Sessione

Paleoantropologia

comunicazioni orali

Sandrone cracks a half-smile. Virtual reconstruction and analysis of the Oreopithecus bambolii mandible.

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Oreopithecus bambolii is a fossil primate that lived during the latest Miocene in the regions corresponding to present-day Tuscany and Sardinia. Its remains have been found in a cluster of fossiliferous localities in southern Tuscany and in a single site in northern Sardinia. At that time, these areas were part of a paleo-archipelago made up of several islands, resulting from complex tectonic and sea-level changes in the central Mediterranean region. The most iconic specimen of this species is IGF11778, a nearly complete skeleton commonly referred to as "Sandrone." A major challenge in studying this specimen is its significant diagenetic fragmentation and deformation. In this study, we applied a virtual retrodeformation method to reconstruct the mandible of IGF11778 and to evaluate its morphological affinities with a comparative sample of 300 catarrhine primates. We selected a set of homologous landmarks previously used in studies of mandibular variation among catarrhines, restricting the analysis to 31 landmarks that could be reliably placed on IGF11778. The comparative sample comprised 300 previously published specimens representing the natural range of mandibular variation in extant and fossil catarrhines.
To isolate the deformation component in IGF11778, we used an algorithm that fits a hyperplane to the principal component scores of the reference sample. This hyperplane is assumed to represent biologically plausible, undeformed variation. The deformed specimen was then projected orthogonally onto the hyperplane to obtain an estimated undeformed shape. Based on this configuration, we analysed the morphology of the mandible in relation to that of living non-human catarrhines.
After Procrustes superimposition, a principal component analysis was conducted on the Procrustes coordinates. The first principal component reflects allometric variation among catarrhines. By plotting PC1 against centroid size, we identified two main allometric trajectories: one shared by all great apes, and another shared by the remaining catarrhines and lesser apes (i.e., gibbons). IGF11778 mandible falls within the latter trajectory, suggesting a shared allometric pattern among catarrhines prior to the divergence of Hylobatidae and Hominidae.

Sandrone in the trees: swinging through the past of Oreopithecus bambolii

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Oreopithecus bambolii is a Late Miocene hominoid from the Tosco-Sardinian bioprovince which has prompted discussions about its locomotor adaptations, manipulative capabilities, and phylogenetic positioning for decades. In the present study, a virtual approach was applied to investigate *Oreopithecus* locomotion through the analysis of postcranial skeletal elements of the nearly complete fossil IGF 17788 known as "*Sandrone*" housed in the Geological and Paleontological Museum of Florence, Italy. We analysed the morphological traits of proximal epiphysis of the humerus and carried out a geometric morphometric analysis of the scaphoid, comparing *Oreopithecus* with a large sample of extant and extinct primate genera to minimize the impact of taphonomic deformation. In addition, linear morphometric analyses were performed on cranial and postcranial elements (mandible, humerus, hands, and femur). Despite its relatively large body size, the skeletal proportion of *Oreopithecus* aligns it with lesser apes. The principal component analysis, conducted on the surface areas of the humeral head and the greater and lesser tubercles across 26 primate genera, positioned *O. bambolii* within extant suspensory primates, such as Hylobatidae, Ponginae and Atelinae. The geometric morphometric analysis of the scaphoid was carried out due to its role in inferring locomotor behaviour. Hominoids exhibiting a fused scaphoid–central bone were excluded from the analysis to ensure reliable comparisons. The *Oreopithecus* scaphoid showed large size and morphological similarities to *Pongo* consistent with prior literature. In addition, its trajectory in morphospace aligns it to hylobatids. In conclusion, the integration of linear and geometric morphometric data supports an interpretation of suspensory locomotor adaptation of *O. bambolii* and may suggest a hominoid mainly involved in forelimb-dominated suspension, broadly similar to Asian apes. Future analyses will expand the investigation including additional elements such as vertebrae, metacarpals, and other carpal bones, some of which may also contribute to clarifying the phylogenetic positioning of *O. bambolii*.

Inferring locomotor repertoires of South African australopiths from distal tibial trabecular architecture

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South African hominins display variation in ankle joint morphology, with each taxon showing a different combination of ape-like and human-like features, as well as unique traits. However, the functional implications of these morphological differences on ankle posture and loading remain insufficiently tested through internal bone architecture analysis. This study examines the trabecular structure of five South African hominin distal tibiae within a comparative context of extant hominoids and cercopithecoids to infer their joint loading patterns at the talocrural joint and, in turn, locomotor behavior.

Using microCT data, we investigate the following fossil specimens: StW 358 and StW 389 from Sterkfontein Member 4 (3.4–2 Ma), attributed to *Australopithecus*; StW 567 from Sterkfontein Member 5 East (undated), attributed to Homo sp.; U.W. 88-97 from Malapa (1.98 Ma), attributed to *Australopithecus sediba*; and SWT1/HR-2c from Swartkrans Member 1 (2.3–1.7 Ma), attributed to *P. robustus*. Our extant sample includes distal tibia of *Homo sapiens* (N=15), *Pan troglodytes* (N=23), *Gorilla gorilla* (N=13); *Pongo* sp. (N=7), hylobatids (N=7), and *Macaca fascicularis* (N=5). We used canonical holistic morphometric analysis (cHMA) to holistically compare relative bone volume fraction (rBV/TV) distributions throughout the distal tibia.

A principal component analysis of rBV/TV distribution revealed a clear separation along PC1/PC2 between humans and other taxa. In PC2, great apes separate from Asian hominoids, distinct from macaques. The Sterkfontein M4 *Australopithecus* tibiae exhibit an intermediate pattern with a human-like concentration of high rBV/TV centrally — indicative of a vertically loaded ankle during bipedalism — associated with an ape-like concentration anteriorly, possibly related to loading in ankle dorsiflexion. StW 567 shares this pattern but with higher posterior-central rBV/TV and an observable epiphyseal line. *A. sediba* displays a human-like central concentration, with an Asian hominoid-like concentration of high rBV/TV antero-laterally, possibly related to hyperpronation during bipedal gait. The *P. robustus* specimen from Swartkrans shows a gorilla-like rBV/TV distribution, suggesting frequent dorsiflexed and plantarflexed ankle postures, possibly related to a high degree of vertical climbing in their locomotor behaviour.

These findings support hypotheses of variation in bipedal gait and behavioural repertoires among hominin taxa.

Taung's hidden smile: the morphology of permanent teeth revealed a century later

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The Taung fossil has played a central role in the historical development of paleoanthropology, redirecting the interest of earlier scholars to the African continent as the cradle of humankind. This specimen is the Holotype of the species *Australopithecus africanus* and was first published by Dart in 1925.
In the 100 years following Dart's original publication, numerous works have focused on the erupted deciduous teeth and first permanent molars, associating the Taung specimen with fossils from the sites of Sterkfontein and Makapansgat, and distinguishing it from those from Swartkrans, Kromdraai, and Drimolen. While the pattern of the skull's developing permanent dentition has been investigated radiologically, the morphology of these teeth has not yet been examined in detail using advanced radiographic methods. This work contributes to our knowledge of the permanent dentition of the Taung specimen through the employment of micro computed tomography (CT) scans of the maxilla and mandible to describe and provide metrical information on the crowns of its permanent teeth. The permanent dentition was manually segmented from microCT scans although the high density and heavy mineralization of the bone surrounding the developing teeth, along with the occurrence of calcite encrustations on some of the crowns hindered resolution of some fine-scale morphological details. We here present preliminary descriptions of the outer enamel surfaces of the developing permanent teeth. We also recorded standard MD and/or BL crown measurements from our segmented 3D models of the unerupted dentition using Avizo v. 7.1 software. We compare these linear measurements to samples of *A. africanus* (specimens from Sterkfontein and Makapansgat) and *Paranthropus robustus* (specimens from Kromdraai, Swartkrans, Drimolen, Cooper's. Gondolin, and Sterkfontein Member 5). Overall, the MD and BL diameters of the Taung infant's developing permanent crowns show similarities with the *A. africanus* sample and notable differences from the *P. robustus* dental sample.

Volumetric and Shape Divergences Between Brain and Endocast: Methodological Considerations for Paleoneurology

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The study of brain evolution has long been a significant and debated topic in paleoanthropology. Attempting to analyze and reconstruct soft tissues such as the brain based on proxies is inherently a complex process. In recent years, much research attention has focused on better understanding the relationship between the brain and endocast, as well as the validity of the latter as a proxy. This study presents comparative analyses of the brain and endocast in a sample of 37 living individuals, utilizing a methodological approach that integrates volumetric and geometric morphometric techniques to provide a comprehensive assessment of their correspondence. High-resolution magnetic resonance imaging (MRI) data facilitated the precise segmentation and extraction of soft tissues, defining the brain hull (brain and meningeal layer) for accurate morphological representation. Endocasts were reconstructed from Computed Tomography (CT) scans, capturing the imprint of the brain's outer surface on the inner cranial vault. To evaluate the impact of segmentation parameters, both brain and endocast were segmented using five distinct threshold values. Volumetric assessments were conducted using several software packages to ensure methodological robustness and cross-validation. To conduct the geometric morphometric analyses, a 16-landmark configuration was optimized (following the identification of homologous structures on endocasts and brains) and manually placed. Subsequently, a dense cloud of 1000 semilandmarks was generated to capture finer surface detail.

Data demonstrated a robust positive correlation between overall brain and endocast sizes. However, our analyses revealed significant volumetric variations as a function of the segmentation threshold values. Notably, endocast volumes exhibited a positive correlation with increasing thresholds, whereas brain volumes showed an inverse relationship. Furthermore, Principal Component Analysis (PCA) performed on landmarks and semilandmarks configurations delineated a degree of separation between the distribution of endocast and brain shapes within the multivariate morphospace, indicating inherent morphological disparities that extend beyond simple size differences. Collectively, these observations underscore the complexities and potential limitations inherent in using endocasts as a direct proxy for inferring detailed brain morphology in both extant and extinct species.

Steinheim: the new face of a hominin from the Middle Pleistocene of Germany

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The hominin 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 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 significant part of its left side comprising the facial skeleton and the anteriormost portion of the neurocranium. The cranium SMNS-P-17230, better known as Steinheim, also shows substantial signs of taphonomic deformation, which affects its morphology and has led to different taxonomic attributions in the past. An association with the Neanderthal lineage and possible attribution to *Homo heidelbergensis* became increasingly accepted. The debate surrounding the specimen's taxonomy was due to the peculiar morphology of the preserved portion of its facial skeleton, greatly influenced by multiple taphonomic distortions. Throughout its history, the cranium has been shown without the missing part of the left side. Although fragments of the upper left side of the face were found alongside the cranium, these have been generally overlooked by the scientific community and were only described in a relatively recent German review by Wahl and colleagues (2009). The five larger fragments are labeled T1-T5, while five additional smaller fragments (around 1 cm) have no individual labels and are difficult to refit into the fossil. T1-T5 vary 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 possibly belongs to the inner surface of the neurocranium. Here, we present the digitization by computed tomography of the fragments and an attempt at their integration into a digital reconstruction of the cranium. Both the fragments and the cranium underwent a new micro CT scanning by the Paleoanthropology working group (University of Tübingen), which also allowed a high-quality digital removal of sediment from the virtual model of the fossil. The fragments were then aligned on a corrected model, performed through a published protocol of retrodeformation. The possibility of appreciating an unknown missing portion of the Steinheim face contributes to better assessing possible affinities of this specimen with penecontemporaneous populations of the European Middle Pleistocene.

Beyond Robusticity: Exploring functional and phylogenetic traits in the Neanderthal calcaneus

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While Neanderthals and H. sapiens share several foot features, Neanderthals exhibit unique adaptations in their foot structure, which provide important insights into the evolutionary pressures and locomotor demands specific to their lineage. Neanderthals exhibit distinct calcaneal traits like larger talar facets, a projecting sustentaculum tali, and a broader tuberosity. These differences from modern humans are thought to reflect greater robusticity linked to experiencing higher loads in Neanderthals, but general postcranial robusticity of Neanderthals may not be sufficient to explain their calcaneal uniqueness. This study aims to determine whether Neanderthal external calcaneal shape primarily results from functional behaviors, phylogenetic heritage, or derived features. A total of 85 adult calcanei (7 Neanderthals and 78 H. sapiens) were analyzed using a 3D geometric morphometric approach. The Neanderthal sample includes Regourdou 1, La Chapelle-aux-Saints, La Ferrassie 1 and 2, El Sidrón SD-2192 and SDR-112, and Spy 2. The H. sapiens sample includes Early and Late Upper Pleistocene individuals, Holocene hunter-gatherers, Iron Age individuals, and Post-Industrial groups, representing diverse mobility strategies — from highly mobile hunter-gatherers, either barefoot or wearing soft foot coverings, to highly sedentary post-industrial groups wearing hard footwear. Calcaneal shape variation was assessed using a 3D template of 276 (semi)landmarks. Generalized Procrustes analysis was followed by statistical analyses, e.g., Procrustes ANOVA and PCA, to assess group differences. Neanderthal calcanei exhibit a combination of distinct traits compared to H. sapiens: a more medially convex and laterally expanded posterior talar facet, an enlarged anterior talar facet, a more plantarly oriented sustentaculum tali, and a markedly reduced lateral plantar process of the tuberosity. These traits support the hypothesis that Neanderthals had a pronated foot posture, likely reflecting different force transmission at the heel at touchdown. A short antero-posterior sinus tarsi may be an archaic trait shared with other Pleistocene *Homo* fossils. Shared features with H. sapiens hunter-gatherers, such as a broad calcaneal tuberosity, suggest high load from long-distance barefoot travel on natural substrates. While H. sapiens calcaneal morphology varies with levels of mobility and footwear, Neanderthal calcanei display a mixture of derived, ancestral, and functional traits.

ERC Project "Last Neanderthals" and the fire making skills of Homo neanderthalensis

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Full control of fire is one of the most important behavioral acquisitions of our genus. It expanded the adaptive capability of early humans, triggered many co-evolutionary processes, and enabled some of the cognitive skills unique to our species. To date, several contrasting pieces of evidence fog the picture of how early humans incorporated fire in their life and how they became able to fully control it by starting it at will. In particular, contrasting evidence exists regarding the fire skills of Neanderthals, our closest relatives. There is no doubt that Neanderthals, like archaic modern humans, were using fire extensively, at least in specific periods of the Pleistocene. However, while some evidence suggests that Neanderthals could have struck flint and pyrite to produce sparks, no compelling evidence exists that they were able to start a fire in every environmental condition as we, modern humans, do. The ERC Synergy project "Last Neanderthals", among other goals, seeks to achieve a deeper understanding of the ability of Neanderthals to start a fire by identifying overlooked fire strikers, looking for pyrite dust and microscopic remains of organic materials used as tinder, and extract fire-derived organic molecules such as Pyrogenic Polycyclic Aromatic Hydrocarbons in the archaeological deposits of over 30 Eurasian archaeological sites dated between 60,000 and 40,000 years ago. The new data collected will invaluably contribute to advance our understanding of the fire-making skills of the last Neanderthals, adding to the research on their adaptability, competitiveness with Homo sapiens and eventually their demise around 40,000 years ago

A multi-stage mortuary landscape in the Late Upper Paleolithic: genomic and bioarchaeological evidence from Arene Candide Cave (Italy)

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With a minimum of 22 individuals interred over a millennium, the Epigravettian "necropolis" of Arene Candide Cave (ca. 12,800–11,800 cal BP) stands as a major source for understanding the biological composition, social structure, and funerary practices of Late Pleistocene hunter-gatherers. Dominated by a 90-meter-high white sand dune rising to its entrance, the site was likely a ritual landmark, used by local groups to reaffirm territorial claims through ancestral ties. A complex, multi-stage mortuary program was enacted within the cave, involving manipulation and secondary deposition of skeletal elements – particularly crania – from previously buried individuals, placed in and around new inhumations. These practices, along with double burials, suggest efforts to establish ritual links between individuals, possibly reflecting kinship or shared congenital conditions.

Indeed, several individuals exhibit skeletal dysplasias, a phenomenon also seen in other European Gravettian and Epigravettian groups. This supports the idea that formal burial was a selective rite – reserved for "exceptional events and exceptional people" – serving to ritually contain biological uniqueness and negative events such as violence or trauma. Still, key questions remain regarding the span of the cave's funerary use, kinship relationships among the deceased, and the prevalence of congenital conditions – questions that can be addressed through ancient DNA (aDNA) analysis.

In this study, we successfully extracted DNA from 11 individuals following strict aDNA protocols optimized for highly fragmented molecules. Shotgun sequencing and a target enrichment approach were used to reconstruct mitochondrial and nuclear genomes. Initial results identified at least three female individuals, including one adult (AC3) originally sexed as male underscoring the limitations of morphological sex estimation, especially in Paleolithic contexts. This individual was previously diagnosed with hypophosphatemic rickets, a rare X-linked dominant disorder, based on limb bowing and diffused enthesopaties. Further genome data will explore the genetic bases of this condition, mainly linked to mutations of the FGF23 gene.

All mitochondrial DNA haplogroups are closely related and include individuals with identical haplotypes, suggesting a shared maternal lineage. Ongoing genomic analyses will help clarify the presence of a tightly knit kin network among Epigravettian foragers buried at Arene Candide.

Between Normal Variation and Disease: Craniofacial Abnormalities in an Upper Paleolithic Hunter-Gatherer from Maritza Cave (Abruzzo, Italy)

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Upper Paleolithic European hunter-gatherers are well known for their symbolic art, personal ornaments, sophisticated hunting techniques, long-distance exchange networks, and complex burial practices. Their skeletal remains also exhibit a notable frequency of developmental skeletal and dental anomalies. Some of these conditions are extremely rare, of unknown aetiology, or may have a genetic basis—raising important questions concerning inbreeding levels, biological resilience, and social care within these populations.

The skull of the adult male individual from Maritza Cave (Mtz2 – L'Aquila, Abruzzo) shows clear evidence of abnormal bone remodeling, particularly in the craniofacial region (e.g., os zygomatic), with marked bone thickening. Distinctive features include a prominent supraorbital ridge, enlarged mandible, frontal bossing, and hypertrophic mastoid processes. These traits are consistent with pathological or chronic conditions that typically develop after the completion of skeletal growth, such as Paget's disease or acromegaly—both adult-onset disorders characterized by excessive and disorganized bone remodeling, often affecting the craniofacial skeleton.

To better quantify the morphological features of the Mtz2 skull and refine the diagnostic interpretation, virtual anthropology and geometric morphometric (GM) techniques were applied. Landmarks, curve, and surface semilandmarks were recorded on 3D digital models, focusing on the frontal bone, facial skeleton, and temporal bone. After Procrustes superimposition, data were analyzed using Principal Component Analysis (PCA) to explore variations in both shape and form (no size adjusted coordinates) space. Mtz2 was compared with Epigravettian, Mesolithic and Neolithic adults from Italy, two documented cases of pituitary gigantism from infancy, and modern individuals from the Anthropology Museum of the University of Florence. Preliminary GM results showed that, in the form space, the two pathological individuals clearly separate from the comparative sample, with Mtz2 clustering near them, alongside only a few other paleolithic individuals. However, in shape space, no clear pathological signal was observed either in Mtz2 or in one of the two individuals diagnosed with gigantism.

Although the preliminary analysis reveals some morphometric affinities between Mtz2 and the individuals with pituitary gigantism, it does not provide definitive evidence of acromegaly in this case based solely on GM data.