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

Erick Setiyabudi¹, Bambang Prasthisto², Iwan Kurniawan¹, and Teguh Jatmiko²

¹Geological Museum, Geological Agency, Bandung, Indonesia
²University of Pembangunan Nasional (UPN) "Veteran" Yogyakarta, Indonesia

Abstract - An excavation of a vertebrate fossil site was carried out in 2012 in the Seropan Cave of Gunung Sewu karst area. 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 C₁₄ 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" Yog-yakarta, 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 hominin fossils.
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

| 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            |                                                  |                                                  |                                      |                                      |                                                  |
| Hystrix javanica          |                                                  |                                                  |                                      |                                      |                                                  |
| Ursus malayanus           | x                                                |                                                  |                                      |                                      |                                                  |
| Cuon alpinus              | x                                                |                                                  |                                      |                                      |                                                  |
| Cuon javanicus            |                                                  |                                                  |                                      |                                      |                                                  |
| Panthera tigris           |                                                  |                                                  |                                      |                                      |                                                  |
| Panthera cf. pardus       |                                                  |                                                  | x                                    |                                      |                                                  |
| Felis bengalensis         |                                                  |                                                  | x                                    |                                      |                                                  |
| Paradoxurus hermaphroditus| x                                                |                                                  |                                      |                                      |                                                  |
| Elephas maximus           | x                                                |                                                  | x                                    | x                                    |                                                  |
| Rhinoceros sondaicus      | x                                                |                                                  | x                                    | x                                    |                                                  |
| Tapirus indicus           | x                                                | x                                                | x                                    | x                                    | x                                                |
| Muntiacus muntiac         | x                                                | x                                                | x                                    | x                                    | x                                                |
| Cervids                   | x                                                | x                                                | x                                    | x                                    | x                                                |
| Cervus timorensis         |                                                  |                                                  | x                                    |                                      |                                                  |
| Cervus hippelaphus        |                                                  |                                                  | x                                    |                                      |                                                  |
| Capricornis sumatrensis   | x                                                |                                                  |                                      |                                      |                                                  |
| Bubalus palaeokerbau      | x                                                |                                                  |                                      |                                      |                                                  |
| Bubalus sp.               | x                                                |                                                  |                                      |                                      |                                                  |
| Bos javanicus             | x                                                | x                                                | x                                    | x                                    | x                                                |
| Bibos palaeosondaicus     | x                                                |                                                  |                                      |                                      |                                                  |
| Sus vittatus              | x                                                | x                                                | x                                    | x                                    | x                                                |
| Sus barbatus              | x                                                |                                                  | x                                    |                                      | x                                                |
| Sus verrocosus            | x                                                | x                                                |                                      | x                                    | x                                                |
| Prebystis sp.             | x                                                |                                                  | x                                    |                                      | x                                                |
| Trachypithecus auratus    | x                                                |                                                  |                                      |                                      | x                                                |
| Macaca sp.                | x                                                |                                                  |                                      |                                      | x                                                |
| Macaca irus               |                                                  |                                                  |                                      |                                      | x                                                |
| Macaca fascicularis       | x                                                |                                                  |                                      |                                      | x                                                |
| Hylobates syndactylus     | x                                                |                                                  |                                      |                                      | x                                                |
| Pongo pygmaeus            | x                                                |                                                  |                                      |                                      | x                                                |
| Homo sapiens              | x                                                |                                                  |                                      |                                      | x                                                |
| Acanthion brachyrus       | x                                                |                                                  |                                      |                                      | x                                                |
| Rattus tiomanicus         | x                                                |                                                  |                                      |                                      | x                                                |
| Sciurus notatus           | x                                                |                                                  |                                      |                                      | 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 m² 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 (C₁₄) 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 C₁₄ 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).

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, Wono-sari, 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 elastic limestone (Figure 1b). Some parts of
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), Wono-sari Formation obtained a dry climate of extreme dry conditions that characterized the last glacial stage 18,000 yrs. B.P.

**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.

**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**               | **42**     | **1**          |
| **%**            | **50.6**    | **2.2**             | **46.1**   | **1.1**        |
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).

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 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).
The Early Holocene Vertebrate Faunas from Seropan Cave, Gunung Sewu, Yogyakarta, Indonesia (E. Setiyabudi et al.)

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 mostly 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 ectostyloid developed from the posterior lobe, and lack metastyloid. Protoconid is sharp compared to that on hypoconid. Entostylid buccal side is present, slightly abrasive and covered by carbonaceous matrix. Ectostylid is present in the third molar.

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

| GSP65 | GSP69 | GSP77 |
|-------|-------|-------|
| l: 10.41 | l: 10.99 | |
| w: 6.05 | w: 6.29 | |
| h: 8.56 | h: 5.58 | |

| P4    | l: 10.0-10.1 | l: 11.5 | l: 10.5 | l: 10.0 |
|-------|--------------|---------|---------|---------|
| w: 6.0-6.8 | w: 6.4 | w: 15.0 | w: 11.1 |
| h: 11.0-13.2 | w: 13.0-13.5 | w: 21.0 | w: 16.0 |
| M1    | l: 12.24 | l: 10.74 | l: 17.0 | l: 15.6 |
|-------|---------|---------|---------|---------|
| w: 8.26 | w: 8.47 | w: 21.0 | w: 16.1 |
| h: 8.51 | h: 7.56 | |

| M2    | l: 12.1-13.0 | l: 10.5-12.7 | l: 19.0 | l: 16.5 |
|-------|--------------|--------------|---------|---------|
| w: 12.6-14.8 | w: 13.5-15.1 | w: 21.5 | w: 19.2 |
| h: 10.84 | h: 10.1 |

| M3    | l: 12.0-13.5 | l: 10.0-15.0 | l: 16.5 | l: 16.7 |
|-------|--------------|--------------|---------|---------|
| w: 12.4-14.2 | w: 12.0-15.5 | w: 20.0 | w: 18.1 |
| h: 10.74 | h: 10.1 |

Tabel 3. Teeth of Seropan Cervidae Measurements

| Muntiacus muntjak Cervus sp. | Cervus kuhli |
|------------------------------|--------------|
| Recent Java | Fossil, Punung | Fossil, Punung | Recent Java |
| P4 | l: 10.0-10.1 | l: 11.5 | l: 10.5 | l: 10.0 |
| | w: 6.0-6.8 | w: 6.4 | w: 15.0 | w: 11.1 |
| M1 | l: 10.0-11.6 | l: 10.0-15.0 | l: 17.0 | l: 15.6 |
| | w: 11.0-13.2 | w: 13.0-13.5 | w: 21.0 | w: 16.0 |
| M2 | l: 12.1-13.0 | l: 10.5-12.7 | l: 19.0 | l: 16.5 |
| | w: 12.6-14.8 | w: 13.5-15.1 | w: 21.5 | w: 19.2 |
| M3 | l: 12.0-13.5 | l: 10.0-15.0 | l: 16.5 | l: 16.7 |
| | w: 12.4-14.2 | w: 12.0-15.5 | w: 20.0 | w: 18.1 |

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.

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

| Sus macrognathus | Length Lower M3 mm: 42.3 - 47.8 (n=9) | Width lower M3 mm: 16.7-17.6 (n=9) | Author |  |
|------------------|--------------------------------------|----------------------------------|--------|--------|
| Sus verrucosus   | 42.3 - 52.0 (n=12)                    | 17.18                            | Hardjasasmita, 1987; p.29 |

Sus GSP73/2012

This paper
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).

#### 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 coronoind 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*.
Table 6. Measurement of Seropan Tiger

|                          | Shaft length | Middle shaft width | Distal epicondylic 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 Panthera cf. pardus | Ngandong Panthera tigris (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 entepicondylar 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 pardus melas 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., Hyllobates syndactylus, Hyllobates 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 Hyllobates 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 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, Nyticicebus javanicus, Galeopterus variegatus, Ratufa bicolour, Callosciurus sp., Hystrix sp., Leopoldamys sp., Niviventer sp., Panthera tigris, Prionailurus sp., Cuon alpinus, Tragulus sp., Sus verrucosus,

![Figure 9](https://example.com/figure9.png)

**Table 2**

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