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First fossil cobitid (Teleostei: Cypriniformes) from Early-Middle Oligocene deposits of South China

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Abstract †*Cobitis nanningensis* sp. nov., the earliest fossil cobitid fish from Early-Middle Oligocene deposits of Nanning Basin, Guangxi Zhuang Autonomous Region, southern China, is described here. The new species is represented by specimens of the distinctive suborbital spine. The bifid suborbital spines are 1.8−3.0 mm in length. Their laterocaudal processes are thinner and shorter than their mediocaudal processes, and the lengths of the laterocaudal processes are about 1/3 of those of the mediocaudal ones. The lateral process of the spine is prominent. The new species most closely resembles †*Cobitis primigenus* from the Late Oligocene deposits of Germany, but in †*C. nanningensis* the lateral process of the suborbital spine is more developed. The discovery of the new species and other previously known fossils of *Cobitis* indicate that the Cobitidae family has had a wide distribution in Eurasia since at least Oligocene.

Key words Nanning Basin, Guangxi; Early-Middle Oligocene; Cypriniformes, Cobitidae, suborbital spine

Nanning Basin is a Paleogene inland faulted basin situated in the southern part of Guangxi Zhuang Autonomous Region, South China. Since the first investigation by Zhu Tinghu in 1920s in this basin, many Eocene and Oligocene fossils of invertebrates (e.g. bivalves, gastropods, and ostracods) and plants (mainly angiosperm) have been found from the basin (Bureau of Geology and Mineral Resources of Guangxi Zhuang Autonomous Region, 1985; Deng and Wu, 1992; Ning et al., 1994; Tian et al., 2013), whereas fossil vertebrates are relatively rare, let alone the study on them. To date, the reported fossil vertebrates from Nanning Basin include only several Oligocene species as follows: 1) part of a pectoral spine of *Pseudobagrus* sp. (Bargardae, Suluriformes) (Zhao, 1981); 2) three vertebral centra and three incomplete lower jaw bones with no teeth of *Crocodilus* sp. (Crocodylidae, Crocodiliformes) (Zhao, 1981); 3) a turtle carapace of Emydidae (Testudoformes) (Zhao, 1981); and 4) several teeth and jaw bones of three species of the genus *Heothema* (Anthracotheriidae, Artiodactyla) (Zhao, 1981, 1983, 1993).

During 2000s, some Paleogene strata in Nanning Basin were outcropped with the urban

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development and construction. Many disarticulated bones of fossil fishes (e.g., Cyprinidae of Cypriniformes and Siluriformes) and reptiles (Crocodiliformes and Testudoformes) were exposed on the surface of the outcrops in the localities, such as the area near the Lining Sports Park, Langdonggaopo, Liluo Coal Mine, Santang, and Qitang, Nanning Basin (Fig. 1). The first three localities are relatively rich in fossils. Screenwashing done at these three localities produced abundant fossil pharyngeal teeth of Cyprinidae. From a morphological viewpoint, the constitution of these pharyngeal teeth differs from that of the contemporary Bohai gulf fauna (Chang et al., 1985). In addition to the pharyngeal teeth of cyprinids, more than one hundred suborbital spines of Cobitidae (Cypriniformes) were discovered from Langdonggaopo and Liluo Coal Mine. These materials represent the first records of Oligocene cobitid from Asia, and the earliest cobitid from the world thus far. Here we describe the fossil-bearing strata and the cobitid suborbital spines. The terminology used herein follows Nalbant (1963). A dagger symbol "†" is used to denote the extinct taxa. The fossils of other taxa will be described in a separate study.

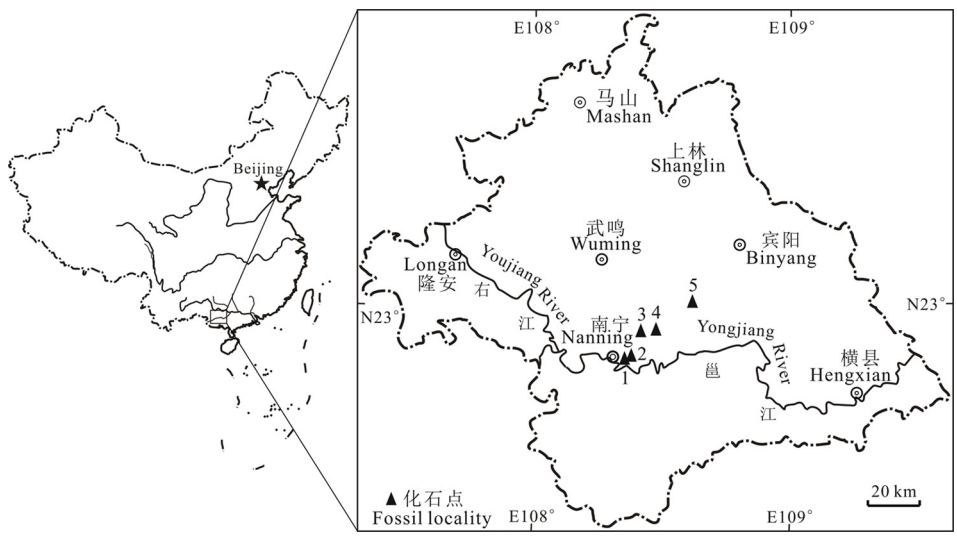

Fig. 1 Oligocene fossil fish localities in Nanning Basin, Guangxi, South China
1. Side of the Lining Sports Park, Langdong; 2. Langdonggaopo; 3. Liluo Coal Mine; 4. Santang; 5. Qitang

1 Geological setting

The cobitid fossil-bearing strata belong to the lower part of the Yongning Formation in the geological map (Zhao, 1981). The Yongning Formation is Oligocene in geological age, distributed in all the Nanning Basin with a thickness of about 270−617 m. The deposits are mainly grey-green silty mudstone, siltstone, and mudstone, with several layers of coal in the lower and upper parts (Ning et al., 1994). The strata of the outcrop in Langdonggaopo (N 22°49′39.5″, E 108°25′19.7″) from the top to the bottom see Wang et al., 2015: fig. 2.

According to Wang et al. (2015), the palynoflora from Langdonggaopo and Liluo outcrop reveals a warm and humid climate during the depositional period, with a vegetation type of subtropical wet evergreen, and deciduous broad-leaved mixed forest. They are likely Early-Middle Oligocene in geological age.

2 Systematic paleontology

Superorder Ostariophysi Sagemehl, 1885
Order Cypriniformes Bleeker, 1859/60
Family Cobitidae Nalbant, 2002
Genus *Cobitis* Linnaeus, 1758
† *Cobitis nanningensis* sp. nov.

(Fig. 2)

Etymology Nanning, name of the locality where the specimens were collected.

Holotype NHMG (abbreviation of Natural History Museum of Guangxi Zhuang Autonomous Region) 011653.1, collected from Liluo Coal Mine.

Referred specimens NHMG 011653.2-90, collected from Liluo Coal Mine; NHMG 011653.91-113, collected from Langdonggaopo. These suborbital spines are morphologically similar and consequently are tentatively treated as the same genus and species.

Locality and horizon Liluo Coal Mine (N 22°53′35.8″, E 108°29′56.4″) and Langdonggaopo (N 22°49′39.5″, E 108°25′19.7″), Nanning, Guangxi. Lower-Middle Oligocene, lower part of Yongning Formation.

Diagnosis Small bifid suborbital spines with their length about 1.8−3.0 mm, length of mediocaudal process about three times of that of the laterocaudal process, the lateral process prominent and closer to base of spine than to bifid point of spine.

Description The suborbital spines are small. Among them, the lengths (the distance between the anterior tip and the posterior end) of those collected from the Langdonggaopo are about 1.8−2.5 mm, while the lengths of those collected from the Liluo Coal Mine vary from 1.8 to 3.0 mm. The mediorostral process, in contact with the orbitosphenoid, is long. The laterorostral process, linked with palate, is short and stout. The spines are bifurcated. The mediocaudal process is long and stout, with the posterior end slightly curved medially, whereas the laterocaudal process is short and thin, with its length about 1/3 of that of the mediocaudal process. The posterior end of the laterocaudal process is slightly curved medially as well. The lateral process is prominent and the medial process is moderately developed. The lateral process is closer to the base of the spine than to the bifid point of the spine (Fig. 2A-H).

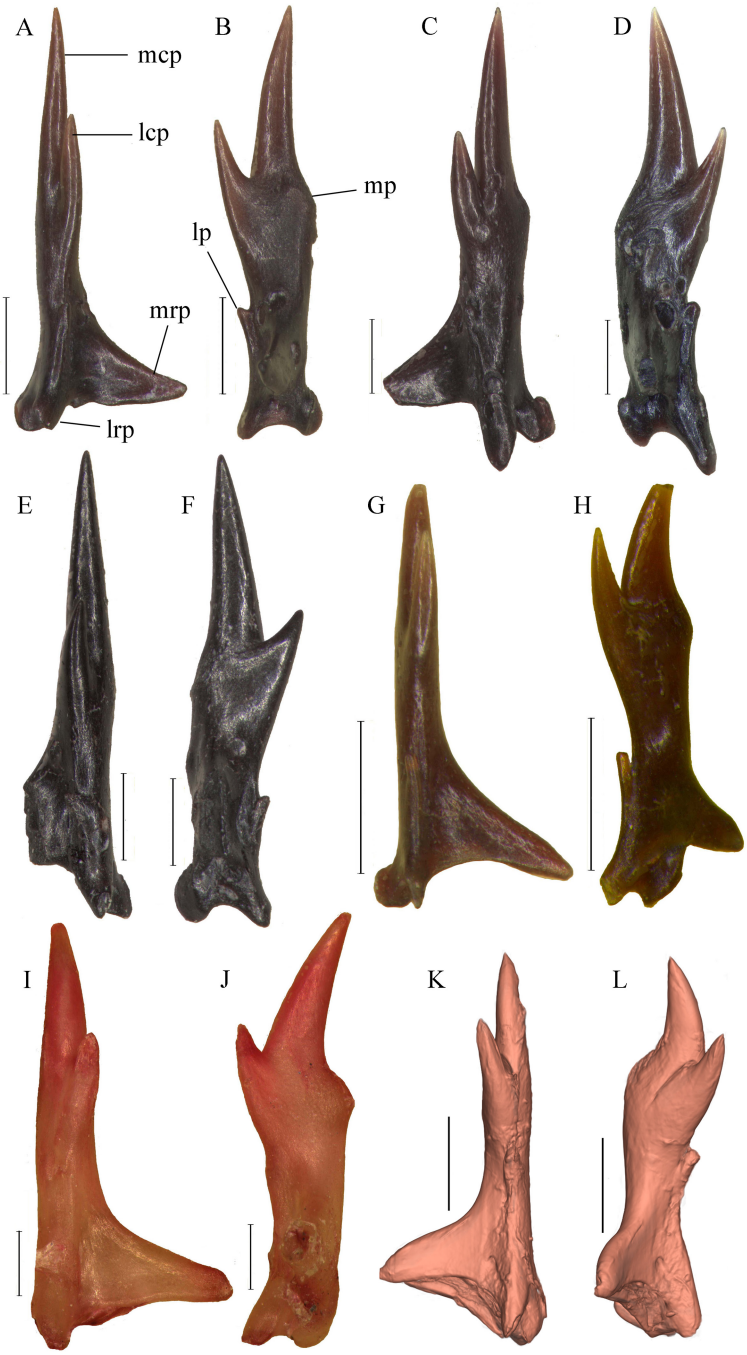

Fig. 2 Comparison of suborbital spines of †*Cobitis nanningensis* sp. nov., *C. sinensis*, and *Bibarba micoculum* A-H. †*Cobitis nanningensis* sp. nov., A-B. holotype, NHMG 011653.1, A. lateral view, B. dorsal view; C-D. NHMG 011653.2, C. lateroventral view, D. laterodorsal view; E-F. NHMG 011653.3, E. lateral view, F. laterodorsal view; G-H. NHMG 011653.91, G. lateral view, H. dorsal view; I-J. *Cobitis sinensis*, NHMG 011654, 85.0 mm SL, I. lateral view, J. dorsal view; K-L. *Bibarba micoculum*, GIF (Guangxi Institute of Fisheries) 08090070, female, 56.7 mm SL, K. lateral view, L. dorsal view. Scale bars equal 0.5 mm
lcp. laterocaudal process 侧后突; lp. lateral process 侧突; lrp. laterorostral process 侧吻突; mcp. mediocaudal process 中后突; mp. medial process 中突; mrp. mediorostral process 中吻突

3 Comparison and conclusion

The suborbital spine is formed by the modification of the lateral ethmoid. In loaches, the anterior end of the lateral ethmoid movably articulates to the anterolateral side of the orbitosphenoid, and the posterior part of the lateral ethmoid extends backward, forming a spine. The spine can stretch out and draw back, and consequently can act as an effective defense organ (Nalbant, 1963; Chen, 1981; Sawada, 1982). These modified movable lateral ethmoids − suborbital spines, can only be seen in fishes belonging to families Botiidae and Cobitidae, although they are prominently different in morphology. Nalbant (1963, 2002) pointed out that the mediocaudal process and the laterocaudal process on the suborbital spines of cobitid fishes are in a horizontal plane, and there are two additional processes, i.e., lateral and medial processes, situated on the outer and inner edges of the spine respectively. In contrast, the processes in botiid fishes are in a vertical plane, and there are no lateral and medial processes on the spine. In addition, the mediorostral process is more developed in cobitids than in botiids. There is a sizable lateral process in the suborbital spines from Yongning Formation, and the mediorostral process is very developed, therefore, these fossil spines undoubtedly belong to the Cobitidae.

The Cobitidae is a clade of small, bottom-dwelling freshwater fishes, widely distributed in Eurasia and Morocco, with the greatest diversity in southern Asia (Bănărescu, 1990). The number of genera included in the family varies from 12 to 20 according to different authors, and no consensus has been reached (Nalbant, 1963, 1994; Nelson, 2006; Slechtová et al., 2008). In addition to color pattern, morphometric characters, fin formula, development of the barbels and mental lobes, and the shape and size of scales and their extent over the body, the presence or absence of the suborbital spine and its shape and size are usually used as important characters in diagnosing subdivisions within the family (Vladykov, 1929, 1935; Nalbant, 1963; Sawada and Kim, 1977; Siebert, 1991; Yang et al., 1994; Chen and Chen, 2005a, b, 2007). This is common practice especially in identifying fossil taxa (Sytchevskaya, 1989). For example, *Cobitis arenae* Lin, 1934 was first described as *Misgurnus arenae* based on the specimens collected from Huiyang, Guangdong Province. Later, Nichols transferred this species to the genus *Cobitis*, because the presence of the suborbital spine and the body shape of the nominated species is not observed in the genus *Misgurnus* (Chen, 1981). Among the cobitid fishes, *Paramisgurnus* is another genus without suborbital spines resembling *Misgurnus* (Chen, 1981; Sawada, 1982). Nalbant (1963) pointed out that in *Sabanejewia* the suborbital spine is stronger than that in *Cobitis*. The suborbital spines among genera *Bibarba*, *Cobitis*, and *Niwaella* are all quite different from each other (Chen and Chen, 2007). In genus *Kottelatlima* the suborbital spine is only a single hook (Nalbant, 1994), different from the bifid spines in other cobitid genera. At present, there are five cobitid genera distributed in the rivers within Guangxi: *Protocobitis*, *Bibarba*, *Cobitis*, *Misgurnus*, and *Paramisgurnus*. The new material is compared with the first three genera, because the remaining two possess no suborbital spines.

Protocobitis are endemic to Guangxi dwelling in underground water source with blind eyes and a weak suborbital spine (Yang et al., 1994; Zhu et al., 2008). In *Protocobitis* the laterocaudal process of the suborbital spine is short, with the length less than 1/3 of the mediocaudal process (Yang et al., 1994: fig. 2b). *Bibarba* are currently known only inhabiting in Guangxi; their suborbital spines are thicker and shorter than in *Cobitis*, and the lateral process is strong and closer to the bifid point of the spine comparing with *Cobitis* (Chen and Chen, 2007; Fig. 2I-L). Our fossil cobitid cannot be assigned to neither *Protocobitis*, nor *Bibarba*: it differs from *Protocobitis* in having a longer laterocaudal process of the suborbital spine, differs from *Bibarba* in possessing a thinner suborbital spine and the mediocaudal process of the spine is longer, and the lateral process is closer to the base of the spine and less prominent. Overall, the fossil suborbital spine resembles that of *Cobitis*.

There are three species of *Cobitis* in southern China: i.e., *C. arenae*, *C. multimaculata* and *C. microcephala* (Chen and Chen, 2011). The lateral process is undeveloped in the suborbital spines in the latter two species (Chen and Chen, 2011). The lateral process on the suborbital spine in *C. arenae* has not been described by previous researchers (Chen, 1981; Chen and Chen, 2005a, b; ect.), but Chen and Chen (2007) pointed out that the lateral process of the suborbital spine in genus *Cobitis* is underdeveloped or lacking. Therefore, we treat *C. arenae* as of the same case. Consequently, the fossil cobitid differs from not only the three species of *Cobitis* mentioned above, but also all other species of *Cobitis* distributed in China, in its suborbital spine possessing a developed lateral process. Furthermore, *Cobitis* is the most species-rich and widespread genus in Cobitidae, distributed widely in Eurasia and Morocco. According to the fig. 2A of Ludwig et al. (2001), some species of *Cobitis* such as the Balkan loach (*C. elongate*) and *C. fahireae* (endemic to Turkey) have developed lateral processes on their suborbital spines resembling that of our fossil form. However, our new form differs from them in the larger ratio of length of mediocaudal process/length of the body of the spine. Thus, the new fossil form is tentatively assigned to the genus *Cobitis*, but cannot be assigned to an extant species.

Fossil cobitids have been discovered from several localities thus far (Chang and Chen, 2008; Conway et al., 2010) (Fig. 3). Among them most are isolated suborbital spines from Neogene and referred to *Cobitis* (Chang and Chen, 2008; Chen et al., 2010). The first described fossil cobitids are †*Cobitis* centrochir and †*C. angustus* from the Upper Miocene of Öhningen, Baden, Germany (Agassiz, 1833-1843). Both are represented by nearly complete skeletons but the suborbital spine was not described in detail in the former and was not preserved in the latter. †*C. longipectoralis* from late Early Miocene of Shanwang, Shandong, China is the first fossil cobitid from East Asia (Zhou, 1992). It is represented by complete skeletons with presence of suborbital spine. The spine is bifid with a slightly curved and long mediocaudal process and a very short laterocaudal process (Chen et al., 2010). Our form differs from it in having thinner spine and longer laterocaudal process. Another known nearly complete skeleton of fossil cobitids is *Cobitis* cf. *C. taenia*, from the Pliocene of Rochefort-Montagne, Puy-de-

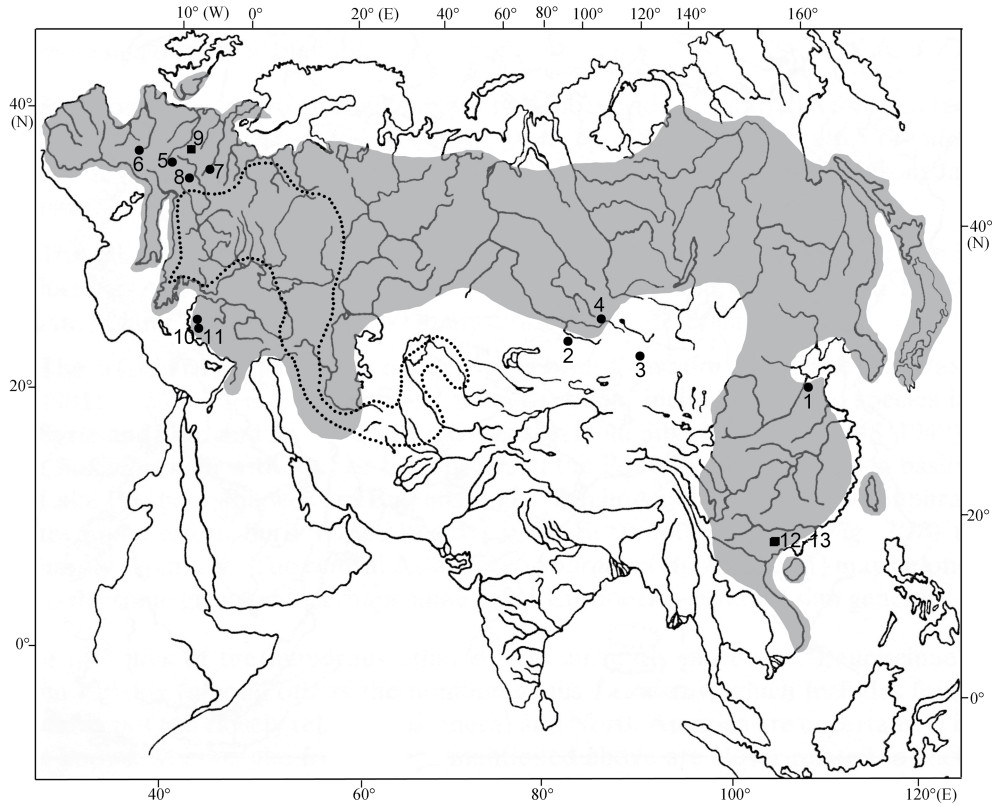

Fig. 3 Localities of fossil cobitids from Oligocene (black square) and Neogene (black circle) and distribution of living *Cobitis* (shaded) and *Sabanejewia* (area circled by dots) (modified from fig. 2/30 in Bănărescu, 1990) 1. Shanwang, Shandong Province, East China; 2. Zaisan Basin, eastern Kazakhstan; 3. Shargain-Gobi, Mogolia; 4. Chui Basin, Altai Mountains; 5. Oeningen, Baden, Germany; 6. Rochefort-Montagne, France; 7. Browncoal Basin, North Bohemia, Czech; 8. Sandberg, Vienna Basin, Austria; 9. Oberleichtersbach, Rhon Mountains, Germany; 10. Develikoy, 11. Safran Coal Section, western Turkey; 12. Langdonggaopo, 13. Liluo, Nanning, Guangxi, South China

Dome, France (Gaudant, 1976). Its suborbital spine is missing. Apart from the articulated skeletons, isolated suborbital spines of cobitids were found from the Middle-Late Miocene and Pliocene of Zaissan Basin in East Kazakhstan, Altai, and West Mongolia (Sytchevskaya, 1989), the Late Miocene-Early Pliocene of Turkey (Rückert-Ülkümen et al., 2002; Rückert-Ülkümen and Yiğibaş, 2007), the Miocene of Vienna Basin, Austria (Böhme, 2002), and the Late Oligocene of North Bavaria, Germany (Böhme, 2008). Based on the isolated suborbital spines, several new species and subspecies of *Cobitis* (†*C. zaisanica* from East Kazakhstan, †*C. ichberchae* and †*C. zaisanica orientalis* from West Mongolia, †*C. centralasiae* from Altai, †*C. martinii* from Austria, and †*C. primigenus* from Germany) and a new species of *Sabanejewia* (†*S. shargaensis* from West Mongolia) were erected. Compared with all the isolated suborbital spines mentioned above, the spines in our new form are thinner than †*C. centralasiae*, and the mediocaudal process is longer and the laterocaudal process is shorter than

that in †*C. centralasiae*. The new form is also prominently different from the other Central Asian species in having a smaller size and some other characters, and different from †*C. martinii* in the thinner body of the spine and the longer laterocaudal process. The new spines most closely resemble †*C. primigenus* and †*C. centralasiae* except that the lateral process of the spine is less developed in †*C. primigenus*. Therefore, the new form is distinguishable from its fossil relatives, and thus should be a new species of the genus, *Cobitis nanningensis* sp. nov.

Oligocene cobitids, †*C. nanningensis* sp. nov. and †*C. primigenus*, currently represent the earliest cobitids. The fossil localities fall in the geographic range of Recent *Cobitis*, but the Neogene fossil localities from the Central Asia are either situated outside the recent geographic range of *Cobitis* or just at the southern boundary. Thus, it is most likely that *Cobitis* had a wider distribution during the Neogene than the present day. Chen et al. (2010) speculated that the absence of *Cobitis* in Central and most part of South Asia today is possibly attributable to the uplift of this area caused by the rigorous tectonic movement during the Cenozoic, as has been suggested by some ichthyologists (Chen and Zhu, 1984). The discovery of material of *Cobitis* in southern China, along with the previous known fossils from Germany, indicates that the family Cobitidae has been widely distributed in Eurasia since at least the Oligocene.

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广西南宁盆地发现渐新世早−中期鳅科眼下刺化石

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摘要：根据产自广西南宁盆地渐新世早−中期的鳅科鱼类眼下刺化石建立了鳅属新种：南宁鳅†*Cobitis nanningensis* sp. nov.。眼下刺长1.8~3.0 mm, 粗细适中，刺二分叉，侧后突较中后突短而细，长度约为中后突长的1/3, 侧突发育。这些眼下刺与德国晚渐新世的†*Cobitis primigenus*最为相似，但又以侧突更为发育而与之区别。这是迄今最早的鳅科化石记录，为了解早期鳅科鱼类的分布和眼下刺的形态特征提供了有益证据。南宁鳅及德国晚渐新世的†*C. primigenus*揭示，渐新世时期鳅科鱼类已广布于欧亚大陆。

关键词：广西南宁盆地，渐新世，鳅科，眼下刺

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