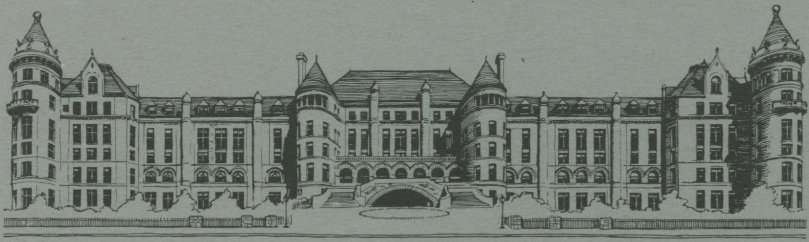

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JEFFREY H. SCHWARTZ, VU THE LONG,
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JEFFREY H. SCHWARTZ

Research Associate, Department of Anthropology
American Museum of Natural History
Professor, Department of Anthropology
University of Pittsburgh

VU THE LONG, NGUYEN LAN CUONG

Institute of Archaeology
Hanoi, Republic of Vietnam

LE TRUNG KHA

Social Sciences Council of Ho Chi Minh City
Ho Chi Minh City, Republic of Vietnam

IAN TATTERSALL

Curator, Department of Anthropology
American Museum of Natural History

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ABSTRACT

The cave of Tham Khuyen in Lang Son Province, northeastern Vietnam, has yielded a large mammalian fauna of probable late middle Pleistocene date. A series of isolated hominoid primate teeth, formerly allocated to the extant orangutan *Pongo pygmaeus,* has recently been reexamined and found to represent more than one species. These specimens are described in detail in this paper and are analyzed as follows. Some of the teeth are indeed clearly identifiable as those of *Pongo pygmaeus,* but the majority appear to belong to a species related to the orangutan but not identical with it. A few teeth are distinct from either of the above, both in size and morphology, and are interpreted here as representing a previously undescribed genus and species of a large-bodied hominoid. In addition, a few teeth are regarded as indeterminate at present. With the recognition of this multiplicity of hominoid species at Tham Khuyen, it is evident that the large-bodied hominoid fauna of middle Pleistocene Vietnam was considerably more diverse than formerly supposed, including *Gigantopithecus blacki* and *Homo* sp. in addition to the species noted above.

INTRODUCTION

Several caves formed by solution in the limestones of northern Vietnam's karst region have yielded mammalian faunas dating from the middle to the late Pleistocene (e.g., Kha and Long, 1976; Cuong, 1985, 1992). One such locality is the cave of Tham Khuyen (figs. 1, 2), situated on the border of a stream valley in northeast Vietnam, approximately 7 km SE of Binh Gia, Lang Son Province, and 65 km NW of the provincial capital Lang Son. The entrance to the cave (fig. 2) lies about 200 m west of Route 1b (fig. 1) and about 20 m above the valley floor, well above flood level. In earlier times, however, periodic flooding appears to have washed river sediments and the remains of vertebrates into the cavity (Bao and Kha, 1966; Kahlke, 1967), and redeposition ultimately resulted in the formation of heavily calcified breccias that are rich in fossil bone and teeth. A relatively high-energy depositional regime is suggested by the coarseness of the breccias and by the inclusion within them of cobbles and small boulders. It is also implied by the fact that most fossils within the breccias are highly fragmentary and typically show mechanical breakage.

Two distinct breccia layers, a lower light red unit and an overlying darker red one, were identified by the excavators, the darker one containing most of the fossil vertebrate remains. The two breccia units were initially considered to be of disparate ages (middle and late Pleistocene, respectively: Bao and Kha, 1966; Huong et al., 1975). However, lithological and pollen analyses reported by Huong et al. (1975) have demonstrated that there is no sharp discontinuity between the layers, which were deposited during the same period. This finding is consistent with the faunal analyses of Bao and Kha (1966), whose comparisons with southern Chinese faunas suggested a late middle Pleistocene age (probably about 300–250 Ka) for the entire contained mammalian assemblage. Table 1 lists the mammalian fauna recovered from Tham Khuyen (as reported by Cuong, 1985).

The breccia deposits at Tham Khuyen were initially located in 1965 by a joint Vietnamese and German (DDR) group following excavation of the Hang Hum cave in Yen Bai Province. Systematic excavations were subsequently undertaken, between August 1965 and January 1966, by a Vietnamese paleontological team under the direction of one of us (L.T.K.) and Mr. Tran Van Bao. Blocks of fossiliferous breccia were removed from the cave using hammers and chisels, following which manual preparation of the specimens was completed in the laboratories of the Institute of Archaeology in Hanoi.

HOMINOID REMAINS

All hominoid fossils so far identified from Tham Khuyen consist of isolated teeth. This

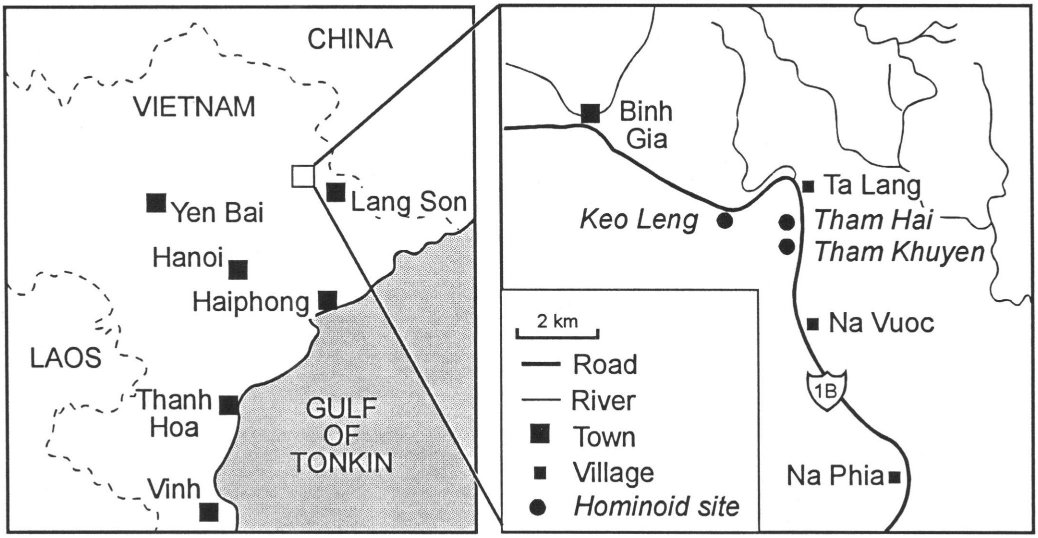

Fig. 1. Map showing northern Vietnam and the location of Tham Khuyen and other breccia caves in the vicinity of Binh Gia.

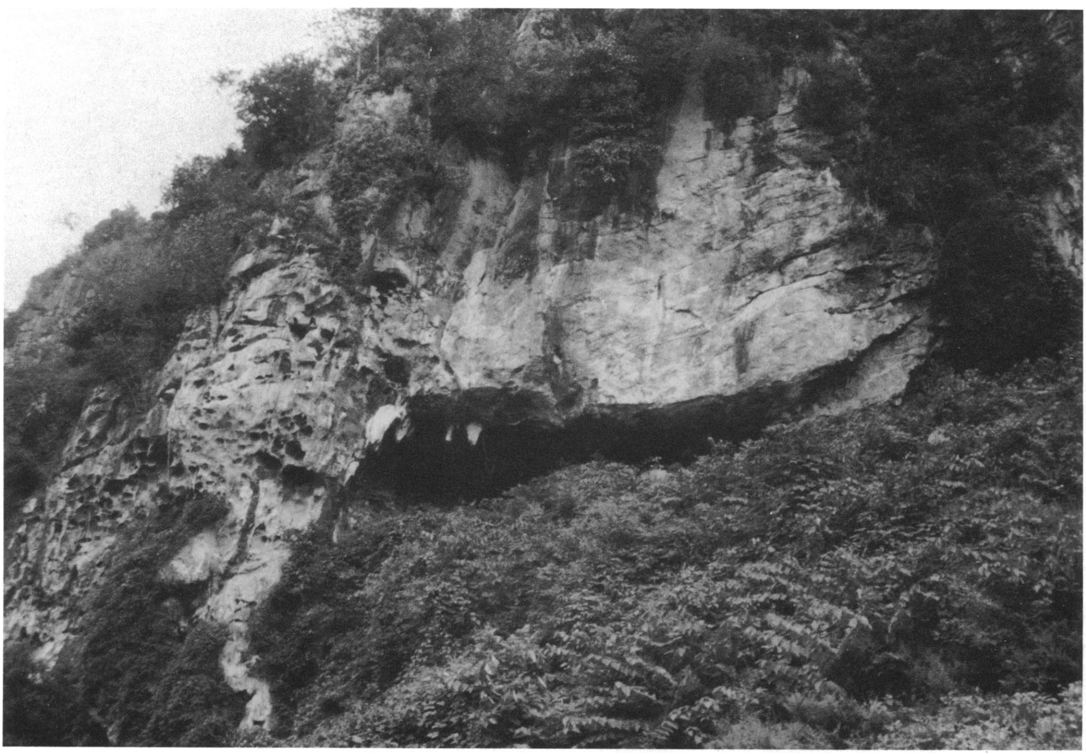

Fig. 2. View of the entrance to Tham Khuyen cave.

TABLE 1
Mammalian Fauna Recovered from Tham Khuyen Cave (as reported by Cuong, 1985)

Primates	Artiodactyla
Hominidae	Suidae
Homo erectus ssp.	*Sus scrofa*
Pongidae	*Sus* cf. *lydekkeri*
Gigantopithecus blacki	*Sus* sp.
Pongo pygmaeus ssp.	Cervidae
Hylobatidae	*Muntiacus muntjac*
Hylobates cf. *concolor*	*Rusa unicolor*
Cercopithecidae	*Cervus* sp.
Macaca cf. *assamensis*	Bovidae
Macaca sp.	*Bubalus bubalis*
Chiroptera	*Bibos gaurus* ssp.
Chiroptera gen. et sp. indet.	Carnivora
Rodentia	Procyonidae
Hystricidae	*Ailuropoda melanoleuca fovealis*
Hystrix subcristata	Ursidae
Hystrix sp.	*Ursus thibetanus kokeni*
Atherurus sp.	*Ursus malayanus*
Rhizomyidae	Canidae
Rhizomys cf. *troglodytes*	*Cuon* sp.
Muridae	Mustelidae
Rattus sp.	*Arctonyx collaris* cf. *rostratus*
Mus sp.	Viverridae
Proboscidea	*Paradoxurus* cf. *hermaphroditus*
Stegodontidae	
Stegodon orientalis	
Perissodactyla	
Tapiridae	
Tapirus (*Megatapirus*) *augustus*	
Tapirus sp.	
Rhinocerotidae	
Rhinoceros sinensis	

collection contains nine hominid specimens that have been attributed to *Homo erectus* (Cuong, 1984) and three that have been attributed to *Gigantopithecus blacki* (Cuong, 1985). The remaining 54 reasonably complete hominoid teeth were provisionally allocated to the extant species *Pongo pygmaeus* (Cuong, 1985), but closer analysis has revealed that at least two large-bodied hominoid species can be distinguished in this sample in addition to the extant orangutan. In the next section we briefly describe the material initially attributed to *P. pygmaeus* by tooth type, and within each tooth category by the morphs into which these teeth appear to fall. Note that there are occasional duplications of specimen numbers.

We recognize three major dental morphs. One of these (morph 1) does indeed represent the extant orangutan *Pongo pygmaeus*, although such specimens are not particularly abundant in the sample. The second and most heavily represented morph (morph 2) constitutes a dentally primitive species of *Pongo*, and includes two variants (2a and 2b). These variants are distinguished principally by size, and with a high degree of probability represent males and females of the same species. The rare third major morph (morph 3) appears to represent a hominoid belonging to a previously undescribed genus. The affinities of a few further teeth cannot be determined with any certainty, but these specimens may represent atypical individuals of one or another of the species of *Pongo* in the sample. When we refer to orangutans in the discussion below, we are alluding expressly to the species *Pongo pygmaeus*.

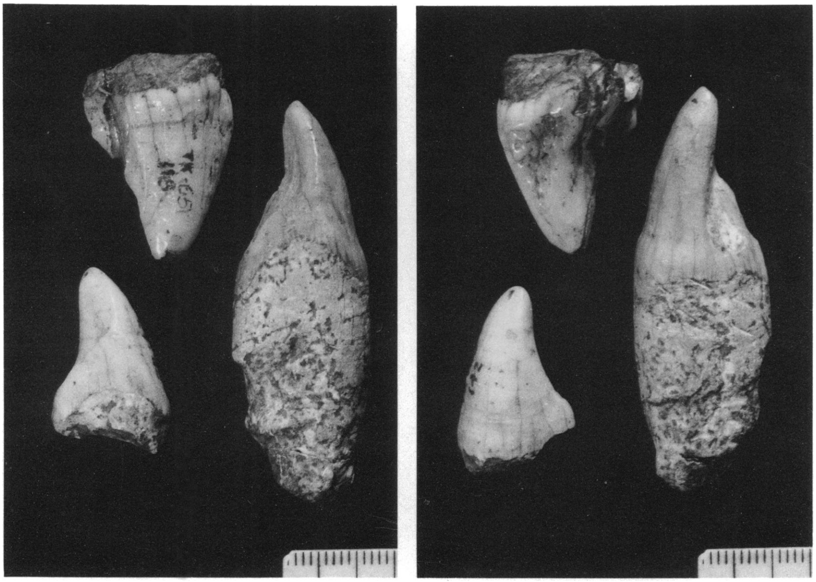

Fig. 3. Hominoid canine teeth from Tham Khuyen. From left to right: TK 65/142, left lower canine, lingual view (2b); 118, right upper canine, buccal view (indet.); 157, left lower canine, lingual view (2a); 142, buccal view; 118, lingual view; 157, buccal view. Morph assignments are in parentheses. Scale is in millimeters.

MORPHOLOGY[1,2]

Deciduous Teeth

Only one definitely deciduous tooth was found in the Tham Khuyen hominoid sample: TK 65/100, a left dm_1. It generally resembles the homologous tooth in an orangutan, but differs in showing less crown wrinkling and a smaller trigonid basin. Its affinities presumably lie with the adults that comprise morph 2.

Incisors

The sample contains three incisors: TK 65/137, an unerupted lower crown, shorter than is typical for orangutans; and TK 65/42 and 139, both lower right teeth, both heavily worn and undiagnostic.

Canines

Morph 2a. Three teeth: TK 65/157 (a lower left: fig. 3); TK 65/138 (upper left); and TK 65/142A (lower left). All of these specimens resemble male orangutan canines, but are highly worn distally as well as on the tips. Two fragmentary canine tips (TK 65/145, probably upper right, and TK 65/140, probably upper left) may also belong in this subgroup.

Morph 2b. Three teeth: TK 65/46 (upper right); TK 65/142 (fig. 3) and 143 (both lower left). All of these resemble large female orangutan canines.

Indeterminate Morph. One canine (TK 65/118, upper right; fig. 3) stands out from all the others. It generally resembles a massive male orangutan canine, but does not bulge laterally in profile as such teeth typically do.

Upper Premolars

Morph 1. Two P^4s: TK 65/45 and 107, both from the right side. TK 65/107, in particular, is proportioned exactly like that of the living orangutan although its occlusal sur-

[1] Upper teeth are indicated by superscripts and lower teeth by subscripts. Deciduous teeth are distinguished from permanent teeth by a d preceding the designated tooth.

[2] Measurements of teeth are presented in table 2, at the end of this section.

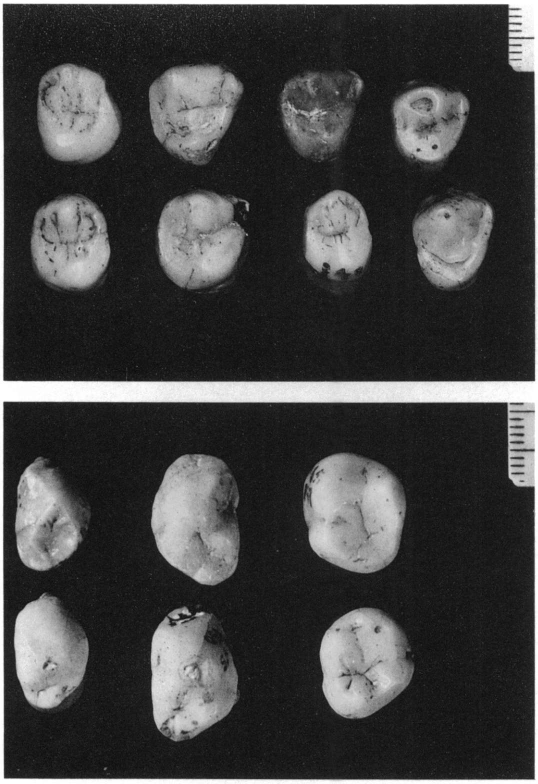

Fig. 4. Hominoid premolars from Tham Khuyen. Above: Upper premolars. Top row, from left to right: TK 65/135, LP4 (2a); 11, RP3 (2a); 3, RP3; 39, RP3 (2a). Bottom row, from left to right: 162, RP4 (2a); 156, RP3 (2a); 148, RP4 (2b); 37, RP3 (2b). Below: Lower premolars. Top row, from left to right: 47, RP3 (2b); 155, LP3 (2a); 197, LP4 (2a). Bottom row, from left to right: 12, RP3 (2b); 150, RP3 (2a); 9, RP4 (2a). Morph assignments are in parentheses. Scales are in millimeters.

face is not noticeably wrinkled; TK 65/45 is missing most of its enamel but shows signs of wrinkling.

Morph 2a. Three P^3s: TK 65/3, 11, and 156 (fig. 4), all from the right side. TK 156 is more swollen than the others in the mesial portion of the protocone, and less swollen in the parastylar region. TK 65/3 and TK 65/11 resemble each other in being somewhat triangular, with a more distended parastylar region; they are similar in shape to premolars of male orangs, but differ in lacking crenulation, plus they have a thick preprotocrista running across the tooth to the parastylar region. A similar structure can also be discerned in TK 65/156, but it is less distinct because of the local swelling.

Two P^4s: TK 65/135 (left side; fig. 4); 162 (right side; fig. 4). These differ from the homologous elements in orangutans in having a less straight distal margin, in possessing a basin between the paracone and protocone, and in being less crenulated.

Morph 2b. Three P^3s: TK 65/37, 39 (fig. 4) and 58, all of the right side. These teeth differ from orangutan P^3s in being uncrenulated, with the paracone and small protocone more distinct. As in female orangutans, the parastylar regions are relatively less distended.

One P^4: TK 148 (right side; fig. 4). This differs from those of orangs in being less wrinkled and more distended distally.

Lower Premolars

Morph 2a. Seven P_3s: TK 65/1, 4, 150 (fig. 4), 1152 (right side); TK 65/6, 155, 161 (left side). These teeth are reminiscent of those of male orangutans in overall shape and in the development of the talonid basin, but are totally devoid of crenulations.

Three P_4s: TK 65/5 and 9 (fig. 4) (right side), TK 65/197 (left side, fig. 4). These also resemble premolars of orangutans but lack crenulations.

Morph 2b. Five P_3s: TK 65/12 (fig. 4), 37 and 47 (fig. 4) (right side); TK 65/2 and 36 (left side). These teeth resemble those of female orangutans, with almost no trigonid basin, but differ in lacking any wrinkling even in the talonid basin.

Upper Molars

Morph 1. Two upper molars unquestionably are those of orangutans: TK 65/10 (RM2, fig. 5), and TK 65/40 (LM^2, Fig. 5). Two more upper molars may also belong to this species: TK 65/56 (RM^1) and TK 65/34 (LM^3). These two teeth, though variably worn, show a typically orangutan pattern of crenulations, as opposed to the other upper molars shown in figure 5 which, though less worn, are virtually smooth-enameled. In addition, there are three possible M^4s (supernumerary last molars are relatively common among orangutans): TK 65/152 and 164 (right side) and TK 65/158

Fig. 5. Hominoid upper molars from Tham Khuyen. Left: TK 65/34a, RM1 or 2 (2a); top center: 10, RM2 (1); bottom center: 112, LM1 or 2 (2b); top right: 40, LM2 (1); bottom right: 115, LM1 or 2 (indet.). Morph assignments are in parentheses. Scale is in millimeters.

(left side). If these teeth are not M^4s, they are M^3s.

MORPH 2a. Three teeth: TK 65/13, 34a (fig. 5) and 79, all RM^1s or RM^2s. All are distinguished from those of orangutans by greatly reduced wrinkling, by more distinct cusps, by a hypocone region that is more swollen posteriorly, and by a greater lingual slope to the crown.

MORPH 2b. Nine teeth: TK 65/51, 137 (RM^1s or M^2s); and TK 65/45, 57, 112 (fig. 5), 119, 136, 150 and 159 (LM^1s or M^2s). All differ from the equivalent teeth in orangutans by having more distinct cusps (especially the paracone and metacone), and much less enamel wrinkling. The occlusal surface is more compressed, with a lingual slope. In contrast with morph 2a, where the upper molar hypocone and protocone bulge outward to the same extent, in this morph the hypocone bulges much less than does the protocone. TK 65/51 has a Carabelli's pit. This subgroup may also contain TK 65/33, an anomalous unerupted molar.

INDETERMINATE MORPH. Two upper molars in the Tham Khuyen hominoid sample are of uncertain affinities. One of these is TK 65/115 (fig. 5), a very large LM^1 or M^2 that lacks crenulation. It has a distally swollen hypocone, and a robust crest between the protocone and hypocone that squeezes the postprotocrista toward the center of the tooth. The protocone is obliterated, exposing the dentine. The paracone and metacone are higher and closer together than is typical of *Pongo,* and are more distinct; the lingual face of the tooth is vertical. With this tooth may belong TK 65/135, which has an enormous posterior distension of the hypocone, lacks a hypocone crest, and is slightly more wrinkled than that of TK 65/115.

LOWER MOLARS

MORPH. 1. Six teeth: TK 65/128 (RM_3); TK 65/131 (LM_1 or LM_2); TK 65/128 and 41 (LM_2s); 65/149 (LM_3; fig. 6); and TK 65/151 (Rdm_2). All of these teeth are typical of *Pongo pygmaeus* except for TK 65/134, which is borderline in that crenulation is only moderate, cusp height and delineation are more accentuated, and the crown is very high. This tooth possibly belongs with subgroup 2a.

MORPH 2a. Three teeth: TK 65/123 (RM_1 or M_2; fig. 6); TK 65/130 (LM_1 or M_2; fig. 6); and TK 65/125 (LM_3). These teeth differ from their orangutan homologs in having markedly less enamel crenulation and trigonid cusps which are relatively larger than the talonid ones.

MORPH 3. Three teeth: TK 65/44 (RM_1; fig. 6); 52 (Rdm_2 or possibly RM_1; fig. 6); and TK 65/121 (LM_1 or M_2). These teeth are completely nonorangutanlike. They are small, and show no crenulation at all; the trigonid cusps are aligned in an almost loph-like fashion; the metaconid and entoconid are subequal in height (in orangutans the meta-

Fig. 6. Hominoid lower molars from Tham Khuyen. Top row: TK 65/128, LM2 (1); 52, Rdm2 or M1 (3); 123, RM1 or 2 (2a); 134, LM2 (1). Bottom row: 149, LM2 (1); 44, RM1 (3); 130, LM1 or 2 (2a); 121, Ldm1 or M1 (3). Morph assignments are in parentheses. Scales (applying to all specimens to their left) are in millimeters.

conid is bulkier and higher); the enamel is thick; the crown shows a pronounced buccal flare, especially on TK 65/44; and the hypoconid is small relative to the entoconid. TK 65/52 is very similar to 44, though with a slight color difference. These two teeth are both from the right side, and their interproximal facets appear to match well. Plausibly, they are from the same side of the same jaw, and if so are most likely the last deciduous molar and first permanent molar of the same individual.

DISCUSSION AND CONCLUSIONS

Fossil and subfossil orangutan teeth that are essentially indistinguishable in morphology from living forms have been reported from a variety of sites in southern China, Vietnam, Borneo, Sumatra, and Java, notably by Hooijer (1948). Hooijer noted that the extant *Pongo pygmaeus* falls at the lower end of the known dental size range, and regarded the surviving Bornean and Sumatran populations as representing the distinct extant subspecies *P. p. pygmaeus.* He named a new subspecies, *P. p. palaeosumatrensis,* for slightly larger subfossil teeth from early Holocene localities in Central Sumatra, and referred yet larger fossil orangutan teeth from Pleistocene localities in Java, Vietnam, and southern China to the subspecies *P. p. weidenreichi.* In a later work, Hooijer (1960) referred late Pleistocene orangutan teeth from Borneo's Niah Cave simply to *P. pygmaeus* subsp. Orangutan teeth from Tham Khuyen identified in this study fall in the size range quoted by Hooijer for *P. p. weidenreichi.*

Despite their slightly larger size, none of the isolated *P. pygmaeus* (morph 1) teeth from Tham Khuyen differs significantly in morphology from those of the living orangutan. Commonly the molar cusps are low and peripherally displaced, providing a sharp edge to the occlusal surface. Enamel wrinkling is notable on the occlusal faces of all referred upper and lower cheek teeth, and the disposition of the cusps is characteristic for the species. Wear patterns and the persistence of wrinkling in heavily worn teeth are also comparable to what is seen in living orangutans.

The second morph identified here (2a plus 2b) appears to represent a dentally more primitive species of the genus *Pongo.* The two size variants within it are most plausibly explained by sexual dimorphism, the larger individuals representing males and the smaller ones females. Unfortunately, the small sample sizes currently available preclude quantitative investigation of this hypothesis. Morphoscopically, however, inferred males and females differ in canine and anterior premolar morphology and proportions in the same way as do the sexes in modern orangutans, while retaining similar molar and pos-

TABLE 2
Mesiodistal Lengths, Buccolingual Breadths, and Morph Allocations of Measurable Tham Khuyen Hominoid Molars and Premolars
(by specimen number within tooth categories, in millimeters)

Specimen	M/D L	B/L B	Morph
Upper Premolars (P3)			
TK 65/3	12.85	14.06	2a
TK 65/11	12.86	14.58	2a
TK 65/37	11.73	14.17	2b
TK 65/39	11.17	13.40	2b
TK 65/156A	12.98	15.00	2a
Upper Premolars (P4)			
TK 65/45	9.78	11.69	1
TK 65/101	10.15	13.05	1
TK 65/148	9.12	12.76	2b
TK 65/156B	11.51	14.72	2a
TK 65/162	12.00	14.77	2a
Lower Premolars (P3)			
TK 65/1		12.06	2a
TK 65/4	18.39	11.68	2a
TK 65/6	17.35	11.81	2a
TK 65/12	14.47	9.56	2b
TK 65/36	15.22	9.42	2b
TK 65/47	15.06	9.77	2b
TK 65/150	19.76	11.44	2a
TK 65/155	17.89	11.35	2a
TK 65/161		11.54	2a
TK 65/1152	18.04	11.21	2a
Lower Premolars (P4)			
TK 65/5	12.94	12.62	2a
TK 65/9	13.24	12.41	2a
TK 65/197	15.52	12.67	2a
Upper Molars			
TK 65/10	13.65	15.06	1
TK 65/34A	14.86	15.60	2a
TK 65/34B	12.54	15.56	1
TK 65/40	15.45	16.15	1
TK 65/50	13.16	14.36	2b
TK 65/51	12.88	14.44	2b
TK 65/56	13.92	15.24	1
TK 65/57	12.94	14.26	2b
TK 65/79	14.78	15.72	2a
TK 65/112	13.80	14.80	2b
TK 65/115	16.82	17.05	*
TK 65/119	13.48	14.24	2b
TK 65/135	15.71	16.07	*
TK 65/136	14.08	15.11	2b
TK 65/137	14.24	15.02	2b
TK 65/150	12.66	14.49	2b
TK 65/152	11.60	13.48	1
TK 65/158	11.58	13.67	1
TK 65/159	13.40	14.68	2b
TK 65/164	11.27	12.49	1
Lower Molars			
TK 65/41	16.38	14.56	1
TK 65/44	13.92*	11.65*	3
TK 65/52**	13.82	12.90	3
TK 65/121	14.76	12.80	3
TK 65/125	16.92	15.00	2a
TK 65/128	15.71	14.62	1
TK 65/130	16.04	14.85	2a
TK 65/134	16.81	14.41	1
TK 65/149	16.90	13.86	1
TK 65/151**	13.44	12.11	1

* Not allocated to morph.
** Deciduous.

terior premolar cusp configurations (cf. Kelley and Etler, 1989). Both sexes differ significantly from *Pongo pygmaeus* in the lack of wrinkling of the molar surfaces even in unworn teeth; such wrinkling is also absent in the basins between the cusps of the premolars. The molars differ markedly from those of *P. pygmaeus* in that the cusps are noticeably rounded, are less ridgelike laterally, and are positioned further from the periphery of the occlusal surface. Pending a fuller review of approximately contemporaneous hominoid fossils from other sites in Vietnam, we shall for the moment simply refer to this new hominoid species as *Pongo* sp.

Three lower molars (TK 44, 52, and 121) are clearly hominoid, but are not in the least orangutanlike. They have no cercopithecoid traits, and have too much cuspal relief to be hominin: the cusps are puffy and well delineated as is typical of primitive large-bodied hominoids. These molars are small compared to those of living orangutans and the other *Pongo* species in the Tham Khuyen sample, and totally lack any crenulation. The trigonid cusps are transversely aligned, and the metaconids and entoconids are almost of equal height, in striking contrast with those of orangutans, where the metaconid is taller and broader. The enamel is thick; there is a pronounced buccal flare, especially on specimen TK 65/44; the hypoconid is rather small relative to the entoconid; and the distobuccal corner of the tooth is reduced. For their size, these teeth also appear to be rather high-crowned. We are not aware of any other hominoid possessing this combination of lower dental traits, and must conclude that these teeth provide evidence of a large-bodied hominoid that has hitherto been undescribed.

Certain other hominoid teeth from Tham Khuyen appear to lie outside the limits of any of the morphs characterized above. Specimen TK 65/115, LM^1 or M^2, is very large and is distinguished from orangutan teeth by lacking crenulation. The hypocone is distally swollen; a crest equal in robusticity to the postprotocrista runs between the metacone and the hypocone, and the lingual face of the tooth is vertical. TK 65/135, a left upper M^1 or M^2, is slightly more wrinkled than 115, has an enormous posterior distension of the hypocone, and lacks a hypocone crest. Neither of these teeth closely matches anything else in the Tham Khuyen sample, and we regard their affinities as indeterminate. The same applies to the upper right canine TK 65/118, which, although massive like a male orangutan canine, does not show the typical lateral bulge. On the basis of size, this canine might be associated with the two molars just discussed.

Our reanalysis of the Tham Khuyen hominoid teeth thus makes it evident that the diversity of large-bodied hominoids in the area of northern Vietnam (and by implication more widely in mainland southeastern Asia) was considerably greater during the middle to late Pleistocene than has previously been realized. In addition to *Homo* sp. (cf. Cuong, 1984), *Gigantopithecus blacki* (Cuong, 1985), and *Pongo pygmaeus* (Cuong, 1985 and this study), there also existed at least one further species of *Pongo,* and a species of another large-bodied hominoid genus that has yet to be named. The coexistence of at least five species of large-bodied hominoids is unexpected at this late date in the Neogene, a period during which the diversity of hominoids has generally been reckoned to have undergone a consistent decline. Planned future researches in Vietnam will, it is hoped, help shed light on the nature and extent of this diversity.

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