Thalattosauria is a clade of marine reptiles exclusively known from the Triassic (Nicholls, 1999; Rieppel et al., 2000). It remained poorly understood until the end of the 20th century, because the only records then known were from North America and Europe. In recent years, abundant, well-preserved thalattosaur material has been excavated in sediments of Middle to Upper Triassic age of southwestern China. Four genera and eight species have been recognized amongst this Chinese material: *Anshusaurus huangniensis* Liu, 1999; *Xinpusaurus suni* Yin in Yin et al., 2000; *Xinpusaurus bamaolinensis* Cheng, 2003; *Xinpusaurus kohi* Jiang et al., 2004; *Anshusaurus wushaensis* Rieppel et al., 2006; *Anshusaurus huangnihensis* Cheng et al., 2007a; *Miodentosaurus brevis* Cheng et al., 2007b; and *Concavispina biseridens* Zhao et al., 2013. Among the taxa, the type species of the genus *Xinpusaurus suni* Yin in Yin et al., 2000 was described on the basis of four poorly prepared specimens that were collected from the Carnian (early Late Triassic) Wayao Member of the Falang Formation of Guizhou Province, southwestern China (the lithostratigraphic unit name ‘Wayao Formation’ used by Yin et al. [2000] was proposed to be invalid by Wang et al. [2002], who alternatively proposed a new lithostratigraphic unit name, ‘Xiaowa Formation,’ but Jiang et al. [2005] and Li [2006] suggested continuing to use the traditional unit name, as is done in this paper). The original description of the species was brief and short, illustrated with low-quality photographs, and the taxon was incorrectly referred to Ichthyosaurus. Liu and Rieppel (2001) identified an isolated skull (IVPP V11860) collected from the same locality and same stratigraphic level as *Xinpusaurus* cf. *X. suni* and referred *Xinpusaurus* to Thalattosauria. Their phylogenetic analysis indicated that *Xinpusaurus* is the sister taxon of *Nectosaurus* from North America. Subsequently, this isolated skull and two additional incomplete specimens (IVPP V12673, IVPP V14372) were referred to *X. suni* by Liu (2001) and Rieppel and Liu (2006), whereas the skull of the holotype was redescribed by Luo and Yu (2002) along with one additional specimen (GGM 6001).

The second species of *Xinpusaurus*, *X. bamaolinensis* Cheng, 2003, was based on a single specimen (SPCV 30015) that was incompletely prepared and imperfectly described. The third species, *X. kohi* Jiang et al., 2004, was erected on the basis of a nearly complete skeleton (GMPKU2000/005). Liu and Rieppel (2005) proposed that *X. kohi* is a junior subjective synonym of *X. bamaolinensis*, whereas Liu (2013) suggested that both *X. bamaolinensis* and *X. kohi* are subjective junior synonyms of *X. suni*. However, Maisch (2014) countered that *X. kohi* was valid and could be taxonomically distinguished based on diagnostic characters, whereas the taxonomic status of *X. bamaolinensis* remained problematic. Our personal observation of GMPKU2000/005 supports Maisch’s (2014) interpretation of the taxonomy of *Xinpusaurus*. Therefore, in this paper, we follow Jiang et al. (2005) and Maisch (2014), in treating *X. kohi* as a valid species and *X. bamaolinensis* as a species inquirenda.

All specimens of *Xinpusaurus* previously known were collected in the Carnian (Upper Triassic) deposits of Guanling County, Guizhou Province. Here, we report a new specimen from the Ladinian (Middle Triassic) of Xingyi, Guizhou, southwestern China. Journal of Vertebrate Paleontology. DOI: 10.1080/02724634.2016.1218340.
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(2013), and the coding for *X. suni* was modified based on our personal observations (Appendix 1). The new data matrix comprised 18 ingroup taxa and three outgroup taxa, and 40 characters that were treated as unordered and unpolarized (Supplemental Data). The branch-and-bound search found two equally parsimonious trees with a tree length of 93 steps, a consistency index of 0.5484, and a retention index of 0.7614.

**Institutional Abbreviations**—GMPKU, Geological Museum of Peking University, Beijing, People’s Republic of China; Gm, GGSt, Geological Survey of Guizhou, Guiyang, Guizhou, People’s Republic of China; IVPP, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, People’s Republic of China; SPCV, formerly Yichang Institute of Geology and Mineral Resources, now Wuhan Institute of Geology and Mineral Resources, Wuhan, Hubei, People’s Republic of China; XNGM WS, Xingyi National Geopark Museum at Wusha, Xingyi, Guizhou, People’s Republic of China.

**Systematic Paleontology**

**Thalattosauria** Merriam, 1904

**Thalattosaurus** Nopcsa, 1928

**Xinpusaurus** Yin in Yin et al., 2000

**Type Species**—*Xinpusaurus suni* Yin in Yin et al., 2000.

**Emended Diagnosis**—Medium to large thalattosaur with moderately long rostrum; rostrum straight or slightly bent dorsally with pointed anterior tip; anterior alveolar margin of maxilla curved dorsally, carrying enlarged procumbent teeth; nasal forming entire dorsal margin of external nares; pineal foramen situated on posterior part of parietals; vomer and pterygoid dentigerous; alveolar margin of dentary straight anteriorly and curved posteriorly; slender mandible with dentary symphyseal region tapering to a narrow tip; strong obvrite between upper and lower jaws; anterior teeth (on premaxilla, anterior maxilla and dentary) conical and pointed, more posterior teeth blunt; number of cervical vertebrae no more than seven; neural spines of anterior caudal vertebrae more than seven; neural spines inclined posteriorly; humerus wider proximally than distally; radius strongly broadened.

*XINPU SAURUS XINGYIENSIS*, sp. nov. (Figs. 1–3)

**Holotype**—XNGM WS-53-R3, a nearly complete and articulated skeleton.

**Horizon and Locality**—Middle part of Zhuganpo Member (= ‘Zhuganpo Formation’ of Wang et al. [2002]), Falang Formation; about 0.6 m below the base of the ammonite *Haoceras xingyiensis* Zone, which is in part equivalent to the lower part of the North American *Frankites sutherlandi* Zone, of the middle Late Ladinian, Middle Triassic (Zou et al., 2015). Nimaigu Village, Wusha Town, Xingyi City, Guizhou Province, People’s Republic of China.

**Etymology**—The specific epithet is derived from the name of the city in the territory from which the specimen was excavated.

**Diagnosis**—Posterior process of jugal absent; coracoid oval; radius only about half as long as humerus; dorsal and ventral margins of ilium approximately equal in width; femur without mediolateral constriction; fibula without mediolateral expansion.

**Description**

The specimen is nearly complete except for the tail (Fig. 1), with a preserved length of 2.1 m. Including the estimated length of the missing distal part of the tail, the complete skeleton may have exceeded 3 m in length. The length of the skull may be estimated to exceed 42 cm, as indicated by the length of the mandible. This specimen is larger than any other known specimen of *Xinpusaurus*, in which the total body length is ≤ 2.38 m long, with a skull that is at most 34 cm in length (Yin et al., 2000; Luo and Yu, 2002).

**Skull**

The premaxillaries are disarticulated and exposed in medial view. They are elongate elements, with straight dorsal and alveolar margins. Each element is medially thickened, both dorsally and ventrally, resulting in the formation of an elongate groove running along the middle part of the medial surface. Posteriorly, the postero-dorsal ramus of the premaxilla is longer than the posterodorsal ramus. Three teeth are preserved on the left premaxilla and six on the right one, all of which are conical and pointed. The maxillae are large, elongate triangular elements with long posterior processes. The anterior-most part of the maxillary alveolar margin is curved dorsally, carrying procumbent teeth, similar to those of *Xinpusaurus suni* (Liu and Rieppel, 2001; pers. observ.), *X. kohi* (Jiang et al., 2004; pers. observ.), *X. bamaolinensis* (Cheng, 2003), and *Concavispina biseriata* (Luo et al., 2013; Zhao et al., 2013; pers. observ.). There are four teeth exposed on each maxilla. All teeth are subthecodont, relatively blunt, and located on the anterior part of the maxillae. Both jugals possess long anterior and dorsal processes, but unlike in other thalattosaurs, a posterior process is uniquely absent. The smooth posterodorsal margin on both jugals indicates that no process that

FIGURE 1. Skeleton of the holotype of *Xinpusaurus xingyiensis*, sp. nov. (XNGM WS-53-R3). Scale bar equals 10 cm.
might originally have been present was broken off during fossilization or preparation. All previously known specimens of *Xinpusaurus* are smaller in size, but a posterior process of the jugal is well developed in all of them. The absence of a posterior process of the jugal in the new specimen thus cannot be explained by ontogenetic variation because it is unlikely that the process was resorbed with growth. Both quadrates are dislocated. One is mostly obscured by other skull elements, whereas the other one is well exposed (Fig. 3). The quadrate is a large and robust element, with a prominent anterior flange.

The vomers appear fused along the midline at least posteriorly and form the anterior margins of the internal nares. The posterior end of the vomer is embraced by the anterior ramus of the pterygoids. Each side of the fused vomers bears three blunt teeth. The palatine is poorly preserved. The pterygoids are triangular, each with a slender anterior ramus, a broad transverse process, and a long posterior ramus. Many teeth concentrate on the transverse process of the pterygoids, as is also the case in *X. suni* (Liu and Rieppel, 2001; Luo and Yu, 2002; Rieppel and Liu, 2006; pers. observ.), *X. bamaolinensis* (Cheng, 2003), and *X. kohi* (Maisch, 2014; pers. observ.). The interpterygoid vacuity is narrow. The parabasisphenoid is partly preserved. Anteriorly, it appears to extend into a long and narrow cultriform process located within the interpterygoid vacuity. Posterolaterally, it possesses prominent paired basipterygoid processes like those of *Anshunsaurus huangguoshuensis* (Lü and Rieppel, 2005), but only the left one is complete.

The lower jaw is exposed in ventral view. The right mandibular ramus is well preserved, although partially concealed by overlapping bones. The anterior part of the left ramus is missing. The length of the mandibular symphysis is unknown because of the incomplete preservation. The dentary bears a long posterodorsal process that contacts the underlying surangular, as is also the case in *X. suni* (Liu and Rieppel, 2001; Rieppel and Liu, 2006; pers. observ.), whereas a posteroventral process as observed in *X. kohi* (Jiang et al., 2004; pers. observ.) and *Concavispina biseridens* (Liu et al., 2013; Zhao et al., 2013; pers. observ.). The neural spines and hemal arches of the caudal vertebrae are extremely slender, as in other thalattosaurs. All caudal neural spines are posterodorsally inclined, a feature that Jiang et al. (2004) considered a diagnostic feature of the genus *Xinpusaurus*. The fused neurocentral suture throughout the vertebral column indicates that the specimen here described is an adult.

The left scapula is partly preserved; it appears elongated judging by its outline (Fig. 3). Its posterior margin is concave, whereas most of the dorsal and anterior margins are convex. In *X. suni*, both the anterior and posterior margins of the scapula are almost straight (Liu, 2001:fig. 1; pers. observ.). Both coracoids are slightly deformed, but they appear to be oval in shape. In contrast, *X. suni* possesses a more elongate, trapeziform coracoid (Liu, 2001:fig. 1; pers. observ.). The interclavicle is cruciform, with a short anterior process and an elongate posterior shaft. The shaft is much narrower posteriorly than anteriorly, resembling that of *Miodentosaurus* (Wu et al., 2009). The clavicles are robust, with the shaft curved at an angle of about 120° (Fig. 2). The humeri are relatively short, with expanded proximal and distal ends. Similar to *Xinpusaurus suni* (Yin et al., 2000; Liu, 2001; pers. observ.), *X. bamaolinensis* (Liu, 2013), *X. kohi* (Jiang et al., 2004; pers. observ.), and *Concavispina biseridens* (Zhao et al., 2013; pers. observ.), the proximal end of the humerus is wider than the distal end. The deltopectoral crest is

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**FIGURE 2.** Skull and mandible of *Xinpusaurus xingyiensis*, sp. nov. (XNGM WS-53-R3). A, photograph; B, interpretive drawing. Abbreviations: ang, angular; ar, articular; axar, axis neural arch; ca, caudal vertebra; d, clavicle; cvar, cervical neural arch; dr, dorsal rib; dv, dorsal vertebra; ha, hemal arch; j, jugal; m, maxilla; pm, premaxilla; psbs, parabasisphenoid; pt, pterygoid; q, quadrate; sang, surangular; spl, splenial; v, vomer. Both scale bars equal 5 cm.
well developed and exposed in ventral view on the right humerus. The radius is short (32 mm) and broad, with a convex lateral margin and a concave medial margin, showing a roughly reniform shape. The length of the radius is 0.54 that of the humerus, whereas in the holotype of *X. suni* (Gmr010), this ratio is 0.63 (Liu, 2001:table 1). Specimen Gmr010 is in some respects a smaller skeleton (34 cm in skull length, 2.38 m in total length), but its radius is longer (39 mm). In other known specimens of *X. suni*, this ratio ranges from 0.63 to 0.69 (Liu, 2001:table 1) and is 0.63 in *X. kohi* (pers. observ.). The difference in radius/humerus length ratio between these taxa and among these specimens does not reflect ontogenetic variation, but is probably taxonomically significant. The anteroproximal notch of the radius is absent, a trait that is different from *X. suni* (specimen GGSr001; pers. observ.) and *X. kohi* (Jiang et al., 2004; pers. observ.) but similar to *X. suni* specimen IVPP V12673 (Liu, 2001:fig. 1; pers. observ.).

The ilium (Fig. 3) is curved, bearing a rectangular dorsal blade. The ventral (acetabular) margin is approximately as wide as the dorsal margin, a morphology similar to that observed in *Concavispina biseridens* (Liu et al., 2013; pers. observ.), but dissimilar from *X. suni* (Gmr010), in which the ventral and dorsal margins of the ilium measure 20 and 12 mm, respectively (Yin et al., 2000). The pubis is incomplete, but a small obturator foramen can be discerned. The cylindrical femur is much longer than the humerus. The shaft of the femur shows no mediolateral constriction, which is different from *X. suni* (Liu, 2001:fig. 1; pers. observ.) and *X. kohi* (Jiang et al., 2004:fig. 3C; pers. observ.). Although the surface of the femur is damaged, a well-developed internal trochanter can be recognized. Both tibiae are well preserved; the left one is preserved in articulation with more distal limb elements. The tibia has a strongly expanded proximal end, and slightly expanded distal end, as is also the case in other thalattosaurs. The fibula is of nearly the same length as the tibia. It
is expanded distally but not laterally, which is different from the condition of *X. suni* and *X. kohi* (Liu, 2001: fig. 1; Jiang et al., 2004: fig. 3C; pers. observ.). Three tarsals are present: the astragalus and one distal tarsal of the right side, and the calcaneum of the left side. Both the astragalus and calcaneum are reniform, the former larger than the latter. The distal tarsal is oval and smaller than the calcaneum. Five metatarsals of the left hind limb are preserved, of which the first is the shortest, showing a distinct proximal expansion, and the fourth is the longest. Several phalanges are preserved, including two ungual phalanges, but the phalangeal formula remains unknown. The ungual phalanges are triangular in shape, with a sharp distal tip.

**DISCUSSION**

The new specimen, XNGM WS-53-R3, described above can be easily identified as a thalattosaur based on its strongly elongated caudal neural spines and hemal arches, and the stout and flat limbs, which are important diagnostic features of Thalattosauria (Müller, 2007). Furthermore, XNGM WS-53-R3 clearly belongs to the genus *Xinpusaurus*, because it shares the following synapomorphies of the genus: the anterior alveolar margin of the maxilla curves dorsally and carries procumbent teeth; the proximal end of the humerus is wider than the distal end; the lateral margin of the radius is convex; and the medial margin is concave. Specimen XNGM WS-53-R3 also shares some morphological similarities with *Concavisina*, such as the neural spines of dorsal vertebrae that show a concave dorsal margin. However, *Concavisina* possesses two rows of large and blunt maxillary teeth, with a height/basal diameter ratio of the largest tooth crown of only about 0.6 (pers. observ.), corresponding to crushing teeth as defined by Massare (1987) on the basis of a height/basal diameter ratio of 1.0 or smaller. In contrast, the maxillary teeth of XNGM WS-53-R3 are relatively small, and the height/basal diameter ratio of the largest tooth crown is larger than 1.5, thus corresponding to crunching teeth as defined by Massare (1987). Furthermore, *Concavisina* differs from specimen XNGM WS-53-R3 here described by its dentary, which carries a long postero-dorsal process, and by its fibula, which shows a strongly constricted shaft. In conclusion, the new specimen XNGM WS-53-R3 here described must be referred to the genus *Xinpusaurus*, rather than to *Concavisina*.

Within the genus *Xinpusaurus*, *X. xingyiensis*, sp. nov., can be distinguished from *X. suni* by the following features: the posterior process of the jugal is absent; the coracoid is oval rather than trapeziform; the radius is relatively short; the ventral and dorsal margins of the ilium are nearly equal in width; the femur shows no mediolateral constriction; and the fibula shows no mediolateral expansion. Most of these features also distinguish *X. xingyiensis*, sp. nov., from *X. kohi*. The original description of *X. bamaolinensis* is brief, rendering a detailed comparison difficult, but at least it can be distinguished from *X. xingyiensis*, sp. nov., by the unique morphology of the jugal that characterizes the latter species. We therefore conclude that *X. xingyiensis*, sp. nov., represents a separate species of *Xinpusaurus*.

To test the phylogenetic position of *X. xingyiensis*, sp. nov., within its genus, a phylogenetic analysis was carried out. The strict consensus tree shows the genus *Xinpusaurus* to be a

![FIGURE 4. Strict consensus tree indicating relationships between *Xinopusaurus xingyiensis*, sp. nov. (XNGM WS-53-R3) and other thalattosaurs (see text for more details). Values above branches leading to the nodes represent Bremer support.](image-url)
monophyletic grouping, in which X. xingyiensis, sp. nov., appears in a basal position (Fig. 4). This clade is supported by the following characters: 22(1), posteroventral process of dentary indistinct in a basal position (Fig. 4). This clade is supported by the follow-

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APPENDIX 1. List of coding for four additional taxa and one modified taxon, based on the matrix in Liu et al. (2013)

| Additional Taxa                     | Coding                             | Description                                      |
|-------------------------------------|------------------------------------|--------------------------------------------------|
| **Xinpusaurus xingyiensis**         | ?????  ?1???? ??????? ???1??    | (based on Cheng, 2003; Liu, 2013)                |
| **Xinpusaurus bamaolinensis**       | ?210? 01101 1?011 2?1?10 11??0 11?03 | (based on Jiang et al., 2004; Maisch, 2014;     |
|                                    |                                    | pers. observ.)                                   |
| **Xinpusaurus kohi**                | ??2100 01101 10011 2??10 10100 11?03 | (based on Cheng et al., 2007, 2011)              |
|                                    | 11???? 1?2?2                      |                                                  |
| **Anshunsaurus huangnihensis**      | 0?20? 0?110 01000 20011  ???00 | (based on Cheng et al., 2007, 2011)              |
|                                    | 20112 0?111 00001                 |                                                  |
| **Anshunsaurus huangnihensis**      | 0?20? 0?110 01000 20011  ???00 | (based on Cheng et al., 2007, 2011)              |
|                                    | 20112 0?111 00001                 |                                                  |
| **Modified Taxon**                  |                                    |                                                  |
| **Anshunsaurus huangnihensis**      |                                    |                                                  |
|                                    |                                    |                                                  |
| **Anshunsaurus huangnihensis**      |                                    |                                                  |
|                                    |                                    |                                                  |
| **Anshunsaurus huangnihensis**      |                                    |                                                  |
|                                    |                                    |                                                  |