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The Early Holocene Vertebrate Faunas from Seropan Cave, Gunung Sewu, Yogyakarta, Indonesia

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Abstract - An excavation of a vertebrate fossil site was carried out in 2012 in the Seropan Cave of Gunung Sewu karst area, Wonosari, Yogyakarta. Among the discovered mammal fossils there are *Cervus* sp., *Sus verrucosus*, *Bubalus* sp., and *Panthera* cf. *pardus*. Small mammal bone fragments of GSP (Gua Seropan/Seropan Cave) Nos. 38, 67, 91-113 have been analyzed for C_{14} radiocarbon age dating, which gave a date of 9,450 ± 400 yrs. B.P. or Early Holocene. The Seropan fauna is part of the succession series of Braholo fauna that migrated before the Late Pleistocene, and was isolated after the last Ice Age. The Seropan fauna developed and adapted their morphology to the local habitat.

Keywords: mammal fossils, Early Holocene, Braholo Fauna, Seropan Cave, Gunung Sewu, Yogyakarta

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Introduction

Gunung Sewu is a vast karst area with thousands of caves and rock shelters. There are 253 underground rivers recorded in Gunung Sewu area (Kusumayudha *et al*., 2000). Seropan is a cave of an underground river which has an evidence of vertebrate fossil material. The Seropan Cave is located in the hamlet of Ketonggo, Semuluh Village, Ponjong Sub-regency of Gunung Kidul Regency. The position coordinates are 08°00'55.5" S and 110°40'56.9" E, situated in the western part of Gunung Sewu, about 45 km east of Yogyakarta (Figure 1). In 1988, Hening, a student of Geology Department, Universitas Pembangunan Nasional (UPN) "Veteran" Yogyakarta, carried out a field work and informed the authorities of the presence of vertebrate fossil in the deposits of the Seropan Cave. In 2012, a joined research team, the Centre for Geological Survey (CGS) and UPN "Veteran" Yogyakarta, made an excavation of vertebrate fossils in the ancient river deposits within the Seropan Cave. The Seropan fossil site is an accumulation of fossil material covered by a terrarosa matrix in the underground river deposits of the cave. This condition is a new characteristic of natural occurrence in this region. The cave and rock shelter are usually associated with the presence of ancient human dwellings, because several sites also contain hominid fossils.

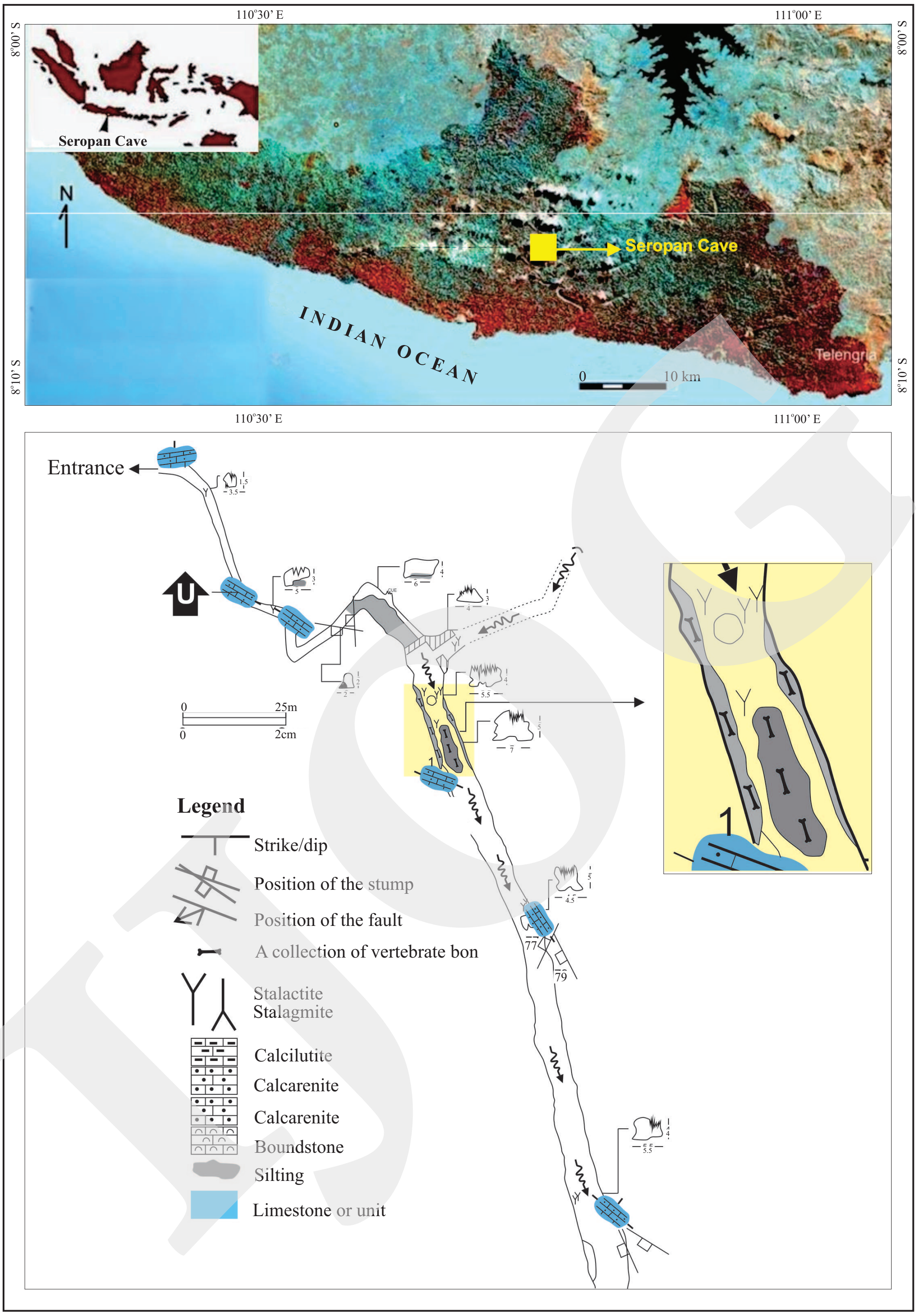

Figure 1. a). Seropan Cave locality within Gunung Sewu complex and, b). Location of mammal bone bed inside the Seropan Cave (modified from Haryono and Suratman, 2010; Google Earth).

The discovery of abundant bones and teeth from several different mammal species in the limestone cave of Seropan is remarkable, considering the very accessible nature of the caves in a residential setting. It looks as if only dominantly long bones of mammals are preserved. No evidence had been made of definite gnawing-marks on the fossils associated human remains or any prehistoric remains (Hunt *et al*., 2015). Punung is the oldest mammal fossil site in Gunung Sewu.

Punung fossils are found within yellowish sediments in the eastern part of Gunung Sewu (Table 1). The Punung fauna, in the dated breccias, is of Early Last Interglacial or Late Pleistocene (between 128,000±15,000 and 118,000±3,000 yrs. BP). The samples were collected in Gunung Dawung near Tabuhan Cave (Westaway *et al*., 2007). The Punung fauna is recognized as the youngest biostratigraphic unit of the Pleistocene vertebrate fauna unit in Java (Sondaar, 1984; de Vos, 1985; Aziz, 2000), although Wadjak is younger (Storm *et al.*, 2013). There are other Holocene sites in Gunung Sewu such as Sampung, Song Gentong, Tabuhan Cave, Song Agung, Song Terus, and Song Keplek in the eastern part of Gunung Sewu, and Seropan and Braholo in the western part of Gunung Sewu. The Early Holocene site of Braholo Cave gives an age of

Table 1. Mammal Fossils from Punung, Wajak, Seropan, Sampung, and Braholo Sites in the Gunung Sewu Areas (Modified after Erdbrink, 1954; Sondaar, 1984; de Vos, 1985; Amano *et al., 2016*)

Taxa	**Late Pleistocene PUNUNG (rockshelter) rainforest**	**Late Pleistocene WAJAK (rockshelter) open woodland**	**Holocene SEROPAN (cave) open woodland**	**Holocene SAMPUNG (cave) open woodland**	**Late Pleistocene – early Holocene BRAHOLO (cave) open woodland**
Echinosorex sp.	x				
Manis javanica		x			
Hystrix javanica				x	x
Ursus malayanus	x				
Cuon alpinus					x
Cuon javanicus				x	
Panthera tigris	x	x			x
Panthera cf. *pardus*			x		
Felis bengalensis				x	
Paradoxurus hermaphroditus				x	
Elephas maximus	x				x
Rhinoceros sondaicus	x	?		x	x
Tapirus indicus	x	x			
Muntiacus muntjac	x	x		x	x
Cervids	x		x		x
Cervus timorensis		x			
Cervus hippelaphus				x	
Capricornis sumatrensis	x				
Bubalus palaeokerabau	x				x
Bubalus sp.			x		x
Bos javanicus				x	x
Bibos palaeosondaicus	x				
Sus vittatus	x	x		x	x
Sus barbatus	x				
Sus verrocosus			x		x
Prebystis sp.		x			x
Trachypithecus auratus					x
Macaca sp.	x				
Macaca irus				x	
Macaca fascicularis					x
Hylobates syndactylus	x				
Pongo pygmeaus	x				
Homo sapiens	x	x			
Acanthion brachyurus	x	x			
Rattus tiomanicus		x			
Sciurusnotatus		x			

13,765±143 yrs. B.P. of layer two in 290 cm depth (Amano *et al*., 2016), and Song Keplek (11,200 ± 600 – 5,770 ± 60 yrs. B.P. (Sémah *et al*., 2004). On the other sites, Song Gentong and Sampung Cave, human remains and stone tools (Simanjuntak, 2001) were found. Both fossils of the Seropan Cave have more or less the same age as those sites. However, the Seropan fauna collection has never been described or identified in detail in such a way that can be used in biostratigraphic and environmental studies. In this paper, the mammal fossils from Seropan will be reported, described, and discussed with other mammal fossils in surrounding areas.

Materials and Methods

Vertebrate fossils were collected from the underground river deposits of the Seropan Cave in 2012 (Figure 2). The vertebrate fossil deposits were situated upstream of the dam in the middle of the river, and on both sides of the river banks of approximately 25 m in length. The fossils were unearthed in the middle deposit of the river by 1 x 1.5 m^2 and 10 cm depth from the surface. The vertebrate fossils were also collected on both sides of the bottom wall of the river bank. It was done to look at Number of Identified Specimens (NISP) (Table 2), and the percentage of each taxon (Val and Stratford, 2015). The materials are generally found intact, dominated by long bones, such as femur and humerus with some fragments of jaws and teeth. Fossils were cleaned from the matrix cover. Broken fragments are fixed to their original position using a solution of Paraloyd B72 crystal and acetone that are useful to coat and strengthen fragile fossil material. The vertebrate fossils are stored in the Bandung Geological Museum (MGB) with the collection code of GSP (Gua Seropan/Seropan Cave) from GSP1/2012 to GSP113/2012. Radiocarbon dating (C_{14}) on fragments GSP Nos. 38, 67, 91-113 were analyzed at the laboratory of the Centre for Geological Survey (CGS), Bandung. Based on the analysis of the C_{14} carbon dating on the fragmented fossil numbers GSP/2012 Nos. 38, 67, 91-113 provides the age of 9,450±400 yrs. B.P. Fossils are photographed and measured using a digital slide caliper ("Mitutoyo") with an accuracy of 0.1 mm. A comparative morphological analysis was done by using bones from living and extinct species currently found in Java as well as material described from previous literatures. Terminology of the bones from the mammals follows those of Bibi (2014) and Tomar *et al*. (2014).

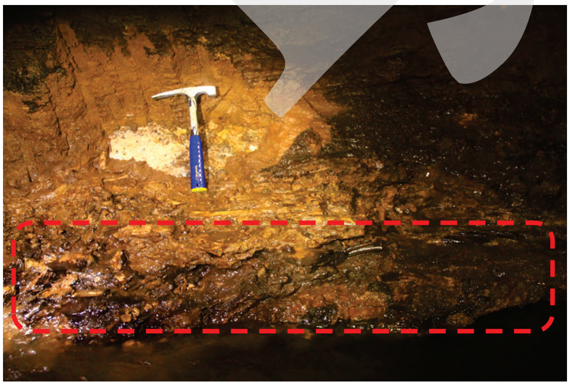

Figure 2. Vertebrate fossil deposits occupying the lower wall of the Seropan cave (in dash red line; Photo by Yulianto ASC, 2012).

Geological Setting

Gunung Sewu (Southern Mountains of Central Java, Indonesia) has many limestone caves with underground rivers, and the Seropan Cave is one of them. The Seropan area has a hilly morphology with sinusoid than conical shape (Haryono and Day, 2004). Physiographically, the Gunung Sewu area is part of the southern mountainous zone (van Bemmelen, 1949). The stratigraphy of Gunung Sewu, from old to young, comprises Semilir, Nglanggran, Sambipitu, Oyo, Wonosari, and Kepek Formations as well as locally developed terrarosa and alluvial deposits (Tjia, 2013; Kusumayudha *et al*., 2015; Pandita *et al*., 2016). The lithology of the cave is made up of reef limestones, partly in the form of calcilutite, calcarenite, and calcirudite. The lithology of vertebrate fossil deposits consists of terrarosa supported by 1m thick, brown mud of caliche with localized patches of carbonate cement fractions. Wardhana and Wilopo (2012) reported that the Seropan tunnel has dominantly been arranged by clastic limestone (Figure 1b). Some parts of

Table 2. Number of Identified Specimen (NISP) of Seropan Mammals Representation

Skeletal Element	*Bubalus* sp.	*Panthera* cf.	*pardus*	*Cervus* sp.	*Sus verrucosus*
Cranial	1			5	
Tooth	2			4	1
Scapula	2				
Humerus	7	1		7	
radius	5			5	
cervical	2			1	
caudal	1				
femur	6			9	
tibia	3			4	
Phalanx	1			2	
Metatarsal	9			4	
Metacarpal	6	1		1	
Calcaneum	1				
TOTAL	**46**	**2**	2	**42**	1
%	**50,6**	**2,2**		**46,1**	**1,1**

the tunnel show the reef limestone that exposes in the bottom of the cave. The geological structure is tangible alignment of stalactites in the form of shear join and tension join. According to Urushibara-Yoshino and Yoshino (1997), Wonosari Formation obtained a dry climate of extreme dry conditions that characterized the last glacial stage 18,000 yrs. B.P.

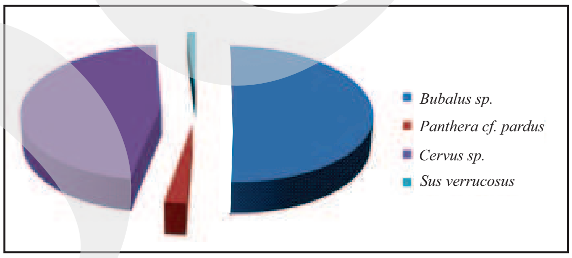

Figure 3. Composition of Seropan mammals.

Results of Paleontology

Faunal Composition

There are 113 bone and teeth fragments from large mammals collected from the cave fossil chamber of Seropan. These fossil materials are highly variable, varying in broken specimen of distal or proximal long bones. The vertebrate fauna identified in Seropan Cave is shown in Table 2. The Seropan fossil assemblage is characterized by its relatively low diversity with only four taxa identified. The fossil materials comprise large sized mammals, representing 1.1% of common wild pig (*Sus verrucosus*), 2.2% of carnivore (*Panthera* cf. *pardus*), 46.1% of cervid (*Cervus* sp.), and 50.6% of bovid (*Bubalus* sp.) (Figure 3). Long bones of the common bovid (*Bubalus* sp.) are abundant with high frequency of the humeral bones.

Faunal Preservation

These fossil materials show a fairly good state of preservation. However, most of the long bones are incomplete consisting of proximal or distal shaft remains. The incomplete condition is related to manner in which bones were broken. It is indicated that the more fragile shaft of the bone might have destroyed or removed from the site (Todd and Rapson, 1988). Meanwhile, the assemblage of the shaft of the long bones was compared to each other and accounted. It is difficult to distinguish the long bones whether as a single individu or not. It has a similarity of morphologies within the assemblage. The dominant long bone fossils are related to and controlled by depositional processes. The low flood current brought them to their deposition site. The bones entered into the sinkhole drainage system of Seropan underground streams, then deposited along the bottom by a liquid mixture of ground material terrarosa concentrated solution. It can be seen from the ground terrarosa, binding a matrix deposition pile of the bones. Compact skeletons show dominantly greater survival rather than the fragile bones. Breakage bones are due to collision, or were naturally occurring during sedimentation processes.

Cervidae

Orde Artiodactyla Owen, 1848
Family Cervidae Goldfuss, 1820
Subfamily Cervinae Goldfuss, 1820
Tribe *Cervini* Weber, 1928
Genus *Cervus* Linnaeus, 1758
Cervus sp.

It is is represented by the presence of a fragmented mandible and post cranial material of some fragmented long bones such as femora, humeri, and phalangi. GSP65 is a fragmented left mandible with M1 and P4. The other left mandible fragment is GSP69. which bears M2-M1 and P4. GSP77 is a well preserved single left mandible with small portion of slightly broken ramus side (Figure 4). The GSP77 represents M3 and M2, but the other teeth are missing and already erupted. Some measurements were taken: length, width, and the height of crown teeth were measured at the border enamel of dental (see Table 3). However, a single left mandible (GSP77) is well preserved with a small portion of a little bit broken ramus side (Figure 4).

Figure 4. The GSP 77/2012 of the left mandible of *Cervus* sp. (a. occlusal, b. lingual, c, buccal views; scale bars are 5cm).

Based on its size and dimension, the size of various M3-P4 (Table 3) from three fragmental mandibles of Seropan could be corresponded to *Cervus* sp. (Badoux, 1959). The dimension values these fragmental mandibles show a resemblance with its reference of juvenile *Cervus* sp. (Badoux, 1959). However the M3 is present, thus it is adult. In another site of the Holocene, Song Terus, *Muntiacus muntjak*, *Axis* sp., and *Cervus* sp. are present (Ansyori, 2010). Furthermore, the Sewu Mountain area in Java also has an existence of small sized deer of genus *Axis* and large sized taxa of genus *Cervus s.l.* (Meijaard and Groves, 2004; Ansyori, 2010; Gruwier *et al.*, 2015). Thus, it is argued that Seropan cervids consist of a single genus of *Cervus,* even though *Axis* or *Muntiacus* in the Seropan site is not obtained. It might be, based on a different habitat or any other separated habitat, another taxa of cervid.

Suidae

Order Artiodactyla Owen, 1841
Family Suidae Gray, 1821
Genus *Sus* Linnaeus, 1758
Sus verrucosus Müller and Schlegel, 1845

The suid fossil fragment is a left lower third molar GSP73/2012 (Figure 5). The third molar has three pairs of cusps instead of two pairs. The cusps are worn, thus they can also be called pillars. The third molar has a part of rudimentary of medial pillar in the back of posterior pair of lateral pillars. The third molar is an isolated molar ridge, elongated shape, worn, and showing the dentine. The general shape is triangular. It is measured 43.00 mm in transverse length and has a height ridge of 7.05 mm and width of 17.18 mm. The dimensions and the shape is similar to *Sus macrognathus* (Hardjasasmita, 1987). He explained that M3 of *Sus verrucosus*is is intermediate between the M3 of *Sus brachygnathus* and that of *Sus macrognathus*. These similarities in morphology of the M3 is considered to be *Sus verrucosus* that evolved from *Sus macrognathus* (Hardjasasmita, 1987; Ansyori, 2010; Frantz *et al.*, 2016) (Table 4).

Tabel 3. Teeth of Seropan Cervidae Measurements

	GSP65	GSP69	GSP77	***Muntiacus muntjak Cervus* sp.** (Badoux, 1956) Recent Java	Fossil, Punung	Fossil, Punung	***Cervus kuhli*** (Badoux, 1956) Recent Java
P4	l: 10,41 w: 6,05 h: 8,56	l: 10,99 w: 6,29 h: 5,58		l: 9,0-10,1 w: 6,0-6,8	l: 11, 5 w: 6,4	l: 10,5 w: 15,0	l: 10,0 w: 11,1
M1	l: 12,24 w: 8,26 h: 8,51	l: 10,74 w: 8,47 h: 7,56		l: 10,0-11,6 w: 11,0-13,2	l: 10,0-15,0 w: 13,0-13,5	l: 17,0 w: 21,0	l: 15,6 w: 16,1,0
M2		l: 14,56 w: 8,75 h: 9,09	l: 16,67 w: 7,01 h: 10,84	l: 12,1-13,0 w: 12,6-14,8	l: 10,5-12,7 w: 13,5-15,1	l: 19,0 w: 21,5	l: 16,5 w: 19,2
M3			l: 17,56 w: 6,92 h: 10,74	l: 12,0-13,5 w: 12,4-14,2	l: 10,0-15,0 w: 12,0-15,5	l: 16,5 w: 20,0	l: 16,7 w: 18,1

l:length; w:width; h: height

Bovidae

Order Artiodactyla Owen, 1848
Family Bovidae Gray, 1821
Bovini Gray, 1821
Bubalina Pilgrim, 1939
Bubalus Hamilton-Smith, 1827
Bubalus sp.

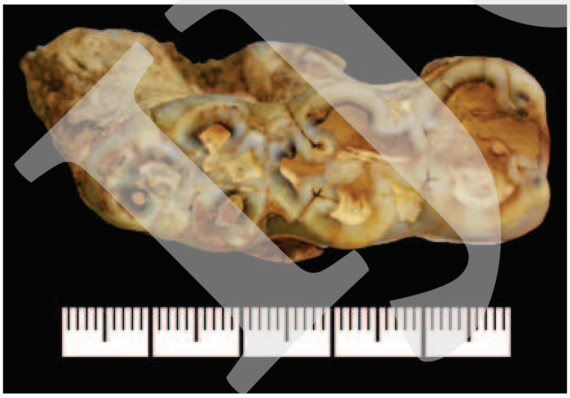

Figure 5. GSP. 73/2012 of the left lower third molar of pig (occlusal view; scale bar is 5cm).

The fossil materials collected were dominated by long bones of the bovids. Moreover, mandible and isolated teeth were also present in the collection. The long bones are humerus, femur, and tibia. The cranial portion is represented by a fragmented mandible and some isolated teeth. There is no completely long bone preserved. The long bone and mandible are most broken at their tips. The fragmented left mandible GSP63 preserved the lower M3 and M2 (Figure 6).

The teeth are hypsodont, narrow crowned, and the enamel is thick and wrinkled. Both molars have sharp cusps and show fully developed major cusps and high occlusal relief. The molars show moderately wears. The buccal side is covered by carbonate cement due to weathering effect. M3 and M2 have the ectostylid developed from the posterior lobe, and lack metastylid. Protoconid is sharp compared to that on hypoconid. Entostylidon buccal side is present, slightly abrasive and covered by carbonaceous matrix. Ectostylidis present in the third molar.

Tabel 4. Lower Third Molar (M3) of Seropan *Sus* Measurement

	Length Lower M3 mm	Width lower M3 mm	Author
Sus macrognathus	42.3 - 47.8 (n=9)	16.7-17.6 (n=9)	Hardjasasmita, 1987;p.29
Sus verrucosus	42.3 - 52.0 (n=12)		Hardjasasmita, 1987; p.38
***Sus* GSP73/2012**	43.0	17.18	this paper

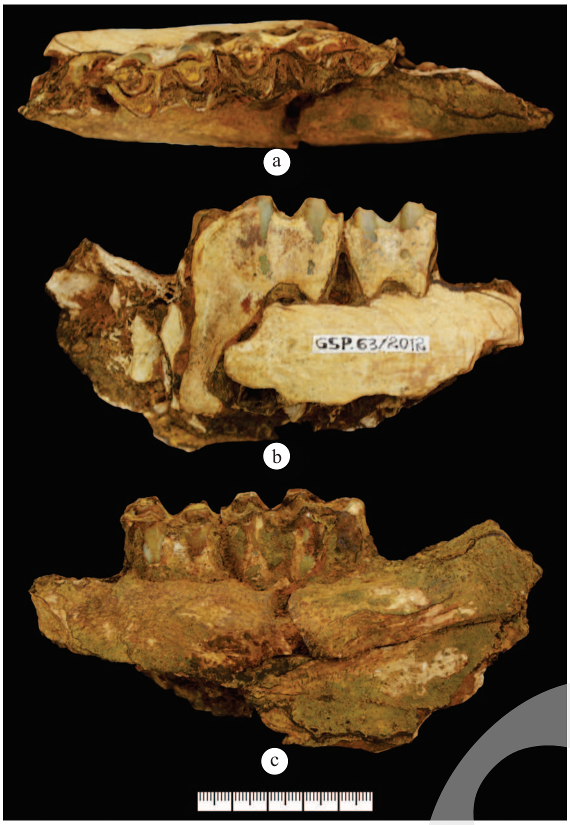

Figure 6. The left right mandible fragment GSP. 63/2012 (a. occlusal, b. lingual, c, buccal views; scale bars are 5cm).

The back fossa part developed, its fossa form is strong curved comparing to *Bos*. Posthypoconulidcristid is also present. A molar fragment of a bovid is difficult to determine to species level. Moreover, a horncore is not found, although it is a diagnostic character. The difference of *Bos* and *Bubalus* is very difficult to determine by lacking in the horncore. Based on the back fossa form of the M3 and the presence of the ectostylid, it is proposed that it is similar to the *Bubalus*. Therefore, that molar is identified to the genus *Bubalus* (Table 5).

Tabel 5. Lower Third and Second Molar (M3-M2) of Seropan Bovid Measurements

	Bos sauveli	***Bos gaurus***	***Bubalus arnee***	***Bubalus* GSP63/2012**
	Suraprasit *etal*., 2016; p.56			This paper
M3	L: 35,5 W: 23,6	L: 36,9 W: 26,9	L: 36,1 W: 26,3	L: 36,4 W: 14,6
M2	L:- W: -	L:- W: -	L: 36,1 W: 26,3	L:26,1 W: 15,1

Felidae

Order Carnivora Bowdich, 1821
Suborder Feliformia Kretzoi, 1945
Family Felidae Fischer De Waldheim, 1817
Genus *Panthera* Oken, 1816
Panthera cf. *pardus* Cuvier, 1809

The right humerus of GSP1 belongs to a felid specimen (Figure 7). The humerus is heavily damaged, missing in the humeral head (greater tubercle) proximally. The remaining length of the humerus material from Seropan can give useful measurements (Table 6). This humerus is considered to be of a matured individual. GSP1 has an entepycondylar foramen tapering shaped with curved tips. The epicondylar edge is shown in the GSP1 with blunt ridge. The humerus of Seropan carnivore distinguished from Ngandong *Panthera tigris* by oval and elongated supracondylar foramen (SFo), blunt supracondyloid ridge (SCr), flat coronoid fossa (Cf), and undeveloped deltoid tuberosity (Dt) (Table 7; Figure 8).

Distal portion of the diaphysis consists of capitulum and trochlea. The distal portion performing the humerus Seropan felid is flat coronoid fossa. However, the morphology of Seropan felid differs from the *Panthera tigris*

Figure 7. The left distal humeral shaft (a. dorsal, b. lateral, c. ventral). Scale bars are 5cm.

Table 6. Measurement of Seropan Tiger

	Shaft lenght	Middle shaft width	Distal epicondyle width
Panthera Ngandong (Reg. No. K13; Koenigswald, 1933)	384.5	53.4	103.5
Panthera Ngandong (Reg. No. K19; Koenigswald, 1933)	-	26.5	55.8
GSP1/2012	-	42.1	85.6

Table 7. Morphological Observation between Seropan Carnivore and Ngandong *Panthera*

	Seropan big cat *Pantheracf. pardus*	Ngandong *Pantheratigris* (von Koenigswald, 1933)
Supracondylar foramen (SFo)	oval elongated	narrow elongated
Supracondyloid ridge (SCr)	blunt	sharp and extended
Coronoid fossa (Cf)	flat	depressed
Deltoid tuberosity (Dt)	undeveloped	developed and sharp ridge

Figure 8. Comparison of Humerus Seropan leopard and Ngandong *Panthera tigris*. Scale bars are 5cm.

(von Koenigswald, 1933) by narrow curved tips of entepycondylar foramen. Furthermore, it is contrast with Ngandong Javanese tiger *Panthera tigris* by flat and shallow supracondyloid, and the ridge of epicondylar edge is sharp. The distal humerus of the Seropan felid is distinguishable from the extinct Javanese tiger *Panthera tigris.* It is supposed that the humerus material of GSP1 is not *Panthera tigris,* or maybe it is just a variation within the species. The distal humerus of K19 (von Koenigswald coll. no. 19) of the Late Pleistocene Javanese leopard from Ngandong deposits (von Koenigswald, 1933) is similar with the distal form of Seropan material. The Ngandong humerus is smaller than the Seropan humerus, half size compared to the Seropan material (Tabel 7). However, the flat coronoid fossa form is similar with a leopard type (Rebekka Volmer; *pers. comm*). Thus, it is supposed that this specimen refers to *Panthera pardus*.

The living Javanese leopard *Panthera pardusmelas* is still inhabitant of Java (Meijaard, 2004; Wilting *et al*., 2016). Recently, the *Panthera tigris* has been already established to be a distinct species based on the morphological evidence and phylogenetic species concept (Mazak and Groves, 2006), and separated the continental tigers *Panthera tigris* from the island tigers, and elevated them to the specific level as *P. sumatrae* of Sumatra Island and *P. sondaica* of Java Island (Feiler and Stefen, 2009). It is suggested that Seropan specimen refers to Javanese leopard *Panthera pardus melas*. The

Javanese leopards are clearly distinct from Sumatra, Kalimantan, and all other Asian leopards (Meijaard, 2004; Stein and Hayssen, 2013; Volmer *et al.,* 2016), revealing a deep history of vicariant evolution (Wilting *et al*., 2016).

Discussion

In Gunung Sewu, Punung fauna is older than Seropan mammals, and it is of Late Pleistocene (between 128±15 and 118±3 ka) (Westaway *et al.,* 2007). The Punung fauna is characterized by abundant primates such as *Macaca nemestrina, Macaca* sp.*, Hylobates syndactylus, Hylobates* cf. *leuciscus, Trachypithecus* sp., and especially *Pongo pygmaeus,* which indicated humid forest environment (Tabel 2) (de Vos, 1983; Storm and de Vos, 2006; Storm *et al.,* 2005). In Seropan mammals, four taxa are identified such as *Bubalus* sp., *Panthera* cf. *pardus*, *Cervus* sp., and *Sus verrucosus*. In Seropan mammal and other Holocene sites such as Braholo Cave and Song Keplek (Simanjuntak, 2001), *Pongo pygmaeus* is obviously not present. They had probably lost their environment and habitats due to the climatic change. During the beginning of Holocene, the increased precipitation caused the opening of savannahs and the disappearance of tropical rainforest. The climatic impact appears to the cooling and drying observed in mainland Asia, Southeast Asia, and also in South Java Island (Marwick and Gagan, 2011).

Pongo, Elephas maximus, Ursus malayanus, Macaca, and *Hylobates* are absent in Wajak, which is younger than Punung (de Vos, 1983). The average age of Wajak skull site is between 39,500±5,600 yrs. (WH1-1) and 42,000±5,100 yrs. (WH1-2), and the condition is of an open woodland environment, which fits colder and dryer climates (Storm *et al.,* 2013).

The fossil site of Wajak in the eastern part of Sewu Mountain is much older than the Seropan and Braholo fauna in the western region of Gunung Sewu (Figure 9). Song Gentong site is located near the Wajak site, but has a younger fauna containing Muridae, Suidae, Bovidae dominated among

Ages	Gunung Sewu Western	Gunung Sewu Eastern	Environment
8.7-7.7 kya		Song Gentong	Open woodland
13-9.5 kya	Seropan Cave Braholo Cave		
42-39 kya		Wajak	
128 kya		Gunung Dawung (Punung)	Rainforest

Figure 9. Scheme of the vertebrate fossil sites in Gunung Sewu.

Chiropteridae, Viveridae, Hystricidae, Cervidae, Cercopithecidae, and *Homo* sapiens. The age of Song Gentong is 8,760±190 to 7,690±70 yrs. B.P. (Simanjuntak, 2001; Marliach and Simanjuntak, 1996). The Seropan fauna resembles the Song Gentong fauna evidenced by Suidae, Bovidae, and Cervidae content. Even though the later does not have *Panthera* which may depend on the environment, it is difficult to discover due to its rarity and solitary behaviour. Sampung Cave fauna in the eastern part of Gunung Sewu also has cervids with the size and missing in *Panthera* (Erdbrink, 1954). A large cervid is present (Tabel 2).

The Braholo Cave fauna has the age of 13,765±143 yrs. B.P. of layer two in 290 cm depth (Amano *et al*., 2016), which is more or less similar to Song Keplek 11,200±600 to 5,770±60 yrs. B.P. (Sémah *et al*., 2004). These sites also show human remains and stone tools. Both fossil sites are relatively as young as Seropan Cave fauna. Moreover, Seropan is similar to the Braholo fauna and environment. The Seropan and Braholo sites are clearly in the same region in the western part of Gunung Sewu. The fauna and environment of Braholo was regarded as Late Pleistocene - Early Holocene age, due to the fauna contains *Cyclemys dentata, Cuora amboinensis, Amyda cartilaginea, Python* sp.*, Varanus* sp.*, Presbytis* sp.*, Macaca fascicularis, Trachypithecus auratus, Nycticebus javanicus, Galeopterus variegatus, Ratufa bicolour, Callosciurus* sp.*, Hystrix* sp.*, Leopoldamys* sp.*, Niviventer* sp.*, Panthera tigris, Prionailurus* sp.*, Cuon alpinus, Tragulus* sp.*, Sus verrucosus,*

Sus vittatus, Muntiacus muntjak, Axis sp.*, Rusa* sp.*, Bos javanicus, Bubalus* sp.*, Rhinoceros,* and *Elephas*, reflected as open woodland environment by the presence of bovids and cervids (Amano *et al.,* 2016). This indicates that the Seropan fauna could be part of the Braholo succesion in this region of the western part of Gunung Sewu. Hence, the Early Holocene Seropan mammals might have migrated since Late Pleistocene or earlier and isolated themselves after the postglacial age. Species diversification in a region with relative climatic stability is shown when migrated *Bubalus* sp., *Cervus* sp.*, Sus verrucosus, Panthera* cf. *pardus* developed and adapted with their morphological characters for natural adaptation in the local habitat.

Conclusion

The Seropan site is a unique karst system in Gunung Sewu with paleontological sites.The Seropan fossil mammals consist of *Bubalus* sp., *Cervus* sp.*, Sus verrucosus,* and *Panthera* cf. *Pardus* that provides the age of 9,450±400 yrs. B.P. or Early Holocene. The Early Holocene Seropan fauna is considered as part of Braholo succession in the western region of Gunung Sewu, which has migrated since Late Pleistocene, and was isolated after the last Ice Age. The mammals developed and adapted their morphology to the local habitat.

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