**Supplemental Information**

**Paleoenvironmental reconstructions of catarrhine-bearing sites**

**1 Moroto (Kogole Beds), 20.6 Ma, Uganda**

The site of Moroto, some 13km from the Moroto volcano, is extremely important because at 20.6Ma (Gebo et al., 1997) it is one of the oldest catarrhine yielding fossil sites of the early Miocene in Africa (see Pickford et al., 2003 for a younger age assesment). In addition, the mammalian fauna include certain unique species (Pickford and Mein, 2006), of which the non-cercopithecoid catarrhine *Morotopithecus bishopi* is regarded by some as the leading candidate for the oldest hominoid(Gebo et al., 1997; Maclatchy, 2004; MaClatchy et al., 2000). It is thus unfortunate that detailed environmental assessments of Moroto are few (Kingston et al. 2009; 2011). The fossils were deposited in fluvial deposits and the presence of aquatic fauna demonstrates permanent water. Some of the fauna indicate that some closed-canopy woodland or forest was present, but some open areas likely existed as well (Pickford and Mein, 2006).

**2 Tinderet (Songhor, Koru), 20–19 Ma, Western Kenya**

The numerous Koru (Tinderet) localities are located on the slope of the ancient Tinderet volcano (Cote, 2008; Pickford and Andrews, 1981). Songhor is a single large site that, while also part of the Tinderet set of localities, differs slightly from the rest in its catarrhine assemblage (Cote, 2008; Harrison, 2010). The newly discovered nearby locality of Lower Kapurthay is possibly very similar to Songhor (Cote et al., 2014). In general, both Songhor and Koru are forests and despite some differences in the catarrhine and artiodactyls at Songhor compared to the Koru localities, any differences among them are very subtle and hard to recognize by comparing the vertebrate fauna (Cote, 2008). Several paleonvironmental reconstructions of Songhor argue that it was perhaps similar to a modern tropical forest (Andrews et al., 1997) or a modern montane or submontane forest (Pickford, 1995). Microwear analyses of tragulid teeth suggest some open areas at Songhor (Ungar et al., 2012). Hill et al.’s (2013) summary of faunal analyses indicates low forest habitats at the Tinderet localities. However, based on primate fossil distributions, these authors argued that Koru was a wetter forest than Songhor. Fossil land snails at these localities indicate a wet rainforest with a mean annual rainfall of 1270–1780 mm at Koru, but a drier forest with a mean annual rainfall up to 1020 mm at Songhor (Pickford, 1983). Fossil-bearing strata at Songhor are thought to have accumulated under fluvial or lacustrine conditions and, during subaerial exposure, through volcanic and/or volcaniclastic sedimentation on floodplains or exposed mudflats (Pickford and Andrews, 1981; Hill et al., 2013).

**3 Napak, 20–19 Ma, Uganda**

The Napak localities are located on modern day Akisim, the remains of the slopes of the ancient Napak volcano (Cote, 2008). Faunal analyses highlight Napak's similarity to the Tinderet sequence sites, suggesting a similar age (Pickford et al., 1986; Cote, 2008; Grossman et al., 2014). Analyses of gastropods indicate that forest conditions at Napak perhaps varied between dry forest and rainforest (Pickford, 2004), making it difficult to distinguish from either Tinderet or Koru (Cote, 2008). Two newly discovered localities at Napak indicate variable paleoenvironments (Cote et al., 2014b): one represents a montane forest, whereas the other typifies a more open habitat. Pickford et al. (2010) suggest that the localities at Napak are sampling a mosaic of woodland and forest on the slopes of the volcano, but Cote’s detailed analyses do not support more open habitats at Napak (Cote, 2008). Depositional environments at Napak were fluvial for the older sites and subaerial for the younger sites. Whether the lower and upper sites differ much in age and represent different members is debated (see: Cote, 2008; Pickford et al., 2010).

**4 Kisingiri (Rusinga Island: Hiwegi Formation, and Karungu: Ngira Formation) >18 Ma, Western Kenya**

The Miocene deposits at Rusinga Island include numerous localities, with the majority of the fossils, including most of the catarrhines, coming from localities within the Hiwegi Formation (Drake et al., 1988; Werdelin, 2010). Early analyses of the fossil flora of Rusinga indicated tropical rainforest (Chesters, 1957), but other researchers reconstructed more open habitats from the floral remains (e.g., Kortlandt, 1983). Analyses that focused primarily on the fauna reconstructed forested conditions (Andrews, 1981, 1992; Andrews et al., 1979) but these combined fossils from many localities are probably time-averaged localities from slightly different ages (Lukens et al., 2017). Interpretations of the environment(s) of individual localities of the Hiwegi Formation range from a forest at R3 (Michel et al., 2014) to woodland conditions indicated by the fossil flora at locality R117 (Collinson et al., 2009). What is clear is that while the Rusinga localities are all from some kind of woodland, they are sampling diverse depositional environments, including riparian conditions and floodplains (Andrews et al., 1997), and varying climatic conditions that led to a mosaic of open woodland to forest habitats.

The fossil fauna at the Ngira locality in Karungu does not differ from the Hiwegi Formation in the types of species found, but perhaps differs in the relative abundance of species, particularly the catarrhine primates (Lukens et al., 2017). Recent analyses of the soil structure and composition of the Ngira locality, particularly NG15, indicate that this was a relatively open riparian woodland to grassy woodland, with at least some C4 plants, growing in a seasonally dry, warm climate (Driese et al., 2016; Lukens et al., 2017), indicating that Ngira was probably more open than the Hiwegi Formation localities at Rusinga.

**5 Buluk and Nabwal Hill (Bakate Formation), >17.2 Ma, West Lake Chew Bahir, Kenya**

The depositional setting of Buluk began as lacustrine, but was replaced by fluvial and volcanic sedimentation higher in the section as the lake regressed (Harris and Watkins, 1974). The fossils at Buluk are retrieved from channel deposits of the Buluk Member of the Bakate Formation, east of Lake Turkana. The Buluk Member is composed of claystones with coarse sandstone and conglomerate channel fill. The fauna from Buluk requires further analysis and its current sample lacks small mammals (Geraads and Miller, 2013; Grossman, 2008). However, there are certain differences in the faunal composition of Buluk compared to contemporaneous sites in West Turkana such as Kalodirr and Moruorot (Leakey et al., 2011), even though all the non-cercopithecoid catarrhines found at Buluk are found at Kalodirr and Moruorot. Whether these differences in the fauna were caused by environmental, geographical, or some other factor cannot be ascertained at this time.

Nabwal and Irilie are catarrhine-bearing sites located about 20km north of Buluk (Fig. 1). The vertebrate fossils are found within fluvial deposits (McDougall and Watkins, 2005) and are very similar to those found at Buluk (McDougall and Watkins, 2005), although the cercopithecoids, at least, are distinct species (Miller et al., 2009). Fejej, another nearby site within the Bakate Formation, has a small faunal assemblage that includes a non-cercopithecoid catarrhine ulna whose morphology is consistent with arboreal climbing (Richmond et al., 1998), suggesting the presence of trees. Fossil wood from a close-by locality at Fejej indicates a dense tropical woodland of deciduous forest lacking a fully closed canopy (Wheeler et al., 2007). Currently, this provides the best hypothesis about the environment at Buluk.

**6 Kalodirr and Moruorot (Lothidok Formation), 17.7-16.6Ma, West Turkana**

The two sites, Kalodirr and Moruorot, represent a single region and their fauna are similar (Grossman, 2008; Grossman et al., 2014; Leakey et al., 2011). The sites share non-cercopithecoid catarrhines with Buluk, but lack any cercopithecoid remains. Unlike the primates, Kalodirr and Moruorot differ from Buluk in many of their large mammals, especially the suids and rhinos (Leakey et al., 2011). Kalodirr and Moruorot include some taxa not known from other early Miocene sites (Adrian et al., 2018; Grossman et al., 2013; Grossman and Holroyd, 2009). Based on their fauna, they are reconstructed as wooded rather than forested habitats with meandering streams and some possible swampland (Grossman, 2008; Grossman and Holroyd, 2009; Leakey et al., 2011).

**References Cited:**

Adrian, B., Werdelin, L., and Grossman, A. (2018). New Miocene Carnivora (Mammalia) from Moruorot and Kalodirr, Kenya. *Palaeontologia Electronica* 21.

Andrews, P. (1974). New species of *Dryopithecus* from Kenya. Nature. 249, 188–190.

Andrews, P. (1978). A revision of the Miocene Hominoidea of East Africa. *Bulletin of*

*the British Museum (Natural History), Geology* 30.

Andrews, P. (1981). Species diversity and diet in monkeys and apes during the

Miocene. *Aspects of human evolution*.

Andrews, P. (1992). Evolution and environment in the Hominoidea. *Nature*

360(6405)**,** 641.

Andrews, P. (1996). Palaeoecology and hominoid palaeoenvironments. *Biological*

*Reviews* 71(2)**,** 257-300.

Andrews, P., Begun, D.R., and Zylstra, M. (1997). "Interrelationships between

functional morphology and paleoenvironments in Miocene hominoids," in *Function, Phylogeny, and Fossils*. Springer), 29-58.

Begun, D.R. (2015). "Fossil record of Miocene hominoids," in *Handbook of paleoanthropology*. Springer), 1261-1332.

Benefit, B.R. (2000). "Old World monkey origins and diversiﬁcation: an evolutionary study of diet and dentition," in *Old world monkeys,* eds. P.F. Whitehead & C.J. Jolly. (Cambridge, UK: Cambridge University Press), 133-179.

Brand, U., and Veizer, J. (1980). Chemical diagenesis of a multicomponent carbonate system—1: Trace elements. J. Sed. Pet. 50, 1219–1236.

Chesters, K.I.M. (1957). The Miocene flora of Rusinga Island, Lake Victoria, Kenya. Palaeontographica B. 101, 30–71.

Collinson, M.E., Andrews, P., and Bamford, M.K. (2009). Taphonomy of the early

Cote, S.M. (2008). Sampling and ecology in three Early Miocene catarrhine assemblages from East Africa. [Ph.D. Dissertation]. [Cambridge (MA)]: Harvard University.

Deane, A.S. (2012). New evidence for canine dietary function in Afropithecus turkanensis. *Journal of human evolution* 62(6)**,** 707-719.

Drake, R.E., Van Couvering, J.A., Pickford, M.H., Curtis, G.H., and Harris, J.A. (1988). New chronology for the Early Miocene mammalian faunas of Kisingiri, Western Kenya. *Journal of the Geological Society* 145(3)**,** 479-491.

Fleagle, J., and Kay, R. (1985). The paleobiology of catarrhines. *Ancestors: the hard evidence***,** 23-36.

Fleagle, J.G. (1983). *Locomotor adaptations of Oligocene and Miocene hominoids and their phyletic implications.* Springer.

Fleagle, J.G., and Simons, E.L. (1978). *Micropithecus clarki*, a small ape from the Miocene of Uganda. *American Journal of Physical Anthropology* 49(4)**,** 427-440.

Fleagle, J G. (2013). Primate Adaptation and Evolution. San Diego: Academic Press.

Foley, R. (1987). Another Unique Species: Patterns in Human Evolutionary Ecology. London: Longman Publishing.

Forbes, M.S., Bestland, E.A., Krull, E.S., and Dicker, D.G. (2004). Palaeoenvironmental mosaic of *Proconsul* habitats: geochemical and sedimentalogical interpretation of Kisingiri fossil sites, Western Kenya*.* J. Afr. Earth Sci. 39, 63–79.

Fourtau, R. (1920). *Contribution à l'étude des vertébrés miocènes de l'Egypte.* Government Press.

Gebo, D.L., MacLatchy, L., Kityo, R., Deino, A., Kingston, J., and Pilbeam, D. (1997). A hominoid genus from the early Miocene of Uganda. *Science* 276(5311)**,** 401-404.

Geraads, D., and Miller, E. (2013). Brachypotherium minor n. sp., and other Rhinocerotidae from the Early Miocene of Buluk, Northern Kenya. *Geodiversitas* 35(2)**,** 359-375.

Grossman, A. (2008a). *Ecological and morphological diversity in catarrhine primates from the Miocene of Africa.* PhD, State University of New York at Stony Brook.

Grossman, A., Flynn, L., and Manthi, F.K. (2013). "Rodents from the Lothidok Formation, early Miocene, West Turkana, Kenya". Journal of Vertebrate Paleontology Program and Abstracts ).

Grossman, A., and Holroyd, P.A. (2009). Miosengi butleri, gen. et sp. nov.,(Macroscelidea) from the Kalodirr Member, Lothidok Formation, early Miocene of Kenya. *Journal of Vertebrate Paleontology* 29(3)**,** 957-960.

Harris, J., and Watkins, R.T. (1974). New early Miocene vertebrate locality near Lake Rudolf, Kenya. Nature. 252, 576–577.

Harrison, T. (2010). “Dendropithecoidea, Proconsuloidea, and Hominoidea,” in Cenozoic Mammals of Africa, eds. L. Werdelin and W.J. Sanders(Berkeley, CA: University of California Press), 429–469.

Hopwood, A.T. (1933). XI.—Miocene Primates from British East Africa. *Journal of Natural History Series 10* 11(61). doi: 10.1080/00222933308673629.

Jacobs, B.F., Kingston, J.D., and Jacobs, L.L. (1999). The origin of grass-dominated ecosystems. *Annals of the Missouri Botanical Garden*.

Kay, R.F., and Ungar, P.S. (1997). "Dental evidence for diet in some Miocene catarrhines with comments on the effects of phylogeny on the interpretation of adaptation," in *Function, Phylogeny, and Fossils*. Springer), 131-151.

Kelley, J. (2002). Life-history evolution in Miocene and extant apes. *Human evolution through developmental change*.

Kelley, J., Andrews, P., and Alpagut, B. (2008). A new hominoid species from the middle Miocene site of Paşalar, Turkey. *Journal of Human Evolution* 54(4)**,** 455-479. doi: <https://doi.org/10.1016/j.jhevol.2007.08.007>.

Kelley, J., and Smith, T.M. (2003). Age at first molar emergence in early Miocene Afropithecus turkanensis and life-history evolution in the Hominoidea. *Journal of Human Evolution* 44(3). doi: 10.1016/s0047-2484(03)00005-8.

Kingston, J.D. (2007). Shifting adaptive landscapes: progress and challenges in reconstructing early hominid environments. *American Journal of Physical Anthropology* 134(S45)**,** 20-58.

Kingstone, J., MacLatchy, L., Cote, S., Kityo, R., and Sanders, W. (2011) Isotopic evidence of paleoenvironments and niche partitioning of early Miocene fossil fauna from Napak and Moroto, Uganda. J Vert. Paleo, 31: 136A.

Kortlandt, A. (1983). "Facts and fallacies concerning Miocene ape habitats," in *New interpretations of ape and human ancestry*. Springer), 465-514.

Leakey, M. (1985). Early Miocene cercopithecids from Buluk, Northern Kenya. *Folia primatologica* 44(1)**,** 1-14.

Leakey, M., Grossman, A., Gutiérrez, M., and Fleagle, J.G. (2011). Faunal change in the Turkana Basin during the late Oligocene and Miocene. *Evolutionary Anthropology: Issues, News, and Reviews* 20(6)**,** 238-253.

Leakey, R.E., and Leakey, M.G. (1986a). A new Miocene hominoid from Kenya. *Nature* 324(6093)**,** 143-146. doi: 10.1038/324143a0.

Leakey, R.E., and Leakey, M.G. (1986b). A second new Miocene hominoid from Kenya. *Nature* 324(6093). doi: 10.1038/324146a0.

Maclatchy, L. (2004). The oldest ape. *Evolutionary Anthropology: Issues, News, and Reviews* 13(3)**,** 90-103.

Maclatchy, L., Gebo, D., Kityo, R., and Pilbeam, D. (2000). Postcranial functional morphology of Morotopithecus bishopi, with implications for the evolution of modern ape locomotion. *Journal of Human Evolution* 39(2)**,** 159-183.

McDougall, I., and Watkins, R.T. (1985). Age of hominoid-bearing sequence of Buluk, northern Kenya. Nature. 318, 175–178.

McNulty, K.P., Begun, D.R., Kelley, J., Manthi, F.K., and Mbua, E.N. (2015). A systematic revision of Proconsul with the description of a new genus of early Miocene hominoid. Journal of Human Evolution. 84, 42-61.

Michel, L.A., Peppe, D.J., Lutz, J.A., Driese, S.G., Dunsworth, H.M., Harcourt-Smith, W.E., Horner, W.H., Lehmann, T., Nightingale, S., and McNulty, K.P. (2014). Remnants of an ancient forest provide ecological context for early Miocene fossil apes. NatureComm. 5, 3236.

Miller, E.R. (1999). Faunal correlation of Wadi Moghara, Egypt: implications for the age of Prohylobates tandyi. .J. Hum. Evol. 36, 519-533.

Pickford, M. (1983). “Sequence and environments of the lower and middle Miocene hominoids of western Kenya,” in New Interpretations of Ape and Human Ancestry, eds. R.L. Ciochon and R.S. Corruccini, (New York, NY: Plenum Press) 421–439.

Pickford, M. (1983). “Sequence and environments of the lower and middle Miocene hominoids of western Kenya,” in New Interpretations of Ape and Human Ancestry, eds. R.L. Ciochon and R.S. Corruccini, (New York, NY: Plenum Press) 421–439.

Pickford, M. (1995). Fossil land snails of East Africa and their palaeoecological significance. J. Afr. Earth Sci. 20, 167–226.

Pickford, M. (2004). Palaeoenvironments of early Miocene hominoid-bearing deposits at Napak, Uganda, based on terrestrial molluscs. Annls. Paléont. 90, 1–12.

Pickford, M., and Andrews, P. (1981). The Tinderet Miocene sequence in Kenya. J. Hum. Evol. 10, 11–33.

Pickford, M., Senut, B., Hadoto, D., Musisi, J., and Kariira, C. (1986). Nouvelles découvertes dans le Miocène inférieur de Napak, Ouganda Oriental. C. R. Acad. Sci. Paris. 302, 47–52.

Pickford, M., Senut, B., Gommery, D., and Musiime, E. (2003). New catarrhine fossils from Moroto II, early middle Miocene (ca 17.5 Ma) Uganda. *Comptes Rendus Palevol* 2(8)**,** 649-662.

Pickford, M., and Mein, P. (2006). Early Middle Miocene mammals from Moroto II, Uganda. *Beiträge der Paläontologie* 30**,** 361-386.

Pickford, M., Musalizi, S., Senut, B., Gommery, D., and Musiime, E. (2010). Small apes from the early Miocene of Napak, Uganda. Geo-Pal Uganda.3, 1–110.

Pilbeam, D. (1996). Genetic and Morphological Records of the Hominoidea and Hominid Origins: A Synthesis. Molecular Phylogenetics and Evolution. 5(1)**,** 155-168. doi: <https://doi.org/10.1006/mpev.1996.0010>.

Pilbeam, D., and Walker, A. (1968). Fossil monkeys from the Miocene of Napak, north-east Uganda. Nature. 220(5168)**,** 657-660.

Reed, K.E. (1997). Early hominid evolution and ecological change through the African Plio-Pleistocene. J. Hum. Evol. 32, 289–322.

Richmond, B.G., Fleagle, J.G., Kappelman, J., and Swisher, C.C. (1998). First hominoid from the Miocene of Ethiopia and the evolution of the catarrhine elbow. *American Journal of Physical Anthropology* 105(3)**,** 257-277.

Rose, M., Leakey, M., Leakey, R., and Walker, A. (1992). Postcranial specimens of Simiolus enjiessi and other primitive catarrhines from the early Miocene of Lake Turkana, Kenya. .J. Hum. Evol. 22(3)**,** 171-237.

Rose, M.D. (1994). Quadrupedalism in some Miocene catarrhines. *Journal of Human Evolution* 26(5)**,** 387-411. doi: <https://doi.org/10.1006/jhev.1994.1025>.

Sanders, W.J., and Bodenbender, B.E. (1994). Morphometric analysis of lumbar vertebra UMP 67-28: implications for spinal function and phylogeny of the Miocene Moroto hominoid. J. Hum. Evol. 26, 203-237.

Smith, T.M., Martin, L.B., and Leakey, M.G. (2003). Enamel thickness, microstructure and development in Afropithecus turkanensis. .J. Hum. Evol. 44(3)**,** 283-306. doi: <https://doi.org/10.1016/S0047-2484(03)00006-X>.

Ungar, P., Scott, J., Curran, S., Dunsworth, H., Harcourt-Smith, W., Lehmann, T., Manthi, F., and McNulty, K. (2012). Early Neogene environments in East Africa: Evidence from dental microwear of tragulids. Palaeogeogr. Palaeoclimatol. Palaeoecol. 342, 84–96.

Von Koenigswald, G. (1969). "Miocene cercopithecoidea and oreopithecoidea from the Miocene of East Africa," in *Fossil vertebrates of Africa,* ed. L.S.B. Leakey. (London: Academic Press), 39-52.

Werdelin, L. (2010). "Chronology of Neogene Mammal Localities," in *Cenozoic mammals of Africa,* eds. L. Werdelin & W.J. Sanders. (Univ of California Press), 27-43.

Wheeler, E.A., Wiemann, M.C., and Fleagle, J.G. (2007). Woods from the Miocene Bakate Formation, Ethiopia: Anatomical characteristics, estimates of original specific gravity and ecological inferences. Rev. Palaeobot. Palynol. 146, 193–207.

Wynn, J. G. (2013). “Miocene and Pliocene paleosols of Lothagam,” in Lothagam: The Dawn of Humanity in Eastern Africa, eds. M.G. Leakey and J.M. Harris (New York: Columbia University Press) 31–42.