Program for the 2nd Lembersky Conference in Human Evolutionary Studies

Advances in Paleoecology

Sponsored by the Rutgers Center for Human Evolutionary Studies

Ryne Palombit, Director

Alexander Library Lecture Hall, 4th Floor, 169 College Avenue

Scientific Committee

W. Andrew Barr, Co-Chair

Robert S. Scott, Co-Chair

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Conference Factotum

Tim Bransford

Wednesday, November 14

9:30 am: Registration & Breakfast

10:15 am: Opening Remarks

Andrew Barr, George Washington University

10:30 am: Larisa R.G. DeSantis, Vanderbilt University

Integrating and validating paleoecological tools

11:00 am: Fire Kovarovic, Durham University

Mammal communities in context: present day patterns and interpretations of the past

11:30 am: Andrew Du, The University of Chicago

Developing a theoretical framework for time-averaging and understanding its effects on the interpretation of fossil communities

12:00 pm: W. Andrew Barr, George Washington University

Bovid locomotor ecomorphology and ecometrics as paleoenvironmental proxies

12:30 pm: Lunch Break - Gerlanda's

1:30 pm: Discussion

What do we hope for the future of paleoecology?

3:00 pm: Adjourn for the Day

Thursday, November 15

10:15 am: Breakfast

11:00 am: Craig Feibel, Rutgers University

New paleoecological perspectives from deep drilling in East Africa

11:30 am: Maryse Biernat, Arizona State University

Spatial differences of mammal communities between 2-1.4 Ma in the Turkana Basin, northern Kenya

12:00 pm: Sarah Hlubik, Rutgers University

Preliminary microbotanical investigation of FxJj20 AB, Koobi Fora, Kenya: potential for environmental reconstruction, fire incidence, and human behavior

12:30 pm: Lunch Break - Efes

1:30 pm: Dan Peppe, Baylor University

Reconstructing ancient climate and ecology using fossil plants

2:00 pm: Regan E Dunn, Field Museum of Natural History

From cells to canopies: reconstructing vegetation structure in the fossil record

2:30 pm: Aly Baumgartner, Baylor University

Preliminary paleobotanical paleoclimate estimates from the Early Miocene Rusinga Island, Lake Victoria, Kenya

3:00 pm: Keynote Address

Gildas Merceron, CNRS - Université de Poitiers

6:00 pm: Reception – 3rd Floor RAB Building, 131 George St

Friday, November 16

10:15 am: Breakfast

11:00 am: Sean Hixon, Pennsylvania State University

Patterns in amino acid δ 15 N values of lemurs are inconsistent with aridity driving megafaunal extinction in southwestern Madagascar

11:30 am: Enquye Negash, George Washington University

Stable isotopic study of soil organic matter: understanding differences in woody cover in modern African Ecosystems

12:00 pm: Deming Yang, Stony Brook University

Intratooth isotope profiles of fossil suids from the Koobi Fora Formation (East Turkana, Kenya) indicate seasonally stable C4 diets but seasonally variable body water or hydroclimate

12:30 pm: Lunch Break – Delhi Garden

1:30 pm: Kendra Chritz, Smithsonian Institution's National Museum of Natural History

Using Isotopes to explore the past, present and future of people and ecosystems in East Africa

2:00 pm: Robert S. Scott, Rutgers University

Dental microwear and paranthropit diets

2:30 pm: Amy Rector, Virginia Commonwealth University

Robust australopith paleobiology: The biogeography and paleoenvironments of eastern and southern African Paranthropus

3:00 pm: Discussion

A general concluding discussion, informed now by all talks

4:00 pm: Closing Remarks & Announcement of Excellence Award

Robert S. Scott, Rutgers University

Ryne Palombit, CHES Director, Rutgers University

Abstracts of 2nd Lembersky Conference in Human Evolutionary Studies

(*Alphabetical By First Author*)

BARR, W. ANDREW[1]. *Bovid locomotor ecomorphology and ecometrics as paleoenvironmental proxies.*

[1]Anthropology, The George Washington University

Ecomorphology is the process of using functional morphology to link an organism's anatomical features with its ecological traits (e.g., diet, locomotor style, habitat preference), often with the goal of inferring those traits from fossil individuals. Here, I describe my study of bovid locomotor ecomorphology of astragali, calcanei, and metapodials in connection with the habitat preference of modern bovids (antelopes). I then use these links established in modern bovids to predict the habitat preferences of fossil bovids in the Plio-Pleistocene Shungura Formation of Ethiopia as a proxy for habitat change through time. Finally, I describe my recent work to scale up these individual-level studies to a community-scale "ecometric" analysis predicting mean annual precipitation and land-cover from community-level ecomorphic trait distributions in modern communities and the fossil record.

BAUMGARTNER, K.A.[1] & DAN PEPPE[1]. *Preliminary paleobotanical paleoclimate estimates from the Early Miocene Rusinga Island, Lake Victoria, Kenya*.

[1]Geosciences, Baylor University

The Early Miocene of Rusinga Island (Lake Victoria, Kenya) is best known for its vertebrate fossil assemblage, and particularly its remarkable record of early hominoids and catarrhines. However, there are also well-preserved plant fossils that have received much less attention. There are three plant fossil rich intervals within the Hiwegi Formation: Kiahera Hill (~18.3 ma), R5 (~18.1 ma), and R3 (~17.8 ma). Here we present preliminary paleoclimate estimates for Kiahera Hill and R3. These new results revise previously published paleoclimate estimates for R3. The MAT and MAP of Kiahera Hill is reconstructed to be 31.7 °C and 1183-2425 mm/yr, respectively, and the MAT and MAP of R3 to be 17-23.5 °C and 858-1760 mm/yr. The estimates for R3 are cooler and drier than previous estimates. These climate estimates indicate that the Kiahera Hill site falls within a tropical seasonal forest biome, and the R3 site within a transitional woodland-tropical seasonal forest biome. The flora of Kiahera Hill has few monocots or herbaceous taxa and is dominated by large leaves, which also suggests a warm, forested environment. Collections from the R3 flora indicate it was spatially heterogeneous with monocots and herbaceous taxa found dominating patches on the landscape. In addition, the presence of reed-like monocots and emergent aquatics (e.g., aff. *Potamogeton*) indicates at least periodic standing water. These results, coupled with previous research, suggest that the Hiwegi Formation on Rusinga Island samples multiple environments in the Early Miocene, which in turn likely influenced the evolution and habitat preferences of early hominoids.

BIERNAT, MARYSE[1], D.B. PATTERSON[1] & K.E. REED[1]. *Spatial Differences of mammal communities between 2-1.4 Ma in the Turkana Basin, northern Kenya*.

[1]Human Evolution and Social Change, Arizona State University

Fossil sediments of the Turkana Basin in northern Kenya have provided a vast amount of paleoecological data that have allowed researchers to contextualize the evolution of hominins during the Plio-Pleistocene of eastern Africa. The majority of paleoecological studies of the Turkana Basin, however, have either analyzed specific regions within the basin or combined all regions. During the early Pleistocene, well-documented changes in paleolake Lorenyang may have resulted in the restructuring of the terrestrial ecosystems in the Basin. This study analyzed the three major formations of the Turkana Basin (i.e., Koobi Fora, Nachukui, and Shungura) to elucidate the relationship between shifting Basin hydrology and ecosystem restructuring. Using multiple proxies such as faunal abundance data (n> 6,000) and enamel carbon isotopes (n > 400) of the mammalian communities, we identified region-specific changes through time compared with the movement of Lorenyang between ~2-1.4 Ma. At maximum lake recession (~1.87-1.56 Ma), the Shungura Formation displayed a significant increase in mesically-adapted taxa (Reduncini) while the Nachukui Formation increased in xeric-adapted taxa. Enamel carbon isotope data supports differences between the Koobi Fora and Nachukui formations, with Nachukui displaying increasing trends towards C4 diets through time compared to Koobi Fora. Correspondence analysis shows differences in habitats reconstructed for each formation. The use of spatial analysis in the Turkana Basin has revealed heterogeneity in the early Pleistocene ecosystems surrounding Lake Lorenyang that could have created a variety of adaptive scenarios for hominins during this period.

CHRITZ, KENDRA[1]. *Using Isotopes to explore the past, present and future of people and ecosystems in East Africa*

[1]Human Origins Program, Smithsonian Institution's National Museum of Natural History

Archeologists and paleoecologists have long relied on stable isotope analysis (SIA) of mammalian tooth enamel from archaeological sites in order to reconstruct ecology and environment through time. SIA of fossil teeth has given us critical insights into how changing ecosystems may have influenced key moments in human evolution, such as dietary and technology change. The framework for interpreting SIA of fossil material has been based on modern living African mammals from a variety of environments in eastern Africa, but these comparisons often do not account for ecological issues that may affect extant mammalian diets and behaviors, such as fluctuating environments, human disturbance and ecosystem degradation. We present a dataset of $\delta^{13}C$ values from 31 different species of large mammals (n=252) from the collections of the 1909-1910 Smithsonian Roosevelt expedition to reconstruct the ecology of African mammals a century ago. These data show a shift in environment in ecosystems in southern and central Kenya from open grasslands in 1909 to mosaics in post-1990s Kenya. These data show that comparisons made between dental SIA from fossil sites and modern sites are skewed by a century of modern environmental change.

DESANTIS, LARISA R.G.[1]. *Integrating and validating paleoecological tools.*

[1]Earth and Environmental Sciences, Vanderbilt University

Morphology has long been used to study the ecology and evolution of plants and animals across the globe. Advances in paleoecological tool development have provided more precise understandings of mammalian responses to changing climates

and insights into predator-prey interactions. However, it is fairly rare that paleoecological tools are integrated with one another; their integration is critical to informed interpretations about the diet of ancient mammals, including humans and their ancestors. With a focus on stable isotopes, dental microwear, and dental mesowear, I will discuss: the importance of integrating paleoecological tools, lessons learned from validating these tools, and the need to revisit old assumptions with new technology. Dietary interpretations are often incomplete and contradictory with only one method. For example, a study of herbivore responses to changing climates at Rancho La Brea provides two completely different interpretations depending on if stable isotopes or dental microwear methods are employed. We have also learned that not all animals or teeth are equal—tooth form and function must be taken into consideration when assessing diets via dental microwear. Further, experimental and field studies help inform debates regarding dental microwear formation, stable isotope fractionation, and the utility of dental mesowear. More is better, but only when tools are thoroughly validated and metrics are well understood.

DU, ANDREW[1]. *Developing a theoretical framework for time-averaging and understanding its effects on the interpretation of fossil communities.*

[1]Organismal Biology and Anatomy, The University of Chicago

Ecological data from fossil communities are time-averaged relative to the time scale at which modern communities are studied. It is well known from research on modern communities (i.e., neoecology) that community patterns and the processes influencing them change with spatial or temporal scale. This presents an obstacle for the exchange of theory and data between neo- and paleoecology. Here, I combine previous research with my own on the time-averaged (10^{0-1} years) large mammal skeletal assemblage from Amboseli National Park, southern Kenya to begin to develop a theoretical framework for time-averaging. I do so focusing on the ecological metrics studied by macroecologists: number of species, their abundances, and their spatiotemporal distributions. In short, species in a community can be roughly divided into two categories: core/source species and transient/sink species. The former describes common species, which are well-adapted to the local habitat, exhibit net positive population growth, and interact strongly with other species in the community. The latter describes rare species, which are opposite in all these respects and are only present in a given community due to stochastic dispersal from their own core/source community. As a community becomes more time-averaged, the proportion of transient/sink species increases, and because these species are indicative of non-local ecological conditions, a time-averaged community is equivalent to a spatially averaged one. Moreover, I have shown that even if one scales up a modern community to fossil time scales, the number of species is underpredicted, demonstrating that speciation, large-scale climatic shifts, and other rare, large-magnitude events not observed on modern time scales are important drivers of fossil community structure. These results demonstrate that modern and fossil communities, and the processes affecting them, are fundamentally different. This requires a reorientation of how we interpret fossil communities in the context of human evolution, especially when it comes to inferring small-scale ecological processes (e.g., interspecific interactions, habitat reconstructions).

DUNN, REGAN E[1]. *From cells to canopies: Reconstructing vegetation structure in the fossil record.*

[1]Field Museum of Natural History

Vegetation is the context in which the terrestrial biota exists and evolves. Knowing the structure of vegetative communities through space and time is key for understanding how modern ecological communities have evolved to their present form and how climate has influenced and continues to influence them. In the biological realm, the major challenge for reconstructing changes in vegetation structure in the fossil record is finding a way to detect it and quantify it from plant remains. How can a forest canopy be reconstructed from plant cells?

My approach is morphology-based and depends on phenotypically plastic traits that affect cells of the leaf epidermis. Light interception by plants varies tremendously with vegetation structure and the amount of light filtering through a canopy is exponentially dependent on the amount (total surface area) of leaves in the canopy. Specifically, plants in open habitats receive more direct solar radiation than plants in shaded forested environments. The shape and size of epidermal cells on leaf surfaces is determined by the amount of solar radiation received by a leaf during development whereby plants growing in shade have larger cells that are more undulated in outline. This pattern has been detected in studies comparing leaf epidermal morphology in sun and shade leaves and has been further investigated in the field and in controlled growth experiments in many plant taxa. Leaf epidermis is preserved in two ways, as isolated epidermal phytoliths and as organically preserved cuticle. I present two models from which vegetation structure can be reconstructed as the metric Leaf Area Index (LAI = foliage area/area of ground) from epidermal cell morphology. To demonstrate the utility of the LAI method in paleoecology, and I present two examples of LAI histories from the fossil record including a middle Cenozoic record of canopy change in Patagonia, and canopy change during the Paleocene-Eocene Thermal Maximum (~56 Ma), a greenhouse event likened to anthropogenic climate change.

FEIBEL, CRAIG S.[1] & CATHERINE C BECK[2]. *New paleoecological perspectives from Deep Drilling in East Africa.*

[1]Anthropology, Rutgers University

[2]Geosciences, Hamilton College

The past decade has seen a number of long (100s of meters), continuous, subsurface records recovered from East Africa. The Hominin Sites and Paleolakes Drilling Project (HSPDP), the Olorgesailie Drilling Project (ODP) and the Olduvai Gorge Drilling Project (OGDP) have all captured hundreds of meters of sedimentary archives with rich paleoecological potential.

Long cores provide several unique perspectives on ecological character and change. Continuous sampling allows investigation at a variety of scales over relatively long intervals. Preservation of many proxies is often better than comparable outcrop material. Integrated approaches can combine signals from multiple proxies, and take advantage of variable preservation signatures to develop more detailed and complete records than may be possible in conventional studies.

The WTK13 core, collected at Kaitio in West Turkana, Kenya, illustrates many of the unusual opportunities afforded by deep drilling. This core records a half-million years of lake and lake-margin accumulation,

and preserves a rich assemblage of ecological proxies reflecting environmental dynamics in this rift basin, and provides important context for the associated record of hominin evolution and early cultural development.

HIXON, SEAN W.[1], EMMA A. ELLIOTT SMITH[2], BROOKE E. CROWLEY[3], GEORGE H. PERRY[1], DOUGLAS J. KENNETT[1], SETH D. NEWSOME[2]. *Patterns in amino acid $\delta^{15}N$ values of lemurs are inconsistent with aridity driving megafaunal extinction in Southwestern Madagascar*

[1]Anthropology, Pennsylvania State University

[2]Biology, University of New Mexico,

[3]Geology & Anthropology, University of Cincinnati

Past human colonists of Madagascar encountered a diverse endemic fauna during the Holocene that included elephant birds, pygmy hippos, and giant lemurs. All species >10 kg went extinct by ca. 1,000 years ago. Direct human predation and anthropogenic landscape transformation help explain aspects of the extinction pattern. Increasing aridity may have also played a role in some regions, but its contribution remains controversial. We present nitrogen isotope ($\delta^{15}N$) values of individual amino acids preserved in bones from extinct *Pachylemur insignis* and extant *Propithecus verreauxi* from two subfossil sites in southwestern Madagascar: Tsirave and Taolambiby. The amino acid specific approach enables us to identify environmental signals that are difficult to recognize in bulk collagen $\delta^{15}N$ values. Specifically, we use the $\delta^{15}N$ values of source amino acids as a proxy for aridity and the spacing of $\delta^{15}N$ values between source and trophic amino acids to quantify the trophic level of these two lemur species. Despite paleohydrological evidence for a lowering water table and paleoecological evidence for the expansion of relatively arid savanna between 4,000 and 1,000 years ago, isotope data indicate that extinct lemurs did not live in increasingly arid habitats and thus support the argument that aridity did not play a major role in late Holocene extinctions, at least not in southwestern Madagascar.

HLUBIK, SARAH[1], RAHAB KINYANJUI, DAVID R BRAUN[2], CHLOE DANIEL, AMANDA STRICKLAN, GEORGIA OPPENHEIM. *Preliminary microbotanical investigation of FxJj20 AB, Koobi Fora, Kenya; potential for environmental reconstruction, fire incidence, and human behavior*

[1]Anthropology, Rutgers University

[2]Anthropology, The George Washington University

Microbotanical remains reflect the environment immediately around a sample, and can be used to build a detailed picture of the environment around a site. We present preliminary results of microbotanical samples from the 1.5 mya site of FxJj20 AB, Koobi Fora, Kenya. We present a detailed picture of microbotanical samples from within the site and discuss the potential for fine-grained analysis of environment in and around a site.

KOVAROVIC, FIRE[1]. *Mammal communities in context: present day patterns and interpretations of the past.*

[1]Anthropology, Durham University

Mammal community structure analysis is a frequently employed analytical strategy in the reconstruction of past ecologies. The sum total of the species' niche exploitation profiles (i.e. the "community structure") provides a useful indicator of the available

trophic and spatial niches in a given locality. The method is mooted as holistic and independent of taxonomic identifications, among other benefits. Using a large comparative dataset of modern faunas from the tropical zone, I provide some "methodological musings" on the perceived benefits and drawbacks of this approach, illustrated with examples. Palaeoecologists are far from ironing out the exact circumstances when this method is or is not appropriate, and these circumstances are likely to differ on the basis of geography.

MERCERON, GILDAS[1]. *Keynote Address: Dental microwear and evolution of Primates.*

[1]CNRS - Université de Poitiers

In his address, Gildas Merceron will briefly expalin the dietary proxies that a paleontologist has access to, with a special emphasis on the most recent developments in dental microwear analysis. He will review how this tool has provided key information for our understanding of primate evolution, with several examples from different past and current research projects of his own.

PEPPE, DAN[1]. *Reconstructing ancient climate and ecology using fossil plants.*

[1]Geosciences, Baylor University

Plants are strongly influenced by their surrounding environment, which makes them reliable indicators of climate and ecology. In particular, leaves, which are a plant's primary photosynthetic unit, are the plant's primary mechanism for regulating water loss and uptake, light and carbon fixation, heat gain and loss from the environment, and photosynthetic capacity. Given this, a plant's leaf traits are intrinsically linked to the climate and environment in which a plant is growing. These relationships between climate, ecology, and leaf traits have been used to develop leaf-based proxies for reconstructing paleoclimate and paleoecology that can be applied to fossil leaves. These proxies are some of the most accurate and precise methods for reconstructing the climate and ecology of ancient terrestrial ecosystems and have been applied from the Cretaceous to the Quaternary. Despite their utility, the relationships between plant traits and climate that underlie these methods are confounded by other factors such as leaf life-span and phylogenetic history. Future research focused on assessing the influence of these confounding factors on the relationships between leaf traits and climate, how to recognize the leaf economic spectrum leaf traits in fossils, and developing computer algorithms to accurately measure and quantify leaf traits promises to yield new and improved tools for reconstructing the paleoclimate and paleoecology of ancient terrestrial environments.

RECTOR, AMY[1]. *Robust australopith paleobiology: The biogeography and paleoenvironments of eastern and southern African Paranthropus.*

[1]Anthropology, Virginia Commonwealth University

The genus *Paranthropus* shared derived morphology associated with heavy chewing. The different geographic distributions of congeners, however, may have been concomitant with differing diets, niche spaces, and ecological contexts. Here, paleocommunity analyses of *Paranthropus* faunal assemblages are combined with biogeographic analyses to investigate the paleoecological contexts of different *Paranthropus* species, and how broad-scale African biogeographic patterns likely influenced their diverging habitats.

To compare paleoecological contexts, associated assemblages of large mammals

from 11 South African and 6 east African *Paranthropus* sites were analyzed using a community approach. Multivariate correspondence analyses compared fossil communities to 191 extant communities in modern African habitats with known climatic variables. Using presence/absence data of 243 extant large mammal species and their locomotor and dietary adaptations, modern communities were described in terms of abiotic data, and this variability was used to retrodict ecological parameters for *P. boisei* and *P. robustus*. Biogeographic analyses included genus-level calculations of Dice and Simpson's faunal resemblance indices of >75 eastern and southern African fossil assemblages spanning the last 7+ million years.

Multivariate analyses suggest that while *P. boisei* sites were likely wetter over the course of the year, *P. robustus* sites were influenced more by seasonality in temperature and rainfall. Further, pan-African biogeographic patterns indicate that habitats, seasonality, and lineages began diverging between eastern and southern Africa ~3 million years ago. *Paranthropus boisei*and *Paranthropus robustus,* while both able to take advantage of a limited range of seasonal habitats, in fact existed in significantly different ecological and biogeographic contexts.

SCOTT, ROBERT S[1]. ***Dental microwear and paranthropit diets***

[1]Anthropology, Rutgers University

The megadont hominins *Paranthropus robustus* and *Paranthropus boisei* share a suite of dentognathic characters that suggests a capacity for powerful chewing. This common morphology has been interpreted as adaptation to similar foods – possibly ones that were mechanically challenging to process. Yet, their dental microwear differs posing a problem for long-standing hypotheses and interpretations. Alternate explanations for their similar dentognathic morphology rely on phylogeny or recent challenges to links between diet and dental microwear. Resolving these outstanding questions require experimental, comparative, phylogenetic, and paleoenvironmental analyses. In particular, paleoenvironmental reconstructions and an increased understanding of the role of food properties, geometry, and grit in dental microwear formation may be critical.

YANG, DEMING[1] & KEVIN T. UNO[2]. ***Intratooth isotope profiles of fossil suids from the Koobi Fora Formation (East Turkana, Kenya) indicate seasonally stable C_4 diets but seasonally variable body water or hydroclimate***

[1]IDPAS, Stony Brook University

[2]Biology and Paleo Environment, Lamont-Doherty Earth Observatory of Columbia University

Previous studies investigating the changing environment in eastern Africa have employed stable isotope analysis of enamel that often utilizes a single sample from each tooth. Alternatively, sampling a tooth along its growth axis produces an intratooth isotope profile. It can reveal seasonal changes in diet and body water, which can serve as a proxy for environmental seasonality in vegetation or rainfall. Most suids in the Early Pleistocene have high-crown molars or long tusks, both of which are ideal for intratooth profiles.

We selected canines of *Kolpochoerus*, third molars of *Metridiochoerus* and *Notochoerus* from Upper Burgi and KBS members of the Koobi Fora Formation (2.1 – 1.54 Ma). We investigated their dietary response to seasonality by examining carbon and oxygen isotopes in enamel using intratooth profiles.

The $\delta^{13}C$ values indicate that the suids were predominantly C_4 grazers throughout the year, with a small degree of intratooth

variation (Δ = ~1‰ to 2‰), whereas a much greater range is observed in $\delta^{18}O$ (Δ = ~1‰ to 7‰). This range in $\delta^{18}O$ is similar to that of extant warthogs and bushpigs from Kenya, Malawi and Congo (Δ = ~2‰ to 6‰).

Intratooth profiles can provide insights into vegetation and hydroclimate variations of hominin fossil sites. This preliminary dataset allows for limited interpretation of long term climatic trends. Additional samples will be analyzed, which will shed light on paleoenvironments across space and time of the Turkana Basin. Similar methods can be extended to other fossil mammals, particularly those with hypsodont or continuously growing teeth/tusks.