Geography: Different lemur species have clear geographical distribution. Others can be found in each province in Madagascar.
Therefore, I propose that lemurs should be used to teach in school at different levels.

In primary school: Students should learn about the different species of lemurs including subfossils occurring in each province and different habitat types (rainforest, dry forest, spiny desert, marsh) and their conservation.

In secondary school: Students should learn about behavior, diet, locomotion, and social organization of the different lemurs.

In high school: Students should learn about the phylogeny of lemurs and also the other non-human primates in Asia, Africa, and South America. The initiation of the concept of Anthropology should start at that level.

At the university: The different aspects of primates in general and lemurs in particular listed above should be learned more deeply in the different departments within the University. A Conservation Biology Department should be created. And more importantly, students and faculty should be encouraged to write and publish scientific papers furthermore collaboration between departments must be promoted.

Report on Findings of Subfossils at Ampoza and Ampanihy in Southwestern Madagascar

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Key words: *Archaeolemur,* paleoecology, carbon 14 dating, southwest Madagascar, *Hippopotamus*

Introduction

Sixteen species of large-bodied lemurs have gone extinct within the last 4,000–450 years (Simons 1997; Godfrey *et al.* 1999). These numbers are based on findings from about 40 subfossil lemur sites which range from northern to southern tips of Madagascar, and from the Mozambique Channel east to the central sites of Sambaina, Masinandriana and Andrahomana (Godfrey *et al.* 1997). Excavations in the southwestern Madagascar date back at least to the White/Ramamonjy expedition to Manombo in 1929 (White 1930) and Lamberton's discoveries at Lamboharanana, on the coast north of Tulear (Lamberton 1932). Recent expeditions have provided a more detailed view of the taxonomic composition of the past communities (Simons 1997; Godfrey *et al.* 1997a, b, 1999) and pollen cores have revealed the increased aridity of the area during the past 4 millenia (Burney 1993; Burney *et al.* 1998). This condition of relative aridity and periodic drought continues today (Gould *et al.* 1999; Wright 1999). In 1995 our team explored the Ampoza region in order to document the potential for reconstructing the paleoecological setting of the region (Fig. 1).

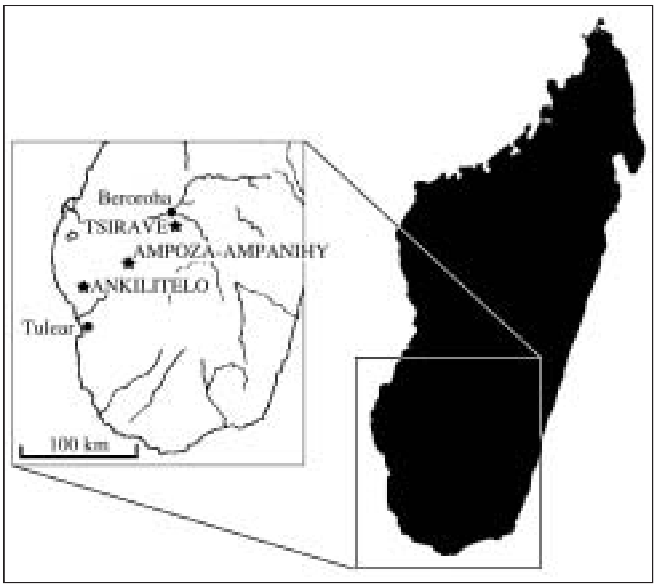

Fig. 1: Map of the study sites in southeastern Madagascar in context of other subfossil lemur sites.

With the Malagasy Academy records Claude Chanudet (1975) reviewed the documents about early excavations at Ampoza, in southwestern Madagascar. He found that in a 1921 letter from Dr. Razafindramanana to Battistini he describes this site which has a spring that never dries up, and in its course this water exposes bone beds. Mahe took samples in the bone beds at a depth of 200cm which gave radiocarbon dates of 1910 ±120 BP (Mahe and Sourdat 1972). Recently a humerus of a new species of ground roller, a bird with close relatives in the present day Malagasy rain forest, was identified from Ampoza (Goodman 2000). The subfossil lemurs found at Ampoza include inferred forest-dwelling species such as *Hadropithecus stenognathus*, *Paleopropithecus* sp., *Indri* sp. *Archaeolemur edwardsi*, *Megaladapis* sp., and *Archaeolemur majori* (Tattersall 1982; Godfrey *et al.* 1997a,b, 1999).
The objective of this paper is to report preliminary data on the findings at the Ampoza and Ampanihy sites with particular emphasis on their paleoecological context.

Field observations

In November, 1995 an ICTE/ANGAP team from Ranomafana National Park visited the areas around the village of Ampoza (Fig. 2). Today, the region is characterized by open grassland covering gently sloping hills. Trees and bushes are mostly confined adjacent to small rivers running north west. Water levels in the streams were low at the end of November.
The first locality visited was next to the Ampoza river (the river Ampoza is named after a fresh water crab there), a tributary to the Ampanihy river. The site is located at 44° 42.3´ E, 22° 18.9´ S. This site is most likely the classic Ampoza locality and local villagers also recalled earlier ex-

peditions to the site. The river runs through a forty-meter long section of rich bone accumulations. The bone-containing deposits began at the surface and extend down to over one meter and are underlain by sand and sandstone formations that also form the bottom of the river. The bone deposits appear to be slightly more concentrated in the top layer and bottom half of the deposit with finer sediments layered between them. The bones lie predominantly horizontally in the deposits and were not clearly associated. The banks of the bone bed have been continuously eroded by the river and bones can be found in the bottom of the stream.

The second site visited is located about two kilometers south east from the Ampoza locality and is on the Ampanihy river (Fig. 2). The site is located at 44° 42.7´ E, 22° 19.8´ S. Portions of the bone deposits are under the grassland and only a five meter section is exposed by the river. Unlike the Ampoza site, the bone bed of the Ampanihy river is several meters above the present day river bed. We made surface collections of both of the deposits with the only aim of selecting bones with identifiable features.

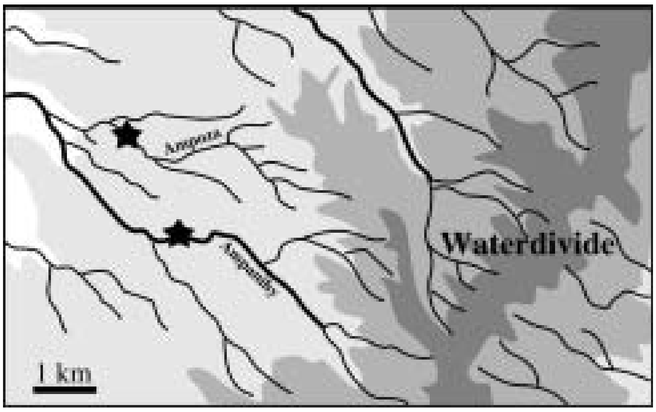

Fig. 2: Closeup schematic map of region of Ampoza and Ampanihy. The patchwork of small streams and hills spans about 40 km along the waterdivide.

Fig. 3: Photo of front and back views of distal humerus (cast) of *Archaeolemur* sp. uncovered at Ampoza.

Results and Discussion

The majority of bones recovered were from hippopotamuses. Of 269 specimens recovered from Ampoza, 122 were hippos as were also 30 out of 46 specimens from the Ampanihy river site. Several cranial fragments and partial mandibles with teeth were recovered as also fore and hind limb bones including metapodials. Teeth, vertebrae, and femurs made up 58 % of all the hippo bones. The remaining specimens were mostly from medium size crocodilians, large tortoises, and elephant birds. Only one clearly identifiable lemur specimen was recovered. This is a distal humerus of *Archaeolemur sp. from the Ampoza site* (Fig. 3).

The stark contrast between the relatively arid present day conditions of the area and the seemingly wet conditions of the past raises the question of the age and nature of the bone deposits. A 5000 year stratigraphic record containing fossil pollen, charcoal and bones of the extinct Quaternary megafauna from Andolonomby, a hypersaline pond near Ambolisatra in arid southwestern Madagascar shows evidence for climatic desiccation beginning about 3000 years BP. Between 3000 and 2000 yr BP, the site became increasingly arid, with charcoal and pollen evidence indicating increased fire activity beginning ca 1900 yr BP (Burney 1993). Even in the present, years of drought occur each decade (Gould *et al.* 1999; Wright 1999).

We next obtained radiocarbon dates for the Ampoza and Ampanihy river deposits. Samples of unidentifiable bone fragments were collected from the top, from 65 cm, and 110 cm depth of the Ampoza bone bed and dated by the University of Helsinki dating laboratory (Hela). Dates are uncalibrated and reported as ^{14}C yr BP using the international standard half-life of 5568 yr. The top sample date is 1850±55 (Hela-158), the 65 cm sample date is 1705±55 (Hela-157), and the 110 cm sample date is 1810±60 (Hela-156).

The roughly 150-year span of these dates suggests that even the thickest bone deposits in Ampoza have accumulated relatively quickly. These three dates do not exclude the possibility that the bones were deposited in a few decades. Only one date was obtained for the Ampanihy river site which gave the age of 2430±100 yr BP (Hela-3854). This suggest that the two localities visited, while separated by only two kilometers, may have been deposited around 600 years apart in time. Interestingly, the Ampanihy site has also a higher elevation (660 m) than Ampoza (570 m) and is located higher above the riverbed, suggesting that the local streams had not yet eroded to the sandstone bedrock as was apparently the case by the time the deposits at Ampoza were formed. Both these sites are located about 6 km west from the local waterdivide which has an elevation of 750 to 780 meters and presumably had already functioned as the waterdivide when the bone deposits were formed (Fig. 2).

The relative vicinity of the waterdivide and the presence of springs that still feed water to the Ampanihy and Ampoza streams is indicative of local origins of the bones. Present day hippos in Africa spend the entire day in the water and typically leave the resting pools and streams only after nightfall (Owen-Smith 1988). The present data do not allow firm conclusions whether the bones were deposited as a result of normal mortality or whether they might represent the death rate during severe drought years. Nevertheless, the slightly different concentrations of bones in different layers in the Ampoza site suggests that droughts may have caused increased hippo mortality. African hippos are well documented to congregate at the last remaining pools during drought and there to suffer heavy mortality (Owen-Smith 1988). The association of Ampoza and Ampanihy with springs may also in part suggest that the locations of the bone beds could have been the last remaining hippo rest sites during drought years. It is noteworthy that these sites are unlikely to represent mass-kills by humans because all body parts of the hippos were collected and also no butchery marks were observed.

It remains to be investigated how long the hippo dominated ecosystem existed in the region. Modern day hippos have been documented to exert a strong influence on their surroundings. Regular movements of hippos between their rest sites and grazing grounds create channels and paths that cause erosion (Owen-Smith 1988, McCarthy *et al*. 1998). Furthermore, grazing of hippos opens the landscape near the streams, and also changes the species composition of grasses (Owen-Smith 1988). At least *Cyperus* grasses that are found around streams in eastern valleys of Madagascar are also a favored diet of African hippos. If the 600-year separation of Ampoza and Ampanihy river sites is representative of the hippo occupation, this could have been a long enough timespan for the hippos to have had a visible impact on the landscape.

The presence of several kinds of giant subfossil lemurs as well as hippos at Ampoza suggests that these taxa may have existed in the vicinity of the site. However, should the bone beds represent major drought events, animals could have been attracted from broader areas. Hence, the presence of *Archaeolemur* and the other primates may not indicate necessarily that these species shared the same habitat with hippos. The *Archaeolemur* dentition suggests that it fed on foods requiring some preparation with enlarged incisors, such as fruit with tough rinds and seeds with hard outer shells (Godfrey 1988; Simons 1997; Tattersall 1972, 1982). Similar considerations also apply to the other species of large lemurs mentioned above as reported from this site. Also, more intensive efforts to recover microfauna at these sites will likely contribute to a better understanding of the paleo environments from which these subfossils came. Future work is needed to ascertain whether *Archaeolemur*, or some other lemurs, may be more typically associated with putative hippo rest sites and may thus be interpreted to have shared the same habitat.

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