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The Leakey Foundation News

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MOUNTAIN GORILLAS



Female Migration and Differential
Social Development in
Infant Mountain Gorillas

Pascale Sicotte

Université de Montréal

The L.S.B. Leakey Foundation was established in 1968 by a group of eminent scientists and informed lay people who recognized a critical need to strengthen financial support for new multi-disciplined research into human origins, our evolving nature and environmental future. It was named in honor of the man who had become known as "the Darwin of pre-history," Dr. Louis B. Leakey.

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PRESIDENT'S MESSAGE

Dear Fellows and Members of the Leakey Foundation:

Ours is a partnership that provides a practical way to help deal with questions and answers related to man's origins, social behavior and how we might best forge a path to avoid catastrophe. Most important is the fact that as Fellows and Members we are in touch with people who are "doing something about it." As of the beginning of the year and reported in the spring issue of *AnthroQuest*, there were no less than 37 new science grants awarded. You'll find an equally varied selection listed in this summer issue. Whether beginners or renowned specialists in their fields, these researchers are on the front line in matters that may be appropriate to major concerns of our time.

The mystery of early man unfolds like a tale with unexpected twists and turns and small hints scattered along the way. As keen as your favorite detective, field and lab workers probe small clues for a pattern to develop. Slowly, information begins to fall into place like a great jigsaw puzzle until a plausible picture begins to emerge.

Leakey Foundation grantees gather the raw evidence and put it to the test by applying today's technology as they accumulate data that sometimes leads to startling conclusions; lively debate and contention is part of the fabric of the tapestry as their efforts are made public. It's your support that helps make these ventures possible. Without the necessary funding, any one or more of the basics—air fares, a place to stay, subsistence, salaries and shovels—would be put "on hold" and the academic sharing subsequently much reduced.

Sometimes, a lucky accident triggers a new find. Some twenty years ago in Kenya, a tired camel led Richard Leakey to the discovery of a landmark fossil skull dating back two or three million years. The complaining beast named George prompted a halt after a gruelling 3-day desert trek—just in sight of a grey-brown outcrop of sediment that proved to be a treasure trove of extinct animal bones and more.

Good fortune in solving problems related to pre-history more often comes from a cross-feed of ideas linking several disciplines. The free-flowing exchange between varied areas of interest is but one more reason for the importance of sponsorship. There's still plenty of work to be done, and far more requests for grants are submitted than can be met by the Foundation.

The enormous body of information collected, for example on the social lives of our near relatives, the great apes, provides an astonishing reflection of the way we might have been. Continuing with studies in the tradition of the pioneer work done at the Gombe Stream Game Reserve demands a special fortitude and patience as well as sensitivity. Much more has yet to be accomplished—and without delay—in undisturbed ecosystems and forests that have so far escaped the impact of industrial development or population spread of the kind that can destroy both the environment and its inhabitants.

In many ways, we're in a race against the hectic pace of change. We are ourselves in some measure an endangered species and, like the Red Queen in "*Alice in Wonderland*," we must move twice as fast just to stay in touch with the dynamics of each passing day. Nevertheless, ours is a fascinating pursuit where the prize is to know more about ourselves than ever before. And, along the way is the possibility of choosing a worthy destiny for children of all nations and those future generations who must be sure that we did not let them down.



Mason Phelps

FEMALE MIGRATION AND DIFFERENTIAL SOCIAL DEVELOPMENT IN INFANT MOUNTAIN GORILLAS

Pascale Sicotte

Département de Anthropologie, Université de Montréal

Initial research conducted at the Karisoke Research Center in the Birunga Volcanoes of Rwanda concerned the phenomenon of female transfer in gorilla groups. During twelve months in the field, I collected some 700 hrs. of focal observations as well as *ad libitum* observations on rare events such as group interactions. Another nine months' field work will complete the data collection.

My principal goal is to investigate whether patterns of female migration reflect choice of an environment that is favorable for the rearing of offspring (one factor suggested by Harcourt et al 1976). Since information relevant to transfer of females must be collected whenever possible and such female transfer is rare, data collection has usually centered on a better understanding of the reasons that might lead to the females staying in their original group. One reason could be that the optional group satisfies the female's needs, or perhaps she wants to leave but has no opportunity to do so. (Females do not travel alone and have little contact with other groups.) A third reason could be that she wants to leave and has the opportunity but is restricted in her movements during group interactions.

In order to test each hypothesis, our observations concentrated on the social relationships of the sub-adult and adult females of each study group: Group 5 and Beetsme's group. Observations were also made on the two silverbacks of each study group in order to collect data on the relationship between males and infants. Naturally, this information needs to be analyzed in detail before any conclusions can be drawn. If, for instance, differences in male/infant relationships are identified, they will be reviewed primarily in relation to the mother's dominance status and her affiliation with the silverback.

Inter-unit encounters are of particular interest because it is during

these interactions that female transfer may occur (Harcourt 1978, Fossey 1982). However, interactions between units are relatively rare, and encounters between units that are accustomed to the presence of human observers are even more rare.

Eleven inter-unit interactions occurred during the first year of collecting data. I was present for five of these, but only two involved at least one reproductive unit (as opposed to all-male groups and lone silverbacks) and consisted of units that were habituated to observers. The most striking event noted was that in both situations at least one male was seen preventing at least one female from getting close to the other group. It is obvious to me that in doing so the male was trying to prevent the female from transferring to another group. Despite this, one of these interactions resulted in the transfer of a young primiparous female and her three year old son. The transfer itself was not witnessed because of dispersion of the group during the interaction. It is unknown if the silverback from this female gorilla's group tried to herd her away from the alternative unit. These inter-unit interactions and the transfer will be discussed briefly along with some questions that they raise.

Inter-unit interactions. In the last ten years (see Wrangham 1979 and Watts 1983), group living in gorillas has been explained in terms of sexual selection. Considering the pattern of food distribution, females do not seem to have any major advantage in living in a group. Competition between males for access to females would appear to have shaped the grouping pattern.

Males are thought to control access to females in their group mainly through displays and fights directed at opposing males during inter-unit encounters. Another way of doing so would be to control the movements of

the female. On the basis of the data collected during my first year of field work, this latter strategy would appear to be more frequent than was previously thought.

One of the inter-unit interactions described here occurred between Group 5 and Beetsme's group, and a second interaction took place between Group 5 and the Susa group. During each of these encounters a young nulliparous female from Group 5 repeatedly attempted to get close to one of the other groups. Each time, she was strongly herded back through contact aggression by either a young silverback or by the dominant one of Group 5. It should be noted that she was sexually receptive on both occasions. But, receptivity does not appear to be a prerequisite to herding, since two other females from Group 5 - a young primiparous and a multiparous - were herded back to their group by one of the silverbacks during the interaction with the Susa group. Each female had an infant about two and a half years old.

These observations seem to contrast with those of Harcourt et al where "in only three of more than twenty situations of potential transfer were males observed actively preventing females from approaching the strange males." Even if the number of interactions between units observed in the course of my research is still low, the present data suggest that herding may be more prevalent than noted by previous observers. If this difference between the two studies is real, it could arise from several factors related to group composition and group history, and there are the varying conditions of observability and group habituation to take into account. Three factors come into play: 1) The number of females likely to transfer within a group; 2) The number of silverbacks in the group; and 3) The quality of the relationship between the two units involved. These factors

are not mutually exclusive; their verification will be effected using Karisoke Research Center long-term records. For now, I present them briefly.

1 - Number of females likely to transfer. Theoretically, those more likely to transfer are natal nulliparous females. It is also known that females have a tendency to transfer more than once. Further, those with infants at least partially weaned are also likely candidates for transferring since the infant is no longer strictly dependent on its mother for survival. An infant younger than about 2½ - 3 years old could be a potential victim of infanticide (see Fossey 1984) by the silverback of the new group.

Given the fact that there could be more females in the group than a silverback can possibly herd - and given also the density of the vegetation - one can expect that if herding is to occur it will be first directed at females likely to transfer.

2 - Number of silverbacks. A factor limiting ability of males to herd females is the number of silverbacks in the group. If there is only one, he is likely to be mostly involved in displays and fights with the extra-group male. In this case, a female could transfer from one group to the



other with relative ease. When there is more than one silverback in the group - which is the case about 40% of the time - herding is probably more likely to happen.

3 - Relationship between units. It is possible that groups interacting frequently come to know each other. This might reduce the likelihood of actual fights between silverbacks and limit their encounters to displays and mutual avoidance. Consequently, they might have more time to devote to their own group which in turn would increase the likelihood of herding. Another aspect to consider is that the silverback could simply increase herding because he has more time to do so. But, he could also have learned from the experience he's gained from interactions with this given group and from the reaction of his females toward the same group. This is a case where the silverback could possibly "predict" the behavior of his females, always assuming that frequency of contact with a group has no influence on the decision of a female to transfer.

The transfer. Harcourt has shown that females tend to transfer to smaller units, probably as a means of increasing their dominance status. Transfer may also be a way of reducing food competition since it has been shown that such competition increases with the number of females per group.

The transfer described here took place during the interaction between Group 5 and Beetsme's group. A primiparous female (Tuck - natal from Group 5) left the group with her three year old son. She belonged to the largest matrilineage in Group 5 and left behind her a mother and older sister as well as a younger sister.

Tuck left a group of 27 individuals - including 13 sub-adult and adult females - to join a group of only ten comprising six sub-adult and adult females. This accords with the pattern identified by Harcourt. However, a problem remains. Because Tuck was one of the dominant females in her group, second in rank just below her mother, the competition she had to face from other females was probably very low. The transfer did not result in a rank increase; she now ranks below the two adult females in Beetsme's group.

The advantages, if any, of this transfer for Tuck's infant are difficult to identify. In fact, he experienced a very stressful situation. He left a group where he was the offspring of the dominant silverback to join one where he had to develop a new social network. Definite weaning occurred about six months later. His mother was observed copulating with the two silverbacks from Beetsme's group soon after the transfer.

A detailed analysis will be possible since Tuck and her infant were observed for three months while living in Group 5 before the transfer and are being followed on a regular basis thereafter.

Conclusion: The second year. Data collection during the second part of this study will involve direct observations and research in Karisoke long-term records. By concentrating on the silverbacks, more information on their relationships with infants will be collected which can then be analyzed against data gathered on male-female relationships. My purpose in this research is to investigate these subtle interactions and the context of the social development in which they occur. ■

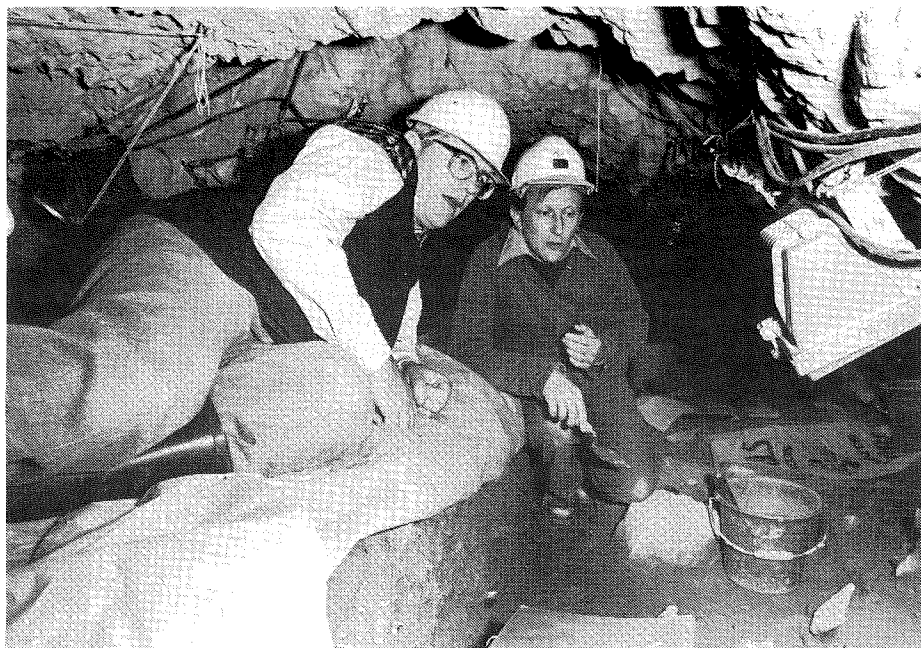
EXCAVATIONS AT PONTNEWYDD CAVE CLWYD, WALES, 1988

Dr. H. Stephen Green

Keeper of Archeology & Numismatics, National Museum of Wales

Several past seasons' work at the Pontnewydd Cave, Wales, have established that the cavern and its immediate environs were probably occupied by early humans of the Neanderthal lineage some quarter of a million years ago. Previous excavations had led to the discovery of around 750 stone implements, some 10,000 animal bones and, most important, actual remains of the human occupants of the cave.

Our work in 1988 concentrated on two areas: the archeological deposits inside the cave, and a completely new entrance that was revealed in 1987 for the first time since the end of the last Ice Age. The discoveries at the new entrance perhaps pose at this stage more queries than they answer, and a considered interpretation must await the results of scientific work which will take place in the course of next winter. In outline, however, the archeological sequence in this new entrance seems to belong to the quarter-of-a-million year old occupation already attested to in the main cave. An interim study of the fauna by Andrew Currant of the Natural History Museum has revealed an assemblage of deer, bear, bison, rhinoceros, horse, wolf, fox, hare and bird. The presence specifically of the woodland species, roe deer, in the lowermost deposits is indicative of an interglacial climate. The deposits in the entrance comprised scree which had been transported as debris flows into their present position. Of special interest was a greater than usual frequency of flint and also of quartz in contrast to that found in the main cave. This may suggest that the new entrance occupation is not precisely of the same age as that represented in the main cave. A number of the flints we found had been burned, and these will be dated by Dr. Nicholas Debenham of the British Museum Research Laboratory by thermoluminescence. Of further interest was evidence of the recession of the cliff



Dr. D. Roe (left) and Dr. H.S. Green at Pontnewydd Cave excavations, 1988.

in which the new entrance is located since the site was humanly occupied. This feature alone is suggestive of the great age of the deposits contained.

Two new human finds were unearthed inside the cave. Previous discoveries have comprised the remains - mostly of teeth and jaw fragments - of three individuals, one an adult and two children, the latter aged respectively eight and twelve years. The 1988 finds which comprise two additional teeth have been studied by Dr. Chris Stringer of the Natural History Museum. One is a fragment of incisor of an adult or young person, the other is a complete left lower first molar of a child perhaps aged about twelve. Of additional interest is the fact that this tooth is probably *not* from the twelve-year-old already represented from earlier discoveries but belongs instead to a new, previously unattested individual. The tooth also differs from all permanent molars found so far on the site in that it does not show evidence of "taurodontism," a coales-

cence of the roots associated with an enlarged pulp cavity, which is characteristic of many "early Neanderthal" molars.

These discoveries attest to the richness and continuing potential of this remarkable Pontnewydd Cave site. The excavations were funded by the National Museum of Wales with the valued support of the British Academy, the Society of Antiquaries, the L.S.B. Leakey Foundation, the Royal Archaeological Institute, the Board of Celtic Studies of the University of Wales, and the Cambrian Archaeological Association. ■

GRANT SPOTLIGHT

The grant program, the major purpose of the L.S.B. Leakey Foundation under the guidance of the distinguished Science and Grants Committee, depends upon public support for its success. Every penny of your contribution dollar directly supports the grant awards.

Gary G. Tunnell \$3,500 funded

ACTUALISTIC SCAVENGING AT OLARE OROK

This continuation of a project started in 1984 will obtain real data on the probable amounts of food available to a hominid adopting a subsistence strategy of scavenging and opportunistic hunting in the Serengeti ecosystem to provide a database to better judge the feasibility of central place foraging models.

Mark F. Teaford \$4,000 funded

DENTAL MICROWEAR AND THE PLIO-PLEISTOCENE CERCOPITHECINES OF THE OMO VALLEY

This project will use dental microwear analysis to look at the Plio-Pleistocene cercopithecines of the Omo Group deposits. Since these techniques are relatively recent, modern comparative data samples will also be collected to aid in the development of new methods of analysis. The work will shed light on the functional morphology and evolution of an intriguing group of modern and extinct primates and aid in paleoecological interpretations of deposits which have yielded some of the most important early hominid fossils. While this study is designed to stand on its own, it is also planned as a first step towards a large-scale analysis of the Plio-Pleistocene cercopithecoids of East Africa.

I. Odhiambo-Nengo \$5,500 funded

AN EXPEDITION TO THE EARLY MIOCENE SITES OF SONGHOR AND KORU IN KENYA

The aim of this project is to increase the East African early Miocene hominoid fossil sample with a two-week excavation for more of the hominoid *Rangwapithecus gordonii* whose mandible was found in 1986. On a two-day reconnoiter of these sites, Mr. Odhiambo-Nengo discovered many fossils washing out and collected a proximal phalanx of a hominoid at Songhor. The discovery of more fossils should clarify several questions regarding the systematic status of taxa. All finds will become the property of the Kenyan government under the care of the National Museums of Kenya.

Nelson Mkandawire \$3,180 funded

NEW ADAPTATIONS TO THE YAO MATRILINEAL INHERITANCE SYSTEM: AN EVOLUTIONARY PERSPECTIVE

This research is designed to examine from an evolutionary perspective the effects of a cash economy on the matrilineal inheritance system of the Yao of Malawi. It will determine the amount and precise nature of men's allocation of the resources and the forms of aid to children of selves, wives and sisters, and whether men who control resources insist on exclusive sexual access to their wives in order to raise their confidence of paternity. Also, whether men who have high confidence of paternity invest more in wives' children who are their's too than in their sisters' children in accordance with the evolutionary biology kin selection theory.

Daniel Sellen \$3,900 funded

FORAGING AND REPRODUCTION: A PILOT STUDY FOR THE HADZA- AKIE COMPARISON

Mr. Sellen will conduct the first systematic comparison of the constraints on female reproduction in the Hadza and the Akie of Tanzania, both little-studied sub-Saharan foraging peoples that show different tendencies towards settlement. It will establish the feasibility of measuring the relevant dependent and independent variables among the two groups, train the applicant in the relevant field methods, and gather specific preliminary data.

Christophe Boesch Designated funds
up to \$35,339

TRADITION IN WEST AFRICAN CHIMPANZEES

Dr. Boesch will investigate forest populations of West African chimpanzees and their nutcracking behavior with natural hammers. One way to protect the survival of heavily-threatened populations of wild chimpanzees is to increase international scientific awareness through the presence of field workers near intact populations.

G. Agoramoorthy \$5,200 funded

A FIELD STUDY OF THE BEHAVIOR AND ECOLOGY OF THE GOLDEN LANGUR IN NORTHEAST INDIA

Dr. Agoramoorthy's major objectives are to determine the population density of golden langurs in Meghalaya and northwest Assam, India, and study their social organization and behavior.

Richard Leakey Designated funds
up to \$35,000

**CONTINUED
EXPLORATION AND
PROSPECTING FOR
MIOCENE AND PIOCENE
FOSSIL SITES
IN TURKANA**

The National Museum has continuing work at Lake Turkana where archeological sites and fossil occurrences are being sampled over the period from the Miocene through to the recent. During the next five years, particular emphasis will be placed on prospecting small and remote localities that have been missed over the past twenty years.

Prosper Ndessokia \$7,900 funded

**GRADUATE WORK FOR
Ph.D. AT UC BERKELEY**

Mr. Ndessokia has completed all the necessary field work in Laetoli and is now compiling his dissertation at UC Berkeley on the vertebrate paleontology, stratigraphy and associated archeology of the higher geologic formations in the area.

Ann M. Palkovich \$2,500 funded

**HEALTH AND BIOLOGICAL
ADAPTATION DURING THE
PASTORAL NEOLITHIC**

Studying the health and biological adaptations of Late Stone Age Groups undergoing a "pastoral neolithic" transition, this work tests the hypothesis that, unlike incipient agriculturalists, dietary changes from early pastoral or mixed subsistence economy adaptations did not significantly alter the health status and disease patterns of these hominid groups. Skeletal data will be systematically recorded for the Holocene hominid collection housed at the National Museums of Kenya.

Naama Goren-Inbar \$8,000 funded

**HOMINID ADAPTATION
AND
PALEOENVIRONMENTS AT
THE SITE OF GESHER
BENOT, YAAQOV**

Dr. Goren-Inbar proposes a multi-year interdisciplinary project to excavate, analyze and study the material culture at the site of Gesher Benot, Ya'Aqov. Future research activities at G.B.Y. will be dedicated to a comparable study of different paleoenvironmental aspects, the understanding of which will serve as an additional basis for the study of hominid behavior. Given the threat posed to the site by civil development plans, this research is a matter of some urgency. The uniqueness of finds and the geographical location of the Acheulian site at G.B.Y. makes it one of the most important localities for the research of early hominids in Southwestern Asia. No other similar sites have been found in Israel. The discovery of pre-*Homo sapiens* remains and organic material (wood) further indicates the exciting research potential of the site.

Peter Andrews \$9,537 funded

**MIOCENE EXCAVATIONS
AT PASALAR, TURKEY**

This ongoing project will continue excavating to recover more of the fauna, especially more of the hominoids, and continue work on the stratigraphy and environment of the deposition in order to understand more fully the conditions under which the deposits were laid down and the fossils accumulated. Field work will end after the 1989 season and it is planned to publish the results in a special edition of the *Journal of Human Evolution*.

Samuel Wasser \$4,000 funded

**MAINTENANCE OF LONG-
TERM BABOON PROJECT IN
MIKUMI NATIONAL PARK,
TANZANIA**

This grant will maintain the long-term baboon field site at Mikumi National Park, Tanzania, for a nine-month period. In operation for fourteen years, the site is the source for detailed information on the behavior, reproduction and survivorship of more than 250 animals. It is intended to apply recently developed techniques to measure steroid hormones excreted in primate feces with studies on the behavior ecology of stress and reproductive failure in these baboons.

Dovi Kuevi \$6,000 funded

**WRITE AND DEFEND Ph.D.
DISSERTATION AT UCLA:
THE ARCHEOLOGY OF
EARLY SETTLEMENTS
IN SOUTHWEST TOGO**

Mr. Kuevi has completed his fieldwork under the guidance of his academic advisor and will now complete his dissertation.

Frederick E. Grine \$5,000 funded

**DENTAL MICROWEAR AND
DIET OF EARLY HOMO**

Dr. Grine will undertake a pilot study of the dental microwear of six North American Indian populations with well-documented diets. The project entails a comparative quantitative analysis of microwear on *Homo erectus* and *H. habilis* molars from southern Africa. Microwear will be examined by scanning electron microscopy (SEM) of epoxy crown replicas. Comparative quantitative data are available for a number of extant primate species but are lacking for modern humans in whom microwear may be influenced by cultural factors.

ESTABLISHING THE TAXON-SPECIFICITY OF CARNIVORE TOOTH MARKS FOR PLIO-PLEISTOCENE ZOOARCHEOLOGY

This proposed research has two goals, the first of which is to establish the taxon-specificity of tooth marks of East African canids, felids and hyaenids by collecting quantitative data on the size, shape and depth of tooth marks on different limb bone segments of different class-sized bones. This data will be obtained from bones collected after controlled observations of gnawing by felids, canids and hyaenids. The second goal is to test a model of the timing of carnivore vs. hominid access to limb bones by replicating with canids and felids Dr. Blumenschine's experiments which demonstrate that hyenas produce a high frequency of tooth-marking on fragments from whole limb bones vs. a low frequency on limb bones that were first fractured using the hammer-on-anvil technique.

Laszlo Kordos \$5,000 funded

COMPARISONS OF RUDAPITHECUS WITH THE MIOCENE GREAT APES OF AFRICA

Dr. Kordos proposes to study the direct anatomical comparison of the skulls of *Rudapithecus*, *Proconsul africanus* and *Afropithecus turkanensis*, respectively, with special emphasis on supraorbital and zygomatic regions and to the morphology of the maxilla. Attempts will be made to analyze and evaluate the morphotype of the Miocene Apes of Rudabanya, Hungary, and those of Africa. Dr. Kordos expects to learn which African characteristics will be found with the *Rudapithecus* and, through this line, to the *Dryopithecus* and how they are phylogenetically related.

GRANT GUIDELINES

The Foundation was formed to further research into human origins, behavior, and survival. Recent priorities have included research into the environments, archeology, and human paleontology of the Miocene, Pliocene and Pleistocene; into the behavior of the Great Apes and other Old World primate species; and into the ecology and adaptations of living hunter-gatherer peoples. Other areas of study related to human evolution have been funded occasionally.

The majority of the Foundation's general grants have been between \$3,000-\$5,000. Priority is normally given to the exploratory phase of promising new projects. Doctoral students and post-doctoral researchers are encouraged to apply.

Deadlines for submission of the formal applications are: General and Baldwin: March 1, September 1 and December 1. Fellowship for Great Ape: May 1. Fellowship for the Study of Foraging Peoples: May 1.

For further information and application forms, contact the L.S.B. Leakey Foundation, Foundation Center 1-7, Pasadena, CA 91125.

Nina Jablonski \$6,500 funded

THE FUNCTIONAL ANATOMY AND EVOLUTION OF THE GOLDEN SNUB-NOSED LANGURS OF YUNNAN PROVINCE, CHINA

The project goal is to expand the comparative anatomical database which can be used in studies of the functional anatomy, phylogeny and historical biogeography of the species of *Rhinopithecus* with special reference to the species native to Yunnan Province, *R. bieti*, by collection of a series of morphometric data from cranial and postcranial osteological specimens of selected species of Asian colobine monkeys held in museums and research institutions.

BOOKS

The following is a list of books of possible interest to AnthroQuest readers. While they are not sold by or available through the Leakey Foundation office, they can be ordered from local or specialty bookstores.

FOOD, GENDER, AND POVERTY IN THE EQUADORIAN ANDES by M.J. Weismantel. University of Pennsylvania Press, Philadelphia, PA, 1989. pp 234, illustrated. \$33.95.

This detailed study embraces the complex roles that food plays in all aspects of society in rural, highland Ecuador. This welcome addition to the important body of literature on food and agriculture "uses food and cooking, realms of ordinary life, to explore the underlying structures of Zumbagua," an impoverished rural parish of the Equadorian Andes.

Dealing with food as a focus of daily activity which carries a heavy symbolic load, author Weismantel, Asst. Professor in the Dept. of Sociology and Anthropology at Occidental College, makes clear that "each chapter, though addressed to specific theoretical and substantive issues, constantly reaffirms their interdependence." A major contribution to the understanding of the culture of a contemporary Northern Andian people, the book explores Zumbagua culture and achieves its dual roles: An ethnography - and an explanation of cooking and food which as a single domain of everyday life becomes a tool for the study of social life and historical process.

THE ENCYCLOPEDIA OF HUMAN EVOLUTION AND PREHISTORY edited by Ian Tattersal, Eric Delson and John A. Van Couvering. Garland Publishing, New York. pp 639, illustrated. \$87.50.

Each entry in this comprehensive encyclopedia has been written by a leading scientist in the field. It covers human and primate evolution in geological, paleontological, zoological and archeological contexts. The book is written in a style easily understood by the general public, students and professionals.

CANNIBALISM IN THE STONE AGE

Paola Villa

Department of Anthropology, University of Colorado

The taboo against eating human flesh is very strong in most societies, including our own. Today, cannibalism is an aberrant and exceedingly rare form of behavior associated with insanity or practiced under conditions of extreme duress. But, was there a time in our past when cannibalism was more widespread, perhaps triggered by factors other than extreme hunger?

Throughout history, the existence of the cannibalism taboo is a fact. In Greek and Roman times, anthropophagy implied deviant or savage behavior; then and later the practice was attributed to primitive tribes in far-away countries as well as social deviants at home, people at the edge of "civilized" society. Historian LeRoy Ladurie tells us that heretics and rebellious peasants in pre-modern France were often accused of cannibal acts. Between the 1300s and 1600s, French chronicles repeatedly accused Southern French peasants of having murdered, mutilated and eaten the flesh of kings' officers and aristocrats during popular insurrections against royal authority and the taxation system. The same accusation was repeated against Protestants during religious wars, and Huguenots in 1573 were said to have eaten the mummified body of Saint Fulcran which had been miraculously preserved for centuries in the cathedral at Lodeve in Southern France. In Catholic and monarchic France, being Protestant and not wanting to pay taxes was clearly outrageous, "cannibal" behavior. These preposterous accounts reveal the pervasive use of cannibalism as an insult and as a political device to justify repression. Similar ideological biases color early reports of cannibalism in non-western societies and thereby make the veracity of such reports questionable.

In the animal world, and specifically among mammals, the practice of eating conspecifics is documented (e.g. among marmots, squirrels, lions, hyenas and chimpanzees) but it is not

common. Cannibalism is often associated with conflict among strangers with the victor taking advantage of an immediate food source once aggressiveness escalates into killing.

According to anthropologist Marvin Harris, a similar combination of extreme antagonism and opportunism transforming a hated enemy into a prey characterized cannibalism of war captives, a variety of human cannibalism reported by ethnographers. He speculates that the cannibalism taboo originated in early state societies where prisoners of war were valued as a source of cheap labor and were thus kept alive as slaves.

Seen in an evolutionary perspective, the history and meaning of cannibalism pose interesting research questions. Unfortunately, the variety of cannibalistic behaviors - for survival, in warfare or as ceremonial consumption of flesh from one's dead relatives - and the poor credibility of ethnographic sources are a cause of confusion and dispute. The evidence of socially approved cannibalism occurring under more or less normal conditions is contested; some have concluded that cannibalism never occurred except in extreme cases of starvation.

Whatever the cause, the lack of a reliable and systematic body of factual knowledge on cannibalism in historic times means that many questions are bound to remain untested and unanswered. Nevertheless, since aggressive cannibalism occurs among mammals, including non-human primates, we should keep an open mind about the possible occurrence of such a maladaptive behavior among humans.

What about the prehistoric past? The idea that some ancient men were cannibals is a recurrent theme in many accounts of prehistory, but it is not easy to separate fact from fiction.

The debate about Stone Age cannibalism has been going on since the second half of the last century when

human bones were found at several Upper Paleolithic caves in France and seemed to evoke cannibalism. Isolated and scattered on cave floors, some had cut marks very much like the bones of animals used as food. Archeologists Emile Cartailhac and Edouard Piette argued that the bones were not food remains but were traces of funerary rites involving bone cleaning and disposing of the bones in a bundle. This custom of post-mortem dissection and secondary burial is well-known among various modern and late prehistoric societies, including some North American Indian groups.

Piette and Cartailhac's hypothesis of secondary burial was no more plausible than a cannibalism hypothesis, but the argument found favor with colleagues. To date, twenty Upper Paleolithic, Mesolithic and Neolithic sites in France alone have been reported as having yielded scattered human bones with cut marks. None were in clear ceremonial context, but the cannibalism hypothesis is generally rejected in favor of other less savage rites (secondary burial, skull cult). Perhaps we have here a sort of cannibalism prejudice in reverse whereby European *Homo sapiens* is too close to us to be a cannibal! Such abhorrent behavior can only be attributed to primitives, heretics and pre-human hominids.

In the first half of this century cannibalism was reported from Neander and earlier sites: Krapina in Yugoslavia, Mount Circeo in Italy, and the Fontéchevade and Hortus caves in France as well as at Choukoutien in Northern China. But there were flaws in the arguments used to prove the reports. Skeptics argued that the traces of violence and the damage seen on the human bones could just as well be ascribed to carnivores or chance processes such as trampling, sediment pressure or roof fall. Excavations carried out before the 1950s provide little information on the exact provenience and disposition of

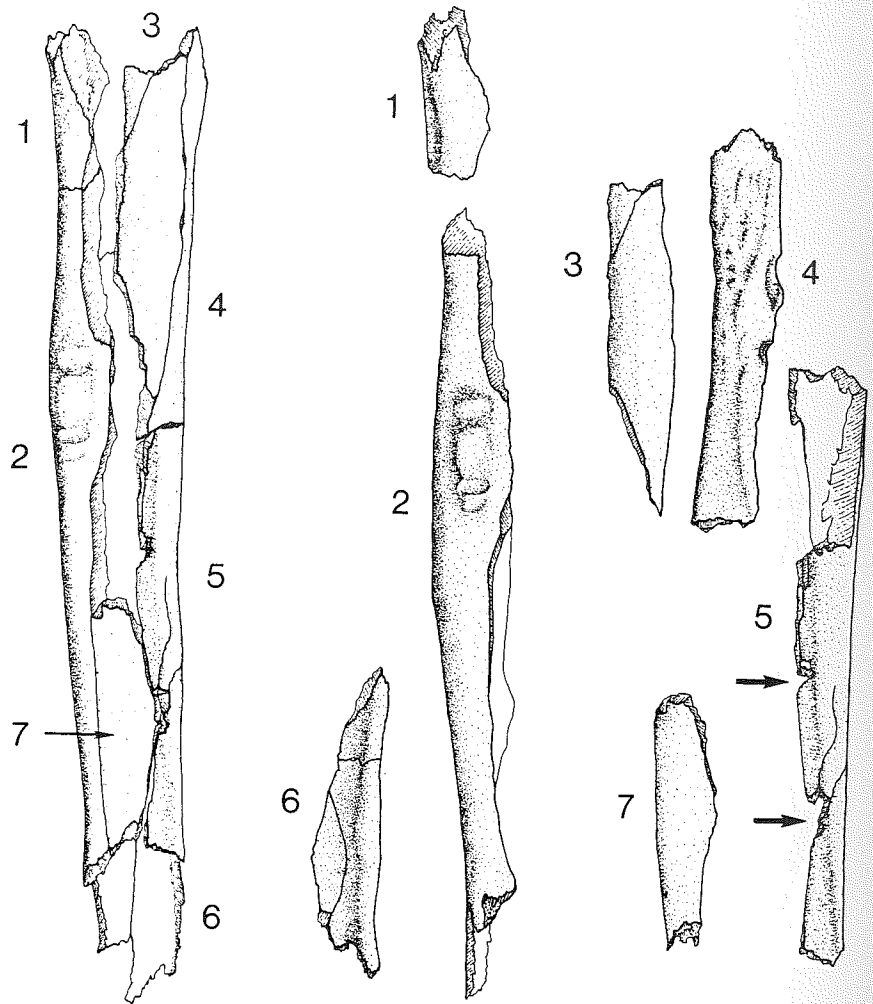
materials, the type of sediment or natural disturbance processes. Fine excavation techniques and careful observations of materials in the ground are needed to distinguish between the effects of natural processes and human activities.

The debate underlined the complexity of the problem. Since archeologists cannot rely on eyewitnesses, they must seek and follow multiple lines of evidence leading to one conclusion. But, at many sites there were too few bones or too few diagnostic criteria to build a valid argument. When several traces were present (e.g. bone breakage and burning, in addition to cut marks), accidental bone damage or secondary burial could not be excluded, due to poor recording of excavation data and unsystematic analyses of sediments and bones. In sum, prehistorians had reached an impasse. Not only was it impossible to prove the widespread existence of cannibalism in the past, but proving a cannibal act whether for survival or other reasons seemed close to impossible. The hypothesis appeared untestable.

The first step to a resolution of the debate was to identify a case of cannibalism beyond reasonable doubt. This we did in 1986 by publishing the first well-documented evidence of cannibalism in Old World prehistory.

The Fontbregoua site in the hills of Provence is a large, well-lit cave at 400m elevation and 30m above a freshwater spring. During Neolithic times, the vegetation was formed primarily by deciduous oaks, Aleppo pines and juniper. The fauna, now largely extinct, included red deer, roe deer, aurochs, wild boar, badgers, wolves and, in the creek fed by the spring, water tortoises. At that time the cave was used as a temporary residential camp by early farming groups. These people kept their herds of sheep and goat in pens inside the cave. They were active hunters of deer and wild boar (which provided almost half their meat supply) and had domestic cereals, pottery and personal ornaments.

Jean Courtin of the French CNRS has been directing excavations at the cave since 1971. I joined him in 1980 and have since been involved in studying patterns of site use and ac-



Seven fragments of a human tibia, broken to extract marrow, from feature H3. The fragments join together as shown in the drawing and were found at some distance from each other but within the same small pit. This shows that the bone was not broken by sediment pressure in the

pit. In fact, the tibia was first deliberately broken for marrow and then the fragments were discarded together. Many bones have been conjoined or rearticulated. The arrows in the drawing show the location of two impact scars, the result of hammer blows.

tivities at the site together with Daniel Helmer, a specialist in early animal husbandry.

In most caves, natural processes and reuse of living surfaces causes dispersal of materials and destruction of habitation features. At Fontbregoua, several features have escaped various disturbance processes, including the inhabitants' own digging activities. Several clusters of bones which occur in loosely dug hollows are especially remarkable. Each cluster represents the refuse of an individual butchery episode, and the discarded bones may be the remains of a single domestic sheep or several

wild animals. In each cluster many bones bear cut marks made by stone knives during skinning and dismembering operations. Such marks on limb shafts and other meaty bones indicate that the meat was systematically removed; for example, marrow bones were also broken with a stone to extract the marrow. The uncooked fragments were discarded in a single pile together with other bones left intact because they had little food value. Ten clusters of animal bones have been studied but more are found each year.

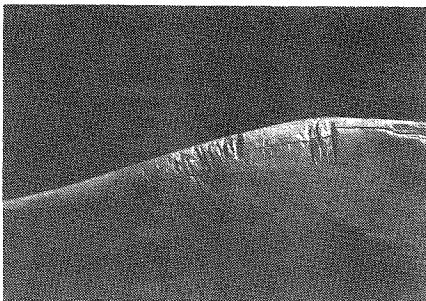
Three features called H1, H2 and H3 contained human bones and we

sought the help of two physical anthropologists, Eric Mahieu and Claude Bouville, to identify and study them. H1 contained the broken skulls and some limb bones of three adults and four children; a few bones of a single adult were found in H2. H3, discovered in 1984, yielded many broken post-cranial bones from a minimum of six individuals: two adults, three children and one individual of indeterminate age. Cut marks and patterns of bone breakage indicated that the humans had been butchered.

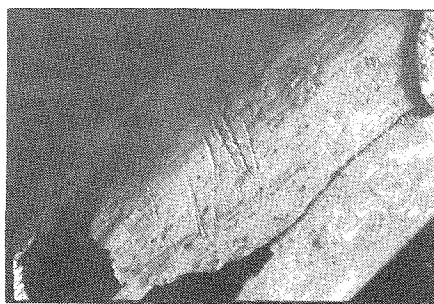
The H1 and H2 clusters had probably been disturbed by burrowing animals, and their content had been dispersed vertically and horizontally in the soil. Patient work identifying, conjoining and mapping each fragment enabled us to reconstruct the two original bone accumulations. The H3 cluster was intact and very similar in size and shape to the animal bone clusters.

Being familiar with the cannibalism controversy, it was clear that the task of proving that an act of cannibalism had taken place consisted in fact of two successive operations. First, we had to prove that the cut marks and bone breakage were man-made and not due to carnivore gnawing or to accidental processes of trampling and sediment pressure, as there are no traces of roof fall in the Neolithic deposits. Second, we had to prove that the flesh had been eaten.

Evidence for the first point runs as follows: (1) Pat Shipman of Johns Hopkins University examined a sample of 31 cutmarks on human and animal bones with a scanning electron microscope and confirmed them as having the diagnostic features of stone tool marks and not of carnivore teeth. In addition, my French colleagues and I examined all bone surfaces. We recorded and made drawings of 246 cutmarks on 223 human and animal bones of the same type; in macroscopic morphology and anatomical placement they are identical to marks known from modern butchery studies and experiments. (2) It is known that trampling can cause marks similar in microscopic features to tool marks. However, trampling by either humans or animals would disperse the bones and leave a disorderly pattern of marks, and the sharp horizontal



Child's clavicle with dismembering cut marks.



Upper third of a human femur with defleshing marks. Similar marks are found on sheep and wild boar bones.



Slicing (vertical) and scraping (long horizontal) marks on a human rib. Similar defleshing marks are found on ribs of wild boars.

boundaries of the bone clusters and the systematic localization of marks in certain anatomical areas are incompatible with trampling. (3) Bone breakage by sediment pressure is excluded by maps of conjoining fragments. Within each hollow, fragments of the same bone are found not adjacent to each other as would be expected if they had been broken in place by pressure or a falling rock, but separated by considerable distances of up to two or more feet. Additional evidence is provided by impact scars that cannot be produced by pressure but result from percussion blows. (4) Bone breakage was not

done by dogs or wolves. The repetitive shape and size of the clusters, their homogeneous content and the absence of gnaw marks indicate that the clusters were intact and man-made.

We used several lines of evidence: (1) Humans and animals had been butchered in a very systematic fashion using the same techniques. The frequency and location of cut marks was almost identical in bones of both groups. In all cases, meat had been removed from the bones. Defleshing marks, such as long oblique or short transverse cuts on limb shafts, were very common on human and animal bones. (2) Long bones had been systematically broken to extract marrow. (3) Human bones had been carelessly discarded in the same type of hollows where animal bones were found. (4) A constant feature of all clusters is the absence of some anatomical segments such as crania or limb extremities or portions of the axial skeleton. Selection of parts for immediate or delayed consumption is normally practiced when butchering animals. That the same butchery strategy was used in dealing with human bodies is, I believe, highly significant.

The use of ordinary butchery practices clearly indicates that humans had been processed for meat and marrow. The extraction of marrow and unceremonious mode of discard is incompatible with known secondary burial practices. Pat Shipman also noted that marks had been made on fresh bones; in contrast, secondary burial may cause weathering of bone surfaces.

If one is to argue that bodies were defleshed but that the flesh was not eaten, one must believe that the Fontbregoua people butchered but did not eat their meat animals and that they gave secondary burial to boars, badgers, deer and sheep. Clearly cannibalism is the only satisfactory explanation for the evidence found at Fontbregoua.

The Lyon radiocarbon laboratory had dated the H3 cluster to 3930 ± 130 B.C.; the other two clusters are dated to between 4300 and 3700. Thus we do not know if the three butchery episodes were contemporaneous or happened at different times. If the limb bones of cluster H3 belong to the

skulls of clusters H1 and H2 (we can neither prove nor disprove this idea since the bones are too fragmented and cannot be matched for size and age), the number of victims from the three clusters is eight; alternatively, the total number is 14 (i.e. 7+6+1).

While cannibalism is proven beyond doubt, more research at the cave and other sites is needed to understand the factors that triggered the behavior. We can definitely exclude the idea of a mortuary rite involving the ceremonial consumption of flesh from dead relatives. The number of people who died at the same time as well as their age distribution eliminates this possibility. Moreover, the usual burial custom in the region was individual inhumation.

We have good reason to believe that this was not a case of survival cannibalism either. The Fontbregoua peo-

ple were certainly not trapped inside the cave; it is in country of low relief, and the climate was - and is - Mediterranean with mild winters and little snowfall. The herders had abundant wild and domestic food resources, and since the cave was used only as a temporary camp, they were used to being on the move. Intergroup aggression seems a more reasonable explanation to me.

Based on finds of broken and cut-marked human bones from the region during Neolithic and earlier times, I tend to believe that cannibalism occurred at low but significant rates. Proof that aggressive cannibalism existed in prehistoric Europe will come when we can demonstrate that it happened more than once - either in the cave or at other sites. We may soon be able to do so since methods for identifying cannibal acts are now in place.

It is clear that archeology can provide answers to some of the questions about this behavior. In fact, since ethnographic observations of cannibalism in human social groups are no longer possible, archeology has become the only possible source of new systematic data.

The study of prehistoric behavior is most successful when meticulous excavation data are used in conjunction with a variety of analytical techniques and an integrated multidisciplinary approach. In our case, conjoining of bone fragments and precise maps of each find were essential for reconstructing each butchering episode. Simultaneous analyses of human and animal bones from the same site clinched the argument. An additional and very helpful ingredient was the generous support of the Leakey Foundation. ■

SOCIAL ECOLOGY AND CONSERVATION OF PANAMANIAN TAMARINS

Dr. Dennis R. Rasmussen

Wisconsin Regional Primate Research Center

Since 1981, we have been studying the endangered Panamanian tamarin monkeys along the verdant cove of Gatun Lake on the Panama Canal at a field site, Clara, 5km west of the Smithsonian Tropical Research Institute's Barro Colorado Nature monument. The primary reason for the endangered status of these tamarins is the rapid destruction of their habitat caused by the demands of a growing population. Clara may become the first refuge managed for the propagation of the tiny Panamanian tamarins.

Adult Panamanian tamarins weigh about a half-kilogram and have a body length averaging only 24cm. This small monkey has the most Northern range of all species in its family, the Callitrichidae, extending as far south as the Rio Atrato in Northern Columbia and north to Costa Rica along the Panamanian border. The majority of the extant population is in central

Panama along the canal in the San Blas province on the Atlantic coast and in the untamed forests of the Darien.

Panamanian tamarins thrive in forest that has been cleared and then regenerated for some 10-40 years. When such secondary growth is ideal as it is at Clara, population densities may exceed 50 per km². Secondary growth occurs naturally in clearings made by fallen giant trees and fire, and at edges between forests and rivers, lakes or oceans. The most common source of tamarin habitat is naturally-reverted land after slash-and-burn agriculture use. The Panamanian tamarins' preference for secondary growth has led to speculation that they have lived in close association with human agricultural activities for centuries and that their range is in part the result of those activities. Indeed, agricultural practices may have affected the selection

aspects of the behavior and reproductive biology of this monkey.

The complete protection of an area may cause elimination of tamarins since secondary growth will in time become mature forest. For example, tamarins were abundant on Barro Colorado Island forty years ago when there was more secondary growth. Careful protection of the island by the Smithsonian Tropical Research Institute has led to the replacement of secondary growth by a magnificent primary forest, maturation of which has been paralleled by decreased numbers of tamarins. Only fourteen remained on the entire island in 1983. A refuge for Panamanian tamarins must, therefore, be managed in a way that fosters secondary growth associated with high population density.

The most preferred food at Clara is large orthopterans and cicadas. With insects making up as much as 30-50% of the diet, tamarins thereby help con-

tol insect pests. Fruits and flowers are the most favored plant foods at Clara.

Tamarins are territorial at Clara; at other sites where ranges are larger, several groups may share some areas. Groups contain an average of about five individuals, and ranges vary in size from 8.16 to greater than 15 hectares. Our main study group, Peninsula Group, tends to visit the border of their range between 7-9 am. The further one group penetrates into a neighboring group's territory, the less confident they seem and the more easily they are chased by the resident group. While at the border between territories, the tamarins frequently make bird-like Normal Long Whistles and Soft Long Whistles. The Normal Long Whistles usually occur between groups or between widely separated members of the same group - or sometimes signal other group members about an abundant food source. The eerie chorus of the Soft Long Whistle seems to be used to alert the community to the presence of another group and the need for a concerted attack or flight.

Males chase back and forth across territorial borders more than females. Females scent mark more frequently, a trait associated with their larger suprapubic glands. Females tend to stay 15 or 20 meters away from the territorial boundary during chases by males and, after interactions cease, may approach, smell and scent mark the boundary areas. During the breeding peak from November to February, fighting between groups intensifies and tamarins may fall 20 meters or more to the forest floor and suffer broken tails, ripped nails and slashed skin. The worst injury we observed was the result of a fight between two females in a recently-formed group when the loser, Kink, had nails ripped from her fingers and a compound fracture of the tail.

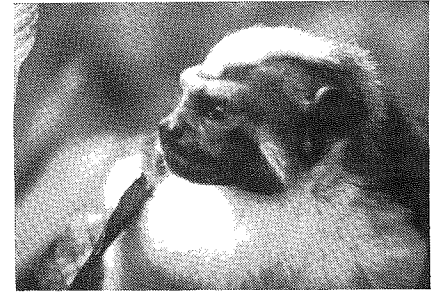
Community compositions change rapidly; tamarins frequently move between groups at Clara, and entire groups may coalesce and dissolve over a period of a few weeks. Not all group movements are accompanied by fights; some tamarins move into groups as if already well-known to the members. A high frequency of movements between groups suggests tamarins in neighboring groups know each other.

Adult females may meet most resistance when transferring between groups. Tamarins, strangers in protective cages, were introduced into the ranges of four wild groups during field experiments. The results suggest that adult female strangers are approached most and receive most aggression and that adult males receive more approaches and aggression than juveniles of either sex. The results are consistent with Dr. Gary Dawson's findings that turnover within groups occurs quickest in immatures, less rapidly in adult males and slowest in adult females. The higher rate of transfer by adult males could explain the greater chasing between males in territorial encounters.

Tamarins sleep in the tall trees at Clara at a mean height of 9.7 meters. Sleeping trees are characterized by dense foliage, an abundance of vines, isolation from others by height or absence of connecting branches, and often offer a particularly good vantage point. The group forms into a tight ball while in a sleeping tree, lying in accumulated debris, the nests of squirrels or other animals. They have not been seen to sleep in tree cavities as do many closely related species. Sleeping trees may be located near the center of territories as well as at the junction between territories and, when a sleeping site near the border of a territory is used, the next morning's border encounters tend to be longer.

Usually only one female per group bears offspring. Laboratory evidence suggests that the presence or smell of the reproductive female prevents other adult females from conceiving. Field observations of two closely related species of tamarins indicate that on exceptionally rare occasions, two females in the same group may give birth.

Panamanian tamarins usually bear twins after a gestation period of about six months, but both seldom survive in the wild. In Peninsula Group, one adult male, Click, always carried Kelly's 2 month old infant, Rasper. Rasper was only passed back to Kelly for occasional grooming. This group also contained Kink - the female who was severely injured a year before upon her ouster from another group - and an adult male, Point, who often seemed to travel on the edge of the

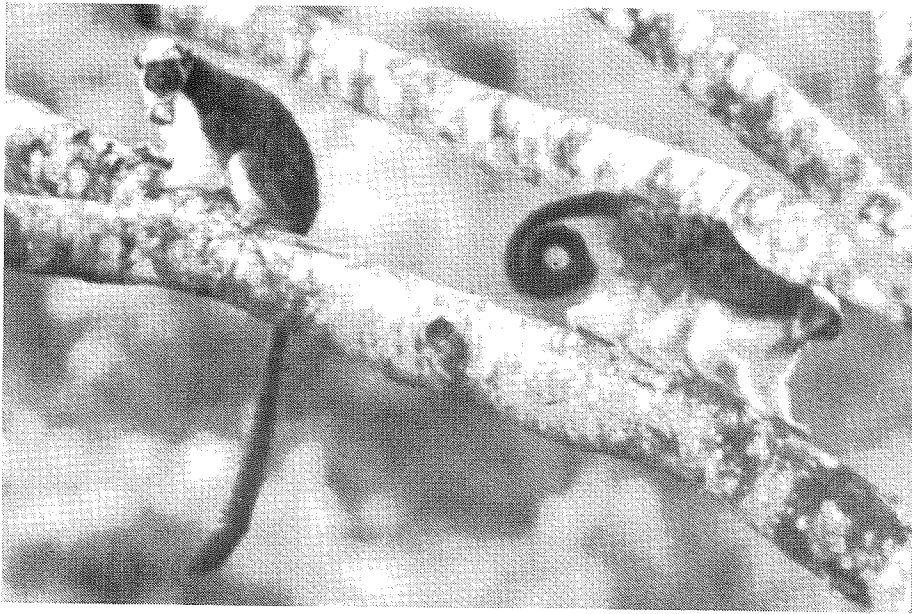


Close-up by Jolly of a decoy tamarin, Monine.

group. The pattern emerging from our study, and those of closely related species, is that a very unusual trait among non-human primates exists whereby one adult male often carries the infant or infants more than do other group members or even the mother.

The breeding pattern of the Panamanian tamarins is still a mystery, but some of the above facts do narrow the possibilities: if the one reproductive female breeds with only one male then there is a monogamous breeding system. Any promiscuity by the reproductive female will necessarily result in polyandry. The high frequency of successful transfer between groups indicates that they are not exclusively composed of the reproductive adults and their mature and immature offspring.

A monogamous breeding system is suggested by the presence of only one reproductive female per group and primary care of offspring by one of the adult males. Male care extends beyond carrying the infant; for example, Click braved closely approaching human observers to within 5 meters on several occasions in order to pick up Rasper and carry him away from this perceived hazard - an approach 10 meters closer than any group member would attempt under other circumstances. Our observations of sexual behavior also suggest a monogamous breeding pattern: we have observed eight instances of males mounting females at our study site and all copulations have occurred between the same pairs of animals. The nearly identical weight, body and tail lengths of Panamanian tamarins also suggest monogamy: reviews of literature have found that species of non-human primates with monogamous breeding systems are character-



Point leaving Click: note Point's coiled tail, often associated with grooming.

ized by an absence of difference in size between males and females.

Our observations of sexual interactions are not consistent with a breeding pattern in which the father is the male who carries the offspring most. To our surprise, all the mounts we observed in the sample group were between Kelly and Point. It may be that a "divorce" had occurred between Click and Kelly and a new pair-bond had formed. Click could also be the son of Kelly and therefore be carrying his brother. Another possibility is that Click would be more likely to copulate with Kelly from November to February, months when copulations would be more likely to result in conception. The ambiguities here indicate the need for long-term observations of single groups.

Grooming patterns between the two adult males and Kelly do not suggest an exclusive social relationship such as one that might accompany a pair-bond; they do suggest a stronger social relationship between Click and Kelly than between Point and Kelly. We observed Click groom Kelly 182 times whereas Point groomed her only 71 times. Kelly groomed Click 42 times and Point 26 times.

Females may be more competitive and less cooperative than males: 28% of all grooming occurred between Point and Click but only 5.9% occurred between Kelly and Kink. Greater competition between the females sug-

gests that females may vary more in reproductive success within groups than do males, a predictable consequence of polyandry.

Data from other field and laboratory studies on closely-related species have led some scientists to believe tamarins are polyandrous. A Princeton research team reported that in four of five groups of Saddle Backed tamarins containing two adult males, both males copulated. Copulations have been observed between an adult female in one group and one or more adult males in another group in the common marmoset, a species in the same family as tamarins. Such extra-group breeding may explain why we have observed males aggressively chasing female members of their group away from a territorial border after inter-group interactions. Promiscuous matings are frequently observed in laboratory colonies of *Callitrichidae*; groups composed of one adult female and two adult males may sometimes more successfully breed than those composed of monogamous pairs. Even in species where mating almost exclusively takes place between a particular pair of animals, such as with the Lion tamarin, a second male may sometimes copulate with the female.

While monogamy often implies an absence of sexual dimorphism, the reverse is not necessarily true; unequal body size indicates the larger

sex may compete more and therefore vary more in reproductive success. If tamarins are polyandrous, why then are the females not larger than the males? Perhaps at the level of a population composed of many groups of Panamanian tamarins, males may experience equal variance in lifetime reproductive success. For example, more frequent transfers between groups by adult males could lead to a higher mortality rate. There also may be a faster rate of turnover of breeding males in groups than there is of breeding females. Male and female tamarins could thus have nearly identical levels of variation in reproductive success. Similar sizes of adult male and female Panamanian tamarins may not be the result of a monogamous breeding system; rather it may be due to an equal amount of variation in reproductive success within each sex.

The predators who currently kill the most Panamanian tamarins are probably hawks and eagles. We've seen a hawk swoop down and attempt to grasp a juvenile tamarin in its talons and witnessed the tamarin escaping by falling to the forest floor. Panamanian tamarins may rapidly swing themselves under the very tree branch they were previously sitting on when a large bird passes overhead, a movement that puts the branch between themselves and the potential source of danger. When they're high in the canopy and in areas of low cover, we have found tamarins tend to scan more frequently. Raptors approach tamarin vocalizations, perhaps because they seek them as potential prey. Experimental playback of tape recordings of tamarin vocalizations lure raptors; most of these are vultures, but hawks also approach and investigate.

Vigilance and crypticity are the main defenses against raptors, small mammalian predators and, perhaps, large snakes. While large numbers of tamarins may more successfully detect a predator, the greater the number present the less capable they are of concealing their presence. The balance of these two factors may be one reason for their relatively small group size.

We feel that the social organization of the Panamanian tamarin has

adapted to exploit the shifting habitat of secondary growth. The capability to produce twins and the care of the offspring by others in the group permits a high rate of reproduction when tamarins first move into a new area. The reproductive female is then freed to put all new energy into obtaining the food that's necessary for lactation and the nurture of new fetuses. In areas of secondary growth with low population densities, Marleni Ramirez found Moustached tamarins to have fewer adult females in groups. Such a group composition allows for a maximum rate of reproduction when population density is low. When it increases, food availability may dissipate and the likelihood of raising both twins may decrease. The number of adult females per group might also enlarge, and this too would lower the number of offspring produced per adult female. At high population densities, it may be necessary for the reproductive female to put her effort into the production and care of only one infant per year; food resources, increased competition from other adult females and other factors would make intensive investment in only one offspring more advantageous.

Our current knowledge of the social organization of this species is sketchy. Of particular importance is the need for long-term study of individually recognized Panamanian tamarins where kinship between neighboring groups members is known, length of tenure of reproductive females is determined, and the biological paternity is identified. ■

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The Foundation is seeking support in several areas of human origins research. These "named" funds honor a special individual and provide support in perpetuity for knowledge of our earliest ancestors. We would like to ask you to consider adding your name to the list of donors by making a contribution to any of the following named funds.

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Dian Fossey's twenty years of research changed the world's perception of this endangered species. The work continues at the Karisoke research site in Rwanda, but research must be expanded and efforts must be accelerated to protect this threatened species.

The support generated by this fund will continue Dian Fossey's work.

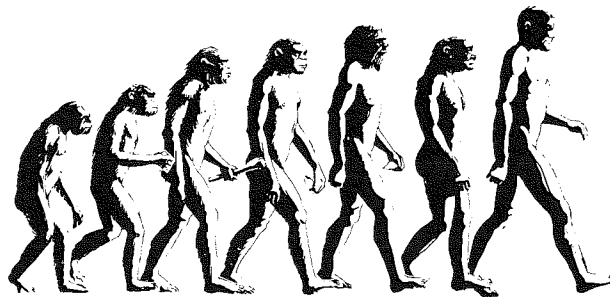
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Named to honor the late wife of Dr. Murray Gell-Mann, this fund will be used to finance research relevant to the preservation of the great apes or to the preservation of the physical existence or cultural continuity of hunting and gathering peoples. These are the two classes of living beings of greatest interest to the Leakey Foundation and both are in grave danger of extermination.

GLYNN L. ISAAC FELLOWSHIP FUND

During the twenty years that span the period of his work, Glynn Isaac was an acknowledged leader in the most significant advances in the understanding of human behavior from study of prehistoric cultural residues. With a deep and genuine love of teaching, Glynn was interested in training nationals from African countries in various branches of paleoanthropology.

This fellowship will enable young researchers to continue and expand the new approaches to the study of human origins that Glynn Isaac so successfully developed in Africa.



1988 RESEARCH AT SOLUTRE, FRANCE

Sandra L. Olsen

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Sandra Olsen

Solutre is famous as the eponymous site for the Upper Paleolithic phase known as the Solutrean and because 19th century artists depicted hunters driving large groups of horses off the steep precipice near the site to their death on the rocks below (Comber 1955 & 1976). Analogies have been made between Solutre and North American bison drives (Tretschoks, 1986), but recent research sheds new light on the hunting strategies employed at Solutre. Research on the faunal remains at this French site has progressed substantially thanks to funding received from the L.S.B. Leakey Foundation.

Located about 10km west of the Saone River and the modern city of Macon, it is undoubtedly the best example we have of a large game kill site in Western Europe and consists of over 9m thickness of deposits dating from the Mousterian through the Final Magdalenian spread over an area more than one hectare (about 2.5 acres) in size. The site is located on the southern talus slope of the Roche de Solutre, a Jurassic limestone ridge which is one of a series of parallel for-

mations. The topography of the region is extremely important to the reconstruction of the hunting methods used in the Middle and Upper Paleolithic. The valley below the Roche de Solutre links the vast Saone floodplain to the eastern-most foothills of the Massif Central and probably served as a major migration route for horse populations seeking fresh grazing land at higher elevations in the spring.

Studies of modern feral horse populations illustrate significant differences between equids and bison or other ruminants. These differences in social organization, linked to dietary requirements, lead horses to travel in small bands of 8 to 18. The bands come in two forms: a family group consisting of a stallion, his harem of mares and their offspring; and smaller, noncohesive bachelor groups. Horses do not travel in herds of hundreds the way bison once did and cannot, therefore, be driven "en masse" off the edges of cliffs.

A better explanation of how the enormous quantity of bones, prob-

ably representing between 30,000 and 100,000 individuals, arrived at the site has been researched in detail. This hypothesized hunting strategy would have the horses passing through the valley in small bands in the spring to reach the hills in search of new pastureland and returning to the floodplain via the valley with the advent of winter snows. Along the way, the horses were intercepted and driven a short distance up the talus slope and into a natural cul-de-sac formed by an indentation in the southern cliff face that served as a corral. Trapped in the cul-de-sac, they were then killed with spears.

To evaluate this and other hypotheses, the topography of the region, the faunal remains and modern equid behavior were examined closely. This past summer's research also focused on the taphonomy of the site and what natural formation processes altered the archeological record.

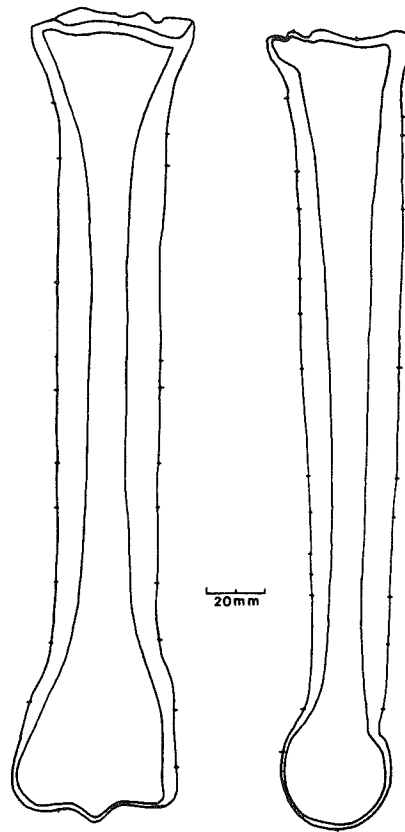
In 1988, a further 3,000 identifiable bones were analyzed, bringing the total to 5,000. Samples of horse molars were collected to be sectioned for cementum analysis, a topographic study of the region around the site was completed, and replicas of butcher marks and taphonomic surface modifications were taken for scanning electron microscopic analysis. Further measurements of cortical bone thickness were recorded for all the elements. A general paper describing the results of this research will appear in the *Journal of Human Evolution*.

Solifluction and sediment loading. One of the primary foci of the 1988 research was a detailed study of the effects of solifluction (or freeze/thaw slope movement) on animal bones using the vast collection of horse remains from Solutre. Given the geologic setting at Solutre (on the talus slope of a large limestone ridge) and the conditions of the deposits themselves, it is apparent that downslope migration of the deposits

and sediment loading had altered the archeological record significantly. The effects of solifluction and sediment loading on the bone include displacement of associated or articulated elements, breakage and destruction of thin cortical bone, and sedimentary abrasion of bone surfaces.

This study was concerned with documenting that variation in element frequencies was due to these natural taphonomic processes rather than cultural processes such as marrow extraction and transport of meat-bearing parts out of the site. To determine which elements were under-represented, minimum numbers of individuals (MNI's) were calculated for identifiable teeth and limb bones. (Skulls, ribs and vertebrae were too fragmentary to assign MNI's.) The MNI's showed that bones with thin cortical tissue not supported by substantial amounts of cancellous structure, like scapulae, ulnae and innominates, were less common than other more durable elements in the Aurignacian and Gravettian deposits which had suffered most from sediment loading and solifluction. Similarly, the portions of any given element which were preserved in an identifiable state were usually the more durable parts like the glenoid fossa and neck of the scapula, the articular surface of the ulna and the acetabulum of the innominate. Rib heads and vertebral centra were more common than rib bodies and the neural arches and processes of vertebrae. No patterns emerged of element frequencies relating to the transport of high meat or marrow-yielding bones in or out of the site.

A closer examination of cortical thickness in *Equus* bones is currently being undertaken. Cortical thickness was measured on the fragmentary bones from Solutre and recorded on outlines of each element drawn as both antero-posterior and medio-lateral sections. This provided composites of the distribution of cortical thickness around each element since it was not possible to obtain complete measurements for any individual bone. Sectioning of whole bones, even if such bones existed, would have been too destructive. In any case, many elements such as humeri, femora, and tibiae were extremely fragmentary.



Reconstructed cortical bone thickness on horse metatarsal from Solutre, coronal and sagittal sections. Marks indicate where actual measurements were taken.

To confirm the reconstruction of cortical thickness of elements of the Pleistocene horse *Equus ferus*, X-rays are being taken of the bones of *Equus przewalski* in the Smithsonian Institution. The Przewalski horse, a closely-related form, is comparable in size and proportions to the European Pleistocene horse. The X-rays will be used to check the accuracy of the composite drawings of sections of the Solutre horse elements.

Replicas of the surfaces of bones from Solutre are being examined with a scanning electron microscope to determine the extent of sedimentary abrasion caused by pedoturbation. Abraded areas of horse long bones were molded using 3M Express silicone rubber. Tapox epoxy resin casts were then poured into the molds, removed, and gold coated for viewing by a SEM. Micrographs have been taken comparing the surface abrasion to marks identified as butcher marks on the Solutre material (see illustrations) and to experimental pieces with sedimentary abrasion and modern butcher marks made with a

stone tool. This work will supplement experiments in trampling of large mammal bone conducted in 1987 (Olsen & Shipman 1988).

It is interesting to note that while many researchers have feared that sedimentary abrasion like that inflicted during trampling can mimic butcher marks (Behrensmeier et al 1986), very few marks found on the bones from Solutre exhibited characteristics of butchery, despite serious pedoturbation. Though solifluction, sediment loading, and very likely trampling by horses have disturbed and modified the faunal material at Solutre, there is little to suggest that these processes produced cutmark mimics.

Butcher marks. Replicas were made of 17 butcher marks on horse bones and 18 on reindeer bones from Solutre. These have been examined with the SEM in order to assess their reliability as genuine cutmarks based on their microscopic morphology. Interpretations of the cutmarks were made based on their locations and orientations. Most were made during dismemberment, but a few marks represented skinning, filleting, and tendon removal. The relatively low number of butcher marks on horse bones as well as the lack of evidence for transport and marrow extraction and the finding of many articulated body parts suggest that the horse carcasses were only minimally exploited and that waste was considerable. This may suggest that, once corralled, the horses were relatively easily killed and that spoilage may have deterred the hunters from taking more meat during the summer. If only choice parts such as the tongue, heart, liver and large muscles were taken, few butcher marks would have been produced.

Cementum analysis. Another important aspect of the work conducted at Solutre this summer is the collection of 40 horse cheek teeth to be sectioned for cementum analysis. The primary interest in this research is to identify the season of death by closely examining the outermost layer of cementum. A narrow, highly mineralized outer layer indicates that the animal was killed in the winter (roughly December to March), while a broader, more organic layer is laid down during the warm months (April to November). If the broad, more

organic band is just beginning to form, then a spring death is indicated, but if it is nearly completed, death occurred in late summer or autumn. In 1986, 75 teeth were taken for sectioning. Of these, 30 have been completed and 21 yielded adequate results.

All of the 30 sectioned teeth collected in 1986 were studied with an optical polarizing microscope by Margaret Beasley, a researcher at the University of London Extra-Mural Studies Department. The tooth samples collected in 1988 are currently being sectioned and examined with both an optical microscope and a scanning electron microscope. Both backscatter and secondary electron modes will be used to interpret the outer layer of cementum. The preliminary results of the analysis bear on interpretations of the Paleolithic hunting strategies and are important since they show that the horses were predominantly killed during the warm months when migration through the valley would have been predicted. Bryan Gordon's 1988 analysis of 14 reindeer teeth from Solutre revealed that this species was taken mainly in the winter and early spring suggesting there may have been some degree of scheduling involved.

Topographic survey. The topography of the area around the site was studied through a walking survey with the aid of a topographic map. This information helped supplement the faunal data in reconstructing the hunting strategies employed at Solutre and the post-depositional taphonomy of the site.

Conclusions. At this stage in the project, several points have emerged. First, although there are some differences in preservation of the faunal remains from the various time periods (Aurignacian, Gravettian, Solutrean and Magdalenian), there seems to be no evidence that elements of high utility – that is, those bearing large quantities of meat, containing marrow or of use as artifacts – were under-represented in the samples examined. There is, therefore, no indication that parts of the horses' carcasses were being transported away from the kill site. In fact, the carcasses appear to have been only minimally exploited.

Second, the topography and the location of the site do not support the originally proposed idea that the horses were driven off the cliff to their demise below. Rather, it appears that they were driven into a cul-de-sac at the base of the cliff. Studies of modern feral horse behavior have also indicated that long drives culminating in a jump would be extremely difficult with horses.

Third, the preliminary results of the cementum analysis suggests that the horses were generally killed during the summer months, a time when they were probably migrating to and from their highland grazing grounds.

Fourth, a study of the surface modifications and breakage patterns on the Solutre faunal material reveals that solifluction and sediment loading are probably the chief causes of differential preservation of elements, particularly in regard to the Aurignacian and Gravettian deposits. The Solutrean and Magdalenian material was exposed to more root etching, weathering, carnivore and rodent-gnawing, all of which suggests that these deposits were not rapidly covered by talus like the earlier levels.

Future research. An important area that needs to be explored further is the age profile of the death assemblage of horses at Solutre. Levine (1983) did a study of eruption and crown heights on samples of teeth from Solutre, but, given the vast collection of well-preserved cheek teeth, a more thorough analysis is merited. This study requires first, however, that accurate age categories be established for crown heights of all of the cheek teeth based on skulls of feral horses of known age. Previous control groups for aging equid teeth by crown height have had their ages inferred from incisor wear (Spinage 1972). I hope to obtain mandibles from several populations of feral horses in North America which have been the subjects of close behavioral studies for ten years or more. Over 300 cheek teeth from Solutre have had crown height measurements taken, but I intend to greatly expand this sample in 1989.

At present, approximately 13% of the material excavated by Jean Comber between 1968 and 1976 has been analyzed. Many questions remain to be answered, so the work should con-

tinue in the years to come. Solutre has produced the largest collection of European Pleistocene horses (*Equus ferus*) known, so it is also important as a paleontological sample. Metric analysis of the limb bones as well as the teeth could provide information about the similarities and differences between these European wild horses and the Asiatic wild horse (*Equus przewalski*). As more material is gradually being analyzed, more butcher marks will be found and more data regarding human utilization of the horses will begin to accumulate. The differences between the more extensive utilization of reindeer and the under-exploitation of horses becomes more apparent as the sample size increases. The reason why this should be the case is not fully understood yet, although it is almost certainly linked to the hunting strategies employed or the seasons of the kills. ■



EXPLORATORY ARCHEOLOGICAL FIELD STUDIES IN THE UPPER SEMLIKI VALLEY, WESTERN RIFT, ZAIRE

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J.W.K. Harris with skilled Zairean workers at the Senga 5A late Pliocene site, Upper Semliki Valley, Eastern Zaire, 1985.

Almost all the hominid fossils and archeological sites which bear on an understanding of the earlier stages of human evolution come from two regions on the African continent: the Eastern Rift Valley from Ethiopia to Tanzania, and the interior plateau of South Africa. This means that our knowledge of early hominid activity and behavior comes from a highly biased sample of localities. Stone artifacts recovered *in situ* from the Senga 5A site in the Upper Semliki Valley in 1985 provide important new evidence for the presence of hominids by the late Pliocene in Central Africa. These stone artifacts are important as "markers" for hominids' movements over ancient landscapes. They indicate that by at least 2.5 - 2 million years ago hominids had expanded their range into the Western Rift of Central Africa.

With funding from the Leakey Foundation in 1985 and at the invitation of Dr. N.T. Boaz of the Virginia Museum of Natural History, I began an archeological survey of the late Pliocene deposits known as the Lusso beds and found outcropping along the northern shores of Lake Edward (now Lake Rutanzige) in the Western Rift Valley of Eastern Zaire. Attention

was first drawn to the potential of this area as a source of evidence bearing on human origins by the work in the 1950's of Professor Jean de Heinzelin, a Belgian geologist and paleontologist. In addition to large-scale archeological excavations carried out in much younger beds of late Pleistocene and Early Holocene age at Ishango, de Heinzelin reported several small archeological occurrences with artifacts of Oldowan character, particularly from a site called Kanyatsi. The area has been of great interest for some time and pointed out as a site with possibilities.

Field research was resumed in the Upper Semliki area by a small group of researchers headed by Dr. Boaz in 1982. A surface survey by de Heinzelin and Boaz two years later recovered additional artifacts of possibly Oldowan character just to the northeast of the original trench at Kanyatsi 2. At Boaz's invitation, I joined the Semliki Research Expedition to direct further survey and, if warranted, undertake excavation in the oldest deposits.

An extensive survey over a 5 week field season in 1985 was conducted in the late Pliocene Lusso deposits along

the northern shores of Lake Rutanzige as well as along the banks of the Semliki River which drains out of the north end of the lake. Some 18km of the eastern bank of the Semliki River were surveyed, and 4km of the western bank accessible only by boat were also investigated.

de Heinzelin's original geological trenches were relocated and a small number of quartz and quartzite artifacts of Oldowan character were observed scattered along the outcrops adjacent to the trench. However, no clear point of derivation could be determined. Moreover, the beds dipped inwards at 45° which would have necessitated the removal of massive overburden. Clearly, there was not the time available during the brief field season to undertake large-scale excavation. Instead, the major focus became a careful survey of the Lusso beds.

Compared to the large, laterally well-exposed deposits of the Eastern Rift Valley's fossiliferous and artifact-bearing localities, a survey in the Upper Semliki Valley is extremely difficult. In contrast, the outcrops are small and discrete while the exposures are often covered by lush and thick vegetation which makes visibility difficult. Small diffuse occurrences of Oldowan artifacts were observed on the surface at several places. However, it was not until the Senga locality was reached some 12km downstream that a highly promising surface occurrence of quartz artifacts and fragmentary fossil bone was discovered eroding out of a cemented ironstone. It was decided in the remaining two weeks of the field season that a small area be opened up by test excavation at this locality.

The surface finds include 45 stone cores and flakes of Oldowan character and 100 fragmentary fossilized faunal specimens. A further five fragments of fossilized bone were traced up-

slope to a capping ironstone horizon in which a complete fossil hippopotamus canine tooth and a whole quartzite flake were firmly embedded and exposed *in situ*. These finds clearly indicate that the densest concentration of artifacts and fauna was derived from the ironstone horizon some 40 meters in from the cliff edge that stands about 12 meters above the level of the Semliki River.

It was at this point that two small test trenches measuring about 12 sq. meters were excavated. These yielded fragmentary fossil fauna and approximately 300 stone artifacts consisting largely of smashed quartz, diminutive flakes and fragments as well as several cores very similar in size and character to the Omo assemblages excavated by Harry Merrick and Jean Chavaillon from Member F dating to 2.4 million years. The faunal assemblage contained both aquatic and terrestrial vertebrate forms. Several pig and bovid specimens have been identified and are useful for correlation purposes to determine a faunal age for the site. These specimens have been crucial in assessing the age of the site as approximately 2.3 million years because of the absence of any volcanic material for radiometric dating.

Preliminary studies on orientation and dip of the stones and bones from the Senga site and the lack of size sorting do not indicate any significant disturbance or transport of specimens. Only more detailed taphonomic studies can confirm whether the assemblage has suffered any significant transport during pre- and post-depositional processes.

In addition, there are a number of fish and mollusk specimens in association with the stone artifacts and fossil vertebrates. These finds together with geological details provide useful insights into the probable paleoenvironmental setting. The evidence currently available suggests that the archeological horizon was deposited at a time of climatically-induced lake regression, probably in a low-energy, beach-like setting. Moreover, the composition of the fossil mammalian fauna suggests that, in adjacent areas of the newly emerged landscape, a variety of savanna habitats were available including bush and more open grassland. ■

TALES OF GOMBE CHIMPS AS TOLD IN THEIR BONES

Adrienne L. Zihlman,

Mary Ellen Morbeck, Dale Richman Sumner, Jr.

Studied by Jane Goodall for more than 25 years, Gombe chimpanzees are well-known, and her book, *The Chimpanzees of Gombe*, richly illustrates the complexities of their lives. When individuals died, she retrieved the bodies whenever possible and cleaned the bones.

We came to know many individuals including the matriarch Flo, her offspring Fifi and Flint, and then her grandchildren. The skeletons of Flo, her son Flint and twenty other chimpanzees make up a unique skeletal collection with known sex, age and body weights. Skeletons in museum collections rarely have accurate ages or body weights nor is information about their lives available.

The Gombe skeletons take on new meaning when behavioral observations – of an animal's entire lifetime in many cases – are integrated with skeletal data. We know what they ate and where and when, how they traveled to get food, when they were injured or ill, how they interacted with others in the social group, and when and how often they had offspring. Many of these events are recorded in bones and teeth.

We used a variety of ways to extract information from the bones, including linear and areal measurements and new "high tech" methods that sampled across individuals at different times in the life cycle. We also characterized and compared Gombe adults to other chimpanzee populations, sub-species, and species.

This skeletal series with its extensive life history data serves as a "test case" for our explanations of measured anatomical variation. How much about an individual – its age, diet and nutrition, disease, locomotion and reproduction – can be read in bones and teeth?

The small, non-random Gombe sample mirrors the problems we face when studying fossils. But, instead of

being limited by having only fragments of mineralized bones and teeth, we can check our interpretations of Gombe bone size and shape against known events that influence anatomy during an individual's life. Our results may help to interpret past populations, especially those of fossil hominids. Since we know about females and their offspring and, in many cases, whether their children have children, the Gombe data also may be applied to testing ideas about evolutionary mechanisms.

We analyzed the Gombe skeletons and compared them to 50 common chimpanzees (*Pan troglodytes*), 22 pygmy chimpanzees (*Pan paniscus*) and 66 humans (from the prehistoric Grasshopper Pueblo ruin of Arizona) as well as to many captive chimpanzees we had dissected. We measured bone lengths to define size and proportions and combined these linear measurements with other data: volume measurements of body weight and cranial capacity, areal measurements of joint surfaces and bone cross-sections, and mineral content. This gives a more complete biological profile of Gombe individuals and of the local population.

Computed tomography (CT scans), photon absorptiometry (bone mineral scans) and x-ray data describe the distribution and composition of bone and allow us to "see inside" bones without damaging them. We used five "slices" of the humerus in the upper limb and six of the femur in the lower limb to measure the amount of cortical bone (i.e., the dense bone of a long bone's outer tube) relative to the area of the scan site cross-section with computed tomography and the amount of bone mineral relative to bone width using photon absorptiometry at the same scan sites. Results reflect the loading conditions that helped to shape bones during life. As in humans, they also

reveal the effects of disease, nutrition, aging and other factors that influence bone size, shape and composition.

Bones tell us many tales and we relate four of them here: 1) The nature of chimpanzee variation in body size and shape; 2) Life history stories as related to individual survival and reproduction; 3) Bone loss associated with aging; and 4) A personal profile of Flo.

VARIATION: The Gombe chimpanzees provide a "natural experiment" for ideas about chimpanzee variation. Some researchers predicted that small, common chimpanzees would be like pygmy chimpanzees, a view that implies continuous variation across species. Others recognized different patterns of anatomical variation in the two species.

Our research revealed that adult Gombe chimpanzees weigh less and have shorter limb bones than both pygmy and other common chimpanzees. However, in cranial capacity, tooth size and limb proportions the Gombe adults are the same as other common chimpanzees, *Pan troglodytes*, and have a pattern unlike that of pygmy chimpanzees, *Pan paniscus* (see chart), confirming that the two species are distinct in anatomy. The bottom-line is that a small-bodied common chimpanzee is still a *Pan troglodytes*.

INDIVIDUAL LIFE HISTORY: An individual is someone's offspring and perhaps another's parent or grandparent, but this fact may be lost in the abstraction of the population statistics. A close look at individual chimpanzees illustrates how anatomy and behavior interact during life in the context of a dynamic social, biological and physical environment.

Two females, Gilka and Madam Bee, suffered from polio and both had partial paralysis of an upper limb. This viral disease that attacks nerves and motor units and paralyzes muscles thus influences bone size, shape and mineral content. Our CT and bone mineral scans reveal different patterns of mineral loss and bone remodeling in the two females. The bones tell us which muscles and thus which nerves were affected by the disease.

In a general way, we can infer at what stage in the life cycle polio had been contracted and the kinds of locomotor, feeding or infant care dif-

GOMBE CHIMPANZEES COMPARED TO OTHER PAN TROGLODYTES

Body Weight.....	LOWER
Cranial Capacity.....	SAME
Tooth Size.....	SAME OR SLIGHTLY LOWER
Forelimb Long Bones.....	SHORTER
Hindlimb Long Bones.....	SHORTER
Limb Proportions.....	SAME

GOMBE CHIMPANZEES COMPARED TO PAN PANISCUS

Body Weight.....	LOWER
Cranial Capacity.....	HIGHER
Tooth Size.....	LARGER
Forelimb Long Bones.....	SHORTER
Hindlimb Long Bones.....	SHORTER
Limb Proportions.....	DIFFERENT

ficulties these females may have encountered. Unlike other studies of skeletons, we can verify our interpretations of these Gombe chimpanzees by using Goodall's field observations. Thus we can add information about how a disease such as polio affects reproductive outcome.

Gilka contracted polio as a growing seven year old. The disease retarded her growth and produced asymmetry in bone lengths, joint and bone cortical size, shape and mineral content. Although she bore at least three infants, none survived. Her low social status and poor general health compounded by disease no doubt contributed to her lack of reproductive success.

Madam Bee contracted polio as an adult after she had given birth to two females which survived to adulthood, one with offspring. The paralysis did not affect bone length but produced asymmetries in bone shape, weight and mineral content. Like Gilka, when her limb was paralyzed she had difficulty in caring for infants and two did not survive.

Only with field observations can we understand the importance of timing of a disease, injury or nutritional deficiency relative to the life cycle and its role in survival and reproduction.

Both females were affected by polio and both lost infants. But we know that Madam Bee contributed to the gene pool of the next generation and Gilka did not.

AGING: Our third study focused on apparent age-related bone loss in older Gombe females, including Flo. This bone loss is called osteoporosis in humans and currently is the topic of intense clinical research.

The pattern of bone loss in older Gombe females differs from that of older women. Six CT and bone mineral scans through the thigh bone show that, in contrast to humans, more bone is lost at midshaft cortical sites than in the less dense bone of the femoral neck.

Osteoporosis in women has been linked primarily to hormonal changes at the end of the reproductive period. However, laboratory studies have not verified menopause in common chimpanzees, and field observations indicate that Flo, for example, had reproductive cycles within 2-1/2 years of her death.

Causes for bone loss and its different pattern in older chimpanzee females may differ from those in humans. Dietary inadequacy in part related to tooth loss and extreme wear along with decreased activity coupled with the long-term demands of pregnancy and lactation probably contribute to decreased cortical area and bone mineral content. Once again, data from field studies allow interpretations of skeletal observations.

THE MATRIARCH FLO: No discussion about Gombe chimpanzees is complete without further consideration of Flo. She was an adult with three offspring when Goodall first met her in 1963. Flo's skeleton shows that she was large relative to other Gombe adults and that during her lifetime she fractured her collar bone, ulna, fingers and toes. They healed and apparently did not interfere with survival and reproduction.

Flo lived to be an estimated 43 years - old for a chimpanzee. She suffered from age-related bone loss as described above, but Robert Jurmain's study of her bones showed that she had no joint degeneration. She had lost most of her teeth and those remaining were very worn, and Lynn Kilgore has shown that Flo had nine caries or abscesses. We know from

field studies that she lost weight and was less active toward the end of her life.

Goodall's observations revealed that Flo was high-ranking and popular with males. During one of the rare days when she was not pregnant or lactating, she was involved in 50 copulations. Her reproductive legacy includes Faben who contracted polio in 1966 and died in 1975; Figan, a dominant male for eight years; and Fifi, currently a high-ranking adult

with four offspring now 17, 12, 7, and 3 years old. Later in her life, Flo produced Flint and Flame, but both died before reaching reproductive age; Flint at 8-1/2 and Flame while still an infant.

Life histories such as Flo's emphasize the importance of synthesizing field observations with data from bones and teeth. This approach is exciting because it shows us which factors influence anatomy and what it takes to survive and reproduce.

Studies of the Gombe skeletons as individuals and aggregated as a local population therefore help us to explain anatomical variation and its relation to potential evolutionary change.

Finally, chimpanzees are our closest living relatives and we share a long period of common ancestry with them. Understanding their behavior and biology has important implications for interpreting human origins and evolution. ■

SMALL GAME HUNTING AT NEOLITHIC 'AIN GHAZAL

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Analyses of Near Eastern faunal assemblages from the Neolithic period generally have the beginnings of animal husbandry as their central concern and hence they focus on detecting indications of domestication in various ungulate taxa.

Attention to these matters is predictable and justified in view of the pivotal consequences of the transition from hunting to herding. However, the often competitive absorption with determining the exact locale and time period of the first occurrence of these developments has to some extent precluded occupation with other equally or even more crucial aspects. A number of questions that are of unrivaled significance for ultimately evaluating the success of the "Neolithic Revolution" in ecological terms have hardly been touched upon. For instance, was the decline in the importance of hunting that accompanied the rise of animal husbandry a matter of choice or force – that is, a question of cultural preference or of ecological necessity? Especially significant in this respect is the temporal relationship between the decrease in hunting and the adoption of herding since it could provide clues to their causal relationship. For example, did husbandry evolve as a response to the lack of game in the vicinity of permanent settlements or was the paucity of wild faunal resources a consequence of the spread of domesticates?

In the context of such fundamental queries, the extensive sample of carnivore and other small mammal bones recovered during four seasons of excavations at the Pre-Pottery Neolithic B and early Pottery Neolithic site of 'Ain Ghazal in Jordan takes on special significance. Previous excavations of Neolithic sites in the area conducted during the 1950s and 1960s had proceeded without special attention to the recovery of such zoological remains, and the omission of systematic sieving had resulted in inadequate and very limited retrieval of smaller faunal components. The 2,000 fragments of small mammal remains reported on here represent a subsample of about 10% of the total animal bones collected from 'Ain Ghazal. The sample as a whole is dominated by the remains of goats undergoing domestication; other members of the megafauna are gazelles, cattle and pigs.

Prerequisite for analyzing and documenting this material was access to a comparative collection containing skeletons of the small mammals, especially carnivores, presently and previously extant in the Near East and adjoining areas. The L.S.B. Leakey Foundation supported a 3-month stay at the British Museum of Natural History in London early in 1988 which enabled me to identify most of the small mammal bones from 'Ain Ghazal. Special thanks are due to Dr.

Juliet Clutton-Brock, Head of the Osteology Section in the Zoology Department of the BM(NH) who gave me access to the collections, and to Sebastian Payne of British Heritage's Ancient Monuments Laboratory in London who took an active interest in the project.

Summary of preliminary results. The fox (*Vulpes*) is easily the most frequently represented taxonomic group. Most of the material can be ascribed to the Red Fox, *Vulpes vulpes*, but metrical analysis indicates that an additional much smaller fox species is also present, albeit only in a very low frequency. This could be one of three related taxa known to occur in the southern Levant, *Vulpes rüppelli*, *Fennecus zerda*, or *Vulpes cana*. None of these species was contained in the postcranial material of the BM(NH), so final identification is still pending.

The next most frequent carnivore is the wild cat, *Felis sylvestris*, which is of similar importance in numerical terms as the hare, *Lepus europaeus*.

The European badger, *Meles meles*, occurs much less frequently. There was no clue for the presence of the related species, the ratel, *Mellivora capensis*.

Only occasionally represented was a species of marten that is adapted to fairly dense vegetational cover and is probably close to extinction in the area today. Even slightly rarer are the remains of the mongoose, *Herpestes ichneumon*, a taxon of African origin.

Represented by only one molar was the lynx, *Felis lynx*.

However, there still remain a number of specimens which are potentially identifiable but for whom no parallels were contained in the BM(NH) collections. For example, it is thought that the marbled polecat, *Vormela peregusna*, is represented among the sample, but it has not been possible to verify this.

Other small mammals that have been identified include the European hedgehog, *Erinaceus europaeus*, the longeared hedgehog, *Hemiechinus auritus*, the squirrel, *Sciurus anomalus*, and a vole, but these are the subject of a separate study by William Gillespie of the Department for Geosciences, University of Arizona.

Spatial and temporal context. In terms of differentials in spatial distribution, a relatively high proportion of small mammalian remains was derived from one particular square (3082) which represents the inside of a PPNB house. On the other hand, some of the other houses from this period hardly produced any small mammal remains. Very tentatively, this could indicate some degree of economic specialization, i.e., that some people remained hunters while

others obtained their animal products from goat husbandry. Alternatively, this circumstance could mirror personal food preferences rather than occupational specialization; this would be an indication of an exchange system within the community.

Concerning temporal variability, it is noteworthy that practically all small mammal remains originated from PPNB deposits and only very isolated specimens from the later horizons. This could simply be a sampling distortion. For example, if square 3082 had not been chosen to be excavated, the overall proportion of small mammal bones would be much smaller, even in the PPNB. Assuming that the difference does reflect an actual shift in the faunal spectra exploited by PPNB and Yarmoukian populations, it could be explained by the two alternative scenarios mentioned in the introduction: depletion of the surroundings of the site of game by the advent of the Yarmoukian period or a cultural preference for goat herding and consumption.

Skeletal representation. The different parts of the skeleton all appear to be approximately equally well represented. This unfortunately means that there are no hard clues as

to the purpose of small animal hunting: might it be as a source of food, to obtain skins, furs and medical products, or to acquire raw material for bone tools and bone jewelry? (A study of the bone beads indeed confirms that the longbones of small mammals constituted the preferred source for producing them.) Most longbones have been separated into proximal and distal halves, but it is not obvious from macroscopic inspection alone if this happened due to natural breakage or human manipulation. Traces of burning are visible only in less than 5% of specimens.

Outlook. At this stage of the investigation we are left with almost as many questions – or even more – as before. Metrical documentation of the material has almost been completed. It is hoped that, by entering the data into the computer, a more concise picture of the spatial distribution will emerge. Faunal materials retrieved during the 1988 excavations from strata of the late PPNB will also help us to obtain a clearer idea of when the final decline of small game hunting took place at 'Ain Ghazal. At this point of our analysis it appears that this economic pursuit was still a viable option at around 6,500 BC but had ceased to be one by about 6,000 BC.

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BOOKS

EARTH AND LIFE THROUGH TIME by Steven M. Stanley. 2nd edition. W.H. Freeman, New York, 1989. pp 736, 869 illustrations. Large format, \$39.95 cloth.

Teachers and students familiar with the first edition of this book will recall the author's aim to treat the physical and biological history of the planet as intertwined, in concert, but presented against a background of regional events in the context of global plate tectonics. Thus, in the preface to this second edition, author Stanley explains the expanded scope of the various new chapters, beginning with elementary principles in historical geology and leading through an overview of ecological principles and the nature of our planet's ecosystem. Valuable chapters include a review of important non-marine and marine depositional settings that account for the bulk of the sedimentary record. Stratigraphic procedures and prin-

ciples are carefully delineated. Much new information on the development of western North America is included in this second edition, along with an updated discussion of human evolution.

Detailed illustrations of mountain-building processes and plate tectonics serve, along with useful charts and tables, to make this work a combination of the earth's history and life on our planet.

HUNTERS AND GATHERERS, Vol. I: History, Evolution and Social Change; Vol. II: Property, Power and Ideology edited by Tim Ingold, David Riches and James Woodburn. Berg, distributed by St. Martin's Press, New York, 1989. \$55 each vol.

The articles edited and published in these companion volumes were selected from some seventy-four papers presented at a major London

conference, the Fourth International Conference on Hunting and Gathering Societies, in September, 1986.

Dedicated to the memory of Glynn Isaac and Eleanor Leacock, editor Tim Ingold pays tribute to both distinguished professors for their contribution to this fascinating field and the overall understanding of the evolution of humanity.

The London conference attracted 114 scholars from eighteen different countries, and the papers presented in these two volumes meet the objective of presenting the results of new field work and advancing the overall comprehension of hunting and gathering societies with relevance to the construction of anthropological theory. A revisionist and more complex picture of the social life of hunter-gatherers emerges which may well affect conceptions of some of the most pressing social questions of our time.

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