A revision of *Testudo tungia* Yeh, 1963 from the Lower Pleistocene Gigantopithecus cave, Liucheng, Guangxi Province, China

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Abstract

Testudo tungia Yeh, 1963[1] from the lower Pleistocene Gigantopithecus cave, Liucheng, Guangxi Province, China is revised. Based on the characters of the plastron/carapace connection and neural pattern, this taxon can be confidently assigned to the genus *Cuora*. The combination of characters including a long and narrow pygal which is as long as the peripheral 11, a wide fourth vertebral scute which is clearly wider than the third vertebral, a trapezoid fifth vertebral scute and the pluromarginal sulcus running the same level with costoperipheral suture are different from other *Cuora* species. *Cuora tungia* (Yeh, 1963) is thus considered as a valid species. The presence of some testudinid characters such as high domed carapace suggests that *C. tungia* is a terrestrial species.

Keywords: revision, *Testudo tungia*, *Cuora,* Lower Pleistocene, China

Introduction

Testudo tungia was erected by Yeh in 1963 on the basis of an almost complete carapace without plastron (IVPP V2768) from the Lower Pleistocene *Gigantopithecus* cave, Liucheng, Guangxi Province, China[1]. Yeh assigned this small turtle with a high domed carapace to the genus *Testudo* (Testudinidae). This assignment was first questioned by Auffenberg, who suggested that it is 'Probably not even a testudinid, perhaps referable to the genus *Cuora'* (Auffenberg, 1974[2], p. 211). The taxon is nevertheless remains in the literatures[3,4,5] and has never been revised. Here we provide the systematic revision of *Testudo tungia* Yeh, 1963[1]. Our study confirms that this specimen is referable to the genus *Cuora* (Geoemydidae) and the species remains valid. The specimen is housed in the Institute of Vertebrate Paleontology and Paleonantropology (IVPP), Chinese Academy of Sciences, Beijing, China.

Systematic palaeontology

Order Testudines Linnaeus, 1758
Suborder Cryptodira Cope, 1868
Superfamily Testudinoidea Batsch, 1788
Family Geoemydidae Theobald, 1868
Genus *Cuora* Gray, 1855
Cuora tungia (Yeh, 1963)
(Figures 1 and 2)

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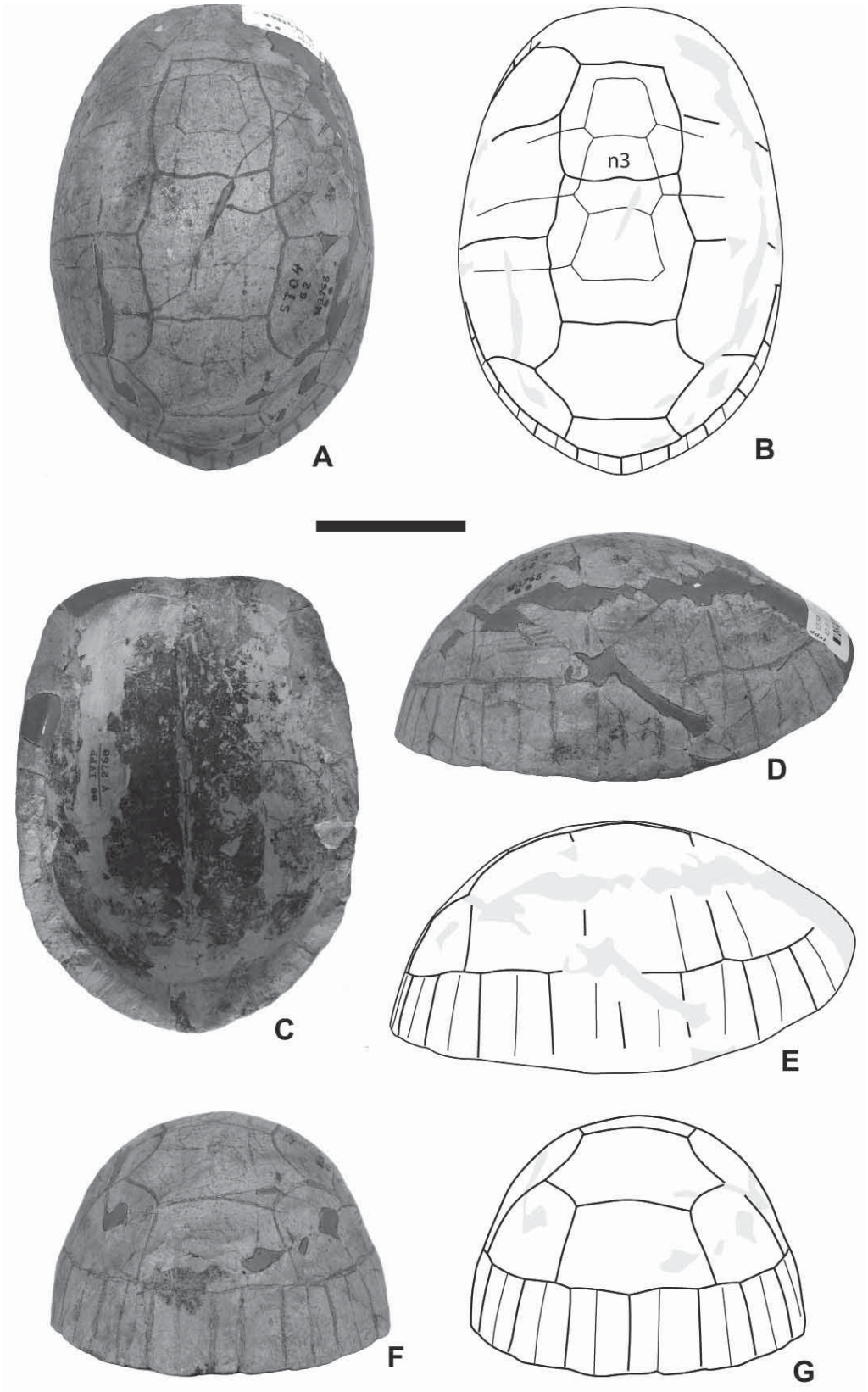

Figure 1 Carapace of *Cuora tungia* (Yeh, 1963) from Gigantopithecus cave, Liucheng, Guangxi Province, China. Holotype (IVPP V 2768): carapace in dorsal view, photograph (A), drawing (B); in visceral view, photo graph (C); in lateral view, photograph (D), drawing (E); in posterior view, photograph (F), drawing (G). Scale bar equals 5 cm.

Holotype: A nearly complete carapace (IVPP V 2768)
Type locality and horizon: Gigantopithecus Cave, Liucheng, Guangxi Province, China. Lower Pleistocene[1].
Measurements: Carapace length 14.5 cm; width 10 cm; and height 6.5 cm.
Modified diagnosis:
A species of *Cuora* of medium size (carapace length about 15 cm). Carapace high domed and oval in shape with smooth anterior and posterior margins. It differs from all other *Cuora* species in having a narrow and elongated pygal which is as long as peripheral 11, a wide fourth vertebral scute that is clearly wider than the third vertebral scute, a trapezoid fifth vertebral scute, and pleuromarginal sulcus matching the costoperipheral suture.

Description

IVPP V 2768 is a nearly complete carapace with some restorations indicated by smooth darker bands. Sulci are well preserved in vertebral and marginal scutes while some sutures are fused except the second to fourth neurals, peripherals and a few costals (Figure 1).

The carapace has an oval outline and is high domed (Figure 1, A). The outer surface of carapace is rather smooth; but some growth annuli are visible in lateral view. There is no cervical notch. The posterior carapace margin is smooth. There is no midline keel.

The anterior rim of the nuchal is straight. The sutures between nuchal and peripherals, as well as the nuchal/first neural suture are not discernible. Most of neurals are fused together except the second to fourth. They are hexagonal with short postero-lateral sides and wider than long. The third neural is crossed by the vertebral sulcus at about the mid-length of the plate. The remaining neurals and suprapygals are not distinguishable. The pygal is narrow and as long as the peripheral 11. The anterior margin of this plate matches the pleuromarginal sulcus, and the plate is crossed by the twelve marginal sulcus at the midline. The posterior margin of the pygal is not notched. All costals are preserved but most of their sutures are fused. The peripheral sutures are well visible. They are slender and elongated. One musk duct foramen is presented on the fourth peripheral (Figure 2). The fourth to seventh peripherals contribute to the bridge.

The cervical scute is not visible. The sulci of the first vertebral scute are mostly missing while the second through fifth vertebrals are well preserved. The second vertebral scute is roughly as wide as long. The third vertebral scute which is the longest, is longer than wide. The fourth vertebral scute is wider than long with angled lateral sulci. The fifth vertebral scute is narrower than the fourth. It is trapezoid in shape. Most pleural scute sulci are visible. The third pleural scute is the longest. The fourth pleural is shorter than the second and third. It contacts the anterior half of the ninth to the posterior half of the eleventh marginals. The pleuromarginal sulcus matches the costo-peripheral suture (Figure 1, D-G). The marginals are high, even in the posterior part of carapace.

In ventral view, the weak axillary and inguinal buttresses do not reach the costal plates, and contact the fourth and seventh peripherals respectively. The bridge is thus very short (Figure 1, C). The carapace is not sutured with the plastron. A medially directed triangular process is present on the medial margin of the fifth peripheral, which is well preserved on the left side (see Figure 1, C). This structure suggests the presence of a hinge between the hyoplastron and the hypoplastron.

Figure 2 *Cuora tungia*: musk duct foramen is presented on the fourth peripheral at the right side indicated by tip of the pencil.

Comparison and discussion

Although IVPP V2768 present some testudinid characters such as the pleuromarginal sulcus matches the costoperipheral suture and the elongated pygal that is as long as the peripheral 11. This specimen should be excluded from *Testudo* and Testudinidae (see Table 1), mainly because the carapace is not sutured to the plastron. The presence of musk duct foramen enclosed on the peripheral is characterized of Geoemydidae[6,7,8]. It does not have the differentiated neurals with octagonal alternate with tetragonal which is common in testudinid turtles. The presence of the wide neural plates with short posterolateral sides, short bridge, the ligamentous plastron/carapace connection and the presence of a hinge between the hyoplastron and the hypoplastron are characteristic of the genus *Cuora* (Geoemydidae). Among geoemydids, *Notochelys* and *Cyclemys* have also a hinge on the plastron. However, the carapace of *Notochelys* has a flat top and six vertebral scutes; while *Cyclemys* has a more flattened carapace with a distinct midline keel. The specimen belongs to an adult individual as indicated by the absence of the fontanelles between the costals and peripherals, and the fusion of some plates on the carapace.

Cuora is a genus of the family Geoemydidae which contains twelve living species[9,10] including *Cuora amboinensis, C. aurocapitata, C. bourreti, C. flavomarginata, C. galbinifrons, C. mccordi, C. mouhotii, C. pani, C. picturata, C. trifasciata, C. yunnanensis,* and *C. zhoui*. IVPP V 2768 differs from *Cuora mouhotii*, *C. bourreti*, and *C. yunnanensis* by its smooth anterior and posterior carapace margins and the absence of a pygal notch. It is similar to *C. amboinensis, C. flavomarginata, C. galbinifrons, C. mccordi* and *C. picturata* but different from *C. aurocapitata*, *C. bourreti*, *C. mouhotii*, *C. pani*, *C. trifasciata*, and *C. zhoui* in having a high domed carapace.

The genus *Cuora* is present in the fossil record since the Miocene[4,11]. IVPP V2768 differs from *Cuora chiangmuanensis* from the late Middle Miocene of Thailand[11], *C. pitheca* Yeh, 1981[12] from the Late Miocene of Lufeng, Yunnan, China[4,13,14] and *C. miyatai* (Shikama, 1949)[15] from the Middle Pleistocene of Japan[15,16,17,18,19] and also most living species by a longer pygal plate. The position of the pleuromarginal sulcus relative to the costoperipheral suture in IVPP V2768 is similar to that of *C. aurocapitata*, *C. flavomarginata*, *C. miyatai, C. mccordi, C. pani,* and *C. mouhotii*. The fifth vertebral scute of IVPP V2768 is a trapezoid. This character differs from all other *Cuora* species except *C. galbinifrons and C. mouhotii.* In addition, IVPP V2768 differs from other *Cuora* species in having a wide fourth vertebral. The comparisons of IVPP V2768 with other fossil and living species of *Cuora* and some Testudinid turtles are shown in Table 1.

Conclusion

Our revision confirms that IVPP V2768 is not a *Testudo*, but belongs to *Cuora*, as suggested by Auffenberg (1974). The comparisons with the fossil and living species of the genus *Cuora* support the validity of the species. Within the genus *Cuora*, the carapace morphology of *Cuora tungia* (Yeh, 1963) is closer to that of *C. flavomarginata* than to other species. The presence of some testudinid characters such as high domed carapace, pleuromarginal sulcus matching the costoperipheral suture and a high pygal suggest that *C. tungia* is a terrestrial species.

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Table 1 Comparisons of *Cuora tungia* (Yeh, 1963) with other fossil and living species of *Cuora* and some testudinid turtles.

Taxa / Characters	Carapace height	Neural pattern*	Plastron/carapace connection	Bridge length	Posterior carapace margin	Length of pygal	Pygal notch	Fourth vertebral	Shape of fifth vertebral	12th marginal scutes	Pleuromarginal sulcus**
Cuora tungia	High	A	Ligamentous	Short	Smooth	As long as peripheral 11	Absent	Clearly wide	Trapezoid	Unfused	C
Testudo graeca	High	B	Sutured	Long	Slightly serrated	As long as peripheral 11	Absent	Relatively wide	Fan-shape	Fused	C
T. hermanni	High	B	Sutured	Long	Slightly serrated	As long as peripheral 11	Absent	narrow	Fan-shape	Unfused	C
T. horsfieldii	High	B	Sutured	Long	Serrated	As long as peripheral 11	Present	Relatively wide	Hexagonal	Fused	C
T. kleinmanni	High	B	Sutured	Long	Slightly serrated	As long as peripheral 11	Absent	Relatively wide	Hexagonal	Unfused	C
Cuora chiangmuanensis	Low	A	Ligamentous	Short	Smooth	Shorter than peripheral 11	Absent	Relatively wide	Hexagonal	Unfused	D
C. pitheca	?	A	Ligamentous	Short	Smooth	Shorter than peripheral 11	?	Wide	Hexagonal	Unfused	D
C. miyatai	High	A	Ligamentous	Short	Smooth	Shorter than peripheral 11	Present	Relative wide	Hexagonal	Unfused	C
C. amboinensis	High	A	Ligamentous	Short	Smooth	Shorter than peripheral 11	Absent	Wide	Hexagonal	Unfused	D
C. aurocapitata	Low	A	Ligamentous	Short	Smooth	Short, wider than long	Absent	Wide	Hexagonal	Unfused	C
C. bourreti	high	?	Ligamentous	Short	Slightly serrated	Shorter than peripheral 11	Present	Relatively wide	Hexagonal	Unfused	?
C. flavomarginata	High	A	Ligamentous	Short	Smooth	Shorter than peripheral 11	Absent	Relatively wide	Hexagonal	Unfused	C
C. galbinifrons	High	A	Ligamentous	Short	Smooth	Shorter than peripheral 11	Absent or present	Relatively wide	Hexagonal or trapezoid	Unfused	D

Table 1 Comparisons of *Cuora tungia* (Yeh, 1963) with other fossil and living species of *Cuora* and some testudinid turtles (cont.).

Taxa / Characters	Carapace height	Neural pattern*	Plastron/carapace connection	Bridge length	Posterior carapace margin	Length of pygal	Pygal notch	Fourth vertebral	Shape of fifth vertebral	12th marginal scutes	Pleuromarginal sulcus**
C. mccordi	High	A	Ligamentous	Short	Smooth	Shorter than peripheral 11	Present	Relatively wide	Hexagonal	Unfused	C
C. mouhotii	Low	A	Ligamentous	Short	Serrated	Shorter than peripheral 11	Present	Wide	Hexagonal or trapezoid	Unfused	C
C. pani	Low	A	Ligamentous	Short	Slightly serrated	Shorter than peripheral 11	Absent	Relatively wide	Hexagonal	Unfused	C
C. picturata	High	?	Ligamentous	Short	Smooth	Shorter than peripheral 11	Present	Relatively wide	Hexagonal	Unfused	?
C. trifasciata	Low	A	Ligamentous	Short	Smooth	Shorter than peripheral 11	Absent	Relatively wide	Hexagonal	Unfused	?
C. yunnanensis	high	?	Ligamentous	Short	Slightly serrated	Shorter than peripheral 11	Present	Wide	Hexagonal	Unfused	?
C. zhoui	Low	A	Ligamentous	Short	Smooth	Shorter than peripheral 11	Absent	Wide	Hexagonal	Unfused	D

*A= Hexagonal with short posteroanteriorly sides, B= Alternative octagonal with tetragonal;

**Pleuromarginal sulcus at posterior marginals; C= At same level of costoperipheral suture, D= Below costoperipheral suture