{18}O$ tooth enamel data can be used for reconstruction of plant-based diets of animals and seasonal environmental patterns. These isotopes are routinely measured in the bioapatite of tooth enamel, which is highly resistant to diagenetic alteration. Similarly, $\delta^{15}N$ can be used to reconstruct trophic level and food webs. $\delta^{15}N$ is traditionally measured in organic material such as dentin or bone collagen, which rarely preserves during fossilization. Therefore, it has been nearly impossible to measure $\delta^{15}N$ in specimens >100,000 years old and to reconstruct the food webs of our early ancestors. Recently, an oxidation-denitrification method was developed [1], which allows us to measure the nitrogen isotope composition of the intra-crystalline organic component of enamel, even in fossil teeth. This is possible because the small amounts of organic matter are well-protected from diagenesis in the bioapatite of this highly mineralized dental hard tissue [2]. Therefore, we can now measure $\delta^{13}C$, $\delta^{15}N$, and $\delta^{18}O$ on the same aliquot of this taphonomically robust material.

Here we present combined $\delta^{13}C$, $\delta^{15}N$, and $\delta^{18}O$ isotope data from tooth enamel of 14 serial-sampled fossil equid (*Equus* sp.) third molars from the ~120,000-year-old Middle Paleolithic site of Neumark-Nord 2, Germany [3]. Each tooth was sampled along the growth axis and yielded up to 26 sub-samples, resulting in a total of 259 enamel samples. Neumark-Nord is a well-preserved archaeological site with a rich vertebrate fauna, that has yielded one of the oldest $\delta^{13}C$ and $\delta^{15}N$ bone collagen datasets, including isotopic data of equids [4]. Bulk enamel $\delta^{18}O$ values were also measured for equids from this site [5]. This study allows us to expand the isotopic dataset of this site by data of serial samples, which, in contrast to a bulk sampling approach, enables us to reconstruct seasonality for the Last Interglacial (Eemian; MIS 5e/5d transition).

In our study, we measured $\delta^{13}C$ and $\delta^{18}O$ of all enamel samples (n=259) using a technique for the precise analysis of <100 microgram enamel samples. Based on these isotope patterns, we selected 72 out of the 259 samples (including serial measurements of three of the equid teeth) for $\delta^{15}N$ measurement, to assess potential seasonal variation in the $\delta^{15}N$ composition of dietary nitrogen. Our enamel $\delta^{13}C$, $\delta^{15}N$, and $\delta^{18}O$ results are consistent with previously published equid collagen $\delta^{13}C$, $\delta^{15}N$, and bulk enamel $\delta^{18}O$ values. A clear seasonal signal is present in the $\delta^{18}O$ values of each tooth, with higher $\delta^{18}O$ values in summer vs. winter ($\bar{x}$=-6.2 ‰ vs VPDB, max=-4.6‰, min=-8.7‰, average intra-tooth range=2.4‰), but absent in both the $\delta^{13}C$ and $\delta^{15}N$ values. Furthermore, there is a strong positive correlation present between $\delta^{13}C$ and $\delta^{15}N$ enamel values.

This study shows that there is no strong effect of seasonal variation detectable in the $\delta^{15}N$ values of enamel-bound nitrogen isotopes of horses in temperate environments. This suggests, that bulk samples of tooth enamel from equids – and likely other large herbivores – in temperate environments do not need to cover an entire year of growth in order to measure an accurate average $\delta^{15}N$ value. In addition, the correlation between $\delta^{13}C$ and $\delta^{15}N$ seems to indicate that, in such environments, the mechanisms controlling carbon and nitrogen isotope fractionation are positively related. Lastly, this study improves the time-resolution of the geochemical dataset of the faunal remains at Neumark-Nord 2 allowing us to better reconstruct the past ecosystem, in which Neanderthals lived, by providing seasonal environmental and dietary data.

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Pecha Kucha Presentation, Session 1, Thursday 11:30-12:45

## A different angle: the evolutionary implications of greater sciatic notch dimorphism in primates

**Nicole M. Webb[1,2], Mark Grabowski[3], William E.H. Harcourt-Smith[4,5,6], Herman Pontzer[7,8], Martin Haeusler[1]**

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The greater sciatic notch is one of the most sexually dimorphic characteristics of the modern human skeleton. It is believed to serve an obstetric function by contributing to the overall space allocated to the pelvic inlet, thus facilitating the birth of our large-brained fetuses. Exactly when this distinct pattern of pronounced sexual dimorphism evolved in hominins remains unclear, as does the general pelvic morphology characterizing the *Pan-Homo* last common ancestor (LCA). Further, the mosaic pelvic configuration exhibited by *Ardipithecus ramidus*, temporally situated near the human-chimp divergence, reiterates the need to contextualize these dimorphic traits to elucidate when key adaptations related to obstetrics, locomotion and body size evolved [2]. Recent speculation that pelvic sex differences may stem from a conserved pattern shared across mammals, rather than evolving *de n*ovo in modern humans, necessitates additional investigations into pelvic morphology that include adequate primate outgroups [1].

Our study uses a Brownian motion evolutionary model to reconstruct ancestral state estimates and explore sex differences in greater sciatic notch shape across extant primates, enabling inferences regarding the *Pan-Homo* LCA. Greater sciatic notch shape was approximated by the angle between three anatomical landmarks defined by the posterior inferior iliac spine, ischial spine and the deepest point of the greater sciatic notch. The sample included a total of 43 species covering extant hominoids (n=173), cercopithecoids (n=115), platyrrhines (n=55), and strepsirrhines (n=46). Greater sciatic notch angles were calculated separately for males and females for the respective species to generate a mean ratio (female/male greater sciatic notch angle), which was subsequently used to reconstruct the nodes of the evolutionary tree using the maximum likelihood method for continuous characters [3]. Several fossil hominins were included to test evolutionary hypotheses regarding the LCA of chimpanzees and hominins, including a heuristic model of the 4.4-million-year-old *Ardipithecus ramidus* pelvis from the Afar region of Ethiopia. In addition, our statistical analyses considered locomotor and postural preferences.

Unexpectedly, the predicted greater sciatic notch angle ratio for the *Pan-Homo* LCA was comparable to extant *Gorilla*. These findings indirectly corroborate other anatomical postcranial evidence such as the scapula, suggesting *Gorilla* as a more accurate model for the LCA condition, especially when considering the primitive morphology seen in some australopithecine fossils [4]. This evidence also includes previous data obtained from ancestral state estimations of lower ilium proportions that similarly implicate *Gorilla* as a likely representative of the hominoid ancestral state for this anatomical region [5]. Our analyses confirm that *Pan* and *Pongo* are derived relative to *Gorilla* in their reduced degree of sexual dimorphism in greater sciatic notch angle. Additionally, our comparative investigations revealed that *Propithecus* had a similarly high degree of sexual dimorphism in greater sciatic notch as in modern humans. This warrants further investigation as there is no obvious obstetric constraint to explain the larger angle in females. Accordingly, careful consideration of the role of body size, neonate size and locomotion are needed, especially as statistically supported differences in greater sciatic notch ratios were revealed for most locomotor categories included in our analyses ($p=0.039$).

We thank the Middle Awash research project, T. White, C.O. Lovejoy and G. Suwa for permission to measure and include their heuristic *Ardipithecus ramidus* pelvis. The data used in the study was collected under a former affiliation (New York Consortium in Evolutionary Primatology/ The CUNY Graduate Center) via funding provided by the National Science Foundation IGERT grant #0966166. Financial support was also provided via Swiss National Science Foundation Grant No. 310030_212984. This work is part of Leibniz-Kooperative Exzellenz project K438/2022.

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Podium Presentation Session 3, Thursday 16:30-17:30

## Human bio-cultural evolution and its relationship to cranial capacity

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The increase in brain size and related cognitive abilities of humans supported the progressive development of a second inheritance system, commonly referred to as "culture". Human evolution of the last million years can only be understood in a bio-cultural framework [1]. Cranial capacity, as one of the few accessible factors in the case of fossils, is used in this contribution as a biological proxy for cognitive abilities, although it needs to be noted that not only size, but also brain organization influences cognitive performance [2]. Cranial capacity and chronological age of 193 hominin fossils were obtained from published scientific sources, giving an emphasis to the latest results using more modern methods. All juvenile specimens with immature brain development were excluded. These data from the Late Miocene to the Late Pleistocene show that in the last seven million years there are two conspicuous breakpoints observable in the development of hominin endocranial volume: one at around 2 million years, and one around 100,000 years ago [3]. The first breakpoint coincides roughly with the proliferation of the genus *Homo*, who started to leave the canonical evolutionary pathway, which otherwise pertains to all other organisms, by enhancing their fitness using an increasing number of aids from the abiotic domain. Producing more sophisticated tools and techniques, moving into the Eurasia continent, including fire and weapons into their inventory, are some characteristics of this phase. It finally led to the second breakpoint in brains size increase, which coincides approximately with growing evidence of symbolic behavior and lastly with the globularization of the *Homo sapiens* brain [4]. In the present, humanity seems to have arrived at a new point: the one where evolution can be taken into one's own hands which presents a new challenge: "intentional evolution". The parallel and accelerating developments which are recognizable in both the biological and the archaeological record are discussed. With increasing computer power and the tendency to outsource memory and calculation tasks to machines, particularly to artificial intelligence (AI) systems, human brain size might lose importance in the future. It remains unclear at the moment how this shift from the organic to the abiotic domain will influence the fate of humanity.

I thank Sarah Kainz for reviewing cranial capacity and chronological age data from the literature and Anne Le Maitre (both University of Vienna) for helping with R statistics. I am indebted to Annette Günzel for her artistic illustrations. Project funded by University of Vienna, project number BE547005.

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Podium Presentation Session 5, Friday 14:30-16:10

## The climate niche space of Neanderthals in Western Eurasia

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Neanderthals occupied western Eurasia between 350 and 40 ka, roaming a diversity of ever-changing landscapes through multiple cycles of extreme climate change. Based on the distribution of Middle Paleolithic sites, the geographic range of Neanderthals generally expanded during warm phases and contracted during cold phases. A key issue in Neanderthal research is to what extent Neanderthal populations expanded into northern latitudes, particularly those above 55°N, and what conditions facilitated such range expansions [1].

The Eemian Interglacial (MIS 5e/c. 130-116 ka) is often identified as a period of peak Neanderthal range expansion, with an increasing number of Middle Paleolithic sites reflecting Neanderthal occupation of the North- and East European Plain, teasing the possibility of higher latitude occupation [2]. However, the land-altering nature of more recent glacial expansion, such as the LGM, has erased much, if not all, of the already sparse archaeological material evidence of Neanderthal occupation in the northern latitudes [3].

Spatially and temporally constrained species distribution models have already been implemented to address to estimate past distributions of Neanderthals and gauge the impact changing climates had on their distribution. However, to fully understand the climatic niche space of Neanderthals, we need a spatiotemporal species distribution model with an unconstrained sample of observations derived from across Eurasia and the Middle Paleolithic. Here, using dated Neanderthal sites from across western Eurasia, paleoclimate reconstructions, and a new implementation of a spatiotemporal species distribution model using Maximum Entropy [4], we a) infer the climatic niche space of Neanderthals from 130-50 ka, b) test the impact of climate on Neanderthal niche size and distribution, and c) estimate the northern extent of Neanderthal occupation. The results have important implications for how we understand the climates that Neanderthals lived in and can tell us how Neanderthal populations reacted to the volatile climate of Pleistocene Eurasia, in both periods of expansion and contraction, and their extinction.

The current abstract submission does not have results as we are still in the process of completing the study. We anticipate we will have preliminary results for the ESHE conference. We understand that there is limited space for Podium talks, and would consider doing a poster if not selected for a Podium talk due to our current lack of results.

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Podium Presentation Session 1, Thursday 9:20-11:00

## Taxonomic reassessment of the Middle Pleistocene Baringo mandibles

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Two hominin mandibles (KNM-BK 67 and KNM-BK 8518), as well as some postcranial remains (KNM-BK 63–66) were found between 1966 and 1982 on the west of Lake Baringo, northern Kenya, in the Middle Pleistocene sediments deposited along the Kapthurin River [1-4]. The two mandibles KNM-BK 67 and KNM-BK 8518 were found in the K3 Member of the Kapthurin Formation, at the Leakey Hominid Site and MAS locality, respectively. The sediments that yielded the two hominin mandibles are estimated to 512–510 ka [5]. The corpus of KNM-BK 8518 is recognized as being more robust than that of KNM-BK 67, but they are reported to share similar morphological features of the teeth (multirooted premolars, molarized P4, M3 with seven cusps and larger than M2) and have been regarded as likely belonging to the same taxon [2-3]. Based on the small dimensions and morphology of the mandibles, teeth and post-cranial remains, they have been regarded as falling outside the known variation of australopiths, and attributed to *Homo* sp. indet. (aff. *erectus*) [2-3]. In this study, we evaluate the current taxonomic affiliation of the Baringo mandibles based on new analyses of the mandibular corpus, dental arcade and internal structures of the preserved teeth. We use microtomographic imaging to investigate the external and internal morphology of teeth and bone and to characterize their taxonomy.

We conducted geometric morphometric (GM) analyses of the shape of the mandibular symphysis and dental arcade, and of the enamel-dentine junction (EDJ) morphology of the teeth. The comparative sample differed for each analysis but included specimens from African, European and Asian sites representing *Australopithecus*, *Paranthropus*, and *Homo* (including early *Homo*, *Homo erectus* and Middle Pleistocene *Homo*). EDJ morphology of the M2 and M3 of KNM-BK 67 (not KNM-BK 8518 due to poor dental tissue contrast) was analyzed using 3D diffeomorphic surface matching, while the mandibular symphysis cross-section and the dental arcade shape in superior view were analyzed using 2D landmark-based GM. Group differences and taxonomic affinity of the Baringo mandibles were analyzed using principal component analyses, bgPCA, CVA, and the computation of typicality probabilities.

Results of the geometric analyses of the EDJ, symphysis and dental arcade shape show that both KNM-BK 67 and KNM-BK 8518 are unlikely to belong to *Homo* aff. *erectus*. The shape of the EDJ of the M2 and M3 of KNM-BK 8518 resembles those found in both *Paranthropus* and early *Homo*. They also present a protostylid morphology that is typical of australopiths, displaying a marked and extended protostylid in front of the protoconid and hypoconid. The symphysis of both KNM-BK 67 and KNM-BK 8518 exhibits a wide anteroposterior diameter, together with a thick and marked inferior transverse torus, as generally found in australopiths and early *Homo*. The dental arcade shape is more rounded than in *Australopithecus*, but more elongated than in *Homo erectus*. Our results present strong evidence that the taxonomic affiliation of the Baringo mandibles should be considered uncertain as should the other hominin post-cranial remains from Kapthurin. Their morphology is more consistent with material currently attributed to early *Homo* and even *Paranthropus* (acknowledging the small size of the teeth and mandibles relative to this genus). The presence of this robust gnathic and dental morphology is unexpected at ~500 ka and requires further investigation.

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Poster Presentation Number 68, Session 2, Friday 11:40-13:00

## What makes you run more; makes you walk worse? Body size, aerobic capacity, and walking activity during *Homo* evolution

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Humans are the only primates that can run long periods due to their higher aerobic capacity (AC) [1]. It is proposed that this AC appeared 1.8 Myr ago with the emergence of *Homo* genus in Africa (particularly *H. erectus*) when body size increased and modern anthropometric proportions emerged. These traits could propitiate new foraging behaviors, increasing catchment areas, traveling larger daily ranges, and increasing animal foods in the diet [2]. However, these behaviors might not appear due solely as a by-product of selection for long-distance walking but also for long-distance running. In this vein, some authors suggested that *Homo* genus began to occupy a new ecological niche as a consequence of improving their AC through Endurance Running activities (ER) [3], and new body features (e.g. long spring-like tendons: Achilles tendon) were more beneficial for running than walking (only long legs are beneficial for both). However, those changes (both having a larger body and having higher AC) entail higher O2 consumption and therefore, a higher energy expenditure (EE). Due to the higher costs, could these great adaptations negatively affect another aerobic task such as walking, a basic activity for human survival? This study aims to test whether bigger body size and higher AC impose an extra cost on walking activities or if other mechanisms may be buffering these costs.

Anthropometric and energetic data were collected on 51 adult individuals (23 males; 28 females). Each walked at their preferred pace on a treadmill for 5 min. Then, they completed a VO2 max running test. O2 consumption and EE were monitored using indirect calorimetry. Simple linear regressions were used to examine relationships between Body Mass (BM, kg) and Height (H, cm) on AC (VO2 max, mlO2/kg/min), Walking EE (mlO2/kg/min), and Walking speeds (m/s). The percentage of VO2 max dedicated to walking activity was calculated as a ratio for each participant (%VO2 walking). Multiple stepwise linear regressions via forward selection were computed to explore the relationship between VO2 max, H and BM and the %VO2 walking (selection criteria to enter $p<0.05$).

Our results show that only H is positively correlated to VO2 max ($R2 =0.084$; $p<0.05$). H was not correlated with walking speeds (Speed ~ H: $R2 =0.0009$; $p>0.05$), neither with Walking EE (Walking EE ~ H: $R2 =0.017$; $p>0.05$).

VO2 max and H (but not BM) were correlated with %VO2 walking (model adj. $R2 =0.67$; $p<0.001$). As expected, as expected higher VO2 max was inversely correlated with % maximal AC used in walking (Partial correlation: -0.338; $p<0.0001$) but, surprisingly, H contributed negatively to this percentage (Partial correlation: -0.149; $p<0.01$) without multicollinearity (VIF=1.09), reducing the walking cost.

We propose that, throughout our evolution, height increment could be partly accompanied by an increase in AC. Although a larger body involves higher energy costs, the adaptative advantages of a higher size are well known in *Homo* genus, such as a higher capability to procure and distribute energy, *inter alia* (see [4] and references therein). On the other hand, AC is a condition *sine qua non* for long-distances running, which would be essential for the onset of the ER in *Homo* genus. Our results suggest that an increment in a more demanding body height and AC in *Homo* genus did not draw back walking locomotion costs. Therefore, we can interpret that despite taller individuals having higher VO2 max levels and consequently higher energy expenditure, body height may compensate for their walking costs. Perhaps, these individuals could buffer the higher energetic costs thru several tradeoffs5. For instance, *Homo* size's augmentation also implies raised leg proportions that may reduce the walking cost, and improve heat dissipation and body thermoregulation.

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