Dental tissue proportions in fossil orangutans from mainland Asia and Indonesia

Tanya M. Smith,[1,2] Anne-Marie Bacon,[3] Fabrice Demeter,[4] Ottmar Kullmer,[5] Kim Thuy Nguyen,[6] John de Vos,[7] Wang Wei,[8] John P. Zermeno,[1] Lingxia Zhao[9]

[1]Department of Human Evolutionary Biology, Cambridge, MA, USA

[2]Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

[3]CNRS UPR 2147, Dynamique de l'Evolution Humaine: Individus, Populations, Espèces, Paris, France

[4]Muséum National d'Histoire Naturelle, Dépt. Homme, Nature, Sociétés, UMR 7206/USM104 Ecoanthropologie et Ethnobiologie, Paris, France

[5]Department of Paleoanthropology and Messel Research, Senckenberg Research Institute, Frankfurt am Main, Germany

[6]Institute of Archaeology, Vietnam Academy of Social Siences, Ha Noi, Vietnam

[7]Department of Geology, Netherlands Center for Biodiversity Naturalis, Leiden, The Netherlands

[8]Natural History Museum of Guangxi Zhuang Autonomous Region, Nanning, China

[9]Institute of Vertebrate Paleontology and Palaeoanthropology, Chinese Academy of Sciences, Beijing, China

Supplementary Information

Supplementary Methods

A total of 186 fossil orangutan postcanine teeth were imaged with a Skyscan 1172 micro-computed tomograph (micro-CT) at the Max Planck Institute for

Evolutionary Anthropology at 100 kV, 100 mA, with an aluminum-copper filter and isometric voxel sizes of 14 to 39 microns. Of these, 153 fossil teeth (Table 1) were deemed sufficiently preserved for 2D enamel thickness quantification (detailed below). Thirteen molars were of uncertain position in the molar row, which is a common complication with isolated hominoid remains.[1] The Sumatran material is detailed in Hooijer[2] and includes 88 molars from Lida Ajer, Sibrambang and Djamboe Caves. These caves have been suggested to be temporally equivalent to the Javan Punung deposits,[3] which have been dated to 118-128 thousand years ago (kya).[4] However, Harrison[5] and others (reviewed in [3]) believe that these fossils date from the Holocene. Further study is necessary to resolve this. Three molars are also included from the Late Pleistocene Bornean site Niah Cave.[6,7] The mainland Asian material includes 14 teeth from Duoi U'Oi Cave, Vietnam (dated to 66 kya[8]), 10 teeth from Gangian (Tubo) Cave, China (dated to 94-220 kya[9]), and 38 teeth from the Chinese apothecary collections of the Senckenberg Institute[10] and the Chinese Institute for Vertebrate Paleontology and Paleoanthropology. This unprovenienced material is believed to come from Middle Pleistocene southern Chinese deposits.[11]

Virtual 2D section planes were generated from three-dimensional (3D) models with VG Studio MAX 2.0 software (Volume Graphics, Inc.). For premolars, the buccal and lingual cusps of 3D models were aligned in an occlusal view, the dentine horn tip of the buccal cusp was set as the center of rotation, and a perpendicular plane was created. To generate a buccal-lingual 2D section along the axis of the tooth, the model was rotated to locate the plane midway between the maximum buccal-lingual bi-cervical diameter and the maximum cervical enamel

extension (Figure 1A). For molar teeth, the 3D coordinates of the two mesial dentine horn tips and two pulpal horn tips were first found and recorded. Molar 2D planes were located as the midpoint between the dentine horn and pulp tips using rotational vectors (with a dentine horn tip set as the center of rotation). This method was designed to yield a 2D plane perpendicular to the developmental axis of the crown that captures the maximum extension of cervical enamel (Figure 1B), as is standard practice for physical sectioning. When 2D sections demonstrated light to moderate wear, the outer enamel surface was manually reconstructed prior to quantification (based on the profiles of unworn teeth) (Supplementary Figure 1). Corrections were also made when small areas of cervical enamel were missing (based on the curvature and orientation of the outer enamel surface relative to the enamel-dentine junction). Sections with heavy wear, or with both cervices missing, were excluded.

Supplementary References

1. A-M. Bacon, V.T. Long. The first discovery of a complete skeleton of a fossil orang-utan in a cave of the Hoa Binh Province, Vietnam. *J. Hum. Evol.* **41**, 227-241 (2001).
2. D.A. Hooijer. Prehistoric teeth of man and of the orang-utan from central Sumatra, with notes on the fossil orang-utan from Java and Southern China. *Zool. Meded. Leiden* **29**, 175–301 (1948).
3. J. de Vos. The *Pongo* faunas from Java and Sumatra and their significance for biogeographical and paleo-ecological interpretations. *Proc. B* **86**, 417-425 (1983).

4. K.E. Westaway et al. Age and biostratigraphic significance of the Punung Rainforest Fauna, East Java, Indonesia, and implications for *Pongo* and *Homo*. *J. Hum. Evol.* **53**, 709-717 (2007).
5. T. Harrison. Archaeological and ecological implications of the primate fauna from prehistoric sites in Borneo. *Bull. Indo-Pacific Prehist. Assoc.* **20**, 133-146 (2000).
6. D.A. Hooijer. The orang-Utan in Niah Cave pre-history. *Sarawak Mus. J.* **15-16**, 408-421 (1960).
7. G. Barker et al. The 'human revolution' in lowland tropical Southeast Asia: the antiquity and behavior of anatomically modern humans at Niah Cave (Sarawak, Borneo). *J. Hum. Evol.* **52**, 243-261 (2007).
8. A-M. Bacon et al. The Late Pleistocene Duoi U'Oi cave in northern Vietnam: palaeontology, sedimentology, taphonomy and palaeoenvironments. *Quat. Sci. Rev.* **27**, 1627-1654 (2008).
9. G-J. Shen et al. U-series dating of the hominid site Ganqian Cave at Tubo, Liujiang, Guangxi in south China. *Acta Anthrop. Sinica* **20**, 238–244 (2001).
10. G.H.R. von Koenigswald. Eine fossile Säugetierfauna mit Simia aus Südchina. *Proc. Sec. Sci. K. Akad. Wetensch. Amsterdam* **38**, 872–879 (1935).
11. G.H.R. von Koenigswald. Distribution and evolution of the orang utan, *Pongo pygmaeus* (Hoppius). In: L.E.M. de Boer (Ed.), The Orang utan. Its Biology and Conservation, pp. 1-15. The Hague, Dr. W. Junk Publishers (1982).
12. T.M. Smith et al. Variation in enamel thickness within the genus *Homo*. *J. Hum. Evol.* (in press)

Supplementary Table 1. Fossil *Homo sapiens* molar material employed in Figure 5.

Site	**Individual**
Dar es Soltane II, Morocco	Dar es-Soltan II-4
Equus Cave, South Africa	EQ H5
Grotte des Contrebandiers, Morocco	H
Jebel Irhoud, Morocco	Irhoud 3
Jebel Qafzeh, Israel	Qafzeh 10
Jebel Qafzeh, Israel	Qafzeh 15
Die Kelders Cave, South Africa	SAM-AP 6242
Die Kelders Cave, South Africa	SAM-AP 6277
Grotte des Contrebandiers, Morocco	T3b
Grotte des Contrebandiers, Morocco	"Temara mandible"

Primary data are from Smith *et al.*[12]

Supplementary Figure 1. Example of minor molar wear reconstruction (dotted line).

Profiles of unworn teeth are employed to correct light to moderate wear.
The scale bar in the lower right is equal to 5 mm.