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Late Pleistocene fossil record of *Cuora amboinensis* (Testudines: Geoemydidae) from the Wajak site, East Java, Indonesia, and its paleozoogeographic and archeozoological implications

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Abstract. A Late Pleistocene fossil represented by an incomplete right hypoplastron of *Cuora amboinensis* was recovered from the Wajak site (ca. 37 ka–29 ka: Late Pleistocene) in East Java, Indonesia. The fossil constitutes the first certain prehistoric record of this species from Java, which implies that the current conspecific population in this island is indigenous to the region rather than artificially introduced from the Southeast Asian continent in historic times. The specimen has four small distinct impact pits on the hypoplastron in dorsal view, which were possibly caused by a pointed stone artifact or a bone tool. The presence of such percussion marks suggests that this turtle was consumed by the Wajak people.

Key Words: island fauna, indigenous population, percussion marks, skeletal remains, Wajak Man

Introduction

The Asian box turtle *Cuora amboinensis* (Riche in Daudin, 1801) is a middle-sized geoemydid with a movable hinge on the plastron. Its habitat ranges widely from Bangladesh, Bhutan, India, Indochina, the Malay Peninsula, Indonesia, Borneo, the Philippines, and Timor Leste (TTWG, 2017).
Based on morphological characteristics, this species has been divided into four subspecies: 1) *C. a. amboinensis* (Riche in Daudin, 1801) in the Moluccas, Sulawesi, and the Philippines exclusive of the Sulu Archipelago, 2) *C. a. couro* (Schweigger, 1812) in Sumatra, Java, and the Lesser Sunda Islands, 3) *C. a. kamaroma* Rummler and Fritz, 1991, ranging from India and Bangladesh to continental Southeast Asia, Borneo, the Nicobar Islands, and the Sulu Archipelago, and 4) *C. a. lineata* McCord and Philippen, 1998 in Myanmar (Schoppe and Das, 2011). This view was largely supported by a recent research based on geometric morphometric and molecular phylogenetic analyses (Protiva *et al*., 2016). On the other hand, Ernst *et al.* (2016) questioned the validities of the subspecific statuses of *C. a. couro* as well as *C. a. lineata* on the basis of morphological comparisons as well as their current geographic ranges. Of these two subspecies, Ernst *et al.* (2016) assumed that the former represents a hybridized form of *C. a. amboinensis* which was originally indigenous to Sumatra, Java, and the Lesser Sunda Islands, and *C. a. kamaroma* which might have been derived from either an overseas dispersal from the continent during the Pleistocene glacial periods when the sea level dramatically dropped or that it might have been artificially introduced as part of turtle trade with continental Southeast Asia, because *C. a. couro* has morphological features that are mixed between *C. a. amboinensis* and *C. a. kamaroma*. Further, Ernst *et al.* (2016) proposed that the subspecies status of *C. a. couro* should be invalidated and that this turtle should simply be synonymized with *C. amboinensis*. However, this synonymization has been challenged by TTWG (2017) based on the poorness in the number of *C. a. couro* specimens examined and the absences of statistical or graphical results from the analyses in Ernst *et al.* (2016).

The prehistoric records and fossils of *C. amboinensis* from Java, Sumatra, and the Lesser Sunda Islands would provide substantial evidences to verify the above assumptions by Ernst *et al.* (2016). However, no conspecific fossils or skeletal remains with certainties have been reported from prehistoric deposits in these islands (Naksri *et al*., 2013; TEWG, 2015). Setiyabudi (2016) reported the occurrence of a few turtle fossils temporarily referred to as *Cuora amboinensis* from a fossil bearing layer, dated 0.90 ± 0.07 mybp (Morwood *et al*., 1998), at Tangi Talo in central Flores, the Lesser Sunda Islands, Indonesia. If this is true, it would be the first Pleistocene record of this species. However, Setiyabudi (2016) lacked
appropriate morphological comparisons, descriptions, and figures for the material, verification for this identification is strongly needed. We recently searched for fossils or skeletal remains of *C. amboinensis* among the Pleistocene fossiliferous deposits on Java and discovered a small shell fragment attributed to this species from the Wajak site in East Java, Indonesia (Figure 1). In the present study, we describe this fossil and discuss its paleozoogeographic and zooarchaeological implications.

**Materials and methods**

The turtle fossil described in the present study was collected from a limestone breccia layer overlaid by recent soil (ca. 0.4 m thick from the surface) of a small excavation pit (3.7 m long, 1.3 m wide, and 0.6 m deep) at the Wajak site on September 10, 2015 (Figure 2). This site is an abandoned marble quarry in Gamping Village, Campurdarat District, Tulungagung, East Java, Indonesia. It was long considered to have been destroyed by quarrying; however, it was rediscovered in 1985 (Aziz and de Vos, 1989). The fossil-bearing deposit at the Wajak site was first excavated by van Rietschoten in 1888 and subsequently by Dubois in 1890 (van den Brink, 1982). It yielded various remains of terrestrial vertebrates known from the Greater Sunda Islands (e.g. *Prebystis* sp., *Panthera tigris*, *Manis javanica*, *Rhinoceratidae* indet., *Tapirus indicus*, *Sus scrofa*, Bovidae indet., *Cervus timorensis*, *Axis kuhlii*, *Muntiacus muntjak*, *Hystric* cf. *brachyurus*, *Callosciurus notatus*, *Rattus tiomanicus*, *Trionychidae* sp., “emydine” [a geoemydid turtle in current turtle taxonomy], and several birds and fishes) as well as the remains of a few invertebrates, the Wajak Man, and a few microliths (van den Brink, 1982; Storm, 1995).

Previously, the age of the Wajak site had been estimated as dating between the Late Pleistocene to the early Holocene on the basis of faunal characteristics (Jacob, 1967) as well as radiocarbon dates (6,560 ± 140 ybp and 10,560 ± 75 ybp [Shutler et al., 2004]). However, Storm et al. (2013) recently conducted the laser ablation U-series dating on hominid and other terrestrial vertebrate bones from the fossil-bearing deposit in this site, which provided a reliable minimum age ranging from 37.4 ka to 28.5 ka. These results
strongly suggest that the present material can be attributed to the Late Pleistocene. The fossil material is stored as WJ15/F122 in the Geological Museum Bandung, West Java, Indonesia.

Morphological comparisons were confined within the family Geoemydidae with the movable plastral hinges known from the Quaternary of Indonesia (Ernst and Barbour, 1989; TEWG, 2015; Setiyabudi et al., 2016; TTWG, 2017). Such comparisons were made with extant turtle skeletal specimens in the zoological collection of Okayama University of Science (OUS). Measurements were taken with a digital slide caliper to the nearest 0.1 mm and the shell terminology followed Zangerl (1969).

The agent and process of impact pits observed on the dorsal surface of WJ15/F122 were identified based on the criteria provided by Blumenschine et al. (1996) and Fernández-Jalvo and Andrews (2016). The configurations of the vertical and horizontal cross-sections of the percussion marks were drawn on the basis of negative casts made using a vinyl polysiloxane impression material (Exafine Putty Type, GC Corporation, Tokyo, Japan).

**Systematic paleontology**

Family Geoemydidae Theobald, 1868

Genus *Cuora* Gray, 1856

*Cuora amboinensis* Riche in Daudin, 1801

Figures 3, 4A, 5A

*Material.*—A partial right hypoplastron (WJ15/F122).

*Locality and age.*—Wajak site (08° 11’ 03,8”S, 111° 50’ 32,7”E) in Gamping Village, Campurdarat District, Tulungagung, East Java, Indonesia; Late Pleistocene, 37.4–28.5 ka (Storm et al., 2013).

*Description.*—WJ15/F122 is represented by a partially preserved right hypoplastron being semirectangular in shape and missing its anterior and medial portions. It is 38.9 mm long, 30.2 mm wide,
and 6.9 mm thick at the posterolateral plastral lip and 9.5 mm high from the basal part of the inguinal buttress. On the ventral surface, the sulcus between the abdominal and the femoral scutes (= the abdomino-femoral sulcus) is clearly defined, extending posteromedially from the basal part of the inguinal buttress. The sulcus on the lateral part of the hypoplastron is slightly projected anteriorly. The width of the sulcus between the abdominal and femoral scutes range from 0.6 to 0.7 mm. The inguinal buttress is very much reduced dorsally, with a rugose attachment scar on the lateral side for ligamentous connection with the peripherals.

Remarks.—The hypoplastron has four small and shallow pits on the dorsal side (Figure 4A: p1–p4). Of these, the pit located at the lateral part (p1) exhibits a trapezoidal shape (6.9 mm long, 4.1 mm wide, and 1.8 mm deep) and the others (p2–p4) are in semicrescent shapes (p2: 5.6 mm wide, 1.7 mm deep; p3: 3.7 mm wide, 0.9 mm deep; p4: 9.4 mm wide, 0.3 mm deep in anterior and 0.6 mm deep in posterior parts) in shapes. The abdomino-femoral sulcus produces five short aberrant sulci (Zangerl and Johnson, 1957). There are no cut marks or scratches on the dorsal and ventral surfaces.

Discussion

Within the present comparative taxa, the greatly reduced inguinal buttress with a rugose attachment scar for ligamentous connection with the peripherals on its lateral side in WJ15/F122A (Figure 3C) is seen in *Cuora amboinensis*, *Cyclemys dentata*, *Cy. enigmatica*, and *Notochelys platynota* (Smith, 1931; Yasukawa, *et al*., 2001; Fritz *et al*., 2008; Takahashi and Setiyabudi, unpublished data). WJ15/F122A lacks the anterolateral expansion of the hypoplastron (i.e. bridge part; Figure 5, Appendix 2), which is shared exclusively with *Cu. amboinensis* (Naksri *et al*., 2013). In the other three taxa, the anterior part of the hypoplastron expands laterally to form a part of the bridge connecting to the mid-lateral part of the carapace. Furthermore, WJ15/F122 is similar to *Cu. amboinensis* and differs from the others in having the inguinal buttress with extensive dorsoventral reduction. Based on the above characteristics, WJ15/F122 is attributed to *Cu. amboinensis*. 6
The present specimen (WJ15/F122) found from the Wajak site is the first certain prehistoric record of *Cu. amboinensis* from Java, suggesting that this species occurred in East Java in the Late Pleistocene (37.4–28.5 ka). Unfortunately, the systematic relationship in subspecific level between the fossil material described herein and all of the extant conspecific populations is unknown due to its poor preservation and lack of any diagnostic characteristics informative for each subspecies as indicated by Rummler and Fritz (1991) and McCord and Philippen (1998). Further studies are desired to obtain better prehistoric material of *Cu. amboinensis* from the Wajak site and confirm its subspecific attribution.

Nevertheless, the occurrence of this turtle remains from the Wajak site (Late Pleistocene, *ca.* 37–29 ka) is discordant with one of the Ernst *et al.*’s assumptions (2016) that the current *Cu. amboinensis* populations in Java were transported from the Southeast Asian continent via artificial introduction. In fact, the Wajak site yielded various terrestrial vertebrate taxa, most of which are indigenous to Java and the others became extinct from this island, both living in the Greater Sunda Island or continental Southeast Asia (van den Brink, 1982; Storm, 1995). Storm (1995) suggested that the faunal remains from this site are *ex situ*, derived by human activities and other accumulator agents (e.g., *Hystrix javanica*) on the basis of scarcity of the skeletal elements in number of each taxon, their various ecological features, and absence of abrasion or transportation marks from taphonomic perspective. Storm (1995) further assumed that these represent a subrecent (Mesolithic) faunal assemblage of Java because this site lacks any skeletal remains of domestic animals. Other late prehistoric sites in Java such as the Kecil site (3,060 ± 85 ybp) and the Hoekgrot site (895 ± 40 ybp), which have yielded domestic animals (*Felis silvestris catus* known at the former site and *Canis familiaris* at the latter), are much younger than the Wajak site (Storm, 1995; Storm *et al.*, 2013). These are no more than circumstantial evidences, but it is very likely that the Wajak people did not introduce any animals from outside of Java.

These four impact pits observed on the dorsal surface of the present right partial hypoplastron (WJ15/F122) were identified with percussion marks derived by human, based on their broad-based shapes with irregular edges (Fernández-Jalvo and Andrews, 2016) and the absences of those without shallow U-shaped cross sections, crushings on their internal surfaces (Blumenschine *et al*., 1996), and any damage
on the ventral surface, which are clearly different from bite or gnawing marks made by the humans, carnivorous and rodentian mammals, or reptiles such as crocodiles and large lizards. Two simple stone blades (microliths) made of limestone as well as a bone artifact have been found at the Wajak site (Storm, 1992, 1995). The pits on the hypoplastron might possibly be engravings by a stone or a bone tool. Because polishing, sharpening, and sculpturing all of which are generally recognized in artifacts (e.g., Claude et al., 2019) are absent, such percussion marks on this fragmentary plastral bone imply that this turtle was used as a food resource along with other hunted animals by the Wajak people.

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References


Figure captions

Figure 1. Map of Java, showing the location of the Wajak site in Gamping Village, Campurdarat District, Tulungagung, East Java, Indonesia (modified from the digital map of Indonesia Geospatial Agency, 2001). The star mark indicates the Wajak site.

Figure 2. Photographs showing the outcrop of the Wajak site before excavation (A) and the excavation pit from which the present material was found (B and C) in 2015. A, a view of the outcrop wall (c.a., 9.0 m high and 9.0 m wide) facing northeast direction; B, the excavation pit (3.7 m long, 1.3 m wide, and 0.6 m deep) set along the northeastern half the wall; C, an enlargement of the pit showing the lower fossil bearing layer (limestone breccia) and recent soil from the surface to a depth around 0.4 m. The arrow indicates the level where the fossil was found.

Figure 3. Right hypoplastron of *Cuora amboinensis* (WJ15/F122) from the Wajak site. A, dorsal view; B, ventral view; C, right lateral view. Abbreviation: ib, inguinal buttress.

Figure 4. Line drawing (A) of the right hypoplastron of *Cuora amboinensis* (WJ15/F122) from the Wajak site in dorsal view. Cross-sections (B) of the four percussion pits (p1–p4) are shown in a–b and c–d; e–f and g–h; i–j and k–l; and m–n, o–p, and q–r, respectively.

Figure 5. Right hypoplastra of the turtle remains from the Wajak site (A, WJ15/F122), *Cuora amboinensis* (B, OUS-AT437), *Cyclemys dentata* (C, OUS-AT524), *Cy. enigmatica* (D, OUS-AT412), and *Notochelys platynota* (E, OUS-AT77) in ventral views. Abbreviations: ab, the area covered by the abdominal scute; afs, the abdomino-femoral sulcus; fe, the area covered by the femoral scute; mhyp, medial border of the hypoplastron; ae, anterolateral expansion of the hypoplastron (= the bridge part).
Appendix 1. Comparative skeletal specimens of the geoemydid turtles examined in the present study.


Appendix 2. Reconstruction of the present fossil material (WJ15/F122: right hypoplastron) based on the plastron of Cuora amboinensis (OUS-AT437) in ventral view.
Figure 1. Map of Java, showing the location of the Wajak site in Gamping Village, Campurdarat District, Tulungagung, East Java, Indonesia (modified from the digital map of Indonesia Geospatial Agency, 2001). The star mark indicates the Wajak site.

170x66mm (300 x 300 DPI)
Figure 2. Photographs showing the outcrop of the Wajak site before excavation (A) and the excavation pit from which the present material was found (B and C) in 2015. A, a view of the outcrop wall (c.a., 9.0 m high and 9.0 m wide) facing northeast direction; B, the excavation pit (3.7 m long, 1.3 m wide, and 0.6 m deep) set along the northeastern half the wall; C, an enlargement of the pit showing the lower fossil bearing layer (limestone breccia) and recent soil from the surface to a depth around 0.4 m. The arrow indicates the level where the fossil was found.

80x109mm (300 x 300 DPI)
Figure 3. Right hypoplastron of *Cuora amboinensis* (WJ15/F122) from the Wajak site. A, dorsal view; B, ventral view; C, right lateral view. Abbreviation: ib, inguinal buttress.

170x72mm (300 x 300 DPI)
Figure 4. Line drawing (A) of the right hypoplastron of Cuora amboinensis (WJ15/F122) from the Wajak site in dorsal view. Cross-sections (B) of the four percussion pits (p1–p4) are shown in a–b and c–d; e–f and g–h; i–j and k–l; and m–n, o–p, and q–r, respectively.

79x69mm (300 x 300 DPI)
Figure 5. Right hypoplastra of the turtle remains from the Wajak site (A, WJ15/F122), Cuora amboinensis (B, OUS-AT437), Cyclemys dentata (C, OUS-AT524), Cy. enigmatica (D, OUS-AT412), and Notochelys platynota (E, OUS-AT77) in ventral views. Abbreviations: ab, the area covered by the abdominal scute; afs, the abdomino-femoral sulcus; fe, the area covered by the femoral scute; mhyp, medial border of the hypoplastron; ae, anterolateral expansion of the hypoplastron (= the bridge part).

169x44mm (300 x 300 DPI)
Appendix 2. Reconstruction of the present fossil material (WJ15/F122: right hypoplastron) based on the plastron of Cuora amboinensis (OUS-AT437) in ventral view.

79x110mm (300 x 300 DPI)