



## New fossil material of clam shrimps and insects from the Lower Cretaceous Duoni Formation of eastern Tibet



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
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### Abstract

The Duoni Formation represents a key Early Cretaceous shallow marine to coastal deposit along the Bangong-Nujiang suture zone of the Tibetan Plateau. Previous studies have primarily focused on its marine fauna, whereas research on terrestrial fossils has been largely limited to plants in eastern Tibet. In recent fieldwork near Lingka Village in Baxoi County, eastern Tibet, we collected abundant fossil material from the middle part of the Duoni Formation, including terrestrial organisms such as insects, ostracods, non-marine bivalves, and clam shrimps. This paper presents the first description of insect and clam shrimp fossils from the Duoni Formation, contributing to a more comprehensive understanding of Early Cretaceous terrestrial ecosystems in eastern Tibet. While the uppermost Duoni Formation has been dated to around the Aptian–Albian boundary, the fossil evidence suggests that the base of the formation may extend to the Barremian or earlier.

**Keywords:** Early Cretaceous, terrestrial fossils, beetles, clam shrimps

### Introduction

The Bangong-Nujiang suture zone (BNSZ) is an east-west trending tectonic belt over 1500 km long in central Tibet (Taylor *et al.*, 2003; Ma *et al.*, 2023). It marks the collisional boundary between the Qiangtang and Lhasa blocks, and therefore constraining the timing of

this collision is essential for reconstructing the tectonic evolution of the Tibetan Plateau. The Duoni Formation, widely distributed along the BNSZ, is regarded as a key volcanic-sedimentary unit associated with the Lhasa-Qiangtang collision (Zhu *et al.*, 2019; Zhang *et al.*, 2024).

The Duoni Formation was initially defined as a suite of Cretaceous coal-bearing deposits in Duoni village, Lhorong County, eastern Tibet, and was originally named the “Duoni Coal System” (Li, 1955). It was later redefined as a lithostratigraphic unit composed of dark grey, coal-bearing clastic rocks and formally named the Duoni Formation (Xia & Liu, 1997). Lithologically, it consists predominantly of sandstone, siltstone, mudstone, shale, and slate, with localized occurrences of volcanic rocks (Xia & Liu, 1997).

Geochronological studies of the Duoni Formation have yielded zircon U-Pb ages ranging from 110–123 Ma (Barremian–Albian) from dacite, andesite, and tuff layers in the upper part of the formation in the central and western segments of the Bangong-Nujiang belt (*e.g.*, Kapp *et al.*, 2007; Kang *et al.*, 2009; Sun *et al.*, 2017; Zhang *et al.*, 2024). Based on detrital zircon analyses and zircon age constraints, the age of the upper section of the Duoni Formation in the eastern BNSZ has been interpreted as approximately 113 Ma (close to the boundary of Aptian and Albian) (Yin *et al.*, 2024). Zhang *et al.* (2024) obtained zircon U-Pb ages of 110.95–112.8 Ma from three tuff layers in the uppermost Duoni Formation at

the Wadag Coal Mine section in Baxoi County, eastern Tibet, corresponding to the early Albian. These ages are generally consistent with those reported from the central and western segments of the suture belt (Zhang *et al.*, 2024).

The Duoni Formation is fossiliferous, yielding a diverse assemblage comprising ammonites, bivalves, gastropods, corals, stromatoporoids, echinoids, brachiopods, ostracods, orbitolinids, abundant plants, and pollen and spores (Bureau of Geology and Mineral Resources of Xizang Autonomous Region, 1993; Xia & Liu, 1997; Lin & Li, 2019; Zhang *et al.*, 2019; Tan *et al.*, 2023). Previous studies have primarily focused on its marine fauna and plants; however, to date, no definitive records of insect or clam shrimp fossils have been described from the Duoni Formation. Here, we briefly describe the first discoveries of beetle elytra (Coleoptera) and clam shrimp specimens from the middle section of the Duoni Formation in the black mudstone of the Wadag Coal Mine section, Baxoi County, eastern Tibet.

## Material and methods

The study area is located at the Lingka section in Baxoi County, Chamdo City, Tibet (Fig. 1). In this section, the Duoni Formation is composed of interbedded quartz sandstone, black siltstone, and shale. The uppermost layer contains andesite, quartz sandstone, volcanic rocks, and tuff. More than 30 coal seams have been identified in the adjacent Wadag Coal Mine section (Yin *et al.*, 2024; Zhang *et al.*, 2024). The fossil specimens described in this study were collected from the black mudstone in the middle part of the Duoni Formation.

Photographs were taken using a Zeiss AxioZoom V16 stereomicroscope. A Thermo Scientific Quattro S scanning electron microscope (SEM) was employed to examine and document the micro-ornamentation. The map was prepared using CorelDRAW 2024 graphic software. All specimens are deposited in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (CAS), Nanjing, China.

## Geological setting

The Lower Cretaceous Duoni Formation exhibits significant regional variation along the BNSZ. In the eastern segment, it consists predominantly of coal-bearing interbedded quartz sandstone, dark siltstone and mudstone, with volcanic rocks occurring at the top, whereas in the central-western segment, it is characterized by a suite of variegated clastic deposits with localized

coal seams and volcanic rocks near the top (Xia & Liu, 1997). Regionally, the Duoni Formation unconformably overlies older stratigraphic units of varying ages. In eastern Tibet, it typically overlies the Upper Jurassic–Lower Cretaceous Lagongtang Formation, and its upper boundary is generally in conformable contact with the overlying Langshan Formation.

The Duoni Formation is widely developed in eastern Baxoi County and constitutes an important coal-bearing stratigraphic unit. Liu *et al.* (2007) interpreted the strata at the Wadag Coal Mine section as belonging to the Lower Cretaceous Duoni Formation, while considering the Lingka section to be mainly composed of the upper parts of the Lagongtang Formation, with only its uppermost part representing the Duoni Formation. However, based on our field investigations at the Lingka section and its lithological correlation with the Wadag Coal Mine section, we interpret both sections as representing the Duoni Formation in its entirety, and consider the Lagongtang Formation to be absent. The Wadag Coal Mine section represents the upper part of the Duoni Formation, whereas the Lingka section, with its base not exposed, represents at least the middle to upper part of the Duoni Formation.

## Results

Seven beetle elytra and some potential insect fragments and three clam shrimp specimens have been discovered from the black mudstone of the middle parts of the Duoni Formation at the Lingka section in eastern Tibet. Some poorly-preserved ostracods and abundant non-marine bivalves co-occurred in these bedding planes.

The beetle elytra (Fig. 2) are variable in shape and are relatively well preserved in three dimensions. Specimen 1 (Fig. 2A): the elytron is about 3.25 mm in length and 1.28 mm in maximum width, with a length about 2.5 times its width; the anterior part of the inner margin is inflexed, the outer margin is well defined, the apical portion is moderately pointed; the surface bears distinct punctation and approximately 11 longitudinal costae extending toward the apical part of the elytron along the inner margin. Specimen 2 (Fig. 2B): the elytron is 0.91 mm in length and 0.49 mm in maximum width, with a length about 1.86 times its width; the elytron is relatively short and broad; the posterior portion gradually becomes bluntly rounded, the anterior margin is arched, the inner margin is straight in its anteromedial part but becomes arcuate posteriorly, the outer margin is broad and arched. These elytra may indicate a possible affinity with the suborder Polyphaga, the largest and most diverse beetle lineage.

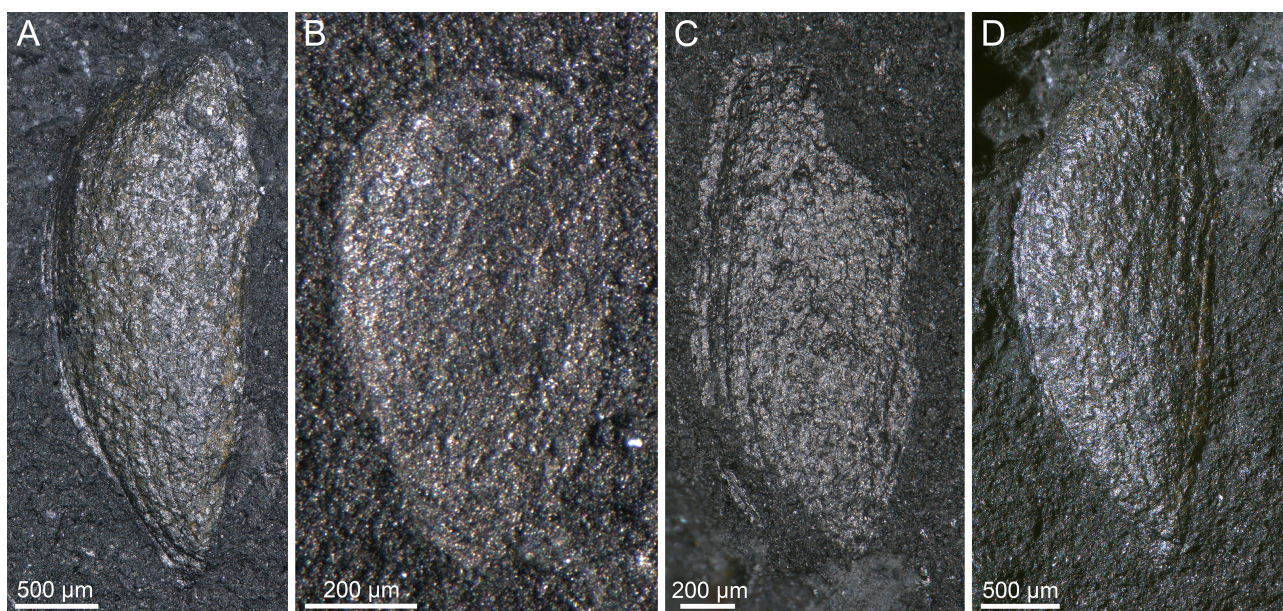


**FIGURE 1.** Fossil locality of the Duoni Formation at the Lingka section, eastern Tibet. **A**, Geographical map of the fossil locality near Lingka, Baxoi County. **B**, The position of fossil locality in China. **C**, Field photograph showing the fossil-bearing outcrop of the Duoni Formation. **D**, *Peregrinoconcha* sp. from the Duoni Formation.

Liu *et al.* (2007) noted that, during their participation in the Comprehensive Hengduan Mountains Scientific Expedition, they measured the stratigraphic section together with Prof. Qibin Lin and colleagues. They mentioned the presence of insect fossil fragments recorded from the ninth layer of the upper part of the

“Lagongtang Formation” at the Lingka section in Baxoi County, without any descriptions or illustrations provided (Liu *et al.*, 2007). One of the present authors (DYH) subsequently consulted Prof. Qibin Lin regarding these fossils; he did not recall having examined any insect fossils from this assemblage (pers. comm.).





**FIGURE 2.** Photographs of beetle elytra (A–D), Duoni Formation.

The clam shrimp specimens represent two distinct morphotypes. However, due to the limited number and incomplete preservation of the specimens, precise taxonomic identification is currently not possible, and additional material will be required to clarify their taxonomy and biostratigraphic significance.

Morphotype 1 (Fig. 3A–C): Only the middle ventral portion of a single valve is preserved. The valve possesses narrow, irregularly spaced growth bands ornamented with fine irregular lirae, some of which bifurcate and are occasionally intersected by weak transverse striae. These characters show a vague similarity to *Orthestheriopsis*, a genus reported from the Lower Cretaceous Puchanghe Formation in Xiangyun, Yunnan Province.

Morphotype 2 (Fig. 3D–F): The specimen preserves the anteroventral portion of a valve, characterized by indistinct ornamentations which appear to be reticulate on the growth bands. Serrated structures are aligned along the growth lines. These structures are actually insertion remains of simple setae on growth lines and should not be regarded as an important taxonomic characteristic (Liao *et al.*, 2019). However, when the available morphological features are considered comprehensively, this species bears a tentative resemblance to *Eosestheriopsis* known from the Tuodian Formation in central Yunnan.

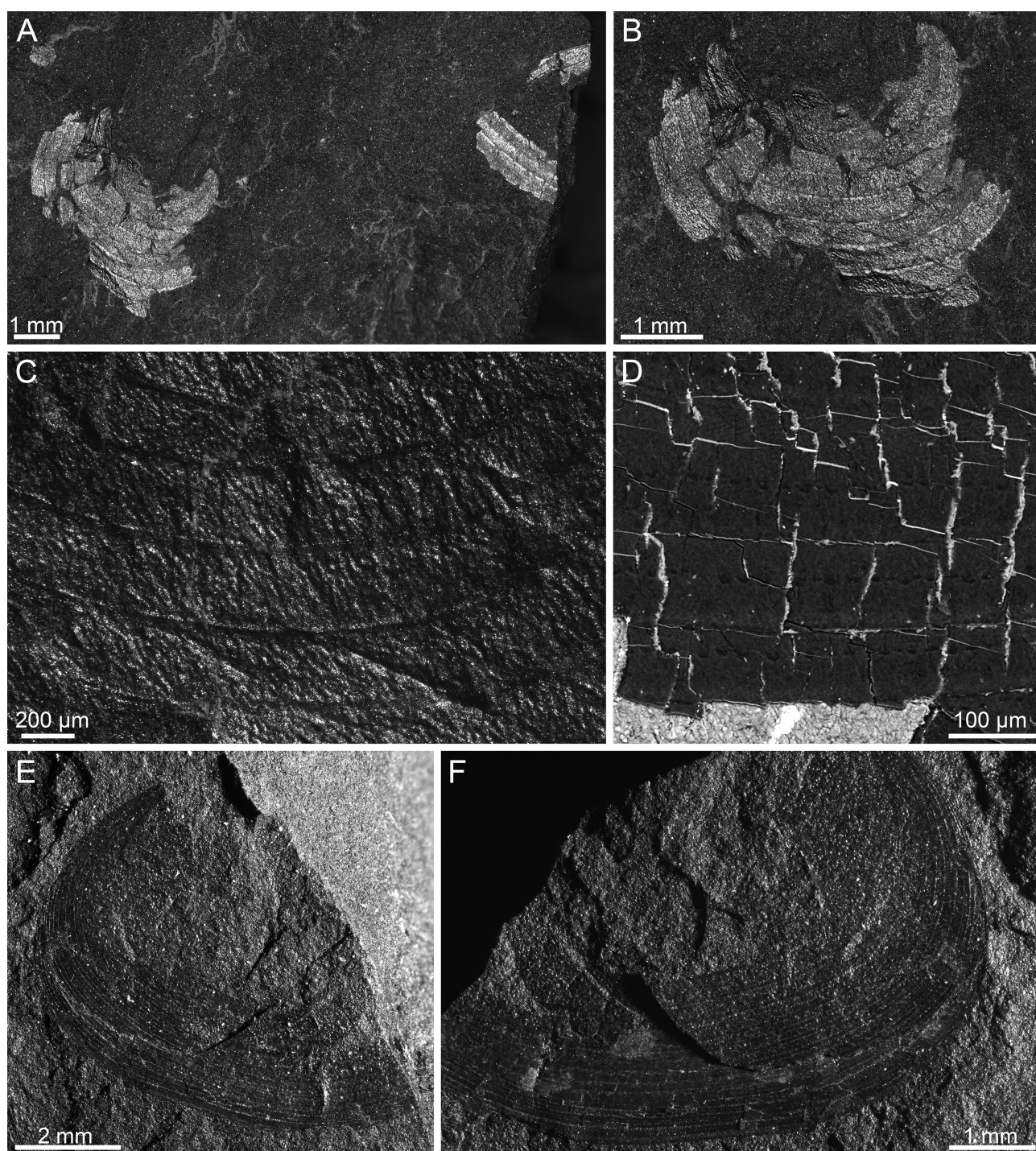
Huang *et al.* (2021) proposed that the first appearance of *Eosestheriopsis* marks the beginning of the Cretaceous. *Eosestheriopsis* occurs in the upper part of the Suining Formation, which is interpreted as representing the onset of the Cretaceous, and subsequently becomes abundant in the overlying Penglaizhen Formation (Huang *et al.*, 2021). The Penglaizhen Formation correlates to the

Tuodian Formation in central Yunnan Province, both of which yield *Eosestheriopsis*; therefore, the Penglaizhen and Tuodian formations were interpreted as early Early Cretaceous. The age of the Puchanghe Formation is regarded as Barremian–Albian (Xi *et al.*, 2021), or alternatively Aptian–Albian (ChinaLex, 2024).

## Discussion

Bureau of Geology and Mineral Resources of Xizang Autonomous Region (1993) presented conflicting biostratigraphic interpretations of the Duoni Formation based on different fossil groups. The ammonite assemblage was considered to indicate a Berriasian–Valanginian age; the stromatoporoid assemblage was regarded as Late Jurassic to Early Cretaceous in age; among bivalves, *Pterinella*, a standard Early Cretaceous index fossil widely distributed in the Tethyan realm, as well as *Xenocardita* and *Fenestricardita fenestrata*, were considered to indicate an Aptian age; orbitolinids were identified as typical Aptian taxa; other fossil groups, including gastropods, brachiopods, corals, and echinoids, were likewise considered to indicate a Late Jurassic to Early Cretaceous age. Additionally, foraminifers, bivalves, and ammonites collected in Baingoin County were interpreted to indicate age ranges of Barremian–Cenomanian and Berriasian–Valanginian (Zhang *et al.*, 2019). In the Xiongmei–Qusongbo area, bivalves and foraminifers were regarded as indicating a Barremian–Aptian to Albian range (Zheng *et al.*, 2003; Xi *et al.*, 2019).





**FIGURE 3.** Photographs of clam shrimp specimens from the Duoni Formation. **A–C**, Morphotype 1, light microscopy. **D–F**, Morphotype 2. **D**, Scanning electron micrograph (SEM). **E, F**, Light microscopy. The SEM image (**D**) was acquired using an accelerating voltage of 20.0 kV and a working distance of 16.9 mm.

Abundant plant fossils from the Duoni Formation of eastern Tibet also support an Early Cretaceous age (Li, 1982; Liu *et al.*, 2007). The *Zamiophyllum-Weichselia-Klukia* assemblage, discovered in the lower and middle parts of the Duoni Formation in eastern Tibet (Chen *et al.*, 1983; Yang & Chen, 1983), was assigned to the Neocomian. The discovery of *Grammatodon carinatus* and *Lopha shadingensis* sp. in the middle part of the

formation was interpreted to suggest an Aptian–Albian age (Yang & Chen, 1983). Pollen and spores extracted from the plant specimens of Liu *et al.* (2007) of the Duoni Formation at Wadag Coal Mine imply an Early Cretaceous or Berriasian–Barremian age (Lin & Li, 2019).

Provided that the identifications of the clam shrimp genera are reliable, they would imply a relatively broad range extending from the early Cretaceous to the late Early



Cretaceous. However, owing to the poor preservation of these clam shrimp specimens, their diagnostic characters remain uncertain. Nevertheless, they still support an interpretation of the Duoni Formation as an Early Cretaceous unit rather than a Late Jurassic one.

Based on the biostratigraphic evidence from multiple fossil groups outlined above, together with recent advances in isotopic geochronology, we suggest that the uppermost Duoni Formation may extend to the early Albian, that its main depositional interval corresponds to the Aptian and Barremian, and that its basal part is likely to be older than the Barremian.

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