Hominoid fossils discovered from Chiang Muan, northern Thailand: the first step towards understanding hominoid evolution in Neogene Southeast Asia

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Abstract The Thai-Japanese Paleontological Expedition Team (TJPET) has been conducting paleontological and geological fieldwork in Thailand for a number of years. In January 2000, an upper molar (CMu6-1'00) of a large-bodied Miocene hominoid was found by TJPET in a lignite mine in the Chiang Muan basin, northern Thailand. It was the first record of a Miocene hominoid from a Southeast Asian country. Two years later, TJPET found a second hominoid specimen (CMu15-5'01) in the same lignite mine. The second specimen was collected from the Upper Lignite Member, while the first one had come from the Lower Lignite Member. The age of Chiang Muan is estimated to be at around the boundary of the Middle/Late Miocene (ca. 10–12 Ma) based on mammalian fauna and paleomagnetic study. There may be several hundred thousand years temporal difference between the Upper and Lower Lignite Members. Chaimanee et al. (2003) reported more hominoid specimens from the same site, and created a new species, cf. Lufengpithecus chiangmuanensis. The taxonomic status of the Chiang Muan hominoids, however, is still a matter of debate. Nevertheless, the discovery of Miocene hominoids from Chiang Muan has revealed the potential of Thailand for understanding hominoid evolution in Southeast Asia.

Key words: Miocene hominoids, Thailand, Chiang Muan, Lufengpithecus, Southeast Asia

Introduction

Around the end of the Early Miocene, hominoid primates started to expand their distribution from Afro-Arabia into Eurasia (Heizmann and Begun, 2001). In western Eurasia (Europe to Anatolia), various fossil hominoids have been reported mainly from the Middle and Late Miocene (Andrews et al., 1996; Begun, 2002). In eastern Eurasia, the majority of Miocene hominoid fossils have been discovered from two regions: Siwaliks in India and Pakistan, and Yunnan Province in the southwestern part of the People’s Republic of China (Kelley, 2002). For more than a century, the Siwaliks have yielded Miocene hominoid fossils, most of which are now assigned to Sivapithecus, while a few specimens belong to Gigantopithecus (Kennedy, 2000). In Yunnan, since the 1950s when Wu Rukang (old spelling: Woo Ju-kang) described a new species, “Dryopithecus keiyuanensis”, from a lignite mine at Xiaolongtan, Kaiyuan district (Woo, 1957, 1958), numerous Miocene hominoid remains, which are assigned to Lufengpithecus, have been reported from Lufeng and Yuanmou (for a recent review, see Harrison et al., 2002). In other parts of eastern Eurasia, no Neogene hominoids have been known except for a single upper molar from Tinau Khola in Nepal (Munthe et al., 1983) and a relatively small and damaged mandible from Wudu in Gansu province, China (Xue and Delson, 1989). Although it is in Southeast Asia that extant hominoid primates such as orang-utans and gibbons survive today, our knowledge of hominoid evolution in this region is still very poor (Kunimatsu, 2002a). In order to fill this gap of knowledge, the Thai-Japanese Paleontological Expedition Team (TJPET) has been conducting paleontological and geological field research at late Cenozoic fossil sites in Thailand (Saegusa et al., 1999; Kunimatsu et al., 2000b; Nagaoka and Suganuma, 2002; Nakaya et al., 2002a; Suganuma et al., 2002; Yabe, 2002).

Historical sketch

Fossils from Thailand and adjoining areas have been reported since the early 20th century (for review of early works, see Kobayashi, 1964). Andersson (1916) studied Tertiary fish remains from northern Thailand. Even during the Second World War, paleontological work was done on Permian fusulinids (Minato, 1944; Toriyama, 1944).
After the Second World War, von Koenigswald (1959) examined proboscidean teeth from the Mae Moh lignite mine (Middle Miocene: Benammi et al., 2002) near Lam-pang (Figure 1), and assigned them to a new species, *Stegolophodon praelatidens*. Later, Ginsburg et al. (1983) studied other mammalian remains, as well as proboscidean fossils from this site. Tassy et al. (1992) treated the Mae Moh proboscidean remains as *Stegolophodon cf. latidens*.

In the Li Basin, Endo (1963, 1964) reported plant fossils from the eastern part of the basin (17°50′N, 99°05′E), estimated to be of Paleogene age, referring to the Late Eocene flora of Fushin in south Manchuria. Based on pollens and spores, Ratanasthien (1984) suggested a wide temporal range from the Senonian or Paleogene to the Oligocene/Early Miocene. The age of initiation of Tertiary-aged basin development in northern Thailand is now considered to be in the Late Oligocene (Ratanasthien, 2002). Recently, Yabe (2002) analyzed plant megafossils collected from Ban Pa Kha by TJPET, and reconstructed the paleoclimate of this area. Ban Pu and Ban Na Klang, several kilometers north of Ban Pa Kha, also yielded plant megafossils (Kunimatsu et al., 2000b).

In 1982, Ukkakimapan found the first mammalian fossils from Mae Long in the southern part of the Li basin, which included an antler of *Stephanocemas* (a Miocene cervid genus) (Ginsburg and Ukkakimapan, 1983; Ginsburg et al., 1991). Jaeger et al. (1985) reported two rodent taxa, *cf. Diatomys* sp. and *Antemus thailandicus*, and suggested a middle Middle Miocene age for this site. On the other hand, Mein and Ginsburg (1985) reported six rodent taxa from the same locality, and proposed a late Early Miocene age (MN3b). Mein et al. (1990) further described rodent fossils from Mae

![Figure 1: Geographic locations of Neogene fossil sites in Thailand.](image-url)
Long, including two new species, and slightly emended the age to be equivalent to MN4. Later, Mein and Ginsburg (1997) gave a comprehensive report on small and large mammalian fossils of this site, and placed its age to the beginning of MN4 (late Early Miocene: ca. 18 Ma) with a suggestion that the paleoenvironment of Mae Long was a tropical rain forest near a shallow lake.

In the mid-1980s, one of us (B.R.) collected fossils, including a proximal part of a humerus belonging to an indeterminate large-bodied mammal (rhinocerotid size) and a complete fish, from a small lignite mine at Ban Na Sai (Ginsburg et al., 1991). Subsequently, proboscidean remains were discovered (Ginsburg et al., 1991) and described as a new species, *Stegolophodon nasaiensis*, that is more primitive than the *Stegolophodon* species from Mae Moh (Tassy et al., 1992). Rhinocerotid remains from Ban Na Sai have been assigned to *Gaindatherium* (Ginsburg and Tassy, 1985; Ducrocq et al., 1994), but a newly found rhinocerotid partial skeleton by TJPET suggests that the generic assignment of the Ban Na Sai rhinocerotid remains should be revised (Saegusa et al., 1999).

In the Pong Basin, Sickenberg (1971) reported *Deinotherium cf. pentapotamiae* from Ban Sop Kham. There are two other fossil sites in this basin. One is Huai Siew, 5.5 km north-northeast of the township of Pong (Ginsburg, 1989), and the other is Ban San Klang located in the eastern part of the Pong Basin (Suteethorn et al., 1990). Both of them are considered to be early Middle Miocene with the former seeming to be slightly older than the latter (Ducrocq et al., 1995) (Figure 2). The mammalian material from Huai Siew includes a number of tragulids as well as proboscideans, perissodactyls like *Chalicotherium* (Chalicotheriidae) and cf. *Gaindatherium* (Rhinocerotidae), and an artiodactyl genus *Brachyodus* (Anthracotheriidae) (Ginsburg, 1989). Based on silicified woods from this site, Vozenin-Serra (Vozenin-Serra and Privé-Gill, 1989; Vozenin-Serra et al.,

![Figure 2. Ages of Neogene fossil sites in Thailand (after Nakaya et al., 2002a).](image-url)
1989) suggested that mangrove vegetation had preceded the tropical rain forest there. Interestingly, an isolated lower molar of a small Miocene catarrhine was discovered from Ban San Klang (Suteethorn et al., 1990); we will discuss this tooth in more detail below.

Some other Neogene fossil sites that were previously known include Had Pu Dai in the Lampang Basin, the Mae Teep lignite mine located ca. 80 km northeast of Lampang, and Nong-Hen I (A) near Pitsanulok. Had Pu Dai (or Nah Nai Yod) yielded suids (*Conohyus*), tragulids (*Siamotragulus*), indeterminate rhinocerotids and proboscideans, and micromammals (Pope and Bernor, 1990; Ducrocq et al., 1995). The age of this site is estimated to be the early Middle Miocene (Ducrocq et al., 1995). From Mae Teep, Buffetaut et al. (1988) reported *Stegolophodon* sp. Nong-Hen I (A) is different from the other fossil sites in that fossils of this site were discovered from drilling cores for exploration wells (Legendre et al., 1988). The Nong-Hen I (A) material consists mainly of bat remains, the majority of which belong to a new species, *Mormopterus* (*Hydromops*) *nonghenensis* (Legendre et al., 1988).

**Thai-Japanese Paleontological Expedition**

Since 1996, our joint project consisting of Thai and Japanese researchers and graduate students of paleontology, anthropology, and geology has been conducting paleontological and geological fieldwork in Thailand. This Thai-Japanese Paleontological Expedition Team (TJPET) has investigated both new and previously known fossil sites such as Mae Soi, Sop Mae Tham, Chiang Muan, Mae Oo, the Li Basin (Ban Na Sai, Mae Long, Ban Pu, Ban Pa Kha, Ban Na Klang), Huai Siew in the Pong Basin, the Mae Moh lignite mine near Lampang, Mae Lai, Mae Lamao, Tha Chang near Nakhon Ratchasima, and Krabi in the Malay peninsula (Saegusa et al., 1999; Kunimatsu et al., 2000b, unpublished data; Nakaya et al., 2002a, b, c, 2003; Yabe, 2002).

In Mae Soi, there are two subareas called Doi Chang and Kew Hoi Tal. The Doi Chang subarea was named after a hill called Doi Chang, which means ‘elephant hill’ in Thai. Coincidentally, from a locality of the Doi Chang subarea (TJPET locality DCh1 [GPS data: 18°17'10.5"N, 98°36'28.7"E], Kunimatsu et al., 2000b), we excavated a skeleton of an amebelodontid proboscidean assigned to *Archaeobelodon* (Saegusa et al., 1999; Nakaya et al., 2002a). In addition, we collected a number of vertebrate, invertebrate, and plant fossils from twelve localities in the Doi Chang subarea (DCh1 to DCh12) and six localities (KHT1 to KHT6) in the Kew Hoi Tal subarea (Kunimatsu et al., 2000b, unpublished data). Based on the mammalian fauna, the age of Mae Soi is most likely the late Early Miocene (MN4) (Nakaya et al., 2002a).

Sop Mae Tham is a village located 45 km southwest of Lampang. The fossil-yielding area is approximately 2.5 km north of the village. The land is covered with vegetation and agricultural fields, but there are patches of outcrops around two small hills that we called the Eastern and Western Hills. We have extensively collected fossils from more than thirty localities (Kunimatsu et al., 2000b, unpublished data). Among these fossils, we identified hipparion teeth, which are the first record of the Hippariomini from Southeast Asia (Nakaya et al., 2001, 2002a).

We have conducted paleobotanical work, especially in Mae Lai, Ban Pa Kha, Ban Pu, Ban Na Klang, Mae Lamao, and Chiang Muan. Yabe (2002) examined fossil leaves that TJPET collected at Ban Pa Kha (Late Oligocene) and Mae Lai (late Early to middle Middle Miocene), and reconstructed the paleoenvironment of these two areas by using CLAMP (Climate Leaf Analysis Multivariate Program). His results indicate a trend of increase in mean annual temperature (MAT) with an apparent rise of the cold month mean temperature from the Late Oligocene to the early part of the Miocene in northern Thailand. In addition, Yabe (2002) suggested the possibility of paratropical rain forests existing in this region during the Early to Middle Miocene with a warm
In Chiang Muan, we discovered two molars of a large-bodied Miocene hominoid from the lignite mine (Figure 3) operated by the Chiang Muan Mine Company (CMMC). The first specimen (TJPET No. CMu6-1’00) was discovered during the field season of January 2000 (Kunimatsu et al., 2000a; Suvunsavate et al., 2001). In the same year, the discovery was announced at the 16th annual meeting of the Primatological Society of Japan. This was the first report of a Miocene hominoid from a Southeast Asian country (Kunimatsu, 2002a). Another hominoid specimen (CMu15-5’01) was discovered from the same lignite mine nearly two years later (Kunimatsu et al., 2002, 2003). We also collected more than 200 specimens of vertebrate, invertebrate, and plant remains. In addition, thanks to the efforts of the CMMC staff, a number of fossils have been rescued during lignite excavation, and these fossils are stored in a small exhibition room at the Chiang Muan mine (Suvunsavate et al., 2001). We have examined these fossils under the care of the CMMC, and have given them accession numbers with the prefix CM (after Chiang Muan). The vertebrate fossils from Chiang Muan include three partial skeletons of *Tetralophodon cf. xiaolongtanensis*, suids such as *Hippopotamodon cf. hyotherioides*, *Conohyus sindiensis*, and *Parachleuochoerus sinensis*, a tayassuid species *Pecarichoerus sminthos*, tragulids (*Dorcatherium sp.* and *Tragulidae indet.*), *Chilotherium (Subchilotherium) intermedium* a rhinocerotid, and bovid, as well as fish, birds, and aquatic reptiles like crocodiles and turtles (Kunimatsu et al., 2000b, unpublished data; Nakaya et al., 2001, 2002a, b, c, 2003; Pickford et al., 2004; personal communications from A. Fukuchi). The mammalian fauna and paleomagnetic study by Suganuma et al. (2002) suggests that the age of Chiang Muan is the latest Middle to earliest Late Miocene (ca. 10–12 Ma).

### Large-Bodied Miocene Hominoids from Chiang Muan

An isolated upper molar (CMu6-1’00) of a large-bodied Miocene hominoid (Figure 4) was discovered at a lignite mine in Chiang Muan, northern Thailand, through the fieldwork by TJPET on 22 January 2000 (the discoverer was Nikorn Wongchai of the CMMC) (Kunimatsu et al., 2000a; Suvunsavate et al., 2001). The place of discovery (TJPET locality CMu6) was a slope near the southern end of the mining pit. The surface of the slope was covered with remnants of lignite, and is almost parallel to the general dip of the strata. Although the hominoid upper molar was found on the surface, it most likely derived from the Lower Lignite Member (Nagaoka and Suganuma, 2002). The discovery of this hominoid fossil was immediately reported to the office of the CMMC, according to established procedures for field research at the mine (Suvunsavate et al., 2001). This specimen is a right M1 or M2 crown of a large-bodied hominoid. The size of the crown (MD 11.8 mm / BL 14.0 mm) is similar to that of extant orangutans (*Pongo pygmaeus*). The paracone is broken off. The occlusal surface is heavily worn (Kunimatsu et al., 2005).

Nearly two years later, a second specimen (CMu15-5’01) of a large-bodied hominoid was discovered on 20 December
2001 at the Chiang Muan lignite mine by Bantita Udomkan, a graduate student of Chiang Mai University, during TJPET fieldwork. The place of discovery (TJPET locality CMu15) is situated in the Upper Lignite Member, approximately 60 m higher than the Lower Lignite Member (Nagaoka and Suganuma, 2002). This specimen is a fragment of a right lower molar preserving the protoconid and metaconid (Figure 4). The cusps are unworn. The two cusps are relatively low, rounded, and voluminous, and connected with each other by double mesial transverse crests. The mesial fovea is restricted. The preserved part of the talonid basin is coarsely crenulated.

Apart from the hominoid fossils discovered through TJPET field research, Chaimane et al. (2003) reported additional hominoid specimens from the same lignite mine in Chiang Muan. They assigned these hominoid specimens to a new species, cf. Lufengpithecus chiangmuanensis.

With the aid of peripheral Quantitative Computer Tomography (pQCT) and a 3D reconstruction computer program (INTAGE), relative enamel thickness (Martin, 1985) is estimated to be 22.6 for CMu15-5’01, which means that this specimen has thick molar enamel (Kunimatsu et al., 2005). This value is similar to the average (22.4) of extant Homo sapiens, and slightly exceeds the range of intraspecific variation (11.3–20.5) in extant orang-utans (Martin, 1985). Chaimane et al. (2003) provided slightly smaller values for two other hominoid molars from Chiang Muan (17.23 and 17.80), but these values are also included within the range of intraspecific variation of extant H. sapiens (13.8–32.3) (Martin, 1985). The difference of relative enamel thickness between CMu15-5’01 and the two specimens in Chaimane et al. (2003) is not so great, and can be interpreted as intraspecific variation. Proconsul nyanzae (22.3–27.6), Afropithecus turkanensis (19.9–22.9), Lufengpithecus lufengensis (24.1–24.6), and Graecopithecus freybergi (28.3) show similar or slightly larger values compared to CMu15-5’01 (Beynon et al., 1998; Schwartz et al., 2003; Smith et al., 2003).

CMu15-5’01 and all hominoid specimens described by Chaimane et al. (2003) derive from the Upper Lignite Member (Nagaoka and Suganuma, 2002). They are similar in size and share general morphological traits such as low and voluminous cusps, reduced buccal cingulum, and double mesial transverse crests (at least in CMu15-5’01 and TF6179, a left dp4). Therefore, they should be assigned to the same species. On the other hand, the first hominoid specimen (CMu6-1’00) was discovered from the Lower Lignite Member (Nagaoka and Suganuma, 2002), which is ca. 60 m below the Upper Lignite Member, so that CMu6-1’00 is probably several hundred thousand years older than the other hominoid specimens from Chiang Muan. However, since CMu6-1’00 is similar in size and morphology to the hominoid specimens from the Upper Lignite Member, it seems appropriate to provisionally treat them as the same species at present. However, the taxonomy of the Chiang Muan hominoid material is still a matter of debate.

Among the Miocene hominoid sites in eastern Eurasia, the Xiaolongtang lignite mine in Kaiyuan is geographically closest to Chiang Muan (ca. 650 km northeast). The age of Xiaolongtang (Kaiyuan) is estimated as MN9 (early Late Miocene: Dong, 1987; Harrison et al., 2002) or MN7+8 (late Middle Miocene: Qiu and Qiu, 1995). Therefore, these two sites are also close to each other in geological age. Nearly half a century ago, a famous Chinese anthropologist, Wu Rukang, described a new species of large-bodied hominoid “Dryopithecus” keiyuanensis based on several lower cheek teeth from Xiaolongtang (Woo, 1957, 1958). Although he used the generic name Dryopithecus according to the taxonomy accepted in those days, he correctly pointed out the similarities of the Xiaolongtang material to the Siwalik Miocene hominoids (Dryopithecus punjabicus in Woo, 1957), which are now treated as Sivapithecus. Zhang (1987) added to the Xiaolongtang hominoid material a palate with right C–M2 and left I1–M3, and a left lower tooth row with M1–M3. He suggested similarities of the Xiaolongtang material to “Ramapithecus” lufengensis (now Lufengpithecus lufengensis) from Lufeng, a Late Miocene hominoid site west of Kunming, Yunnan Province. More recently, other researchers (Zheng and Zhang, 1997; Harrison et al., 2002; Kelley, 2002) have included the Xiaolongtang hominoid material in Lufengpithecus (here we tentatively call it “L. keiyuanensis”). The relationship of “L. keiyuanensis” to the other Lufengpithecus materials from Lufeng and Yuanmou is still debated, but it is apparent that “L. keiyuanensis” is morphologically, geographically, and temporally similar to the Chiang Muan hominoid material, and is important in determining the taxonomic status of the Chiang Muan hominoids. Unfortunately, the Xiaolongtang hominoid material was not mentioned in the description of cf. L. chiangmuanensis by Chaimane et al. (2003), so that it is not yet clear whether these two materials are really two different species or not. The above-mentioned situation suggests that cf. L. chiangmuanensis could be a junior synonym of “L. keiyuanensis” (Kunimatsu et al., 2005; Pickford et al., 2004).

A Small ‘Hominoid’ Molar from Ban San Klang

Before the first announcement (Kunimatsu et al., 2000a) of a large-bodied hominoid fossil (CMu6-1’00), Suteethorn et al. (1990) had reported an isolated lower molar of a small catarrhine from an early Middle Miocene site at Ban San Klang in the Pong Basin, northern Thailand. They assigned it to a new species of small-bodied hominoid, Dendropithecus orientalis. The type species of the genus is Dendropithecus macinnesi from the Early Miocene of East Africa, thousands of kilometers away from Southeast Asia, and it is the only species of the genus that had been known before the Ban San Klang lower molar was described. Dendropithecus and some other small Miocene catarrhines in East Africa have been called small-bodied Miocene apes, but their hominoid status has been doubted (Harrison, 1988). It is more likely that they are a group of primitive catarrhines that diverged before the split of extant hominoids and cercopithecoids (Harrison, 2002). In addition, it is often difficult to precisely identify a single isolated molar of hominoid or hominoid-like primate. The description by Suteethorn et al. (1990) does not give clear characters that uniquely connect the Ban San Klang molar to the East African D. macinnesi. In their revision of the Early Miocene primate fossils from Sihong, Jiangsu Province of the People’s Republic of China,
and Gu (1999) interpreted the Ban San Klang molar to be closely related to pliopithecids from Sihong (Dionysopithecus shuangouensis). With the paucity of the Ban San Klang primate material, it appears better to treat it as Dionysopithecus orientalis for the time being (Harrison and Gu, 1999).

Discussion

Little is known about Neogene hominoid evolution in the Indochina peninsula and Southeast Asian archipelago. However, recent TJPET paleontological fieldwork in Chiang Muan (Kunimatsu et al., 2000a, b, 2002, 2003, 2005; Nakaya and Suganuma, 2002; Nakaya et al., 2002a, b, c; Suganuma et al., 2002) revealed that hominoids had already inhabited Thailand by the latest Middle Miocene. Chiang Muan is the first Miocene hominoid site that lies south of the Tropic of Cancer in eastern Eurasia (Kunimatsu, 2002a; Kunimatsu et al., 2005). This also means that Chiang Muan is currently the southernmost Miocene hominoid site of the Eurasian continent (Kunimatsu, 2002b). Although the hominoid material collected from the Upper Lignite Member was assigned to a new species, cf. Lufengpithecus chiang-muanensis (Chaimanee et al., 2003), the taxonomic status of the Chiang Muan hominoid material has yet to be carefully investigated (Kunimatsu et al., 2005). In addition to work at Chiang Muan, TJPET is conducting paleontological field work and analyses of museum specimens at various places in Thailand. For example, we have collected vertebrate and plant fossils from sandpits in Tha Chang near Nakhon Ratchasima (or Khorat). We have also analyzed the vertebrate fossils that were previously discovered from Tha Chang and stored in the museum of Rajabhat Institute Nakhon Ratchasima, and in some other public and private collections. We have recognized in the Tha Chang material multiple mammalian assemblages of the Middle Miocene, latest Miocene to Early Pliocene, and Early Pleistocene (Nakaya et al., 2002b, c, 2003). Previous Neogene fossil sites in Thailand were estimated to be between the Early to early Middle Miocene in age (Ducrocq et al., 1994, 1995), but the above-mentioned work by TJPET has revealed the existence of much younger Neogene fossil sites from the late Middle Miocene to Early Pliocene. These results, as well as the discovery of Miocene hominoids at Chiang Muan, suggest that Thailand has strong potential for investigating hominoid evolution in the Neogene of Southeast Asia.

Notes

Since this paper was submitted to Anthropological Science in July 2003, a new hominoid specimen (Khoratpithecus piriyai) was assigned to a new species, cf. Khoratpithecus piriyai (Chaimanee et al., 2004) has been reported from Nakhon Ratchasima, northeastern Thailand. Although its age and taxonomy have yet to be confirmed at present, this new finding, in addition to the Chiang Muan hominoid, also indicates the potential of Thailand for the study of Southeast Asian hominoid evolution.

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References


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