

Morphology of cervical vertebrae of *Annemys* and variability of neck morphotypes in xinjiangchelyid turtles

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Background. Xinjiangchelyidae are a group of basal cryptodires from the Middle Jurassic – Early Cretaceous of Asia and Early Cretaceous of Europe. Recent studies show that xinjiangchelyids are rather uniform and conservative in their shell morphology and comparatively more variable in skull shape. Morphology and variability of cervical vertebra(e) (*cv*) of xinjiangchelyids remain poorly known. More or less complete series of *cv* were described for *Xinjiangchelys qiguensis* and *X. tianshanensis*, whereas for other xinjiangchelyids they are alternately unknown or often incomplete, deformed and need additional preparation.

Methods. We examined several hundred isolated *cv* of a xinjiangchelyid *Annemys* sp. from the Middle Jurassic (Bathonian) Itat Formation of Berezovsk Quarry, Krasnoyarsk Territory, West Siberia, Russia. Some of these *cv* are well preserved and three-dimensional and allow reconstruction of the complete series of *cv* of *Annemys*.

Results. The formula of *cv* is (II(III)IV)V(VI)VII(VIII), although *cv* VIII is rarely amphicoelous. Previously, xinjiangchelyids were thought to have only amphicoelous *cv*. All *cv* are relatively short (similar to other forms of *Annemys*, shorter than in *X. tianshanensis* and much shorter than in *X. qiguensis*). The anterior and posterior central articulations are approximately on one level. The anterior central articulations form a wide triangle (II), equilateral triangle (III, IV), or wide oval (V–VIII); the posterior central articulations form a narrow oval (II–V, VIII), roundish (VI) or wide oval (VII). The ventral keel is low on the anterior *cv* and high on *cv* VII and VIII, a condition similar to some sinemydids/macrobaenids

and more advanced cryptodires. The parapophyses are located at the posteroventral edge of the centrum in *cv* II–V, and at the anteroventral edge of the centrum in *cv* VI–VIII. The articular surfaces of the prezygapophyses face dorsolateral in *cv* II or dorsomedial in more posterior *cv*, forming an angle of about 20° from the horizontal in *cv* III and IV and about 30–35° in *cv* V–VIII. The postzygapophyses are widely separated, unlike *X. qiguensis* and similar to other forms of *Annemys* and *X. tianshanensis*. Isolated cervical ribs are present in the material, but their associations with *cv* are unclear.

Discussion. Our study shows that xinjiangchelyids were more variable in the morphology of their *cv* than thought previously. They demonstrate three neck morphotypes: the short-necked (*Annemys*), medium-necked (*X. tianshanensis*) and long-necked (*X. qiguensis*). In addition to length of *cv*, these morphotypes differ in cervical formula, shapes of central articulations, and patterns of cervical rib attachment. Morphology of the *cv* of *Annemys* suggests the possibility of both vertical and lateral movements of the neck that agrees with recent studies on neck mobility of primitive turtles.

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