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Rediscovery of the Late Pleistocene Punung hominin sites and the discovery of a new site Gunung Dawung in East Java

With 4 Tables and 15 Text-figures

PAUL STORM & JOHN DE VOS

Abstract

In the 1930s VON KOENIGSWALD collected a fauna from two Pleistocene deposits, close to the village of Punung, East Java, in which hominin remains were found in association with mammals which clearly indicate the presence of a tropical rainforest, like orang-utans (*Pongo*) and gibbons (*Hylobates*). Although the Punung fauna is of scientific importance for understanding the distribution and evolution of mammals, including hominins, in Australasia, the location of the deposits was unknown. In the late 1990s BOSSCHA ERDBRINK, who was present during the excavations in the 1930s, released photographs made by him and he expressed his willingness to help locate the original sites. In 2003 a joint Dutch-Indonesian team of Naturalis at Leiden and the Geological Museum at Bandung visited the region of Punung and rediscovered the two original Punung sites. In addition, we found and documented fossils *in situ* stemming from a tropical rainforest at a new site, Gunung Dawung.

K e y w o r d s : Late Pleistocene fossil fauna, tropical rainforest, VON KOENIGSWALD, porcupine bone collection, biostratigraphy Java, *Homo sapiens*.

Introduction

The Punung fauna is the only Pleistocene Javanese bone assemblage that reflects a tropical rainforest environment and it represents the first appearance of a fully modern extant mammalian fauna on this island (STORM et al., 2005). Considering the Javanese biostratigraphy (DE VOS, 1983; SONDAAR, 1984; LEINDERS et al., 1985), Punung plays an important role between the archaic Middle Pleistocene open woodland faunas which contain *Homo erectus*, and the late Late Pleistocene / Holocene open woodland faunas, which contain *Homo sapiens* (STORM, 1995). Moreover, hominin remains had been found in the Punung assemblage (VON KOENIGSWALD, 1939, 1975; BADOUX, 1959; STORM et al., 2005).

Unfortunately, *in situ* evidence was lacking because the exact location of the Punung sites was not reported. Fortunately, thanks to the generous help of BOSSCHA ERDBRINK and financial support of the Leakey Foundation, a joint Dutch-Indonesian team was able to visit the region of Punung in September 2003 to search for the original sites and fossils. In this paper we report our search for the Punung sites and excavation of fossils in a new site: Gunung Dawung.

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Brief history of the Punung Sites

In the early 1930's VON KOENIGSWALD and TWEEDIE surveying the region of Pacitan and Punung found besides stone tools (Pacitanian) a few fissures that contained a fauna suggesting a more humid climate than at present (VON KOENIGSWALD, 1956). The remains of this fauna are stored in National Museum of Natural History, Leiden, The Netherlands and in the Naturmuseum Senckenberg, Frankfurt am Main, Germany, and have been described by BADOUX (1959). In 1935-1936 VON KOENIGSWALD excavated one of these fissures west of Mendolo Kidul which is nowadays known as Punung 1 (BOSSCHA ERDBRINK, 1997). In this fissure indications for a tropical rainforest were found, like *Pongo pygmaeus*, *Hylobates* and *Helarctos malayanus* (BOSSCHA ERDBRINK, 1998). Later, in the late 1930's VON KOENIGSWALD excavated a second fissure (near Tabuhan) which is now known as Punung 2 (BADOUX, 1959; BOSSCHA ERDBRINK, 1998). According to MOVIUS, VON KOENIGSWALD had found - among other fossils - the remains of *Pongo*, *Hylobates* and *Helarctos* near Tabuhan (BADOUX, 1959). The fossils of Punung 1 and 2 have been thrown together and are known as the Punung fauna (BADOUX, 1959).

In 1976, HOOIJER published a fauna list of the fissure fauna of Punung (table 1), the material was collected by BARTSTRA. HOOIJER mentioned that the material was collected from "the Punung fissure", but it is not clear from which of the two fissures. There is a possibility that the material is collected in a third fissure because VON KOENIGSWALD and BADOUX had not recorded the exact location of the two original fissures. Also HOOIJER failed to give the exact location.

Rediscovering the sites

The key site for the rediscovery of the lost Punung sites was the site Song Agung, a site that is younger than the Late Pleistocene Punung sites (based on faunal composition and absolute date, see table 2 and 3). In 1996 we had visited this Holocene site and one year later a photograph of it was published (STORM, 1997). November 7, 1997, BOSSCHA ERDBRINK responded in a letter and wrote the following about Song Agung. "The "newly" described site Song Agung is without doubt (considering the picture, which I recognised immediately) the abri-sous-roche which was mentioned 'Tampat 2' by VON KOENIGSWALD, and in which he had dug two trenches. In those days I took part in the excavations myself, and of that I have still three well preserved photographs (fig. 1, 3 and 5)." Furthermore he wrote: "On one of these photographs of the excavation of 'Tampat 2' one sees, in the distance, that small mountain of Tampat 1 (=Punung 1), with the 'trench' as a sort of small terrace lying in section (fig. 5)." This meant that if VON KOENIGSWALD 'Tampat 2' was indeed the same site as Song Agung, we had been, without knowing it, very close to one of the Punung sites, and it should be easy to find this lost Punung site.

As a boy, who was at school in Bandung (Lyceum), BOSSCHA ERDBRINK joined VON KOENIGSWALD during his vacations as a kind of service in return, because BOSSCHA ERDBRINK's father financed VON KOENIGSWALD's fieldwork (personal communication BOSSCHA ERDBRINK, 2003). Luckily BOSSCHA ERDBRINK had taken photographs during his fieldtrips, was keen till

Tab. 1. Fossil mammals from the Punung area. – Punung A is a mixture of Punung 1 and 2, excavated by VON KOENIGSWALD, and based on a reinterpretation of BADOUX (1959) by DE VOS (1983,1985). Punung B is based on HOOIJER (1976), who mentioned that the material was collected from the "Punung fissure", but it is not clear from which of the two "fissures". There is a possibility that the material is collected in a third site because VON KOENIGSWALD and BADOUX had not given the exact locations of both of the original sites of Punung 1 and 2. Gunung Dawung is the only localised unmixed site of East Java, which contains mammals that indicate the presence of a tropical rainforest. - = absent, + = present, ? = uncertain.

Taxon		**Punung A (Punung 1+2)**	**Punung B**	**Gunung Dawung**
Excavated / collected in:		**1930's**	**1970's?**	**2003**
Insectivora				
Moon rat	*Echinosorex* sp.	+	-	-
Rodentia				
S.E. Asian porcupine	*Hystrix brachyura*	+	+	+
Small porcupine	*Hystrix lagrelli*	-	-	+
Long tailed giant rat	*Leopoldamys sabanus*	-	-	+
Rat	*'Rattus'* sp.	-	-	+
Primates				
Modern human	*Homo sapiens*	+	-	-
Orang-utan	*Pongo pygmaeus*	+	+	+
Siamang	*Hylobates syndactylus*	+	-	+
Gibbon	*Hylobates* cf. *leuciscus*	+	-	-
Macaque	*Macaca* sp.	+	-	-
Leaf monkey	*Trachypithecus* sp.	-	+	+
Carnivora				
Tiger	*Panthera tigris*	+	-	-
Sun bear	*Helarctos malayanus*	+	+	+
Clouded leopard	*Neofelis nebulosa*	-	+	-
Artiodactyla				
Bovids	Bovidae	+	+	+
Mountain goat	*Capricornis sumatrensis*	+	-	-
Muntjak deer	*Muntiacus muntjac*	+	-	+
Deer	*Cervus* sp.	+	-	+?
Pig	*Sus* sp.	+	+	+
Perrisodactyla				
Rhinoceros	*Rhinoceros* sp. (*sondaicus*)	+	+	+
Tapir	*Tapirus indicus*	+	+	+
Proboscidea				
Elephant	*Elephas* sp. (*maximus*)	+	+	-

Tab. 2. Mammals from late Javanese prehistoric sites. – Sources: Wajak (VAN DEN BRINK, 1982); Song Agung (STORM, 1997); Sampung (DAMMERMAN, 1932, 1934; MIJSBERG, 1932); Kecil (SPAN, 1993); Hoekgrot (STORM, 1995); Jimbe (WHITTEN et. al., 1996); Roto (LUYTEN, 1994). – + = recorded; - = not recorded; ? = uncertain. *P.=Paradoxurus; R.=Rousettus*. The presence of human remains in Song Agung is uncertain because human teeth have been found in this site but it is not known were they are (BOSSCHA ERDBRINK, 1997) and they have not been published.

Taxon		**Wajak**	**Song Agung**	**Sampung**	**Kecil**	**Hoekgrot**	**Jimbe**	**Roto**
Dermoptera								
Flying lemur	*Cynocephalus sp.*	-	-	-	-	-	+	-
Chiroptera								
Dog-faced fruit bat	*Cynopterus sphinx*	-	-	-	-	-	+	-
Common rousette	*R. amplexicaudatus*	-	-	-	-	-	+	-
Rodentia								
S.E. Asian porcupine	*Hystrix brachyura*	+	+	+	+	+	+	+
Giant flying squirrel	*Petaurista petaurista*	-	-	+	-	-	-	-
Giant bicoloured squirrel	*Ratufa bicolor*	-	-	+	-	-	+	-
Palm squirrel	*Callosciurus notatus*	+	-	+	-	-	-	-
Long tailed giant rat	*Leopoldamys sabanus*	-	-	+	-	-	+	-
Javan flat-nailed rat	*Kadarsanomys sodyi*	-	-	-	-	-	+	-
Black rat	*Rattus rattus*	-	-	+	-	-	-	-
Field rat	*Rattus tiomanicus*	+	-	-	-	-	-	-
Primates								
Modern human	*Homo sapiens*	+	+?	+	+	+	+	+
Macaque	*Macaca* sp.	-	+?	+	+	+	+	+
Leaf monkey	*Presbytis* sp.	+	+	+	-	+	+	+
Slow loris	*Nycticebus cougang*	-	-	+	-	+	+	-
Carnivora								
Tiger	*Panthera tigris*	+	-	+	-	-	-	-
Domestic cat	*Felis silvestris catus*	-	-	-	+	-	-	-
Leopard cat	*Felis bengalensis*	-	-	+	-	-	-	-
Wild dog	*Cuon javanicus*	-	-	+	-	-	+	-
Domestic dog	*Canis lupus familiaris*	-	-	-	-	+	-	+
Common palm civet	*P. hermaphroditus*	-	-	+	+	+	-	-
Small-clawed otter	*Aonyx cinerea*	-	-	+	-	-	-	-
Yellow-throated marten	*Martes flavigula*	-	-	-	-	-	+	-
Palm civet	*Arctogalidia* sp.	-	-	-	-	-	+	-
Artiodactyla								
Bovids	Bovidae	+	+	+	+	+	+	+
Mouse deer	*Tragulus javanicus*	-	-	+	+	+	+	+
Muntjak deer	*Muntiacus muntjac*	+	+	+	+	+	+	+
Deer	*Cervus spec.*	+	-	+	+	+	+	-
Pig	*Sus* sp.	+	+	+	+	+	+	+
Perissodactyla								
Rhinoceros	*Rhinoceros* sp.	+	+	+	-	+	+	-
Tapir	*Tapirus indicus*	+	-	-	-	-	+	-
Proboscidae								
Elephant	*Elephas* sp. (*maximus*)	-	-	+	-	+	-	-
Pholidota								
Pangolin	*Manis javanica*	+	-	-	-	-	+	-

Tab. 3. C-14 dates of late Javanese prehistoric sites. – The date of Song Agung is registered at R.J. van de Graaff Laboratorium (University of Utrecht, the Netherlands), named Punung. SONDAAR took this sample in 1991 from the site Song Agung near Punung.

Site	**Reference nr.**	**Dated material**	**Uncalibrated**
Wajak	AA7846	bone, fauna	10,560 ± 75
Wajak	AA7718	bone, human	6,560 ± 140
Song Agung	UtC-1700	charcoal	8,800 ± 60
Kecil	AA7849	bone, fauna	3,060 ± 85
Hoekgrot	AA7848	bone, fauna	2,655 ± 60
Hoekgrot	AA7845	bone, human ('red painted')	3,265 ± 55
Hoekgrot	GrA-25744	bone, dog	895 ± 40
Jimbe	AA7847	bone, fauna	2,650 ± 55

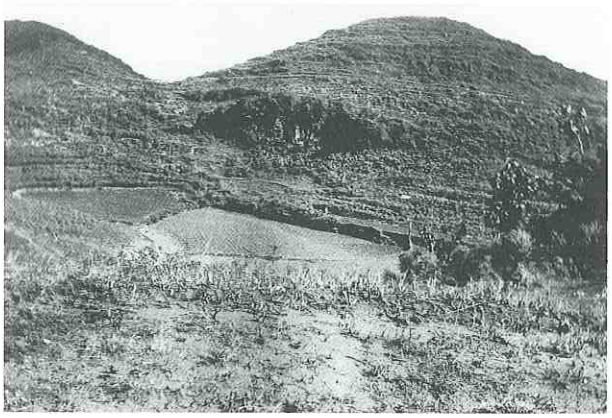

Fig. 1. The site Song Agung (=Tampat II). Photograph taken by BOSSCHA ERDBRINK. At the back he wrote "VON KOENIGSWALD Tampat II, Mendolo Kidul, seen to the west, June 1936".

Fig. 2. The site Song Agung (=Tampat II). Photograph taken by STORM, September 2003. It was tried to take this picture from the same position as fig. 1.

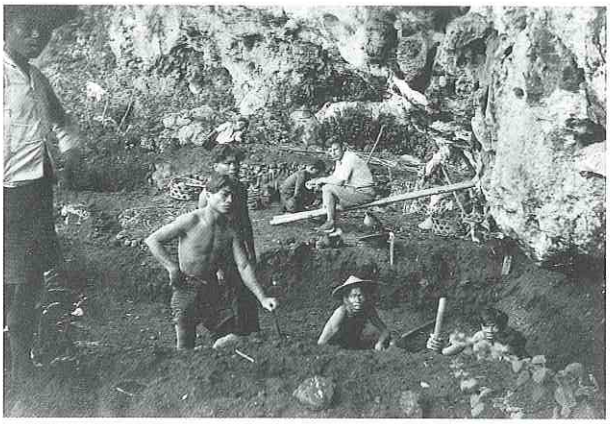

Fig. 3. Excavation of the site Song Agung by VON KOENIGSWALD (sitting at sticks). Photograph taken by BOSSCHA ERDBRINK. At the back he wrote "VON KOENIGSWALD Tampat II digging trenches, June 1936, seen to the s(outh)".

Fig. 4. DE VOS sitting at the site Song Agung in 2003, at the same spot as VON KOENIGSWALD in 1936 (see fig. 3). Photograph taken by STORM, September 2003. It was tried to take this picture from the same position as fig. 3.

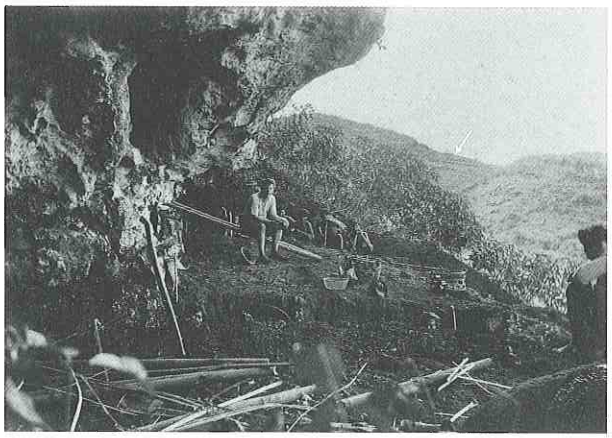

Fig. 5. Excavation of the site Song Agung by VON KOENIGSWALD (sitting at sticks). The arrow at the background indicates the area of Punung I (=Tampat I). Photograph taken by BOSSCHA ERDBRINK. At the back he wrote "Excavations (2 trenches) VON KOENIGSWALD's Tampat II near Mendolo Kidul, seen to the north, June 1936. Tampat I in the hill at the background, seen from aside, arrow (stairway like)."

Fig. 6. STORM sitting at the site Song Agung in 2003, at the same spot as VON KOENIGSWALD in 1936 (see fig. 5). Photograph taken by DE VOS, September 2003. It was tried to take this picture from the same position as fig. 5.

the end of his life (2004) and had held an enthusiastic lifelong interest in palaeontology and had become a professional in the field.

Of course the photographs made in 1996 were not taken from the same perspective as those made in 1936, nevertheless BOSSCHA ERDBRINK and STORM considered that it was not impossible that Song Agung was indeed von Koenigswald's 'Tampat 2'. Moreover, BOSSCHA ERDBRINK could show teeth of macaques (according to him *Macaca fascicularis*) of 'Tampat 2', and these looked similar to the teeth that we had prepared out of blocks from Song Agung in 1996 (STORM, 1997).

September 14 and 25, 2003, we visited the site Song Agung and were able to compare the three photographs made by BOSSCHA ERDBRINK in 1936 with the present situation in the field. The situation of the site (fig. 1 and 2) and details on the rock (fig. 3, 4, 5 and 6) confirm beyond doubt that this site is VON KOENIGSWALD's 'Tampat 2'. The co-ordinates for Song Agung are: S. 08° 08.543, E. 111° 01.837.

Tab. 4. Number of fossil mammals of Kedung Brubus and Trinil. – The two richest Middle Pleistocene East Javanese sites (from the Kendeng Hills) excavated by Dubois at the end of the 19e century. Numbers are based on the computerlist 2002, National Museum of Natural History, Leiden, The Netherlands.

	Kedung Brubus	Trinil
Rodentia		
Hystrix lagrelli	0	2
Rattus trinilensis	0	2
Muridea	0	1
Primates		
Homo erectus	1	9
Macaca fascicularis	0	11
Trachipithecus cristatus	0	1
Colobinae	0	1
Carnivora		
Crocuta bathygnatha	1	0
Panthera tigris	15	10
Panthera sp.	6	3
Lutrogale palaeojavanica	1	0
Prionailurus bengalensis	0	1
Artiodactyla		
Axis lydekkeri	39	1075
Rusa sp.	5	0
Muntiacus muntjak	2	0
Epileptobos groeneveldtii	9	0
Bibos palaeosondaicus	28	51
Bubalus palaeokerabau	25	94
Bovidae	233	1406
Duboisia santeng	26	231
Hexaprotodon sivalensis	35	0
Sus brachygnathus	4	78
Sus macrognathus	6	0
Sus sp.	13	0
Perissodactyla		
Rhinoceros kendengindicus	14	0
Rhinoceros sondaicus	26	44
Rhinoceros sp.	23	6
Tapirus indicus	3	0
Proboscidae		
Elephas hysudrindicus	23	0
Stegodon trigonocephalus	129	499
Proboscidae	130	1
Pholidota		
Manis palaeojavanica	29	0

Punung 1

November 7, 1997, BOSSCHA ERDBRINK wrote in his letter: "Secondly, the place of the Punung fissures: also of that I have a, not very good, photograph, what V.K. mentioned 'Tampat 1' (fig. 7), an irregular formed, trench like excavation (executed by him somewhat earlier, in 1935-'36, again paid from the fund of my late father) situated at the east flank, close by the top, of another of the countless number of pudding formed small mountains of the karstified landscape of the Gunung Sèwuh". Interestingly BOSSCHA ERDBRINK wrote at that time on the back of the photograph of the excavation of Punung 1 that orang-utan, Sun bear and gibbon were found in this site (fig. 7). All three taxa can be considered as rare in Javanese paleontological contexts. Orang-utans and gibbons are reliable indicators for the presence of a tropical rainforest. These taxa can be considered as characteristic for the Punung fauna (table 1) and are missing in younger and older deposits (table 2 and 4).

September 14, 2003, we visited the area of Song Agung. From here it was easy to find the area of Punung 1 (opposite Song Agung, a slope of a hill). It was not possible to find the exact spot (in terms of meters) of VON KOENIGSWALD's excavation. Searching was difficult because of ground, dead leaves and vegetation covering the limestone. According to BOSSCHA ERDBRINK (personal communication 1998) Punung 1 was excavated thoroughly, which diminishes the change to find more fossils. Moreover, we had not found the exact VON KOENIGSWALD spot. Therefore it was decided not to start with excavations in this area. During a second visit, September 25, we found a "yellow" breccia (without fossils) and a white

Fig. 7. Excavation of the site Punung 1 by VON KOENIGSWALD (in a light shirt, sitting on a rock). Photograph taken by BOSSCHA ERDBRINK. At the back he wrote "VON KOENIGSWALD's Tampat I (excavated fissure filling with orang-utan, Ursus malayanus, gibbon) June 1936."

Fig. 8. HANS BRINKERINK sitting in the area of Punung 1, where he found a fossil fragment of the tooth of a deer.

breccia with a fossil (fragment of a tooth of a deer, fig. 8). The co-ordinates for the area of Punung 1 are: S. 08° 08.511, E.111° 01.975).

Punung 2

December 6, 1998, one of us received 5 photographs from BOSSCHA ERDBRINK, among them one photograph of the "other fissure filling" (fig. 9). This had to be Punung 2. It was known that after collecting, fossils from both Punung 1 and 2 were mixed (BADOUX, 1959), however, it was unknown that the activities that had taken place in both sites differed meaningfully. Punung 1 (fig. 7) was excavated, but at Punung 2 (fig. 9) only surface finds had been collected (BOSSCHA ERDBRINK, 2003, personal communication). The photograph of Punung 2 was taken while BOSSCHA ERDBRINK stood with his back to the opening of the cave of Gua Tabuhan. Seen from his position, Punung 2 lies at the right side of the entrance of the cave. According to BOSSCHA ERDBRINK, the persons on this photograph are collecting fossils (almost all were teeth) at the bottom of the original fissure filling. As far as BOSSCHA ERDBRINK (2003, personal communication) could remember, all three mammal taxa (*Pongo*, *Hylobates* and *Helarctos*) had probably been found at this site, which is in agreement with MOVIUS' remark (BADOUX, 1959).

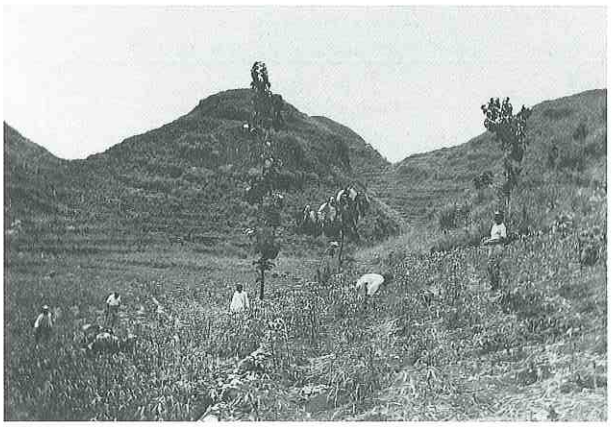

Fig. 9. Searching for fossils at site Punung 2. Photograph taken by BOSSCHA ERDBRINK. At the back he wrote "Searching fossils! Other fissure filling, in front of the entrance of Guwo Tabuhan near Punung; the Gunung Pengih in the middle at the background, April 15, 1938."

Fig. 10. The entrance of Gua Tabuhan. Next to the tree we found fossilised teeth of extant mammals (muntjak, deer, bovid and pig). Photograph taken by DE VOS, September 2003.

September 15, 2003, we visited the cave Gua Tabuhan. Unfortunately it was not possible to translate the situation of BOSSCHA ERDBRINK's photograph taken in 1938 (fig. 9) to the present situation (fig. 10). The situation was drastically altered because of the building of a road, stairs to the cave and presence of a large tree. According to BOSSCHA ERDBRINK, Punung 2 is close to the right side of the entrance to Gua Tabuhan. In the present situation this is next to the stairs, around the large tree. Here we found fossils, teeth of extant mammals (muntjak, deer, bovid and pig) but fossilised. Porcupines had gnawed the teeth. This is very characteristic for the Punung fauna. Likely the area were we found the fossils represents a remnant of VON KOENIGSWALD's original place. Nowadays Gua Tabuhan is a tourist attraction. It was hardly possible to start with excavations in this area. Co-ordinates of the cave of Gua Tabuhan are: S. 08° 07.388, E. 110° 58.642.

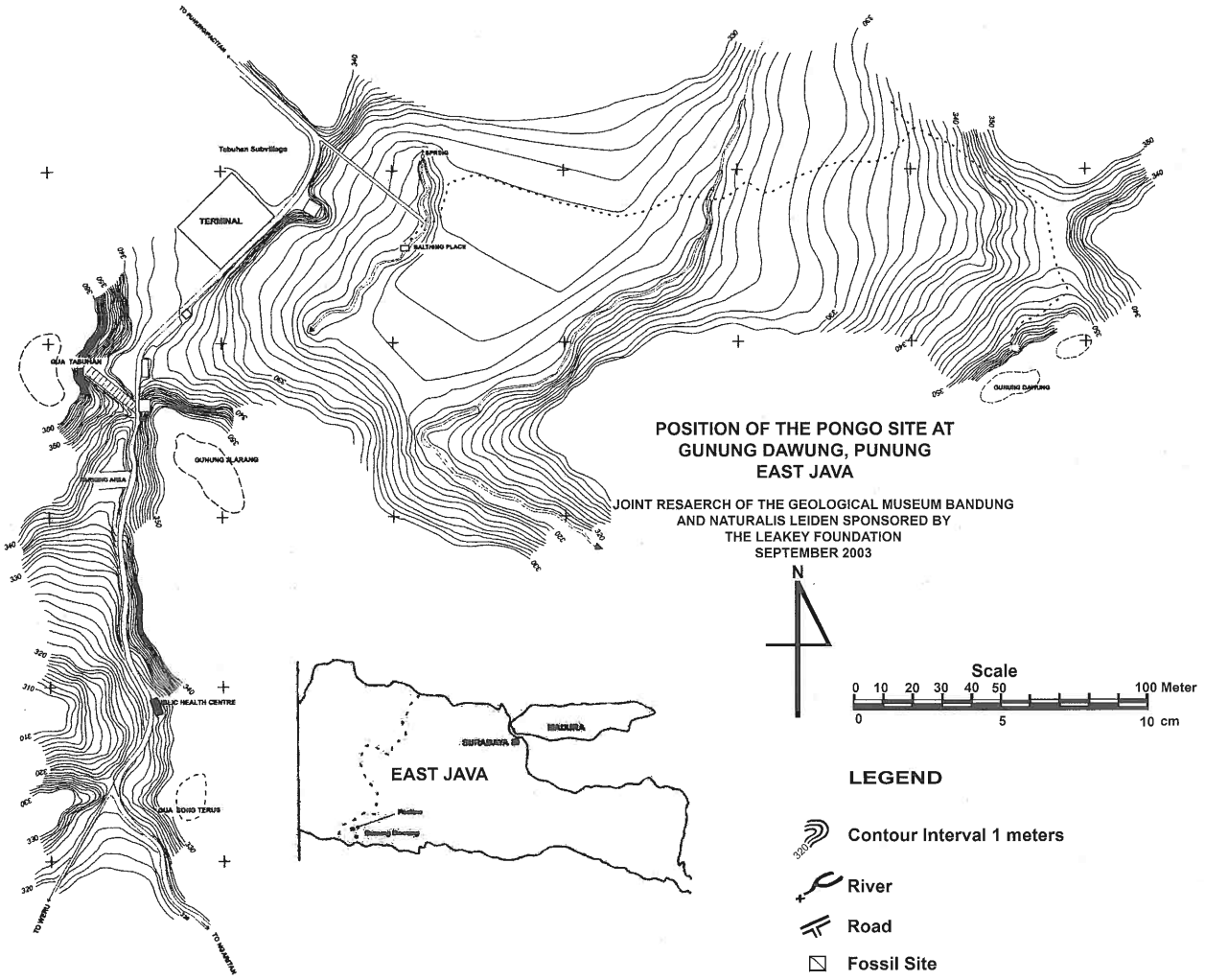

Fig. 11. Location map of the site Gunung Dawung. Made by NGALIMAN.

Gunung Dawung

September 15, 2003, a farmer Mr. SUWARNO, indicated the presence of fossils on his land (this turned out to be a peanut field) about 550 metres from Gua Tabuhan (fig. 11). After some searching we found on the same day fossil teeth of porcupine, pig and rhino. The gnawed aspect and state of fossilisation indicated that these fossils presumably stem from a fauna similar to those collected at the two Punung sites. Because of the objections to start with excavations in Punung 1 or 2, the best option was to start with an excavation at this new site, that we called Gunung Dawung, after the indigenous name of the limestone rocky wall (fig. 11). In the period September 15-27, 2003, fossils at this site were found both in situ, in a "yellow" breccia, and washed out onto the field directly next to the source (fig. 12). In situ fossils were prepared directly out of this breccia. In the field they were found by surveying and sieving with a sieve of 0.5 mm. The co-ordinates for Gunung Dawung are: S. 08° 07.562, E. 110° 59.252.

Gunung Dawung represents the same fauna as those from the so-called Punung sites (Table 1). This means that: 1. the fossils are found in a "yellow" breccia, 2. there are leftovers of the gnawing activities of porcupines (teeth and small bone fragments), 3. all mammals found are extant species, and 4. two taxa (*Pongo* and *Hylobates*) clearly indicate the presence of a tropical rainforest environment. This means that Gunung Dawung confirms the fact that orang-utans have indeed been found in (one of) the Punung fissures. Because of the fossil

Fig. 12. Excavating in the site Gunung Dawung, September 2003. Foreground from left to right: STORM, AZIZ and NGALIMAN. Photograph taken by DE VOS.

Fig. 13. Lateral view of right lower premolar of *Rhinoceros* sp. from the site Gunung Dawung that shows intense wear. In the region of the cervix part of the roots are preserved and show marks of gnawing. MD = 34.9 mm. BL = 23.4 mm. Photograph taken by STORM.

Fig. 14. Bone fragment that shows clear marks of gnawing (all around) from the site Gunung Dawung. Typical left over of a porcupine, in which case it is hard to gnaw further (to keep the bone between its paws while gnawing). Photograph taken by DE VOS.

assemblage collected at Gunung Dawung we are now sure that there has been a tropical rainforest as far as East Java, in the area of Punung. Faunal elements from Gunung Dawung and the other discussed localities in the region of Punung (table 1) will be referred to in the rest of this paper as the 'Punung fauna'. We are now able to date the Punung fauna, because its locality is known.

Porcupines and the preservation of bones

Porcupines were a major agent in the preservation of the Punung fauna. It is well-known that porcupines collect bones and bring them to their lairs (BRAIN, 1981), where they gnaw the bones, often (almost) completely removing the roots of teeth. This activity leaves unmistakable grooves on the small remnants of bones, antlers and roots (BRAIN, 1981; MAUL, 2003). Interestingly, in younger Javanese sites were the bones are less intensively fossilised and three rainforest inhabitants (*Pongo*, *Hylobates* and *Helarctos*) are missing (table 2). Bone fragments gnawed by porcupines are present but they are not abundant (STORM, 1995). In the Punung sites this picture is very different. The assemblages collected are characterised by the presence of crowns (enamel) of teeth and small bone fragments that may show marks of intensive gnawing (fig. 13 & 14).

Two factors are possibly responsible for this observation. Firstly, the above mentioned younger sites, like Wajak and Hoekgrot (table 2), are clearly associated with *Homo sapiens* and are probably the result of human ritual practices (STORM, 1995). Whereas the largest part of the Punung fauna must be the result of bone collecting activities of porcupines. This means that in the younger sites porcupines possibly have had less changes to gnaw on bones. Secondly, in contrast to the Punung fauna, these younger sites point to dryer environmental circumstances (DE VOS, 1983; STORM, 2001). In forests the preservation of bones is less likely to occur because acidic soils cause buried bones to disintegrate (SHIPMAN, 1981). Thus, intense gnawing by porcupines in rainforests is likely related to the relative scarcity of skeletal remains in this environment.

If bones are relatively rare in forest environments (SHIPMAN, 1981) the question emerges: why do we have at all paleontological assemblages stemming from these ecosystems? Rainforest faunas have not only been found in Java, but are also known from Vietnam, Laos, Thailand, Borneo, and Sumatra (DE VOS, 1995; VU THE LONG, 1996). This is probably due to the fact that porcupines carry the collected bones to their lairs (BRAIN, 1981). In karstified regions, this means that the bones are brought out of a hostile situation for preservation and fossilisation into a more conducive environment.

Considering the Punung faunal collection, one of the relevant questions is what do porcupines select? BRAIN (1981, p. 109) remarked about a porcupine named Aristotle: "Manageable objects it simply carried in its mouth, and larger ones it dragged, walking backward all the way to its lair". The impression is that porcupines select what they can find and carry or drag. Objects too small or too large will not find their way into the liar of a porcupine. The largest mammal of Southeast Asia, the Elephant, has been found in the Punung fauna (table 1), which could mean that porcupines managed to carry parts of this proboscidean. The skeletal parts do not have to be com-

plete because porcupines are interested in dry bones, not in fresh ones (BRAIN, 1981). Interestingly, the MNI of porcupine collected remains of the Nossob liar, which lies in the Kalahari National Park, "mirrors" the actual abundance of the antelope species (BRAIN, 1981). In other words, porcupine collected bone assemblages give probably a good impression of the (larger) mammal species living in the area.

Human remains at Punung

The first report indicating the presence of human remains at Punung is given by VON KOENIGSWALD (1939), who remarked that a primitive hominid tooth had been found in one of the fissures.

Twenty years later, BADOUX (1959: 124) reported the find of 5 human teeth in the Punung fauna: "When examining the orang-utan teeth from Punung I discovered two upper incisors, an upper canine and a lower canine among the material, which are altogether too small to belong to the dentition of such a large anthropoid. Moreover, the collection of Prof. VON KOENIGSWALD contains an upper molar from the same locality, which may provisionally be identified as belonging to *Homo* (cf. *Pithecanthropus*). Since Prof. VON KOENIGSWALD has the intention to publish a note on these human remains, I only provisionally mention the occurrence of this hominid among the Punung material."

In 1975 VON KOENIGSWALD remarked that these human remains had still not been published (page 303): "The rock fissures of Punung and Patjitan, in our opinion, are post-Trinil. A few isolated teeth, not yet published, indicate the presenceof man here." A description of these five isolated teeth has never been published. In 1985 DE VOS suggested that the human remains of the Punung fauna are those of *Homo sapiens*.

Unfortunately, in January 2001 the above mentioned teeth could not be found in the collection of VON KOENIGSWALD (Senckenberg Naturmuseum in Frankfurt am Main, Germany). Luckily, we came across a premolar with a note saying "*Homo* sp." We agreed that this premolar (Fig. 15.; PU-198) must indeed be classified as *Homo* (and not as *Pongo*). This tooth can be identified as the left upper P^3, thus it is clearly not one of the teeth mentioned by BADOUX (1959). The crown is completely present and shows some wear. Its mesiodistal and buccolingual measurements are compared with other recent and prehistoric specimens from Australasia. The dimensions of PU-198 place this premolar in the range of *Homo sapiens* (STORM et al., 2005).

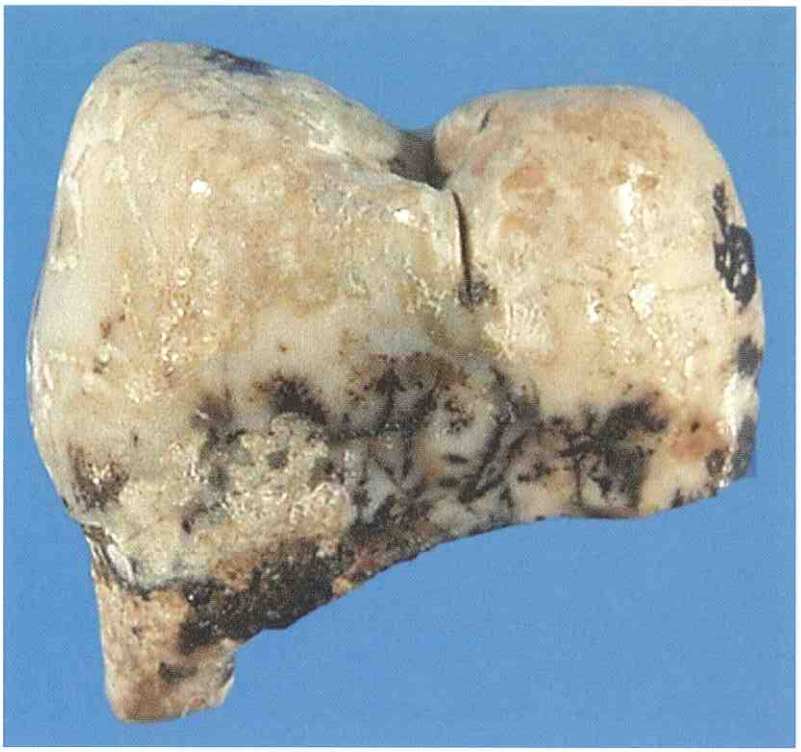

Fig. 15. Lateral view of the left human P^3 (PU-198) from the Punung fauna. MD = 6.7 mm. BL = 10.0 mm. Photograph taken by STOLP (JWG University, Zoological Institute Germany).

Age of the Punung fauna

Absolute dates of Gunung Dawung will become available in the near future (WESTAWAY et al., submitted). Accepting that the other Punung sites are in approximately the same time range as Gunung Dawung, these absolute dating results are in agreement with a number of aspects.

1. The fauna of Ngandong contains extinct species, including *Homo erectus* (Storm, 1995), whereas the Punung fauna contains only extant species. Therefore, it is evident that Punung is younger than Ngandong. An observation supports this logic reasoning. The Ngandong fauna is more heavily mineralised than that of Punung. Interestingly, the U-series near Matar and Tapan (BARSTRA et al., 1988) give a possible time range for Ngandong between 190 and 165 kyr ago.

2. The Wajak fauna resembles the Punung fauna in the sense that it contains only extant species, but lacks the three mammalian taxa adapted to a tropical rainforest: *Pongo*, *Hylobates* and *Helarctos*. Therefore, the Wajak fauna (table 2) can be seen as an impoverished Punung fauna (table 1). Nowadays and in historical times the three above mentioned taxa were not present in East Java. In other words, the Wajak fauna resembles the (pre)historic and present situation better and is therefore interpreted as younger than Punung. The Wajak fauna is dated at 10,560 ± 75 BP (table 3).

3. The interpretation, that an open woodland (Ngandong) was followed by a humid forest (Punung) and again by a open woodland (Wajak) is supported by independent palaeoclimatic reconstructions based on sedimentological and palynological analyses of sediment cores from the Bandung basin in West Java (VAN DER KAARS & DAM, 1995). According to these studies, around 135 kyr ago, the climate was considerably drier and hot. Between 126 and 81 kyr ago, the climate was primarily humid and warm. After 81 kyr the climate became drier and cooler. Therefore it was suggested that a likely age for Punung is between 126 and 81 kyr ago (STORM, 2001).

4. Large primates like *Pongo* and *Hylobates* are not known to cross water barriers like sea straits, and it is unlikely that they are able to do so. In other words, to reach Java, sea levels

must have been lower than at present. Interestingly, between 120 and 90 kyr ago, during the stadials MIS-5b and MIS-5d, sea levels have been 40-60 meters below present levels (LAMBECK et al., 2002). This implies a scenario according to which the tropical rainforest and its inhabitants reached Java around 120 kyr ago. It is possible that the "Punung tropical rainforest stage" continued till about 81 kyr ago. After this date the climate became drier and cooler (VAN DER KAARS & DAM, 1995).

Concluding remarks

The Punung fauna is unique for Java, it is the only fauna that represents a tropical rainforest and the fossil assemblage stems from a breccia. Moreover, Punung can be placed at the important position between the archaic Ngandong fauna (containing *Homo erectus*) and modern looking late prehistoric fauna (containing *Homo sapiens*). Despite this scientific importance, little attention has been paid to Punung. This lack of interest may be due to several factors. Because of the unknown exact locations, the Punung fossils could not be considered as good *in situ* evidence. VON KOENIGSWALD (1939) considered Punung as a "normal Trinil (Middle Pleistocene) assemblage", by doing so, obscuring the existence of the Punung fauna. BADOUX's (1959) dissertation was published in a relatively obscure manner, therefore, his view that Punung was younger than Trinil remained unnoticed. Until 2005 (STORM et al.) the human remains of Punung were never fully described or published only mentioned (VON KOENIGSWALD, 1939; BADOUX, 1959; DE VOS, 1985).

Results of our research so far are: 1. the location of the two original Punung sites, 2. *in situ* evidence in the site Gunung Dawung of the occurrence orang utan (and therefore also a tropical rainforest) as far as East Java, and 3. an indication of the presence of *Homo sapiens* in this tropical rainforest, possibly about 120 to 80 kyr ago. This last mentioned aspect is an interesting ingredient for the question whether hominins were able to survive in a tropical rainforest early in Late Pleistocene. The important implication of the new site Gunung Dawung for the biostratigraphy of Java is that it confirms the existence of the humid forest Punung fauna between the older Ngandong and younger Wajak fauna. The new findings are in agreement with the idea that there has been a faunal turnover between the archaic Middle Pleistocene open woodland fauna of Ngandong and the modern Late Pleistocene humid forest fauna of Punung (STORM, 2001). Because of the above mentioned results, we think that from this moment, Punung must play an important role in future discussions on the dispersal and evolution of mammals (including humans) in Indonesia.

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