

[Original report]

An Early Pleistocene giant tortoise (Reptilia ; Testudines ; Testudinidae) from the Bumiayu area, Central Java, Indonesia

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Abstract

A well-preserved specimen of a gigantic testudinid tortoise from the Early Pleistocene Kali Glagah Formation of the Bumiayu area, Central Java, Indonesia is described in detail. The Bumiayu specimen is referable to the largest testudinid, *Megalochelys sivalensis*, typically known from the Plio-Pleistocene of Siwalik, Punjab, India, based on its huge size and prominent Y-shaped anterior projection of the epiplastron. Although Bumiayu specimen is identified as *Megalochelys* cf. *sivalensis* here, a few distinct characters of the former suggest the possibility of independent evolution resulting from the biogeographical isolation of the insular form from the continental population.

Key words : Pleistocene, Systematics, *Megalochelys* cf. *sivalensis*, Testudinidae, Testudines, Java, Indonesia.

Introduction

The Early Pleistocene non-marine deposits on the Bumiayu area, Central Java, Indonesia, have yielded extinct testudinid tortoises (van der Maarel, 1932; ter Haar, 1934; Koenigswald, 1935: Fig. 1). A large skeleton, from one individual (K1587-1589, GSI) including large part of the shell, is here referred to *Megalochelys sivalensis* Falconer and Cautley, 1837. *Megalochelys sivalensis* was originally described from the Plio-Pleistocene of Siwalik, India, and is considered the largest land tortoise (roughly estimated as 2 m in straight shell length) (Lapparent de Broin, 2002). *Megalochelys sivalensis* is characterized by a prominent Y-shaped anterior projection of the epiplastron (Loveridge and Williams, 1957). The Bumiayu specimen has been tentatively assumed to be conspecific to *M. sivalensis* (ter Haar, 1934; Koenigswald,

1935; Hooijer, 1954, 1971a, b, 1982; Sondaar, 1981). Nevertheless taxonomic status of the Bumiayu specimen should be reexamined, because this fossil has never been described in detail. Recently, I have an opportunity to compare the Bumiayu specimen with *M. sivalensis* and the other gigantic extinct testudinids from different localities of Indonesia, such as Sulawesi, Timor, and Flores Islands. In this paper, I describe the Bumiayu specimen with and discuss its taxonomic identity. Although *M. sivalensis* has been famous as the largest known terrestrial turtle since the 19th Century, its skeletal anatomy was largely obscured by its fragmentary nature of Indian materials. Thus, this report will throw new light on the morphology of this gigantic tortoise species.

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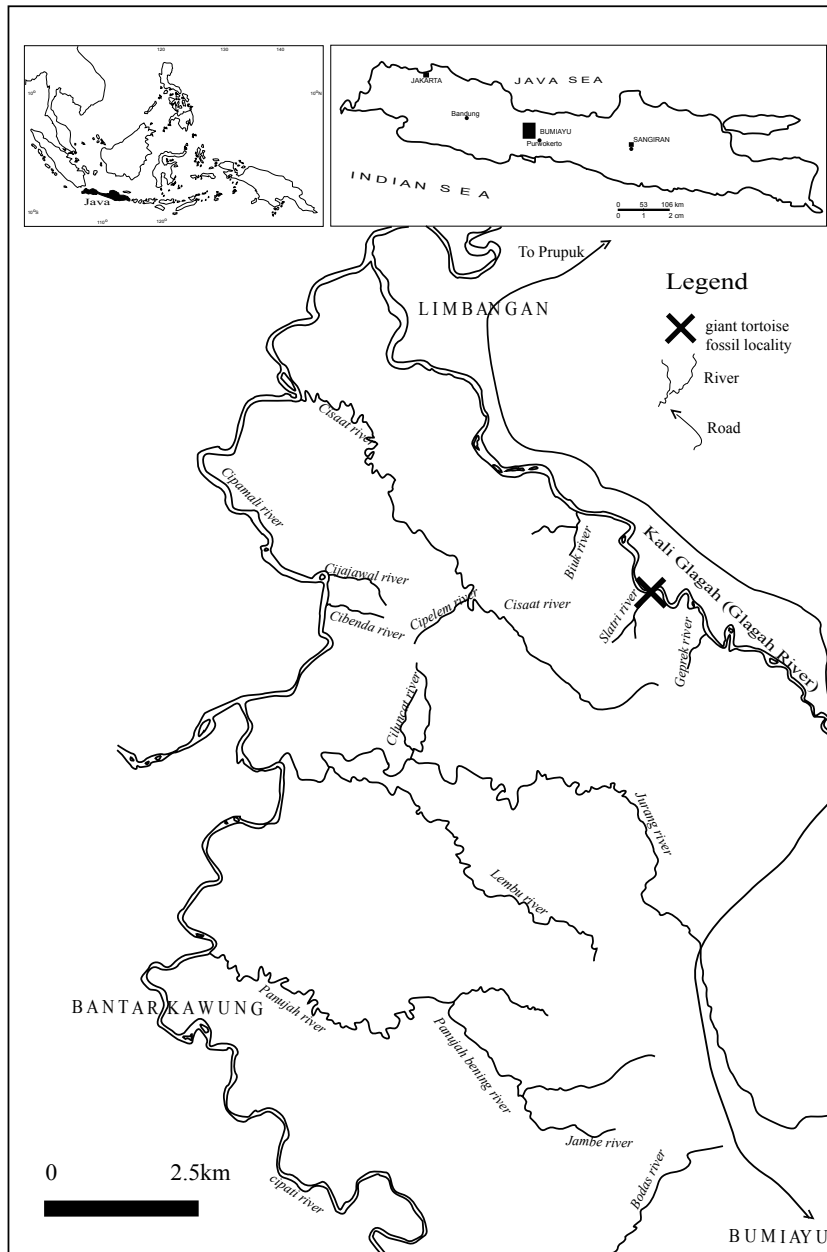


Fig. 1. Map showing the locality of fossil turtle in Kali Glagah (Glagah River) of the Bumiayu area, Central Java, Indonesia.

Materials and methods

I examined the Plio-Pleistocene fossil testudinids from Java, Sulawesi, Flores and Timor Islands of Indonesia. The Geological Museum, Geology Survey Institute, Bandung, Indonesia (GSI) keeps the fossil materials from Java, Sulawesi, and Flores Islands, while other Sulawesi and Timor specimens are stored in the Archaeological Agency in Jakarta

(AAJ) and the Rijksmuseum van Natuurlijke Historie, Leiden, the Netherlands (RMNH). GSI gives the registered specimens from Java as K (Koenigswald). Bumiayu specimen consists of large part of carapace and plastron (K1857a), detached anterior portion of plastron (K1857b), femora (right side : K1588a, and left side : K1588b), and pelvic girdle (K1589) of one individual. K1857a is so fragile that it was difficult to

remove this large shell material from a protective girdle in order to take a photo from the ventral side. Therefore, ventral view of the main part of plastron was shown as a drawn illustration. The Indian materials of *Megalochelys sivalensis* were examined in the Natural History Museum, London (BMNH as catalogued by Lydekker, 1889b). We observed extant testudinid skeletons in the private collections of Ren

Hirayama (RH) and Akio Takahashi (AT) as comparative materials. Skeletal terminology used in this study follows Walker (1973) and Zangerl (1969). The most of comparative characters follows Loveridge and Williams (1957), Crumly (1984), Gaffney and Meylan (1988), Meylan and Sterrer (2000), Takahashi *et al.* (2003), and Claude and Tong (2004).

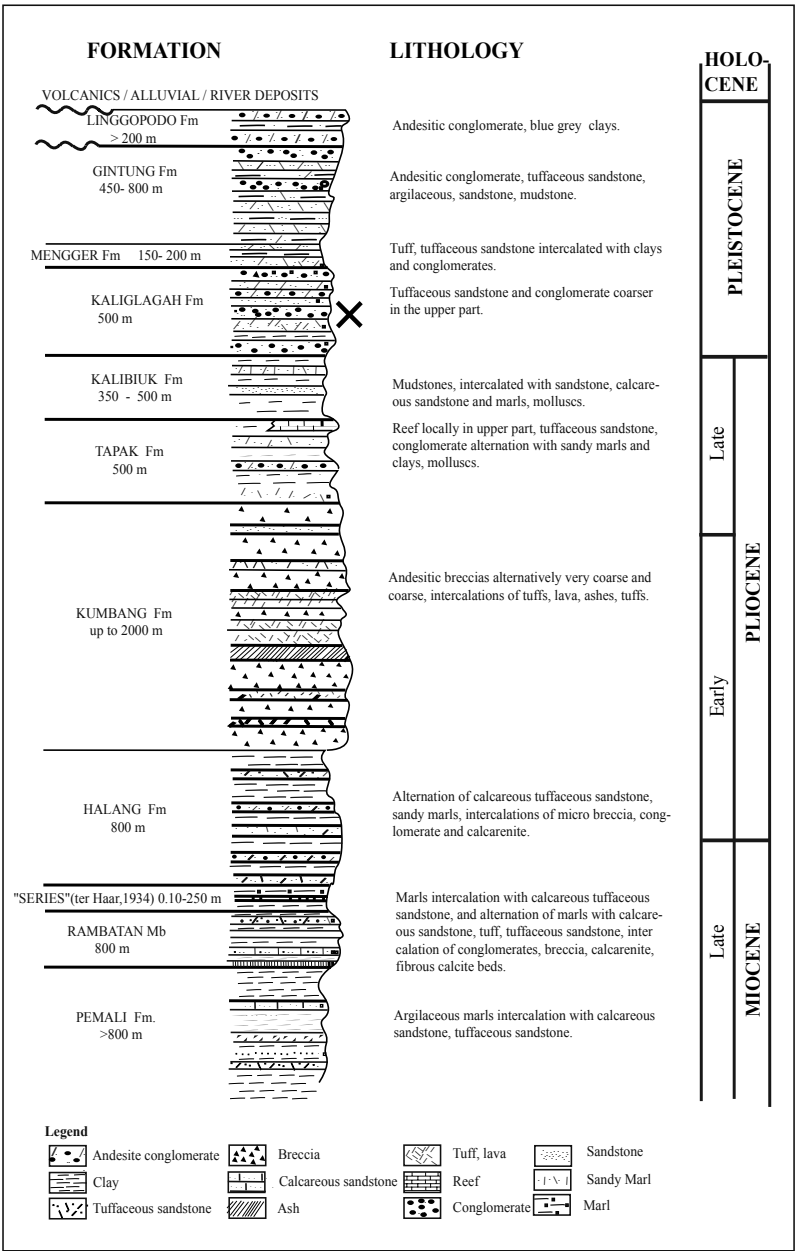


Fig. 2. Stratigraphy of the Kali Glagah Formation in the Bumiayu area (modified from Sumarso and Suparyono, 1974). X indicates the horizon of fossil turtle.

Geological setting

The Kali Glagah Formation mainly consists of tuff and tuffaceous sandstone with intercalation of clays and conglomerates in the upper part, and contains shells of *Unio*, *Melania*, *Corbicula*, and *Viviparus*, plant remains, and vertebrate fossils in lower part (Sondaar, 1984; Sumarsono and Suparyono, 1974; Kastowo and Suwarna, 1996; Fig. 2). Mammals, including carnivores, rodents, artiodactyls, and proboscideans, and reptiles such as testudinids were found from its sandstone beds (ter Haar, 1934). The Kali Glagah Formation is considered to be continental to shallow marine deposits (coastal or fluvio-deltaic near the base, becoming increasingly terrestrial towards the top) (Kastowo and Suwarna, 1996). Leinders *et al.* (1985) dated it at about 1.5 Ma based on its vertebrate fauna from the base of the Kali Glagah Formation. The vertebrates of this horizon are classified as the Satir Fauna, the oldest mammalian biostratigraphic unit in Java (Sondaar, 1984; de Vos, 1985). The paleomagnetic evidence from the base of Kali Glagah Formation is preceding the Olduvai Event (Se'mah, 1986). Van den Bergh (1999) suggests that the first mammalian colonization in western part of Java Island occurred about 2 Mya.

Systematic Paleontology

Class Reptilia

Order Testudines Linnaeus, 1758

Suborder Cryptodira Cope, 1868

Superfamily Testudinoidea Batsch, 1788

Family Testudinidae Batsch, 1788

Genus *Megalochelys* Falconer and Cautley, 1837

Type species—Megalochelys sivalensis

Emended diagnosis—The genus *Megalochelys* is revised according to the following combination of diagnostic characters: gigantic testudinid with shell up to 2 m long; epiplastron with a large Y-shaped projection and pronounced median ventral ridge; posterior excavation of dorsal part of the epiplastron at dorsal part reduced.

Remark—The scientific name of *Megalochelys sivalensis* was first mentioned to the gigantic testudinids from the Pleistocene deposits of Siwalik, Punjab, India by Falconer and Cautley (1837). This name was later replaced as *Colossochelys atlas* by Falconer and Cautley (1844), although neither description nor illustration was given. Fitzinger (1843) designated

Megalochelys to *Testudo gigantea* Schweigger 1812 from the Aldabra Islands (see Williams, 1952), which is now placed in genus *Dipsochelys* (Bour, 1982). *Megalochelys* was also used as a subgenus of *Testudo* Linnaeus 1758 (Falconer and Cautley, 1844; Lydekker, 1889a). The taxonomic history of *Megalochelys* is often conflated with that of *Colossochelys atlas* Falconer and Cautley, 1844 also from the Pliocene of India and Pakistan. Maack (1869) mentioned *C. atlas* as *Colossochelys (Megalochelys) atlas*. Lydekker (1880) retained *Colossochelys* as the subgenus of genus *Testudo*, and Lydekker (1885) first gave a clear diagnosis and illustrations for *C. atlas*. A large portion of carapace of *M. sivalensis* from Siwalik, was reported as the first mounted skeleton of *Testudo atlas* without proper description (Brown, 1931; Ren Hirayama, personal observation). The generic name of *Testudo*, however, was once used as a wastebasket taxon applied to most testudinids (Auffenberg, 1974), of the name of *Geochelone (Megalochelys) atlas* was used by Loveridge and Williams (1957), and Auffenberg (1974). As the holotype of *Colossochelys atlas* designated by Lydekker (1889b) is clearly a part of specimens mentioned by Falconer and Cautley (1837) as *M. sivalensis*, the latter scientific name is considered as valid and has a priority to fulfill the requirement of Article 12 of the International Code of Zoological Nomenclature (ICZN, 2000).

Megalochelys cf. sivalensis

(K 1587a and K 1587b; figs. 3-6)

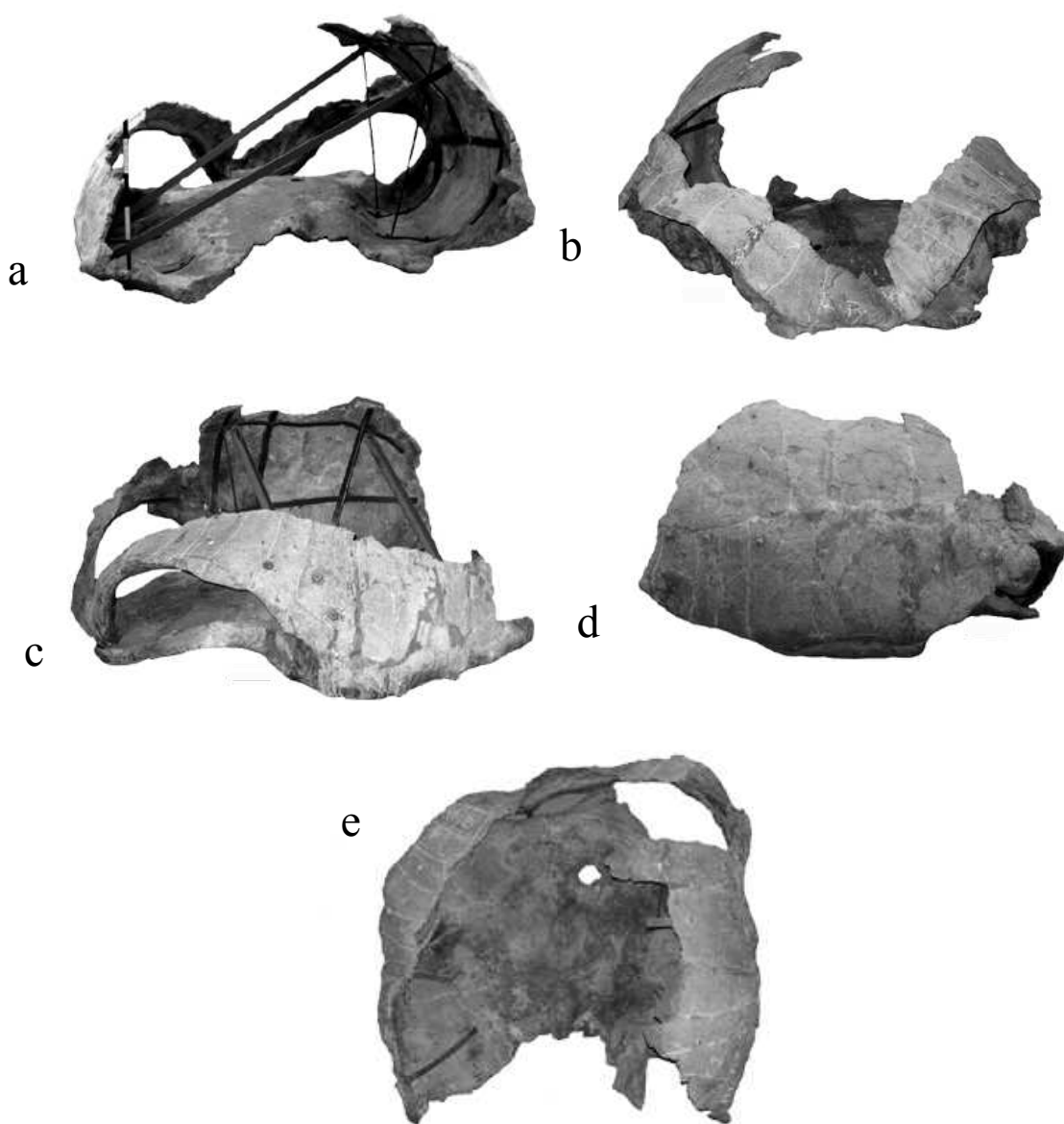
Colossochelys atlas Falconer and Cautley 1844 in ter Haar, 1934: 34

Geochelone atlas Falconer and Cautley 1844 in Hooijer, 1971: 504

Referred specimens.—postcranial materials of one individual; a large part of the shell (K 1587a; Figs. 3-4), anterior portion of the plastron (K1587b; Fig. 5), pelvic girdle (K 1589; Fig. 6), and femora (K 1588a and K1588b; Fig. 6).

Locality and horizon—Lower part of the Kali Glagah (Glagah River) Formation near the Satir village of Bumiayu area, Central Java, Indonesia (Ter Haar, 1934).

Diagnosis—supracaudal single; gular part with smooth dorsal surface; anterior tip of the epiplastron bifurcated in obtuse angle; the inguinal divided into two parts; anal notch of xiphiplastron shallow.



— 10 cm

Fig. 3. Shell of *Megalochelys* cf. *sivalensis* from the Bumiayu area, Central Java (K1587a). Anterior (a), posterior (b), right (c) and left laterals (d), and dorsal (e) views.

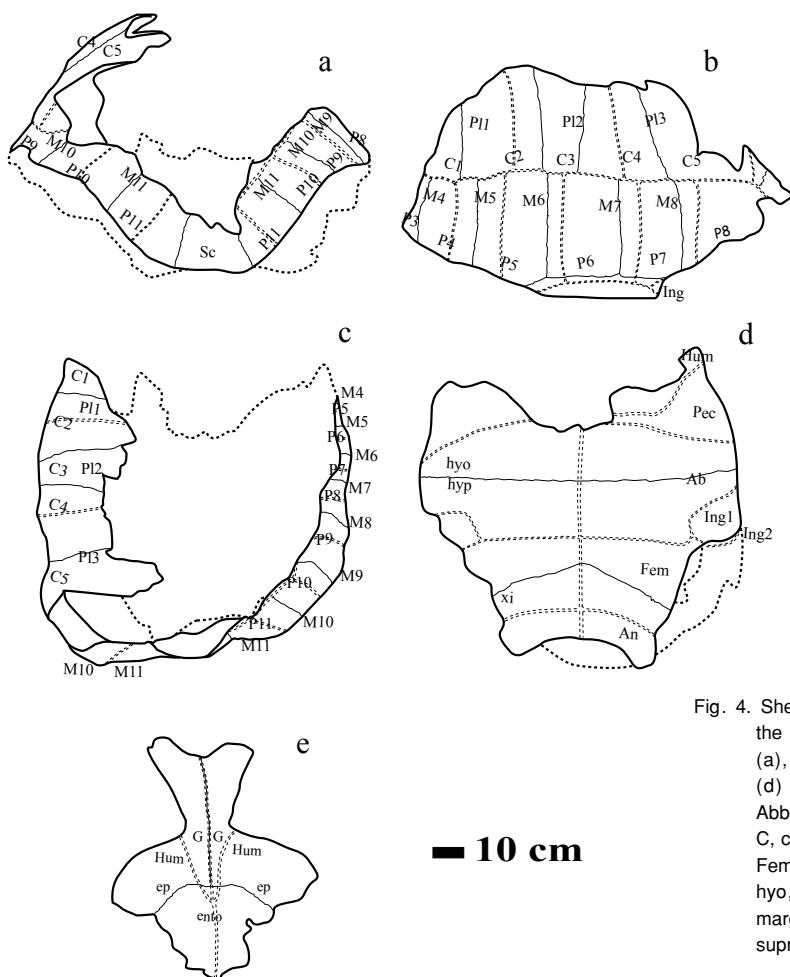


Fig. 4. Shell of *Megalochelys* cf. *sivalensis* from the Bumiayu area, Central Java. Posterior (a), left lateral (b), dorsal (c), and ventral (d) views of the shell (K 1587 a and b). Abbreviations : Ab, abdominal ; An, anal ; C, costal ; ent, entoplastron ; ep, epiplastron ; Fem, Femoral ; G, gular ; Hum, humeral ; hyo, hyoplastron ; hyp, hypoplastron ; M, marginal ; P, peripheral ; Pl, pleural ; Sc, supracaudal ; and xi, xiphiplastron.

— 10 cm

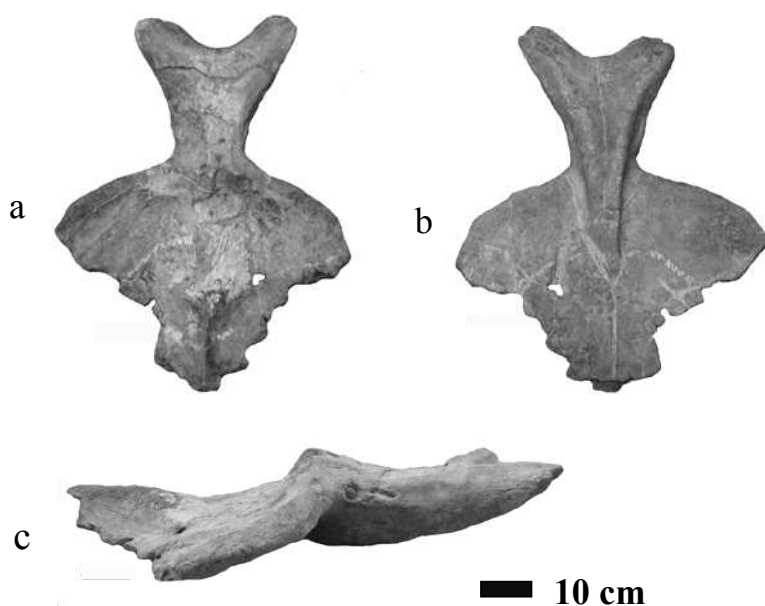


Fig. 5. Anterior portion of the plastron (K 1587b) of *Megalochelys* cf. *sivalensis* from the Bumiayu area, Central Java. Dorsal (a), ventral (b), and lateral (c) views.

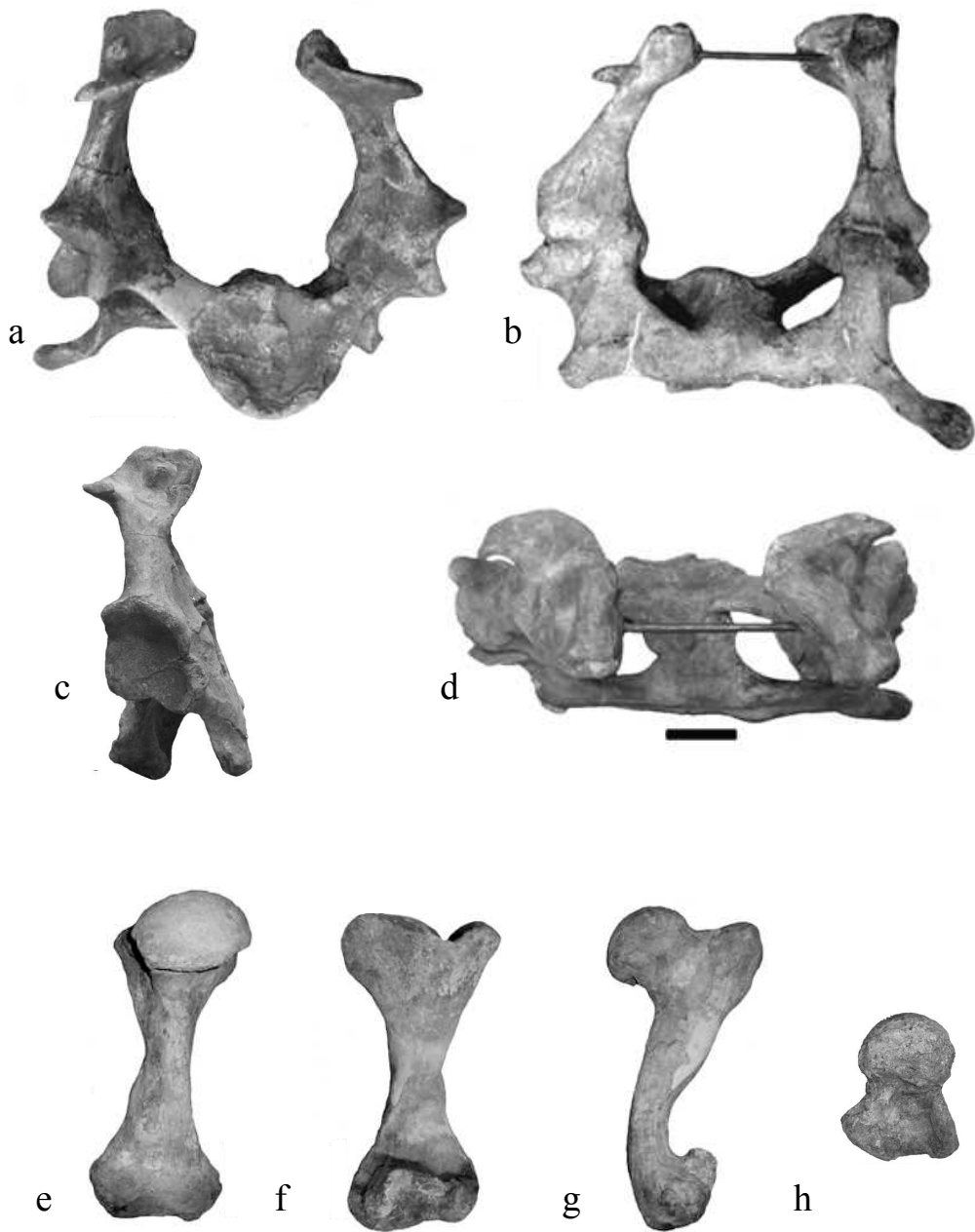


Fig. 6. Appendicular skeleton of *Megalochelys* cf. *sivalensis* from the Bumiyau area, Central Java. Posterior (a), anterior (b), lateral (c) and dorsal (d) views of pelvic girdle (K1589). Dorsal (e), ventral (f), lateral (g), and proximal end (h) views of left femur (K1588b).

Description

Shell (Figs. 3 – 5)

A large part of the shell (K 1587a and b) is preserved. Shell is 1.20 m in height, and 1.1 m in width.

Carapace (K 1587a) is 1.50 m long as preserved, almost oval in dorsal view, but slightly deformed posterolaterally (Figs. 3e and 4f). Of the carapacial elements, left first to fifth costals, left third, both left and right fourth to eleventh peripherals, and the pygal are preserved. The carapace has the thickness of varying from 1 to 7 cm at the costal to bridge parts. The distal halves of the left costals are preserved. The proximal end of the third costal is two times wider than its distal end, whereas width of the fourth costal is narrower at the proximal portion than the distal. This wedge pattern of the costals is very often seen in advanced testudinids (Auffenberg, 1974; Meylan and Sterrer, 2000; Takahashi *et al.*, 2003). The bridge consists of the fourth to seventh peripherals. The thoracic rib ends of third to sixth costals insert at the border of the fourth to seventh peripherals medially. The sulcus between the marginal and pleural scutes runs along the suture between peripherals and costals (Fig. 4b). Supracaudal scute is single as seen in most testudinids

(Crumly, 1984; Claude and Tong, 2004).

The plastron is almost complete, 1.74 m long as preserved. The anterior part of the plastron (K 1588b) is isolated from K 1588a (Figs. 4c-d, and 5). The middle part of the plastron is concave dorsally. This feature is characteristic to the most of male extant testudinids (Auffenberg, 1974). The epiplastra are characterized by a pronounced ventral median ridge and elongate Y-shaped anterior projection as in other *Megalochelys* (Fig. 5). The gular portion has a smooth ventral surface as in other *Megalochelys* specimens from Sulawesi, Flores, and Timor islands, lacking longitudinal ridges seen in *M. sivalensis* from India (Table 1). The posterior excavation of the dorsal part of the epiplastron is reduced as in *M. sivalensis*, and other gigantic testudinids from Indonesian islands. The inguinal scale is subdivided into two parts. The larger one contacts femoro-abdominal sulcus, while the smaller one is located within the inguinal notch. The inguinal buttress (K 1587a) reaches the fifth and sixth costals. The xiphiplastron is thickened, and narrow along the femoro-anal sulcus. Its anal notch is very shallow. The average width of scale sulci on the plastron is 8 mm.

Table 1. Comparisons of *Megalochelys sivalensis* with extinct gigantic tortoises from Indonesia.

Characters	<i>Megalo- chelys sivalensis</i> from Siwalik	Fossil gigantic tortoises from the Indonesian Islands			
		Java	Sulawesi	Flores	Timor
carapacial length	± 2 m	1.74 m (plastron)	1.5 m (plastron)	0.97-1.37 m	?
thick shell	yes	yes	yes	no	yes
single supracaudal	yes/ no	yes	?	yes	?
surface of epiplastral projection	ridged	smooth	smooth	smooth	smooth
angle between both tips of bifurcated epiplastral projection	acute	obtuse	?	obtuse	?
single inguinal	?	no	yes	?	?
shallow anal notch	deep	shallow	deep	shallow	deep
Characters shared with Java tortoise	3/7	—	3/7	5/7	2/7

Pelvic girdle (Fig. 6a-d)

The pelvic girdle (K 1589) is complete except for the right pectineal process. It is 545 mm in height. The acetabulum is 124 mm in height, and 145 mm in width. The iliac blade is thick and a bend medially as in other testudinoids (Hirayama, 1984).

Femur (Fig. 6e-h)

Both femora are preserved. The left femur (K 1588b) is complete, 430 mm in length and 160 mm in width at proximal end. The right femur (K 1588 a), 410 mm long as preserved, is damaged at proximal and distal ends. The femoral trochanters are completely joined by the ventral.

Discussion

The Bumiayu specimen has the following derived features of testudinids; 1) Marginal-pleural sulcus running along the peripheralo-costal suture; 2) Femoral trochanters completely connected by the ventral ridge.

The epiplastron with a large Y-shaped projection and a pronounced median ventral ridge of the Bumiayu specimen are considered as autoapomorphic features shared by *Megalochelys sivalensis* from sub-Indian Continent, as no other turtle has such characters. The gigantic size with shell up to 2 m long is also regarded as another autoapomorphic character of the genus *Megalochelys* (Auffenberg, 1974). The Bumiayu specimen appears to be the most complete among all *Megalochelys* specimens (Hirayama, personal communication).

The Bumiayu specimen differ from *M. sivalensis* from India in having longitudinal ridge, wider angle of Y-shaped epiplastral projection and shallower anal notch of xiphiplastron (Table 1). Thus, the Bumiayu specimen is identified as *M. cf. sivalensis* in this report. Moreover, this testudinid seems to differ from the other extinct gigantic tortoises from Indonesia. Further investigations are needed to reveal testudinid species richness of Indonesia during the Plio-Pleistocene.

Similar gigantic testudinid is also known from the Plio-Pleistocene deposits of Upper Irrawaddy, Myanmar (Zin Maung-Maung, unpublished data). This unpublished material has the ventral gular portion with longitudinal ridges as in *M. sivalensis* from India. Therefore, if ridged gular portion was primitive feature among *Megalochelys*, this might

suggest Indonesian species was an insular form once separated from the continental population (van den Bergh *et al.* 2001), although more detailed taxonomic analysis should be done in future.

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インドネシア・中部ジャワのブミアユ地域から産出した前期更新世大型リクガメ化石

インドネシア中部ジャワのブミアユ地域のカリガルガ層から産出したよく保存された前期更新世の大型リクガメ化石を詳細に記載した。このブミアユ標本は、非常に大きなことや外腹甲骨がY字型に強く前方に曲がるといった特徴によりシワリク、パンジャブ、インドの鮮新—更新統から産出している最大のリクガメである *Megalochelys sivalensis* に比較される。しかし、ブミアユ標本は、大陸の個体群とは生物地理的に隔離された島嶼型であった可能性を示す、いくつかの異なる特徴を持ち、ここでは *Megalochelys* cf. *sivalensis* として同定する。